MOL SCIENTIFIC MAGAZINE 2008 / 2

MOL

MOL Scientific Magazine | 2008 / 2

- The price for supply security. The case of Central Eastern European natural gas market
- Placing energy business in the risk-return portfolio matrix of MOL Group
- Study on enhanced recovery in hydrocarbon fields in Hungary

MOL GROUP

CONTENTS

2008/02

Workshop

HU ISSN 1217-2820

Editorial

Dear Reader,

Tradition may also be maintained by only making slight changes to routine if we feel the timing is right and that there are very good reasons to do so. This is especially true of swiftly-growing companies under great pressure to meet regional communications needs and aspirations.
You will probably notice right away that from this issue onwards, MOL Scientific Magazine will be published exclusively in English, with some Hungarian summaries in each edition.
In doing so, we are sure that we will reach a much wider international audience and sincerely hope that our articles live up to stringent professional standards and offer new ways of looking at things for readers working in our field of expertise. We are very proud of the fact that our colleagues will take the time and energy to share their latest insights, most up-to-date ideas and the results of their latest research projects across a broad range of topics, such as, for example, security of natural gas supplies, enhanced recovery methods in Hungarian hydrocarbon fields, new turbo-feed pump construction or energy efficiency improvements.
You might also care to visit our recently launched MOL Scientific Magazine website at **http://www.mol.hu/hu/a_molrol/mediaszoba/kiadvanyok/** to download articles most closely related to your areas of interest. When creating this online version, it was our intention to make "the MOL knowledge-pool" easily accessible and to demonstrate, in a way, how MOL Group can contribute to better understanding of the latest developments in the energy sector, worldwide.
We hope that the following articles will provide you with fruitful reading and top quality scientific food for thought.

Enjoy your read!

The European Petroleum Industry in 2007

György Wilde, Dr. (56)
Chemical engineer
Hungarian Petroleum Association
E-mail: hpa@t-online.hu

Abstract

2007 was an animated year in the history of the European petroleum industry and trade. The price of crude oil was continuously growing and decisive regulation for the future was accepted in the EU. The present article, based on the lectures held in the General Information Meeting of Europia, reflects the most important events. It discusses the following topics in details:

- **energy policy, efficiency and security**
- **climate change and environment**
- **fuel products.**

Összefoglalás

AZ EURÓPAI KŐOLAJIPAR 2007-BEN

Az európai olajipar érdekképviselete, az EUROPIA éves közgyűlésén áttekintette a kontinenst szakmai szempontból leginkább érintő 2007. évi eseményeket. Ez alapján készült a jelen összefoglaló, melyben a következő témaköröket tekintjük át:

- **energiapolitika, hatékonyság, biztonság**
- **éghajlatváltozás és környezet**
- **üzemanyag minőségek.**

Introduction

The European Petroleum Industry Association (EUROPIA) held the so-called "General Information Meeting" on May 27th, 2008 and information written bellow is based on the materials presented there.

Without doubt Energy climbed to the top of the top of the European policy agenda in 2007. Concerns about high energy prices and price volatility, security of supply and climate change ensured that Energy was not only firmly on the political and policy agendas of Europe but also never far from the newspaper headlines.

Just ten days into the year, the EU Commission presented its long-awaited first Strategic Energy Review for Europe, a comprehensive energy policy and Action Plan proposal for Europe to address the critical issues of sustainability, competitiveness and security of supply. In parallel the Commission put forward a Green Paper on the options for EU climate change policy and perspectives for international co-operation post-2012. This in part resulted in the revision of the EU emissions Trading Scheme in an attempt to provide for stability of investments and to step up the momentum on cutting greenhouse gas emissions.

In no less a significant manner, the close of 2007 was heralded by the signing of the Treaty of Lisbon. Aimed at providing the Union with the legal framework and tools necessary to meet future challenges and to respond to citizens' demands, this historic treaty amends the current EU and EC treaties.

A key objective of the Treaty is to enhance Europe's position as an actor on the global stage and implicit in this is the EU promoting measures at international level to deal with environmental problems and climate change.

Whilst the petroleum industry undoubtedly welcome the initiative to consolidate and harmonise energy and climate change related initiatives, the proliferation of targets that emerged and inconsistencies within a number of the regulations caused concerns. The binding targets of 20% renewables and 10% biofuels by 2020 for instance, remain challenging and a source of much debate, particularly around the implications for, and securing of, sustainable bio-fuel supplies.

In contributing to the significant and ongoing public debate around EU energy policy, industry continues to stress the importance of a balanced approach to the three energy policy pillars of competitiveness, sustainability and security of supply. A strong Refining sector is critical for the secure supply of oil products to Europe's industrial and consumer users and as with many other industrial sectors, Refining is exposed to significant global competition. Recognising this within a balanced policy framework is therefore crucial to ensure that this vital industrial sector is not disadvantaged but rather, a level playing-field of competitiveness and ongoing investment is maintained.

Following its 2006 Green Paper, in January 2007 the European Commission published the 'all embracing' energy and climate package outlining a long-term energy vision for Europe. The package covered a range of issues from the functioning of the internal energy market, security of energy supply and a long term commitment to CO_2 reduction, to the EU Emissions Trading Scheme (EU ETS) and targets for achieving energy efficiency improvements, renewable energy and biofuels.

In addition, a Communication on Climate Change was issued, stating that the EU must adopt the necessary domestic measures to ensure that local average temperatures do not exceed pre-industrial level by more than 2 °C.

In the March Summit of 2007, member states adopted legally binding targets to address climate change, energy security and competitiveness. The famous 20-20-20 aspiration became a reality – a 20% reduction of greenhouse gas (GHG) emissions; a 20% renewables share in the energy mix and a 20% energy efficiency improvement – by 2020. In addition, a 10% biofuels target by 2020 was agreed.

In 2008, attention has turned to the implementation of these targets. However, with an incomplete internal market for gas and electricity and with member states continuing to focus on bilateral energy relationships with supplier countries, a common EU energy policy is still in its infancy. Furthermore, many of the agreed targets remain challenging and the complexity of the legislative proposals has resulted in unnecessary duplication. EUROPIA will continue to engage with stakeholders to address these issues.
Concerns related to energy security and supply transparency continue to occupy both the European Commission and member states. Some member states are looking to introduce changes to the current system regulating compulsory stock levels, in an attempt to achieve a higher degree of assurance on stock availability. Whilst these are understandable and important considerations, our industry continues to engage in the debate, particularly through the Berlin Forum discussions, to ensure a level of practicality and cost-effectiveness for any solutions that may follow.

Energy policy, efficiency and security

The world's and the EU-27's energy consumption by fuel type in 2005 can be seen in Figure 1.

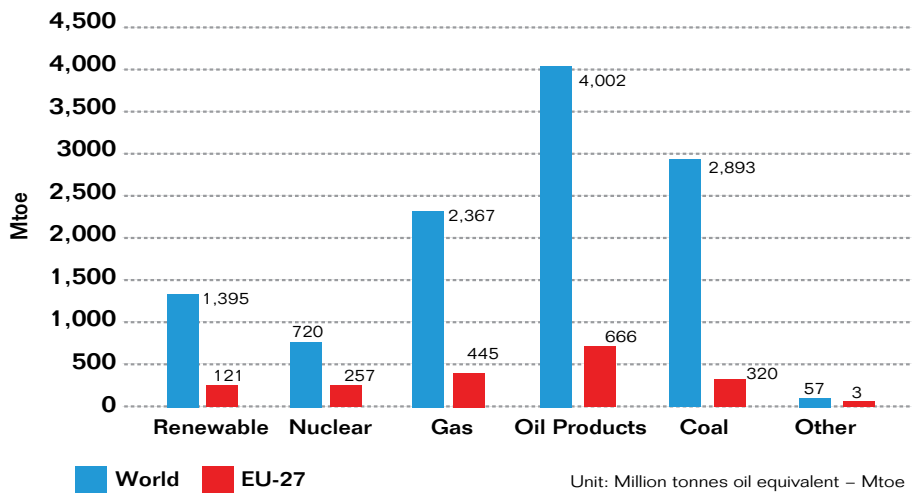


Figure 1. Energy consumption by fuel type in 2005
Source: European Commission 2007, International Energy Agency 2007

From the Hungarian point of view it is interesting that the ratio of oil in the World is 35.1%, in the EU-27 35.2% in Hungary 25.8% whilst ratio of gas in the world is 20.7%, in the EU-27 23.5% in Hungary 43.8% – the latter one is extremely high.

ENERGY PACKAGE OVERVIEW

The Commission's Energy Package issued in 2007 built on the three objectives – sustainability, competitiveness and security of supply (see below) – from the 2006 Green Paper, "A European Strategy for Sustainable, Competitive and Secure Energy".

It outlined a long-term energy vision for Europe covering, among others, functioning of the internal energy market and solidarity between Member States, security of energy supply, a long term commitment to CO_2 reduction and to the EU Emissions Trading Scheme (EU ETS), energy efficiency and targets for renewable energy and biofuels. It also created a foundation for an Office of the Energy Observatory.

In March 2007, the European Council adopted most of the proposals and committed the EU to a series of short and long term measures and targets on climate protection and clean energy, including:

- A binding unilateral EU commitment to cut GHG by 20% by 2020.
- An objective to reduce by 30% subject to international agreement.
- A recommendation that developed countries should aim at collective cuts of 60-80% by 2050.
- Adoption of an EU Energy Action Plan for 2007-2009 including:
  - Binding renewable energy by 2020
  - Binding target of 10% biofuels
  - A non binding commitment to reduce EU energy consumption by 20% through energy efficiency improvements.
  - A European Strategic Energy Technology Plan.

EUROPIA welcomed the publication of the Energy Package and the Climate Change Communication and appreciated that concerns it had raised with the Commission had been taken into account. It continued to stress the importance of a balanced approach to the three pillars of energy policy, competitiveness, and sustainability and security of supply.
In particular, a strong and competitive Refining sector is vital for a secure supply of oil products to industrial and individual consumers. The report by an independent consultant, commissioned by EUROPIA in 2007, demonstrated that the Refining sector is exposed to international competition, and trades actively with countries outside the EU, which are not subject to binding emissions constraints.

Ensuring that EU Refining does not have to bear a cost burden for ETS, not carried by non-EU competitors, is essential to retain a level playing field and to attract vital investment to the EU refining industry.

Renewable energy will have a significant role to play, but the 20% renewables and 10% biofuels targets remain challenging. There is also an overlap and some inconsistencies with the carbon reduction in the Fuel Quality Directive Article 7A. In particular, a proposed 1% per annum reduction in CO_2 related to oil products is extremely challenging. Although energy efficiency in Refining has improved by 13% over the past 15 years or so, the continuing growth in diesel demand and the significantly cleaner fuels produced now result in higher energy consumption in Refining.

ENERGY EFFICIENCY

Energy efficiency is considered as one of the EU top priorities as laid down in the "Energy Efficiency Action Plan" (EEAP) published by the Commission in October 2006. The plan set an objective of 20% energy savings by 2020, was subsequently reiterated by the Commission's energy package proposal of January 2007 and endorsed by the European Council agreement of March 2007.

In particular, the European Council acknowledged energy efficiency activities which can lead to potential annual savings of 100 billion euros (equivalent to 390 million tonnes of oil) by 2020 and to a substantial reduction of Europe's CO_2 emissions.

EUROPIA, in full support of the Commission's efforts to enhance energy efficiency, initiated an industry-wide consumer awareness campaign on promoting an efficient driving behaviour. This initiative, launched in May 2008, is in partnership with the European Commission and is championed by the Energy Commissioner. The campaign spans 45,000 petrol stations across 29 European countries and involves over 40 petroleum companies in Europe.

ENERGY SECURITY

EUROPIA, as well as some Member States, have expressed a wish to see a more detailed justification for changing the current system. EUROPIA believes its fundamental structure is sound and well established and should be retained, while ways to improve its actual implementation are developed. If the system requires changes, EUROPIA is of the view that there are some key observations that should be taken into account.

EU Member States differ in geography, infrastructure, refining coverage, supply and demographics – the system must leave sufficient flexibility to permit an optimal country-specific approach. Any potential structural changes should be examined to achieve the necessary level of security in a cost effective manner; the system should be "fit for purpose".

The system should avoid competitive distortions and/or discrimination between market players. Additionally, any constraints on operators and /or Member States will increase costs, so should only be imposed if they are objectively justified.

It is expected that the Commission will publish a more detailed consultation document, followed by a legislative proposal during 2008.

Climate change and environment

COMMUNICATION LIMITING GLOBAL CLIMATE CHANGE TO 2°C

In order to achieve this objective, the EU proposes to pursue the following targets:

- A firm EU commitment to achieve at least a 20% reduction of GHG emissions by 2020 compared to 1990 levels.
- A 30% reduction in greenhouse gas emissions by 2020 for developed countries, subject to successful international negotiations.
- A 60-80% emissions reduction target by 2050 in developed countries.

The proposal includes: strengthening the EU ETS; limiting transport emissions; tackling emissions from non CO_2-gases; international action in the global fight against climate change, as well as the need for a further international agreement.

The oil industry is committed to the success of the EU ETS and will contribute to the consultation on its review and possible extension to other gases and sectors. EUROPIA has called for a well-designed, stable and predictable regulatory framework to provide more certainty for investments.

EU EMISSIONS TRADING SCHEME

As a result of the extensive consultation, the Refining Industry is considered as being exposed to global competition and therefore will be subject to further analysis to determine the level of entitlement for up to 100% free allowances.

The EU Commission recognised the EU ETS as one of the key tools in achieving Kyoto targets and reaching at least 20% reduction of GHG emissions by 2020 compared to 1990. In 2007 the European Commission engaged in the consultation process leading up to the review of EU ETS. In the 1st half of the year, EUROPIA actively participated in the consultation process and was involved in an intensive advocacy effort, supported by member companies and NOIAs. This aimed at demonstrating that:

- The price of carbon in itself provides an incentive for refiners to reduce emissions.
- Efforts to reduce emissions in other sectors often result in increased emissions in refineries, e.g. as a result of more stringent specifications for transport fuels and shifts in demand.
- The inclusion of more sectors and more GHG into the ETS is desirable, as long as this provides more opportunities for reducing emissions at a lower cost and for stimulating innovation.
- Guidelines for consistent EU-wide monitoring, reporting and verification are critical, however, giving such guidelines the status of Regulation would not bring additional benefits.

In the final proposal for the EU ETS Review issued in January 2008, the Refining Industry is classified within energy intensive industries. Work will continue to resolve the remaining questions and EUROPIA will engage in further advocacy to reiterate the impact of global competitiveness on our Industry.

AIR QUALITY

The Commission's proposal for the Ambient Air Quality Directive was intended to consolidate the existing Air Quality legislation and introduce a limit for airborne concentrations of fine dust particulates – PM 2.5. After the unsuccessful First Reading in 2006, it took most of 2007 to work towards a Second Reading agreement.

The European Parliament approved a compromise on AAQD towards the end of 2007. The Ambient Air Quality Directive will establish the first ever binding EU limits of 25 $\mu g/m^3$ on ambient levels of ultra-fine particles less than 2.5 microns wide (PM 2.5) from 2015 coupled with a provisional binding limit of 20 $\mu g/m^3$ by 2020. The text of the Directive must still be agreed by the Council of Ministers before they can enter into force.

The intention of the NECD review is to ensure that future emission ceilings of nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic components (VOCs), ozone and Particulate Matter (PM) are consistent with the delivery of the Member States' targets in the Thematic Strategy for Air Pollution (TSAP).
The absolute values of the ceilings depend to a large extent on the energy baseline, energy demand and energy mix projections – in particular on the extent of coal usage. The Commission and the Member State representatives could not agree on the baseline energy scenario and it was decided to wait for the burden sharing suggestions as part of the Energy Package.

INTEGRATED POLLUTION PREVENTION AND CONTROL DIRECTIVE

The Commission published its proposal for a revised Integrated Pollution Prevention and Control Directive (IPPC-D) in December 2007. The proposed changes conflicted with many of the key points raised by industrial sectors. EUROPIA, alongside BusinessEurope and other industry organisations, expressed serious concerns about the proposed Directive.

The use of values from the Best Available Techniques Reference guidance documents (BREFs) as legally binding emissions limit values is also a concern. These documents have been developed in open dialogue with the Industry to create a catalogue of available technologies. Individual technologies may not be practically and economically feasible for many installations and should never form the basis of uniform legally binding emission limit values.

Contrary to the expressed views of the Industry, the proposal entails the inclusion of the Large Combustion Plant Directive (LCPD) in the revised directive. The LCPD, which prescribes binding emission levels, is fundamentally different in character to the existing philosophy of the IPPPC-D.

The European Industry is a world leader in terms of environmental considerations and fully supports the EU ambitions to continue to reduce the negative impacts on human health and the environment. However, for the European Industry to remain competitive, it requires that all environmental measures are carefully weighed and that the most cost-effective solutions are found through a contractive dialogue between governments and Industry. The current proposal is a serious retrograde step.

In July 2006, the Commission published a proposal for a Daughter Directive to the 2000 Water Framework Directive. This Daughter Directive will establish environmental quality standards for surface water, i.e. the maximum allowable concentration of specified substances.

The proposal went through First Reading in the European Parliament in 2007. The Parliament proposed some significant changes to the proposal, notably eliminating the so-called transitional areas of exceedance. These are mixing zones around the point where water effluents from industrial installations are discharged, and their introduction was designed to allow for the process of dilution.
Eliminating these would lead to the illogical situation that the environmental quality standards become de facto emission limit values.

EUROPIA is opposed to this change by the Parliament and recommends that during the second reading in the Parliament in 2008 the legislators maintain the pragmatic approach allowing industrial installations to maintain realistic discharge standards, while not compromising the desired water quality of the surface water bodies.

Fuel products

AUTOMOTIVE FUELS

The Fuel Quality Directive Review (FDR), planned for 2005, experienced ongoing delays during 2007. This was largely due to the Commission changing the scope of the draft FDR from specifying fuel quality parameters on health and environment inclusion of greenhouse gases effecting Climate Change.

Of utmost relevance to our Industry is the request for a 10% reduction of GHG emissions from road fuels stipulated in the Directive Article 7a. This concept at its outset was not part of the adequate stakeholder consultation process and as a result suffered from the absence of necessary data and tools to assess its viability. Examples of missing critical elements include a methodology for GHG emission calculation, and a biofuels sustainability certification scheme. Furthermore, the double regulation of European refineries and oil platforms with respect to the EU ETS has not been considered.

The fact that biofuels introduction is the only short- and medium-term option to reduce GHG emissions from road fuels and that 16% (on energy basis) of biofuels would be needed to meet the 10% GHG emissions reduction target. This is both unrealistic and inconsistent with the 10% biofuels target of the Renewable Energy Directive. Inconsistencies in some suggested modifications to the Directive could further hinder the achievement of already unrealistic targets. One example is the request for a minimum 50% reduction of GHG emissions for biofuels compared to fossil fuels. Under this constraint, it is unlikely that EU fuel suppliers would be in a position to source sufficient biofuels, as many domestic biofuel options would likely fail to pass this threshold. Compliance with the targets would depend, to a much larger extent, on non-EU imports of biofuels.

Some suggested changes put an upward pressure on refinery CO_2 emissions, such as the reduction of Polyaromatic Hydrocarbons (PAH) in diesel, which according to the European Parliament, would have to be reduced from 8 to 6%. This change would not result in a reduction of pollutants, but would increase CO_2 emissions from refining by about 2 million tonnes per year, making the achievement of Article 7a targets even more unrealistic. In the Commission proposal, higher Ethanol shares were planned to be enabled through establishment of a separate fuel specification rather than just increasing the limits in the existing one. EUROPIA rejected the proposal as the increased use of biofuels should be associated with standardised grades of road transport fuels and avoid proliferation of additional grades.

The debate on the FDR is continued in 2008, particularly in the context of alignment with the Renewables Directive.

THE DIRECTIVE ON THE PROMOTION OF RENEWABLE ENERGY

The Directive on the promotion of renewable energy (REN) – was issued as part of the European Commission's package of climate and energy-related legislative proposals on 23 January 2008.

The legislation for biofuels, originally planned to be covered by a separate Biofuel Directive, was included in the REN proposal of January 2008. The proposed Directive sets out the principles to ensure that the share of renewable energy in the EU final energy consumption reaches at least 20% by 2020. It also confirms a 10% target for biofuels.

The proposal sets out environmental sustainability criteria to ensure that biofuels are produced in a sustainable manner and not in conflict with the overall environmental goals. This means they must achieve at least 35% of GHG savings and respect a number of requirements related to biodiversity.

The European petroleum industry believes the Directive sets an ambitious target for both renewables and biofuels. Although biomass can play a role in reducing transport GHG missions, it is not a cost-effective way of overall GHG abatement in comparison to the use of biomass in other sectors, such as heat and power generation.

Biofuel content target does not differentiate between different types of biofuels and their varying potential for GHG reduction and fossil fuel substitution. Moreover, this target would require changes in motor fuels specifications. EUROPIA will continue to encourage the Commission to develop a single pan-European certification standard through CEN (European Committee for Standardisation) or an alternative standards organisation for GHG

performance and sustainability. This would avoid multiple country-specific systems and provide a potential stepping-stone to a global standard.

Specifically, EUROPIA supports, among others, the following aspects of a potential certification scheme:

- It must only include criteria that can lead to measurable, verifiable indicators along the production chain and allow maximum flexibility to economic operators.
- There should be one methodology for assessing GHG savings.
- The GHG evaluation should allow use of default values to be used when actual data is not available. There should be a well defined and transparent process for claiming and endorsing deviation from default values.
- Other aspects (e.g. land use changes) related to sustainability have potential large impacts that are not specific to biofuels - a multi-stakeholder approach is needed to establish their full impact.
- EU producers or importers of finished biofuels are responsible for compliance with sustainability / GHG certification regulation and for obtaining certificates, which must be recognized in all Member States.
- The sustainability/GHG certificate trading scheme should facilitate compliance and improve cost effectiveness.
- The design of the chain of custody is crucial to achieve the single pan European scheme in a cost effective and flexible manner. An identity preservation system would not achieve these objectives.
- The EU legislative framework should ensure that enforcement, monitoring and verification are applied consistently throughout the EU following Article 95 of the EU treaty.

In 2008, work will continue to develop the Industry's final proposal on biofuels certification.

EUROPIA also initiated contact with other industry associations to discuss the possible scope for joint work on availability of land and/or biomass vs. demand from the various sectors to meet feedstock and renewables requirements.

Abbreviations used

EA	Association of European Airlines
AQ	Air Quality
BAP	Biomass Action Plan
BAT	Best Available Techniques
CAFE	Clean Air For Europe
CSO	Compulsory Stock Obligation
CONCAWE	Conservation of Clean Air and Water for Europe
DG	Directorate General
ECCP	European Climate Change Programme
EEAP	Energy Efficiency Action Plan
EMCS	Excise Movement Control System
EP	European Parliament
EPCIP	European Programme for Critical Infrastructure Protection
ETS	Emission Trading Scheme
EUROPIA	European Petroleum Industry Association
FDR	Fuel Quality Directive Review
FFF	Fossil Fuel Forum
GHG	Green House Gas
IPPC-D	Integrated Pollution Prevention and Control Directive
JRC	Joint Research Center
MEP	Member of the European Parliament
MS	Member States
NECD	National Emission Ceilings Directive
NGO	National Government Organization
NOIA	National Oil Industry Association
OSOR	One Substance, One Registration
REACH	Registration, Evaluation and Authorization of Chemicals
TAG	Tax Action Group
TSAP	Thematic Strategy on Air Pollution
WFD	Water Framework Directive

Revised by: Norbert Hárs

The price for Supply Security

The case of Central Eastern European natural gas markets

Péter Horváth (28)
Economist / Business administration
project manager
E-mail: peterhorvath@mol.hu

Gergely Szabó (25)
Economist / Business administration
business development expert
E-mail: gerszabo@mol.hu

Abstract

In the first section of the present article we introduce a framework for examining challenges of today's globalizing natural gas markets. This framework is structured around two fundamental levers along the industrial value chain: global competition of supply and demand, and security of supplies. We then apply this framework for Central Eastern Europe (CEE) as this region represents an illustrative example for global challenges. Currently, isolated national markets in CEE with declining indigenous production levels are dominated by Russian imports. There are two possible outcomes of this context. One extreme scenario is that neither the structure of the supply-demand balance nor upstream positions change. The other theoretical extreme is the structure of supplies and demand fundamentally change with the establishment of a single regional gas market, also creating a higher level of supply security within the region. We conclude that the destiny of regional supply-demand balance and supply security depend upon the success of common efforts towards delivering massive infrastructure investments and stronger regional cooperation. These common efforts however are accompanied with a major controversy: the bulk of them will have to be paid beforehand by CEE customers. This mere fact questions the common attitude towards supply security.

Összefoglalás

AZ ELLÁTÁSBIZTONSÁG ÁRA
(a közép-kelet európai földgázpiacok példáján keresztül)

A cikk első részében a globális földgázpiac jelenlegi kihívásainak vizsgálatára alkalmas elemzési keretünk bemutatására kerül sor. Ez a keret az iparági értéklánc mentén épül fel, ezen belül is két szintet különböztetünk meg: a globális keresleti és kínálati versenyt; és az ellátásbiztonság kérdéskörét. E fenti keretet alkalmazzuk a Közép és Kelet-Európai (CEE) régió elemzésére, és bizonyítjuk, hogy e régió jól példázza a globális kihívásokat és az arra adandó lehetséges válaszokat. Jelenleg az orosz import dominanciája jellemző a csökkenő termeléssel rendelkező, különálló nemzeti piacokra osztott CEE régióra. Két lehetséges kimenetel adódhat ebből a helyzetből. Az egyik szélsőséges forgatókönyv az, hogy sem a kereslet-kínálat egyensúlyának struktúrája, sem az upstream pozíciók nem változnak. A másik elméleti szélső pont, hogy a kereslet-kínálati struktúra alapvetően megváltozik egy egységes regionális gázpiac megteremtésével, amely egyúttal nagyobb ellátásbiztosságot is hoz a régiónak. A tanulmányban arra a meggyőződésre jutottunk, hogy a regionális kereslet-kínálat egyensúlya és az ellátásbiztonság jövője, azon múlik, hogy sikerül-e közös erőfeszítéseket végrehajtani a regionális együttműködés és a nagy infrastrukturális beruházások terén. Ezek azonban jelentős problémákkal

küszködnek, mivel a költségek nagy részének CEE fogyasztókra való terhelése elkerülhetetlennek tűnik. Ez a felismerés megkérdőjelez(het)i az eddig megszokott pozitív viszonyulást a régió ellátás-biztonsági kérdéseihez.

In the first section of the present article we introduce a framework for examining challenges of today's globalizing natural gas markets. This framework is structured around two major layers along the industrial value chain: global competition of supply and demand, and security of supplies. In the second half of this article, we apply this framework for Central Eastern Europe (CEE) and argue that this region represents an illustrative example for global challenges and also provides possible answers to them.[1]

1. The main challenges of globalizing natural gas markets

Natural gas markets – opposite to the global oil market – are historically organized on a regional basis. Consequently, natural gas does not exist as a standard commodity with a globally quoted price. This mere fact entails several fundamental challenges. There are separate national or regional markets with no or little exposure to other markets. These markets have been developing separately as well; therefore, different price setting mechanisms and logic has taken place. Hence, the same natural gas molecule that is almost worthless in one market could be priceless in another. The reason for this is simple: due to separate markets, global supply and demand can not meet – supply surplus and deficiency can happen (and happens) in the same time all over the world.

Certainly, besides a tremendous arbitrating and trading opportunity window, the supply security of countries/regions with the "priceless attitude" requires that supply surplus and deficiency should meet in time and place. This is the globalization of the natural gas industry.

There are several forces aiming this procedure. The most important is the increasing demand for the commodity that calls for an immediate solution of linking global supply and demand.

One, and arguably the most significant, mean for this is LNG (liquefied natural gas). Due to liquefaction, natural gas compresses to 1/600 of its volume; therefore, just like oil products could be transported globally. Other factors of globalization are all in infrastructural developments to be found – providing a "platform" for global and more liquid trading.

However, these developments raise a very important challenge for all the stakeholders within the industry: how to integrate into the globalizing natural gas markets. In order to understand the challenge itself, two layers of the issue of globalizing natural gas markets should be distinguished. *global competition and security of supply.*

The globalizing gas market triggers a convergence of formerly regionally organized gas markets. This results in higher price setting, as upstream players aim to integrate their region to global markets in order to capture higher margins. On the other hand, consumers and governments try to maintain (or at least slow down the increase) of gas prices. This essence of pricing conflict can be

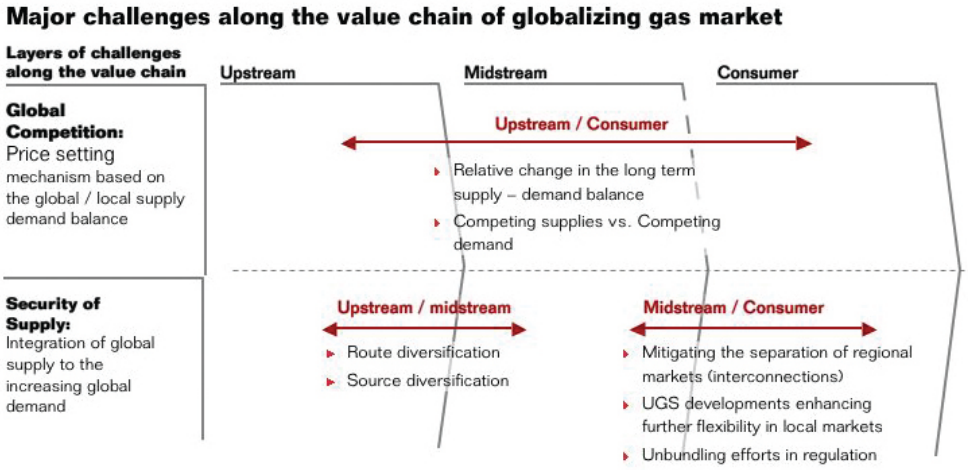


Figure 1. Layers of challenges along the global gas value chain

1 This article is based on the presentation titled Central and Eastern Europe's answers to global challenges of energy dependency, held by Mr. Benjamin Lakatos (Director of MOL Gas) at the 19th World Petroleum Congress in Madrid, June 29-July 3, 2008

captured in various cases all over the world. e.g. Turkmenistan renegotiating its price of gas supplied to Russia or the European energy policy supporting the establishment of competing gas import routes.

The second layer is called *security of supply.* While *upstream and midstream* players cooperate in major international infrastructure developments in order to integrate global supply to distant-located regional demand, these co-operations can be grasped when Middle East national oil companies (NOCs) enter into co-operations with oils majors on massive investments in gas liquefaction capacities.

On the other hand, as global sources are concentrated, most *consumers and midstream players* aim to diversify risks by source diversification and upstream integration. These motives drive LNG regasification projects, Nabucco, market interconnections, etc.

2. Placing current global challenges in a CEE context

Having discussed the main sources of challenges in the globalizing natural gas market, we should place these conflicts to a Central Eastern European context. Defining the main characteristics of this region has a superior importance since both supply security and price competition have a different meaning here compared to other markets.

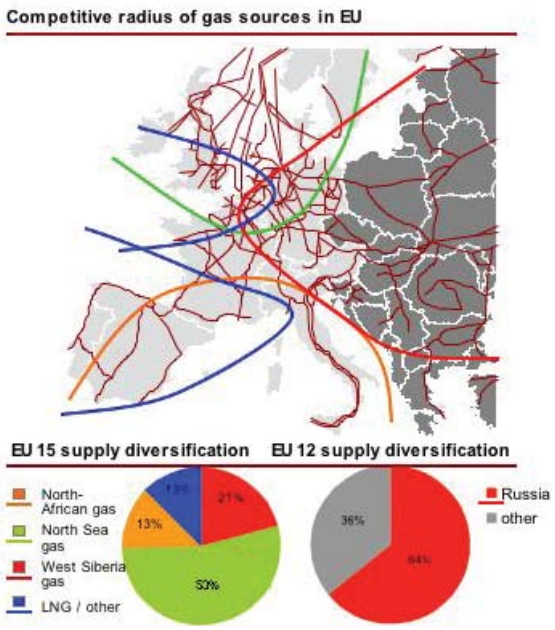


Figure 2. Reliance on gas imports in EU15 (EU members before 2004) vs. EU12 (new accession countries) [1]

When discussing price competition (in other words, the profit re-allocation between upstream players and consumers), the CEE market can be characterized by excessive reliance on one single source instead of a competition between sources (such as in Western Europe).

While suffering from low bargaining power in this situation, the case is further aggravated by a low level of supply security. Looking at the beginning of the value chain (the upstream/midstream conflict), we can see parallel East-West transit routes without

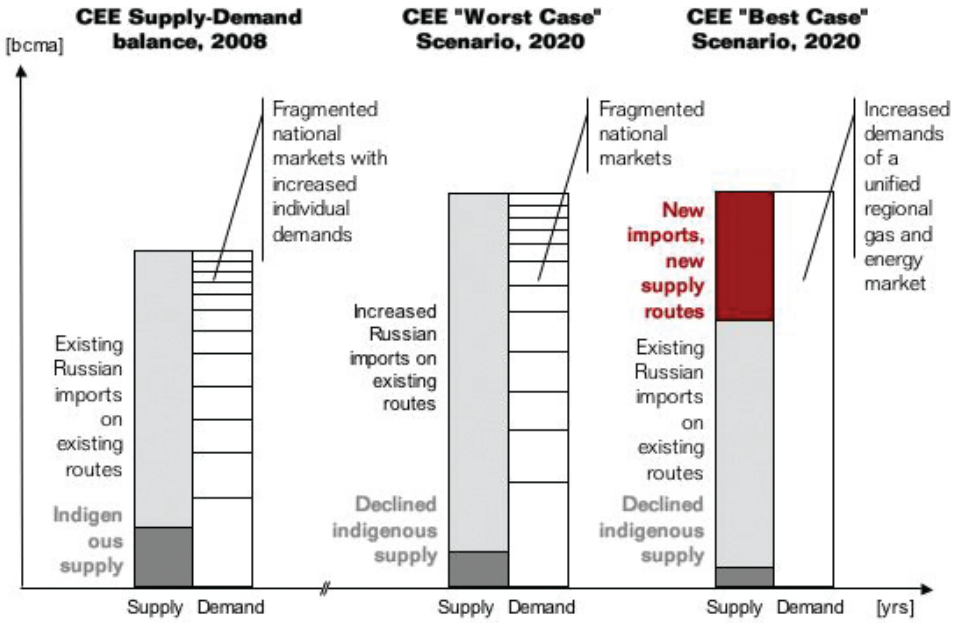


Figure 3. Current and of potential future gas market structures in CEE bcm p.a

existing North-South infrastructure. Besides, the region has practically no connection to the global LNG market. Looking further, the distribution of supplies within the region is also problematic because of mashed networks, lack of interconnections and flexibility problems stemming from insufficient storage capacities.

All in all, the Central Eastern European region provides an illustrative example of the challenges arising from globalizing natural gas markets.

2.1. SUPPLY-DEMAND (IN)BALANCE OF GAS SOURCES IN CEE

As a general rule, there is a natural trade-off between profit available for upstream players and costs of natural gas for end-consumers. In our case, this trade-off is further enhanced by local imbalances in regional natural gas markets.

The results of price competition in a market are determined by the relative bargaining power of supply and demand "forces". The CEE market has been characterized by the overwhelming bargaining power of the supply of upstream player(s) and fragmented and; therefore, competing demand. The price competition (also known in our case as profit allocation between upstream and consumers) will be determined by changes of this one-sided supply-demand structure. Figure 3 shows a schematic figure of current supply-demand balance in the CEE and its two possible extreme outcomes within a decade.

Currently, Russian imports dominate most isolated national markets in CEE. Furthermore, dependency on Russian imports is likely to be increased due to continuously declining indigenous production levels. Therefore, the supply leg of a future market structure is given; the destiny of the demand side depends upon the success of the common efforts made towards establishing new supply routes, interconnection of national gas markets and thereby creating a single gas and energy market in CEE all contributing to a much stronger demand bargaining power.

2.2. SECURITY OF SUPPLY

Having discussed the issues of price competition or profit allocation between upstream players and consumers, we can turn to the other important question along the value chain: how to get supply sources to consumers on a safe basis, in other words, the preconditions of the security of supply. Security of supply could be defined from many points of views. For an upstream player, this means a security of continuous sale of its product. For a consumer, this means a security of access to energy and for a midstream player, the security of "normal" course of business. All in all, players along the value chain are interested in a higher level of supply security in general. However, exceptions from the general provide the nuts and bolts in our case: the most important development projects have a very different impact along the value chain and they could change the uncertain balance of the CEE market.

2.2.1. Upstream/Midstream challenges

Rivalry between upstream and midstream players takes place in various questions of supply security. There are two important fields of this issue: route diversification and source diversification. All three major project concepts aiming to diversify the route or source of gas delivered to CEE could be characterized by different possible outcomes for certain upstream and midstream players.

- Driven by Gazprom's aim to securely reach Italian and CEE markets by offsetting dependency on Ukrainian gas transit, the South Stream project plans to deliver up to 30 bcm gas annually through the Black Sea and CEE.
- Driven by six midstream gas industry players[2] in CEE and under the strong support of the EU Commission, the Nabucco project aims to deliver up to 30 bcm gas annually from the Caspian and Middle East region. These natural gas volumes would otherwise only be able to reach European markets through Russian territory, creating an arbitrage opportunity for Gazprom.
- If the LNG regasification terminal on the island of Krk, Croatia was established, LNG could create a significant impact on the existing gas pricing dynamics of the region. Although the liquefaction and shipping process adds an additional cost element in the gas price compared to pipegas, this source can still be competitive if oil-price linked gas prices remain at the levels of the last 1-2 years,

2 Nabucco project partners are Botas AS (Turkey), Bulgargaz Holding EAD (Bulgaria), MOL Plc (Hungary), OMV AG (Austria), RWE AG (Germany), Transgaz S.A (Romania). Each shareholder holds an equal share of 16.67% in the project company – Nabucco Gas Pipeline International GmbH.

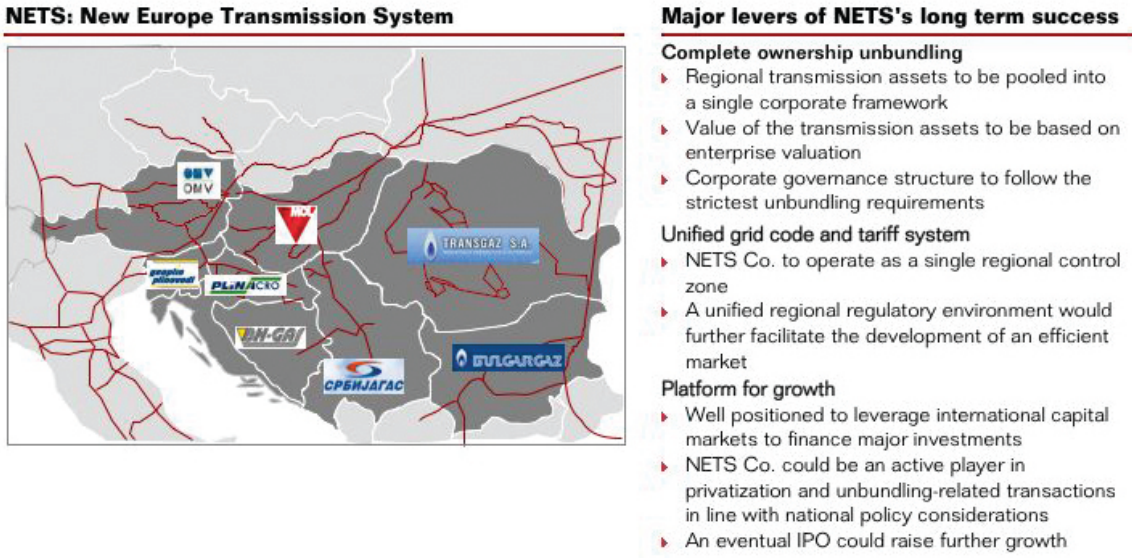


Figure 4. Brief concept of New Europe Transmission System (NETS) [2]

and if significant decline can be achieved on technology costs of the liquefaction process.

Although different in context and feasibility, the above investment concepts share at least two things in common: all of them would significantly increase the supply security in the region; and all of them require enormous investments which will eventually be passed along the value chain to end user gas prices. It is yet hard to foresee which of these investment concepts will be realized. Yet, industry participants and policy makers have to keep in mind, that none of them can be delivered without managing and fulfilling the upstream participants' economic interests.

2.2.2. Midstream / Consumer challenges

On further levels of the value chain, supply security arises as a huge question mark between midstream players and consumers (represented by the government and/through national energy offices). In order to secure supplies to consumers for the long term, massive infrastructure investments (potentially delivered by midstream players) are necessary. However, until supply security of its own is not financially measurable, midstream players should be financially motivated (why would they assume investment and financing risks otherwise?) – This is an additional cost of supply security, which is to be shared between midstream players and consumers, sometimes represents irresolvable tensions, which create certain barriers to planned investments. Positive examples, on the other hand, also exist throughout CEE, such as the ongoing extension of import capacities on the Ukrainian-Hungarian border[3], the establishment of the strategic gas storage facility in Hungary[4], as well as the ongoing investment in the Arad-Szeged interconnection between the gas grids of Hungary and Romania. The above investments share at least one crucial element in common: the costs and risks associated with the investments are shared between the midstream industry players and the gas consumers.

These developments have been achieved with a strong cooperation of industry participants and market regulators. The NETS initiative also provides a live example on such cooperation. Launched by MOL and FGSZ, the concept of NETS is calling for a strong regional cooperation of gas TSOs in CEE, being even further down the road of industry-regulatory cooperation in order to overcome challenges of security of supply.
The above examples show, that there is room for supply security related developments beyond introducing new gas sources and routes to the CEE region. Strategic gas infrastructures, market interconnections, and regional cooperation in midstream gas form just as important pillar of a secure any competitive regional gas market.

3 Performed by FGSZ Natural Gas Transmission Ltd., the Hungarian gas transmission system operator, and part of MOL Group
4 The establishment of Hungary's strategic gas storage facility was ordered by law following the Russian-Ukrainian gas dispute of January 2006. MOL won the right to establish the facility as a majority shareholder in an open tender launched by the Hungarian Hydrocarbon Stockpiling Association. The facility will be operational by January 1st 2010, and will be able to supply up to 1.2 bcm gas in case of shortage or disruption in gas supply.

3. Conclusions

As a basis point of our train of thinking, described in Figure 3., upstream players currently hold key positions in the supply-demand balance in the CEE region. There are two possible directions out of this situation: a so-called worse case scenario where neither the structure of the supply-demand balance nor upstream positions change; and a best case scenario, where the structure of supplies and also demand are fundamentally changed.

In order to achieve the best case scenario, the delivery of massive infrastructure investments is inevitable. That would create a higher level of supply security within the region. However, there comes one of the main controversies around supply security: a high level of supply security entails competition but in order to get there some had to pay huge investment costs upfront.

Because of the key positions of upstream players in the supply-demand balance, these investments can not be delivered without avoiding those players' interests. As a result, only those investments will be accomplished that reflects upstream interest as well.
As a result, efforts strengthening the demand side of the market structure can not be delivered without intensifying supply positions as well. Therefore, there is a considerable price of securing supply for end-users; a price that these consumers have to pay. The acknowledgment of this fact by consumers in CEE is indeed a significant challenge, as they have not been exposed to such situations during the recent decades. Facing this is the joint responsibility of industry players, policy makers, and nevertheless consumers.

References

[1.] BP Statistical Review of World Energy, 2007
[2.] MOL-FGSZ Press release, December 5, 2007.

Revised by: Mrs. Károly Solti

Global base oil tendencies and the role of MOL's base stocks in the region

Enikő Szeitl (30)
Diploma in Business Management; BSc in Economics
MOL R&M, Chemicals – Product manager
E-mail: eszeitl@mol.hu

István Kátai (47)
Diploma of the TU of Budapest in Chem. Eng. and the IFP in Refining
MOL R&M, Downstream Development
E-mail: ikatai@mol.hu

Péter Heiman (61)
Diploma: MSc in chem. Eng – Technical University, Veszprém , College for Foreign Trade, Budapest
MOL-LUB: special projects, OEM – Coordinator
E-mail: pheiman@mol.hu

Abstract

This paper would like to give answers on three basic questions, like how the global base oil trend was modified including driving forces in the last decade, what is the current status and what role will play MOL's base oils in the region in the future and the coincidence of MOL's base oil production technology development with the global one.
However the lubricant consumption was equal worldwide in 2007 and in 1997, major differences were observed geographically. Due to the higher quality lubricant's need, the additive treat rate is increasing as well.
There are two scenarios for the future needs: +0.5 and +1.5%. In terms of quality trend and competitor's structure the change of the lubricant industry is going on.
The driving forces for the production of base stocks are changing dramatically, in the past it was the qualitative and quantitative need for lubricants, but today there are other – „non – lubricants" related factors, namely the increased fuel, especially the diesel needs is the decisive one. On the other hand, there is a new finding, the so called „technology paradox", where the cost of the higher quality base stocks are less, than the conventional ones.
The ongoing development of MOL's base stocks corresponds to the global ones, i.e. Group II and III types are „in the tube". Technological variances are under investigation in order to find the optimum compromise between fuel and „lubricant" production with the optimal combination of the existing solvent extraction and the hydrotreatment based technologies.
The hydrockracking technology would give a synergy between the high quality (low sulphur content and better ignition ability) fuel strategy and base oils for modern lubricants. This development will fit into the regional needs, i.e. towards longer drain intervals with lower evaporation loss.

Összefoglalás

A VILÁG BÁZISOLAJ TENDENCIÁI, A MOL BÁZISOLAJOK RÉGIÓS SZEREPE ÉS FEJLESZTÉSE

Jelen cikk három fő kérdéscsoporttal foglalkozik: betekintést ad a világ kenő- és bázisolaj fogyasztási tendenciáiba, vizsgálja a MOL által gyártott bázisolajok jelenlegi és jövőbeli régiós piacát, valamint a bázisolaj gyártás fejlesztési elképzeléseit vázolja.
Annak ellenére, hogy a világ kenőolaj fogyasztása az elmúlt 10 évben gyakorlatilag nem változott, az egyes években és földrajzilag is jelentős eltérések figyelhetők meg. A magasabb kenőanyag teljesítményszintek iránti növekvő kereslet magasabb adalékolási koncentráció alkalmazását teszi szükségessé. A jövőre vonatkozó igények tekintetében két növekedési ütemmel számolnak: 0,5 és 1,5 %-os bővüléssel.
A bázisolaj gyártás fő hajtóerejében jelentős változás figyelhető meg: míg

korábban a kenőolajok iránti minőségi – de mennyiségi kereslet határozta azt meg, újabban más, nem kenőanyaghoz kapcsolódó paraméterek a döntőek, nevezetesen az üzemanyagok – speciálisan – a dízel üzemanyagok iránti növekvő kereslet. Mindemellett megfigyelhető egy új ú.n. „technológiai paradoxon" megjelenése is, ami azt jelenti, hogy a magasabb minőségű üzem- és kenőanyag alap előállítása olcsóbb, mint a hagyományos technológiák által gyártottak.
A MOL bázisolaj gyártás fejlesztési elképzelései összhangban vannak a világban elfogadottakkal, azaz a Gr II/III gyártás megvalósítása a cél.
A technológiai variációk és kombinációk kidolgozása jelenleg folyik annak érdekében, hogy megtalálják a legjobb műszaki- és gazdaságosági alternatívát minőségi kompromisszumok nélkül. A HC technológia beruházása szinergiát mutat a magas minőségű (alacsony kéntartalmú és növelt gyulladási hajlamú) gázolajok és a nagyobb árbevételt biztosító bázisolajok gyártása terén. Mindez jól illik a régió bázisolajokkal szemben támasztott jövőbeli követelményrendszerébe, amennyiben a növekvő, modern gépkocsi park hosszú csereperiódusú, alacsony párolgási hajlamú kenőolajokat igényel.

1. Lubricants and base stocks tendencies

The worldwide technical evolution was tremendous in the car industry in the past decade, however the lubricant and consequently the base oil need remained unchanged. On yearly and geographical basis the consumption varied, but the total need was equal in 1996 to the one in 2007, i.e. around 38 Million Tons per year excluding marine lubricants. This relative stable lubricant consumption doesn't mean that this period was a quiet one, since very dominant changes, sometimes contradicting trends characterised the start of the 21st century. The evolution of the technology brought significant changes in terms of quality, market and competition structure with and contributed to the above mentioned end-result.

The global GDP growth superceeded the increase of the car population which is in correlation with the demand for lubricants, including sea-carriage. In Western Europe the GDP increase was in negative correlation with the lubricants needs, i.e. increases the GDP, decreases the lubricant consumption. In Central Eastern Europe until 2000, this trend was in positive correlation, now the situation is changing- higher the GDP growth, than the lubricants demand increase, however this increase is a moderate one (Figure 1.).

Globally speaking, the development and use of energy intensive products may drop, i.e. the lubricant efficiency continues to have strong influence tendencies (Table 1.).

The total lubricant need varies geographically and a shifting can also be observed which can be determined by well defined solid tendencies. Taking into concideration the lubricant need per capita in the US is around 24 kg and in the Asian region is only some 3 kg, there is a lot of room for growth potential. On average, global per capita demand is a bit less than 6 kg.

The demand for increased mobility of the world population remain unchanged, but the economic background and even more the reserves on fossile energy resources make barriers for the explosion of energy needs. The 15% increase of the car population in the last decade results in „only" 10% increase of fuel needs on one hand, the development of the engineering of the vehicle industry on the other hand and last but not least the availability of higher quality lubricants – equivalent to increased oil drain intervals made possible the unchanged lubricants

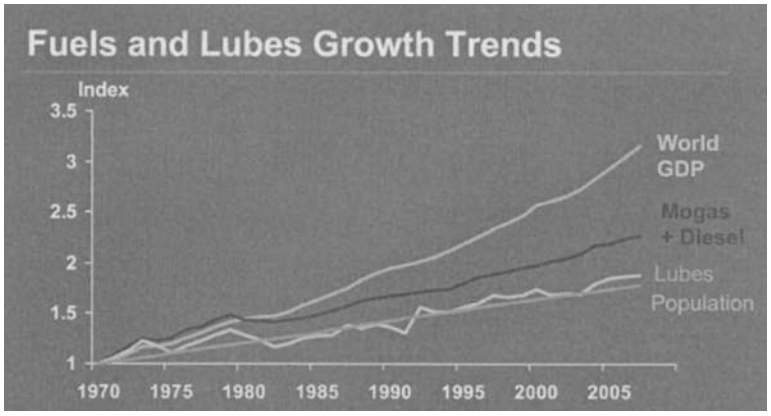


Figure 1. Development of GDP and lubricant need

demand. The widespread of circulation systems whithin the industries helped a lot as well.

Concerning lubricant and base stocks demand: there are many forecasts for the next decade, but their figures show a spread between + 0.5 to + 1.5%, i.e. between 39.1 and 41.4 Mio Tons/ year lubs, consequently between 37.5 and 39.8 Mio Tons base oils in 2016. Paralelly to the increased quality needs, the additive treating level is growing as well. The average of the net additive content raised from 1.4% in 1996 to 6.5% in 2012.

2. Driving forces, refinery implications

The consolidation and globalisation of the lubricant industry is going on in the future too, the number of global players decreased by 35% in 10 years, the independents also droped by 60%.

The number of manufacturers were by mid 90-s around 1,700, today approximately 720. The structure of the global lubricant industry shows a really interesting picture (Table 2.).

In the past the global base oil production were driven by the needs for lubricants in terms of quality and quantity. Generally speaking the base oil production capacities surpassed the demand, however several base oil plant were closed down in the last time, like Shell – Grasbrook, BP – Coryton, Cepsa – Huelva and INA will close it's plant this year. Europe remains long towards Group I base oil capacities. However the needs for Gr I base stocks decreases, for Gr II/ III increases overproportional. Today there are other, so called non-lubricant factors having major impact on the base stocks supplies, like legislations, crude supply position, robust fuel margine and „technology paradox".

Environmental protection becomes a major issue and lubricants have to comply with exhaust gas emission regulations as well. Therefore base oil quality has to improve in terms of saturates content (oxidation stability), sulphur content and volatility.

In order to comply with the increased need for higher quality lubricants and also the need for stable, high quality base stocks independently from crude oil availability, i.e. „unification processess" are necessary.

The increase of fuel demand especially diesel fuel resulted whithin the refinery an internal competition for vacuum gasoil (VGO) feedstock. The different cracking processes for fuel production are expensive and sensitive technologies, but once they are in operation, they produce high quality fuels in high quantities. On the other hand the return on capital is fairly quick since the fuels are sold almost immediately.

The refineries have to decide: due to the limitation on VGO, margine must be maximised, the production has to be optimised.

For the production of Gr I base oils a refinery needs a long chain of technologies, like solvent extractions, dewaxing process, hydrotreating technology, vacuum distillation and blending units which needs amoung financial resources high quality and experienced personel too.
In order to fulfill the quantitative and qualitative demand for „clean fuels", there are options for refineries: alternative crude supply – limited possibility, or configuration change – expensive and can have some drawbacks as well or

	1996	2007	variance/ year	2016 (est.)
North and Latin America	33.7%	30.7%	-2.3 to +1.5%	29.6%
Europe	29.1%	25.9%	-2.3 to +1.5%	24.7%
Asia-Pacific and rest of the W	37.2%	43.4%	+3.0 to +1.5%	45.7%

Table 1. Regional breakdown on lubricant demand

Company headquarter	Europe	N&S – America	Asia-Pacific	Total
Global player	45	20	65	130
Independents	230	160	200	590
Manufacturers	275	180	265	720

Table 2. Regional breakdown of the lubricant industry

investment for a hydrocracker – which can produces high quality fuels and potential feedstock for new Gr II/ III base oils.

Taking into concideration these facts a lot of new hydrockracking units are in installation, which also result in some newcomers on the base oil market, like Petronas, Neste, Pet'chem, ONGC (Table 3.).

As it was mentioned the today's production of base oil is a permanent battle for „death or alive" due to the competition of fuel and base stocks crack spread.

Interestingly enough a new phenomen was observed these days the „technology paradox". This means the new, higher quality base oil refining processes have the lowest cost of production. These new base oil plants are not crude sensitive, offer synergy with fuels strategy, provides high quality and more valueable base oils together with better yield. Their only drawback is the lack on heavy cut base stocks, therefore there is a need to keep traditional solvent technologies as well.

Some other new potential capacities are „in the tube" as well, like in China, Singapore and Iran.

As an important remark: Gr II/III base oils are not equal in terms of performance, like viscosity index (VI), cold flow peoperties, volatility. The chemical structure of the hydrocracking feedstock determines the final quality of Gr II/ III base stocks. API and ACEA are working on the read accross determination for unified formulation practice in order to produce stable, high quality lubricants.

3. Future trends

Taking into concideration the roughly 1% increase in total lubricant need, the base oil supply/ demand ratio remains long. The gap between GDP and lubricant demand will open. The total lubricant/ base oil need will remain different on the regional level due to the industry consolidation and output, car population, consumer behaviour, miles driven.

The volatile crude prices will play an important role in terms of economy for fuel or base oil production. The price sensitivity of lubricant formulations will be modified by the increased competition on the base stock and finished lubricant markets as well. The concentration of lubricant marketers will continue.

The dominance of the use of Gr I base stocks will remain, but the increase of non-conventional, i.e. Gr II/III quality base stocks will be overproportional. Some new supplier – previousely whithout lubricant activity – will appear on the market due to the use of new technologies.

The best option for fulfilling clean fuel and high quality base stocks demand will be the hydrocracking technology together with catalitic dewaxing (CDW) process.

Price escalation of the base stocks and consequently of lubricants will remain in barriers due to the market acceptance and OEM requirements. Therefore, production of base oils for a refinery is a delicate question: on one hand the lubrcants are „goodwill/ image holders", but the economy i.e. margin delivery capability is very much depending on fuel situation.

Company/ Country	on stream	Capacity (kT/y)		
		GrI	GrII	GrIII
Caltex/ Korea	2007 and 2008		500	350
Calumet/ USA	2008Q1		300	
Recoil/ Finland	2008H1		40(re)	
Lukoil/ Russia	2008			25
Pet'chem/ Taiwan	2008Q2		500	
SK-Pertamina/ Indonesia	2008Q2		375	
Petrona/ Indonesia	2008Q4		70	275
Puralube	2008Q4		70(re)	
Pet'chem/ Taiwan	2009		250	
Hindustan/ India	2009Q2		200	
4 projects/ various	2008 and 2009	80	115	40
ONGC/ India	2010			250
Neste/ Bahrain	2011			400
Total	2011			180
Shell/ Quatar – GTL	2011			1,500
Takreer JV/ UAE	2012		500	
3 projects/ various	2010-2012		1,400	500
Total: approx 8 MioT/y		**80**	**3,445**	**4,395**

Table 3. New base oil capacities over the world

4. Regional situation, MOL's position

The regional base oil industry is going through a remarkable period of change. Environmental regulations, crude oil price swings, and new engine oil specifications have been affecting the industry.
The growing vehicle population, upgraded machinery and production facilities have resulted in growing demand for high value lubricants and falling demand for non-additized, low cost lubricants.

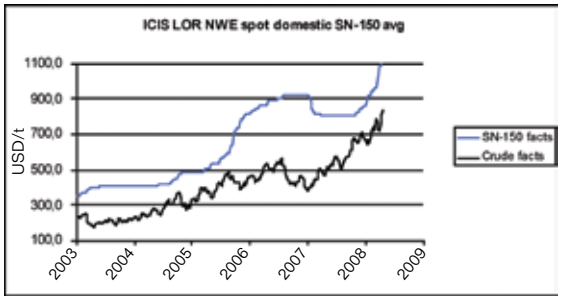


Figure 2. Quotations of crude and base oils

Price escalation
Base oil prices continue to rise and challenge lubricants profitability. The European base oil buyers are concerned too that prices will continue to increase also in 2008.

SUPPLY DISRUPTION

Base oil supply is becoming under increasing pressure from feedstock competition and the margins available in fuels production.

Fuels and lubricants production used to be able to exist independently, but as base oils compete for vacuum gas oil (VGO) feedstock with the diesel production, refiners are favouring production of gas-oil as they look for maximising overall profit.

Europe produces mainly Gr I type of base oils. Many of European base oil plants are more than 30 years old, and their mechanical equipment needs updating and replacement to operate effectively and safely. In the European market, the need for higher fuel economy and higher performance engines created a market for higher quality base oils years ago. Since then, Gr IIIs have grown and spread into this market. Currently Gr II production is virtually absent in Europe probably because the market developed before this technology was available for license and access supplies in the region precluded building new base oil plants. But Gr II imports are now started to fill the gap and will begin to be manufactured in Europe as well. Gr II could become substitute for Gr I in some automotive applications. This new trend away from Gr I oils

Central Eastern Europe Base oil manufacturing capacities (to)

Country	Location	Producer	Group I	Group II	Group III	Producton
Austria		None	0			
Slovakia		None	0			
Czech Rep.	Kolin, Pardubice	Paramo	110.000		15.000	No data
Poland	Gdansk	Lotos	240.000			Also brighstock
	Plock	PKN Orlen	155.000			No light grades
Hungary	Szhbatta	MOL	150.000			
Slovenia			0			
Croatia	Rijeka	INA	105.000			Close in 2008
Belarus	Novopolotsk	PO Naftan	190.000			Deliver to WE & CE
Ukraine	Kremenchug	Ukrtatnafta	365.000			Deliver to WE & CE
Uzbekistan	Fergana	Uzbekneftegaz	475.000			Deliver to WE & CE
Turkmenistan	Turkmenbashi	Turkenneftgas	100.000			
Turkey	Izmir	Tupras	293.500			
Russia	Russia	Many companies	3.600.000			
Greece/ Israel	Agii Theodori,					
	Parnas, Haifa	Hellas	240.000			
Bulgaria	Pleven	Plama Pleven	190.000			Since years out of service
Romania	Ploiesti	Petrotel, Astra	134.000			out of service
Serbia, Bosnia	Novi Sad	NIS ReŢnery	0			Production?
	Modrica	Modrica	0		10,000	Just started
TOTAL			**6.276.500**			**5.952.500**

Table 4. Central & Eastern Europe base oil manufacturing capacities

MOL base oils are in the formulations of many lubricants by the very well known brands.

MARKET

MOL self-supplies its own blending facility with base oils around 30-40% of its production. The main customers for MOL's base oil (s) are small and medium-sized blenders, which are located throughout Central and Eastern Europe (Austria, Czech Republic, Slovakia, Poland, Ukraine, Romania, Bulgaria, Serbia, Croatia, Italy, Germany). Base oils are generally not shipped over large distances so that buyers are confined to source from the nearest manufacturer. The approximate distance over which base oil can viably shipped is max. 1,000 km.

FUTURE

The need for better fuel economy and lower emissions will drive demand for non-conventional base oils while reducing demand for Gr I products however the demand for heavy neutral and for Brighstock will remain. Russian Base oils may change the balance of the Western European area. F.e.Lukoil is investing $270 million to upgrade its base oils. The key trends affecting CEE's base oil market include globalization of the market; introduction of new technical specifications; development of new technologies; more stringent legislative

and towards Gr II and III will especially be felt on lower viscosity grades. Heavy neutral and brightstock supply may be become problematic from 2010.

At MOL Danube Refinery the Gr I base oil manufacturing capacity is ca. 150,000 to / year. From this quantity ca. 55-60,000 to/ year is made from Hungarian origined crude oil. The remaining ca. 90-95,000 to is made from Russian „export blend" crude oil which delivered via the Friendship pipelines. At the base oil unit it is possible to load road and rail tank cars. At the refinery's port barge loading is also possible and can be shipped on the river Danube.

MOL produces different straight cuts and blends of Gr I base oil which can be used as a row material for all kind of lubricants. Around 30 different grades of base oils offered on the market. The sortiment is from SN85 to SN650 grades and MOL also produces Brighstocks.

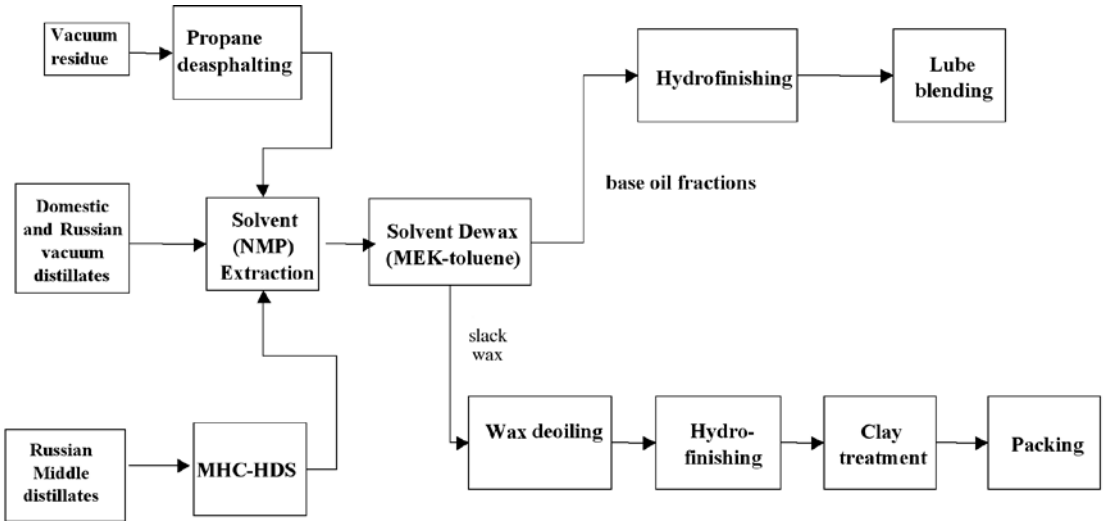


Figure 3. The scheme of the existing base oil and wax production

regulations towards environmental protection for engines; a greater role for brands, and structural changes in the lubricants market.

INVESTMENT

Investments needs to improve quality, production efficiency, to decrease energy costs. About the exact and necessary investment possibilities a study proposal were made last year. The development of the detailed project got „green light" from the EB of MOL.

Namely while the conventional method extracts the undesired components, the HC+CDW technology converts them directly to end products. The base oils are hydrofinished at high pressure (>100 bars) compared to the approx. 30 bar hydrofinishing pressure applied in the conventional base oil manufacturing. While this technology has significantly lower operational cost, it has a much narrower product range than the conventional production: heavy base oils e.g. Bright Stock, paraffins and waxes are not produced at all.

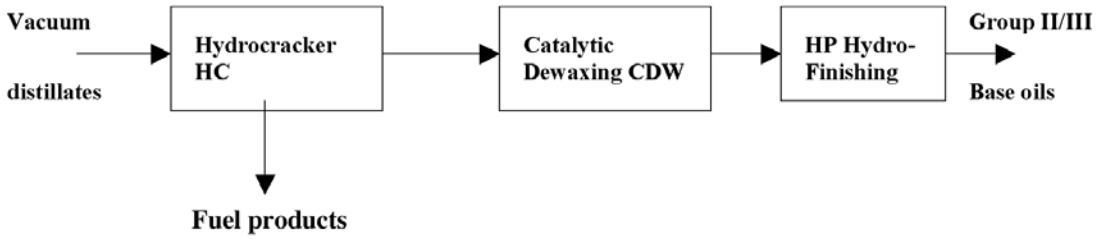


Figure 4. Scheme of the HC+CDW production scheme

MOL will invests into a hydrocracking unit and will produce Gr II/III base oils. The expected quantity will be around 160 – 200 kto/Y, which can be sold in our region.

5. Development of MOL base oil technology

The existing base oil and wax production of MOL uses conventional solvent extraction units and produces Gr I base stocks:
The – for lubricants – undesired aromatic- and naphthenic compounds are removed from the feedstock in the Solvent (NMP) extraction unit, the pour point of the base oils is set by solvent dewaxing process followed by the wax production line. The products are hydrofinished, paraffins and waxes are also clay treated.

A full hydrotreating technology train (Hydrocracking and hydrodewaxing) for base oil production would evidently be simpler:
In the HC+CDW technology the – for lubricants – not favourable aromatic- and naphthenic compounds are converted into paraffinic substances in the Hydrocracker unit, the cold flow properties of the base oils are set by Catalytic dewaxing which converts the higher pour point n-paraffin molecules into i-paraffins that have lower pour point. The difference between the conventional and the hydrotreatment approach is the same in both the dearomatizing and the dewaxing steps.

The two technology trains can be operated simultaneously and even be integrated: Routes a.) and b.) on Figure 5. represent the two previously discussed options, while route c.) represents the base oil production from the redistilled atmospheric residue of the Hydrocracking unit by solvent dewaxing. This HC residue is mostly referred to as UCO (Unconverted oil). [The integration of the technologies along route d.) is not viable because, the CDW catalyst can only receive low nitrogen (N)- and sulphur (S)- content (high pressure hydrotreated) feedstock].

According to MOL Group's approved Hydrocracking concept, a HC unit will be constructed so that – according to market condition- it can be operated either in only fuel mode or to produce also the optimal slate for base oil feedstock. The full conventional (a.) route will be maintained mainly for the production of heavier viscosity grades e.g. Bright Stocks and and their respective wax products, while the combined (c.) new technological scheme will be used for lightrr grades of base oils and paraffin waxes.
The distribution of the vacuum distillates between the fuel and base oil technologies will be an important tool to optimise MOL's production structure.
The CDW remains a future option for development which can serve either for

- replacing or
- debottlenecking

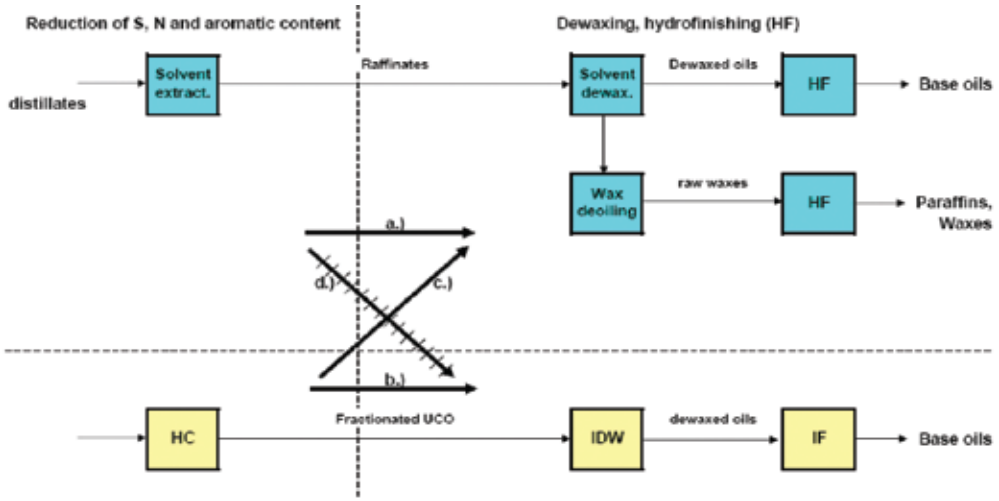


Figure 5. Comparison and possible integration of conventional and Hydrocracking based base oil production

the conventional dewaxing and hydrofinishing technologies.

6. Summary

The worldwide lubricant/ base oil demand will increase between 0.5 and 1.5% on the yearly basis. Gr I base stocks will keep their dominant position in the finished lubricant formulations. The increased demand for higher quality base oils is driven by legislations, customer expectations and technical progress. The top-quality lubricants will be based on advanced base stock technologies.

The new refinery technology makes possible to use synergism with fuel production and at the same time increase the economy of base oil production as well. The market competition will increase on the Gr II/ III segment due to some newcommers using HC technology.

In our region MOL's base stocks are playing a significant role and this situation will remain in the future as well. The quantities possible coming from the East do not have too high market share since the freight rates are becoming more and more a decisive factor. For those producers it will be much easier to deliver their products to Western Europe by ships. Due to the increased quality of car population in the middle eastern european countries local producers have to comply with and bring into the market place higher performance lubricants. In order to be able to do so, they also need to blend these products from base stocks with increased oxidation stability, better cold flow properties, lower volatility, i.e. using Gr II/ III base oils. MOL is developping their base oil production technology in order to fulfil the above mentioned demands. Since the number of diesel cars increase overproportional, diesel fuel, especially low sulphur diesel fuel demand is higher than other fuels, ie.e. it's necessary to use hydrokracking technology . This technology is able to produce high quality fuels together with higher quality base oils. On the Gr II/ III market is expected increased competition due to some newcommers.

At MOL in order to be able to produce conventional – heavier cuts and brightstocks – and unconventional base stocks at the same time, the old solvent extraction technology should remain in operation. This helps to retain a part of the profitable wax production too. The new investment is already approved and will come into operation during 2012. The next step for development could be the installation of a CDW unit which further improve the base oil quality to make possible to blend low- SAPS lubricants. This investment could also increase the output of high quality base oils.

References

11th and 12th ICIS LOR Worldwide Base Oil Conference – London, February 2007 and 2008

Revised by: Ferenc Dénes, Dr.

How to win loyal customers

Anna Éber (28)
Economist (MA)
MOL Group
Shop and Marketing Manager
E-mail: aeber@mol.hu

Gergely Dolezsai (32)
Economist (MSc)
MOL Retail HU
Loyalty Expert
E-mail: gdolezsai@mol.hu

András Balásfalvi-Kiss, Dr. (29)
Jurist-Economist
MOL Retail HU
Junior Marketing Expert
E-mail: abalasfalvi-kiss@mol.hu

Abstract

The marketing activities of the companies are focusing on direct channels instead of the formerly used mass mediums. It means that they prefer to use the BTL tools (DM letters, e-mails and targeted messages) rather than the ATL tools (TV, radio and press advertisements). To be able to use those channels effectively, enterprises need to have an application that stores the customers' data and supports the survey of their behaviour and the analysis of their transactions. Once the buying habits and the preferences of the target group is known we can start to create a loyalty scheme that is attractive for them and helps the organizers to reach their goals by generating regular and repeated purchase. Many researches have shown that keeping the current customers loyal is much more cost effective that winning new ones. The article tells about the major types of the loyalty programmes, the possible technical platforms and systems and shows the best practices from many different sectors. The aim of the publication is to provide up-to-date description of the potential of the loyalty schemes to the marketing experts and those who want to know more about this area.

Összefoglalás

HOGYAN SZEREZZÜNK HŰSÉGES ÜGYFELEKET?

A vállalatok marketing tevékenysége a tömegmédiumok domináns alkalmazása után egyre inkább a direkt kommunikáció irányába tolódik el. A gyakorlatban ez azt jelenti, hogy az un. ATL eszközök, TV, rádió, sajtóhirdetések használata helyett a BTL eszközök, a DM levelek, e-mailek, testre szabott üzenetek célba juttatása kerül a fókuszba. Ahhoz, hogy ezek az eszközök hatékonyan működhessenek, szükség van egy megfelelően kialakított alkalmazásra, amely rendszerezi, kereshetővé és elemezhetővé teszi az ügyfelek és az általuk végzett tranzakciók, vásárlások adatait. Ha megismerjük a fogyasztóink szokásait és ezen keresztül az igényeiket, akkor tudatosan alakíthatunk ki egy olyan hűségprogramot, ami valóban vonzó a számukra és eléri a célját, azaz visszatérő vásárlókat hoz az üzleteinkbe. Számos kutatás támasztja azt alá, hogy lényegesen költséghatékonyabb megtartani a jelenlegi vevőinket, mint újakat meggyőzni arról, hogy a mi cégünket, a mi termékeinket válasszák. A hűségprogramok alapvető típusait, lehetséges technikai platformokat és konkrét példákat, akciókat mutat be a cikk annak érdekében, hogy a terület szakembereinek és a programokban rejlő lehetőségeket még csak most megismerő olvasóknak is naprakész tájékoztatást adjon.

Introduction

Due to the technological, social and economic changes, companies in the Retail sector are concerned that they face much stronger competition than ever before. Besides of acquiring new customer base, companies operating in a dynamic market environment need to concentrate also on retaining their current customers.[1]
Some interesting facts regarding the customer behaviour:

It takes five times more energy to acquire a new customer than to satisfy and keep an old one. It requires big efforts to pursue satisfied customers to leave their supplier.
A company generally looses 10 % of its customers in one year.

If the proportion of leaving customers could be reduced by 5%, the company's profit would increase by 25-85 %, depending on the industry Customer satisfaction and loyalty plays a significant role in the current marketing practices. One of the main tools of creating and maintaining long term customer relationships can be a loyalty programme.

The loyalty

Several definitions exist for describing the term "loyalty". These are more or less unified in a sense that they focus on fidelity, engagement, commitment. According to Tellis, loyalty is a willingness to choose something again.[2] Newman and Webel started from Tellis's point of view, but they went a bit further. According to them, the loyal consumer buys the same brand without doing a comparative benchmarking exercise at each and every new purchase.[3] Oliver distinguishes three different levels of customer loyalty. On the first level, the customer favours a brand against another. This is not a real loyalty but brand preference. On the second level, the customer has a strong intention to choose a certain product or service and does not consider buying another one. On the highest level, the customer retains his or her buying habit under any circumstances. This means that he is not only willing to pay any price for the product or service in concern but even takes substantial sacrifices to buy it.[5] After all, loyalty is a deeply rooted commitment in order to make a repeat purchase of the preferred product or service despite any external influence or other tempting marketing efforts. Marketing is the Art of attracting and retaining the most profitable customers.(see1st illustration)

Customer value, customer satisfaction

The core of customer loyalty is to provide enhanced customer perceived value (CPV). CPV is the difference between the entire customer value (expected advantages in financial terms) and the entire customer cost (expected costs during the evaluation, acquisition, usage and subsequent utilization of the product in financial, timing, energy and psychical terms). The objective of loyalty marketing is to create an advanced level of CPV, which is too high for the competitors to copy.

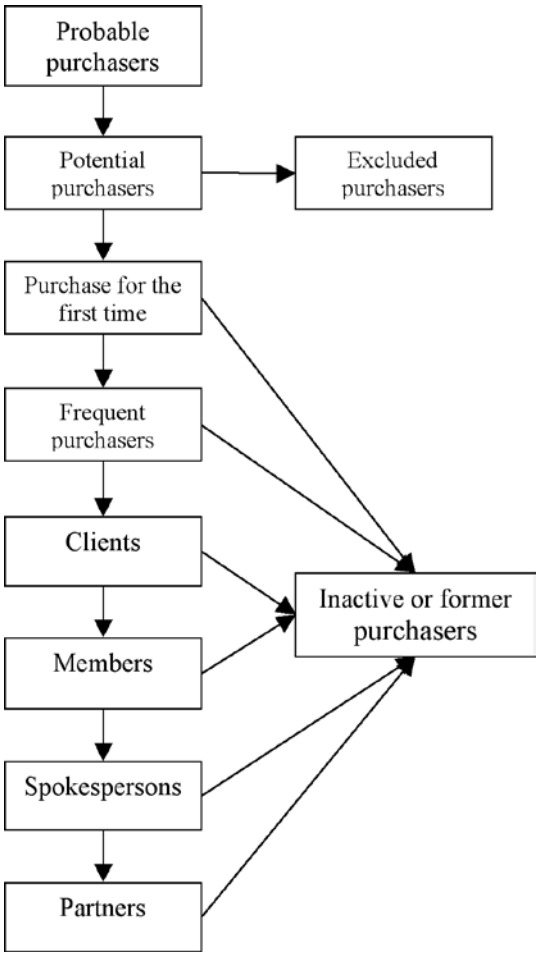


Figure 1. [4]

Customer value contains many emotional elements, such as the image of the product and the company, the quality of services and customer satisfaction. Besides loyalty programmes based on these emotional elements, a strong, customer value based relationship can be built up between customers and companies (see 2nd illustration).

At the beginning of the '90s the vast majority of the customers of furniture stores did not have any emotional link for any brand in Hungary. They made their decisions based on their actual needs and the price. In this environment, IKEA made a revolution by its enhanced comfort services (children supervision baby care facilities, free parking, friendly staff, and furniture exchange guarantee). Since IKEA was the first to provide these kinds of services in Hungary it obtained a significant loyal clientele (see 1st illustration) who was ready to pay prices compared to the Western European ones.

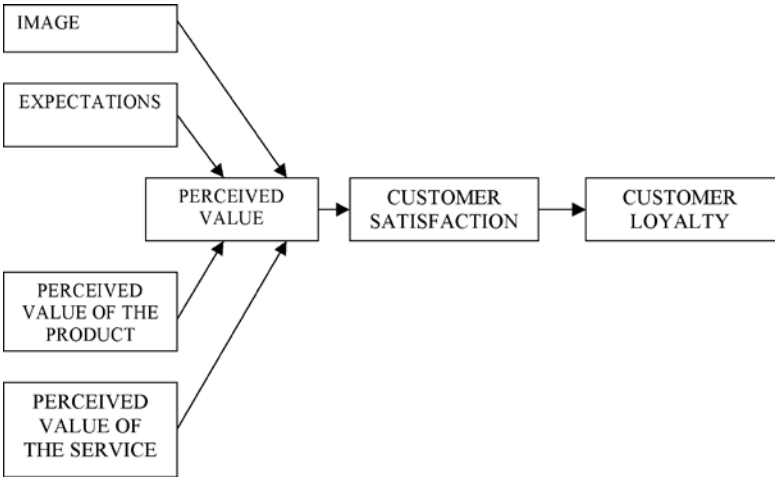


Figure 2. [6]

Among the Hungarian hypermarkets, TESCO utilises the brand value in the most sophisticated way. Due to its price positioning and very simple but unconventional design, "TESCO GAZDASÁGOS (VALUE)" product family is identified as one of the best and cheapest one. However, this example reflects one of the communication pitfalls. Some people though found it embarrassing to buy these products, as they consider that this would diminish their social status (e.g. they did not want to provide "TESCO VALUE" chips for their guest, even if they themselves liked it [7]). Tesco's image was completely built on the "even the smallest counts" slogan. Despite this, the branded goods which were not on promotion were sold on a higher price level. As a respond to this challenge "TESCO SZINES (COLOURED)" range was launched to combine the product benefits of the branded goods with attractive packaging and a reasonable price level in order to win more customers.
One of the most important components of the customer satisfaction is the quality of the products, but it is not all about it. The customer's decision on being loyal or not is based on all the impressions about the given company. This is why the vast majority of companies operating successful retail loyalty programs focus on educated and motivated front office resources (shop assistants, customer service agents).

But high level of satisfaction does not necessarily lead to customer loyalty.[8] One2One channels, direct marketing and the usage of new technologies (SMS, MMS, e-mail, community portals) are in the focus of the loyalty communication.
Thanks to the recent technological developments companies can interact with their potential and existing loyal customers using the World Wide Web. Internet has an increasing importance in customers' decision-making process and is a very good platform for customers to share past negative experiences. A company which is utilising the Internet effectively can realize a substantial competitive advantage.

Types of the loyalty programmes

Having the aim to reach real loyalty, customer commitment and higher customer value, many companies are launching reward card based loyalty programmes.

The name of loyalty cards differs from country to country. In the United Kingdom we can find loyalty cards, in Canada these are typically called reward cards or point cards. In the United States three names are used: discount card, club card and reward card.

The following important milestones are representing the major steps of the development of the loyalty programmes.
On May 1st 1981 American Airlines launched the first full-scale loyalty marketing programme of the modern era. It was the AAdvantage miles program.[9] This revolutionary program was the first to reward "frequent fliers" (passengers) with free miles that could be accumulated and later redeemed for free travel. The AAdvantage programme now includes over 50 million active members.

Loyalty programmes have decade's long history. Their utilization as a tool within the marketing mix heightened during the mid '90s with the TESCO loyalty programme in the UK. In 1995 TESCO introduced its own club card and the related web store where customers

could chose from a large selection of rewards and check their point balance on-line. That year TESCO became the market leader in the United Kingdom in the field of supermarkets. TESCO today has the largest loyalty card system in the UK with around 13 million active Clubcard holders.

After the success of TESCO more and more companies recognized the advantages of the exclusive, own-branded loyalty card system and started to copy it immediately by launching their own programmes. Representatives of many different sectors followed this model from car dealers to drugstores and even filling station networks.

Business models

Loyalty programs are effective marketing tools serving the following main goals:

1. Build a strong link between the company and it's customers
2. Reduce churn (minimize the loss of regular customers)
3. Win greater share of wallet
4. Generate additional visits and volume
5. Provide up-to-date customer data for targeted 1to1 communication
6. Provide basis for using CRM techniques

There are several types of loyalty card programmes. Standalone loyalty programmes are usually founded and operated by one dominant player. The number of the participating partners is limited; point collection is usually restricted to the core products of the founding company. This platform allows the participation of additional partners but their power is much smaller compared with the one of the founding company. The advantage of this type of programme is that the founding company controls the whole scheme and does not need to negotiate terms and conditions with any other enterprises. The disadvantage from the customer point of view is that the point collection process is relatively slow. It is not unusual that a customer with standard purchase potential needs to wait for ages for his or her "object of desire".

In Hungary Shell was the first company in the fuel sector that launched a loyalty card programme in 1997 named Shell Smart. Thanks to the well chosen partners, simple mechanisms and the immediate reward system, Shell Smart Card became popular and was able to maintain this success. By having McDonalds as a point issuer and redeemer in the programme, Shell managed to attract a lot of families to the scheme. Research pointed out that this is the major USP (Unique Selling Proposition) of the SMART system. A few years later Shell has realised that its customers were more and more demanding as the fuel prices were growing, so they offered a 10 HUF price discount against 8 points. Agip have followed the example and started to give the same price advantage to the cardholders against only 5 points.

WestEnd City Centre's loyalty programme is another typical example of a customer club. For the membership a minimum purchase of 20 0000 HUF is required in any store of the shopping mall. The shopping centre does not offer discounts to the cardholders, but occasionally gives them small giveaways, invitations to special events, concerts, etc. The limited offers strengthen the club's exclusivity.

Co-branded or multi partner loyalty schemes are typically founded by 3-6 equal partners, all of them being leaders in their respective sectors. The advantage of this scheme is that the point collection is faster for the customers, they can choose from wider range of rewards, while participating enterprises can share the operational costs of the programme. But it is not always easy to find the right partners for the co-operation that have the same vision, customer segmentation and whose brand values are similar.

MOL, OTB Bank and Matáv launched the Multipont scheme is 2001 in Hungary to utilize the benefits of the market leading companies and give unique offers to the cardholders. The Multipont card combines the best characteristics of a bankcard and a point card. Participants can collect and redeem points at thousands of outlets nationwide.

Coalition programmes are managed and operated by an outsourced specialist. These operators are usually international companies, functioning as a combination of a clearing house and a marketing agency. Their role is to keep the programme attractive for the customers as well as profitable for the partners. The participating retailers pay a predefined fixed fee plus a revenue related contribution.

For example, Nectar programme in the UK reaches every second household while its German counterpart, PayBack is proud of being the best known German brand. PayBack operates as an independent operator that provides to the participating enterprises the

necessary IT background, the customer service, transfers the know-how and regularly organizes BTL (below the line) and ATL (above the line) campaigns to target existing and potential new cardholders. The list of the participants includes brands like Aral, Galerie Kaufhof, Real, Drogerie Markt, etc.

A company joining such a coalition programme has the advantage of getting a ready made solution but, at the same time, is risking to loose its own identity.

Supershop is the leading Hungarian coalition programme. An independent company, Supershop Ltd. helps the participating companies to reach their goals and serve the daily needs of the 1 Million+ card holders. Amongst its partners, we can find many important companies in retailing. It is clear that usually the grocer or the hypermarket partner (Kaiser's and Plus) is the one through which the programme is identified by customers since most of their purchases happen in this channel. Nothing can compete with the daily transaction frequency of that sector.

Bankcard based loyalty programmes are combining the bank card and loyalty functions and provide customers with an automated, easy to use reward system. Since the pay transaction and the point issuance happen at the same time, the chance of fraud can be minimized. However, customers are usually unwilling to switch banks just for the sake of a more favourable loyalty card system.

Three major technical platforms exist for customer identification purposes on the card.

- barcode
- magnetic stripe
- chip

The Chip card technology provides extra security, but has bigger costs. The magstripe card is the most widespread solution thanks to the relatively low cost and durability. Barcode is a typical entry-level solution for SMEs.
Target group segmentation is a key success factor. The effectiveness of loyalty programmes can be further enhanced by defining those sub segments within the card user population that can be approached with a relevant offer.

Shell Driver Club (United Kingdom) offers two levels of membership. For the V-Power Club membership customers need to fill in at least 100 litres of premium fuel within a defined period of time. After reaching this limit, members receive double or triple points and collect them in more attractive conditions. V-Power Club members receive exclusivity and extra services for their commitment. This is a perfect example of treating and rewarding the premium fuel users with special targeted and relevant offers that gives them the feeling of exclusivity.

Customer Relationship Management (CRM) is the process of careful management of all types of customer relations aiming the maximization of the customer loyalty and of customer related, detailed information handling. [10]
It is possible to create a good loyalty programme without CRM and database marketing, but it will never be as efficient as it could be if using these tools.
Companies having an appropriate loyalty programme design are able to set up a database containing up-to-date data to be used for marketing objectives in an organised way.

MOL loyalty card program, Multipont card

MOL loyalty brand card is a typical example of the own-branded scheme while Multipont is a bankcard based co-branded programme.

MOL Loyalty Card is MOL's own, stand-alone loyalty scheme that was launched in 1998. Since the start of the programme the basic offer has not been changed. In order to become members of the programme, customers only need to fill in the application form and they will receive their own, personalised chip card that is ready for usage. For each l liter of fuel or for shop purchases of 100 HUF, the owner receives one point. For the premium fuels (EVO Neo fuels) the cardholder can collect double points. The point collection is very easy, the customers only need to hand over their card after the payment of the purchased goods at the cashier desk.

The biggest advantage of the programme is that the participants can redeem their points against any goods or services that can be found at

MOL's filling stations. This offers the freedom of choice to the members.

Multipont was founded by three market leaders in their respective branch in 2001 (OTP Bank, MOL, Matáv). Matáv left the programme after the merger with T-Mobile. Fotex joined but decided to leave after three years of co-operation. CBA joined the programme two years ago as both point issuer and redeemer. The number of card holders reached half a million in the third year of the operation, which means a massive customer base. The point collection mechanism is even easier with Multipont card, since the payment and the point collection transaction are handled together, so the points are added to the balance automatically without any extra effort.

Keeping the programmes alive

MOL's programmes regularly offer special promotions to the cardholders where they can collect additional points for selected products or the collected points can be redeemed against products at an excellent point rate. The extra offers help keeping the programme attractive and valuable for a long period of time. During the Christmas season of 2007 MOL Loyalty Card and Multipont Card holders could buy two tickets for Magdi Rúzsa's concert for only 300 points. The tickets could cost on the open market 6000-8000 HUF. The special show was dedicated to MOL's stakeholders only. The Budapest Sport Arena was crowded by MOL's most important customers, the loyalty cardholders. A special event like this has both a short term and a long term effect. On the short term the exclusivity of the event was important (the event was organised by MOL, so the tickets were not sold to the public). This show will also be remembered for a longer time thanks to the special guests (Gábor Presser, Boban Markovich Orkestar) and the outstanding duets of the artists.

Pöttyös the favourite snack brand of the country launched a new product this spring and MOL was offering this well promoted item for only 2 points for a limited period of time during the Easter Holidays. The new Pont2 dessert was valued by the cardholders. They were ready to fill in at least 22 litres of fuel which helped MOL to increase the average transaction, in order to benefit from the offer. In addition, MOL has prepared a short animation with an Easter bunny driving to MOL for the desired Pöttyös snacks. The frames of the film were used for a special colouring booklet

that was a special gift for the kids travelling with their parents during the holiday season. Both Friesland (the brand owner of Pöttyös) and MOL were satisfied with the results of the promotion which supported the product launch and helped MOL to reward not only the cardholders but their whole family as well.

Loyalty in MOL Group Countries

An international company can chose from many different scenarios. MOL operates 4 different loyalty programs in 3 countries currently. The systems are managed on different platforms and offer different customer benefits.
MOL is facing new challenges thanks to the fast growth and the entrance to new markets The company is considering to create a platform that helps to optimally serve the local needs and shares the Group level know-how between the participating countries. The goal is to keep the existing customers loyal and attract new drivers to maintain the profitability of the company.

Summary and conclusion

The importance of the customer loyalty was recognized by many companies resulting in a fierce competition on the market. It is not unusual for a housewife or a car driver to have 6-8 different cards in his or her wallet. Each card belongs to a brand or enterprise that is fighting for the biggest part of spenders' money. The result is that the market will only value the best, most sophisticated and attractive schemes in the future. A company willing to launch a loyalty programme needs to identify the target group first. Creating a programme that only serves the top customers with the highest spending potential or one reaching the vast majority of the consumers can make a difference. The right platform depends on the offer, the algorithm and the number of expected cardholders or the outlets where the enterprise is present. Possible partnerships with other industry representatives and future development plans need to be built into the development. The card itself embodies the

Country	Card name	Redemption mode	Card type	No. of cards
Hungary	 MOL Loyalty  Multipont	Any goods or services at the filling station	Chip	550.000 + 450.00
Slovakia	 Bonus	Catalogue based	Chip	350.000
Romania	 MultiBonus	Catalogue based	Magnetic Stripe	507.000

programme to the customers. Personalised cards are more expensive but they can add a personal touch which is usually appreciated by the customers. Launching a loyalty programme requires a dedicated team, the full support of the management of the participating companies and continuous efforts from the organizers. But if it is done well, the cardholders will appreciate the invested energy and will became loyal customers who are able to generate extra profit for the company.

References

[1.] Frederick F. Reicheld: The Loyalty Effect, Boston, Harvard Business School Press, 1996.

[2.] Tellis, G. J.: "Advertising Explosure, Loyalty and Brand Purchase: A Two-Stage Modell of Choiche", *Journal of Marketing Research,* May 1988, 134 -144.

[3.] Newman, J.W. – Werbel, R. A.: "Multivariate Analysis of Brand Loyalty for major Household Appliances", J*ournal of Marketing Research,* Nov. 1973, 404-409.

[4.] Jill Griffin: "Customer Loyalty: How to Earn It, How to Keep It", (Jossey-Bass) 2002. 252pp., ,ISBN:0787963887

[5.] Oliver R. L.: "Whence Consumer Loyalty?", *Journal of Marketing,* Special Issue 1999, 33-44.

[6.] Lars Gronholdt, Anne Martensen, Kai Kristensen: "The relationship between customer satisfaction and loyalty: cross-industry differences", *Total Quality Management,* Vol.11, 2000, 509-514.

[7.] Orovicz Viktor: "A kereskedő – Brandépítés – Üzletláncok kommunikációs stratégiái IV", *Progresszív Magazin,* Vol. 9., 2006.

[8.] 85-95% of car owners are satisfied, but only 30-40% return to the same producer or model Source: Dr. Hetesi Erzsébet: „A közszolgáltatások marketingje és menedzsmentje", *SZTE Gazdaságtudományi Kar Közleményei,* 2002, 205-218.

[9.] Philip Kotler: "According to Kotler: The World's Foremost Authority on Marketing Answers Your Questions", (American Management Association), 2005, 168pp, ISBN:0814472958

[10.] Philip Kotler–Kevin Lan Keller: "Marketingmenedzsment", (Akadémiai Kiadó, Budapest) 2006. , 218. pp., ISBN 963 05 8345 3

Revised by: Sorina Baltatu

Placing energy business in the risk-return portfolio matrix of MOL Group

László Keresztury (31)
MS of Chemical Engineering
Development engineer, MOL
DS Development
E-mail: lkeresztury@mol.hu

Bence Körmendi (25)
Economist / Business administration
R&M Commercial, MOL
E-mail: bkormendi@mol.hu

Attila Steiner (25)
Economist
Business Development, Business Analyst
MOL Power and Gas Division
E-mail: asteiner@mol.hu

Gergely Szabó (25)
Economist / Business administration
Business development expert, MOL
E-mail: gerszabo@mol.hu

Abstract

PLACING ENERGY BUSINESS IN THE RISK-RETURN PORTFOLIO MATRIX OF MOL GROUP

As a result of looking for growth opportunities and possibilities to enter new business areas, MOL decided to build two 800-800 MW gas-firing power plants in cooperation with CEZ at Danube and Slovnaft refineries. Entering power generation business means new challenges and changes in the risk profile of MOL Group. In order to analyze the impact of this, we have established four scenarios, identified the most relevant risk drivers and their impacts on MOL Group profitability using the Enterprise Risk Management method (ERM) applied by MOL. According to the conducted analysis, the most significant risk factors – which are affecting the new business unit - are the following: gas and electricity price evolution, CO_2 price, exchange rates and the merit order position of the power plants.
In case the applied CCGT technology is the price setter technology on the market in the long term, both the Group's return and risk will likely increase. Since the incremental return exceeds the additional risk, entering power business can be accepted on risk/return basis.
In our study we identified the most important risk factors and some possibilities for mitigation. In case MOL management considers these results as main risk drivers, we believe that the rise in external exposure of MOL Group could be reduced in a proactive way.

Összefoglalás

AZ ENERGIAÜZLET ELHELYEZÉSE A MOL CSOPORT KOCKÁZAT-HOZAM PORTFOLIÓJÁBA

A további növekedés és új üzletágakba történő belépési lehetőségek vizsgálatának eredményeként, a MOL-csoport két 800-800 MW-os kombinált ciklusú gáztüzelésű erőművet épít a CEZ -zel közösen a Dunai és a Slovnaft finomító területén.
Az új üzletágba történő belépés újszerű problémákkal jár és megváltoztatja a MOL-csoport eddigi kockázati profilját. Ennek elemzése érdekében 4 szcenáriót hoztunk létre és azonosítottuk a legfontosabb kockázati faktorokat, valamint azok hatását a MOL-csoport eredményeire a jelenleg a társaság által alkalmazott kockázatkezelési modell alapján.
Az elemzés eredményeként a következő faktorok befolyásolják a legjelentősebben az új üzleti szegmenset: a gáz és áramárak változásai, a CO_2 ár volatilitása, az árfolyamváltozások és az új erőművek pozíciója a piac erőműveinek határköltségei alapján felállított sorrendben.
Amennyiben a CCGT technológia

lesz hosszú távon az ármeghatározó a piacon, a csoport kockázatai és hozama várhatóan nőni fog az új iparágba történő belépés eredményeként. Mivel a hozamnövekedés mértéke várhatóan meghaladja a kockázatemelkedés mértékét, az áramtermelésbe történő belépés kockázat-hozam alapon is indokolt. A tanulmányunkban azonosítottuk a legfőbb kockázati faktorokat és néhány megoldási javaslatot is bemutattunk azok hatásainak mérséklésére. Amennyiben a menedzsment kiemelt figyelmet fordít e kockázati elemekre, és azok proaktív kezelésére hangsúlyt fektet, a MOL-csoport kockázati kitettség növekedése jelentősen csökkenthető.

Introduction

ENTERPRISE RISK MANAGEMENT (ERM) IN BIG COMPANIES

Risk management is a recent, but now a widely accepted description of a discipline within large organizations. Originally this concept was elaborated in insurance and financial institutions in the early 90's, but nowadays it has broader scope of activities and responsibilities. Today the main objective of Enterprise Risk Management is "seeking to identify, assess, and control – sometimes through insurance, more often through other means – all the risks faced by the business enterprise, especially those created by growth," as Griffith explained [1]. We can find the ERM department not only in capital-intensive industries like banking or oil and gas, but in FMCG (Procter and Gamble) and fast-food sector (McDonalds) [2]. The main reason is, that the business entities are facing rapid changes in nearly every aspect of their operations, including production, marketing, distribution, and human resources. Such rapid change also exposes the business to increased risk. In response, risk management professionals created the concept of enterprise risk management, which was intended to implement risk awareness and mitigation programs on a company-wide basis. In addition, companies are engaged themselves to use ERM due to the pressure from investors, analysts, insurance institutions, rating agencies, since they want to mitigate their own risks.

SUMMARY OF MOL-CEZ AGREEMENT

Diversification strategy of MOL

In order to look for growth opportunities of MOL Group, possibilities for entering new business areas are investigated continuously. Exploring diversification opportunities along the value chain provides MOL new potential and balances risks on Group-level due to the portfolio effect. Through the application of a strict set of criteria and the evaluation of synergy potentials, entering power generation seemed to be the most attractive option for diversification.

The investment

As a first step of entering power business, MOL plans to build two 800 MW semi-peak load power plants in Danube and Slovnaft refineries in partnership with CEZ. The combined cycle gas turbine (CCGT) power plants will cover the total steam and electricity demand of both refineries after 2013, however significant part of the produced power will be sold in the Hungarian and Slovakian markets. The existing Slovnaft thermal power plant will be upgraded to 160 MW power production capacity. The two parties are establishing a joint venture (JV) company, so investments, profit and risks will be shared by 50%-50%. The whole investment in power plants amounts to EUR 1.5 billion.

Initial expectations

As a mean for diversification, the size of the investment and the different risk profile entail, that the new MOL Group risk profile could differ significantly. Generally, power generation and electricity business are characterized by lower risk levels and more stable cash flows than traditional oil and gas business. However we should distinguish between base and peak load operations. Stable operation with low risk and solid cash flows are the main characteristics of base load production. Opposite to this, peak load operating power generation deals with a much higher priced product but capacity utilization is lower. The level of used capacities is determined by the merit order of generators and therefore, efficiency. Both plants in question are for semi-peak load operation, therefore in our case, it is not unambiguous what the expected result of the investment on Group level would be.

Fundamentally, achievable synergies will answer this question, also providing a basis and reasoning for the investment for MOL. The main

possible advantages and synergies of entering the power business are:

- Reduced energy costs and increased power and steam supply security.
- Utilizing refinery location (i.e. steam market of MOL refineries for CCGT co-generation; avoiding electricity network charges; providing fuel oil storage service by MOL).
- Possibility of further optimization within the MOL supply chain and exploiting electricity market growth opportunities in CEE
- Optimization of MOL Group's existing. natural gas supply portfolio.

Placing energy business in the risk return portfolio matrix

METHODOLOGY OF RISK MANAGEMENT IN MOL GROUP

The MOL Group risk return model is built and managed by Group Risk Management. The activity is continuous from 2001, and the very early model – which mainly focused on financial and market conditions – was developed into a holistic, integrative tool. Today the ERM model includes sub-models of all Business Units, and variables and their effects are defined according to the specific characteristics of Business Units. For example: the growth of gas price burdens the operational costs of Refining and Marketing Division, but simultaneously it means a positive revenue effect for Upstream activity. Nevertheless the size/importance of the up and downside of that movement is very different for the two Business Units.

The risk drivers (model variables) are clustered into three main categories in order to cover all possible relevant issues (see 1. figure):

- Operational risks stem from possible facility breakdowns, supply disruptions usually result in lost revenue and reparation. costs. MOL production sites are already modelled for such risks, so we used existing data of Bratislava and Danube Refinery site for the risk-return calculations of Energy Business Unit.
- Financial risks come from the commodity price volatilities, exchange rate movements and credit risks.
- The most important risk drivers on long term are the strategic ones and they could be mitigated by proactivity and influenced with decisions.

The model analyses all possible scenarios on a 10 year timeframe with repeated random sampling Monte-Carlo computational algorithm, where the predicting radius of variables shall cover the same period. It means that each input data vector has a specific likelihood - impact matrix defined on a 10 year period. Filling these matrices with credible quantified data is the key element for modelling accuracy and we followed the existing best practice: expert interviews were conducted and articles used.

OUR MODELLING METHOD

Every project plan has its presumptions, since these make it easier to plan and model the future. The business model of the JV assumes that CCGT technology becomes the price setter on the market and MOL-CEZ power plants are going to utilize the most

Figure1. Risk clusters in MOL Group ERM practice Source: MOL Group ERM presentation

efficient technology. Although, this is a very likely scenario, we wanted to see the effects on the project if this criterion is not fulfilled. The other event we wanted to simulate and the consequences of which are impossible to quantify, was the possibility of an electricity price-cap. As we unfortunately do not have the fortune teller magic bulb we could not – and did not want to – identify likelihoods for these events to occur, therefore we did not include them in the simulation as variables, so we have created four scenarios and run the simulation for each. This resulted in a wider range of outcomes at the end, however by identifying the differences we could help to get prepared to handle the different situations if they occur.

1. Base case

a. Electricity markets are free, but we are not necessarily setting the price, only following the market

2. Price setter case

a. Electricity markets are free and we are among the price setters

b. CO_2 prices are likely be passed over to the customers in the prices, which increases electricity price volatility, but extinguish CO_2 price risks

3. Base case with regulation

a. As Scenario 1, but with a price cap for electricity

4. Price setter case with regulation

a. As Scenario 2, but with a price cap for electricity

b. Contradiction between price cap and price setting, but technically it means that the CO_2 price is only partly covered in electricity price if cap is reached

RISK-RETURN MATRIX AS A SUPPORTING TOOL FOR INVESTMENT DECISIONS IN MOL

The risk-return matrix is an NPV (Net Present Value) calculation based decision supporting tool which maps the possible outcome of different decisions in a complex environment. Since MOL has a very broad product and activity portfolio, a tool capable of handling complexity is of overriding importance. One of the outcomes of risk managing tools is a risk-return map where the entire MOL Group and also the different business units could be placed separately. In such NPV based models risk is regarded as the volatility of the NPV. Acquisitions and projects should be judged by their contribution to the risk-return attributes of the whole Group. The aim is to move the company closer to the efficiency frontier in order to reach a better risk/return ratio. As a rule of thumb, if the ratio improves, the project should be approved. If it worsens, but both return and risk change in the same direction, the project

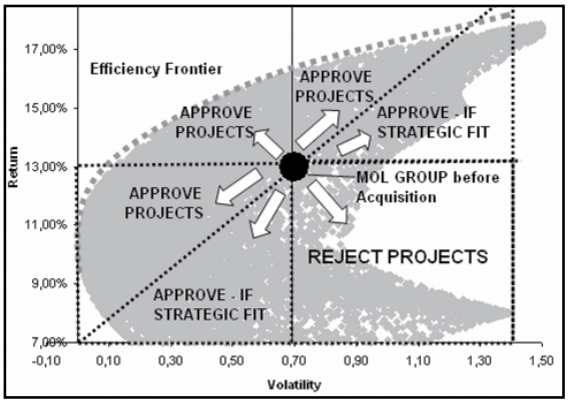


Figure 2. Group risk-return matrix
Source: MOL Group ERM presentation

may be approved if strategic initiatives justify. If return decreases while volatility increases, then the project should be rejected.

FINANCIAL RISKS

As the most important and extensive risk group, we begin with the financial risks. These risks stem from the volatilities of commodity prices

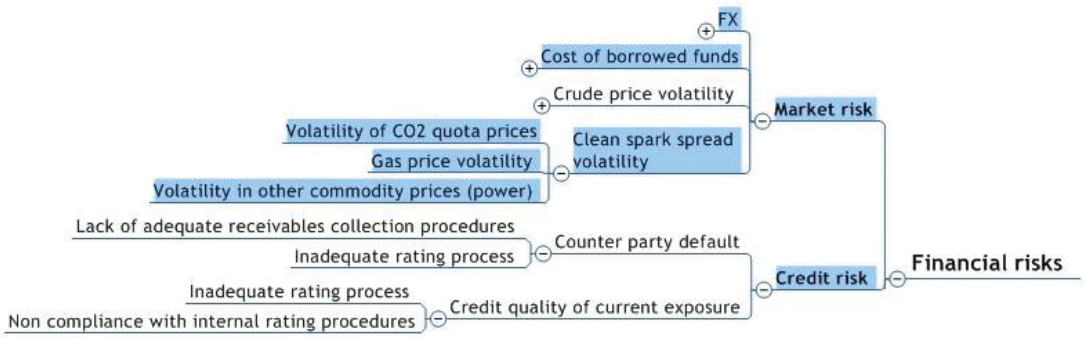


Figure 3. Financial risk tree.

we are exposed to, basically gas and electricity, furthermore exchange rate movements of currencies we use and credit risks. These risk drivers explain most of the NPV variability in MOL Group and we expect the same for the energy business (the investigated risk sources are marked on Figure 3).
For the calculations the historical volatilities were used in case of FX rates, gas and electricity prices. However CO_2 price risk belongs here, it was evaluated separately in order to emphasize its relevance in the power generation business and for the project.

Spark spread
Spark spread is the gross income of a gas-fired power plant from selling a unit of electricity, having bought the fuel required to produce this unit of electricity. All other costs (CO_2 costs, operation and maintenance, capital and other financial costs) must be covered by the spark spread. As a consequence, relative gas and electricity price evolution is important from profitability point of view, not the separate commodity price curves.

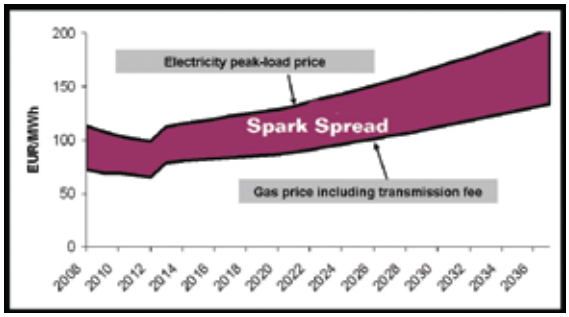


Figure 4. Spark spread based on the Business Model of Edison Project

In Scenario 1 and 3, where long-term peak power prices are determined by other technologies, natural gas and CO_2 price movements are only indirectly influencing the electricity price. In this case, the most important risk factor of the project is the spark spread, since the CCGT production costs could easily exceed the revenue of electricity sales.

In Scenario 2 and 4, when the CCGT technology will be the peak load price setter on the market in long-term, theoretically there is no spark spread risk. Despite of this, a limited spark spread risk comes from the short-term volatility of gas price and peak-load electricity prices are different.

The main assumption of MOL and CEZ about price setter technology can be true only under certain conditions. In case of too high natural gas and/or CO_2 costs, other technologies (coal, nuclear or new technologies) may become more attractive. As a result, CCGT technology could be squeezed out from the merit order.

Electricity price
Expected price development is based on the forecasted supply – demand changes, input prices for price setter technology and market structure development.

- There is a strong link between the GDP and the historical evolution of electricity demand of a given country. According to the forecasts, no significant changes are expected in this correlation.
- In Scenarios 2 and 4 MOL and CEZ assume, that gas fired electricity production will become the price setter technology. In the other two scenarios, other technologies will be the price setters so CO_2 costs are not reflected in the electricity prices.
- The main variable cost elements of this technology are natural gas and CO_2. In our model, prices for both commodities are calculated according to MOL's base line (Déjà vu) presumption.
- Market opening will slowly take place due to the hindering elements in the market structure (e.g.: interconnectivity, Power Purchase Agreements, lack of electricity exchange). Regional markets are expected to remain fragmented even in the mid-term, therefore regional differences in prices will disappear only on the long-term.

Similarly to the current volatility of electricity spot prices of EEX (European Electricity Exchange), we expect high volatility after the market is fully liberalized in Hungary and Slovakia. MOL-CEZ power plants will operate in the semi-peak load segment where the electricity price volatility is even higher according to the historical price evolution.

Gas price
Since gas as feedstock represents a considerable factor (~75% of variable costs) in the CCGTs' cost structure, needless to say that risks related to gas price are of overriding importance. Currently, gas price is calculated according to a formula based on a nine month average of different oil product prices. In order to assess the actual gas price for the JV's power plants, this price should be increased by transit fees. There are two main risks arising from this concept:

- Risks associated with the change of gas price formula
  - Development of the spot market (that is further enhanced by connecting natural gas transmission systems and the development of the LNG market) could change the Central-Eastern European gas pricing based on traditional and conservative oil product formulas. The traditional reasoning behind these formulas are the principle of substitution in power generation; however, gas fired facilities are less and less capable of turning to liquid fuels nowadays. Thus, there is no fundamental reason for using oil product formulas (not reflecting actual supply-demand balance) for the gas price. As a consequence, there is a noticeable tendency that certain oil products (for example the 0.2% gas oil widely used in gas pricing) are losing attractiveness for the market and their market pricing may come to an end.
  - The above reasoning would be further enhanced by the applied take-or-pay agreements. Assuming an 85% ToP, shippers have a 15% volume gap to arbitrate in the market.
  - On the other hand, a transit fee risk arises as well: expected transit fees could change within the final gas purchase contracts compared to the expected price range.

These factors all put pressure on existing gas contracts and question the robustness of a long term natural gas supply contract price. If one of the proxy products loses its quotation while the regional market is getting more and more liquid and linked to other regional spot markets, it could easily lead to a renegotiation of the supply in the middle of operations.

- Risks associated with commodity prices.

Based on the above, natural gas pricing in our region is currently linked to oil product prices. Therefore, gas price risk actually represents a further oil price risk for MOL.

STRATEGIC RISKS

Strategic risks are hardly quantifiable risk items which are depending on managerial decisions and external (macroeconomic and industrial) factors. In our study, we are highlighting only those strategic risk factors which are industry-

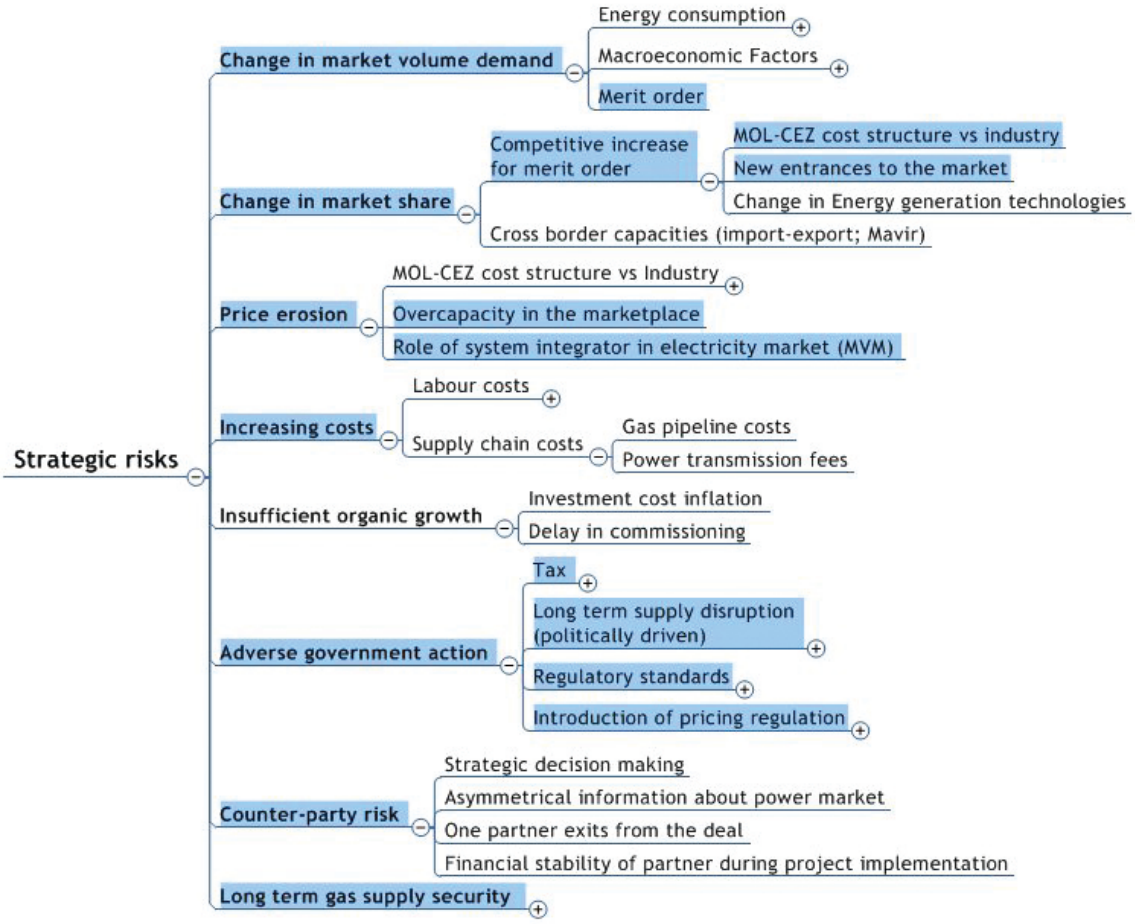


Figure 5. Strategic risk drivers

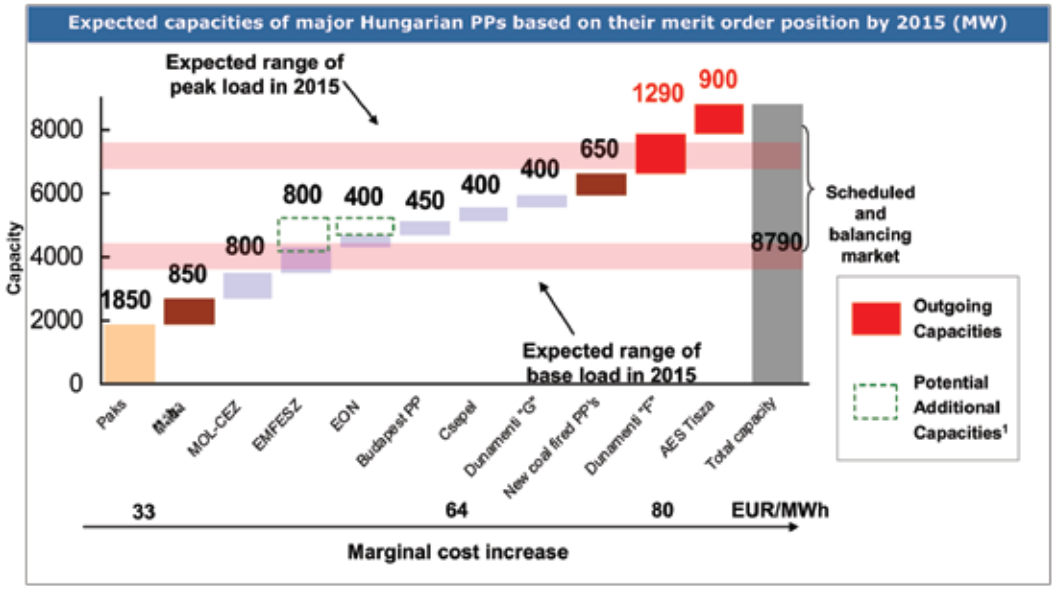


Figure 6. Expected Hungarian merit order in 2015

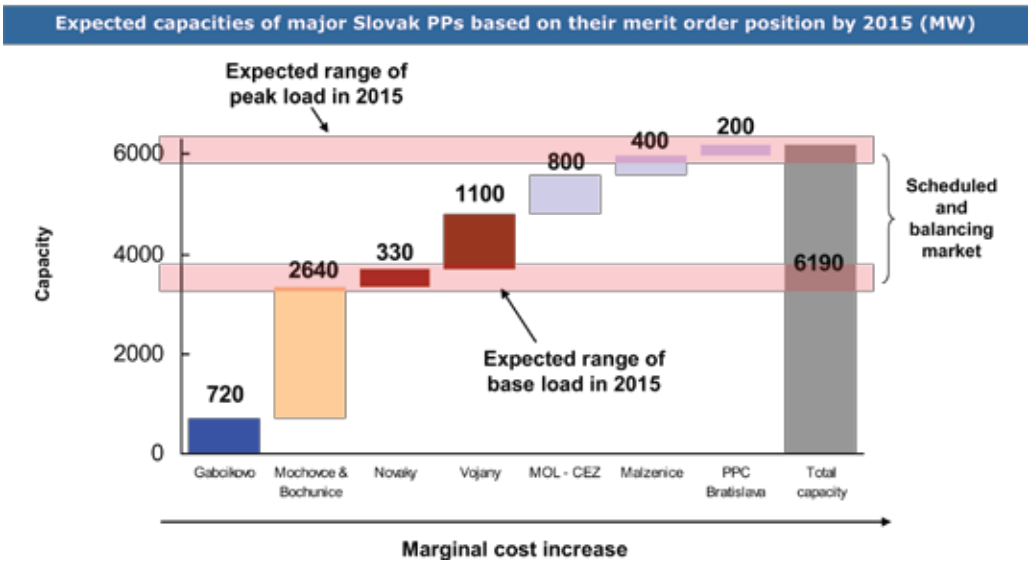


Figure 7. Expected Slovakian merit order in 2015

specific and have an overriding importance in power business. The remaining strategic risk drivers were investigated during the previous Group level risk analysis.

Merit order

Merit order represents the power supply curve of a given country: the power generation assets are ordered by increasing marginal costs per one MWh electricity generation. Due to the decommissioning of old assets and additional new capacities, we expect the following merit order in Hungary and Slovakia by 2015: According to the main assumption of MOL and CEZ, CCGT technology will serve as marginal technology satisfying the expected electricity demand in long-term (after 2020). Hence, gas fired electricity production will become the price setter technology, and so the full cost of CCGT power generation will determine the price level of electricity. According to the synergies between refineries and power generation, new MOL-CEZ power plants will operate on a lower marginal cost compared to other CCGTs.

This assumption could be threatened by the followings:

- Due to the entrance of new nuclear units, hydro power plants and new, more efficient technologies with lower marginal costs, CCGT technology could be squeezed out from the merit order in the long-term.
- Due to the production disruption of base-load facilities, technologies also with lower efficiency should contribute to

the electricity supply. As a result of this, CCGT power generation will not remain the price setter technology.
- Synergies derived from industrial locations could result in a relatively low level of marginal costs in case of other new CCGT entrants, as well.

The risk of new merit order position is represented in our model by the power generating hours of the power plant. In case MOL-CEZ power plant is shifted to the right in the merit order, the marginal cost of their electricity generation is relatively higher. This could be covered only by the higher price of electricity, which could only be reached for less production hours.

Long term gas supply disruptions

Since gas procurement is of crucial importance, supply security of natural gas has to be handled as a significant risk. Inadequate volumes of natural gas could cause serious negative impact on long term project returns. In case of the Százhalombatta plant, the issue is eased by the Hungarian law (the necessity of gas turbine oil stock within the plant) but the Bratislava plant is entirely exposed to any disruption in natural gas supply.

Investors themselves have a limited effect on supply disruption issues since most of the time these problems are lead by political considerations. Still, the optimal strategy for procurement is to use this contract to further diversify MOL Group's natural gas portfolio and put emphasis on contracting a different supplier for CCGT demands.

A long term natural gas contract with the maximum expected demand of even higher volumes should be considered in order to compensate MOL Group's portfolio for some already existing riskier gas supply contracts. Besides, the target take-or-pay level of these contracts creates a sufficient elbow-room for supplies with a higher level of supply security.

Regulatory risks

CO_2 quotas and prices

The most relevant regulatory risk hides in CO_2 regulation since CO_2 represents 25% of MOL Power Business variable costs (at 40 EUR/t). The ETS regulations are changing in 2013, but currently nothing is yet certain about it, so a huge risk stem from the emission pricing. The CO_2 forward prices are expected to be higher in Phase III, at around 40 EUR/t. The top limit of this price originates from the regulation, since the penalty for not purchasing the emission quotas is 100 EUR/t.

The total CO_2 purchases of the JV will reach 4.350 kt in 2013, so the volatility of the expected 40 EUR/t price can even destroy the profits of the company or make it extremely profitable if the ETS collapses.

In Scenario 1 and 3 CO_2 price volatility plays an important role as a risk driver on its own and has a significant effect on the profitability, hence it increases the costs.

In Scenario 2, as we set the electricity price, this CO_2 quota price will likely be covered with the electricity price increase. In this case CO_2 risk is fully covered, unless other greener technologies become more competitive at such higher price levels later on and abolish our price setter situation. This would take us back to the 1st or 3rd scenario.

The Scenario 4 has two faces: in case electricity price does not reach the cap, CO_2 prices and risks are covered in the electricity price /just as Scenario 2/. When it is above the cap the cost of CO_2 is not covered fully anymore and it increases our costs or decreases the revenue, as you take it.

Legislative background

While newcomers of Hungarian electricity market are facing an inefficient legislative background, according to our expectations, MOL's new power plants will operate in a more developed institutional/business environment after 2013. The current movements in the energy generation industry are the followings:
- The already initiated unbundling of the Hungarian Power System Operator Company (MAVIR Zrt.) from the Hungarian Power Companies Ltd. (MVM Zrt.).
- The strong commitment of the European Union to establish a fair market.

These may make a hint to everyone that the future business environment will be more transparent and equal for all players.

In addition, two other models were calculated with electricity price cap – in order to simulate a possible regulative influence on power-generation industry. For the base case, we applied a price cap at 120% of the expected power price. For the price setter scenario, since higher price levels are expected, the cap is at 130% of the currently expected price curve.

INTERPRETATION OF RESULTS

Repositioning of MOL's asset portfolio in the risk-return matrix

Based on our simulation results, the determinant influencing factors for the Power Generation business are financial and market -type variables, as expected (see Figure 8 and 9):

1. Commodity price volatilities
2. Carbon-dioxide prices
3. Exchange rates
4. Merit order

As in energy industries, the commodity price volatilities are responsible for the highest stake of NPV deviation. Surprisingly CO_2 prices are of the second highest importance, which underlines that in such CO_2 intensive industries as power generation this factor should not be underestimated. The exchange rate volatilities could be mitigated with already used financial tools on Group level. As the only strategic risk with significant importance, merit order position could be influenced with decisions, however other power generation alternatives with more favourable merit order position are inapplicable or not yet feasible.

- Scenario 1: The commodity and CO_2 effects cover 74.9% of the whole NPV deviation.
- Scenario 2: Based on our presumption that electricity price volatility increases when CO_2 prices are likely to be built in the price, the overall NPV deviation rises compared to Scenario 1. Financial risk is responsible for 76.1% of the total variation. The probable CO_2 effect is marked on the commodity price bar of Scenario 2, which shows the increased electricity price effect. Practically, this rise in the electricity price volatility could be an advantage in the peak load segment of electricity generation, since price peaks could be exploited by smart optimization and trading competence.
- Scenario 3: Due to the price cap, the electricity price volatility is decreased. In this case, overall NPV deviation is dropped, however there are only limited possibilities to exploit extra profit on peak electricity prices (lower risks - lower returns).
- Scenario 4: Compared to the Scenario 2, the applied price cap is decreasing the NPV effect of commodity prices, which results in a lower risk-lower return profile.

As Figure 9 shows, the risk-return points of the scenarios have marked out a square in

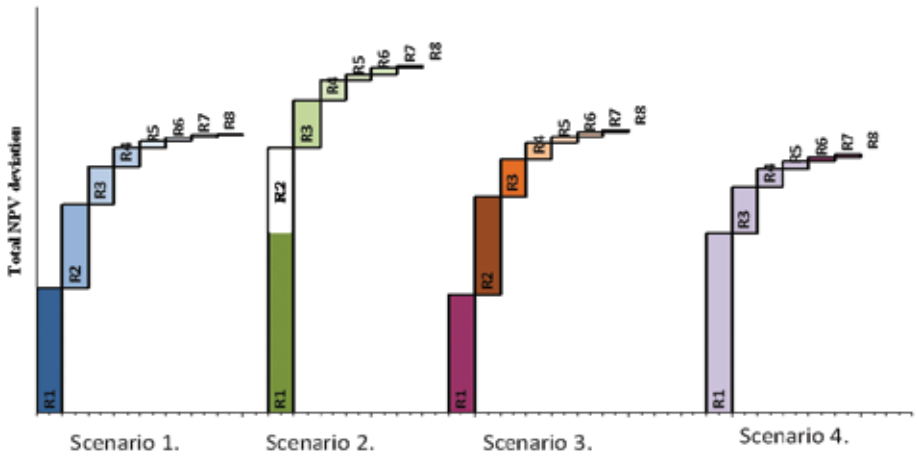


Figure 8.1. Relative importance of risk drivers

RISK DRIVERS	SCENARIO			
	1.	2.	3.	4.
R1. Commodity Price	44,7%	76,1%	41,6%	69,4%
R2. CO_2 Price Risk	30,2%	-	34,6%	17,7%
R3. FX	13,6%	14,0%	13,3%	7,1%
R4. Merit Order Position	6,7%	5,6%	5,9%	3,0%
R5. Insufficient Organic Growth	2,4%	1,8%	2,1%	1,7%
R6. Natural disasters	1,7%	1,7%	1,7%	0,9%
R7. Wholesale Market Share loss	0,7%	0,6%	0,7%	0,2%
R8. Long term gas supply disruption	0,1%	0,1%	0,1%	0,0%

Figure 8.2. Effect ratio of risk drivers

the risk-return matrix, where MOL Group would be located after the JV starts operation. This square could be split into two along the scenarios and according to the evaluation criteria shown on Figure 2.

Limitations of the model

Risk modelling can calculate likelihoods of events, which were experienced or imagined before, but has difficulties in predicting things, which have never happened or imagined. Other limitation comes from the quantification of the inputs, since experts tend to be statistically overconfident, putting higher probability to the favourable outcomes. Additionally there is no existent numerically valid and precise feedback to post-evaluate these given likelihoods on an absolute basis. Despite that, the time horizon and the huge sampling number of the model significantly reduce the distortion effects, but cannot eliminate the aforementioned biases.

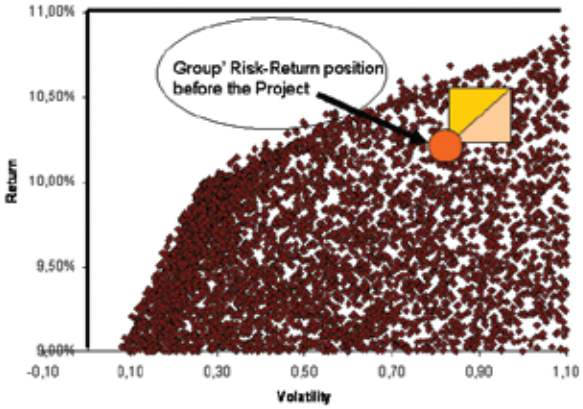


Figure 9. Effect of Energy Business on MOL Group's risk return position

Expected investor reaction on MOL's repositioning

Given the current stock market environment, it is not straightforward to forecast investor reactions on solely MOL's energy business repositioning itself. Still, there are certain fundamental reasons to believe that MOL's new profile could be rewarding in the long term.

- The synergies (described under 1.2.3) secure a solid basis for a successful investment.
- From an analyst point of view, electricity generation is traded on a much higher EV/EBITDA multiple than oil related activities. As a result, the MOL-CEZ JV and the portfolio extension of MOL assets can visibly increase shareholder value.

Possible mitigation methods of main risk drivers

ELECTRICITY PRICE RISK

The high volatility of electricity spot prices could be mitigated/exploited successfully by choosing a flexible technology and establishing trading competences. Therefore MOL could realize extra profit by producing power on maximum capacity in case of high electricity prices. Consequently, the exposure of core businesses to volatile electricity prices is balanced on Group-level due to the new portfolio element.

GAS PRICE RISK

The institutional financing of the project requires a financially stable business model. Since gas procurement is one of the main pillars of success in this case, the already described level of uncertainty around gas pricing must be mitigated through

- A long term natural gas contract in order to eliminate risks associated with changing price formula. The disappearing oil product proxies in a developing market still remain an important question, but this risk also could be handled in the long term contract.
- Hedging in order to eliminate commodity risk. The project increases the commodity (oil price) exposure of the entire MOL Group. More specifically, the project turns a part of MOL Group's commodity exposure into electricity price exposure.

MERIT ORDER RISK

Choosing the location and the power generation technology are among the key elements of influencing the merit order position. The gas firing CCGTs have the lowest emission among fossils and the power plant construction time is relatively short. Compared to other technologies, the low level of CAPEX and high production flexibility of the technology increases the attractiveness of this alternative. Furthermore, this gas-firing power generation technology fits very well to the existing core businesses of MOL and we expect further competitive advantage due to the synergies and substantial heat and electricity demand derived from refinery site (described under 1.2.3).

REGULATION

Regulatory risks, especially in such a changing and politically influenced sector, are hard to mitigate. Strong lobbying and good connections are a must, but still nothing is guaranteed.

Conclusion

The main aim of such risk-return based project evaluation is not exactly quantifying the possible risk drivers and their effect, but identifying the most important and influencing ones. Accordingly, leaders and the management can and should pay more attention to these risk drivers and their mitigation possibilities. As we have shown, the risks could be mitigated, however, due to high exposure to the markets on both revenue and cost sides this has limited capabilities.
Our key finding is that higher electricity price volatilities – although it increases the overall NPV variability significantly – could be beneficial for the joint venture if proper trading competences are established and price peaks are capitalised.

- If Scenario 1, 3 or 4 occurs, both the Group's return and risk will increase.
- Since the incremental risk exceeds. the additional return, the project can be accepted on risk/return basis if it has further non-quantified strategic benefits (see Figure 2).

- If Scenario 2 occurs, both the Group's return and risk will likely increase
- Since the incremental return exceeds the additional risk, the project can be accepted on risk/return basis (see Figure 2).

Further benefits could stem from the exploited synergies, just as more efficient steam generation, HFO burning in Slovnaft, light fuel oil storage service and grid fee savings. The complementary core competences of MOL and CEZ on both ends of the value chain – gas and electricity – help the joint venture gain a competitive advantage on the electricity market. And, after all, placing energy business into MOL Group's portfolio is a proper way for further diversification, hence there is no strong correlation between crack spreads and spark spread.

We would like to thank our experts' contribution in the investigated fields we have contacted, especially the support we received from Group Risk Management!

References

[1.] *"Net Increases Need for Risk Management"*. Griffith, Gary. 2000., Dallas Business Journal. September 22, 2000., old.: September 22.
[2.] "Crabb, Peter R. Financial Risk Management: The Big and the Small." www.huebnergeneva.org. [Online] 2003.
.

Revised by: Tibor Papp

Study on enhanced recovery in hydrocarbon fields in Hungary

László Paczuk (62)
Dipl. Chemical Engineer, dipl. Petroleum Engineer
US – Integrated Field Application – Field Engineering
Head of Field Engineering
e-mail: lpaczuk@mol.hu

Abstract

The Upstream Management decided at the beginning of 2007 to review in details the opportunities for increasing recovery from the 130 domestic hydrocarbon fields under the company's operation.
In the first phase of the revision and based on reservoir engineering studies, the experts identified 36 fields as potentially applicable for further and more detailed studies.
In the second phase the production concepts were elaborated for the relevant fields, the resources required for the developments were identified, and the OPEX estimate was prepared.
Economic feasibility studies were prepared based on the available information and for 27 fields or field-groups the indicators showed certain conditions that could be regarded as attractive enough for launching the preparations for the developments.
The field development proposals were categorised into four groups subject to the technical content and time scale of the projects and the EB approved the proposals.
Based on the preliminary studies MOL will be able to produce 3,5 Moet additional hydrocarbon during the forthcoming years from these domestic fields.
In the meantime, one out of the 27 projects has been implemented, and 9 other projects are in the preparatory phase, whereas the remaining projects will require further and more detailed studies.
Three fields were identified as potentially applicable for underground gas storage with significant capacity. Specific analysis and studies are in progress in the said fields.

Összefoglalás

A KTD vezetése 2007. év elején elhatározta, hogy részletesen áttekinti a kezelésében lévő hazai 130 szénhidrogén mező kihozatalának növelési lehetőségeit.
A munka első fázisában a rezervoármérnöki vizsgálatok alapján a szakemberek 36 mező esetében tettek javaslatot további részletes vizsgálatra.
A második fázisban sor került az érintett mezők termelési koncepcióinak kialakítására, a fejlesztéshez szükséges források nagyságának meghatározására, valamint a tervezhető üzemi költségek megállapítására. A rendelkezésre álló információk birtokában elkészített gazdaságossági vizsgálatok 27 mezőnél, illetve mezőcsoportnál mutattak olyan kondíciókat, ami alapján érdemes elindítani a fejlesztések előkészítését.
A szükséges intézkedések műszaki és időbeli tartamától függően a négy csoportba sorolt mezőfejlesztési javaslatokat az EB elfogadta.
Az előzetes vizsgálatok alapján 3,5 Moet szénhidrogén többlet termelhető ki a következő években a hazai mezőkből.
A 27 projektből egy időközben megvalósult mellett 9 projekt az előkészítés-előterjesztés stádiumában van, míg a többi esetében további részletes vizsgálatokra van szükség.
Három mező alkalmassá tehető jelentős kapacitással rendelkező földalatti gáztároló kialakítására. Ezek esetében az ilyen irányú vizsgálatok is napirenden vannak.

Hydrocarbon production in industrial scale has been pursued in Hungary since 1937. During this past 70 years the exploitation of our major fields with sizeable reserves have gradually got in their final stage, accompanied with permanently declining production levels. Hungary has to-date produced 93.000 tht crude oil and 203 billion m^3 (bcm) natural gas. In case of crude oil this represents an average 42% recovery ratio, and the typical values for the recovery factor within that are in the range of 20-50 %. In case of natural gas the average recovery factor is 69 %, but there are domestic gas fields, where the current recovery factor is higher than 90 %. [1]

Hungarian hydrocarbon reservoirs have an extremely divers structure and operation mechanism during field exploitations. Quality of crude oil and natural gas discovered in the reservoir rock formations shows a very wide range of variety. All these conditions have enabled the representatives of every discipline participating in exploration and field development to acquire very extensive and deep knowledge during these decades.

Figure 1. presents the recovery methods widely applied in crude oil fields and the related production techniques in the international practice. [2]

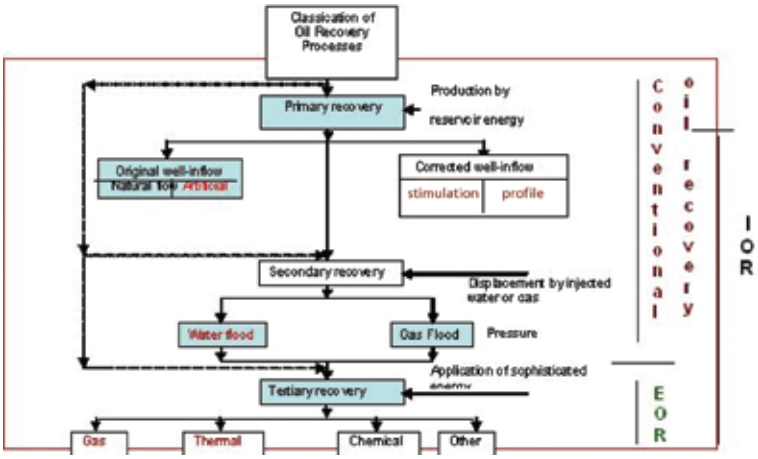


Figure 1. Classification of Oil Recovery Methods

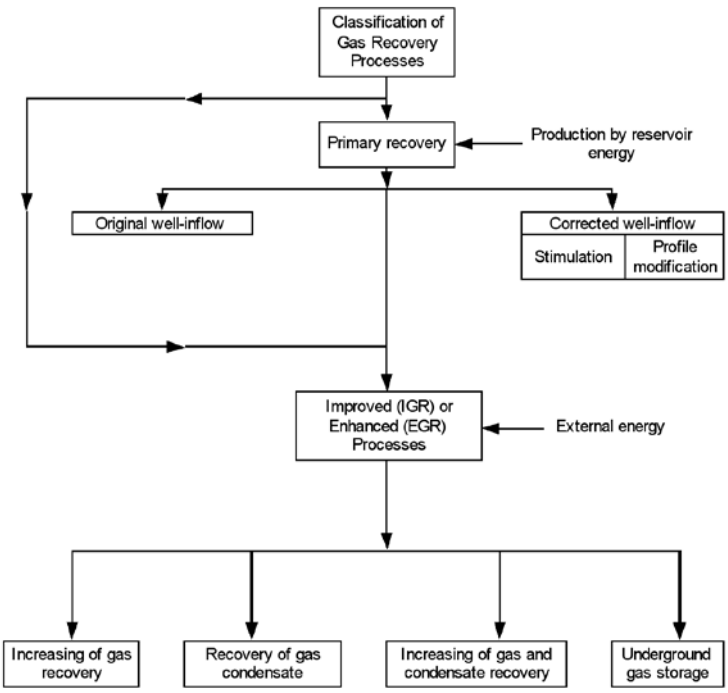


Figure 2. Classification of Gas Recovery Processes

As Figure 1. can clearly demonstrate, most of the methods presented have already been applied during exploitation in the domestic oil fields.

While the number of primary recovery methods has also significantly increased during the past three-four decades (just think about the rapidly growing application of horizontal wells, or major advance in the well stimulation technology), the secondary crude oil recovery methods (i.e. water and gas injection) were applied in the early phase of domestic production (Budafapuszta, Lovászi).

Pilot study and large scale industrial application of tertiary recovery methods started at the end of the 60ies and beginning of the 70ies and it is also related to the fact that primary-secondary recovery operations in the larger fields with several decades of production history reached by this date the final stage, accompanied with intensive depletion in production.

Figure 2. presents the potential recovery methods of natural gas reservoirs, similarly to those in crude oil fields.

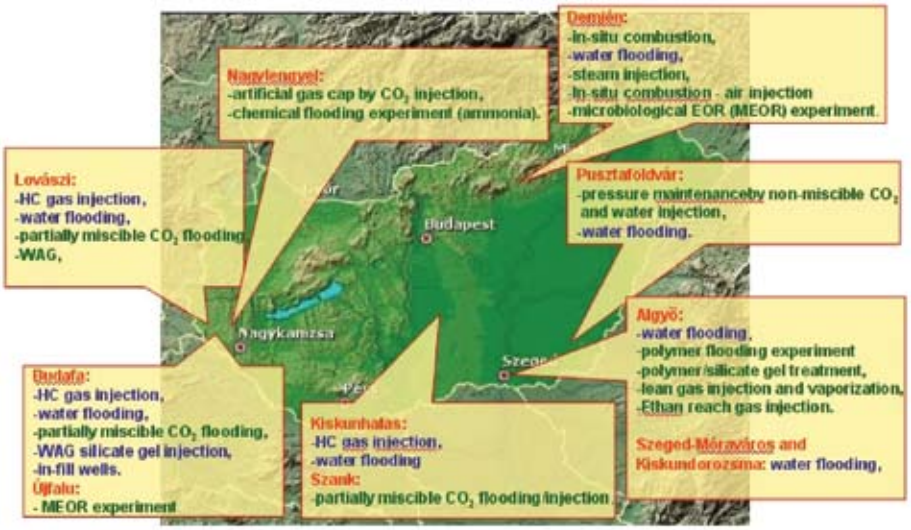


Figure 3. Secondary and tertiary recovery methods applied in domestic CH fields

Primary methods were also applied in the domestic natural gas production practice using the available and permanently advancing technology, however the enhanced recovery methods, except one or two such methods with minor significance, they have not yet been recognised. The exception is, of course, the underground gas storage.

Figure 3. presents the multi-colour application of the secondary and tertiary methods during the past decades. [3]

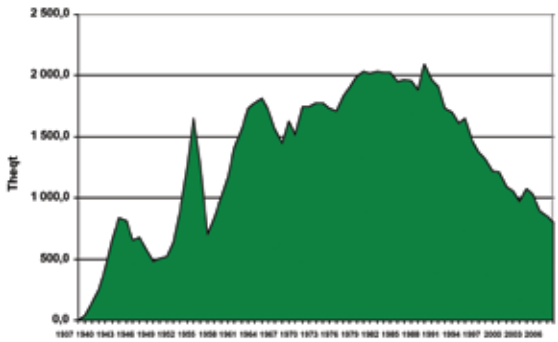


Figure 4. Crude oil production by MOL Plc and legal predecessors – from the beginning to-date

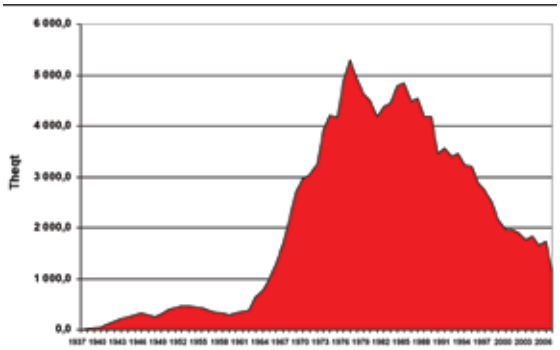


Figure 5. Natural gas production by MOL Plc and legal predecessors – from the beginning to-date

At the beginning the article pointed out that most of the Hungarian hydrocarbon reservoirs are in depletion phase. Figures 4 and 5 clearly demonstrate that the depletion trend started in the second half of the 80ies in both crude oil production and natural gas production in most domestic fields, accompanied with intensively declining production.

Permanently declining hydrocarbon production in Hungary and sky-rocketing international crude oil prices were a kind of incentive for the Exploration & Production Management to thoroughly study and revise the current exploitation status of the 130 fields operated by MOL Plc, assuming that there might be certain fields or sections of fields, where application of recovery methods other than presently used may result in additional recovery under adequate economic conditions.

This field exploitation revision was implemented in January-March 2007. We also involved external experts into the analysis, who used to work in MOL Plc. or its predecessors for quite some time, so they were fully aware of the specifics of the fields, and also held appropriate international experience, competencies and skills.

The revision was highly professional and deep, based on operative reservoir engineering and technology methods, conventional approaches, analogues and experiences in recovery operations.
In the first phase of the work on the basis of reservoir engineering analysis and considerations a prediction of the recoverable crude oil and natural gas volumes were generated, separated for crude oil and natural gas reser-

voirs, including the relevant risk assessment. The work also resulted in a „by-product", namely a list of structures potentially applicable for underground gas storage. As a result of the efforts we managed to identify 24 project elements for crude oil production and 12 elements for natural gas production, so altogether we found 36 project elements for subsequent analysis. We also identified, as part of the study, 10 potential structures for natural gas storage, but this will require further specific studies. [4]

It will be worthwhile to look through the diversity of the recovery methods and production technology solutions, as successful application of such methods may enable us to acquire chances for additional recovery from the crude oil reservoirs.

Primary recovery methods:
- in-fill wells
- drilling of horizontal wells
- high rate production
- gas lift method
- perforation modification
- well stimulation.

Secondary recovery methods:
- water injection
- to create secondary gas cap (CO_2).

Tertiary recovery methods – referred in the international literature as EOR (Enhanced Oil Recovery) methods:
- alternative injection of CO_2 and water
- brine profile control combined with CO_2 injection
- CO_2 flooding.

In case of natural gas reservoirs we should also apply a variety of methods for acquiring additional recovery, and we can deem, among them, as primary methods: in-fill wells, drilling of horizontal wells, and reducing the gathering pressure. The following methods are deemed as enhanced gas recovery (EGR): injection of CO_2 gas into the reservoir with the purpose to displace hydrocarbon gases that remain in the reservoir and not recoverable using the existing solutions. Injection of dry hydrocarbon gases into the reservoir also belongs into this group of methods, where the aim is that the injected gas can push and displace the fluid (condensate) segregated in the reservoir towards the bore hole perforations and improve the flowing conditions in the reservoir.
During the second phase of the revision process, between April and November 2007, we conducted a detailed in-depth study of 36 production fields, prepared specific proposals regarding the underground and surface technologies required for securing the conditions for such additional production, as well as we identified the financial resources for the implementation. We involved nearly 50 experts from several professional units (Production, Operative Reservoir Management, Mining Survey, Well and Surface Facilities Design, Corporate Services-Project Implementation, Project Controlling), and external specialists into the process. In certain fields we had to combine or merge the surveys due to direct and close inter-connections in the technology, thus we finally identified 33 objects in the list.

Based on the CAPEX and OPEX data, as well as recovery and production data of the relevant fields we prepared the preliminary economic feasibility study for the project concepts. These calculations proved that we have realistic chance for developing 27 financially recoverable potential projects, with appropriate preparations.

The professional content and time demand of such preparations vary. There are fields, where we only need to prepare more detailed technical solutions and plans, which requires not more than 6-9 months, but in case of other fields we will have to make more complex preparations (3D measurements, laboratory tests, reservoir engineering studies, etc.). In such fields we may need 3-5 years prior to submitting the specific project proposal.

There were three fields, Pusztaföldvár-Földvár-Felső A-3, Üllés and Szank-Miocene, where we identified the opportunity for implementing underground gas storage offering significant capacity. In these fields results of comparison of economic analysis and market demands will decide the future direction for the project development.

There were three other fields, where further studies will be needed for clarifying the potentials as the rate of return was too low, and the scope of the potentially required technical solutions could not be properly identified.

The EB approved the relevant Upstream proposal on its meeting dd. December 4, 2007 and agreed with the medium term implementation. Table no. 1 presents the various project groups and the key indicators for the complex revision process.

Field group	Recoverable reserve, Theqt
Projects that can be promptly lauched (11)	766,4
Fields applicable as underground gas storage (3)	707,5
Fields that need laboratory test, reservoir engineering studies (10)	1069,0
Fields that need further studies (3)	967,2
Total (27)	3510,1

Table 1.

Figure 6 presents the geographic locations of the 27 proposed projects, and Figure 7 describes the share of each production area from the reserves that are recoverable through the projects.
The figures present the dominance of the West-Hungary region and Algyő.

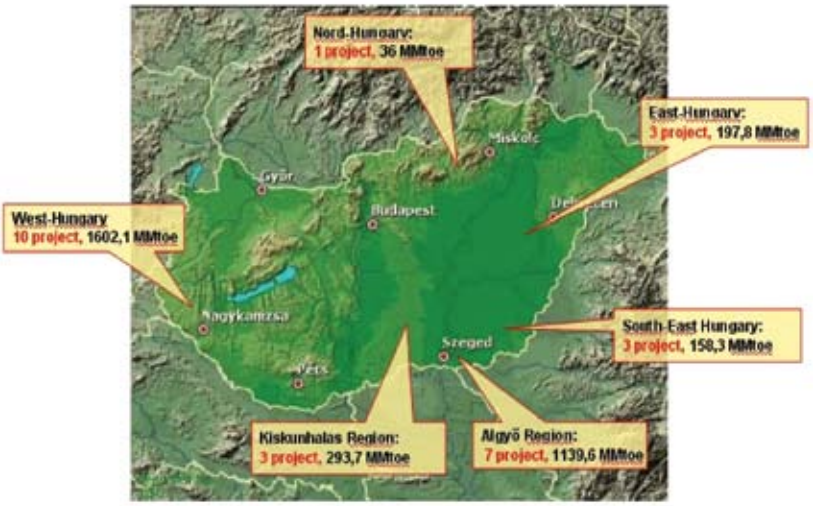


Figure 6. Geographic locations of the projects proposed for implementation

Figure 7. Share of domestic hydrocarbon production regions from recoverable reserves

It is also worthwhile to study Figure 8, which presents the specific share of each recovery method from the total reserve gained from the projects. It can be clearly seen that these volumes keep on declining from the primary towards the tertiary methods.

The study offered the following two key conclusions:

1./ MOL Plc. proved that its experts have competencies in applying modern recovery methods. This will be a good reference for future cooperation in international and domestic operations with partner companies.

2./ Study of domestic fields also enabled us to answer the question: which of our depleting hydrocarbon reservoirs can be converted and used in the future as storage for hydrocarbons or other gas (e.g. CO_2).

Following the EB decision the project preparations for the 27 fields have been continued.

Among the 11 projects that can be launched, one that needed a simple workover operation has already been implemented, one project proposal is under preparation, and in case of the remaining 9 projects we are preparing a specific project preparation proposal, which can ensure that planning and various licensing processes can start as early as possible. In these projects we primarily assume the application of primary recovery methods, but there are some where water injection and an artificial gas cap will be required.

In case of the remaining projects, that will require the application of secondary and tertiary recovery methods, laboratory tests and field measurements will also be needed for supporting the preparation of the relevant reservoir engineering studies in such fields.

The 2008 R+D plan of Exploration & Production contained such laboratory tests, covering the fields involved into secondary and

Figure 8. Share of each recovery method from total reserves gained from the projects

tertiary methods. These plans also include the equipments required for the tests and measurements, as part of the 2008 Project Ensuring Continuous Operation (PECO) fund.

In the Transdanubian and Algyő regions we also calculated with the application of CO_2 gas in some fields. Secondary recovery methods do not necessarily require the use of CO_2, but our analysis so far conducted confirmed that this medium offers the least-cost solution for such fields for creating the required artificial gas cap.

In these projects the highest possible yield requires the identifying of the potential sources of CO_2 gas and also the optimisation of the time sequence in the implementation phase.

In the Transdanubian region the basic source of CO_2 is the gas left inside the Nagylengyel Blocks (used for EOR operations) and this gas should be removed due to safety reasons anyway, as well as the gas with high CO_2 content in Budafa-Deep. As a result of adequate combination of these reserves we can implement the planned exploitation; moreover, we may have further opportunities in case of Budafa-Deep.

The primary source of CO_2 gas in Algyő region at present is the natural gas sweetening unit at Szank. However, the production of fields presently supplying the gas for the sweetening unit will show a significant depletion curve after 2010, so we will need to include other fields with CO_2 reserve. Regarding this the relevant investigations and studies have already launched.

Another opportunity has also emerged, namely, if there is demand for a major quantity of CO_2 we can also use some CO_2 gas from a CCS (Carbon Capture and Storage) project.

Analysis of the source side and reservoir engineering studies for the relevant fields will give us proper and final data feedback for the implementation timetable for the projects planned in the two regions.

Regarding the three fields that can be potentially used for underground gas storage, storage studies are in full progress in order that MOL Plc. can successfully participate also in the emerging competition for the gas storage business.

Taking all these into consideration we can state that the analysis and studies launched at the beginning of 2007 were successful, and it identified economically feasible opportunities for increasing reserves recoverable from the domestic hydrocarbon fields. As a result of preparation and implementation of these secondary and tertiary methods MOL experts will also acquire new competencies, skills and knowledge, which can be successfully and profitably applied in MOL international operations.

References

[1.] Attila, Holoda; György, Palásthy: "Applied Techniques in Marginal and Mature Fields in the Pannonian Basin, Hungary: Case Study" 2008 SPE Indian Oil & Gas Technical Conference and Exhibition, Mumbai, India, 4-6 March, 2008.

[2.] József, Pápay: "Development of Petroleum Reservoirs", (Theory and Practice), 2003, 158 pp, ISBN: 963 05 7927

[3.] Dubravko, Novosel; Péter, Kubus: "EOR Project experience in INA and MOL, past and present" 4th International Oil and Gas Conference Zadar, 3-7 October, 2007

[4.] Study on domestic opportunities for increasing crude oil and natural gas reserves by MOL Plc. Internal Study Budapest, 30 April, 2007.

Revised by: Péter Kubus

Implementation of Operator Training System in the MOL Danube Refinery

Ákos Fürcht, Dr. (35)
Chemical engineer PhD
MOL Plc. R&M Division Refining
Plant manager
E-mail: afurcht@mol.hu

Tibor Kovács (34)
Chemical engineer
Honeywell Kft.
OTS engineer

István Rabi (48)
Chemical engineer
MOL Plc. R&M Division DS Development
Process Engineering Department manager
E-mail: irabi@mol.hu

Abstract

The Operator Training System (OTS) is a useful tool developed to train operators in a virtual environment under offline conditions. With the help of the OTS, operators are able to learn how to operate existing/future plants to maximise the asset value via solving operational problems in the shortest possible time.
The high-complexity and the advanced technical state of the Danube Refinery has required a more effective training system for the shift-leaders/operators. With the completion of the OTS, the current educational system will elevate to a higher level.
The operators are required to have advanced skills and knowledge of the system and to learn the actions to be taken in response to any possible situations including emergencies and malfunctions. Obtaining such knowledge on a real plant is very risky and should be very carefully planned. Training without jeopardizing the plant thus requires years of experience. This increases the necessity of operator training with a simulator that has identical outlook and performance with the real control system. To reach these goals MOL launched its OTS project in 2005.

Összefoglalás

Az Operátor Tréning Szimulátor (OTS) használatával az operátorok egy virtuális felület felhasználásával készülhetnek fel leendő munkájukra. Az operátoroknak így lehetőségük nyílik arra, hogy megtanulják, hogyan üzemeltethetnek már meglévő illetve jövőben épülő üzemeket maximális üzemi hatékonyság mellett, illetve az esetlegesen felmerülő üzemeltetési problémákat hogyan oldhatják meg a lehető legrövidebb időn belül.
A Dunai Finomító összetettsége, és az alkalmazott technológiák bonyolultsága megköveteli a vezérlők, műszakvezetők hatékonyabb képzésének lehetőségét. Az OTS használata nagyban hozzájárul a jelenlegi képzési rendszer hatékonyságának emeléséhez.
Az operátoroknak rendelkezniük kell megfelelő üzemismerettel és meg kell tanulniuk, hogyan reagáljanak különböző üzemi körülmények változására, beleértve a működési hibákat és az esetleges vészhelyzeteket is. Mindezek gyakorlása egy működő üzemen nehezen megvalósítható, veszélyes feladat. Az üzemmenet veszélyeztetése nélküli továbbképzés sok éves tapasztalatot igényel.
Ez a tény tovább növeli annak szükségességét, hogy az operátorok képzésében egy szimulált rendszert használjanak, amelynek felhasználói felülete, illetve viselkedése tökéletesen megegyezik a valós üzemirányítási rendszerrel. A fenti célok elérése érdekében indította a MOL 2005-ben az OTS-projektet.

1. Introduction

The first Operator Training System was developed and launched in MOL's Danube Refinery at Százhalombatta in the Delayed

Coker Unit (DCU), paralelly to unit start-up in 2001. The advanced technical state of the Danube Refinery and the further developments generated extended demand for skilled and well-educated employees. In order to meet this demand, the Refinery management decided to upgrade the existing OTS in the Delayed Coker unit and to implement new systems for the most important units. After the project definition period the OTS Project started at the Danube Refinery in 2005. Based on the results further steps are planned: more Training Systems will be implemented in the 2007-2010 timeframe.

2. Operator Training System

The operator training system is developed to train operators in offline environment where they are able to learn to operate the system and the process using a simulated environment. The OTS is a computerized system, which is suitable for simulation of the refinery unit's operation in different circumstances: normal operation, start up and shut down of the unit or any possible malfunctions.

The training system is a mean to train new operators and provide refreshing training for existing operators.

- The OTS would help operators learn and drill emergency actions thus it would enhance operation safety.
- The OTS would provide continuous improvement in professional skills, which in return would increase cost effectiveness of unit operation.
  - In case of existing units the OTS would provide shorter and more effective start-ups.
  - In case of new units the OTS would provide better pre commissioning checks. The planned system would also prevent knowledge losses caused by extensive use of advanced process control (APC).

3. Project definition for decision-making

In the Project definition phase we made Operator Training System reference visits at different Refineries, collected information about the circumstances of the OTS operations and estimated the necessary human resources to operate and maintain the System.

What are the advantages using an Operator Training System? The new employees can be educated easily using a simulated model before they start to work responsibly in real situation. The skilled operators can be trained and can practice regularly to maintain their knowledge; furthermore, on the simulator they can practice standard procedures (cold start-up or shut-down) during a planned shut-down period preparing for the following start-up. It is an important aspect that they can be preconditioned for a new situation, for example after a revamp or before a test-run; so they might handle more professionally the new process conditions. The OTS allows trying different operation modes without any risk, after practicing it can be implemented safely in the real operation.

For highly similar unit performance and more effective training of the operators custom type model was chosen for the Operator Training Systems instead of generic model. The experience of the reference site visits showed that the users in different refineries emphasize using custom model. The custom model is developed for representing the real existing process and control system using a dynamic simulation model. The trainee can operate the OTS like the real system, can handle different scenarios: normal operation, start up and shut down, furnace start-up or any possible malfunctions.

The user interface and the operator station are identical to the real DCS operator stations, which helps the trainees to be accommodated to the real circumstances. In this case the trainee may feel like in a real control room working on a real DCS station. Easier upgrade of the new DCS pictures and easier maintenance of the system are some of the advantages of the DCS operator station (modification of the control system can be uploaded easily to the OTS DCS station). Its alternative, the emulated user interface allows the trainee to practice different situations as well but the circumstances are different from the real workplace.

At the Danube Refinery 3-4 units are controlled from a common control room, which is located close to the units. Considering the infrastructure of the Danube Refinery the training rooms are evolved in the control rooms instead of one centralised training centre. This structure allows using easily the OTS for the shift leaders and operators. Each Simulator System is located in the control rooms; thus beside the organized training hours operators

are able to practise alone during work hours in their spare time as well.

After preconditioning, the final decision was implementation of custom model on DCS operator station in separated training room located in the control building.

4. Project implementation phase

The 1st phase of the project started in the 2nd half 2005. Besides the DC Unit considering the importance and complexity of the Refinery, the FCC and the CCR units were chosen for implementing new Systems. After the selection of the OTS supplier the available time for the 1st phase implementation was 10 months till end of 2006. Honeywell was awarded after the selection procedure to develop the Operator Training Systems for the dedicated units. The 1st phase of the project included the existing OTS upgrade at Delayed Coker Unit and extending it with the gas processing line. The original model contained only the Furnace and Coker Drum sections. New OTS modules were implemented in the FCC and the CCR units. The FCC unit has Honeywell Distributed Control System so the Supplier Honeywell can fit easier the simulated environment to the DCS Operator station of the Training System. Regarding the CCR where Yokogawa DCS is implemented, the OTS supplier has an opportunity to use the Yokogawa's interface software to fit its simulated environment to the Yokogawa operator stations.

rooms because of the control system similarity. No any additional hardware elements are needed to this phase. The Steam Reformer OTS will be set-up in the same control room with the CCR (Yokogawa), using the implemented OTS hardware, while the FCC Gasoline Hydrotreater and the ETBE – HF Alkylation units are controlled from the FCC control room so these models will use the FCC OTS hardware (Honeywell).

In later phases of the project more units are going to have OTS. This development should be harmonized with the forecasted revamps and the short-term activities.

5. Maintain and operate the OTS at Danube Refinery

The new Operator Training System in FCC and CCR are launched in the beginning of 2007. We have started to collect experience of the operation of the OTS models. Several minor modifications were necessary to fine-tune the model in order to match the real unit process data.

Currently the Operator Training Systems at MOL are controlled and operated by the Technology Department of the Refinery. Maintaining, tuning, and minor modification of the process model shall be done by DS Development (DSD) and Honeywell. Furthermore Honeywell will provide an update service called Benefits Guardianship Program,

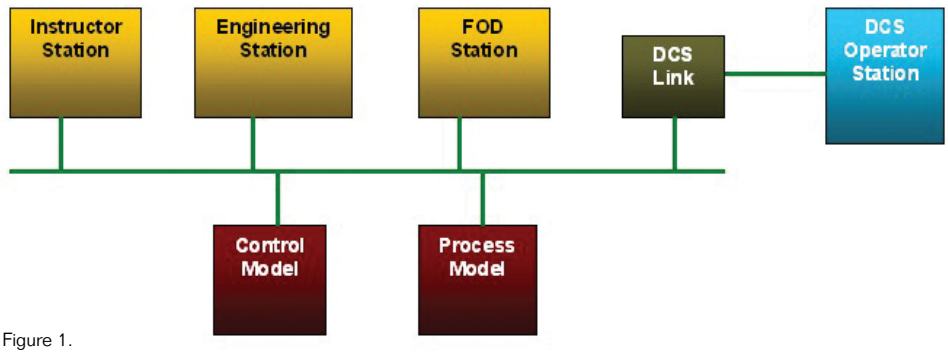


Figure 1.

A simplified general scheme of the custom model structure is shown below on Figure 1. Continuing the 1st phase, in the 2nd project phase the FCC Gasoline Hydrotreater, the Steam Reformer and the ETBE – HF Alkylation units are going to have Operator Training Systems. The new models will be installed on the existing hardware in the same training

which is available to offer additional support. The objective of this support is a long-term strategy that keeps the simulation system problem free, models synchronised with the real plant and running on the latest supported software.

Task		Responsible organization	Human resource
System control, support,	DCS model	Refinery Technology	1 person
Maintain	Simulation model	DSD and HWL	1 person
Examination, trainings		Refinery	1 person/unit

Table 1.

Table 1. shows the staff of the OTS at MOL.

Some shift leaders are educated as trainers to operate the training system in order to assure the possibility of practicing for the operators beside the planned training hours. We have elaborated a matrix, which contains the frequency of the different activities. This matrix was the basis for the training plan. It gives priorities, as more frequent activities and manoeuvres that should be trained regularly. For example: all shift leaders and operators have to be trained once a year (beside other training exercises) going through a cold start-up and shut-down procedure. They should start up the plant in different time periods similar to the real activities, when the duration of the start-up takes more time than a shift. In this case all operators have opportunity to gain experience about the different periods, different activities of the start-up. On the other hand tuning the parameters to reach the satisfying product quality is one of the most important tasks. In order to take that less time we should implement this activity in the training plan.

We laid emphasis on the safe unit operation collecting the most hazardous unit specific activities (for example furnace ignition), which have to be trained on the Operator Training System.

6. Special features, experiences

6.1. MALFUNCTIONS

The OTS model includes two types of malfunctions. The generic malfunctions are those, which are typical problems to a processing unit and are integrated part of the system, like transmitter failure, DCS operated control valve failure, etc. On the other hand, the custom malfunctions are those, which are specific problems to a given processing unit, like temperature runaway, PRS failure in FCC, excessive afterburn, etc.

Of course, both malfunction types are to be avoided, as much as possible, but in case of occurrence, the operator shall be ready to solve the situation. Some failures may cause big trouble, but in turn they are easily recognisable; the cause of the problem in these cases will be obvious after a quick check in the DCS.

The common feature of the minor, less problematic failures is that they are not obvious for the first sight, because they are not causing direct problems. Usually, the effect is indirect and may be noticed only after a couple of minutes. Typical examples are measurement or transmitter failures in this category.

During extensive discussions with unit personnel, we tried to collect and discuss every tricky failure or near miss failure in the past in order to include them in the workbook (the workbook is designed to give elaborated case studies to the trainer) and implement into the OTS.

6.2. MODEL REVIEW

The model review is a critical step in the implementation. During this period several minor inconsistencies may be recognised, thus to provide the human resource from unit operation side is inevitable. Based on our experience the on-site model review may dramatically increase the efficiency of the efforts.

During the review some missing items may be identified, which influences the model accuracy. For instance, running a predefined malfunction or operation mode a missing check valve may overpressure the upstream equipment. The cause shall be determined and cured in order to have properly working model. The very strict replication of the correct P&ID in the model during the model-building period is one of the key factors for the complete system on-time delivery. Every check valve, every hand operated valve, including control valve bypass, pump isolation valves or any valves used to control any process parameters in the field (e.g. pressure relief valve bypass for vessel depressurisation during fill-up) shall be carefully included in the custom model.

6.3. STAFF

We found it a very useful to involve the operators in the model review. When operators hear about OTS their natural response is a kind of antipathy. They may feel that the unit management does not trust them enough. They may feel that the management wants to examine their knowledge in order to surcharge them. In reality, the objective is to have really well trained and responsible operators who are working on equipments worth of millions of euros or US dollars. The involvement of the operators from the very beginning of the installation, like the model review, may help to convince them that the OTS is not against but for them. If they know that their own experience is also built in the system, they will feel the system as theirs and will use it as a "teaching master".

It is also recommended for field operators to be able to check on the DCS the process parameters of their area. They are not allowed to change anything in the real system, however, in order to understand the process better and to analyse the effect of their field actions (ordered by the operator) the OTS is a very good tool for practicing.

Key point for the field operators is to get familiarised with the DCS operations in order to become operators.

6.4. FEATURES

The OTS can be used not only for problem oriented exercises, like malfunctions, but also for target oriented exercises, like product quality change or operation mode change. It is possible to show on the screen the actual product quality parameters (cut point, sulphur content, reaction conversion parameters, etc.), which in real life are analysed only once or twice a day. By means of the OTS the trainee receives an instant feedback of quality change as a result of his manoeuvres in process parameters.

We found it useful to implement a few parameters in the simulator, which can not be found in the real DCS. The instructor can change these parameters during the training at any time. For example the instructor can modify manually the diolefin or sulphur content of a stream, which is fed into a hydrotreater, and the trainee should recognise the effect on the reactor parameters and should react to this composition change.

We emphasized using kinetic reactor models in the simulators instead of regression models to get better reflection of the reactor behaviour. The reactors are important part of the conversion units.

- The kinetic reactor model allows observing the reactor behaviour not only around the working parameters but in different situations, far from the calibrated points without any additional test-run procedures.
- It allows observing comprehensive studies of the effects of different parameter changes on the reactor, which are not implemented into the base model earlier.
- Decrease of the catalyst activity can be followed during the reactor operation.
- In case of using new catalyst, the reactor model can be tuned easier.

6.5. MONITORING

The OTS has two options for the trainer to evaluate the trainee's performance. The Performance Monitor gives a percentage, showing how the trainee solved the situation. The trainer shall be careful with this feature in order to avoid down-hearting the trainee. It is hard to judge and give points for a complex exercise. Better feature is the Event Monitor, where the trainer is able to backtrack all the trainee's movements and can analyse together what would have been the better decision at a given point. This type of evaluation is much more fruitful for the future, although it needs more effort from the trainer side.

7. Summary – recommendations

In the following we summarized the main points of the Operator Training System implementation at MOL and a few useful experiences are mentioned.

- The OTS is a useful tool not only for train the shift leaders/operators but it can be used for problem solving, checking different operation modes, and elaborating studies without any risk. Training System can be used for gain knowledge about effects of minor "tricky" failures, which are not obvious for the first sight; they are not causing direct problems.
- We speak about matching the OTS to the real plant data. During the model building and the simulator-testing phase several discrepancies can occur between

the simulated and real environment. The discrepancies may discover a few hidden problems in the real plant as well.

- Because the Hydrocarbon Processing Industry is a special area, we should elaborate our own educational system. The OTS can complement MOL's job training system and should be integrated into it.
- We suggest implementing custom model to get better reflection of the real plant.
- During the dynamic model-building phase, the P&IDs shall be strictly transformed into the simulator. The heat- and material balance, the equipment data sheets, and any other data should be carefully checked and supplied in order to avoid reworking.
- All historical knowledge shall be incorporated in the system (near miss failures, unit upsets).
- Continuous model review can greatly improve the model-building phase, can help elaborate a more exact dynamic model.

Revised by: László Nagy

Examination of new turbo-feed pumps construction for Power Plant boilers

Ivan Stranovský (29)
Engineer, (thermal power engineering)
Deputy of Power Plant Manager, Slovnaft
E-mail: ivan.stranovsky@slovnaft.sk

Andrea Grmelová (31)
Engineer, (thermal power engineering)
Process Engineer, Slovnaft
E-mail: andrea.grmelova@slovnaft.sk

Abstract

Unit P4.1 Power Plant is situated in Refinery Slovnaft Plc. Power Plant main task is supply superheated steam (pressure levels 0.4, 1.0 and 3.5 MPa) and electric power to Slovnaft refinery. High pressure superheated steam is produced on five high pressure steam boilers with installed load on 780 tonns per hour. Electric power is produced on four steam turbines with installed power 114 MWe. Electricity power production on power plant strongly depends on heat consumption in Slovnaft Refinery. This is the main reason for shutting down the turbogenerator TG 4 in the summer period (June – September). This turbogenerator is back-pressure (0.08 MPa) with controlled steam extraction (0.4 MPa). Reason for TG 4 shut down in summer time is 0.4 MPa steam consumption decreasing. This decreasing would be able to compensate with installation of new 0.4 MPa steam consumer. New 3 pcs of boilers feed water pumps with turbo driver can be suitable steam consumers. The 0.4 MPa steam will be used for it as a live steam.

Összefoglalás

A P4.1 erőmű a Slovnaft kőolajfinomítóban helyezkedik el. Fő feladata a finomító (0,4, 1,0 és 3,5 MPa nyomású) túlhevített gőzzel és villamos energiával történő ellátása. A nagynyomású túlhevített gőzt öt darab nagynyomású gőzfejlesztőn állítják elő, amelyek legnagyobb megengedhető terhelése 780 t/h. A villamos energiát négy darab 114 MWe beépített teljesítményű gőzturbinán termelik. Az erőmű villamos energia termelése

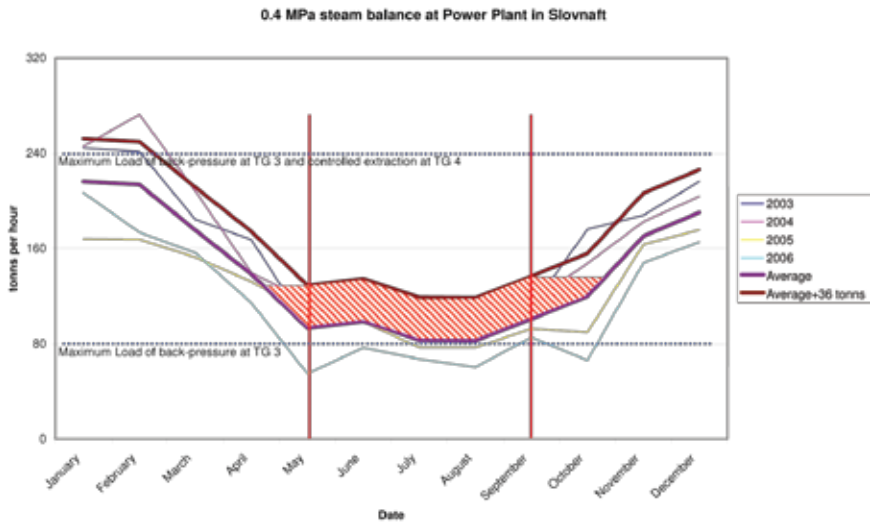


Figure 1.

erősen függ a Slovnaft kőolajfinomító gőzfogyasztásától. Ez a fő oka a TG4 turbógenerátor nyáridőben (június-szeptemberben) történő leállításának. E turbógenerátor ellennyomásban (0,08 MPa) szabályozott gőzelvétellel (0,4 MPa) működik. A TG4 nyáridőszaki leállításának oka a 0,4 MPa nyomású gőz iránti igény csökkenése. A csökkenés kompenzálható lenne egy új 0,4 MPa nyomású gőz fogyasztó beépítésével. A gőzfejlesztő betápjának biztosítására 3 új, magas fordulatszámon működő vízszivattyút lehetne beépíteni, amelyek valószínűleg a kívánt mértékben megnövelnék a finomító gőzfogyasztását. A 0,4 MPa nyomású friss gőzt a szivattyúk meghajtására használnák.

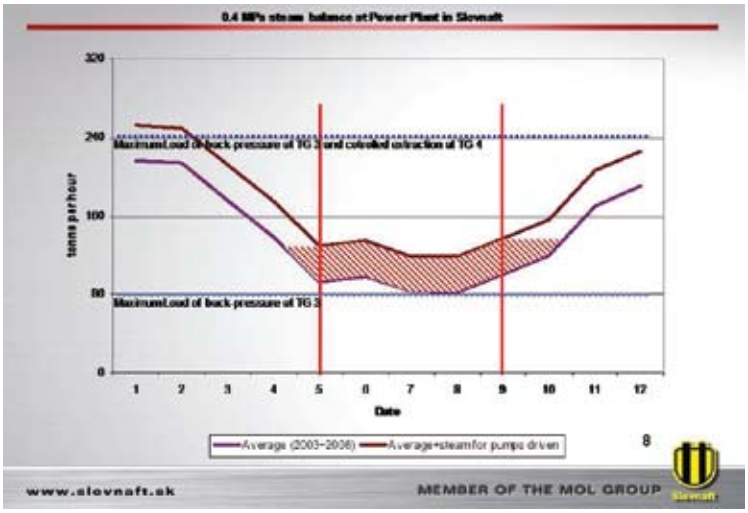


Figure 2.

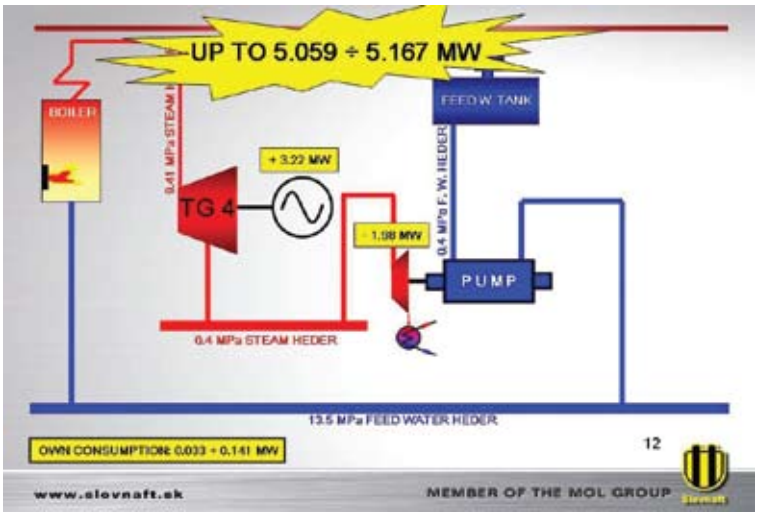


Figure 3.

0.4 MPa steam chart

Steam consumption in Slovnaft refinery is generally not constant. It depends on whether, production unit consumption and year period. In winter time (colder whether) the steam consumption is higher and in summer the steam consumption is lower. Power Plant's electric power production strongly depends on steam production. The strongest changes are made by 0.4 MPa steam and from this steam we can produce the most of electric power (MWh per ton/hour). It is approximately 0.17 MWh/(t/h). As you can see on Figure 1. the depression through summer is too big and we must stop one backpressure turbogenerator at the Power Plant.

The consumer finding

If we want to produce more electric power in Power Plant present configuration, we have to find the steam consumer and increase steam consumption.

One solution is to build up the steam consumer inside of the Power Plant and use the steam right there. The biggest consumers of electric power at the Power Plant are feed water pumps for boilers. We have generally in operation minimum 3 pcs and maximum 4 pcs of these pumps. Average energy consumption for one pump is 0.7 MW. Another advantage of this solution is water pressure regulation in feed water headers too. This solution can save the electric power (pumping work) and the regulation valve too. Expedience of this solution is in that the feed water pumps are close to 0.4 MPa steam producer and from that reason are loss in pipelines minimal.

Thermal evaluation

From these premises we decided to calculate this option. We developed the

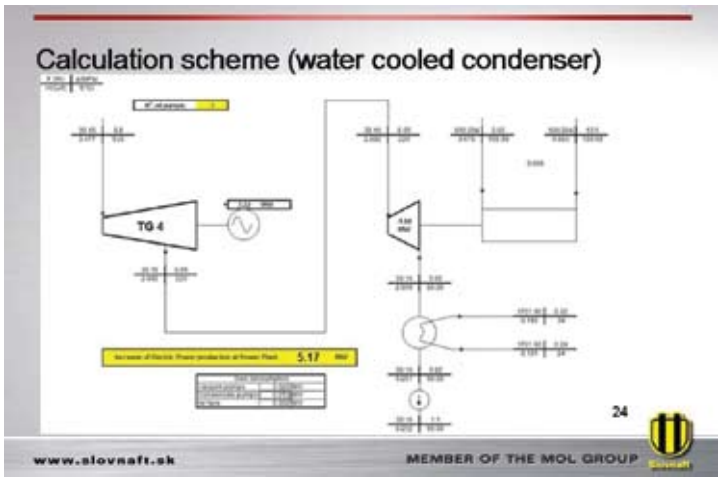


Figure 4.

calculation model in MS Excel and there we calculated the thermodynamic solution (Figure 4.).

In this model we were able to calculate steam increase to operate the feed water pumps, the cooling water amount for condenser cooling and the main self consumption (condensate pumps, fans on air cooled condenser, etc.).
We calculate the water cooled condenser (Figure 5.) and air cooled condensers (Figure 6)

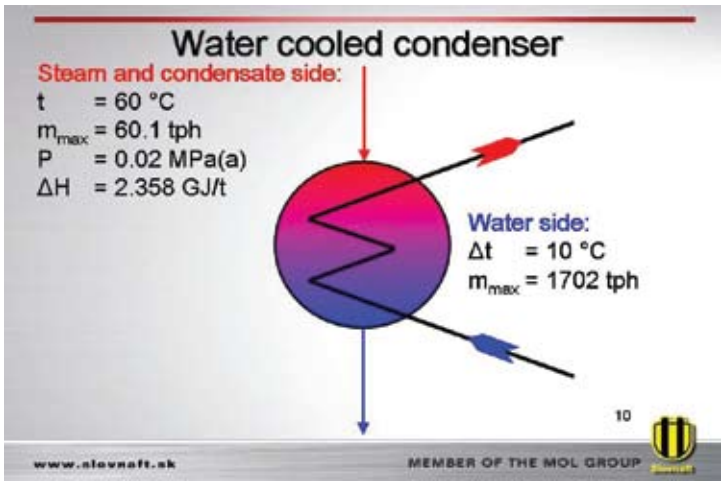


Figure 5.

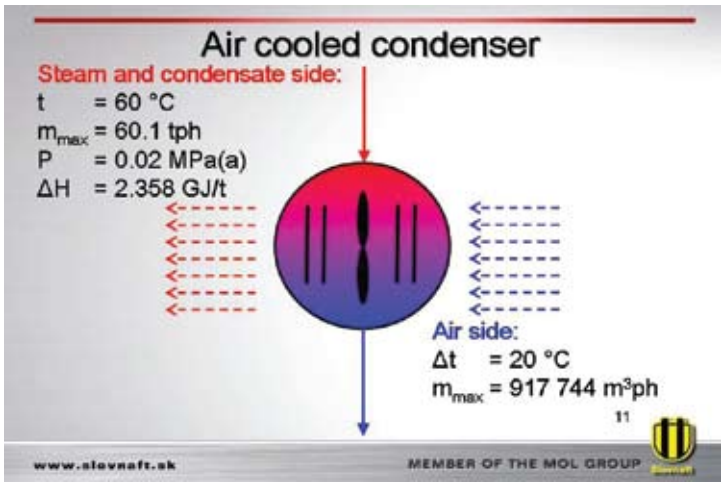


Figure 6.

Economic evaluation

After technical calculation we had to make the economic evaluation of this project. We obtained informative prices of equipments from manufacturers. This prices and prices from internal price list in Slovnaft Plc. were an input data for calculation.
We calculate:

- sensitive analyzes
- cumulative cash flow
- net Present Value – NPV

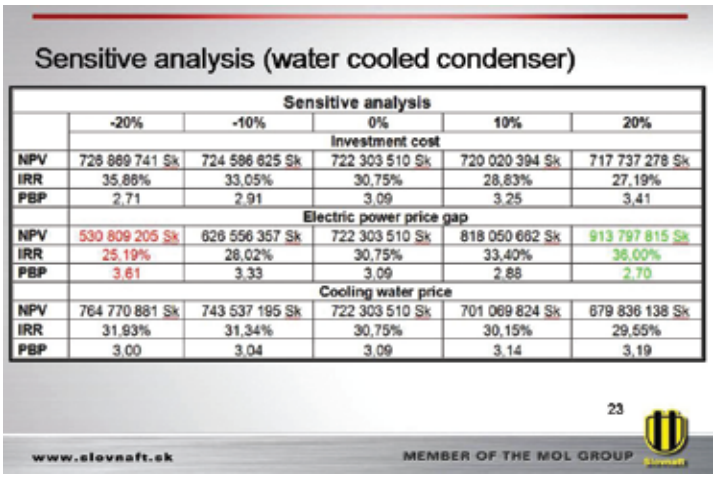
– Water cooled condenser:
Investment: 120.000.000 SKK
NPV: 722.303.510 SKK
– Air cooled condenser:
Investment: 100.000.000 SKK
NPV: 910.845.204 SKK

- Internal Rate of Return – IRR

-Water cooled condenser:
IRR: 30,75 %
– Water cooled condenser:
IRR: 40,75 %

- Payback Period – PBP

–Water cooled condenser:
PBP: 3,09 years
– Water cooled condenser:
PBP: 2,42 years



Sensitive analysis					
	-20%	-10%	0%	10%	20%
	Investment cost				
NPV	726 869 741 Sk	724 586 625 Sk	722 303 510 Sk	720 020 394 Sk	717 737 278 Sk
IRR	35,86%	33,05%	30,75%	28,83%	27,19%
PBP	2,71	2,91	3,09	3,25	3,41
	Electric power price gap				
NPV	530 809 205 Sk	626 556 357 Sk	722 303 510 Sk	818 050 662 Sk	913 797 815 Sk
IRR	25,19%	26,02%	30,75%	33,40%	36,00%
PBP	3,61	3,33	3,09	2,88	2,70
	Cooling water price				
NPV	764 770 881 Sk	743 537 195 Sk	722 303 510 Sk	701 069 824 Sk	679 836 138 Sk
IRR	31,93%	31,34%	30,75%	30,15%	29,55%
PBP	3,00	3,04	3,09	3,14	3,19

Figure 7.

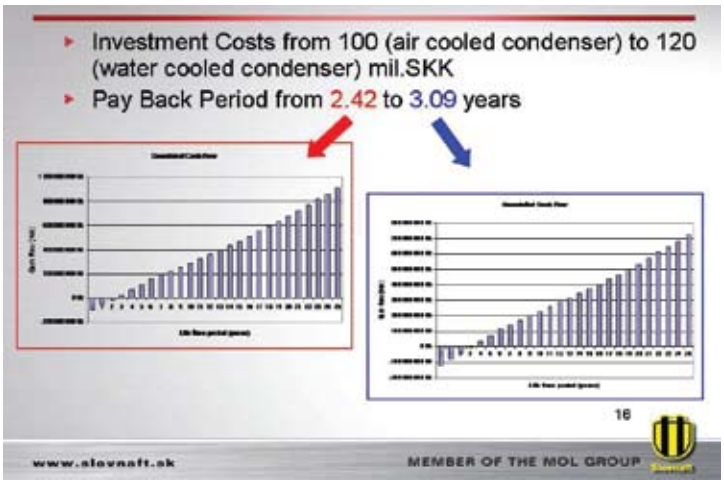


Figure 8.

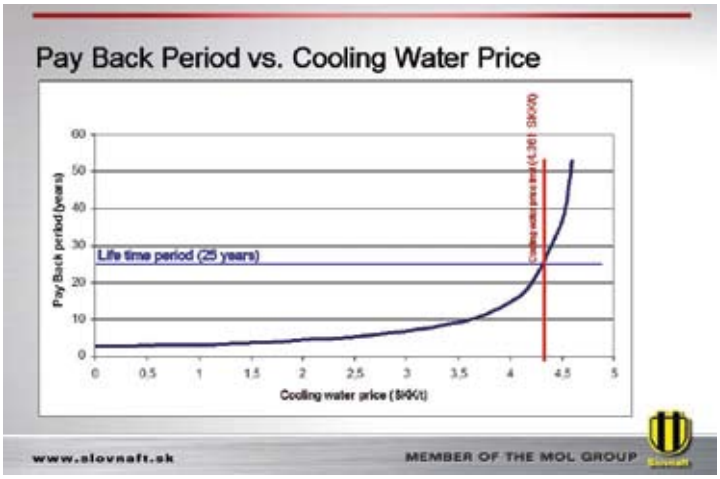


Figure 9.

Conclusion

Based on thermal and economic evaluations it is evident that this project can improve the efficiency of the whole Power Plant and increase electric power production there. It has impact on safety for the whole Slovnaft Refinery because more units can be under the island operation. The utilization of TG 4 will also be significantly increased.

One way of project ineffectively exists. It is, when the throughput cooling is used (Figure 9.).

As you can see the price of cooling water has very strong impact on pay back period. For this reason, it is necessary (if the project will be built) to use the cooling center (CC8 – Slovnaft Power Plant cooling system replacement of through-flow cooling by cooling towers, MOL Group Szakmai Tudományos Közlemények 2007/1, pp. 20-22) or air cooled condenser.

Revised by: László Lázár

Ethylene Recovery from Ethyleneoxide Unit Offgases

Zoltán Dániel (27)
Pannon University (Ásványolaj és petrolkémiai szakirány)
Process engineer, Chief Technologist Department, Slovnaft
E-mail: zoltan.daniel@slovnaft.sk

Abstract

This paper depicts one possibility how to increase the benefit at the Ethylene oxidation 2 unit in Bratislava Refinery. The refinery offgases can contain valuable components e.g. ethylene, propylene or hydrogen, which are used only as fuel gases. There are some possibilities, how to remove them from the offgas stream and use as important raw material. My report deals with Ethylene oxide 2 unit offgases. This stream contains high percent of ethylene and it is possible to take the ethylene out and continuously stream it back to the process. Thanks to this process, the raw material´s cost will be less. The process is cheap and simple and the return on investment time is short.

Összefoglalás

A cikk egy lehetőséget vázol a pozsonyi kőolajfinomító Etilénoxid-2 üzemének hatékonyságjavítására. A finomítói gázokban előforduló értékes komponensek, mint az etilén, propilén, vagy a hidrogén, kizárólag fűtőgázként hasznosulnak. Több lehetőség van arra, hogy ezeket a gázáramokból kivonják és fontos alapanyagként hasznosítsák. A dolgozat az Etilénoxid-2 üzem gázainak hasznosításával foglalkozik. Ezek az anyagáramok viszonylag nagy mennyiségben tartalmaznak etilént, amit ki lehet vonni, és folyamatosan vissza lehet táplálni a folyamatba. Az eljárásnak köszönhetően az alapanyagköltség csökken, ráadásul az eljárás energiatakarékos. Az eljárás olcsó, egyszerű és a fejlesztés megtérülési ideje rövid.

Introduction to Ethylene oxidation technology

For the ethylene oxide production there are two technologies. The older one is a chlorohydrins process; the modern technology is direct ethylene oxidation with air or pure oxygen. In the 70's company Shell had the most effective technology development and in Slovnaft it was installed as well. The unit uses pure oxygen as raw material. The reaction is based on direct oxidation of ethylene on silver catalyst.

$$CH_2 = CH_2 + ½O_2 \xrightarrow{\text{Ag catalyst}} (CH_2 - CH_2)O + 102\ \text{kJ/mol}$$

The side reactions are highly exothermic:

$$CH_2 = CH_2 + 3O_2 \longrightarrow 2CO_2 + H_2O + 1327\ \text{kJ/mol}$$

$$(CH_2 = CH_2)O + {}^{5}/_{2}\,O_2 \longrightarrow 2CO_2 + H_2O + 1223\ \text{kJ/mol}$$

Reaction parameters:

t = 220-250°C (depends on the catalyst age)
p = 1.9-2.1 MPa.
Dilution gas: CH_4 fraction.
Produced CO_2 is separated from the recycle gases based on chemical reaction with potassium carbonate aqua solution. After the following step (because of pressure-drop) the aqua solution falls apart to CO_2, K_2CO_3 and H_2O. CO_2 is vented into the atmosphere; rest is flowed back to the process.

$$CO_2 + K_2CO_3 + H_2O \longleftrightarrow 2KHCO_3$$

$$KHCO_3 \longleftrightarrow CO_2 + K_2CO_3 + H_2O$$

ETOX usage: raw material for a lot organic synthesis, to produce glycols, washing products, textile fibres, ethanolamines, glycol-ethers.

MEG product:

$$(CH_2-CH_2) \longrightarrow O+H_2O$$
$$HO-CH_2-CH_2-OH+92.2\ kJ/mol$$

DEG product:

$$\longrightarrow$$
$$MEG+(CH_2-CH_2)O$$
$$HO-(CH_2-CH_2-O)_2-H+92.2\ kJ/mol$$

TEG product:

$$DEG+(CH_2-CH_2)O$$
$$HO-(CH_2-CH_2-O)_3-H+92.2\ kJ/mol$$

Usage

MEG: to produce organic and inorganic esters, ethers, acethals and kethals, also produce antifreezing mixtures, polyester fibres, resin, plastics, explosives, nitrocellulose, etc.
DEG: it is used as textile and caoutchouc softener, gas-dryer, explosives etc.
TEG: gas-dryer, to produce plastificators, nitrocellulose, softener to various copolymers, etc.

The main process sections are:

1. Methane hydrogenation and purification
2. Ethylene oxide reaction
3. Getting the ethylene oxide
4. Ethylene oxide purification
5. Glycols reaction and getting the glycols
6. Glycols rectification
7. Storage

Financial analysis of the years 2005 and 2006
In the benefit calculations the ethylene's price is an important coefficient. It takes 94% of the total raw material's costs. Fig. 1 shows the ethylene price fluctuation from January, 2005. The table shows, how it had increasing tendency.

In May, 2005 Slovnaft Petrochemicals divided from Slovnaft Refinery. From that date Slovnaft buy ethylene on market prices from the Petrochemicals too. The difference is significant.

The next figure is a detailed table, contains only the year 2006. It shows the ethylene's market price differences between the first half year

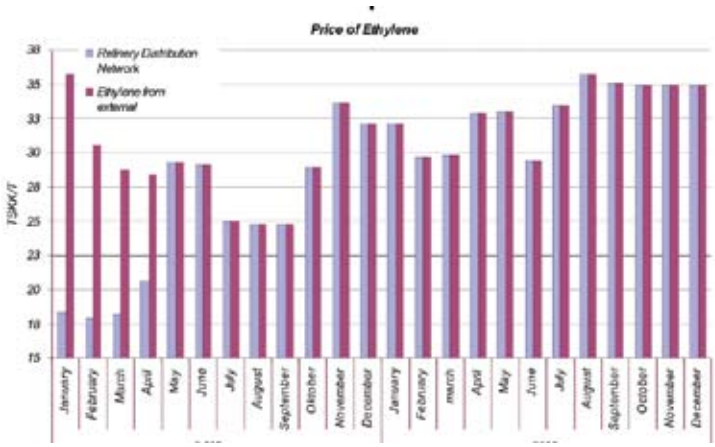


Figure 1. Ethylene Price in 2005 & 2006

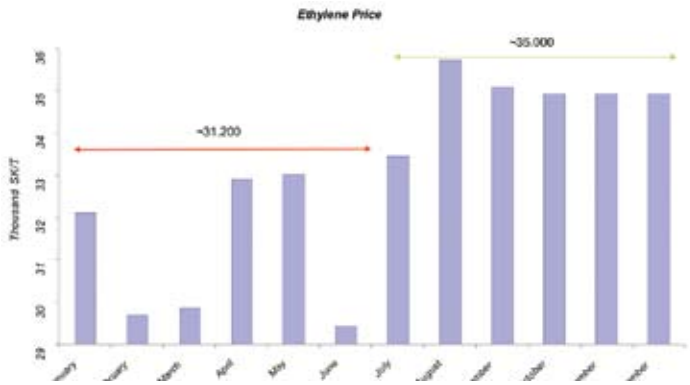


Figure 2. Ethylene Price in 2006

and the second. The average price differences aren't negligible too

As the raw material is cheaper in the first half year, the products are cheaper too. It is more detailed in the next chapter (Income structure).

Income Structure

Figure 3. Income Structure

Figure 3. shows ETOX's, MEG's, DEG's selling prices, which are the most significant products; the TEG, PEG and OGM amounts are insignificant by them and it doesn't make sense take them to count in.
Only for curiosity in Table 1 is introduced what it would be, if we can deposit the products until September and after sell it.

	2006		
	Jan. – Aug.	Sept.– Nov.	
Average Selling Prices in SK/T			**Diff. (SK)**
ETOX	32 200	34 000	1 800
MEG	21 700	27 600	5 900
DEG	23 100	30 000	6 900

	2006	
	Jan. – Aug.	Sept. – Nov
Production (Tons)		
ETOX	9 150	2 770
MEG	30 200	7 920
DEG	3 240	730

Difference * Production	
ETOX	16 470 000
MEG	178 180 000
DEG	22 356 000

Plus 217 006 000

Table 1.

So if we wouldn't sell the products from January till August but from September to November, we could gain plus 217 MSKK. It can be a possibility to increase the benefit. The selling prices are higher from September every time because the supply and demand. MEG is used generally to make antifreeze liquids to the cars and engines. The demand for it is higher then.

The production table shows the low production in October.

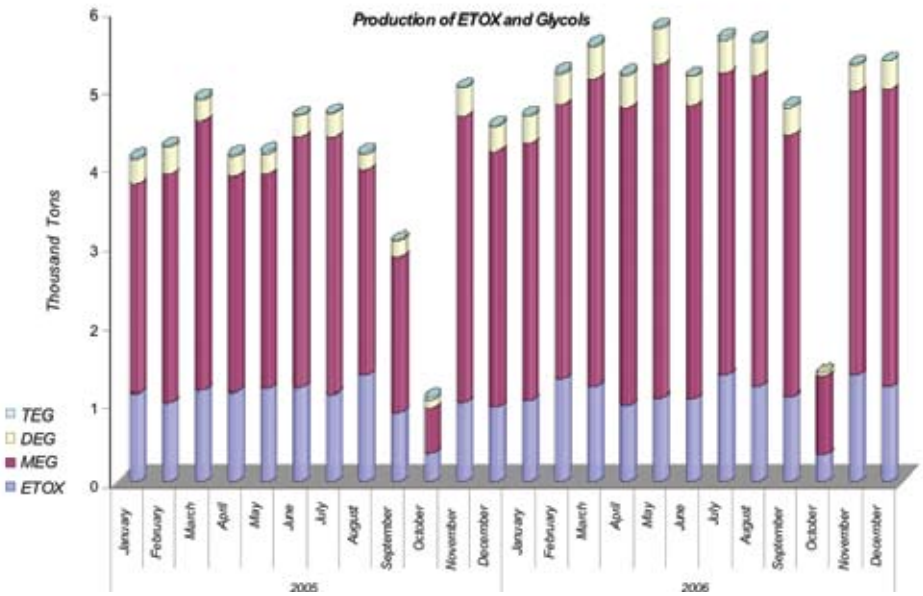


Figure 4. Etox and Glycols production

The Outage in October can make a significant deficit. It is introduced in the below part „Benefit".

Benefit

The benefits are shown in the next figures.

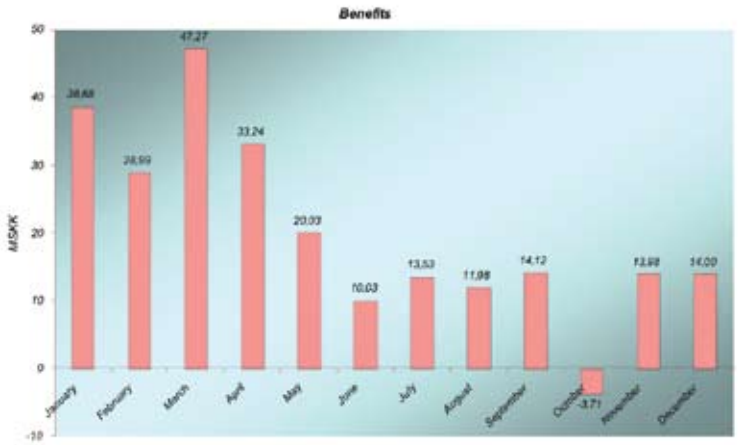


Figure 5. Benefits in 2005

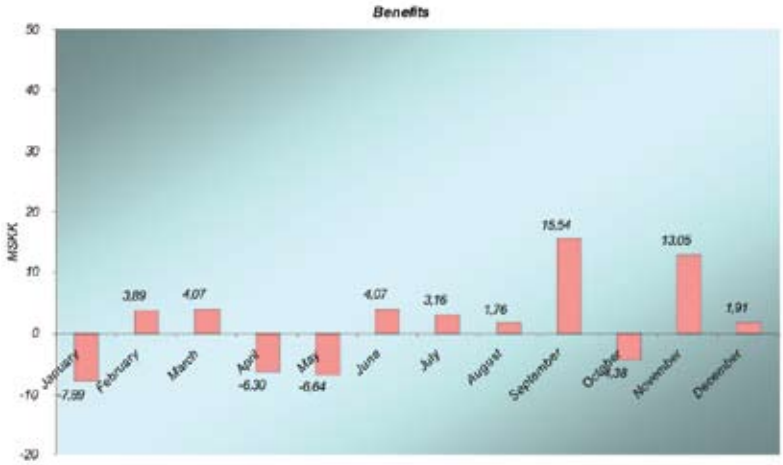


Figure 6. Benefits in 2006

The figures clearly show: September and November were the best months both year (compare only from May, 2005). This figure's curiosity is the low selling amount in October. It is because of the unit-shutdown. The probability calculus shows, October in the future seems to be such profitable month if no shutdown will be.

So in 2005 and in 2006 unit shutdown was September and October, when the selling prices are the highest for the products.

Because the MEG is an antifreeze material and it is used mostly in the winter time (mix it to make antifreeze liquids), it is not suggested to stop its production before winter, when the demand for it is the highest and so is its selling price. Its production should terminate in June or July.

In October, 2006 there could be the benefit instead of -4.4 MSKK approximately approx. 15-20 MSKK.

Only for comparison:
2005. Benefit:238.7 MSKK
2006. Benefit: 22.2 MSKK

Catalyst selectivity

In September, 2005 the oxidation catalyst was replaced. It was necessary due to the selectivity of the catalyst (August, 2005), which was then 76,01% (process selectivity). After 1 operation year (August, 2006) the new catalyst's selectivity was 86,33%. It means saving 100 kg of ethylene and more than 300 kg of oxygen on 1T of ETOX equivalent product. Next figures shows the differences between the old and new catalyst: catalyst S-863 is the old catalyst, catalyst S-882 is the new one.

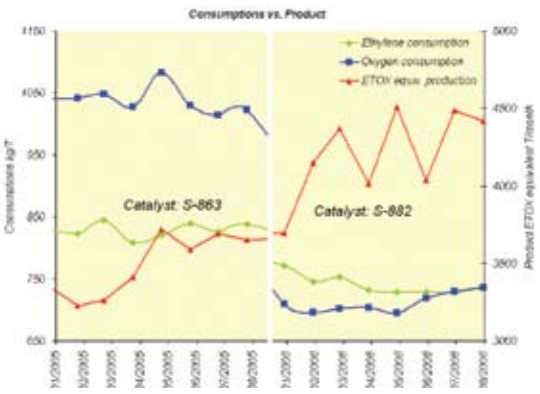


Figure 7. Comparison consumption with the production

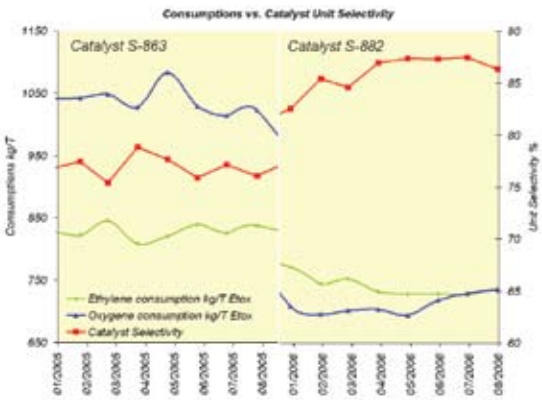


Figure 8. Comparison consumption with catalyst selectivity

ETOX offgas composition

The ethylene oxidation process is highly exothermic; the conversion for ethylene is controlled to 10-11%. The selectivity can be 75-88% depends on the catalyst age. Thus the conversion is low, we reclaim the unreacted gas. Some inert gases e.g. argon are accumulating and vent is necessary. The total offgas amount is shown in the Table 2.

Total amount (2005 and 2006): 2941 Tons.
The composition is as followed in the next table.

Saved Ethylene and Methane

Could be saved in 2005 and 2006 with the VaporSep Membrane:
Ethylene 745 tons
Methane 207 tons.

Average costs per ton: Ethylene – 31200 SK, Methane – 11750 SK.

Income with saving both materials: 25.7 MSKK
Ethylene: 23.24 MSKK.
Methane: 2.43 MSKK.
Minus offgas: 10.700 SK * 952 Tones = Σ 10.186.000 SK.
(average price of the offgas is 10.700 SK/T)

Saved money: 15.5 MSKK / 2 years.

What does it mean VaporSep Membrane for ETOX offgas?

It is equipment, which can separate and recover the ethylene and methane fraction from the ethylene oxide offgas.

Currently 5 such VaporSep units are operating worldwide for ethylene recovery (March, 2007).

Composition	kmol/h	% mol	kg/h	% weight
N_2	0.038	0.389	1.064	0.44
Argon	0.909	9.306	36.313	14.993
O_2	0.397	4.064	12.704	5.245
Methane	4.43	45.352	71.07	29.343
Ethylene	3.13	33.917	92.943	38.374
Ethane	0.1	1.024	3.007	1.241
CO_2	0.563	5.764	24.778	10.23
H_2O	0.018	0.184	0.324	0.134
Σ	**9.768**	**100**	**242.203**	**100**

Table 2. ETOX offgas composition

Figure 9. The recovery unit

References

[1.] PKN ORLEN SA Plock, Poland; Ethylene recovery from argon purge in EO manufacture 2006

[2.] Scientific Design Shanghai, China; Ethylene recovery from argon purge in EO manufacture 2005

[3.] Samsung GeneralChemical Daesan, Korea; Ethylene Recovery from ethylene oxide purge 2001

[4.] Scientific Design Shanghai, China; Ethylene recovery from argon purge in EO manufacture 2000

[5.] Formosa Plastics Corp. Point Comfort, TEXAS; Ethylene recovery from argon purge in EO manufacture 1999

Basic Flow sheet

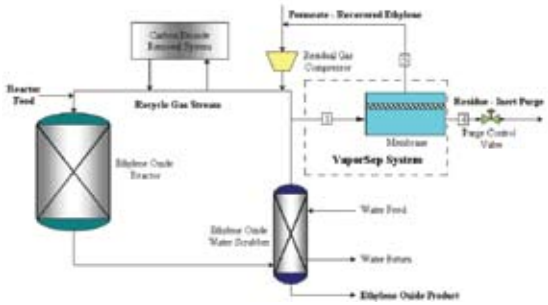


Figure 10. Preliminary Process Flow Diagram of Ethylene Recovery Process

Because the membrane does not separate ethylene from ethane, the ethane concentration in the recycle gas stream will increase until a steady state is reached. This build-up in ethane concentration will however be offset by reaction of ethane with oxygen to form carbon dioxide inside the reactor. Although little ethane will react in each pass, the majority of ethane recycling back to the process will eventually be converted to carbon dioxide after many passes though the reactor. The manufacturers experience about build-up of ethane after the addition of the membrane unit is to be negligible.

Return on Investment

Budgetary price ex crating, loading, transportation, containerisation, installation to process is 250.000 USD (6.25 MSKK).
Total cost of investment ~ 12.5 MSKK.
Return on investment ~ 20 months.

Conclusion

There are more possibilities to increase the profit, I introduced some of them, e. g. shutdown not in October, deposit the products and/or use a VaporSep Unit. The VapourSep Unit can save 5-10 MSKK per year and the investment is about 12.5 MSKK. This machine is independent from the production fluctuation, every time saves the money, if the production is more, than saves more, if less, than less. As Fig. 1 shows Ethylene's price has an increasing tendency and higher Ethylene's price means saving more money with the VaporSep.

Abbreviations

ETOX, EO – Ethylene Oxide
MEG – Monoethylene Glycol
DEG – Diethylene Glycol
TEG – Triethylene Glycol
PEG – Polyethylene Glycol (30% TEG)
OGM – Other Glycol Mixture (80% MEG)
TSKK – Thousand Slovak Crowns
MSKK – Million Slovak Crowns

Revised by: Ing. Milan Beňo

Performance Increase in the Olefin 2 Plant of TVK Plc.

István Balogh (45)
Heavy Industry Technical University,
Mechanical engineer
TVK Plc., Olefin-2 plant
Plant manager
E-mail: vbaloghistvan@tvk.hu

Zoltán Gömöri (30)
University of Miskolc, oil and gas industry engineer
University of Miskolc, IT engineer
TVK Plc. Olefin group
Plant engineer
E-mail: gomoriz@tvk.hu

Szabolcs Simon (30)
University of Veszprém,
Chemical engineer
TVK Plc., Technology Development
Technologist
E-mail: szabolcs.simon@tvk.hu

Abstract

TVK Plc. Olefin-2 Unit was started in December 2004. Elimination of the start up problems even led to increase in capacity. The gasoline processing system was modified in October 2005. This modification allowed the system to produce on-spec BT fraction and to process the full amount of gasoline. The new APC system, which was installed in 2007, works over the DCS and allows the plant to reach a higher production level, while the operation is kept more stable and more even. In August 2007 a new reactor was integrated into the existing C4/C5 hydrogenation system. Due to the new reactor more ethylene can be produced from the hydrogenated C4/C5 fraction at better specific consumptions than earlier. Thanks to the above mentioned facts, the optimal feedstock combination and the newly introduced „4 furnace operation mode", in 2007 a record yield was achieved.

Összefoglalás

A TVK Nyrt. Olefin-2 gyára 2004 decemberében került beüzemelésre. A próbaüzem során néhány olyan technológiai probléma jelentkezett, amelynek felszámolása kapacitásnöveléshez is vezetett. A pirobenzin feldolgozó rendszer átalakítására 2005 októberében került sor. Az átalakítást követően lehetővé vált a megfelelő specifikációjú BT frakció előállítása, valamint a teljes mennyiségű pirobenzin feldolgozhatóvá vált. 2007-ben installálásra került az új APC rendszer, amely a DCS folyamatirányító rendszer felett működve lehetőséget teremt arra, hogy stabilabb, egyenletesebb üzemeltetés mellett magasabb termelési szintet érhessünk el. 2007 augusztusában a C4/C5 hidrogénező rendszer egy új reaktorral egészült ki, melynek köszönhetően nőtt a hidrogénezett C4/C5 frakcióból előállítható etilén mennyisége és a fajlagosok is javultak. A 2007-es rekord termelési eredmény a fentieken kívül az optimális alapanyag szerkezetnek és a bevezetett négy kemencés üzemmódnak volt köszönhető.

Historic review

The extensive period of petrochemical developments in Tiszaújváros, which began in the 1970ies came to completion in the mid 1990ies. By this time, however, the region saw an ethylene shortage, which was only eased, not eliminated by an intensification of the existing Olefin Plant of TVK, which was completed in 2000.

These circumstances and the fact that TVK was listed on the stock exchange required the company to develop a strategy in order to secure its long-term competitiveness. Related actions began in the mid 1990ies. By the

year 2000, a development friendly ownership structure had evolved in the company, and also the majority shareholder supported TVK's intentions for its strategic development. The main idea was that TVK ought to break out of the role of a local market player and become a regional player in a circle of 600-800 km radius in line with improving its competitiveness at the same time.

At its meeting of April 20, 2001, the Board of TVK Plc. approved the medium term development concept of the company. Later potential candidate contractors were invited to make their studies and quotations for the key project, a new olefin plant of the concept. Other contractors were invited to make their detailed bid quotations for a new polyethylene plant. These documents made a basis on which subsequent preparatory actions relied. As a result of careful preparations, the Board authorised the Strategic Program package for implementation on April 26, 2002.

The key element of the Petrochemical Development Project was a new olefin plant. Though, no revolutionary innovations have been made in the past few decades in the steam cracking olefin technology, continuous developments make today's olefin plants more modern and more efficient than their older peers were. The main elements of the technologies operated at present are still the same as earlier:

- The high temperature thermal cracking of hydrocarbons in the presence of steam, to generate a gas mix with optimal olefins content (2.69 tons naphtha/one ton ethylene, or 3.16 tons AGO/one ton ethylene, or, 0.557 tons (ethylene +propylene)/one ton naphtha, or, 0,474 ton (ethylene +propylene)/ one ton AGO);
- The stripping of the steam and heavy hydrocarbon fractions (gasoline, oil);
- The compression of the gas mix, liquefying and separating the components by cooling in more than one step;
- Removal of the contaminants by catalytic hydrogenation primarily.

Today, more modern equipment, more selective catalysts and more developed process control systems, etc. allow lower energy and material consumption, improved product quality and a higher operation safety of the plant.

The „birth" of the plant

Linde AG was selected to supply the process for the Olefin 2, since this company had supplied the process for the existing Olefin 1. The Basic Engineering documents were supplied in January 2002 and the contract concluded with Linde for the implementation of the project came into effect on May 1, 2002.

Figure 1. Planned layout of the Olefin 2 plant

Figure 2. The propane-propylene separation column is being lifted into position.
Column height: 87.3 m; mass: 314 t

Implementation actions commenced soon after the contract was made and the plant would be actually built in 27 months from the date of the contract, a record time for the construction of such facility (the completion time of basic engineering is not considered).

In the last stage of plant construction, commissioning actions began, including the following important milestones:

April 1-May 6, 2004
The cooling tower is commissioned.
October 9, 2004
The firing of the furnaces begins (to dry the refractory).
November 19, 2004
The state of mechanical completion (MC) is reached.
December 11, 2004
Feedstock is introduced into the furnaces (AGO); pyrolysation takes place in the furnaces for the first time.
December 13, 2004
The first on-spec propylene product is released.
December 16, 2004
The first on-spec ethylene product is released.
December 25, 2004
The commercial ethylene production is commenced.
January 6, 2005
The gasoline hydrogenation section is commissioned.
February 21, 2005
The demonstration of the guaranteed values begins.
September 29, 2005
Pilot operation is closed down; the project is capitalised.

Major novelties of the Olefin 2 in comparison to the Olefin 1

- The pyrolysis furnaces are SELAS-LINDE's, which typically have common convection sections, two radiation zones, independent heat utilisation regimes, and TLE quench coolers;
- Two oil circles from the oil stripping column, which secures a better heat utilisation;
- Foul lye is treated whereby 0% free lye is discharged from the system;
- One propane-propylene separation column, which gives a simpler system design;
- A tail gas burning system, which reduces hazardous emissions;
- EBDS system, which allows that the systems are automatically isolated and depressurised;
- Waste water treatment, which secures that the waste water generated in the process is delivered to the central waste water treatment unit in a controlled way;
- Five-year maintenance cycles.

A brief description of the process

Atmospheric gas oil (AGO), naphtha (VB), liquefied petroleum gas (LPG), and recycled

C2-C5 are applied as feedstock. Ethylene and propylene are generated from this feedstock primarily, however, some aromatic components and conversion oil or quench oil are also generated in the process. Ethylene is used as feedstock to make polyethylene in our HDPE 1 and HDPE 2 plants, while propylene gives the feedstock for polypropylene (PP 4 plant). The aromatic components generated in the process (BT, C8 and C9+) are sold to MOL Plc, and the conversion is supplied to CTK (Carbon Black Plant).

The process equipment comprises two major parts: hot section (pyrolysis unit) and cold section (gas separation unit).
The pyrolysis section consists of the pyrolysis furnces where the heat cracking of the raw materials takes place to generate unsaturated hydrocarbons. The pyrogas leaving the furnaces has to be cooled down quickly so that the reactions are frozen at the most favourable point of time. This quenching is made in two steps: first, by the quench coolers on the outlet lines of the furnaces, and then by quench oil injection. Then, the gas is introduced into the oil stripping column where the heavy components (quench oil) are separated, and then, it goes on to the water stripping column. Here, the steam, which has been introduced into the furnaces earlier, as well as most part of the gasoline content will condense. The pyrogas then goes on to the gas separation plant section where first, a five-stage centrifugal pump will compress it to 36 bar pressure. The compressor is driven by a steam turbine operated by the 110 bar steam coming from the furnaces. In the lye washing column the sour components (H_2S, CO_2) are removed and the pyrogas is cooled and dried. After further cooled, the gas is introduced into the C2-C3 separation column from where C2 is taken away as a head product, which will go into the C2 hydrogenation system where acetylene is removed. A selective catalytic hydrogenation process takes place in the reactor. The stream leaving the reactor then enters the chilling system where the C2 fraction is chilled to -145 C° in several steps in order to condense all the other components until only hydrogen remains in the gas. Methane is recovered from the condensed liquid, and then the liquid, still containing ethane and ethylene, is separated. The bottom product, C3+ fraction obtained from the column is introduced into the C3-C4 separation column. The head product of the column is C3 fraction, containing propylene, as well. The C3 fraction also contains homologous acetylene compounds, which will be converted into propylene in a subsequent selective catalytic hydrogenation process. The head product of the propane/propylene separation column is propylene. The gasoline separated in the water stripper and in

Figure 3. Cracking furnaces

between the stages of the pyrogas train will be introduced first into a prestabilizer column and then into the gasoline hydrogenation system. In gasoline hydrogenation system I the homologous acetylene compounds and diolefins are selectively hydrogenated to olefins in the presence of catalysts. The material stream coming from the reactor is cooled and separated. The C5 fraction as the head product of the stabilizer column is recycled back to the C4-C5 hydrogenation system, and the C6+ liquid will go to the redistillation column for separation. The head product of the redistillation column (C6-8) is further hydrogenated and desulphurised in gasoline hydrogenation system II. The bottom product of this column is C9+. In the C7/C8 separation column where the last step of the process goes on, C6-8 is separated to obtain aromatic head products (benzene, toluene), giving raw material for aromatics recovery, as well as a bottom product, C8.

The experience of plant commissioning (2005)

The first half of 2005 was a period of obtaining experience both about the equipment and process. We obtained positive experience in general, however, not the expected or design values were produced by some plant areas. The main problem areas were as follow:

- The bottleneck of the process was gasoline hydrogenation;
- The 0.1 bromine number of BT product was a limit value;
- The performance of C4/C5 hydrogenation needed improvement;
- The operation safety of the major machines supplied by MAN needed improvement.

The modification of the gasoline processing system

The function of the gasoline hydrogenation section is to hydrogenate the raw pyrogasoline generated in the plant and separate it into BT (benzene-toluene), C8 and C9+ fractions. However, the quantity of raw pyrogasoline generated in the plant was higher and its quality poorer than designed, therefore, the quality of the BT fraction could not be kept within the specified range reliably. (The acid wash colour of the BT fraction cannot be higher than 1, and its bromine number shall be 0.1 g/100 g). Due to the higher than designed gasoline quantity generated by the process, hydraulics obstacles turned up.
The above problems caused that the excess amounts of raw gasoline generated in the process could not be handled in the Olefin 2 and had to be transferred to the Olefin 1 plant where they would be added to the process streams.

The pyrogasoline processing system was modified in October 2005 in two main steps:

- Easing up the obstacles of hydraulics;
- Solution of the quality problems.

The following modifications were made to eliminate the obstacles of hydraulics:

- The trays were changed in the stabilization and separation columns;
- Certain control valves were changed;
- Pump rotors were changed;
- Two heat exchangers were replaced;
- Some lines were changed.

In order to solve the problems of quality, a Clay unit, containing a clay charge, was installed downstream the hydrogenation reactors. This modification allowed the system to produce an on-spec BT fraction and to process the full amount of pyrogasoline. In addition to eliminating the problems, the modifications offered a further advantage, namely that this technological unit ceased to be a bottleneck in a further capacity expansion.

The rated capacity was reached (2006)

The Olefin 2 plant produced a higher than planned quantity (251 Kt) of ethylene in 2006. The monthly and daily production data showed that the plant could be operated over its rated capacity. In this period of time, the capacity utilization rate was 91.8% (in the case of Nexant „leader", this rate is 88%), and operation time was utilised to 92% in the plant.

The existing problems of MAN's machinery were not solved in 2006, because we wanted to make use of the then favourable market possibilities and decided not to shut down the plant for an overhaul. It was clear, that the operation safety of the Olefin 2 plant greatly depends on the reliability of MAN's compressors. However, some ongoing problems found during normal operation, and partly certain long postponed repairs, either under guarantee or normal, and also some necessary modifications and developments required us to plan a plant shutdown. Following

careful preparations, we had a longer than two week's shutdown in August 2007 when we managed to eliminate the identified problems and make the system capable of reaching a higher production level.

The following main actions were performed during the shutdown.

- Modification of the seal gas system of MAN's machines;
- Load reduction on the DCS system of the Olefin 2;
- The changing of the seal fluid of compressor C-2061 to ethylene;
- The medium repair of hydrogen compressors C-7261 A/B and C-7661;
- The cleaning of the recycle basin;
- The connection of C4/C5 hydrogenation reactor to the existing system.

The C4/C5 hydrogenation system is intended to hydrogenate a larger part of the C4/C5 acetylenes, diolefins and olefins generated in the plant into saturated compounds. The hydrogenated C4/C5 fractions can be pyrolysed in the cracking furnaces of the plant at a good conversion rate.

The olefins in the C4/C5 fraction can be 15% in weight, maximum, in order to secure a good yield. After the Olefin 2 was commissioned, the existing hydrogenation reactor turned out not to be capable of meeting the required 15 w% olefins in the product. When the Olefin 2 cracked AGO feedstock, the olefins in C4/C5 went up as high as 35% after hydrogenation. When higher olefins C4/C5 was introduced into the cracking furnaces, a lower yield was produced, and therefore a higher feedstock quantity was required to give the same quantity of ethylene. In summary, it was stated that under those conditions the ethylene yield was lower in relation to feedstock quantity. Besides, higher olefins feedstock shortens the run length of the furnaces.

TVK decided to modify the C4/C5 hydrogenation system by adding a new reactor to the unit. The two reactors can operate either in sequence (in any required sequence) or alternately. This way, the time spent on the yearly regeneration of the reactors can be eliminated, too.

Implementation actions began in March 2007, while the entire plant remained in service. The new reactor system was successfully integrated into the existing system during the scheduled overhaul of the plant in August 2007.

Now, the olefins content of the hydrogenated C4/C5 fraction can be kept below 15% reliably. Due to the new reactor, now, about 3000 tons per year more ethylene can be produced from the hydrogenated C4/C5 fraction at better specific consumptions than earlier.

Optimisation of the production process – introduction of APC

After the performance tests were successfully completed in the Olefin 2, it was decided that an Advanced Process Control system (APC) had to be added, which relied on the existing DCS, but represented a higher level of process control.

A tender was invited in September 2005 for the implementation of the APC system in the Olefin 2 in order to improve the technical and commercial competitiveness by process optimisation, relying on the existing physical and mechanical capabilities of the plant. Keeping in mind the most modern technical requirements, it became clear for us as early as the bid enquiry was issued that the APC programs for the process units had to be coordinated with the production targets with the help of real time optimisation (RTO).

APC and RTO jointly secure that process variables, such as product quantity and quality, and specific energy and raw material consumptions deviate from the optimum values to the least possible extent, so that the plant operates in the most profitable regime. The primary objective, which we expected APC and RTO to meet, was to maximise the production quantities of ethylene and propylene.

The process systems of the Olefin 2 plant are controlled through the DCS system in the first place, and the operating personnel have to keep a close eye on the operation parameters and make sure that they remain at the specified levels. In the initial control set-up the process parameters are changed after deviations are observed, and there is no chance to make pre-emptive interventions.

The new APC, however, which is a multi-variable, model-base predictive system, being capable of pre-emptive controlling, works over the DCS and allows the plant to reach a higher production level, while the operation is kept more stable and more even.

Considering the purchase price, bidder's

references, and the guaranteed production increase (+8%), we assigned the contract to Aspentech Ltd who began implementation on May 17, 2006.

The APC project supports on three basic pillars:

- Multivariable, model-based predictive DMCplus controllers;
- RTO, or real time optimisation software;
- SPYRO furnace model.

DMCplus controllers, RTO software and SPYRO model run on designated computers on Windows XP basis. The computers have a two-way communication with the computers of the DCS work stations though the OPC server.

Before the DMCplus controllers were commissioned, the PID loops concerned by the APC control were tuned, the process units step-tested and a model built on the basis of the obtained results.

The DMCplus controllers of the individual process units work according to the resulting models and according to the targets defined by the operating personnel.

At present, 11 controllers and 10 subcontrollers optimise the operations of the furnaces, quench cooler, C2 and C3 lines and of the three compressors. For the time being, the gasoline hydrogenation process and the utility supplies are no APC controlled.

Relying on the prices of the raw materials and of the products as well as the business objectives of the production, the RTO system specifies the optimal production regime.

SPYRO furnace model helps us monitor furnace yields and keep them at an optimal level with the adjustment of furnace temperatures.
The APC project in the Olefin 2 ended with the successful completion of the performance tests. In the studied period of time, production increased by more than 8% when compared to the initial status (see table). The introduction of the APC system not only increased production and improved the yields, but, it made production more even. The diagram below demonstrates these improvements.

Date	Ethylene + Propylene Increment vs initial status (t)	Increment (%)
2007.09.24	93.4	8.03%
2007.09.25	118.4	10.18%
2007.09.26	118.5	10.20%
2007.09.27	101.1	8.70%
2007.09.28	100.9	8.68%
Average	106.5	9.16%

Table 1.

The year of records (2007)

As a result of our efforts to increase operation safety, the reliability of the compressors improved significantly, and the troubles causing production losses greatly decreased. In line with the successful introduction of the APC system, we switched over to a four-furnace experimental operation mode in the last quarter of the year. In normal cases three of the four cracking furnaces are in service, while the fourth one is standby. According to the planned feedstock

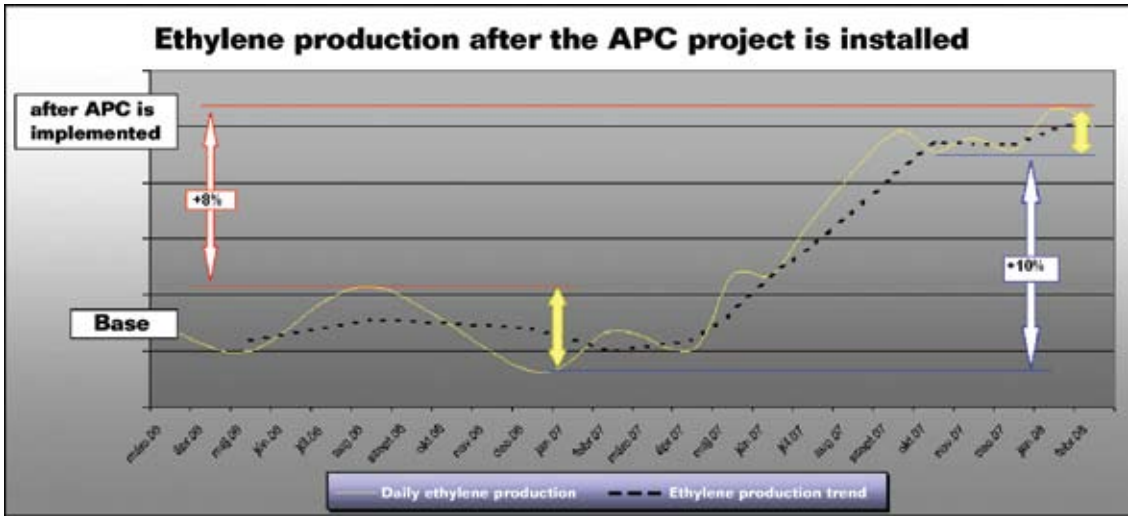


Figure 4. Ethylene production after the APC project is installed

Figure 5. Cracked gas compressor

structure, the plant processes AGO and LPG as feedstocks primarily (Case 1): the plant is designed for these feedstocks. The fact that we processed large quantities of naphtha made a positive effect on production performance. The four-furnace operation mode was made possible when we got MAN to modify the capacity of the pyrogas compressor to 9400 l/min from 9200 l/min during the shutdown in August 2007. The plant tests showed that the process was operable in the four-furnace mode at about 80% load of the furnaces.

The steam demand of the pyrogas turbine and a few pieces of the gas processing system pose a primary bottleneck in the process. The plant can be operated in the four-furnace operation mode when it cracks either naphtha or mixed feedstocks, but this operation mode is not feasible when AGO is processed. Provided a suitable feedstock structure is built and the plant works in this mode for half of its full operation time, about 290 Kt per year ethylene can be produced. The four-furnace mode allows better specific energy consumptions. Specific raw material consumptions in this operation mode are similar to those found with the three-furnace mode, though the accurate evaluation of these values requires that the plant runs in this operation mode for longer.

The run length of the furnaces and the service lives of the tubes are more favourable when the process goes on in the four-furnace mode. (The furnaces operate at lower temperatures and require cooling less often).

All this allowed us to surpass the planned yearly ethylene production by almost 10% in 2007.

Revised by: Tivadar Vályi Nagy

Generation change of truck loading gantry automation at MOL Plc. Terminal Operation

Zsolt Szalay (42)
Information technology engineer, economist
MOL R&MD Logistics/Terminal Operation

Abstract

The tank truck loading process has progressed in the past fifteen years from the manual systems involving many participants to the automated self-service systems. Supervision is required now actually only for the solution of problems which the truck drivers are unable to handle on the basis of the error messages displayed by the system. These systems are able to operate without supervision by operating personnel only with the maintenance of on duty stand-by service. Standard loading processes, standard devices involved in loading operations, the harmonization of legislation within EU in regard of safety & environmental protection requirements and the optimization of operating expenses all incite to move towards fully automated systems. This, naturally, requires considerable investments, to be recovered in the availability achieved. The required availability for a tank truck loading system is minimum 99%, the achievement of which is very challenging task for both the operator and the system installer. In knowledge of the best practice in the most developed countries, it can be stated with perfect confidence that MOL Plc – in cooperation with its trusted partner for many years in the supply of the necessary systems – has developed and is introducing in its regional network of depots one of this systems in line with marketing demands and improving reliability.

Összefoglalás

Az elmúlt tizenöt évben a tankautó-töltés folyamata eljutott a manuális sok szereplős rendszerektől az automatikus, önkiszolgáló rendszerekig. Tulajdonképpen a felügyelet már csak azon hibák megoldására kell, amelyeket a jármű vezetője a rendszer hibaüzenetei alapján már nem tud kezelni. Hollandiában, Norvégiában ezek a rendszerek kiszolgáló személyzet nélkül is képesek üzemelni ügyeleti készenlét fenntartása mellett. A szabványos töltési folyamatok, a töltésben résztvevő szabványos eszközök, az EU-n belüli jogharmonizáció a biztonsági és környezetvédelmi elvárások terén, az üzemelési költségek optimalizálása mind arra ösztönöznek, hogy az automatikus rendszerek felé mozduljunk el. Természetesen ehhez komoly befektetésekre van szükség, amelyek a rendelkezésre állásban térülnek meg. Egy tankautó-töltő rendszerrel kapcsolatban a rendelkezésre állás minimálisan a 99%, amelynek teljesítése igen komoly próbatétel mind az üzemeltetőnek, mind a rendszer telepítőjének. A legfejlettebb országok legjobb gyakorlatának ismeretében bátran kijelenthetjük, hogy a MOL Nyrt. – közösen az évek óta megbízható beszállítói partnerével – ezek egyikét fejlesztette ki, üzemelteti, és terjeszti el regionális telephálózatában, megfelelve a kereskedelmi igényeknek, növelve a megbízhatóságot.

The R&D Logistics organization is responsible for the uninterrupted & trouble-free supply of MOL partners. The direct supply of white prod-ucts, jet fuel and some heating oils to the partners is mostly the task of Terminal Operation (TO). At the present this can be provided by road, rail & barge (as well as by pipeline between MOL sites). Tank truck loaders play an outstanding role in the above secondary distribution process. 85.3% of shipping from TO sites is effected via these tank truck loading gantries (see Figure 1).

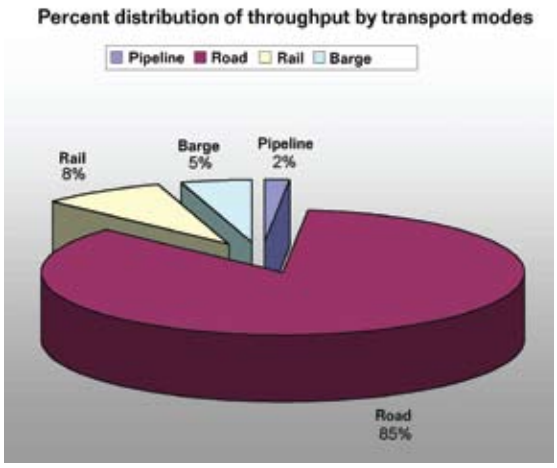


Figure 1.

If an averagely loaded tank truck is taken into account at 26 tonnes useful load, then the number of trucks loaded in a year amounts to 200-300 thousand, equivalent to 3000-4000 loading transactions per day (because of loads filled by compartments).

Historic overview of tank truck loading

MOL's supply system comprised 45 shipping terminals in 1992, among which only 15 terminals were supplied directly from the Refineries by pipelines, while the rest of the depots were supplied from these terminals by rail. Three distribution channels can be distinguished:

- Primary distribution, meaning the supply of terminals by pipelines from the refineries;
- Secondary distribution, covering the sections between the pipeline terminals and the depots supplied by rail;
- Tertiary distribution, meaning the supply routes from the railway terminals and the partners.

These distribution channels, naturally, had not been engraved in stone, since some distribution routes could be omitted in the case of some partners, e.g. partners were supplied directly from tank truck loaders at refineries and the same way from pipeline terminals.

The process systems used for tank truck loading were relatively simple in the initial case: storage tank → pump → an analog meter system (ADAST, SATAM) → top loading system. The loading systems were local installations, manually operated and required a relatively high number of operating personnel. Local regulations applied to documenting shipped quantities, differing even site-by-site, with various data contents. Shipping notes were generated by simple computer dbase software programs as print-outs on single white concertina paper.

The number of terminal depots supplied by rail had been drastically reduced from the mid 90's in the course of supply network rationalization, with the result of only 16 loading depots existing in Hungary by 1996 (see Figure 2).

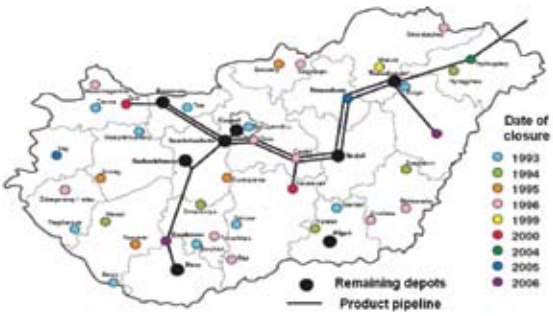


Figure 2.

The number of distribution routes has also been reduced in parallel with the closing down of depots supplied by rail, thus only primary and secondary distribution, respectively, may be taken into consideration today. The remaining reduced terminal system had induced the installation of increased loading capacities at the retained depots, meaning the start of a new era and the end of the heroic age of tank truck loading, respectively.

The appearance of automated tank truck loading gantries

The first automated tank truck loading gantry was installed in 1994-95 at Danube Refinery (Százhalombatta), fitted in its concept to the developing MOL organization, the changed business environment, the excise law and authority expectations. The main requirements imposed on the system were as follows:

- Standard technology
- Custody measurement/meter system
- High-level automation, implementation of self-service type loading
- Partial or total discontinuation of operator supervision
- Compliance with environmental requirements
- Multi-user server-client system
- Record-keeping of master data (partner, vehicle P.O. number, etc.)
- Recording & archiving of loading data
- Graphic/visual display of loading process
- Closed-system loading

Installation of automated tank truck gantries followed the first loader at Százhalombatta in several phases also at the rest of the depots, and the old manually operated loaders were dismantled at all depots by 1998.

Operating principle of automated tank truck loading gantries

The automated tank truck loading gantry installed at the depots is the COTAS system of the Mess und Fördertechnik Gwinner GMBH & Co. (FMC) seated at Hamburg. This **C**omputer **O**perated **T**erminal **A**utomation **S**ystem had fulfilled all the requirements set for it at the standard of that time. This system can be divided into three main parts:

- Mechanical/piping & process system
- High-level control technology
- Administration & controlling software

1. MECHANICAL/PIPING & PROCESS SYSTEM

The existing process systems were modified in two ways: the system was implemented as a greenfield project or with the use of some elements, e.g. pumps from the old systems. The process system is segregated: installed with the logic of one product with a dedicated meter loop, where the product can be tracked from the storage tank up to the end of the loading arm. Each control loop installed comprises the same elements with the same operating parameters, with the only difference that additive dosing facilities were installed only for the gasoline grades in the first phase of implementation. The logic structure of the system is as follows:

- Control loops, each used for the loading & metering of a single product
- Loading bays, each comprising 2 to 6 control loops in general
- Loading islands, which may be only bottom loading or combined, where the bay on one side provides for bottom loading and the other one for top loading
- Tank truck loading gantries, comprising several loading islands

Decree No. 9/1995 (VIII.31.) KTM (on the limitation of hydrocarbon emissions generated during the storage, transportation & transfer of motor gasolines), published by the Ministry of Transportation & Telecommunication in the scope of harmonization with EU legislation, has stipulated conversion to closed loading systems in several stages and prohibited the loading of gasoline species by top loaders. The bottom loading systems installed in compliance with this Decree have taken over handling 90% of loading demands, entailing a large scale conversion also in the tank truck fleet. Thus, both so called top loading and bottom loading has to be discussed with regard to tank truck loading.

Top loading

This is a loading technique where product is pumped in by a tube immersed inside the compartment of the vehicle through standard 3" loading nozzles located on the top of the truck at each compartment or through the dome openings. It is typical in the case of immersion to extend the loading arm with a simple aluminum tube chamfered 45° at the end. Its disadvantage is that loading is carried out with the dome cover open, with the consequence that hydrocarbon vapors displaced from the tank may harm directly the health of the truck drivers and the operating personnel standing by and increase environmental impacts. According to the above Decree, this technique is allowed to be employed today only for the loading of gas oil species and fuel oils.

Bottom loading

In the case of bottom loading product is pumped in through standard 4" loading heads located at the bottom of the tank. The dome covers on the tank remain closed, thus the vapors displaced from the compartment to be loaded leave the vehicle through the so called vapor recovery system connected to the compartment. Vapors displaced from the vehicle flow directly to the Vapor Recovery Unit, providing for the absorption of the hydrocarbon vapors. In the case of bottom loading any type of product can be loaded without subjecting either the participants of the loading operation or the environment to harmful effects.

At combined islands the control loops used for bottom and tops loading circuits are separated downstream of the flow meters, thus a single control loop is capable in effect to handle two bays. The disadvantage of this solution is that only either bottom or top loading can be selected at a time, entailing some waiting period in the case of demands for both loading methods. As top loading is used typically only for maximum 10% of the time, such waiting disturbs or delays loading operations only to a minimal extent. Figure 3. illustrates a P&I diagram typical of a standard control loop used for bottom loading.

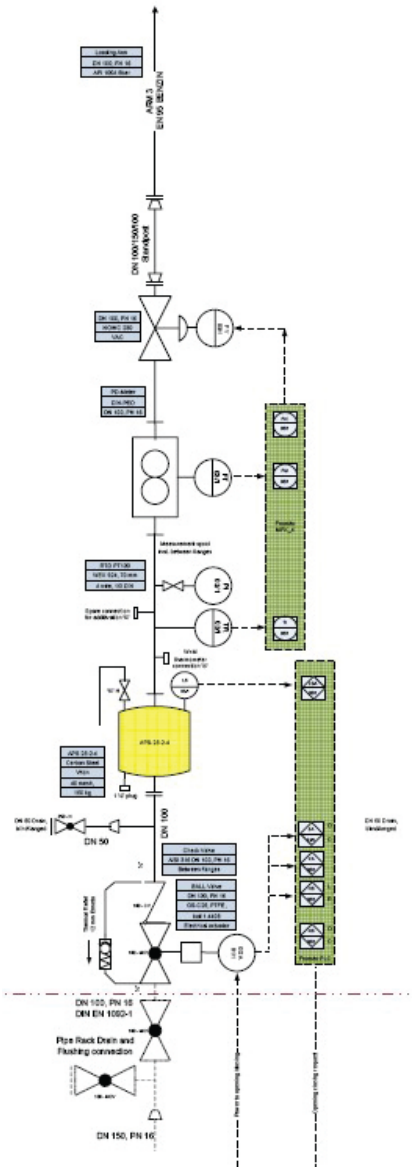


Figure 3. Control loop P&ID

Main components of the control loop:

- motorized & manual block valves,
- vapor separator,
- flow meter,
- control valve,
- loading arm with 4" API drip-proof filling head,
- additive dosing system,
- PT100 thermocouple.

Further main components of the process system are the piping line between the product tank and the control loop, the online densitymeters (SARASOTA, SOLATRON) installed in each control loop and the product pump. All product pumps are provided for each loading island, the principle is: one pump → one product → one control loop. The new pumps were installed by groups in the newly built pump shelter or the existing pumps were reused (following modifications required for meeting the necessary conditions: replacement of impellers & drive motors). Figure 4. shows the pump shelter of the tank truck loading gantry at Szazhalombatta with the Allweiler pumps installed in 1995.

Figure 4.

2. HIGH LEVEL CONTROL TECHNOLOGY

The heart of the high-level control technology in the PLC providing for the management of all equipment: motorized valves, involved in loading, the actuating of pumps and the handling of loading "events".

The system is based on a hybrid technology, utilizing Model ACCULOAD II flow computers for ensuring custody measurement (of volumes compensated to 15°C as required by the Excise Act) certified by OMH, the Hungarian Bureau of Measures) as well as for handling the finetuning of each control loop in addition to the PLC. However, since ACCULOAD was unable to handle additive dosing and density measurement, additional, Model MFX90 flow computers became also necessary. All

system components included RS232 or RS485 serial line communication interfaces, using PTB protocol in standard format for actual communication.

ACCULOAD is the flow computer & controller developed FMC Technologies for the road & rail loading of fuels, it is exceptionally robust and reliable due to its exproof design and the push-buttons. Its disadvantage is that it is capable of managing only two product circuits and is unable to handle additive dosing.

Figure 5. ACCULOAD II

ACCULOAD, although capable of displaying a high number of loading parameters, viewing is cumbersome because of the relatively small size of the display screen and only one single language can be used for communication. In spite of these drawbacks the truck drivers have adopted quickly to its use with a little training and, thus, its employment has not caused any problems.

As density measurement is indispensable for compensation, flow computer Model MFX, also produced by Mess und Fördertechnik, is necessary for processing densitometer outputs, but this flow computer has been utilized also for the handling of additive dosing data.

3. ADMINISTRATION & CONTROLLING SOFTWARE

The highest level of the system is formed by the controlling software. It may be divided into two main parts: one is the interface handling the administrative processes necessary for the loading operations, the other is the SCADA system displaying the loading process.

The software itself has been installed on a server running with UNIX AT&T operating system. Database functions have been provided by an ISAM database engine. Participants of administrative processes have communicated with the server via so-called serial terminals, while the SCADA display was running on an X-WISE graphic terminal.

System management was based on the division of work between the control room operator and the yard master. The control room operator managed the master data: such as the tank truck data, the daily loading orders, supply contracts & frame contracts. At the same time, the task of the yard master was to supervise the loading operations, i.e. the physical control of the system.

Tank truck loading process

The tank truck loading process can be divided into three main parts: entry procedure, the physical execution of the loading operation and permission to exit the site by printing out the necessary accompanying documents (shipping notes, etc.).

ENTRY PROCEDURE

The main task of the entry procedure is to identify the tank truck and the partner(s) whose purchase order is to be loaded. The two elements used for identification are as follows:

- Tank truck cards: magnetic cards marked by rigorously allocated serial numbers, identifying the tank trucks. If the tank trailer and the tractor have different registration numbers, then separate identification cards are issued for each.
- Partner cards: magnetic cards marked by rigorously allocated serial numbers, identifying the customers as partners. Only customers in possession of valid partner cards are allowed to be served.

At the time of entry the tank truck (i.e. logically, the card identifying the vehicle) is assigned to the respective prepared order. Naturally, in the course of the entry procedure all other information, such as the validity of the ADR certificate of the vehicle, is also checked the lack or invalidity of which would prohibit the starting of loading. With the entry permitted, the vehicle may drive inside the site of the tank truck loader, otherwise the system directs the truck driver to the control room operator.

TANK TRUCK LOADING PROCESS

The truck driver selects on the basis of the information board provided at each loading

gantry the bay where all products to be loaded are available. Several safety & loading conditions must be satisfied in order to be permitted to load:

- Preparation for loading in the case of bottom loading:
  - Ground the vehicle using the grounding monitor installed.
  - Connect the overfill protection & emptiness verification monitor. This so-called LIBERTY monitor enables the COTAS system to verify the emptiness of the tank compartment with the main purpose of protecting the product quality, because e.g. gasoline remaining in the compartment may deteriorate the quality of diesel fuel loaded on the next occasion. The second function of the device is overfill protection preventing the spilling of product from the tank compartment during loading, causing thereby loss of product, environmental damage or risk of incidents. Naturally, the tank truck must have this function also implemented. No loading may be started in lack of this.
  - Connect the vapor recovery arm as a precondition of closed-system loading.
  - Connect the loading arms.
- Slide the customer (partner) card through the card reader in order to enable the system to "know" which purchaser order is to be loaded.
  - Select the required products by pressing the product selector buttons.
  - Enter the volume to be loaded on the ACCULOAD keyboard.
  - Start loading.
- Continue repeating the above operations until all compartments have been loaded.
- Finish loading by pressing button LOADING ENDS.
- Disconnect and place into parking position, respectively, in reverse order at this time as done at the time of connecting up, in the sequence of loading arm, vapor recovery arm, overfill protection device & grounding connection all tools used for loading.
- If all interlock conditions have been satisfied, the vehicle is allowed to leave the site of the tank truck loader and drive to the exit zone, otherwise the system will alert the operators by audio and light alarms.
- Upon the occurrence of any discrepancy or problem assistance can be requested from the yard master & control room operator. The cause of the discrepancy or problem can be viewed both in the status line and on the graphic display screen of the COTAS system.

The top loading process is simpler, conditions applicable to overfill and vapor recovery are omitted (as the respective devices do not exist physically in this case).

Exit procedure and print-out of necessary accompanying documents

The exit procedure is a rapid and simple process. The customer (partner) card has only to be slided through the exit-side card reader:

- to exit the vehicle from the system,
- to free the given bay and enable the next loading operation to start,
- to have the shipping note and the accompanying document required by the Excise Act printed. Print-outs are made on concertina paper with automatic page cutting and the paper is containing premade security elements and marked with rigorously allocated serial numbers.

As stipulated by the Excise Act, all devices involved in custody measurement have to be provided with certification documents issued by the National Bureau of Measures (OMH). These devices include: the densitometers, flow meters, temperature instruments (thermocouples) and the ACCULOAD & MFX flow computers themselves. All devices have to be recalibrated & certified at regular intervals specified by OMH, effected in general every year and every two year in the case of ACCULOAD.

It may be stated in general that tank truck loading evolved into a standard process with the implementation of the COTAS system, embracing unified management, unified maintenance principles and calculable operating expenses. In this way the implementation period was completed by 1997 and foundation for the tank truck loading process of today has been formed, although in several steps.

Development of CENTRAL COTAS

Although the COTAS system meant a great advance compared to the manual loading systems, requirements arose very shortly which made further development of the system necessary for the following reasons:

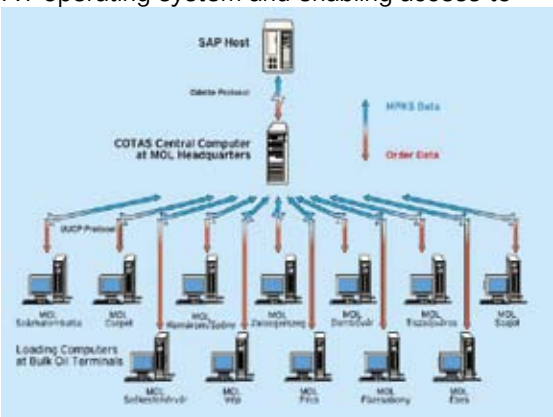
- The management of master data was cumbersome in the COTAS systems operated locally.

- The purchase orders to be managed were received by the depots in paper form (by fax) and had to be recorded in the COTAS systems manually.
- The same data records, such as the registration number of a new tank truck to be loaded, had to be entered as many times as many depots were concerned. The contents of the database at each local site were different.
- The credit lines of customers were difficult to track and manage.
- There was no direct link to the corporate ERP (SAP) system.

The sensible solution was to develop a new operating structure, where the main role was played by a server centralizing the management of master data and operating also as the communication channel between the SAP and local COTAS systems, providing in this way for indirect information flow. This central server was called CCOTAS, i.e. Central COTAS. It had been put into commercial operation from 1998. Figure 6 shows the system structure.

Figure 6. CCOTAS structure

CCOTAS operated on Windows 2000 server, under ORACLE database engine. The system was developed by the specialists of MOL's IS organization and Mess und Fördertechnik. The Multifunctional Cotas Terminals (MFC's) installed at local sites enabled the elimination of the obsolete serial terminals. The MFC terminal is a simple PC running under Windows NT operating system and enabling access to



both the UNIX-based COTAS interface and the client side of the CCOTAS server by terminal emulation. Thus all programs needed for daily work processes could be used from each individual computer.

A further step forward was provided by the two interfaces ensuring duplex data flow between the SAP & CCOTAS systems on the one hand and the CCOTAS & local COTAS systems on the other hand.

The above developments enabled to communicate orders, contracts & master data in online or cyclic flow as well as to transmit tank truck loading (shipping) data to the corporate ERP system on an up-to-date basis.

Invoicing had been carried out at MOL's accounting centers on the basis of certified shipping notes sent by mail from the depots and could take even several days after the actual receipt of goods depending on the length of the mailing route. Since loading data were transmitted through the interface to the SAP system on the day of loading, invoicing became possible on the day following loading, thus the interval elapsing between the receipt of goods and invoicing for the goods could be shortened, and MOL could receive payment for its products on this basis.

No really major development was implemented during the following few years in the COTAS systems, which provided a reliable technical framework in the fulfillment of shipments by tank trucks.

Organizational changes and their effects

New organizational & structural changes occurred in 2004 because of the merger of MOL and Slovnaft (SN) resulting in the formation of a Terminal Operation organization at MOL Group level, incorporating the logistic terminals & depots both in Hungary and Slovakia. Thus the organization of Terminal Operation has been increased by three Slovakian tank truck loading gantries having a similar technological level but operated with a different loading control system in addition to the existing tank truck loading gantries in Hungary.

New development trends and their reasons

As a consequence of organizational changes, a need arose for a unified COTAS system operating in an integrated manner all through the area of group level Terminal Operation, designed to be adequately flexible & automated and capable thereby to reduce further manual

activities and react quickly to changing business demands. This resulted in launching a project in 2005 with the objective of designing a new system.

Naturally, many other reasons – exerting compelling influences on Terminal Operation – existed in addition to the above need, all pointing in the direction of having to develop a completely new system primarily and not patching up the existing COTAS-based system anymore. These compelling reasons include the following ones:

- The Unix-based COTAS system had been initially developed back in the 80's and completed its 20th year of life already in 2004; it could be considered almost an ancient fossil in the past 20 years with the explosion-like evolution in information technology taken into account. The cardinal problem was that the development company, Mess und Fördertechnik Gmbh itself announced that it would not support its systems running on UNIX platform.
- In addition to organizational restructuring, a project aimed at rationalizing the depot /terminal network with the expectable consequence of a reduction in the number of depots – which occurred as well in 2005 & 2006 – and this required all concerned parties to examine carefully whether – after the closing down of earlier plus capacities – the existing COTAS system, not having technical support anymore, would be able to cope with the requirements of the new terminal/depot network.
- The servicing of the PLC & ACCULOAD II units, playing key roles in the system, posed another problem due to the decreasing availability of spare parts and also because the producer(s) of the PLC program ceased to work at Mess und Fördertechnik in the meantime. This had meant a problem even previously, since each modification could be implemented extremely slowly, lead times of 3 to 6 months were recognized as usual.
- With the widespread use of Windows based systems the need for interfaces familiar to users and for standard (SAA) operating systems arose with ever increasing force, and this could not be satisfied by the UNIX system of the age.
- The destruction of the World Trade Center and the subsequent antiterrorism drive effected all areas of life, and consequently modifications were introduced in the ADR regulations applicable to the transportation of hazardous goods. Accordingly, it was not sufficient anymore to verify the ADR compliance of the vehicle but the driver had to be identified as well.
- The magnetic cards used in the system for identification had also became obsolete, their procurement was difficult and the card readers were not produced anymore as well, thus their failure entailed severe consequences in daily operations.

During the investigation of planned development projects it was found that the mechanical and technological elements of the system were suitable for proper longterm operation, thus the control loops, supply pumps and valves need not be replaced. Thus emphasis was placed on the technology of high-level supervision and the control software.

Options taken into consideration for the development project

The primary objective to be achieved in formulating the basic development requirements was that tank truck loading must be maintained as continuous operation, i.e. each modification has to be planned so that they would be carried out during pauses in loading as far as possible or periods entailing the least loss in throughput. Complete shutdown had to be effected for maximum 2-3 days at each depot in agreement with the organizations concerned. This was a fundamental requirement.

The implementation stage was divided into three phases in consideration of the available material resources and the above 2-3 days of system shutdown:

1. Implementation of the vehicle and driver identification system complying with the ADR regulations.
2. Installation of the PLC's and COTAS control software.
3. Installation of the MFX_4 flow computers.

The main phases were shifted in time as well because much work had to be performed over weekends and this was telling on the participants of implementation and also because the users had to adapt to the changes introduced in each phase, plus the defects arising in the course of work had to be managed and rectified.

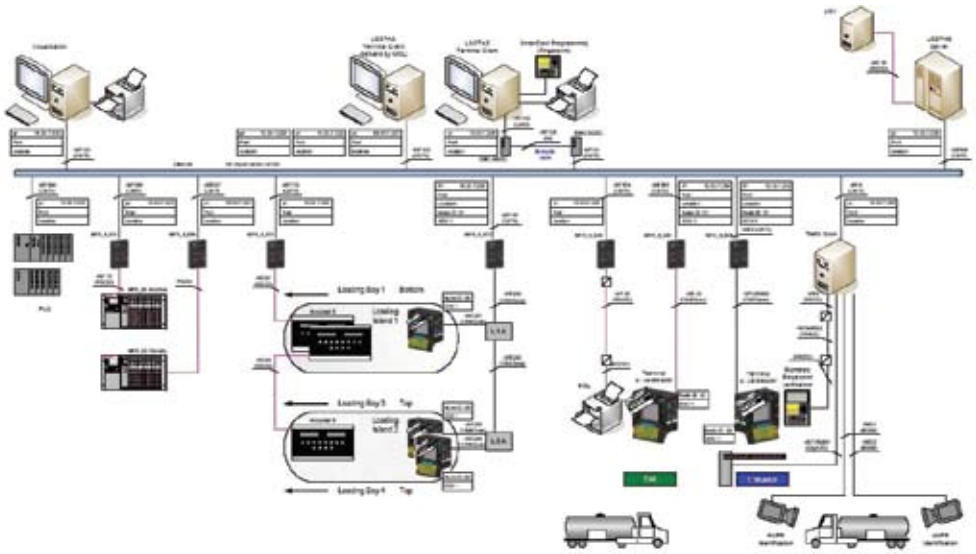


Figure 7. COTAS implementation phases I&II

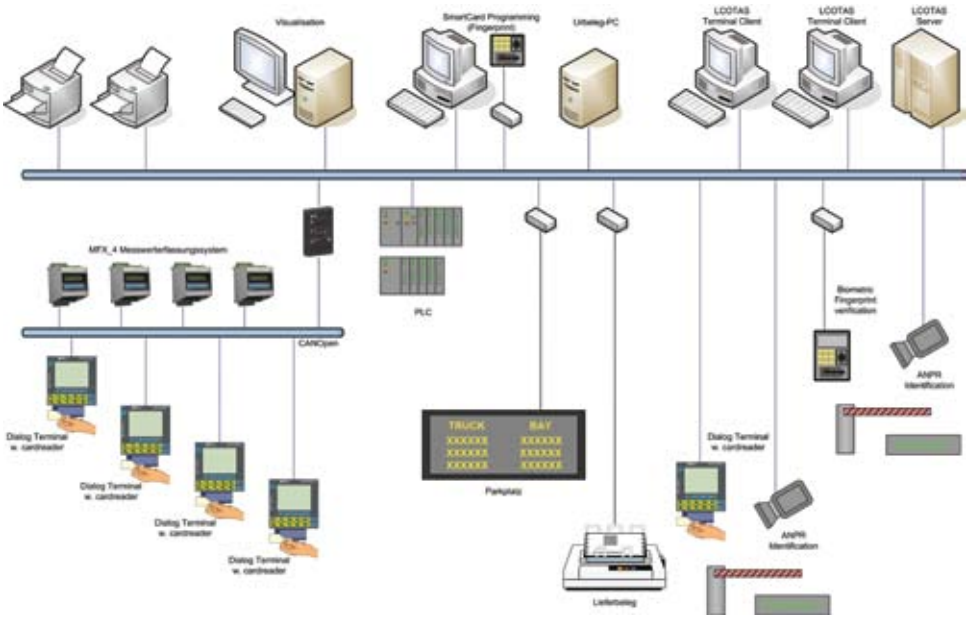


Figure 8. COTAS implementation phase III

Three options were investigated with respect to the replacement of flow computers:

- ACCULOAD II update kit: FMC produced a socalled upgrade kit for improving the ACCULOAD flow computers, enabling the obsolete flow computer to be modified in compliance with the current requirements. The problem was that these devices were still capable of handling only two control loops, i.e. two products. There was no possibility for using several languages and the display screen would have retained its original size.
- ACCULOAD III: The latest FMC controller/flow computer was a significant advance compared to the earlier versions. Its novel appearance and dimensions have also undergone marked changes. It was capable of handling six control loops independent from each other simultaneously, enabling two products and two additives per product to be managed. It was also able to display information in several selectable languages and size of the display screen increased somewhat as well.
- MFX_4: The latest OPC-based series of Mess und Fördertechnik flow computers. Its greatest advantage was that the controller unit and the control terminal had

been separated, thus the installation of a single control terminal in ex-proof zone was sufficient and the socalled controllers could be installed in the control room, therefore the implementation of the system was considerable less expensive than that of the competing products.

Finally, flow computer MFX_4 was selected.

Flow computer MFX_4

Flow computer MFX_4 is the product of Mess und Fördertechnik Gmbh, a company specialized to the controlling of road, rail, barge & airplane loading operations associated with the distribution of petroleum products.

The factory founded in 1968 is a pacesetter today in the oil industry with the design and production of fourth generation measurement & control systems. The latest series MFX_4 flow computer is today already the trademark of the company, although its version MFX_90 earlier by two series has been used in the past 14 years at tank truck loaders for both additive dosing and density measurement.

Features:

- Operation with a single or several products
- Digital or analog valve control
- Configurable inputs/outputs
- Automatic temperature & pressure compensation

Figure 9. MFX_4 controller

Figure 10. MFX_4 terminal

- Graphic display with facilities for presentation in several languages
- Automatic error management
- Integrated event manager and query facilities
- 7-level security management
- CANopen bus communication
- TCP/IP LAN communication
- Serial RS 232/ RS 485/ RS 422 interfaces
- Memory capable to store 200 transactions per counter
- Remote maintenance facilities
- Interface developed for densimeters (frequency or 4-20 mA based, 24 bit)
- Additive dosing management (for max. 16 components)
- Integral ID card reader (transponder or Wiegand)
- PC based features
- MFX_4 Explorer
- Remote diagnostics interface

COTAS system configuration

Although implementation has been carried out in three phases, the completed system is an application covering the entire area of Terminal Operation, which is the largest system of this kind in Europe with the endeavors related to the tank truck loading gantry of MOL Austria at Korneuburg and that of MOL Romania at Teleagd, to be integrated into the system in 2008, taken also into consideration.

While the CCOTAS and local COTAS were software applications operating on different platforms in the previous system, the new system includes only one "single" COTAS running on the central server, called Central COTAS, and the COTAS applications running at the depots on local servers are called Local COTAS.

CCOTAS handles the tasks of the complete master data management and provides for communication to & from SAP and OPM (SN side ERP) to & from LCOTAS as well as for the Logistics Information System (LOGIR).

COTAS is an application running on Windows 2003 server with Oracle 10 based database engine. It is simple and easy to use because of the standard interface and tools.

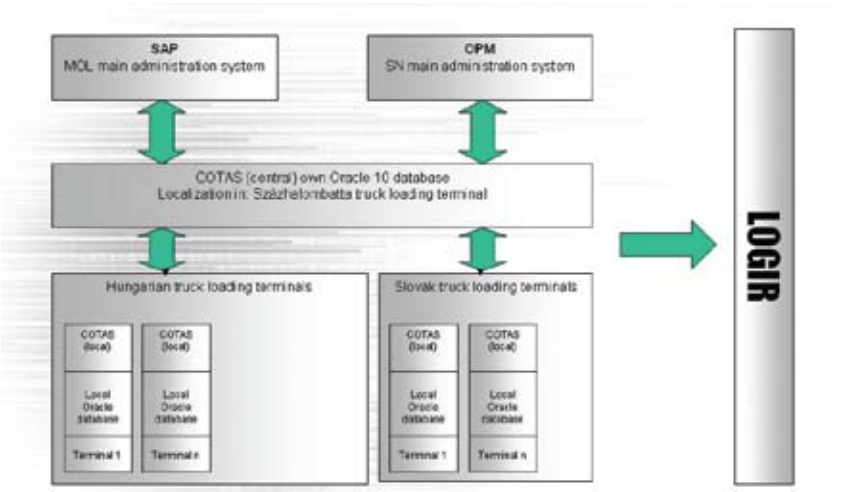


Figure 11. COTAS configuration

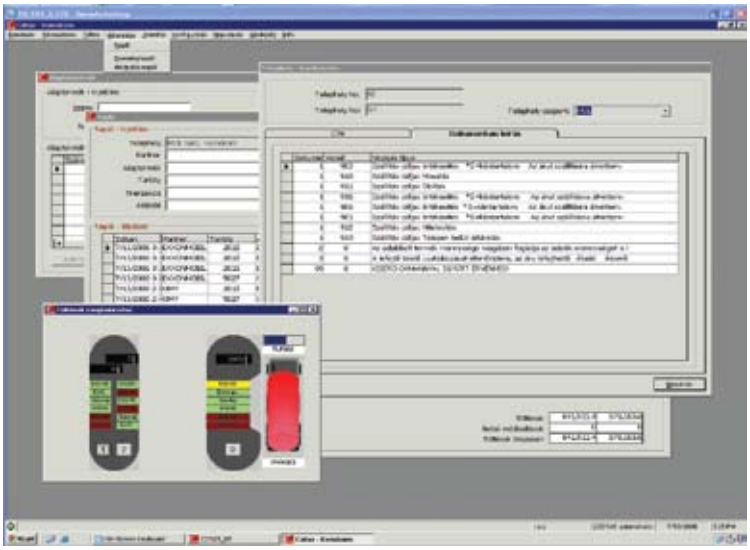


Figure 12. COTAS user interface

Redundancy concept

Failures traceable either to software or hardware problems will occur inevitably in the system, but the intention is to limit shutdowns due to such reasons to the shortest possible duration by all means. For this purpose, CCOTAS is able to take over LCOTAS functions upon an eventual LCOTAS failure with the available server capacity and ensure the continuity of loading at the depot affected thereby. Although this transfer is not automatic, the supervisor concerned is able to realize it within one hour.

Should CCOTAS fail, two possibilities are available: according to one of these, as the server is mirrored on a standby server, transfer is effected to this second server. The other case is where both servers are out of service. The LCOTAS applications remain to functionable even without CCOTAS, but orders have to entered manually, of course, since interfaces are also out of service during such periods.

COTAS replication

The replication process can be divided into two main parts, as described below:

- Each data modification generates one single entry in the course of replication
- A cyclic data transfer, according to which modified data are mirrored at all sites (in all COTAS databases), ensuring thereby the coincident consistency of the system. In order to ensure precise understanding, let's have a look at the following example. If a new tank truck is entered into the

Figure 13. LCOTAS failure

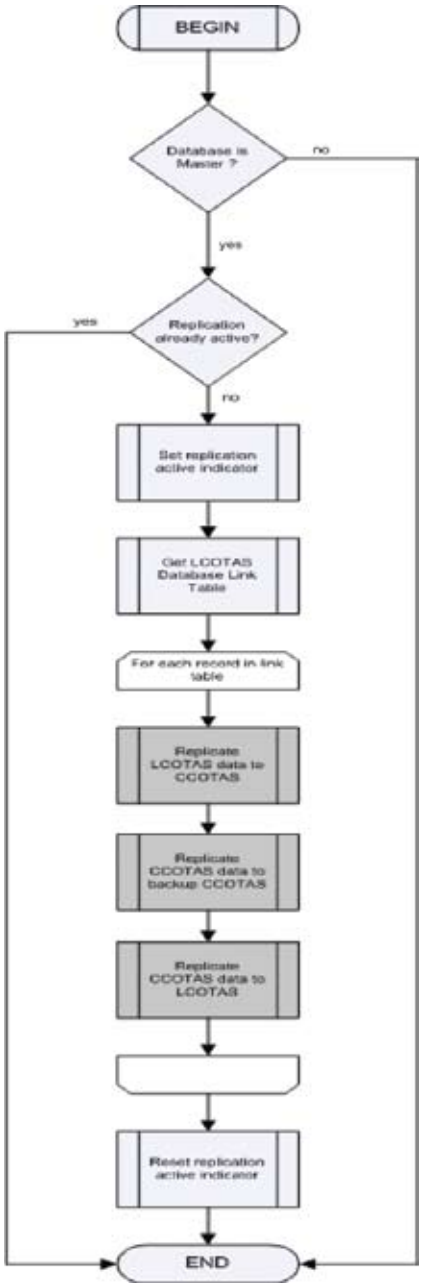


Figure 14. COTAS replication

system at the Pécs terminal, the system records this change in the database as the first step. Secondly, when the cyclic data transfer reaches Pécs, it detects the new record and enters this into the CCOTAS database and then into the local databases of the other depots during the cycle. This is shown in the flow diagram below, illustrating the replication cycle:

Without replication the system would be almost non-functionable, since this facility ensures the homogeneity of the system. Unfortunately, in our experience, the available network resources have proven to be inadequate in many cases, meaning a single WAN fault excludes a depot from the data flow. But the truly serious problem is when the process freezes because of the gradual accumulation of records due to the slowing down of the replication system. This occurs when the response time of the network is too long at some replication point. The replication process attempts to resume cycling, it even receives responses, but it is able to upload and download data only very slowly. Since the cycle will not proceed until all tasks have been performed (this may take even one hour), data will accumulate at all other sites and the process will freeze. In such cases the process has to be restarted on the server and all data will be reprocessed.

Functioning of COTAS system at depots
All business processes have been reviewed in the course of the COTAS design engineering process and have been modified so as to fit the SAP processes better, comply with the OPM and associated operator requirements on the SN side. All loading actions were analyzed and flow diagrams developed from these data. Let's look at the procedure of entry to the COTAS system for example.

The process of tank truck can be divided into two parts, separated physically from each other:

1. Preparation for loading → SAP & OPM events precede each loading operation. These may be orders or shipments. An order contains one product for one customer on the MOL side, while an order may include several products on the SN side. A shipment is associated with a single tank truck and comprises all orders, not more than 10, to be loaded into the particular vehicle.
2. Physical execution of the prepared loading transaction, comprising three steps, then → exit.

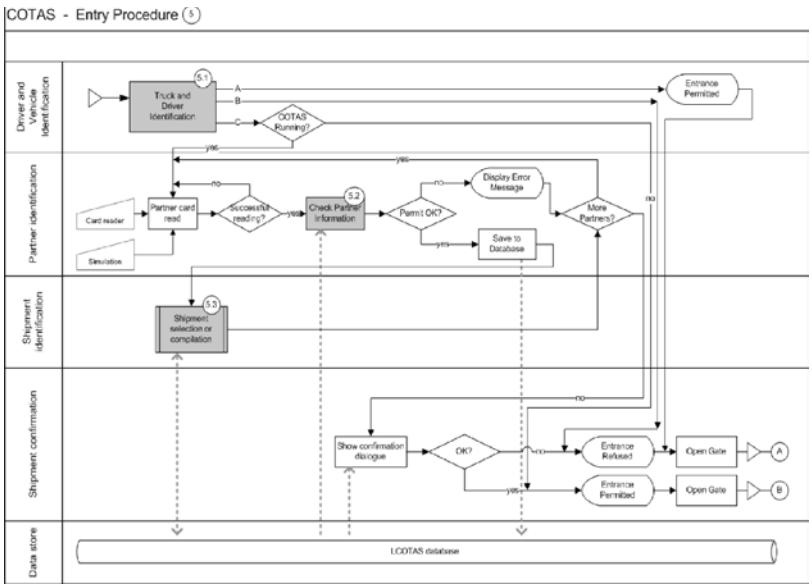


Figure 15. Process flow diagram

COTAS entry procedure

The vehicle as well as its driver is identified in the course of the entry procedure.
Each tank truck driver has an identification card, which is a special proxy card including a 32k memory module, capable of storing all the identification data of the tank truck driver. In the present case this is an identification number derived from the finger print of the tank truck driver. The image of the finger print does not appear anywhere, neither is it stored elsewhere. In the course of the entry procedure the finger print of the tank truck driver is read in every case, his/her identifier is generated from this, and – if both are identical and all other entry conditions are also satisfied – the system authorizes entry. The essential feature of the system is that it prohibits the assignment of the identification cards to other persons. Other entry conditions apply to the validity of the ADR permit, the existence of the annual safety training certificate of the tank truck driver, etc. The vehicle is identified by the automatic recognition of the registration number of the tank truck and the trailer, if any. The registration number recognition system is self learning, it is able to recognize it regardless of its position and is capable also to handle the different letter numeral structures of various countries.

The entry procedure is executed on pylonmounted MFX_4 terminals, each combined with a finger print reader and a card reader. After identification the system requests the data of the customer, the purchase order or the shipment to be entered, in the formulation of which process the primary intention has been to require the tank truck driver to key in the possible minimum information. For this reason the orders or shipments downloaded from the ERP systems appear automatically and can be selected from lists. The system is able to cross-allocate this information logically based on the registration number of the vehicle. The entire entry procedure takes about two minutes. It has to be noted, however, that the registration plates had to be replaced on almost all vehicles in the introduction stage due to the poor reflection coats, but the recognition ration is well above 90% today and the system recognizes the vehicle on the basis of second repeated readings in most cases.

COTAS loading process and exiting

The physical part of the loading process – grounding, overfill protection & emptiness validation, connection of vapor recovery & loading arms – has not changed in its entirety, these tasks have to be completed the same way even today. The real change has occurred in that much more information is displayed on the MFX_4 terminal in comparison to previous versions and communication is possible in the language selected during the entry procedure. Loading is controlled today by tank compartments and all information associated with loaded compartments can be traced back in the database. After the completion of loading exit permission requires the tank truck driver

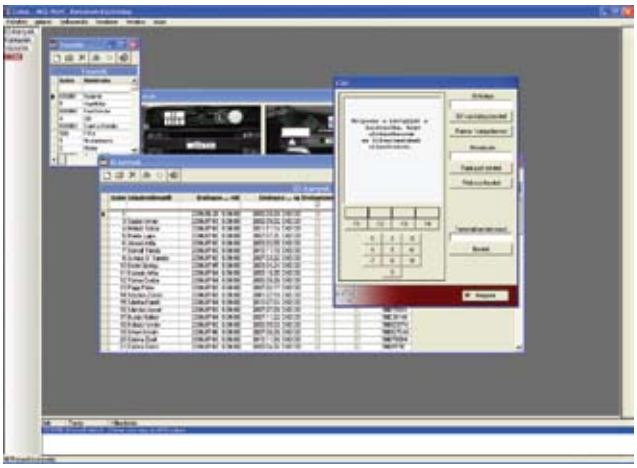


Figure 16 . COTAS Security Module

Figure 17. WinCC display

only to slide a card through the exit terminal. The necessary documents are produced automatically with the use of laser printers today.

Graphic display

COTAS is able to display graphically the entire loading process and provide thereby an accurate picture of loading information and errors occurring in the course of loading to the personnel supervising the loading operations. All loading operations can be tracked from start to end in the sequence of gantry/bay data and control loop.

The various operating modes, such as the connected condition of product loading & vapor recovery arms, grounding, overfill protection, additive dosing system and the data of the counter at the loading by currently in operation. But, naturally, the order and the registration number of the tank truck being loaded can also be seen, thus any problem arising can be exactly located. The event log can be presented both on the display screen and in print-outs.

Revised by: Attila Eichinger

Realization of Energy Efficiency Improvement Project in Solvent Lube Refining Unit

Mrs. Kubovics Klára Storcz (45)
Chemical engineer,
DS Development-Process Engineering
E-mail: kkubovicsne@mol.hu

Alexandra Szűcs (29)
Chemical engineer,
Refining-Chief Technology,
process engineer
E-mail: aszucs@mol.hu

Tibor Karmacsi (39)
Chemical engineer,
Plant Manager,
Baseoil and Wax Production Area
E-mail: tkarmacsi@mol.hu

Abstract

Nowadays the major task is to improve energy efficiency in the Oil Industry. As a high energy consumption unit, we mapped the energy status in Solvent Lube Refining Unit. The main goal is energy and cost savings by thermointegrating conversion.
After we have collected the imperious data within the confines of plant status summing up, reconsidered the heat exchangers' connections by software, developed for thermointegration calculuses, and made suggestions for its realization.
Among the reconsidered heat exchanger connections we chose the most economical and the simplest way carrying out solution by taking into account the quantity of the saved energy.
The chosen heat exchanger connections were subjected to simulating and pre-economical calculuses. As the calculuses certified the effectiveness, the realization was carried out in the Solvent Lube Refining Unit turnaround period, in 2007.
Since the plant started the replicated plant sum up and the economical calculuses certified the success of the project.

Összefoglalás

Napjainkban a kőolajipar egyik legfontosabb feladata az energiafelhasználás hatékonyságának növelése. Mint nagy energia felhasználó üzemben, az OKF üzemben energetikai feltérképezést végeztünk. Célunk volt a hőintegrációs átalakítások elvégzése energiamegtakarítás, és ezzel együtt üzemeltetési költség megtakarítása miatt. Elvégeztük a hőintegrációs számításokhoz szükséges adatok összegyűjtését üzemi állapotfelmérés keretében. Egy erre a célra kifejlesztett szoftver segítségével újragondoltuk a hőcserélő kapcsolatokat, és javaslatokat fogalmaztunk meg a hőintegráció tökéletesítéséhez. Az újragondolt hőcserélő kapcsolatok közül, a maximálisan megtakarítható energia figyelembevételével, kiválasztottuk a leggazdaságosabban, legegyszerűbben kivitelezhető változatokat. Az általunk kiválasztott kapcsolatokat szimulációs és előzetes gazdaságossági számításoknak vetettük alá. Mivel ezek a számítások a megvalósíthatóságot igazolták, az üzemben a 2007. évben történt nagyleállás során az átalakításokat végrehajtották. Az üzem visszaindulása utáni üzemkimérés eredményei a projekt sikerességét bizonyították.

Introduction

Nowadays the major task is to improve the energy efficiency in the Oil Industry. The main aimes are both the energy consumption and the CO_2 emission reduction. For the mentioned reasons it is important to map the high energy consumpting plants in the Danube Refinery and make suggestion for decrease the energy utilization.

Antecedent

The highest energy consumpting part in the Danube Refinery is the Baseoil And Wax Production Area. In 2006 the Solvent Lube Refining Unit's thermointegrational investigation was carried out firstly.

In the last few years the water coolers pluggage became frequent. By reason of the pluggage many bundles were submitted to mechanical cleaning or changing attendant on increasing operational expenses.

In the heat exchangers in the Solvent Lube Refining unit – mainly in the water coolers – scaling was observed. The reasons of scaling are:

- The coolant's fluctuating pH: the protecting effect of the applied chemical agents weren't proper. The effect of the chemical agents is determined by the pH.
- The hydrocarbons' high (180 °C) inlet temperature.

In the case of high inlet temperature there are two solutions against scaling:

- Auxiliary local chemical agent dosage: realization of pH regulation by sulfuric acid dosage system;
- Technological changes by heat exchangers' connections modification; realization of thermointegration

The scaling was decreased significantly but wasn't terminated perfectly by sulfuric acid. Some further changes were necessary to carry out in the technological system for abolishing the scaling.

Scaling on the shell side

Scaling on the tube side

The technological process in a nutshell

The principle:
In the lube oil existing low viscosity index effecting, oxidation stability debasing, higher molecular weighted resinous aromatic compounds are separated by a selective solvent in the extractor.
The selectivity of the solvent can be partway increased by water.
The product is the paraffinic raffinate and the by-product is the extract.
The solvent is recovered by multi-stage distillation.
The raffinate desolventation is carried out by vacuum reboiling and vacuum stripping. The extract desolventation is carried out in two-stage by pressurized reboiling and vacuum stripping. After regeneration the recovered solvent is returned to forward of the process.

Heat integration calculations

Aimed to increase the efficiency of energy consumption, a process integration method based on a new approach that can significantly facilitate the optimization of planning or the selection of the optimal version has been developed in the late 70ies and early 80ies. Drivers of developing the method were ETH Zürich, Leeds University, ICI and University

of Manchester Institute of Science and Technology. The first application and testing for both designing new plants and revamping existing systems were performed at ICI.

Linchoff-March has developed the software for the application of the method.
Above saving a part of energy costs, applying the method offers a reduction of investment costs as well as new plants are designed. Its widespread use is justified by the relatively simple calculation method based on technical data and thermodynamic approach, providing a significantly simplified treatment of the most complex technological systems without affecting accuracy and reliability.

Pinch analyses are based on the exact understanding of heat exchangers and heat flow in the unit. Prior to any heat integration calculation, the preparation of a model simulating unit is required.

During the status survey in the year 2006, technical data of the process were collected, including points that were not provided with automatic gauges. At such locations, temperatures were measured by a manual heat radiation gauge at the inlet and outlet joints of heat exchangers. Stream compositions (such as solvent content in the extract and raffinate phases) required for the simulation calculations were determined from samples by the Quality Control department.

The plant has several operational modes depending on feedstock. The parameters of a frequently applied mode processing domestic middle vacuum distillate were used for the calculations.
The basic simulation model of the Solvent Lube Refining unit was prepared by using the Hysis program.

As our simulation software did not allow to calculate the extractor operating in the unit, two calculations for upstream and downstream of the extractor, respectively, were performed.
In constructing the basic model, the following were considered:

- The bottom product of the extractor contains: the extract discharged from the unit, 95% of the solvent and the added amount of water.
- The head product of the extractor contains: the raffinate discharged from the unit, and 5% of the solvent fed in the column.

Detailed heat exchanger calculations were performed using the geometric parameters of heat exchangers. Heat integration calculations (PINCH analysis) were prepared based on the model described above and using the program SUPERTARGET of the KBC Company.

Considering the flow scheme prior to revamping, the heat exchangers operating in the unit can be grouped as follows:

- Preheating of the feedstock
- Cooling raffinate product
- Heat exchange between columns

This grouping was used in our calculations

PREHEATING OF THE FEEDSTOCK

Simplified connections before and (as proposed) after the revamping are shown in Figure 1. Expected temperature data at processing domestic middle vacuum distillate are indicated on both figures.

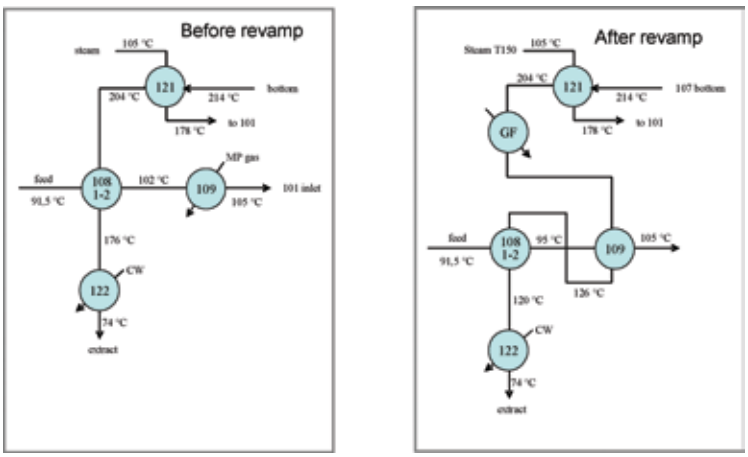


Figure 1. Preheating of the feedstock

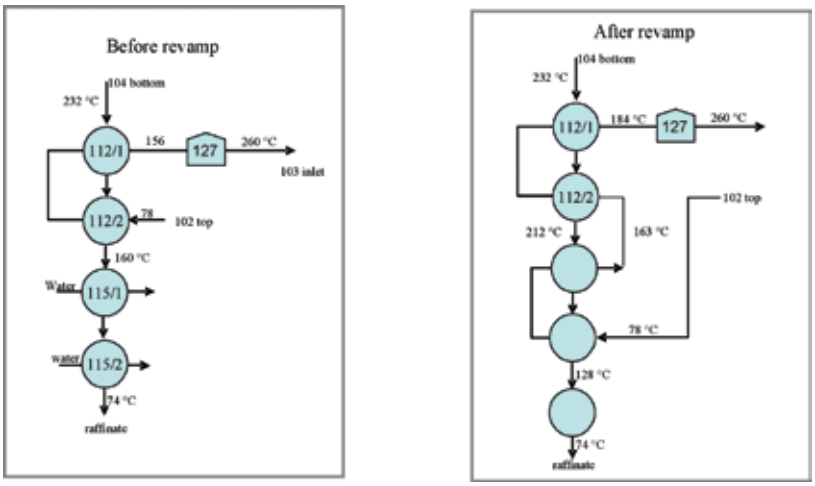


Figure 2. Cooling of the Raffinate

According to the connection before revamping, the extract is cooled to discharging temperature by leading through the heat exchangers as follows:

- 121 heats up steam entering deoxygenizer column 101 to the temperature required;
- 108-1-2 Preheating of the feedstock
- 122 water cooler: experience in the unit has shown, that the temperature of the extract entering the water cooler is 170-180 °C in several operational modes.
- 109 sets in the temperature of the feedstock to the required value (100-105 °C),

Problem: it is applied to heating using middle pressure steam in cases of heat deficiency, or as a water cooler, when the temperature of feedstock inlet is high.

To prevent such problems we recommend the connection shown in Figure, where heat exchanger 121 operates as before, but after it the hot extract is used to generate steam. The extract cooled in this way is led to heat exchanger 109 first, then to heat exchanger 108. The temperature of the extract entering water cooler 122 will be approximately 120°C. Throughput of the steam generator shall be controlled according to the temperature of the feedstock entering column 101.

With the proposed arrangement of the heat exchangers the inlet temperature of column 101 can be set to 105°C, as long as extract yield is not less than 20%.

The dimensions of steam generator were determined considering the operational mode with the highest extract yield (processing Urals vacuum distillate). On this basis, 150-160 m^2 (water on the tube side) or 200-250 m^2 (water on the shell side), respectively, heat exchanging surface is required.

With reconnecting the heat exchangers as described, the middle pressure steam used in heat exchanger 109 can be saved, and cooling water consumption in cooler 122 can be reduced. Depending on operational modes, generating low pressure steam is an option.

COOLING OF THE RAFFINATE

Simplified heat exchanger connections before and (as proposed) after the revamping are shown on Figure 2.

Before the revamp, the head product of extractor 102 is led through heat exchanger 112-2-1 and cools the solvent-free raffinate from column 104, then it is heated to the required temperature by the furnace 127. From heat exchangers 112-1-2 the raffinate enters water coolers 115-1-2 at about 160°C, according to the operating experience.

Based on our calculations, installing a heat exchanger with 200-250 m^2 surface as shown on the figure above, the bottom product of column 104 can be cooled to 120-128 °C, then to the discharging temperature (75-80 °C) by a water cooler having 100-130 m^2 surface. This increasing of surfaces enables a heat reduction in furnace 127 by 20-25%.

HEAT EXCHANGE BETWEEN COLUMNS

In this part of the unit, the removal of solvent and water from the extract leaving column 102 is performed.
A simplified flow scheme of the division before revamp is shown on Figure 3.

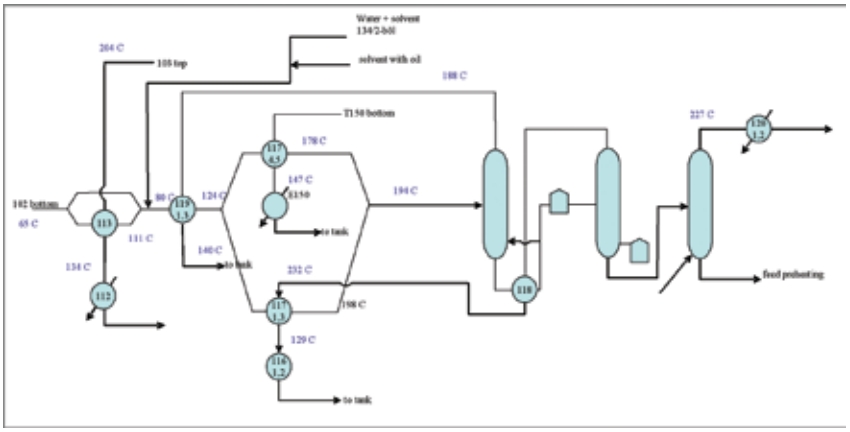


Figure 3. Connection at removal of solvent and water from Extract before revamp

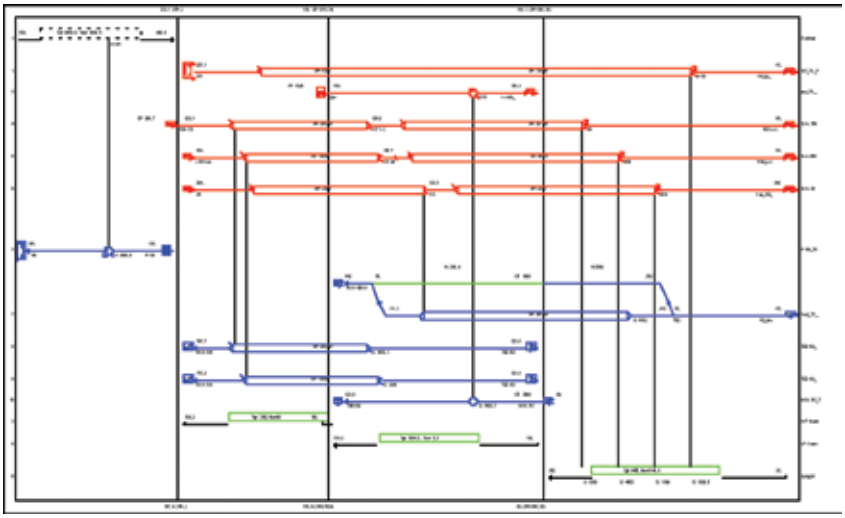


Figure 4. Process diagram

More streams in the division are led through a water cooler:

- The head product of column 107 (above 200°C) to condenser 120-1-2
- The bottom product of column T150, after heat exchangers 117-4-5 (at 145-150°C), to water cooler E-150
- Recovered solvent, after heat exchangers 117-6-2-1-3, to water cooler 116-2

In these cases, high hydrocarbon inlet temperatures resulted extensive scaling in the heat exchangers.

In the division studied, the bottom product of extractor 102 is the only stream that requires heating. This heat exchange was performed by process streams even before the revamp, without the consumption of external energy.

Using the SuperTarget program, a network diagram (Figure 4) and a composite curve (Figure 5) have been prepared and the extent of reachable energy saving has been determined.

It is clear from the composite curve, that further energy saving in this division can be achieved only by converting the cooling energy usage (by steam generation).

In our study, our aim was to find revamping options, that require no or minor changes of the existing preheating line, but the inlet temperature of the streams entering the water cooler is not higher than 130-140°C.

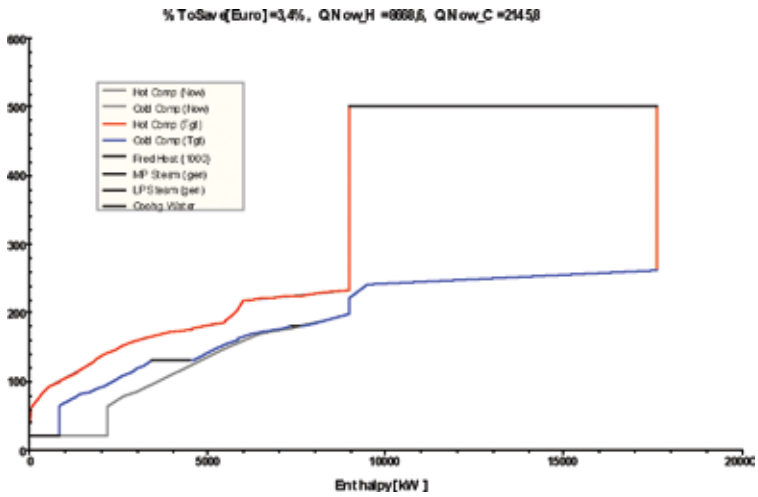


Figure 5. Composite curve

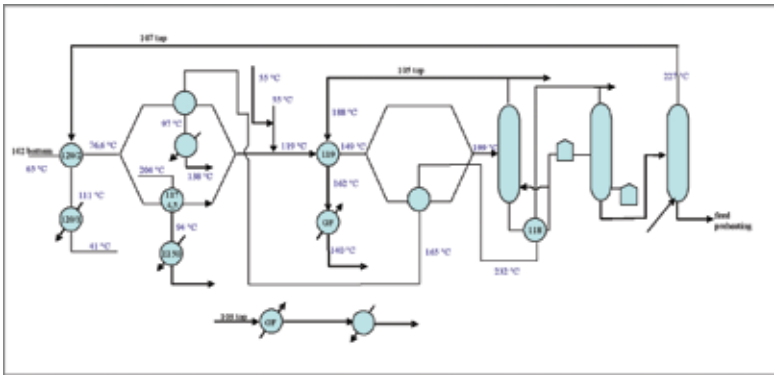


Figure 6. Heat exchanger connection after revamp

Head product of column 107 and bottom product of column T150 are the streams that require cooling in any case.

More versions were studied to solve the problem.

In analyzing the various versions our aim was to achieve the maximum saving of energy with the minimum modification of the existing heat exchanger line.

In the heat exchanger connection presented in Figure 6, the reconnection of existing heat exchangers and installing several new heat exchangers and steam generators provide the reduction of inlet temperatures of the streams entering water coolers to the required level, as well as an option to generate low pressure steam.

Modifications required to establish the connection as proposed:

- Cooling the head product of column 107 is performed in water cooler 120-1, after preheating the bottom product of the extractor in heat exchanger 120-2. Inlet temperature of the head product of column 107 to water cooler 120-1 is 111°C. Installation of a new heat exchanger is not required.
- Heat exchanger 113 is replaced by heat exchanger 117-4-5, where the bottom product of column T150 can be cooled to 90-95°C, then it can be further cooled to the required temperature.
- A new heat exchanger with 340-350 m^2 surface (similar to 117-4-5) is installed in the by-pass of heat exchanger 113, where head product of column 106 arriving from heat exchanger 117-1-3,-6 is cooled. Outlet temperature is 97-100 °C, and can be cooled further in water cooler 116-2.
- Function and location of 119-1-3 heat exchanger is not changed, it cools head product of column 105. Outlet temperature after revamp will be 160-165 °C, higher as compared to the 140°C prior to revamp. If the temperature of the stream is higher even after a heat

exchange, than discharging temperature, then it can be further cooled by steam production. Required heat exchanger surface is 100-120 m^2.

- Function and location of heat exchangers 117-1-3,-6 are not changed. As a result of modified heat conditions, the temperature of the head product of column 106 is 160-165 °C. This is the stream that will be involved in the preheating of bottom product of the extractor by the installation of a new heat exchanger.
- The stream of column 103 head product is excluded from the heat exchanging connection. Being a pure solvent vapor stream, its usage to steam generation is reasonable, as it can be completely condensed under the operating conditions. Required heat exchanging surface is 95-100 m^2. Heat exchanger 113 is suitable for the task.

The heat exchanger connection described above was controlled for feedstocks with high extract yields, as well.

Energy savings that can be achieved by the described modifications in the 3 divisions of the unit processing domestic middle vacuum distillate are compiled in Table 1.
Energy consumption data for the unit depend on the operational mode.

Based on the data of processing domestic middle vacuum distillate, energy savings and steam generation for other operational modes were estimated.

On the solvent-free extract line between the equipment 121 and 108-1-2 a new stream generator and the previously used water/steam cooler/heater equipment 109 were built in. In addition to regulate the temperature of feed a three-way control valve was built in. In case of hot feed the extract is directed to the steam generator and its heat content is utilized for steam generating. In case of feed preheating the steam generator is by-passed. In this way the extract's heat content is utilized for feed preheating.

2. The reconstruction of the raffinate cooling In the raffinate cooling loop assisting water coolers 115-1-2 were converted to heat exchangers. By this method the solvented raffinate is preheated better before the furnace 127, and by the way the unsolvented raffinate's temperature is decreased better before the water coolers.

3. The reconstruction of the solvent recovery heat exchanger line The extractor's 102 bottom product preheating is performed on the condensator 120-2 – previously water condensator – in place of equipment 113. The equipment 113 can be converted to steam generator. The efficiency of preheating can be intensified with installation of two further heat exchangers or rather regrouping the series connected heat exchangers. By this method the extractor top product's heat content can be utilized for steam generating besides preheating.

	Saving MP steam kg/t feed	Generation LP steam kg/t feed	Saving fuelgas kg/t feed	Saving Cooling water m^3/t feed	Usage of Condense m^3/t feed
Preheating of feed	2,81	17,62		1,09	-0,018
Cooling of Raffinate			1,14	0,98	
Heating bottom of column 102		42,8		2,3	-0,043
Total	**2,81**	**46,19**	**1,14**	**4,3**	**-0,060**

Table 1. Process diagram

Construction

The performed technological and pre-economical calculuses accounted for the realization of the suggested reconstructions:

1. The reconstructions of feed pre-heating and extract cooling

After the decision in December 2006 the plan and construction were effected within the bounds of the Refining Energy Efficiency Improvements Project 1. phase.

The Design Engineer selecting competitive tender was won by the TRILAUS Ltd. in February 2007. By the selection the capital aspect was to resolve the most economical

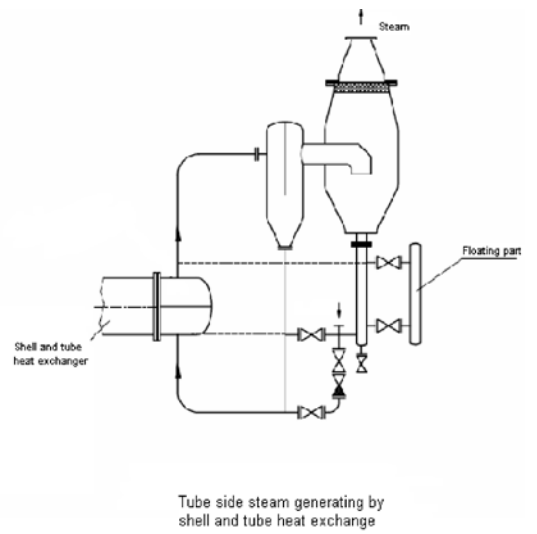


Figure 7.

equipment installation. Simultaneously we started the mapping of the disused but utilizable equipment in the Refinery's stalled units. The reasons were both the measure of expenses and time keeping as the new equipment supply was doubtful as far as the turnaround in 2007.

TRILAUS Ltd took part in equipment selection. By the designer's suggestion shell and tube heat exchangers were installed as steam generators instead of ordinary shell side steam generator. This shell and tube steam generators were completed with special two-stage steam demister. As it was not usually practice in technical process for the proper operation the tube side had to be modified. This new steam generating method illustrated on the Figure 7.

As the surface size was proper the equipment 113 was converted to steam generator with a completion of a steam demister and a stub relocation. In addition two more shell and tube heat exchanger (142; 143) were selected for steam generating function and further two equipment were for solvent-solvented extract heat exchanging function (117-7-8).

In case of converting the equipment 120-2 to heat exchanger, the pump 303 had to be changed as the new expanded system's hydraulic resistance calculuses showed. The technological calculuses accounted for the adequacy of two-way heat exchanger. In case of two-way heat exchanger the pump change was not needful. As this method seemed to be more economical the four-way heat exchanger was converted to two-way heat exchanger.

Equipment reconstructions were carried out forasmuch as the new apparatuses and the altered function ones were not proper for the technological tasks.
Five of the new and altered function equipment had new or renovated bundles. The new bundles – after multi-stage discussion – were produced by UNIWATT Ltd. The covers, return bands and the steam demisters were produced by PANTECH Ltd.

In the course of unit reconstruction four new control loops (steam generators water level controls, feed temperature control), two areal gauges at the battery limits (generated steam and utilized feed water quantity, pressure, temperature), and fourteen new thermometer loops were built in.

The reconstructions had an effect on the extractor bottom discharge. In place of the previously existing two bottom discharge arms only one remained. The remaining bottom discharge arm's instrument was changed as the measuring range was not proper for the task. After specification the new instrument's purchase was started in April 2007.

The architectural, mechanical (TRILAUS Ltd.), and the instrumental plans (PROCOPLAN Ltd.) were ready by June 2007. Subcontractors (PANTECH Ltd., PETRO-SZER Ltd., TOMÉPSZER Ltd.) started to work in July 2007. The new systems were built out under operation. The construction of continually operating system were carried out in the term of the unit turnaround in august 2007.
The new system has had no technical problems since the restart in August 2007.

Evaluation of the project

Since the unit has started a replicated plant summing up was carried out for the sake of the economical evaluation.
The unit has several operational modes. 2006 annual operational mode distribution was assumed for the energy utilization estimation in 2008.

Feed changes and swills were taken into account in hours. Additionally the plant stagnations and circulations, the feed input decreases were assumed equal or less for year 2008 than it were in 2006.

In the course of data collecting, three kinds of plant statuses were predestined for the simplified comparison:

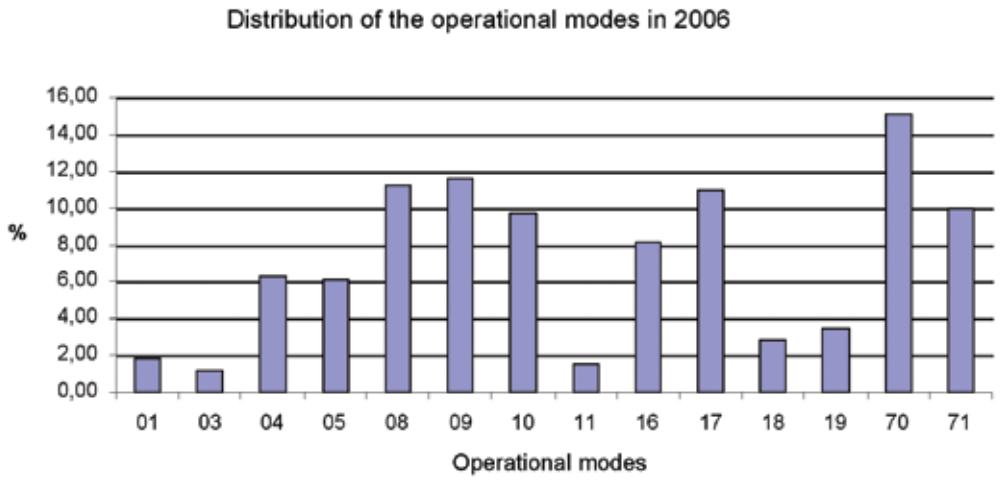


Figure 8.

1. Previous status of reconstruction: the furnace was heated by both fuel oil and fuel gas.
2. Previous status of reconstruction: the furnace was heated exclusively by fuel gas. For the reason of preparing the turnaround the fuel oil system was closed and cut off in advance.
3. After reconstruction when thermointegration has already been existed.

In the course of unit summing up the following data was taken into account:

- The given operational mode depended feed, in tons
- The quantity of product, in tons
- The quantity of by-product, in tons
- The given charge processing time, in hours
- The quantity of fuel oil for processing the given charge, in tons
- The quantity of fuel gas for processing the given charge, in tons
- The quantity of 10 barg steam for processing the given charge, in tons
- The quantity of 2 barg steam for processing the given charge, in tons
- The quantity of coolant for processing the given charge, in cubic meters

Further two data was taken into account after the reconstruction:

- The quantity of the generated steam by processing the given charge, in tons
- The quantity of the utilized feed water by processing the given charge, in cubic meters

In view of the operational modes distribution in year 2006 and yearly energy consumption specifics referred to feed the production data for the year 2008 can be estimated.

Being conscious of the current energy expense specifics, the unit's total utilized energy expenses for year 2008 can be estimated.

Being aware of the total capital investment and the utilized energy expense differences between in year 2006 and 2008 the return on investment (ROI) can be estimated. At a rough estimate the ROI is a short period, around a year.

Revised by: István Rabi

Processing of crude oils transported via Adriatic pipeline

Zoltán Varga, Dr. (39)
Chemical engineer MSc., Ph.D.
MOL Group/Refining and Marketing Division/DS Development
E-mail: ZoVarga@mol.hu

Mrs. Németh Márta Kovács (41)
Chemical engineer MSc
MOL Group/ Refining and Marketing Division/Refining Quality Control
E-mail: MNKovacs@mol.hu

Borkó János (59)
MOL Group/ Refining and Marketing Division/Production – Base-oil Production/ AV1, AV2 and V4 Unit
E-mail: jborko@mol.hu

Marton Zsolt (34)
Chemical engineer MSc
MOL Group/Refining and Marketing Division/Refining Chief Technology
E-mail: zsmarton@mol.hu

Abstract

This paper summarizes the results of the processing of Syrian Light, Siberian Light and CPC Blend crude oils being transported via Adriatic pipeline. Qualities of the obtained products are presented. Properties of the obtained products (sulphur, nitrogen, aromatic and metal content) were better than those of the REB, except for the high sulphur content of the naphtha's of CPC Blend. According to the yield structure the Siberian Light seems to be the best selection. Processing of these crude oils was trouble free at the AV2 unit.

Összefoglalás

A cikk összefoglalja az Adria csővezetéken beérkezett Syrian Light, Siberian light és CPC Blend kőolajok feldolgozása során nyert eredményeket. A termékek minőségi jellemzői (kén-, nitrogén-, aromás- és fémtartalom) alapján megállapították, hogy azok jobbak, mint a REB kőolajból előállított termékeké, kivéve a CPC Blend kőolajból nyert benzin, mert annak kéntartalma a legnagyobb volt az összes vizsgált benzin közül. A hozamstruktúra alapján a legjobban felhasználható kőolajnak a Siberian Light tűnik. A vizsgált kőolajok feldolgozása problémamentesen megvalósult a Dunai Finomító AV-2 üzemében.

1. Introduction

Diversification of the crude oil source of the MOL Plc. and the possibility of partial replacement of Russian crude oil for optimizing the crude oil pool led to the decision to processing crude oils transported via the Adriatic pipeline.

Three different types of crude were bought, pumped and processed in the second half of 2007. Namely, Syrian light, Siberian light and CPC Blend. These crudes were processed in the Atmospheric/Vacuum distillation-2 unit of the Danube Refinery.

The aims of this paper are to summarise the experiences of the processing, comparing the product yields and properties. However, the selection, purchasing and transportation processes were not covered.

2. Results and discussion

2.1. CRUDE OIL PROPERTIES AND THE YIELD OF PRODUCTS

Properties of processed crude oils are summarised in Table 1 and yield of products is shown on Figure 1. Data of Table 1 show that the density of crude oils transported via Adriatic pipeline is lower than that of REB is and figure is similar to the viscosity. One of the important parameters regarding to processability of a crude oil is sulphur content. Comparing this property it can be seen that the non-REB

crudes contain significantly less sulphur than that of the REB. It is advantageous from the aspect of the HDS of products.

Nitrogen content influences negatively the HDS and catalytic conversion processes, too. Lower nitrogen content of non-REB feeds is beneficial from this aspect. Heavy metals have detrimental effect on the activity of catalysts of refinery processes. Data show that the nickel and vanadium contents of CPC Blend, Syrian Light and Siberian Light are lower than those of REB are. It means that the non-REB crudes are better from this aspect.

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, g/cm³	0.8190	0.8389	0.8458	0.8643
Kinematical viscosity, @20°C, mm²/s	3.897	7.234	7.698	12.7
Sulphur content, %(m/m)	0.58	0.84	0.63	1.39
Nitrogen content, mg/kg	700	1002	1316	1631
Water content, %(m/m)	0.05	0.05	0.05	0.05
Sodium content, mg/kg	0.9	1.2	1.0	1.3
Nickel content, mg/kg	3	7.6	6.8	11
Cooper content, mg/kg	0.03	0.03	0.03	0.03
Vanadium content, mg/kg	5.5	11	11	31
Iron content, mg/kg	0.03	3.3	2.9	13

Table 1. Properties of crude oils

Light<CPC Blend. The highest yield of naphtha was obtained in case of CPC Blend. Yield of kerosene of REB and Siberian Light was similar. Practically it was no difference in the yield of kerosene of Syrian Light and CPC Blend and these values were a little bit higher than those of the former crude oils.

The yield of gas oil changed in the following order Syrian Light<REB<Siberian Light<CPC Blend. Considering the highest attainable production of diesel fuel the best selection is the CPC Blend then the Siberian Light. In point of the yield of waxy distillates it can be seen that the highest value was obtained being processing of Syrian Light. The yield of waxy distillates was slightly lower in case of feeding Siberian Light, but this value exceeds that of REB is. Yield of waxy distillates was the lowest for CPC Blend and this value was significantly lower than that of REB is. The higher yield of waxy distillates will be advantageous after the

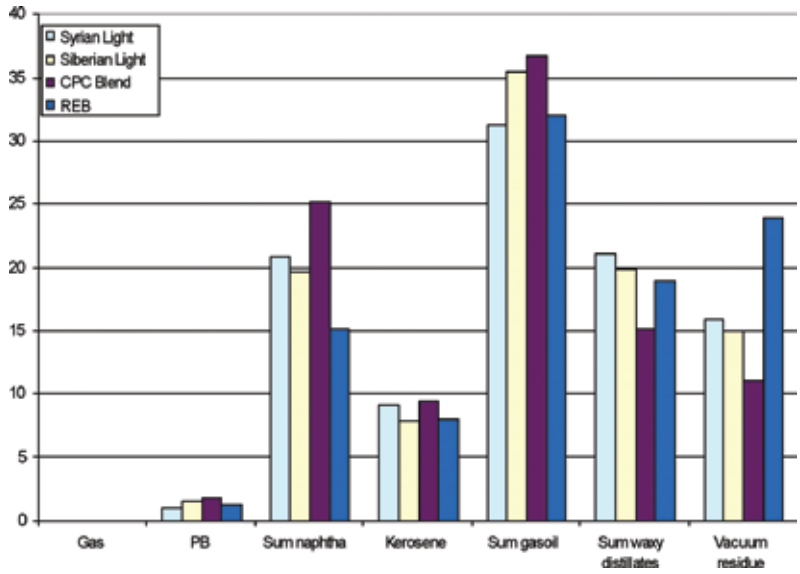


Figure 1. Yield of products of processed crude

Figure 1. shows the yield of products of the processed crude oils. The yield of fuel gas was similar in case of each feed. Comparing the PB yields it can be seen that it was little difference in this parameter for the crude being processed. The total yield of naphtha increased in the following order REB<Syrian Light<Siberian

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m³	676.1	679.2	685.9	682.0
Sulphur content, mg/kg	600	38	16.7	104
Nitrogen content, mg/kg	0.2	0.4	0.9	n.a.
PIONA, %				
n-paraffiin	38.43	37.31	37.16	39.14
iso-paraffin	40.15	40.09	34.64	36.05
naphthene	18.57	19.00	25.44	22.71
aromatics	2.69	3.57	2.73	2.11

Table 2. Properties of light naphtha products

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m³	738.5	740.7	742.3	739.1
Sulphur content, mg/kg	1300	84	41.5	214
Nitrogen content, mg/kg	0.2	0.4	0.4	n.a.
PIONA, %				
n-paraffin	26.08	24.9	24.86	27.23
iso-paraffin	35.62	32.73	29.27	37.44
naphthene	22.92	31.4	36.30	25.52
aromatics	11.24	10.52	9.50	8.30
olefins	2.74	-	-	-

Table 3. Properties of middle naphtha products

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m³	743.2	741.8	741.9	746.2
Sulphur content, mg/kg	1600	130	72.2	371
Nitrogen content, mg/kg	0.5	0.4	0.2	n.a.
PIONA, %				
n-paraffiin	24.42	23.71	23.57	25.79
iso-paraffin	35.17	30.86	27.21	33.37
naphthene	23.83	33.2	38.96	22.16
aromatics	13.55	12.08	10.20	13.58
olefins	1.97	-	-	-

Table 4. Properties of heavy naphtha products

hydrocrack unit comes on stream. Considering the aggregate yield of gas oil and waxy distillates the results showed that the Siberian Light seems to be the best selection.

The yield of vacuum residue of non-REB crude oils was significantly lower than that of REB is. These values were similar in case of processing Syrian Light and Siberian Light crudes and the lowest for the CPC Blend.

2.2. PROPERTIES OF PRODUCTS

2.2.1. Naphtha products

Properties of light, middle and heavy naphtha products are summarized in Table 2-4. On the basis of these data we would like to highlight some interesting results.

As it can be seen the sulphur content of naphtha products of CPC Blend is significantly higher than the other naphtha's despite this crude contained the lowest sulphur. About half of the sulphur of naphtha products of CPC Blend being in mercaptan form which negatively influences the corrosion properties of these products and increase in the hydrogen consumption of the naphtha HDS. Results also show that the sulphur content of products of Syrian and Siberian Light crude was lower than that of the REB was which is advantageous either using them for fuel production or for petchem naphtha.

In point of the hydrocarbon composition of the naphtha products the following can be stated. The middle and heavy naphtha of CPC Blend contained olefins which is not common in the straight run naphtha fractions. Considering the PIONA analysis of the light naphthas it can be seen that the less naphthenic and most paraffinic one was that processed from the CPC Blend. One of the revealing parameters of the reforming feed is the N+2A content. This parameter changed in the increasing order for both middle and heavy naphtha products:

REB (42.1 and 49.3) < CPC Blend (45.4 and 50.9) < Syrian Light (52.4 and 57.4) < Siberian Light (55.3 and 59.4). This shows that the most applicable products are those were processed from the Siberian Light crude.

from CPC Blend, Syrian Light and Siberian Light is lower than that of REB is. Lower aromatic content of gas oil means higher cetane number because the aromatic compounds have bad ignition characteristics. Additionally, lower aromatic content results lower hydrogen

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m^3	823.2	823.8	832.9	831.9
Sulphur content, %	0.30	0.27	0.16	0.53
Nitrogen content, mg/kg	<0.5	12.3	5.7	17
Aromatics, %	21.2	22.4	19.8	25.6
mono	14.9	15.2	14.0	16.6
di	6.2	7.1	5.7	8.0
poly	0.1	0.1	0.1	1.0
Pour point, °C	-28	-23	-30	-25

Table 5. Properties of light gas oil products

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m3	855.2	852.1	853.1	864.0
Sulphur content, %	0.6	0.57	0.49	1.04
Nitrogen content, mg/kg	156	191	158	236
Aromatics, %	25.3	26.6	22.4	35.9
mono	15.8	16.3	14.6	21.4
di	7.6	8.2	6.1	10.4
poly	1.9	2.1	1.7	4.1
Pour point, °C	6	6	0	-2

Table 6. Properties of heavy gas oil products

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m3	874	866.3	871.3	880.8
Sulphur content, %	0.86	0.69	0.62	1.39
Nitrogen content, mg/kg	283	237	279	330
Aromatics, %	29.9	30.4	32.4	39.7
mono	17.2	17.6	19.6	23.0
di	9.5	10.3	11.5	13.7
poly	3.2	2.5	1.3	3.0
Pour point, °C	13	3	6	6

Table 7. Properties of vacuum gas oil products

2.2.2. Properties of kerosene and gas oils

The measured properties of kerosene products of non-REB crude oils (e.g. sulphur and aromatic content, freezing point) satisfied the requirements of JET A-1 product.

Properties of light, heavy and vacuum gas oils are summarized in Table 5-7. Comparing the quality of the light gas oils it can be stated that the sulphur content of products of non-REB crudes is significantly lower than that of REB is. Lower sulphur content results in less strict process parameters for the HDS to obtain same sulphur level or increase the feed rate at unchanged technology parameters. Similarly, the aromatic content of light gas oils processed

consumption during the hydroprocessing. The pour point of the products varied in a relatively narrow temperature range.

Comparing the properties of heavy and vacuum gas oil it can be said that the sulphur content of non-REB products is significantly lower than that of the REB is. Presumably, these products can be desulphurised more easily e.g. lower temperature and pressure which results longer life of the applied catalysts. Data of Table 6-7 also shows that the aromatic content of products of crude oils transported via the Adriatic pipeline is considerably lower than that of REB is. On the one hand, it is advantageous for the quality of the products,

because less aromatics mean higher cetane number. On the other hand, from the aspect of further processing the products since it results in lower hydrogen consumption during the hydroprocessing. Additionally, the aromatic compounds due to competitive adsorption hinder the desulphurisation reactions, too.

2.2.3. Properties of waxy distillates

Properties of the waxy distillates are summarized in the Table 8-9. Data shows that the sulphur content of products of non-REB crude oils is significantly lower than that of REB is. Accordingly, these products can be processed at less strict process conditions in the HDS unit. Additionally, the lower sulphur content of the waxy distillates is advantageous for the production of base oil, too.

The UOPK factor is correlated with the hydrocarbon composition of the crude oil fractions. Values of UOPK vary in range of 12.5-13 for paraffinic distillates, 10.5-12.5 for naphthenic distillates and lower than 10.5 for highly aromatic distillates. On the basis of this characterisation the obtained products were naphthenic. Values of UOPK showed that all products were applicable as FCC feed.

2.2.4. Properties of residue oil fraction (MOP) and vacuum residue

In regarding of properties of residue oil fraction (MOP) of the processed crude oils the following can be determined. The sulphur content of these fractions varied in the range of 1.20% and 1.48%, these values were lower than that of REB is (1.94%). CCR values of MOP products of non-REB crudes (1.02-1.25%) were less than the typical value of REB product (1.8%), too. Asphaltene content of products were similar to that of the product of REB crude is. Considering the nickel and vanadium contents of products it can be stated that the MOP fraction of CPC Blend, Syrian Light and Siberian Light contained significantly lower quantity from these heavy metals.

These results show that the quality of MOP fraction of non-REB crude oils are better than that of REB is from the aspect applying them either as HDS feed blending component or base oil feed.

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m^3	893.9	885.8	895.6	903.2
Sulphur content, %	1.04	1.04	0.88	1.63
Nitrogen content, mg/kg	614	567	687	842
Aromatics, %	32.1	-	-	41.6
mono	18.7	-	-	23.1
di	7.3	-	-	12.2
poly	6.1	-	-	6.3
UOPK	11.809	11.797	12.036	11.821

Table 8. Properties of light waxy distillates

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m^3	899.0	896.7	899.9	915.2
Sulphur content, %	0.9	1.06	0.85	1.60
Nitrogen content, mg/kg	690	793	919	1255
Aromatics, %	31.5	-	-	44.1
mono	17.9	-	-	24.0
di	7	-	-	12.0
poly	6.6	-	-	8.1
UOPK	11.816	11.830	12.046	11.831

Table 9. Properties of middle waxy distillates

Property	CPC Blend	Syrian Light	Siberian Light	REB
Density, @15°C, kg/m3	911.3	911.0	916.1	930.6
Sulphur content, %	0.99	1.15	1.02	1.76
Nitrogen content, mg/kg	1015	1215	1496	1767
Aromatics, %	36.8	-	-	46.1
mono	18.3	-	-	22.7
di	8.1	-	-	10.8
poly	10.4	-	-	12.6
UOPK	11.867	11.813	12.065	11.805

Table 10. Properties of heavy waxy distillates

Properties of vacuum residue of crude oils transported via Adriatic pipeline suggested that these products can only be applied as delayed coker feed. Because their viscosity, asphaltene content, softening point and penetration were lower than those of REB vacuum residue. The lower sulphur, vanadium and nickel contents, and CCR value of vacuum residue of non-REB crude oils are advantageous for using these products as delayed cocker feed.

2.2. OPERATIONAL EXPERIENCES

The most important result of the processing of Syrian Light, Siberian Light and CPC Blend crude oils are that the AV2 unit is capable to process light crudes with trouble free operation. Bottlenecks being arisen during the processing were solved or can be solved with minor modifications.

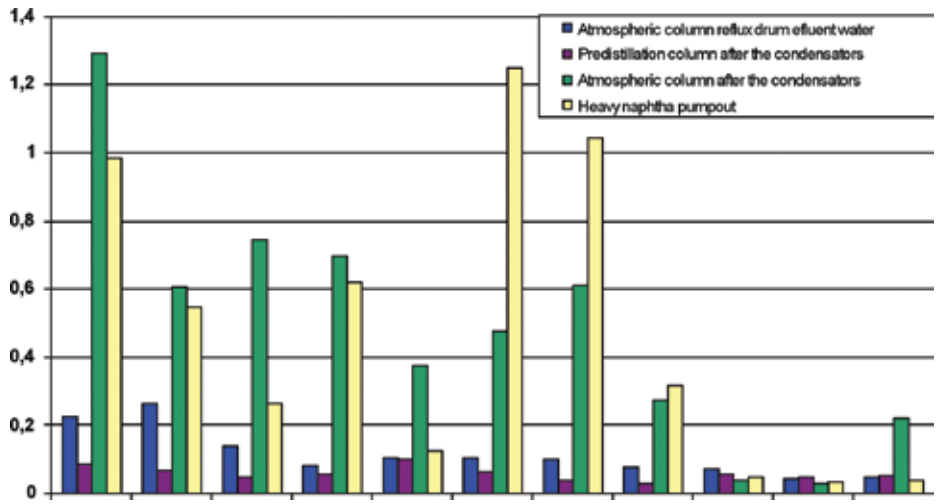


Figure 2. Corrosion rate in 2007 – AV2 unit

2.3. CORROSION OF THE CRUDE OILS

In every month we measure the corrosion rate in all the AV units. These measurements are made in four different places in the units. The results show us the desalting efficiency and the crude oil corrosivity.

As a matter of course we measured this corrosion rate during the processing of the light crudes also. The records can be seen on the Figure 2. and comparable with the previous records (first half of the 2007).
The change is very positive, the corrosion rate is much lower all the places in the case of lighter crude oils comparing to REB crude.

3. Summary

Our paper summarized the results of the processing of Syrian Light, Siberian Light and CPC Blend crude oils being transported via Adriatic pipeline. The processing of these crudes was trouble free at the AV2 unit. According to the yield structure of the crude oils the Siberian Light seems to be the best selection. Properties of the obtained products (sulphur, nitrogen, aromatic and metal content) are better than those of the REB, except the high sulphur content of the naphtas of CPC Blend. The advantageous properties (e.g. hydrocarbon group distribution, low heteroatom content etc.) of the different crude oils would be utilized better in the whole technology line of the refinery in the future.

Revised by: István Rabi

Lubrication Fluid Management

Marek Hatala (34)
Rotating machine specialist
Maintenance Management Department SN
E-mail: marek.hatala@slovnaft.sk

Abstract

The goal of my study is improvement of current Lubrication Fluid Management (LFM) in Slovnaft Refinery by application of LFM software (LFM SW) tool and its integration into the existing Integrated Monitoring System of Rotating Machines (IMSRM).
The result of my proposal is to achieve operating costs saving by the increase of rotating machines reliability and achievement of maximum lubrication oil operating hours during its lifetime under the condition of keeping oil quality and reliability of the rotating machines. Oil quality should be kept in the range of oil parameters defined by oil manufacturer with monitoring and controlling method of lubricant (lubrication oil or grease) filling, refilling, changing or oil treatment (e.g. oil deep mechanical particles and water external filtration).
Proactive lubrication management is rapidly emerging as one of the most important contributions you can make towards improved machinery reliability. Combined with other condition monitoring technologies, such as our existing IMSRM (vibration and bearing status analysis), it provides a complete picture of machine condition and lubricants. Simultaneously this method provides us reliability increment (MTBF) of rotating machines. Machinery and lubrication oil life are prolonged and problems are prevented from occurring in the first place.

Összefoglalás

A proaktív kenésgazdálkodás hamarosan az egyik legfontosabb olyan rendszerként fog elterjedni, amelynek segítségével a berendezések megbízhatóságát hatékonyan növelni tudjuk. Összekapcsolva ezt a létező, integrált forgógép-felügyeleti rendszerünkkel – IMSRM (rezgésdiagnosztika), teljes képet kapunk a berendezésről és a benne használt kenőolajról. Ez a megoldás a forgógépek megbízhatóságának növekedését (MTBF) és az üzemeltetési költségek csökkenését biztosítja azáltal, hogy a kenőolajat a maximálisan megengedett ideig használjuk, az olaj minőségének megőrzése mellett, annak teljes élettartama alatt.

Introduction to Lubrication Fluid Management (LFM)

Lubrication Fluid Management and Monitoring System of Rotating Machines include assigning appropriate machine criticality and maintenance philosophy, optimizing lubricant selection, change and sampling frequency, improving contamination control methods, and storage and handling practices. Applicable maintenance philosophies may include breakdown, preventive, predictive, or proactive. Optimizing lubricant selection as well as change and sampling frequencies, results in the proper lubricants being used to maximize machinery and lubricant life. Minimized purchase, storage and handling, and related costs are additional benefits to proper lubrication selection. After the appropriate lubricant has been selected, controlling both solid and liquid contamination represents the next most important factor in optimizing machinery and lubricant life.

Scheduling of lube oil sampling and lube oil analysis is an important part of an overall machinery condition monitoring program, LFM. One of the key elements of a successful oil analysis program is determining the tests (specially tailored for each rotating machine) that should be performed and their periodicity on the basis of rotating machine criticality.

The primary purpose of oil analysis is to prevent machine damage due to machinery lubrication failures resulting from oil that has degraded or become contaminated. In other words, the oil analysis validates the oil condition to determine if the oil can continue to be used or if corrective

action is required. For an oil analysis program to be successful, it is vital that the appropriate tests be performed. Not performing all the necessary tests can result in lube oil problems being missed that could lead to a sudden machine failure. The tests that need to be performed vary depending on the machine and the severity of the service.

The first step in understanding lube oil analysis is to understand the role of lube oil in rotating machinery. The primary purpose of lube oil is to prevent wear between mating surfaces and cooling function of these machine parts. Secondary purposes include preventing corrosion, scavenging debris.

The second step in understanding lube oil analysis is to understanding how lube oils degrade in service, and what harmful effects can occur as the oil deteriorates. Oils typically degrade due to oxidation, thermal decomposition, and/or contamination.
As a result, oil degradation is normally a consequence of excessive temperature, accumulated water, or ingress of other contaminants.

Current status of lubrication oil monitoring in Slovnaft refinery

LUBRICATION OIL ANALYSIS
Quality of lubrication oil filling applied into rotating machine oil system is monitored and controlled with responsible employee of production unit by system of sampling and analysis of related oil samples. Lubrication oil analysis of related oil samples is ordered by them through OPM part TRIBO (see Figure below), where it's necessary to define data for oil analysis as follows:

- Type and scope of oil analysis,
- Tag. No. of oil sample,
- Type of sample (TRIBO),
- Date and time of oil sampling,
- Place – Production unit, Tag. No. of rotating machine.

Requirements on LFM software tool

LFM SW tool functions, which are required:

a) Import of lubrication oil analysis results from OPM database of Slovnaft laboratories (or others) and their automatic evaluation by comparison with original oil parameters of related lubrication oil. Original lubrication oil parameters, which are used in Slovnaft, should be saved in database (library) of LFM SW tool. This function makes work with oil analysis results easier and evaluation of these data become automatic. Final evaluation and decision is performed by production unit employee.

b) Alarm Function of LFM SW tool. If any of the results of oil analysis is out of defined original oil parameters range, the system has to generate alarm. Alarm notification will be sent to responsible production unit employees by email or SMS immediately. They have to do remedy action, which solves and eliminates the problem.

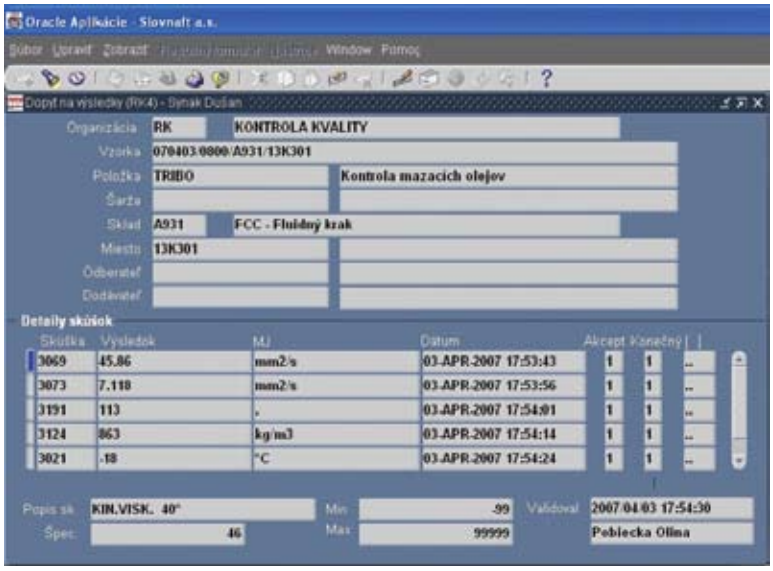


Figure 1. OPM Tribo

c) LFM SW tool has to enable work with oil analysis results by usage of graphical tools as are creation of graphs, trends of oil parameters changes during the time. Possibility to mark of events directly to the trend as are e.g. change or adding of lubrication oil filling, external filtration, overhaul, etc.
d) Scheduling of lubrication oil sampling and creation of labels to marking of the oil sample bottles.
e) Distribution of alarm notification messages. Notification function is required LFM SW tool function, which ensures distribution of email or SMS messages. Messages should contain information regarding current degradation of lube oil quality. This email, SMS message should be distributed to responsible employee, who have to do remedy action immediately. It means that they have to solve and eliminate the problem .
f) Time management of lubricants filling and refilling in case of "time controlled" lubrication system.

Integrated Monitoring System of Rotating Machines (IMSRM)

Main part of Slovnaft IMSRM is System 1 software platform of Bently Nevada. System 1 directly connects all on-line local monitors of rotating machines of production plants through dedicated optical net into one IMSRM. System 1 provides us real-time optimization of equipment and selected processes, condition monitoring, and event diagnostics. System 1 contains main tools such as:

- monitoring function – Data Acquisition,
- diagnostic function – diagnostic tools,
- expert tool – Decision Support with Rule paks for each category of rotating machines,
- sophisticated Alarm management - Event Manager,
- notification function – Notification Manager,
- direct connection with CMMS (Computerized Maintenance Management Systems),
- bidirectional communication with DCS system – process operating data of rotating machines and ESD.

The System 1 platform provides this capability for the assets that drive our process.

The System 1 platform enables operators, equipment engineers, process engineers, instrument technicians, and diagnostic specialists to quickly identify, evaluate and respond to important events to optimize the business impact. This increases equipment availability and reliability, and reduces maintenance costs.

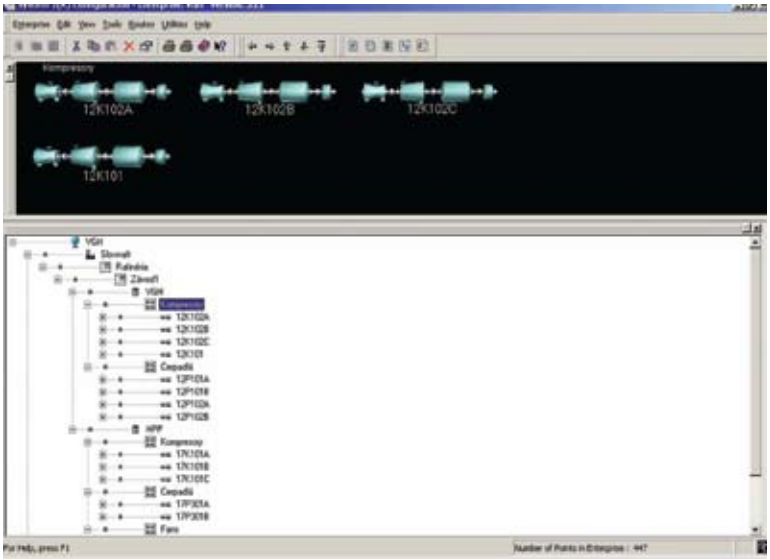


Figure 2. IMSRM

LFM SW tool integration into Slovnaft IMSRM

We know that vibration and lube oil analysis represents two primary methods used to monitor rotating machinery health. LFM SW tool integration provides us possibilities for:

a) Integration of these two systems creates a complex system, which provides IMSRM user complete data for evaluation and analysis – diagnostic of rotating machines mechanical run. On the other hand diagnostic of rotating machines mechanical run and evaluation of their operating parameters to explain us its influence on lubrication oil quality.
b) Usage of IMSRM existing database structure tree of rotating machines. This database was configured in accordance with structure of production units rotating machines. Likewise usages of existing IMSRM interface with the CMMS system.
c) Usage of IMSRM notification function and existing distribution list of responsible production unit employees for distribution of email or SMS messages, which should contain information regarding current degradation of lube oil quality. Notification function is one of the basic functions of S1 as IMSRM software platform.

It is possible to achieve the increase of operating reliability and availability of rotating machines by diagnosing the data provided by both integrated systems.

Proposal of Lubrication Fluid Management realisation

This proposal takes into consideration the targets and laid down requirements on LFM by me, which are solve by optimal way on the basis current situation. Likewise my description of proposed solution is aimed only on one alternative of possible LFM solution, which is less problematic from integration point of view into Slovnaft IMSRM.

A. USAGE OF BENTLY LUBE AS LFM SW TOOL

Bently LUBE is a software tool for monitoring and managing lubrication oil quality. This software is fully compatible with S1 software platform of Slovnaft IMSRM. It means that it is possible to directly install the Benly LUBE into S1 (basic SW platform of IMSRM). This kind of integration provides us also synergy effect that Bently Lube can use existing structure tree database of rotating machines of Slovnaft IMSRM. These properties provide us many advantages.

Bently LUBE provides us:

a) Import of lubrication oil analysis results from OPM database in MS database format and their automatic evaluation. Evaluation of the lubrication oil analysis results is possible to do on the basis of:
   - comparison with original oil parameters of related lubrication oil, which is archived in Bently LUBE library (library contains data about over 1800 kinds of the lubrication oil).
   - comparison with lubrication oil sample (etalon), which was taken during the change of complete oil filling (from new oil filling).

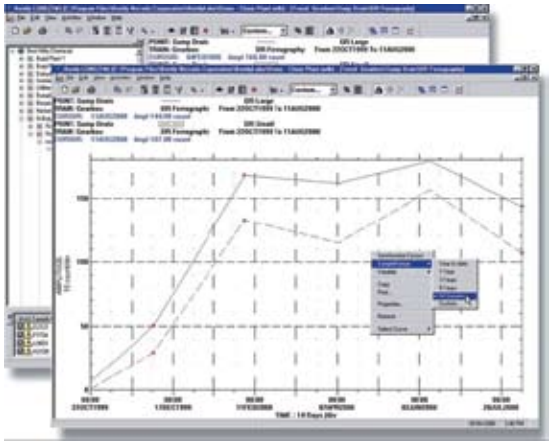
   If any of the results of oil analysis is out of defined original oil parameters range the system will generate alarm.
b) Bently Lube provides work with oil analysis results by usage of graphic tools as are creation of bar graphs, trends of oil parameters changes during the time (see pictures below). Anyway the Bently LUBE fulfil requirement of events marking as are e.g. change or adding of lubrication oil filling, external filtration, overhaul, etc. directly to the trend.
c) Scheduling of lubrication oil sampling and creation of labels to marking of the oil sample bottles.
d) Notifications function of Bently LUBE. Bently LUBE as part of S1 can use S1 Notification function to distribution of alarm email, SMS, which should contain current significant information regarding degradation of lube oil quality. This email, SMS message should be distributed to a responsible employee who has to do remedy action immediately. It means that they have to solve the problem and eliminate it.

B. SAMPLING POINTS OF LUBRICATION OIL SYSTEMS

The sampling points of lubrication oil systems are not standardized by manufacturers of rotating machines. It means they are not identical from the point of view of:

- kind of sampling point,
- placement of sampling point.

Generally the sampling point (sampling valve) is placed on lubrication oil tank of rotating machine



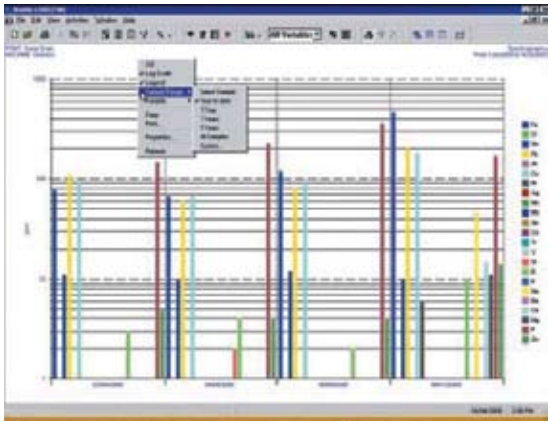


Figure 3., 4. Trends of oil analysis results

oil system, but sometimes this solution does not provide sampling of proper oil sample.

One of the LFM targets is unification of lubrication oil systems sampling points. Unification includes the placement and type of lubrication oil sampling points. The best placement for lubrication oil sampling point is place on lubrication oil upstream and downstream of oil filter (before and after oil filter – pressurized side after oil pump, see picture below). This solution provides us with

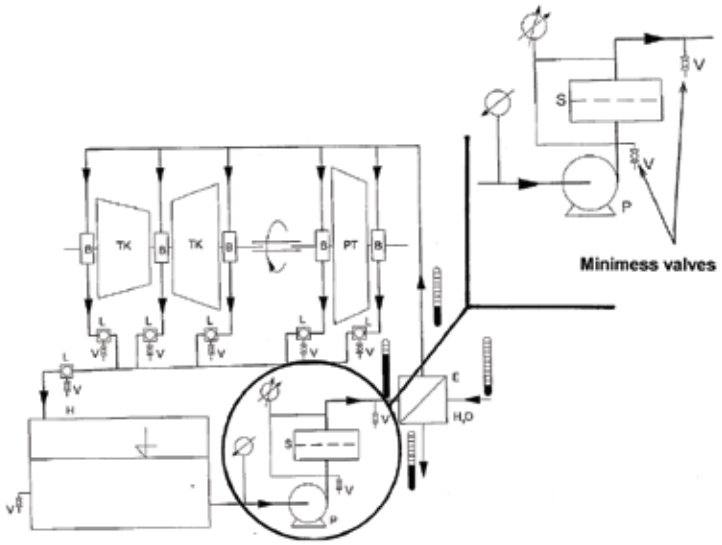


Figure 5. Lubrication oil system equipped with Minimess valves

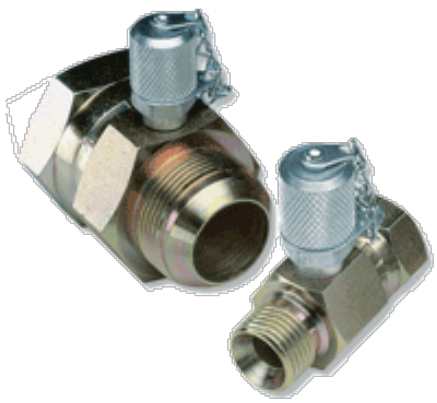


Figure 6. Minimess valves

the oil samples before and after oil filtration, but of course more important is sample before oil filtration, which is in correspondence with lubrication oil filling quality in the oil tank.

The proposal related to oil sampling points is to use the Minimess valves as sampling point (see on the picture below). This kind of valves is designed only for oil sampling and diagnostic. In Slovnaft we have some applications of this kind of the sampling valve on lubrication oil systems of critical rotating machines with good experience.

Trought the use of unified sampling points components (valves, etc.), it is possible to achieve cost saving.

Conclusion

The LFM system can provide us operating cost saving and safety increases by:

- lubrication oil change in the oil system of rotating machines on the basis of current oil quality evaluation and not on the basis of equipment service hours,
- increment of rotating machines reliability and availability,
- unification of sampling points.

Integration of LFM into the existsing IMSRM creates possibilities for:

- complex system of simultaneous evaluation and diagnostic of lubrication oil quality, mechanical and operating condition of rotating machines in IMSRM.
- The folowing synergy effects as follow:
  - software compatibility of LFM SW tool with System 1 as SW platform of IMSRM,
  - usage of IMSRM existing database structure tree of rotating machines,
  - usage of IMSRM notification function and existing distribution list of responsible production unit employees for distribution of ALARM email or SMS messages.

References

[1.] Bently Nevada System 1 – Brochure and Datasheet
[2.] Bently Nevada Bently Lube – Brochure
[3.] Catalogue information of Minimess Valves

Revised by: Mr. Gerard Zima

The method of the lubrication audit and the experiences of it. Implementation of Lubrication Management System in MOL Group refineries

Zsuzsanna Nagy (47)
University of Heavy Industry, Miskolc,
Mechanical engineer
University of Veszprém, tribologist engineer
Tribologist, MOL-LUB Ltd.
E-mail: RneNagy@mol.hu

Zoltán Vaskó (29)
University of Miskolc,
Faculty of Mechanical Engineering,
Specialisation of Information Engineering
University of Miskolc, Faculty of Economics,
Specialisation of Economic Management
Tribologist, MOL-LUB Ltd.
E-mail: zvasko@mol.hu

Abstract

Lubricant audit means a special focus on the correspondence between lubricants and their usage. In these surveys lubricant producers expose their customers to the current situation and give them improvement proposals in an audit report. After a successfully performed lubricant audit this solution can be extended with a higher level service, support of Lubrication Management System software. This can make the daily routine work of the maintenance staff easier and gives the possibility for the management to create reports from the software database. The implementation of LMS software contributes to the reduction of the total cost of the operation and the downtimes coming from the failures of machines meanwhile the operational safety will be increased.

Összefoglalás

A kenőanyag audit a kenőanyagokat és azok felhasználására vonatkozó kapcsolatokat vizsgálja. Ezekben a felmérésekben a kenőanyagok gyártói vázolják a felhasználóik számára az aktuális helyzetet és a kenőanyag auditot lezáró jelentésekben fejlesztési javaslatokkal szolgálnak. Egy sikeresen lezárt kenőanyag auditot követően magasabb szintű szolgáltatás nyújtható a felhasználóknak a Kenésgazdálkodási Szoftver bevezetésével. Ez a szoftver megkönnyíti a karbantartást végző személyzet napi munkáját, illetve a vezetőség számára lehetőséget nyújt különböző lekérdezések elvégzésére. A szoftver bevezetésével elérhető, hogy a teljes működési költség és a meghibásodások következményeként fellépő állásidők lecsökkennek, és az üzembiztonság megnövekszik.

Introduction

Most of the companies have to face the fact that the competition situation on the market requires the continuous development of the products and the manufacturing processes by including the procurement of new equipment and machines, improving the efficiency of the existing ones or keeping the functionality of older machines in everyday life. If these tasks are performed without co-ordination and control, the results can be the following: increasing the number of used lubricants, more difficult administration processes with higher level of stocks, etc. These facts will increase the total cost of the operation and maintenance.

How can a lubricant supplier help the customer's everyday activities?
Audit means an evaluation of a system or a process. The aim of an audit is to clear up the validity and reliability of information and also give an assessment of a system's internal control.

How this definition will be modified if we think of a special type of audit, so called lubrication audit?
To summarize the meaning of this expression we can say that lubrication audit has a special focus on the correspondence between lubricants and their usage. After this survey we expose our customer to the current situation (with methods of SWOT analysis – to show strengths, weaknesses, opportunities and threats in their operation and production processes) and give them improvement proposals as an audit report. We execute the required tasks with close cooperation with the customer's specialists after the management decision.

After a successfully performed lubricant audit we can offer our customer a software support solution which is called LMS software. This way the daily routine of the maintenance staff is rendered easier and the management has the possibility to create reports from the software database. The LMS, discussed in this paper, is based on the audit information collected in 3 Refineries of MOL Group. Currently the audit is in progress in TVK and inside the production process of MOL-LUB Ltd.(hereinafter: MOL-LUB) while a specialist team is working also on the implementation of this system in the Slovnaft Refinery. There were prepared successful audits previously at many regional key customers of the Lubricants Division by MOL-LUB's experts.

1. Lubricant audit in practise

In most of the cases the lubricant users ask the lubricant supplier to do this audit process with their technicians in order to realise potential cost improvements. The main emphasis is on the consideration of the real situation, understanding and acceptance of the necessity of the required changes. The co-operation requirements among the different fields of operation can be seen in Figure 1.

All these fields have their own aims, in line with the corporate strategy, as follows:

- Logistics: the proper lubricant should be available in proper quantity and quality, at a proper place and in time.
- Procurement: minimum stock level of lubricants, lower level of stock financing; lower administration costs (more efficient and more simple).
- Maintenance & Operation: instead of Run-to-Failure Maintenance a new Condition-Based Maintenance can be implemented that will be the base of Reliability Centred Maintenance; operation safety is increasing and downtimes are decreasing.
- Information Technology: nowadays information has become one of the most important resources to reach economical results. The more information we have the less cost we need to run our processes. But it is not enough to have many pieces of information, we have to use and manage them successfully.

How can these fields co-operate with the others in this audit process?
As we could see, each field has individual aims and they have to make compromise with the others. If we want to perform audit processes successfully we have to harmonize these aims.

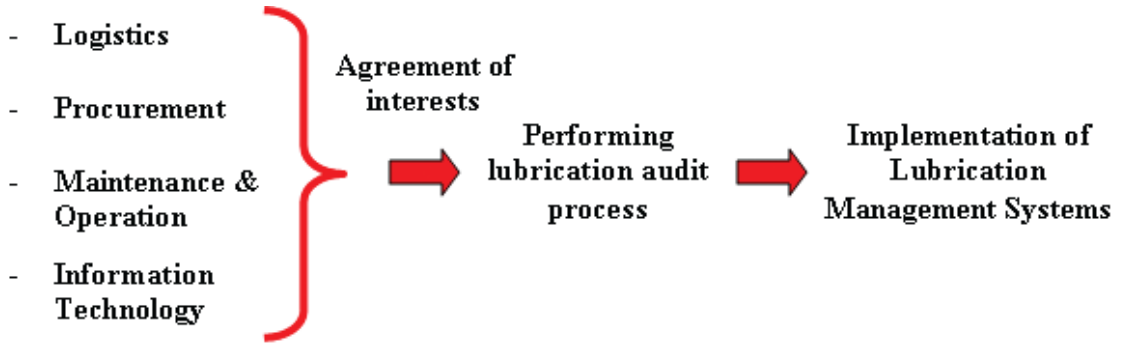


Figure 1. Co-operation among individual fields in the audit process

2. The most important steps of audit and LMS implementation process

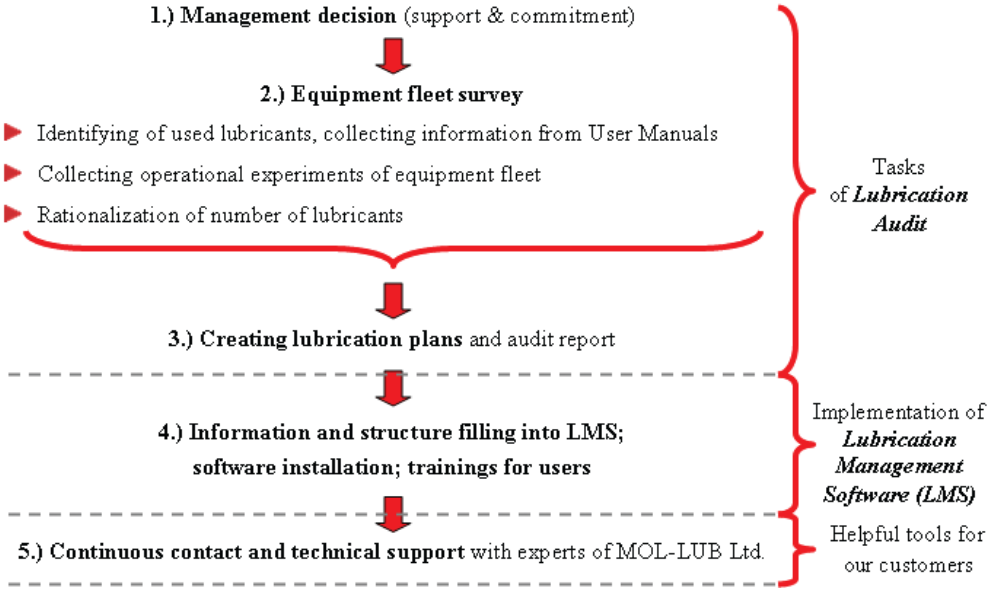


Figure 2. Main steps of audit and implementation of LMS

Figure 2. shows the most important steps and tasks of lubricant audit and the implementation of the Lubrication Management Software. These are the following:

- Management decision: lubricant audit cannot be effectively implemented without engagement and support of the relevant management. During the audit there are lots of data and information to work with and the most important task of the management is to create professional teams, plan the detailed work and to overcome the difficulties.
- Equipment fleet survey: after this decision the start of survey can be launched with the customer's specialists. For the planning of the audit and collecting information, the following has to be executed:
  - creation of a central team with lubrication and operational experts (from the customer and the contractor company as well);
  - at a big company it is necessary to divide the plants into smaller production units;
  - preparation of the list of the currently used lubricants, estimation of the quantity of the required lubricant;
  - grouping the lubricants by types;
  - creation of the preliminary implementation plan of audit;
  - definition of lubrication points, collecting all relevant information about lubricants based on the operational manuals;
  - collection of operational and maintenance experiments;
- Creation of lubrication plan and audit report.
  - The most important part of audit is the creation of decision proposal for each machine. This proposal needs to be based on an agreement with experts of customer and supplier, operator of equipment. The practical form of lubrication plans have to be the same that required at the implementation of LMS software. This is a well-structured Excel-sheet.
  - After the survey and creation of the lubrication plans, one of the most important tasks has to be done by the auditors. This is the preparation of a process evaluation document, the so called lubricant audit report. This is prepared for each of the production units. Audit report contains the actual condition of equipment fleet, efficiency of tasks focused on lubricants and use of them.
- Filling the information and structure into LMS software; installation; trainings for users.
  - After an approved report the implementation of LMS software can

be started. Implementation has to be done together with customer's experts. LMS software usage must be trained which can help the customers in their daily routine connection with lubricants.

- Continuous contact and technical support with experts of Lube Division.
  - If all these steps are successfully performed the connection between the customer and us will not be closed, it will be stronger than before. We can provide them more efficient help in the future because we have a lot of useful information about their equipment fleet and processes.

3. Operation of Lubrication Management System

We can offer our customer a higher level support with the implementation of our LMS software. On the one hand it helps in the maintenance activities and on the other hand it gives them up-to-date information about the lubrication of their equipment. The LMS software is a multilingual tool. At this moment it is available in Hungarian, English and Slovakian languages.

Expressions used in Figure 3:

- Input information. This is necessary for LMS to do its main activity the scheduling of lubrication tasks.
  - Structure of plants. It means the hierarchical structure of our customer's company.
  - Lubrication plans. These are in the well-structured Excel-sheet, mentioned above.
  - Operation data. If operation data are available at our customer we can schedule all tasks based on them.
- Task scheduling. The most important

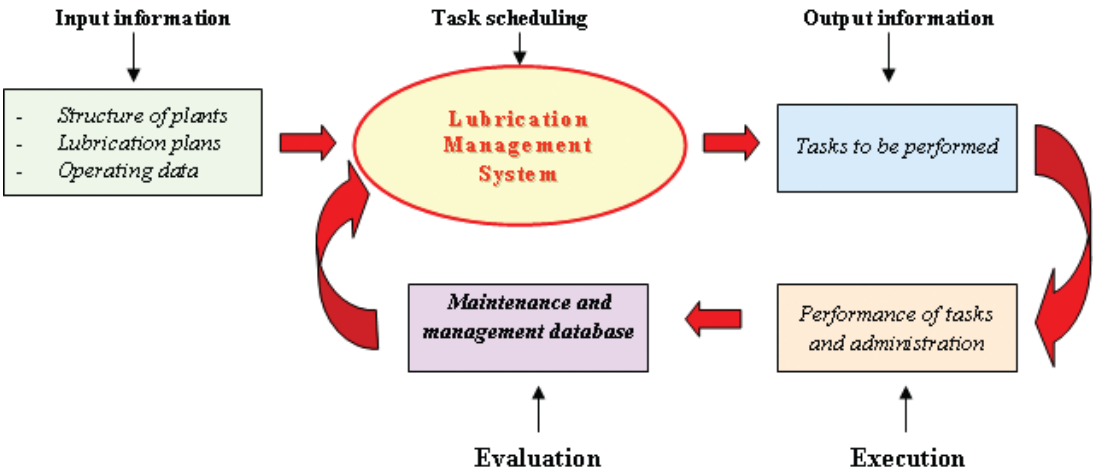


Figure 3. Schematic graph of the operation of LMS

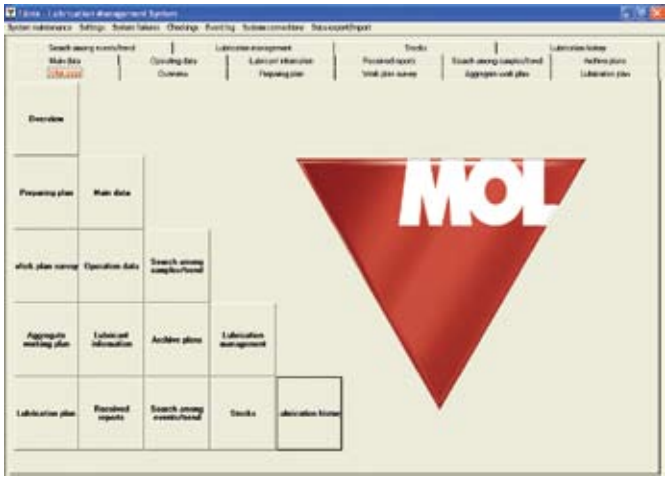


Illustration 1. Starting screen of the LMS software

task of LMS is to schedule lubrication tasks and send them to the customer's technicians.
- Output information. These are the real tasks to be performed. These can be refilling, regreasing, oil changes, sampling and checking, etc.
- Execution. After performing the lubrication tasks the other important activity is to give the software answer from users about tasks (is it performed or not, if not, for what reason, etc.).
- Evaluation. We have the possibility to run some queries, to make trends about lubricant consumption, etc., based on information of execution.

Illustration 1. shows the opening screen of the working LMS system by representing all of its modules built in.

4. Business cases – real results

The Audit and the LMS software implementation in the Hungarian Refineries of MOL Plc.

The implementation period of LMS in 3 Hungarian Refineries of MOL Plc. lasted in January, 2005 and December, 2006.

This project contained the tasks listed below:
- Unification of lubricant consumption in Hungarian Refineries
- Use of a minimum number of up-to-date lubricants
- Complete revision and update of lubrication plans
- Recommendation about the use of modern equipment for filling-in and changing of lubricants (to avoid the entering of any contaminants within the whole logistics chain)
- Electronic logging of operating hours of equipment in LMS software to scheduling the tasks exactly.

Table 1. shows the number of plants, equipment and lubrication points were included in the LMS software.
Main results of LMS implementation:
- All of the relevant information about lubrication is in a complex supporting system.
- Operational safety is increased, the downtimes, caused the rotation machines failures, were reduced.
- LMS software is integrated into the Condition-Based Monitoring System of Rotating Machines.
- The scheduling of the risk-based maintenance tasks is working.
- Interface connection between LMS software and SAP R3 PM (tasks and answer of working plans).
- Interface connection between LMS software and Refinery Information System (operating hours).
- Modernisation of filling-in system of lubricants is performed (closed system, less downtimes due to the contaminated lubricants).

Lubricant audit in an international steel company

In 2005 a lubricant audit was performed in an international steel company by MOL-LUB's experts. At this company only the audit was required but not the implementation of the LMS software.

After the successful lubricant audit these were the real results at this steel company:
- Reduction of the number of previously used lubricants with more than 30%.
- Reduction of the lubricant stock level by approx. 25%.
- Improvement of the continuous material supply.
- Reduction of the risk of mixing several types of lubricants.
- More simple logistic activities and administration.
- Increasing of the lubricant lifetime by more than 15%.

Refinery	Number of production plants	Number of machines	Number of lubrication points
Danube Refinery (Százhalombatta)	67	2696	5758
Tisza Refinery (Tiszaújváros)	17	380	791
Zala Refinery (Zalaegerszeg)	7	137	261
Sum	**91**	**3213**	**6810**

Table 1. The scope of the audit and the implementation of LMS software in Hungarian refineries

- Increasing operational reliability with approx. 10%.
- In general reduction of the cost about lubricants with approx. 8%.
- And last but not least more professional and deeper connection between customer and lubricant supplier.

It can be seen in Figure 4., how the lubricants consumption reduced year by year together with the lubricants consumption in grams/1 metric ton of steel production despite the fact that the produced steel volume increased. By the results of our work, operation safety increased without the changing of the quality of the end-product.

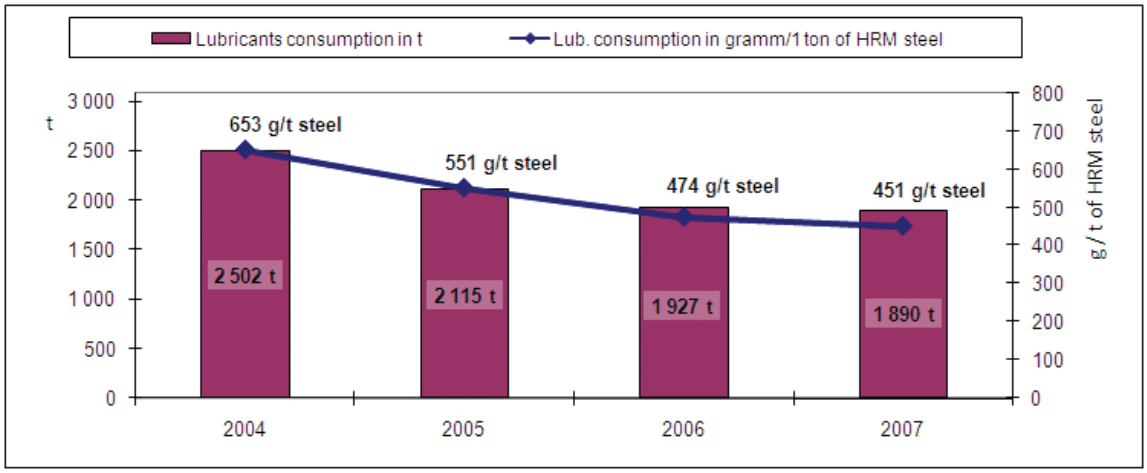


Figure 4. Real results after a lubricant audit at a steel company

5. Practical benefits of using MOL-LUB's lubricant audit service and LMS

Major benefits of a lubrication audit and introduction of the LMS software supplied by MOL-LUB:

- Best practice and efficient support from MOL-LUB.
- Complete revision and update of lubrication plans.
- Use of a minimum number of up-to-date lubricants.
- Optimized consumption of lubricants, improved stock management.
- Use of modern equipment for filling-in and changing of lubricants (to avoid the entering of any contaminants within the whole logistics chain).
- Electronic logging of operating hours of equipment in LMS software.
- Proposal for the optimal stock level of the necessary lubricants (determination of the minimum stock levels).
- Maintenance Department will be able to handle user-friendly supporting software where they can monitor the condition of lubricants and the equipment. This information comes from the accredited WearCheck laboratory of MOL-LUB.
- The main result is that all the relevant information about LUBRICATION is in a complex supporting system which can contribute to the reduction of the downtimes in all of the production processes.

Revised by: Lajos Kisdeák