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Viktor Dank, DSc
BUSINESS RESPONSIBILITY FOR HUMAN RIGHTS IN OIL AND GAS INDUSTRY

Krisztina Szegedi, PhD (43)
Chairperson of the Ethics Council
MOL Group
kszegedi@mol.hu

Pál Kapusy (35)
Head of Environment and Sustainability
MOL Group
pkapusy@mol.hu

ABSTRACT
Over the past decades, considerable debate has unfolded about whether, and if so, what level of responsibility the companies have in the protection of human rights. A number of international organisations point out that globalisation and the role played by companies in it entail corporate responsibility, inter alia, the protection of human rights. Empirical studies have shown that the oil and gas companies make considerable efforts to protect human rights. The aim of this article is to assess how the human rights protection is institutionalised in the oil and gas industry’s companies and to show some good practice examples.

HUMAN RIGHTS
Human rights are often defined in different ways. „Human rights are literally the rights that one has because one is human” (Donelly, J 2003). „Human rights are based on the principle of respect for the individual. Their fundamental assumption is that each person is a moral and rational being who deserves to be treated with dignity. They are called human rights because they are universal” (United for Human Rights 2012). Human rights are „a set of moral and legal guidelines that promote and protect a recognition of our values, our identity and ability to ensure an adequate standard of living” (Australian Human Rights Commission, 2012). According to the Amnesty International (Amnesty International 2012) „human rights are basic rights and freedoms that all people are entitled to regardless of nationality, sex, national or ethnic origin, race, religion, language, or other status.”

Scolars disagree about the source of human rights, but it is clear that the concept of human rights has a long history in various religions and philosophies of the world. The roots of the human rights can be found for example in the Code of Hammurabi, in works of the Buddhist King Ashoka of India or of the Ancient Greeks and Romans. In the West the first systematic human rights theory was written by John Locke in the seventeenth century. In the modern history of the human rights the United Nations General Assembly on 10th December, 1948 adopted the Universal Declaration of Human Rights. It was the foundation of the international system of protection for human rights and the first step for integrating human rights into international and national law (Freeman, MA 2011).

Universal Declaration of Human Rights summarises the fundamental human rights in 30 articles (see Table 1) (United Nations General Assembly 1948). Three generations of human rights are distinguished based on their content and chronological appearance: first-generation civil and political rights (right to life and political participation), second-generation economic, social and cultural rights (right to subsistence) and third-generation solidarity

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rights (right to peace, right to clean environment) (Nickel, J 2012). But “all human rights are universal, indivisible and interdependent and related. The international community must treat human rights globally in a fair and equal manner, on the same footing, and with the same emphasis” (World Conference on Human Rights 1993).

UNIVERSAL DECLARATION OF HUMAN RIGHTS

1. All human beings are born free and equal in dignity and rights.
2. Everyone has all the human rights regardless of race, sex, language, religion, political or other opinion, national or social origin, property, birth or other status.
3. Everyone has the right to life, liberty and security of person.
4. Slavery and the slave trade are prohibited.
5. No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment.
6. Everyone has the right to recognition everywhere as a person before the law.
7. All are equal before the law and are entitled without any discrimination to equal protection of the law.
8. Everyone has the right to an effective remedy when not treated fairly.
9. No one shall be subjected to arbitrary arrest, detention or exile.
10. Every person is entitled to an impartial hearing.
11. Every person shall be considered innocent until proven guilty.
12. Every person has the right to protection of his or her privacy.
13. Every person has the right to freedom of movement within a country and to leave and return to his or her country.
14. Every person has the right to asylum from persecution.
15. Everyone has the right to a nationality.
16. All adults have the right to marry of their own free will and found a family.
17. Every person has the right to own property.
18. Everyone has the right to freedom of thought, conscience and religion.
19. Every person has the right to freedom of opinion and expression.
20. Everyone has the right to freedom of peaceful assembly and association.
21. Every person has the right to take part in the government of his or her country.
22. Every person has economic, social and cultural rights.
23. Every person has the right to work, to just pay, and to form and join trade unions.
24. Every person has the right to rest and leisure.
25. Every person has the right to an adequate standard of living.
26. Every person has the right to education.
27. Everyone person has the right to participate in cultural activities and benefit from scientific advancement.
28. Everyone is entitled to a social order in which these human rights can be realised.
29. Every person has duties to the democratic society according to the law.
30. No person can take away these rights and freedoms.

Table 1. Shortened version of Universal Declaration of Human Rights (United Nations General Assembly 1948)
BUSINESS AND HUMAN RIGHTS

Originally the movement of human rights refers to the relations between governments and their citizens; furthermore the increased activity of nongovernmental organisations plays an essential role in it. But globalisation is converting separate national economies into an integrated world economy, and in this process multinational enterprises play a significant role as they are dominant in international trade, international diffusion of information, knowledge, technology and in capital movements and labour mobility (Kleinert, J 2004). This process has strengthened the Corporate Social Responsibility (CSR) discourse and raised a debate regarding the relationship between business enterprises and human rights in recent years. Human rights are a basis for CSR (Cassel, D 2001 cited by Garri-ga, E & Mele´, D 2004; Vaaland, TI & Heide, M 2005). According to some opinions multinational enterprises (MNE) are driving forces of economic development so they improve human rights conditions. Others argue that MNEs create highly uneven economic development and it contributes to lower levels of human rights protection (Preuss, L & Brown, D 2012).

Margolis and Walsh (Margolis, J & Walsh, J 2003; cited in Cai, Y & Jo, H & Pan, C 2012) summarised over 120 studies between 1971 and 2001 which examined the empirical relation between CSR and financial performance. Because of methodological problems the result is mixed but shows a mild positive correlation. It is sure that bad social performance is disadvantaged to the financial performance of the companies. Upholding or violating human rights is not neutral for companies from economic point of view, as violating human rights can cause serious reputational and business impacts. When Nike was criticised for very low wages, child labor, and sexual harassment in Chinese and South-East Asian factories, the scandal caused a large-scale boycott of Nike’s goods by consumers, non-profit organisations, and the media, which had a negative impact on the company’s profits. However, a solid CSR ranking would enhance the reputation in the eyes of investors, consumers and the public at large which increases the sales (Avetisyan, E & Ferrary, M 2012). According to Amnesty International, the world’s largest human rights organisation, multinational companies and business communities have wide moral and legal responsibility to promote respect for human rights and should not be silent witnesses, even when it is not their business interests (Amnesty International 1998).

Human rights have been discussed in several guidance documents for businesses like UN Global Compact, ISO 26000, Global Reporting Initiative, Guiding Principles on Business and Human Rights and OECD Guidelines for Multinational Enterprises. Table 2 contains the main parts of the mentioned guidance documents.

The role of business in human rights has become more important recently. After a long period of consultation and development from 2005 to 2011 John Ruggie, UN Special Representative developed the United Nations ‘Protect, Respect and Remedy’ Framework (Human Rights Council 2011). It is a significant landmark in role of business in protection of human rights. The International Organisation of Employers (IOE), the International Chamber of Commerce (ICC) and the Business and Industry Advisory Committee (BIAC) to the OECD, which together form the most representative voice of global business, welcomed the United Nations Secretary-General’s report on business and human rights and the UN system (International Chamber of Commerce 2012). As an impact several standards like IFC Performance Standards, ISO 26000 and OECD Guidelines for Multinational Enterprises have been revised based on the Ruggie Framework. It will contribute to more transparent supply chains, where problem solving and dialogue will play more important role than investigation and compliance (Gibbons, S 2011).

The Framework has three main principles: protect, respect and remedy. Protect means the State duty to protect against human rights abuses by third parties, including business enterprises. In order to fulfil this task State has to ensure appropriate legal and guidance framework, to communicate clear expectations for companies, to offer best practice examples and to implement special measures in companies.
owned or controlled by the State. Respect is the corporate responsibility to respect human rights. Remedy is both State and business responsibility to provide greater access by victims to effective judicial and non-judicial remedy (Human Rights Council 2011).

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**ANNEX**

**BIBLIOGRAPHY**

Table 2. Guidance documents on human rights. Source: Websites of the organisations
The corporate responsibility to respect human rights contains the following main practical tasks (Human Rights Council 2011):

› Commitment - Business enterprises should express and communicate internally and externally their commitment to meet this responsibility and integrate it into trainings and business processes. It is essential to involve security personnel into human rights trainings (Amnesty International 1998).

› Human rights due diligence
  › Business enterprises should regularly assess their actual and potential human rights impacts.

  › Assessment is essential in new operation areas, armed conflict areas, regarding high risk products, functions with special emphasis on stakeholders like indigenous peoples, women, national or ethnic, religious and linguistic minorities; children, persons with disabilities; and migrant workers and their families.

  › It is important to involve internal and external experts into the assessment process and to integrate the human rights assessment into the general risk assessment of the company.

  › Effectiveness of the assessment system should be evaluated based on qualitative and quantitative indicators, surveys, feedback from stakeholders and internal and external audits.

  › Business enterprises should take actions in order to prevent and reduce human rights problems and should try to influence firms violating human rights or terminate the business relationship with them. In case of an essential business relationship companies should demonstrate their efforts and be prepared to accept reputational, legal or financial consequences.

› Remediation
  › Where a business enterprise has caused or contributed to adverse impacts, it should provide for or cooperate in remediation with further actors.

  › Precondition of remediation is an effective grievance mechanism, which is legitimate, accessible, predictable, equitable, transparent, rights-compatible, a source of continuous learning and based on engagement and dialogue. It is essential to have clear and published procedure, to conduct fair investigations, to be accessible for stakeholders without barriers of language, literacy, costs, physical location and fears of reprisal and find solutions through dialogue.

  › Where adverse impacts have occurred that the business enterprise has not caused or contributed to, but which are directly linked to its operations, products or services by a business relationship, the responsibility to respect human rights does not require that the enterprise itself provide for remediation, though it may take a role in doing so, for example in cooperation with judicial mechanisms.

In 2012 the United Nations Working Group on Business and Human Rights initiated a pilot survey on implementation of the corporate responsibility to respect human rights, which determined the following main challenges for companies regarding the components of the responsibility to respect (United Nations Working Group 2012):

› Policy commitment: It is difficult to communicate the policy in a clear way to all relevant external parties and to translate policy commitment into relevant operational procedures.

› Understanding impacts: Companies are unsure how far into the supply chain they need to go in understanding impacts. There is a lack of credible information, methodologies and frameworks to assess impacts and it is not clear how to engage with stakeholders where governments restrict dialogue.
Addressing impacts, tracking responses and communication: It is difficult to manage situations where companies’ leverage over business partners is limited, and to operate in situations where human rights are not part of local law or not applied in practice or government institutions are lacking.

Complaints, grievances and access to remedy: It is difficult to adapt a grievance mechanism to a cultural context, to build trust in the mechanism, to move a complaints hotline to an effective grievance mechanism and to incorporate mechanisms into stakeholder management.

CORPORATE SOCIAL RESPONSIBILITY (CSR) AND HUMAN RIGHTS IN OIL AND GAS INDUSTRY
Oil industry is one of the controversial industries from ethical point of view because of its contested environmental and social impacts. Oil and gas companies have been criticised by media, governmental organisations, and non-governmental organisations (NGOs) for issues of environmental violations, detrimental impact on local communities, of breaches of labour and safety standards, corruption and human rights abuses (e.g. Pulver, S 2007; Reiner, K 2010; Adeoye, Y 2012; Du, S & Vieira, ET Jr 2012; De Roeck, K & Delobbe, N 2012). The question is whether such a controversial industry can be developed? According to the opponents Corporate Social Responsibility in controversial industries may be inherent contradiction, but the proponents mean that firms can become better organisations by CSR in such industries as well (Cai et al. 2012). Lindorff et al. (Lindorff, M & Jonson, EP & McGuire, L 2012) emphasise the essential role of CSR in the controversial industries. Companies of such industries are able to be socially responsible in particular areas of their operations, minimising the harm in order to solve particular social problems. Studying data of 475 US firms in controversial industries from the 1995-2009 period researchers empirically investigated the impact of CSR engagement on firm value for firms in controversial industries and found a positive correlation between CSR engagement and firm value (Cai, Y & Jo, H & Pan, C 2012).

De Roeck and Delobbe surveyed 155 employees of a petrochemical organisation in order to study employees’ responses to organisations’ CSR initiatives in the controversial oil industry (De Roeck, K & Delobbe, N 2012). Research findings proved that perceived CSR positively relates to employees’ organisational identification and it is mediated by organisational trust. CSR initiatives can result in employees’ support even in a controversial industry sector.

Du and Vieira studied the CSR practice and its communication by several oil companies (Du, S & Vieira, ET Jr 2012). It was assumed that due to the highly controversial reputation of the oil industry, companies try to achieve their legitimacy by their CSR activities. According to the analysis the bigger companies had more extensive CSR practices and more effective CSR communication strategies than the smaller ones. The studied companies are characterised by ‘CSR as public relations’ mentality and by reactivity. The article suggests a long-term strategic approach and proactive, leadership role for the companies. All companies used multi-media technology in their CSR communication which supports stakeholder involvement and company’s openness and transparency. In contrast to hard, fact-based CSR information, story-based messages, short video interviews with NGOs, community members, employees, and local communities were mentioned as best practice of soft, human face CSR communication. The researchers found not only positive but negative comments and information about the CSR activity of the companies, as well. Authors suggested taking responsibility for negative company actions and publishing two-sided messages in order to mitigate scepticism and to enhance trust in companies and the whole industry (Du, S & Vieira, ET Jr 2012).

An analysis of current trends in corporate human rights reporting (Umlas, E 2009) found several weaknesses like equating community with philanthropy, lack of performance reporting and
Challenges

impact reporting, lack of balance of positive and negative impacts, gap in reporting content and sustainability context, absence of human rights from assurance. Areas for improvement are identifying the key human rights risks, collecting and sharing baseline data in reports on local communities stakeholders’ concerns about human rights impacts, exploring ‘traceability’ in supply chain reporting, developing proactive approaches regarding relevant human rights issues of the industry. The report contains some practical examples from oil industry as well. BP is involved in a joint venture in Brazil to operate an ethanol refinery. Sugar cane plantations and ethanol refineries in Brazil have been found in some cases to use forced labour. The issue of biofuels in the report did not mention any potentially negative human rights practices and its investigation by the company. OMV Group developed its Human Rights Matrix which included company’s human right responsibilities, but the report did not contain detailed information about these issues and the level of performance. The report of Marathon Oil contained its community investment in Equatorial Guinea introducing training programmes and company-sponsored course on rule of law and human rights but did not contain which human rights abuses are rife in that country.

Preuss and Brown analysed how wide-spread the corporate policies on human rights among FTSE 100 firms are and what characteristics these human rights policies have (Preuss, L & Brown, D 2012). According to their survey 57.1% of the studied firms had a separate human rights policy or integrated this issue into a code of conduct or dealt with it in an isolated reference. This rate was high in industries like alcoholic beverages (100%), tobacco (100%), food (100%), oil & gas (85%) and chemical (75%). The rate was medium (between 50% and 66%) in pharmaceutical,
banking, extractive, insurance, telecom and IT, business services, utilities, hotel, leisure and media sectors. The rate was low (below 50%) in retail property and construction, other financial, manufacturing and transport areas. The article emphasises that oil and gas industry is one of the industries having the most thorough engagement with human rights issues. Several studied firms of oil and gas industry (e.g. BP and Shell) had the longest human rights policy which contained the meaning of human rights, discussed potential human rights abuses and described the company’s commitment to protect human rights and the taken actions.

The content analysis of the human rights policies among FTSE 100 firms showed a rather low appearance of UN Declaration Principles: only six of them were found in half or more of the corporate documents. Most of the companies concentrate on avoidance of discrimination and on the right of association and form and join trade unions. Many companies consider important prohibiting slavery, the human dignity and the principle about no torture, cruel or inhumane treatment (Preuss, L & Brown, D 2012). In order to help the oil and gas sector companies, the European Commission Human Rights Sector Guidance Project (European Commission 2012) suggested a special matrix, which contains the adequate human rights of stakeholders (e.g. company workers, supply chain / contractor workers, affected communities, potentially vulnerable groups) during company activities like land acquisition / resettlement, drilling / seismic testing, construction of facilities / pipelines, environmental management, human resources management, security, planning / management of decommissioning.

In our recent survey we studied 15 oil and gas companies which were listed in Dow Jones Sustainability Index 2012. Table 3 presents a summary of the human rights management tools applied by these companies. Main conclusions are as follows:

› Not surprisingly, the most widely applied management tool is the policy which is a cornerstone of a human rights framework: one third of the analysed companies have some sort of explicit human rights policy, while with two exceptions all companies’ code of conduct refers to human rights principles. One remarkable practice: Ecopetrol incorporated a chapter on human rights into the collective bargaining agreement.

› 75% of the studied companies provide ethics training programmes to at least a selected group of employees, five companies apply specific human rights modules, as well.

› Another widely used tool is to incorporate requirements into supplier prequalification or selection criteria (67%). However, only one third of companies monitor or conduct audits on compliance with it. For example, Repsol hired an external company to conduct seven ethics and human rights audits on two suppliers in Spain and five in Peru. In addition, three audits were conducted on suppliers’ contractors, one in Morocco and two in China. As a result of the audits, actions to be implemented were defined.

› More than half of the companies (60%) have a whistleblowing policy or hotline in place where human rights abuses can be noticed. It can be mentioned that ENI reports human rights violations with quantitative data and types of cases as well.

› UN Guiding Principles (‘Ruggie-framework’) is referred to by six companies, while the ‘Voluntary Principles on Security and Human Rights’ is endorsed by almost half of the analysed businesses. BG Group has invited professor John Ruggie, former Special Representative to the UN Secretary General for Business and Human Rights, to address senior managers on the UN Guiding Principles.

› Grievance mechanisms and public report on it remain an area for improvement: only two companies have such processes in place, one of them (Ecopetrol) discloses also examples.
Table 3. Human rights management tools in the oil and gas industry. Source: webpages of the studied companies

*Criteria based on the recommendations by Business & Human Rights Initiative 2010 (Business & Human Rights Initiative 2010)

**MOL Group was listed on the Dow Jones Sustainability Index between 2010 and 2011, but not in 2012, therefore it is included in the Table just for information to readers of MOL Group Scientific Magazine. Analysis has been limited to the listed companies, thus without MOL Group.
CONCLUSIONS
In the last decade various guidances were published to help corporates manage human rights related issues and report on them. The article presented a summary of the main elements of a corporate human rights framework. Our study on the most sustainable oil and gas companies revealed the fact that the most progressive companies apply a wide range of tools to manage human rights, but there is still room for improvement for all industry players. Business sector itself will not be able to solve human rights problems but will have more significant contribution in the future to proliferate universal human rights. However, there is no ‘one-size-fits-all’ solution; each company should be able to identify key impacts and issues and address them with appropriate tools.

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Keywords: human rights, corporate social responsibility, business ethics, sustainable development, oil and gas industry

Reviewed by Pál Kara, Dr.

REFERENCES
Challenges

Krisztina Szegedi, PhD is an independent chairperson of the MOL Group Ethics Council since 1st September 2007 and associate professor of the Faculty of Economics of the University of Miskolc since 2003. In 2002 Ms Szegedi was granted her PhD degree in Business and Organisation Sciences. From 2004 to 2007, Ms Szegedi held various management positions at the University of Miskolc, including Deputy Dean of Scientific and International Affairs and Deputy Dean of Education of the Faculty of Economics. She has been teaching business ethics at the University of Miskolc. She is an advisor and auditor of Ethics Management Systems. Ms Szegedi conducts researches and has more than 60 publications in business ethics, corporate ethics and institutionalising of ethics. She is a member of public body of Hungarian Academy of Sciences, member of the German Business Ethics Network and the European Business Ethics Network.

Pál Kapusy is the head of Environment and sustainability of MOL Group. He has been working with sustainability, corporate responsibility and environmental areas since 10 years. He joined MOL in 2008 as SD manager, previously he worked as executive director of KÖVET-INEM Hungária, a business network promoting SD and CSR among companies. He used to live and study in Italy, France and Denmark. He has MSc in Engineering and Management (Budapest University of Technology and Economics), MA in Philosophy (ELTE Budapest) and he is doing PhD in University of Miskolc.


CUSTOMER CREDIT MANAGEMENT AT MOL - A JOINT EFFORT BETWEEN BUSINESS AND FINANCE

Ilona Koréh
Credit Management Back Office manager
MOL Credit, HU
ikoreh@mol.hu

ABSTRACT
Customers expect credit terms from suppliers in order to finance their working capital cycle, a particularly important aspect of business in economies where banks are reluctant to lend. The credit process, which extends from the request for a credit limit to collection of unpaid trade receivables, must be closely controlled to avoid unnecessary risk. At MOL, the credit management process is jointly approved by business and finance, with well-defined and parallel roles for both the sales and credit management organisations.

COMMERCIAL CREDIT – WHO NEEDS IT?
Commercial credit – business to business - is widespread in Central and Eastern Europe. Customers expect it and almost every supplier provides it. There are approximately 17,000 credit customers at MOL Plc and some 60,000 Group-wide. Before we turn to the ‘how’ of commercial credit, we should examine the question of why suppliers are expected to provide credit to their customers.

The major motivation of the supplier is to sell the product, not to provide credit in the form of deferred payment. The intrinsic risk in an industrial company like MOL is related to the manufacturing of products of a specific quality at a reasonable cost. To take on the additional risk that the customer may not pay for the product seems unreasonable. Nevertheless, that is exactly what we do for approximately 75% of our customers because it is expected by our markets and, hopefully, improves our selling position.

While acknowledging the fact that a sale is truly a sale only if the customer makes payment, MOL provides credit with the sole purpose of increasing sales. Banks take a completely different approach, in that the bank does not have a vested interest in approving a particular credit besides the obvious motivation of increasing its assets and revenues. From the supplier’s perspective, the credit decision is tied to the tangible and ultimate goal of selling the product.

If banks are professional providers of credit, then why are suppliers expected to provide credit at all? One answer is that supplier credit enhances a customer’s liquidity, bypasses the banks and does not impinge on the customer’s ability to expand by requiring it to use its bank credit to pay for goods, while its own customers are buying on credit terms. In the geographical region served by MOL, the availability of bank credit is a determining and limiting factor, as most SME (small and medium-sized enterprise) customers are undercapitalised and have usually exhausted their limited banking sources; if the supplier cannot provide credit, the sale often cannot
be made. In an environment in which banks are reluctant to lend, credit limits are generally required to make the sale, price may be a secondary consideration. In the US and Western Europe, a much larger proportion of SME companies are well-capitalised and can make choices between suppliers and banks as sources of financing. Another answer is that large customers expect credit terms, since supplier credit enhances their financial flexibility and furthermore, they can demand pricing levels which may not reflect the full cost of credit.

**THE COST OF CREDIT**

Although we have stated that supplier credit is primarily a commercial issue, there are two financial aspects which must be consciously managed and which should affect sales decisions. The first is the cost of working capital financing, the second is the cost of non-payment by the customer; the two costs are additive.

The **cost of working capital financing** can be viewed as the cost at which the supplier can obtain external financing to cover the liquidity gap caused by selling for credit instead of for cash, since trade receivables tie up working capital. If the supplier is perceived by the banks and other sources of capital as a significantly better credit risk than the customer, then the customer may be obtaining supplier credit at a considerable discount compared to bank financing. While this is a good deal for the customer, the supplier’s interest is to pass on the cost; otherwise it is lending its balance sheet without being appropriately compensated. This can be achieved in more than one way: either the financing cost is wholly built into the sales price, or if uncompensated, this is considered to be the cost of doing business, i.e., an acceptance of the fact that without credit terms, the sale cannot be made. Another way to look at the issue is to compare the yield of investing in customer receivables to alternative short-term investment opportunities, such as bank deposits or treasury bills, but this does not adequately reflect the need to sell the product. A third approach is to incorporate a cost in the pricing of the product which more closely reflects the financing cost of the customer, as opposed to that of the supplier. A completely different approach is to discourage buying for credit by offering incentives for shorter payment periods, for prepayment or early payment. Prepayment could result in a discount if the supplier is prepared to give up profitability in exchange for liquidity and zero credit risk. The difficulty encountered by suppliers is that while they are usually compelled to provide credit, they are generally unable to fully reflect financing costs in their prices due to fierce competition, and the extent of this problem is determined by other factors, such as:

› The availability of credit to the supplier (by its own suppliers and financial institutions)

› The availability of alternative credit sources to the customer.

At MOL, the latter factor is determining, but the cost of the former is also considerable.

The **cost of non-payment by the customer** must also be consciously managed, but how is this determined? The best source is the supplier’s own present and historical data, although valuable corroborating data may be available from the market. For example, if a level of 2.0% of total receivables are irrecoverable, then the cost of non-payment is 2.0%, divided by the number of times the supplier’s receivables turn over annually; if receivables turn over at an average of 4 times per year, then the overall cost of credit is 2.0% / 4, or 0.5%. On a customer level, if a customer purchases only once per year, then the price of that single purchase should theoretically reflect the full 2.0% premium. If another customer purchases product every month to the extent of its credit limit, then the applicable premium theoretically needs to be only 2.0% / 12, or 0.17%. Another way to look at this issue is to calculate how many times the customer has to turn over its credit limit in order to become ‘risk-free’. For example, if the margin on a product is 5%, then the customer needs to turn over its credit limit 20 times to achieve
a cumulative margin which exceeds the credit limit, i.e., the relationship is profitable even if the customer defaults with the next purchase, an unorthodox but practical approach. Said another way, regular customers are desirable not only from the point of view of generating higher sales, but they also represent a reduced cost of credit as compared to occasional customers, and it is not unreasonable from a credit point of view to apply pricing discounts. Similarly, the sale of high-margin products becomes profitable from a credit point of view earlier than low-margin products. Of course, in a complex industrial process such as oil refining, in which products and by-products are linked in a single process, some products may be chronic loss-makers, but cannot be eliminated, while others will broadly cover these costs; regular evaluation of this effect is essential in making appropriate commercial decisions.

The commercial policy may address these issues, in part, by applying discounts if the credit limit is wholly or partially covered by preferred and liquid forms of security: cash deposits, commercial insurance or bank guarantees, or if the customer pays in advance.

**CUSTOMER CREDIT MANAGEMENT AS A JOINT VENTURE BETWEEN BUSINESS AND FINANCE**

Customer credit management is the process of managing the risk which is associated with sales based on deferred payment. The process extends from determination of credit limits to the collection of unpaid receivables. Supplier credit management works best if it is a joint effort shared by business and finance. The credit management organisation provides a service which is agreed and jointly carried out with the business team. The business team participates throughout the process, including the approval of limits and limit-excesses, as well as the collection of overdue receivables from delinquent customers.

Most importantly, remuneration of the sales team is directly affected by the performance of the receivables portfolio through the application of credit-related Key Performance Indicators (KPI), such as % overdue receivables / total commercial receivables and % bad debt ( overdue >= 90 days) / total commercial receivables. These KPIs are applied throughout the MOL Group, and are agreed each year with the business teams. The target values differ from subsidiary to subsidiary, depending on its activity, when it was acquired and the credit culture of the country in which it is domiciled. While the performance of each subsidiary is different, the trend is toward improvement in line with the adoption of Group credit practices and the cleaning out of portfolios that contain stale debt.

**STEPS IN THE MOL CREDIT PROCESS FOR DEFERRED PAYMENT CUSTOMERS**

MOL Group credit policy includes the following compulsory steps, each of which are jointly carried out by both the business and credit representatives, according to an agreed set of rules (see Table 1).

**DECIDING ON AN APPROPRIATE CREDIT LIMIT**

The required credit limit is calculated by the business representative based on projected purchase volumes and desired terms of payment.

Within the MOL Group, credit decisions on unsecured limits are made with the help of a universally applied internal scoring method, which takes local information sources into consideration and consists of 4 parts (see Figure 1).

The basis of the limit is the estimated monthly (fuel) consumption of the customer (taken as a percentage of the customer’s average monthly net sales), which is reduced proportionately by the scoring result. An additional and important control does not allow the credit limit to exceed 30% of the customer’s equity. Limits calculated using this tool normally cover the fuel requirements of transport, industrial or agricultural customers, provided that payment terms do not exceed 20-30 days. If longer payment terms are requested or if the customer is
a trader whose major supplier is MOL, a larger limit is required, which can only be approved if the customer is an excellent risk. This basic scoring tool is supplemented by information obtained from credit agencies, site visits and interim financial reports.

Table 1. MOL credit process for deferred payment customers (ERP – enterprise resource planning)

<table>
<thead>
<tr>
<th>STEP</th>
<th>BUSINESS</th>
<th>CREDIT / FINANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishing credit limits</td>
<td>Request for credit limit based on expected volumes and contractual terms; approval of limits; negotiation of contract</td>
<td>Recommendation of limit and / or acceptance and assessment of security; participation in approval</td>
</tr>
<tr>
<td>Management of order-blockings due to limit excesses, overdue receivables or expired revision of limit</td>
<td>Approval of release of order-blockings</td>
<td>Administration of ERP-generated order blockings; approval of blocking release jointly with business above set amounts and percentages</td>
</tr>
<tr>
<td>Regular review and monitoring</td>
<td>Contacting of delinquent customers; communication of negative changes to credit department</td>
<td>Weekly reporting of delinquency; regular monitoring of change in legal status; regular annual or semi-annual revision of limits</td>
</tr>
<tr>
<td>Collection processes</td>
<td>Management of internal collection process during first 45-60 days of delinquency</td>
<td>Taking over of collection process following first 45-60 days; use of external collection agencies, legal counsel, credit insurer; application of security</td>
</tr>
<tr>
<td>Reserves, write-offs</td>
<td>Approve write-offs based on uncollectibility of receivables</td>
<td>Create reserves monthly based on delinquency and legal status of overdue receivables</td>
</tr>
<tr>
<td>KPIs</td>
<td>Remuneration of sales staff directly influenced by credit-related KPIs</td>
<td>Reporting of performance against KPIs</td>
</tr>
</tbody>
</table>

Fig. 1. MOL Group internal scoring method for credit decisions on unsecured limits

Table 1.

<table>
<thead>
<tr>
<th>DEMOGRAPHICS</th>
<th>PAYMENT DISCIPLINE</th>
<th>FINANCIALS</th>
<th>BUSINESS RELATIONSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures stability of the customer (corporate legal form, age, ownership, size)</td>
<td>Takes into account external (tax authority, other suppliers, banks) and internal payment experience</td>
<td>Measures liquidity, leverage, working capital, profitability, sales trend</td>
<td>Takes into account importance of the customer (frequency and volume of purchases, length of relationship, market position)</td>
</tr>
</tbody>
</table>
Challenges

The nature of the product itself or the position of the customer or supplier can also influence the credit decision:

› Taking a higher credit risk may be balanced by the importance of the related product to the customer’s operation; customers with limited liquidity prioritise their payments and will continue to make payments for essential supplies long after they have fallen behind in other, less critical payments.

› Similarly, taking a higher credit risk may be defensible if the supplier has a very strong market position; the less alternative suppliers exist, the better the payment discipline generally will be.

› Taking a higher credit risk may be reasonable if there is a pressing need to offload certain products, such as the by-products of the oil refining process, or when storage capacity is limited.

› Taking higher credit risk may be balanced by higher profit margins.

A case should be made for approving an unsecured limit which is substantially higher than that recommended by the credit team, but the limit which is ultimately approved is done at the discretion of the decision-making individuals. Lower limits are approved within the hierarchy of the business organisation; above a certain amount, the approval of credit / finance managers must also be obtained. If the requested limit is not approved, then security in the form of a bank guarantee, letter of credit, cash deposit or credit insurance is recommended.

MANAGING ORDER-TAKING WITHIN APPROVED LIMITS

Approved credit limits are registered in the ERP system, with a compulsory review date of either 6 months or 1 year. Whenever a customer places an order with the logistics department, the ERP system tests the order against credit data in the system in three ways:

› Will fulfilment of the order result in an exceeded credit limit?

› Does the customer have overdue receivables? (Tolerance, in terms of days overdue, depends on the risk rating of the customer.)

› Was the revision date passed without having completed the regular review?

If the answer to any of these questions is YES, the system generates an order blockage, which must be released by approvals under the valid LDA (List of Decision-Making Authorities) or denied, whichever is appropriate.

A customer-friendly credit process includes mechanisms to ensure that the customer, if performing, can be served. This can be achieved by providing a ‘roomy’ credit limit which is large enough to cover all situations, or by establishing a limit which is ‘tight’, but flexible. MOL prefers the latter and manages limit excesses with increased scrutiny of the customer’s performance and approval of excesses if business and credit considerations are in balance.

MONITORING

The most important element of monitoring is the regular review of all credit limits by the credit department, with re-approval by the relevant parties. However, ongoing monitoring of the portfolio is also required. Depending on the country in which the relevant MOL Group company operates, a variety of monitoring tools are available. The most widespread service is external monitoring for liquidation, bankruptcy and dissolution, the source of which is the publication of change in legal status by the commercial court. While this type of information is essential, recovery of receivables at this stage are questionable, at best. Fortunately, there has been a boom during the past few years in the availability of more advanced early warning tools in almost every market in which MOL operates. For example, information is available on payment defaults to authorities, change in address, change in management, negative
change in a credit agency’s rating of the company, increase in the likelihood of default or any combination of these. Tools which provide some information on payment defaults to other commercial partners are the most useful. Although publicly available blacklists of defaulting businesses exist in some countries, this remains fairly uncommon. Several private initiatives, however, have been taken to share early information on delinquency in an ethical manner. Participating businesses regularly provide information on aging of receivables to a central party, which maintains and disseminates the data to participants, so that the source of the data remains anonymous. In some countries – typically in the Balkans - information on defaults to financial institutions and the submission of promissory notes by suppliers as a method of collection of overdue receivables can be tracked and incorporated in the credit assessment.

Reporting of delinquency by credit management to the business is also an essential aspect of monitoring. Sales staff then contacts the customer and obtains the promise to pay within a reasonable deadline or communicates the likelihood of default to the credit department. The earlier a delinquency is treated, the greater the likelihood of recovery.

COLLECTION OF OVERDUE RECEIVABLES

As noted above, collection in the first 45-60 days of delinquency is managed by the sales staff. Not only is this a customer-friendly approach, it underlines primary responsibility for the receivable by the business. The majority of overdue receivables are successfully collected during this period, or payment rescheduling is agreed with the customer. In this interval, credit staff may join salespeople for customer visits, if the likelihood of default is high.

Following the first 45-60 days, the responsibility for managing collection is passed to the credit department. MOL uses external collection agencies, whose success rate is 45-65% and who are compensated only through success fees. Collection agencies are force-ranked on a quarterly basis and are rewarded for high success rates with an increased number of collection mandates in the following quarter.

If the receivable is deemed to be uncollectible by the collection agency, the case is transferred to legal counsel for initiation of legal action. Lawsuits and payment execution often result in up to 70% recovery, but results vary. Similarly, bankruptcy and subsequent restructuring may result in recoveries of 50-70%, but lower rates are also common. The threat of liquidation often produces a payment plan by the previously unwilling customer. If the company goes into liquidation, however, the likelihood of collection drops precipitously to less than 2%. Nevertheless, the goal is to recover 100% of all receivables and to convey a clear message to the market that MOL does not intend to allow its debtors to walk away from their obligations.

RESERVES AND WRITE-OFFS

Receivables above HuF 1 million are revalued every quarter in terms of their recoverability; smaller amounts are revalued once annually, at year-end. The percentage of reserve taken on a receivable depends on the actual stage of collection, but may be influenced by other relevant information. For example, a receivable in the external collection agency stage is typically reserved for at 20%, while receivables of companies in liquidation are reserved 100%, given the very low likelihood of recovery at that stage. The extent to which reserves are taken must be defensible. Reserves are reversible if a positive change should occur in the likelihood of recoverability.

Write-offs of uncollectible receivables reduce the taxable base of the company in almost every jurisdiction in which MOL operates. Therefore, the rules are fairly stringent and established in the accounting law. Uncollectibility must be documented by the liquidator or the court. If a receivable is released, as is typical in the cases of bankruptcy or out-of-court settlements, the released amount may be written off, but this loss does not reduce the taxable base.
LOOKING FORWARD

While the credit management mechanism jointly operated by credit management and business organisations usually works well, there is a need to reset certain aspects from time to time, some of the possible reasons being:

› Perceived increase in the risk of the economy overall or within certain segments
› Business loss to competitors due to inability to approve competitive credit limits
› Deterioration in the quality of the customer receivables portfolio.

The challenge is to respond to these drivers as early as possible, using appropriate leading indicators. (Some examples follow in Table 2.)

As seen above, the possible explanations for the observed anomalies are multiple in every case and must be carefully examined to understand the root cause and to make the appropriate change based on a correct analysis. Only adherence to the valid credit policy can bring about changes which truly address the issues.

Keywords: credit management, customer, receivable, risk

Reviewed by Anna Éber and László Szabó

<table>
<thead>
<tr>
<th>LEADING INDICATOR</th>
<th>POSSIBLE PROBLEM AREAS HIGHLIGHTED</th>
</tr>
</thead>
</table>
| Ratio of denied, cancelled or reduced credit limits increases (including similar actions by credit insurer) | › Increased risk in affected segments  
› Inappropriate, too stringent scoring tool  
› Inappropriate selection of potential customers |
| Increase in number of customers with short-term delinquency; increase in Days Sales Outstanding | › Liquidity problems in affected segments or customers  
› Sales staff not diligent in managing early collections  
› Collection agency ineffective |
| Increase in rate of growth of reserves | › Increased risk in affected segments  
› Early collection efforts ineffective |
| Increase in number of liquidations, bankruptcies, dissolutions, lawsuits; increase in number of cases passed to collection agencies | › Increased risk in affected segments  
› Ineffective monitoring, early collection |

Table 2. Leading indicators for credit management

Ilona Koréh is currently the head of the Credit Management Back Office at MOL plc, and previously managed the Credit Front Office. She has been with MOL for two years and has an extensive background in commercial banking and training in credit and finance.
IN SEARCH OF THE REAL MOL GROUP BRAND IDENTITY

Boldizsár Konja (39)
Marketing Communications expert
MOL Group Corporate Communications
BKonja@mol.hu

Anastasia Girutskaya (21)
Marketing Communications trainee
MOL Group Corporate Communications
AGirutskaya@external.mol.hu

ABSTRACT
Seeking a true and meaningful corporate brand personality, MOL Group’s Marketing Communications experts have made significant efforts in the past years to research and develop a system which can discover the organisation’s true inner character upon which to build its identity. Among different methods the brand elaboration was centred on the archetypal theory, which helped the organisation to translate its valuable benefits and properties into a powerful meaning. Once the principle archetype of MOL Group was identified it became a fundamental step in building up a consistent corporate brand identity that started with defining the brand essence derived from the brand personality and then the mission and vision of a corporation.

WHY?
Companies, just like people, should have their own well-defined identities, manifested in the communicational style and tonality their brands are associated with. Although often misunderstood, a brand identity is not merely a logo or a symbol but comprises all the various associations in consumers’ minds with the company. A consistent brand identity is built not only on the products or symbols a company conveys but also on the organisation and the personality, a company identifies itself with (Aaker, DA & Joachimsthaler, E 2000). It is comprised of all the attributes, personality or inherited benefits – symbolic or experimental – images, thoughts, feelings, attitudes and experiences that form brand knowledge (Keller, KL 2003).

When we think of brand identity as a series of associations and experiences, just as with human beings’ personal identities, we must firstly discover and develop a brand personality.

As Robert T. Blanchard, a former P & G executive put it: “...like a person, a brand has a name, a personality, character and a reputation. Like a person, you can respect, like and even love a brand. You can think of it as a deep friend, or merely an acquaintance. You can view it as dependable or undependable; principled or opportunistic; caring or capricious. Just as you like to be around certain people and not others, so also do you like to be with certain brands and not others. Also, like a person, a brand must mature and change its product over time but its character and core beliefs should not change. Neither should its fundamental personality and outlook on life. People have character ... so do brands. A person’s character flows from his or her integrity: the ability to deliver under pressure, the willingness to do what is right rather than what is expedient. You judge a person’s character by his/her past performance and the way he/she thinks and acts in both good times, and especially bad. The same is true of brands” (Blanchard, RT 1999). Does it make sense to build strong brands with strong personalities? Does a well-defined brand identity generate increased shareholder returns? Indeed, there is clear evidence that strong brands outperform weak ones in total shareholder returns (Fisk, P 2006).
**HOW TO DEFINE THE BRAND PERSONALITY**

Once it is clear that finding a true and meaningful brand personality plays a pivotal role in brand management, we need to develop a system with which we may discover the organisation’s true inner personality upon which to build its identity. The five dimensions of brand personality (Aaker, JL 1997) include sincerity, excitement, competence, sophistication and ruggedness. Research into human personalities used a system of archetypes (Jung, CG 1959) applied to consumer brands (Mark, M & Pearson, C & Pearson, CS 2001) and recommended for brand development by experts (Howard-Spink, J 2003; Jansen, M 2006).

Jung believed that we are made of the ego, the personal subconscious and the collective subconscious and that archetypes exist at the collective subconscious level and they are “ancient or archaic images that derive from the collective unconscious” (Feist, J & Feist, GJ 2009). He also believed that the most powerful ideas in history are based on archetypes (Jung, CG 1960). He originally described four main archetypes but believed that others can exist and he himself described seven additional ones.

**THE 12 ARCHETYPES**

What is an archetype? According to Carl Jung, archetypes are forms or images of a collective nature which occur practically all over the earth as constituents of myths and at the same time as individual products of unconscious origin (Mark, M & Pearson, C & Pearson, CS 2001). “All the most powerful ideas in history go back to archetypes,” Jung explained in his book ‘The Structure and Dynamics of the Psyche’ (Jung, CG 1960). “This is particularly true of religious ideas, but the central concepts of science, philosophy and ethics are no exception to this rule. In their present form, they are variants of archetypal ideas created by consciously applying and adapting these ideas to reality. For it is the function of consciousness not only to recognise and assimilate the external world through the gateway of the senses, but to translate into visible reality the world within us” (Jung, CG 1960).

After 30 years of research into the subject, Dr. Pearson defined 12 fundamental archetypes (Pearson, CS 2001). The following table (Table 1, Figure 1) is just a short summary of the 12 fundamental archetypes; you can read more about the whole system at http://www.herowithin.com/index.html. The different archetypes can be placed around two axes, one leading from order to freedom or change, the other from the ego towards the social aspect (see Figure 1).

Thorough understanding and strengthening archetypal meaning (see Figure 2) in branding not only adds an interesting advantage to effective marketing but also is, rather, a prerequisite. No matter how effective a company’s manufacturing and distribution systems or how distinctive its products are, its competitors can imitate or duplicate them. In such circumstances, businesses have found only two strategic routes: reduce prices or imbue their products with meaning. The truth is that brands prosper not only because of their innovative features or because of the benefits they bring but also because these properties have been translated into powerful meanings.

According to Pearson (Pearson, CS 2001), strong and influential brands are built on a strong and well-defined archetype and all communications of the brand are centred on this key master archetype. Every piece of communication and its whole tonality should be built upon this.

**WHY SEARCH FOR AN IDENTITY FROM WITHIN?**

As the “Beyond Petroleum” image of BP showed us, during a crisis, serious damage can be caused to a company’s reputation if there is a significant gap between the externally communicated identity and the reality of the company’s day-to-day activities (Vetter, J & Konja, B &. Ungár, P 2010). A really truthful image can only be built from within, since if employees and other wider stakeholder groups do not feel the identity as part of their own and valid for the brand, which in this case is represented by the organisation itself, this will lead to negative consequences, namely:
<table>
<thead>
<tr>
<th>ARCHETYPE</th>
<th>MOTTO</th>
<th>CORE DESIRE</th>
<th>GOAL</th>
<th>FEAR</th>
<th>EXAMPLE (INDIVIDUAL)</th>
<th>EXAMPLE (ORGANISATION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE INNOCENT</td>
<td>“Free to be you and me”</td>
<td>To experience paradise</td>
<td>To be happy</td>
<td>Doing something wrong or bad that will provoke punishment</td>
<td>Dolly Parton</td>
<td>Disney, Coca-Cola, Elmo? Volkswagen</td>
</tr>
<tr>
<td>THE EXPLORER</td>
<td>“Don’t Fence me In”</td>
<td>The freedom to find out who you are through exploring the world</td>
<td>To experience a better, more authentic, more fulfilling life</td>
<td>Getting trapped, conforming, inner emptiness, non-being</td>
<td>Amelia Earhart</td>
<td>Starbucks, Red Bull</td>
</tr>
<tr>
<td>THE SAGE</td>
<td>“The truth will set you free”</td>
<td>The discovery of truth</td>
<td>To use intelligence and analysis to understand the world</td>
<td>Being duped, misled; ignorance</td>
<td>Carl Jung, Albert Einstein</td>
<td>PHILIPS, Google, Discovery</td>
</tr>
<tr>
<td>THE HERO</td>
<td>“Where there’s a will, there’s a way”</td>
<td>To prove one’s worth through courageous and difficult actions</td>
<td>To exert mastery in a way that improves the world</td>
<td>Weakness, vulnerability, “wimping out”</td>
<td>The Lone Ranger</td>
<td>FedEx, U.S.Army, BMW, Nike, Olimpia</td>
</tr>
<tr>
<td>THE OUTLAW</td>
<td>“Rules are meant to be broken”</td>
<td>Revenge or revolution</td>
<td>To destroy what is not working</td>
<td>Being powerless, trivialised, inconsequential</td>
<td>Che Guevara, Robin Hood</td>
<td>Apple, Virgin, Harley-Davidson</td>
</tr>
<tr>
<td>THE MAGICIAN</td>
<td>“It can happen!”</td>
<td>Knowledge of fundamental laws</td>
<td>To make dreams come true</td>
<td>Unanticipated, negative consequences</td>
<td>Martin Luther King</td>
<td>intel, SONY, MasterCard</td>
</tr>
<tr>
<td>THE REGULAR GUY</td>
<td>“All men and women are created equal.”</td>
<td>Connection with others</td>
<td>To belong, fit in</td>
<td>Standing out, seeming to put on airs, being exiled or rejected as a result</td>
<td>Jimmy Carter</td>
<td>VISA, GAP, ebay</td>
</tr>
<tr>
<td>THE LOVER</td>
<td>“I only have eyes for you.”</td>
<td>To attain intimacy and experience sensual pleasure</td>
<td>Being in a relationship with people, the work, the experiences, the surroundings they love</td>
<td>Being alone, a wall-flower, unwanted, unloved</td>
<td>Rudolph Valentino, Sophia Loren, Elizabeth Taylor</td>
<td>marie clare, Häagen-Dazs, Victoria’s Secret</td>
</tr>
<tr>
<td>THE JESTER</td>
<td>“If I can’t dance, I don’t want to be part of your revolution.”</td>
<td>To live for the moment with full enjoyment</td>
<td>To have a great time and lighten up the world</td>
<td>Boredom or being boring</td>
<td>Tina Fey</td>
<td>IKEA, Ferrari</td>
</tr>
<tr>
<td>THE CAREGIVER</td>
<td>“Love your neighbour as yourself.”</td>
<td>To protect people from harm</td>
<td>To help others</td>
<td>Selfishness, ingratitude</td>
<td>Mother Teresa</td>
<td>VOLVO</td>
</tr>
<tr>
<td>THE CREATOR</td>
<td>“If it can be imagined, it can be created.”</td>
<td>To create something of enduring value</td>
<td>To give form to a vision</td>
<td>Having a mediocre vision or execution</td>
<td>Martha Stewart</td>
<td>Bang &amp; Olufsen, Crayola, dyson</td>
</tr>
<tr>
<td>THE RULER</td>
<td>“Power isn’t everything. It’s the only thing.”</td>
<td>Control</td>
<td>Create a prosperous, successful family, company or community</td>
<td>Chaos, being overthrown</td>
<td>Alan Greenspan</td>
<td>Windows, Mercedes</td>
</tr>
</tbody>
</table>

Table 1. Summary of the fundamental archetypes (source: Mark, M & Pearson, C & Pearson, CS 2001; own research)
the gap between the projected identity and the perceived or real image becomes exposed in a crisis situation

employees will not be able to identify themselves with the projected identity

employees will feel external communications are not in line with everyday practices.

To avoid the above mentioned problems and project a truthful and valid brand identity the organisation needs to discover the real true characteristics with the help of the archetype methodology.

DEFINING THE MOL GROUP ARCHETYPE – RESEARCH DESIGN

To have a clear understanding of who we are as a Group, we had to discover the MOL Group principal archetype. To do that we used a purpose-built archetype questionnaire (Appendix 1) as well as a series of senior management interviews to discover the real self of the organisation, the brand personality in other words.

More than 250 questionnaires were sent out to different organisations across MOL Group, different in both geographical and organisational terms. With a 71% response rate, the sample was considered representative. The results of the questionnaire were analysed and since all the questions related to a specific archetype from one of the 12 fundamental archetypes, a precise value could be assigned to each which revealed the relative strength of each specific archetype in the archetype set. Results can be found in Appendix 2.

RESEARCH FINDINGS

According to the research, the most predominant archetype for MOL Group was the Ruler. Scores for the different archetypes were very close to each other, a clear indication that since MOL Group did not build its brand according to archetype methodology, no one single archetype was predominant and stronger than the others. The close to even distribution of archetype scores is both a disadvantage and an opportunity. A disadvantage, since there is not a single predominant archetype and an advantage since with continuous communications according to the style and tonality of the archetype with the highest score – the Ruler – the most characteristic brand identity could be built up.

It also has to be noted that there was not much difference between archetype scores across countries, which implies that MOL Group people across a wide geographical spread view their organisation in a similar manner (see Appendix 3).

THE MOL GROUP ARCHETYPE: THE RULER

When we think about the Ruler archetype, we usually think about someone with power, somewhere between the boss, the father or the mother who acts like someone born to rule. The main characteristic of the Ruler is the exercising of power for the benefit of others. The ruler believes that the best way to keep oneself and one’s family, friends or colleagues safe is to create the feeling of being in control, fighting chaos and assuming responsibility. On the other hand, the Ruler is also a facilitator who helps others to fulfil their tasks. Normally the Ruler is recognised as a leader, politician, responsible citizen,
**ARCHETYPES**

**RISK**
- **THE OUTLAW**
  - Rebellion, Nonconventionality
- **THE MAGICIAN**
  - Transformational Power
- **THE JESTER**
  - Fun, Truth, Playfulness

**CHANGE**

**DISCOVERY**
- **THE INNOCENT**
  - Awe, Optimism, Purity, Innocence
- **THE EXPLORER**
  - Discovery, Independence
- **THE SAGE**
  - Awe, Optimism, Purity, Innocence

**KNOWLEDGE**

**ARCHETYPES**

**THE REGULAR GUY**
- Belonging, Utility, Dependability

**THE LOVER**
- Intimacy, Communication, Sensual Pleasure

**THE CAREGIVER**
- Care, Protection

**THE RULER**
- Power, Responsibility

**THE HERO**
- Challenge, Achievement

**THE CREATOR**
- Creativity, Vision

**CARE**

**STRUCTURE**

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Fig. 2. Archetype characters (source: http://www.added-value.com/source/2010/06/added-cnbc-world-news-brand-identity/, characterlab.com)
manager or administrator portrayed as extremely reliable and juggling many important responsibilities. Typical Ruler brands are „THE” brands in their respective product or service category, usually with a long-standing heritage and legacy (see Appendix 4).

FROM ARCHETYPE TO BRAND ESSENCE
It has to be noted that defining the guiding archetype is only a methodology used to really define the brand personality and, taking the analogy of an individual person, it is not the message, not what one says but the basic principle of the style and tonality of brand communications, in other words, how the message is delivered. Accordingly, defining the archetype is just the first step towards building up a consistent corporate brand identity that starts with defining the brand essence derived from the brand personality and then the mission and vision of a corporation.

THE MISSION, VISION AND VALUES OF MOL GROUP
When developing the Vision statement, MOL Group has defined how it relates to the world in the context of its business. The following Vision statement has been developed:

MOL Group keeps people moving ahead by discovering new ways of serving their energy needs better and creating value for generations to come.

It is also important to make clear how the company intends to achieve its vision, i.e. the Mission statement:

Operating across and from Central Europe, MOL Group will systematically overcome all frontiers, inspired by its management and relying on the expertise of its people.

A Value set has also been defined:

› Success and growth
› Courage and decisiveness
› Team-work and partnership
› Expertise and responsibility.

THE BRAND ESSENCE
Based on the main archetype, vision, mission and values, a brand essence had to be created. This might be described as an emotional common denominator ready to resonate across cultures. There are nine criteria for a powerful brand essence. It must be unique, intangible, single-minded, experiential, meaningful, consistently delivered, authentic, sustainable, scalable which means that it should also work for brand extensions (Phillips, K 2009).

Accordingly, MOL Group’s brand essence is value creation made manifest in the following words:

THINK. CREATE. MOVE.

Thinking is characteristic to MOL Group since the core to value creation is thinking about new investment opportunities, new, technologically more advanced ways of drilling for hydrocarbons, exploiting synergies throughout the entire hydrocarbon value chain from well to wheel, thinking about more efficient technical solutions in our refineries or more sustainable retail network expansion with energy savings in mind.

Creating shareholder value, creating products or services day-by-day or talented people creating world class achievements – all this together is the core of the brand. Helping others in the process of creation, bringing to life something genuinely new is also in harmony with ruler characteristics.

Moving physically and moving indirectly, letting others move and being constant facilitators of change is also at the core of our brand. Moving on four wheels or permitting others to move on two wheels in our Bike programme or moving local communities to act in the Greenbelt programme, energising them to create more liveable in, greener local communities is also in the true spirit of the brand. MOL Group also moves sports, the arts and culture.
THE BRAND BOOK

After defining the key archetype, mission, vision and value set, as well as the brand essence, a Brand book had to be created that is much more than a corporate identity manual only defining the mechanics of using different graphic elements, colours and tones. More than that, a Brand book helps us understand the whole brand personality and describes the reason for using a certain style and tonality. It serves as the Bible of every professional engaged in communicating verbally or visually using the brands’ imagery. It gives direction to both creative directors, photographers, copywriters, graphic designers working on different elements carrying the brand message. It is a great help since it can be used across borders to communicate the style, tone and manner of the same brand personality. As a result, the MOL Group Brand book has been created. It builds strongly on Think. Create. Move., and even the new MOL Group brand logo evolution is derived from it (see Figure 3).

The first campaign in which the new communications style was used was the International GLOCAL recruitment campaign (see Figure 4), which ran in eight countries in traditional and online media channels. It was been a clear success from the communications efficiency point of view since from the planned 23,286 clicks it generated 53,778!

FURTHER STEPS

Firstly, it is very important that the new identity be well introduced at MOL Group level and is then communicated across all touch points in Group communications.

Secondly, since MOL Group operates a multi-brand system this means that besides the umbrella MOL Group brand, a number of local market brands exist. The next step in the development process is to harmonise these local brands with the Group brand and cascade the Group brand personality down to local levels. This is not an easy task, since at local market levels different corporate, product and service brands are used. Sometimes these are not even at brand level, since they do not fulfill the most important pre-requisite of a brand - that it evokes feelings. In many cases, they are really at product name level or a pure logo level.

Strategic and conscientious harmonisation and the brand development processes have to be started to guarantee single voice communications as well as integration of the umbrella brand idea into local level communications.

Keywords: branding, archetypes, marketing communications, brand book

WHAT ELSE could be the goals of human thinking and creating? - possibly other than those of developing and moving forward the things that surround us?

What else could our jobs be if not to understand our world, take its meaning, and then make our lives better? What else is the aim and direction of all intelligent human effort. This creates new values and shares them with others. Wherever we live in the world, this is the aim and direction of all intelligent human effort. This makes all our individual and collective actions really have meaning. And so it makes

THINK, CREATE, MOVE - Only mean one thing to us. They very intriguing of existence

The new MOL Group Brand book
Boldizsár Konja joined MOL as a marketing communications expert in 2003 after working in similar positions with brands like Coca-Cola, Aral and Michelin. He joined Group Corporate Communications in 2010 after carrying out numerous international and local retail marketing communications assignments. As Group Marketing Communications expert he was responsible for creating the new MOL Group Corporate Brand. Boldizsár holds MSc in International Marketing Communications, received from University of Lincoln, UK, in 1997.

Anastasia Girutskaya joined MOL Group in summer 2011, starting her first work experience with the internship programme. Currently she is working in the department of International Communications and Corporate Brand Management. Her main activities are related to Group PR, Press monitoring, Internal Communications and Group Marketing Communications. Anastasia is finishing BA in Business Studies, at IBS - Oxford Brooks University in 2013.
<table>
<thead>
<tr>
<th>No.</th>
<th>MOL Group...</th>
<th>STRONGLY AGREE</th>
<th>AGREE</th>
<th>NEUTRAL</th>
<th>DISAGREE</th>
<th>STRONGLY DISAGREE</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Values loyalty</td>
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<tr>
<td>2</td>
<td>Helps people feel unique</td>
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<td>3</td>
<td>Values knowledge</td>
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<td>4</td>
<td>Rewards people who follow the rules</td>
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<td>5</td>
<td>Rewards pioneers</td>
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<td>6</td>
<td>Believes the truth will set you free</td>
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<td>7</td>
<td>Associates itself with images of goodness, innocence, or renewal</td>
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<td>8</td>
<td>Has an adventurous spirit</td>
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<td>9</td>
<td>Rewards expertise</td>
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<td>10</td>
<td>Emphasizes the importance of being trustworthy</td>
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<tr>
<td>11</td>
<td>Encourages people to find their own unique paths</td>
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<td>12</td>
<td>Emphasizes the need for ongoing learning</td>
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<tr>
<td>13</td>
<td>Provides clear guidelines to employees</td>
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<td>14</td>
<td>Supports employee autonomy</td>
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<td>15</td>
<td>Fosters continuous learning</td>
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<td>16</td>
<td>Offers employees long-term security</td>
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<tr>
<td>17</td>
<td>Makes a practice of encouraging employees to speak their minds</td>
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<tr>
<td>18</td>
<td>Provides for peer evaluation of personnel and projects</td>
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<tr>
<td>19</td>
<td>Has the feel of a small family business or a “mom and pop” store</td>
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<tr>
<td>20</td>
<td>Encourages staff to get out and meet new people</td>
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<td>21</td>
<td>Has systems in place to monitor quality standards</td>
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<tr>
<td>22</td>
<td>Offers an atmosphere of trust and loyalty</td>
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<tr>
<td>23</td>
<td>Values independence</td>
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<tr>
<td>24</td>
<td>Invests in research and development</td>
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<tr>
<td>25</td>
<td>Values a can-do spirit</td>
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<tr>
<td>26</td>
<td>Prides itself on being revolutionary</td>
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<tr>
<td>27</td>
<td>Prides itself on making miracles happen</td>
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<tr>
<td>28</td>
<td>Rewards people who are consistently productive</td>
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<tr>
<td>29</td>
<td>Has an unconventional image</td>
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<tr>
<td>30</td>
<td>Rewards self-awareness</td>
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<tr>
<td>31</td>
<td>Prides itself on besting the competition</td>
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<tr>
<td>32</td>
<td>Could have the motto “power to the people”</td>
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<tr>
<td>33</td>
<td>Believes in finding win/win solutions</td>
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<tr>
<td>34</td>
<td>Encourages people to make a difference</td>
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<tr>
<td>35</td>
<td>Rewards people who have radically new ideas</td>
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<tr>
<td>36</td>
<td>Aspires to create magical moments</td>
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<tr>
<td>37</td>
<td>Is good at getting things done</td>
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<tr>
<td>38</td>
<td>Is good at eliminating projects that are not working</td>
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<td>39</td>
<td>Develops consensus around a compelling vision</td>
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<td>40</td>
<td>Creates clear goals and outcomes</td>
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<td>41</td>
<td>Is willing to take great risks</td>
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<td>42</td>
<td>Develops flexible structures to respond to changing needs</td>
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<tr>
<td>43</td>
<td>Operates like a winning team</td>
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<tr>
<td>44</td>
<td>Achieves breakthroughs by challenging conventional thinking about how things have to be done</td>
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<td>45</td>
<td>Maximizes the synergy of coordinated efforts</td>
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<tr>
<td>46</td>
<td>Utilizes strategic planning to focus efforts</td>
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<tr>
<td>47</td>
<td>Provides an outlet for people’s wilder sides</td>
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<tr>
<td>48</td>
<td>Encourages self-organizing teams</td>
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</tbody>
</table>

Appendix 1. The questionnaire
<table>
<thead>
<tr>
<th>NR.</th>
<th>MOL GROUP...</th>
<th>STRONGLY DISAGREE</th>
<th>DISAGREE</th>
<th>NEUTRAL</th>
<th>AGREE</th>
<th>STRONGLY AGREE</th>
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</thead>
<tbody>
<tr>
<td>49</td>
<td>Believes in the dignity of the common man or woman</td>
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<tr>
<td>50</td>
<td>Wants to help people feel attractive and lovable</td>
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<tr>
<td>51</td>
<td>Wants to help people enjoy their lives</td>
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<tr>
<td>52</td>
<td>Rewards employees who are solid and unpretentious</td>
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<tr>
<td>53</td>
<td>Rewards people who have emotional intelligence</td>
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<tr>
<td>54</td>
<td>Makes work fun</td>
<td></td>
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<tr>
<td>55</td>
<td>Prides itself on being fair to everyone</td>
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<tr>
<td>56</td>
<td>Values consensual decision making</td>
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<td>57</td>
<td>Rewards ingenuity</td>
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<tr>
<td>58</td>
<td>Believes in banding together to survive tough times</td>
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<tr>
<td>59</td>
<td>Sees employees or customers as friends</td>
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<tr>
<td>60</td>
<td>Values experimentation</td>
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<tr>
<td>61</td>
<td>Rewards employees who try</td>
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<td>62</td>
<td>Fosters a real sense of caring among employees</td>
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<tr>
<td>63</td>
<td>Excels at brainstorming</td>
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<td>64</td>
<td>Has a personnel system and/or union that protects employees</td>
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<tr>
<td>65</td>
<td>Treats each employee as special</td>
<td></td>
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<tr>
<td>66</td>
<td>Encourages employees to find enjoyment in their work</td>
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<tr>
<td>67</td>
<td>Has fair employment policies</td>
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<td>68</td>
<td>Has systems in place to foster consensus building</td>
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<td>69</td>
<td>Has an atmosphere of playfulness</td>
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<td>70</td>
<td>Is sympathetic with employees when they have troubles</td>
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<tr>
<td>71</td>
<td>Invests in building community within the organization</td>
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<td>72</td>
<td>Recognises the restorative value of recreation</td>
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<td>73</td>
<td>Believes in nurturing and supporting people</td>
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<tr>
<td>74</td>
<td>Values creative endeavours</td>
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<td>75</td>
<td>Likes to set the standards others will follow</td>
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<tr>
<td>76</td>
<td>Rewards caring employees</td>
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<td>77</td>
<td>Rewards the creation of imaginative products</td>
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<td>78</td>
<td>Prides itself on having the power to keep people safe</td>
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<tr>
<td>79</td>
<td>Associates itself with images of kindness and concern</td>
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<td>80</td>
<td>Encourages self-expression</td>
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<td>81</td>
<td>Sees itself as setting the tone for how things should be done</td>
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<td>82</td>
<td>Believes worker satisfaction comes from being of service</td>
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<td>83</td>
<td>Believes in the importance of good taste</td>
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<tr>
<td>84</td>
<td>Values power and prestige</td>
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<tr>
<td>85</td>
<td>Has well-designed customer service systems</td>
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<td>86</td>
<td>Has highly functioning creative teams</td>
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<td>87</td>
<td>Has clear lines of authority</td>
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<td>88</td>
<td>Cares for the caregivers</td>
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<td>89</td>
<td>Invests in designing things beautifully</td>
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<tr>
<td>90</td>
<td>Is so respected, people who work there gain status by association</td>
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<td>91</td>
<td>Has systems in place to be sure it does no harm</td>
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<tr>
<td>92</td>
<td>Allows employees the freedom to be imaginative</td>
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<tr>
<td>93</td>
<td>Has clear policies and procedures</td>
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<tr>
<td>94</td>
<td>Provides a warm, nurturing environment</td>
<td></td>
<td></td>
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<tr>
<td>95</td>
<td>Creates outstanding new products</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>96</td>
<td>Ensures that key players sign off on initiatives before they are launched</td>
<td></td>
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</tbody>
</table>
Appendix 2. Results of the MOL Group organisational archetype survey

Appendix 3. Geographical spread of the results
Appendix 4. Examples of brands communicating according to the ruler archetype in the US/UK/HU (from Young and Rubicam Brand Asset Valuator presentation, plus own research)
THE BUSINESS CASE FOR GENDER DIVERSITY

ABSTRACT
Gender diversity is expected soon to become a business imperative due to its impact on economic results. Not only countries but also companies have already recognised its importance and initiate actions in order to tighten the gender gap. This article shows the facts that companies who promote gender diversity perform better in financial terms and this is not the only benefit. Special trends in oil and gas companies are also elaborated in detail with special focus on MOL Group.

The objective of the article is to give a throughout understanding why considering gender diversity means competitive advantage for companies.

INTRODUCTION
Globally, over the past years more women graduated from college or university than men. Meanwhile the average employment rate of women (49%) is significantly lower than that of men (73%), which suggests that almost every second woman drops out of the workforce at a certain stage of her career for a certain period of time (ILO 2011). Going further on the path only 21% of senior management roles are held by women and this proportion has not significantly improved in the past five years (Grant Thornton IBR 2012). On the list of Fortune 500 companies there were 20 female CEOs in 2012. Why women ‘disappear’ while moving up the ranks?

A part of gender explanations is based on the idea that the male and female characteristics are different. Suppose that women’s and men’s socialisation differ, they have different experiences and skills as well. For this reason they embrace different values. With this background they can contribute to the management of a company with special and unique insights. In case a management lacks women, that company will be deprived of important aspects and perceptions, hindering effective decision making.

This study is to give place to the different views on the two genders and opinions about them. It means that instead of comparing the two sexes or genders we argue for the necessity of paying attention to the presence of both.

THE WHY OF GENDER DIVERSITY
On the macroeconomic level gender diversity matters because the increase of women’s participation in the workforce has accounted for a quarter of annual economic growth since 1995 (European Commission 2011). Research shows that closing the male / female employment gap would have a positive impact on the economic results of developed markets. The growing talent shortage foreseen in Europe may also require the increase of women in the active workforce. Figure 1 shows that if the employment rate for women and men grows...
equally, the employee shortage narrows down to 3 million by 2036 (McKinsey 2007).

Regarding the age composition in Europe, fertility highly influences the demographic phenomenon of ageing. Meanwhile the fertility rate is an important indicator of future economic growth. Table 1 explains that there are more children born in countries where women’s employment rate is higher. In other words, more children are born in countries where women can stay active in the workforce and have an opportunity to balance work and private life commitments.

Currently there is a huge untapped talent pool of women who are not active in the labour market which is a lost investment in human capital. One cornerstone of the Europe 2020 Strategy is to raise the employment rate for women and men (aged 20 to 64) to 75% (European Commission 2011).

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**Table 1.** Fertility and employment rate in European countries in 2006 (OECD 2006)

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>FERTILITY RATE (CHILD / WOMAN)</th>
<th>EMPLOYMENT RATE OF WOMEN (%)</th>
<th>EMPLOYMENT RATE OF MOTHERS (%) (WITH 0-16 YEARS OLD CHILDREN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>1.94</td>
<td>63.7 (22.9)</td>
<td>59.9</td>
</tr>
<tr>
<td>Norway</td>
<td>1.84</td>
<td>72.3 (32.9)</td>
<td>69.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.80</td>
<td>66.8 (38.8)</td>
<td>61.7</td>
</tr>
<tr>
<td>Spain</td>
<td>1.34</td>
<td>54.0 (21.4)</td>
<td>52.0</td>
</tr>
<tr>
<td>Hungary</td>
<td>1.32</td>
<td>51.2 (4.2)</td>
<td>45.7</td>
</tr>
<tr>
<td>Slovakia</td>
<td>1.25</td>
<td>51.9 (4.1)</td>
<td>48.4</td>
</tr>
<tr>
<td>Poland</td>
<td>1.24</td>
<td>46.2 (16.3)</td>
<td>46.4</td>
</tr>
</tbody>
</table>
While women have a higher level of tertiary educational attainment than men in the EU, their professional careers do not fully reflect their skill levels, which is a waste of human resources and competences at a time when human capital is the key to competitiveness in the global economy (European Commission 2011).

There are many examples of how governments initiate actions in favour of gender balance. Since 2010, the Finnish Corporate Governance Code includes a ‘comply or explain’ rule, which obliges all publicly listed companies to explain why there is not at least one woman on the board of the company. Consequently the number of female board members has increased during the past years.

In September 2012 a proposal was submitted to the European Commission which aims to ensure that at least 40% of nonexecutive director board seats are taken by women in Eurozone publicly listed companies larger than 250 employees or with more than Euro 50 million in annual revenues by 2020. Recent news announces that the proposal has been adopted by the Commission (EUobserver 2012).

France already introduced legislation for increasing gender diversity in boardroom positions in 2011. The targeted measures fully comply with the EU initiative.

From the perspective of corporations, recent studies have found that gender diversity enhances economic competitiveness. Data shows that companies with better financial performance are the ones with higher share of women in their executive committees compared to companies with no women in the highest decision making bodies (see Figure 2). In terms of return on equity (ROE), companies with the highest share of women in their executive board (in top-quartile group) outperform those with no women (22 vs. 15%). Concerning earnings before interest, taxes (EBIT) margin, the more gender-diverse companies reach better operating results (17 vs. 11%) (McKinsey 2010).

Fig. 2. Companies’ financial performances (McKinsey 2010)
There is a positive correlation between the proportion of women in senior positions and company performance. Furthermore certain studies explain that a diverse team (meaning not only corporate governance bodies but any working group) is more creative and innovative due to the complementary knowledge and skills (McKinsey 2007).

From corporate and employer brand perspective, companies that can create a family friendly culture which offers flexibility and better balance between professional and private life are also more successful in attracting and retaining talents, especially female candidates.

“There is a strong statistical correlation among large numbers of senior women, financial performance, and organizational health. The bottom line: companies gain hard business benefits from a more diverse senior team” (Barsch, J & Yee, L 2011).

Based on these findings it is clear that companies where gender diversity is on the strategic agenda hence there are more senior women, perform better in financials terms and also tend to be the employer of choice.

GENDER DIVERSITY IN THE OIL INDUSTRY

If an industry is considered traditionally masculine, it is hard to reach a higher proportion of women employees. Oil industry is inheritably considered as such.

Almost all major oil companies describe gender diversity and indicate measures in their sustainable development reports referring to its importance as an area of improvement. Companies also want to comply with the world’s leading and most trusted business and sustainability ratings (e.g. Dow Jones SI, OEKOM) in which gender diversity and equal opportunity are important social indicators.

Although a majority of leaders seem to recognise the impact of gender diversity on business performance, this belief is not translated into actions. Indeed, gender diversity is not high on companies’ strategic agenda and the implementation of dedicated programmes remains limited overall.

Only limited amount of information is available on companies’ websites which may reflect the related ‘activity’ of the companies. The selection of companies in Figures 3 and 4 is different referring to the fact that the publicly available data is very limited and the topic is hidden, it does not appear on the front page. The content also differs on a wide scale therefore more in-depths comparison can only be made if the data set is homogenous, hence derived from various sources besides company website.

First data to be found on the oil companies’ website is the proportion of women within total employees. Figure 3 shows that the tendency has not changed in the past years.

In Figure 3 Statoil leads the group of selected companies with 37% of women in 2011, followed by Total and Repsol in the top quartile and Eni is the first from the bottom with less than half of Statoil’s score. There is an average disparity of 20 percentage points between Eni and Statoil during the measured period. MOL Group is in a mid-field position where women represented 24% of total workforce in 2011.

Figure 4 details the proportion of women in managerial positions. In the collection of companies Statoil takes the first rank again with 31% in 2011. Moreover there is a steep increase at Statoil during the last one year. In decreasing order MOL Group is the fourth from the back, where the ratio of women in managerial positions was 15% both in 2010 and 2011.

As the studied companies’ websites indicate, the higher the position in the organisational hierarchy the smaller the percentage of women. While moving up the ranks women often ‘disappear’ and in some cases there is no woman in the main decision making bodies. As Table 2 indicates, at Statoil and Total more than one third of board members are women.
Focus

(in Norway corporate quota has been adopted since 2003 which requires 40% women in board seats). On the other hand, there is no woman in Boards of Directors’ (BoD) of Eni and MOL Group. The rank of companies in Table 2 is very close to the rank of Figure 4 which explains well that quick conclusion cannot be drawn. Although at Eni the ratio of female managers is fairly high, there is no woman in the BoD. While the proportion of female managers is clearly low at ExxonMobil and Chevron, there are women sitting in board seats.

WHY ARE THERE SO FEW WOMEN IN THE OIL INDUSTRY?
Based on the figures mentioned above, the question arises: why women disappear along the way? Eve S. Sprunt, 2006 SPE president conducted a survey within the oil and gas industry (Sprunt, E 2006). The main focus of her study was to discover the drivers behind that lead women to quit the company or made them stay. The below described reasons are the most frequently mentioned ones.

Fig. 3. Ratio of women in total number of employees [%] (Respective company websites 2012)

Fig. 4. Proportion of women in managerial position (Respective company websites 2012)
It may take 5 to 10 years for someone joining the oil industry to be fully competent (considering the special industry-related professions). The women with university degrees at the age of 30-35 usually consider starting family. Therefore the special needs of young families should be acknowledged and translated into actions that help them balance private life and professional commitment.

Lack of advancement is a sore point mainly for middle aged or older women. While filling senior / executive positions, employers often do not consider women, as real candidates. Employers prefer the ‘monotonic’, traditional upward careers. Those, who slow down for a certain period of time (e.g. due to pregnancy and having children) often fall off the fast track and immediately get on the ‘mommy track’. Employers should recognise and promote those who are able and willing to be highly productive at work later in their career.

Even if there are women in top positions, their career path is rarely transparent for the young followers. Women in senior positions, who can successfully balance private life obligations and work demands, could serve as good examples for the ambitious younger generation.

**GENDER DIVERSITY MEASURES**

Actions and measures also appear to promote gender diversity across the industry. The following examples come from the practice of three international oil and gas companies.

**OMV considers** the increase of gender diversity a high-level objective. Therefore a target has been introduced for female representation at senior management positions which should reach 18% by 2015 and 30% by 2020. OMV also encourages women to enter the science and technology industry. One initiative is to provide scholarship for female graduates who come from economically disadvantaged Austrian communities, where OMV operates (UN Women 2011).

**BP is committed** to diversity and inclusion. A global women’s networking group (‘BPWIN’) has been founded to support and encourage women within the company to successfully develop their careers. The aim of the network is to create a forum to connect and learn from each other. BP also recognises that at certain phases in people’s careers priorities change. At these times it might become even more important to establish effective work-life balance. As an answer to that BP offers flexible working conditions and also shares case studies to serve as best practices (UN Women 2011).

**Total’s Diversity Council** was set up in 2004 with the objective to increase the percentage of non-French, local and women managers in their workforce, including at the most senior level. Since then guidelines are built in every HR process related to recruitment, development, career management and resource planning (in Respective company websites 2012).

**GENDER DIVERSITY IN MOL GROUP**

As previously shown figures indicated, the average proportion of women at MOL Group is 24% during the last four years and it is not changing significantly. The basis of further analysis is MOL Plc. therefore the next data is limited to this company of the Group.

<table>
<thead>
<tr>
<th>Company</th>
<th>Statoil</th>
<th>Total</th>
<th>Repsol</th>
<th>Eni</th>
<th>Shell</th>
<th>MOL Group</th>
<th>BP</th>
<th>Exxon Mobil</th>
<th>Chevron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women%</td>
<td>40%</td>
<td>36%</td>
<td>11%</td>
<td>0%</td>
<td>15%</td>
<td>0%</td>
<td>12.5%</td>
<td>9%</td>
<td>9%</td>
</tr>
</tbody>
</table>

*Table 2. Ratio of female members in companies’ Board of Directors (BoD) in 2011 (in Respective company websites 2012)*

A further breakdown explains that most women take white collar positions (see Figure 5). It highlights the masculine characteristic of the industry meaning that traditional blue collar jobs that are in close connection with production or refining are taken by men. The nature of such roles requires strength or
Focus

physical condition while the work environment is also associated better with men. Therefore such positions are overrepresented by men due to the assumed necessary skills. Furthermore these professions attract fewer women.

As mentioned previously, the female ratio of all managers at MOL Group is 15%, which is positioned in the last third of the analysed benchmark group of oil industry companies. Nevertheless, it is worth taking a closer look at where women are concentrated in the organisational hierarchy.

Figures 6 and 7 detail the breakdown of MOL Plc.’s grades\(^2\) by gender. Each position is linked to a grade which determines a wage range. The percentage indicates the ratio of women in the given grade.

The grades at non-managerial level (Figure 6) can be broken down into 3 parts. The first includes the blue collar positions, the second means the fresh graduates, entry level positions and associates, while the third part represents the expert jobs which is the highest rank of non-managerial positions. The domination of men in the first third clearly supports the previously described finding, namely the large number of blue collar positions which are typically taken by men. Meanwhile, in the upper two thirds of the grades (E07-E03) the ratio of positions taken by women increases significantly. It suggests that most women are in white collar positions. A significant drop appears at the grade E02 which can be considered as the threshold for managerial positions.

Figure 7 explains the same nature of grading system but for managerial positions including also advisor positions according to data from early 2012. The graph shows a completely different trend. The majority of female managers take the positions that are ranked in the first third of the grades. It proves the above mentioned assumption that the ratio of women decreases moving up along the ranks. This suggests that only lower level managerial positions are taken by women.

Combining the findings of the two charts, it is shown that there are many women entering the company at an early stage of their career in white collar jobs who later become experts, but hardly any women make it to top graded positions. This phenomenon is commonly called as glass ceiling\(^3\). This latter statement is also supported by the composition of the company’s governing bodies.

According to MOL Group annual reports of the past years there were no women among BoD, Executive Board, or Supervisory Board members. In other words, there is no woman in the main decision making bodies of MOL Group.

As a result of the Glocal Project\(^4\) personal changes are on-going in positions and a new role known as thematic leader has appeared therefore a new analysis is needed. How is this going to change the proportion of women after restructuring?

THE WAY FORWARD FOR MOL

After introducing company specific background data, the following section details some of MOL Plc. existing practices followed by best practices as a proposal for the way forward.
Over the years more and more women enter the workforce meanwhile the ratio of women is not increasing in the oil industry. In 2011, while less than one-third of the total workforce was woman at MOL Plc., 44% of newly hired employees were women. Still only one in five managers is female and no woman is in the main decision-making bodies (Hanti, Sz & Kormos, J 2012). Based on the results of research, it has also been introduced in the previous paragraphs, why it is worth for companies to take actions in order to promote gender diversity. It is clear that gender diversity can be a competitive advantage for MOL Group.
In order to leverage that advantage, one target area is to increase the presence of women in senior managerial positions. First step might be to detect why women are not moving up on the career ladder after a certain level.

One key turning point in a woman’s career is the time of parental leave. According to an internal study which was prepared in MOL Plc. in February 2012, more women explained that the main disadvantage of being woman is the less time due to ‘maternity leave’ to walk through the same path as men. And in fact they can (re)start their career after returning from maternity leave (Hanti, Sz & Kormos, J 2012). At this stage women tend to leave the company either because of the change in aspiration or the lack of sufficient opportunities at the former workplace.

At the beginning of 2012, 2% of the employees in MOL Plc. were on parental leave. At the same time nearly 10% of the employees were parents raising 2 or more children under 10 years of age. The result showed that 45% of new mothers return to work after parental leave which also includes different positions from the previous one (owned before parental leave). Although this result is better than the Hungarian average, which is 30-35%, there is still a pool of potential women who either continues their career at another company or becomes inactive on the labour market (Fertetics, M 2009).

The other 55% leaves MOL Plc. within 1 year after returning to work (Hadházy, T 2011) which means a loss of talents for the company.

The following example translates the tendency into numbers. The ‘Growww’ programme started years ago at Group level with the concept of creating a talent pool in order to bring the next generation into the company, balance out the age composition and ensure sufficient succession for the future. Taking ‘Growww’ participants of 2011 in Hungary as an example, the following hypothetic result was revealed considering the above mentioned tendency. Almost one third (27%)
of ‘Growww’ participants were women. At the stage of becoming mothers, after returning to work from parental leave only every second woman has remained at the company longer than 1 year. It also means that out of 90 people 24 are women, once recruited as potentials, out of which there might be a loss of 13 talents.

After a successful return, approximately 15% of mothers start working part-time, while the majority starts working full time immediately. Although this proportion is significant in the practice of MOL Plc. (considering the fact that only 1.4% of total employees work part-time) the company’s goal is to raise the proportion. Telework is very rare, but flexible work time and occasional home office – depending on the type of the job and based on the agreement with the direct manager – are available options at the company.

These figures suggest that this is one key stage of a woman’s career where the employer can support the young families in order to retain the potential talents.

MOL has already recognised this and introduced special services for employees on maternity leave:

› Monthly newsletter about company events, news, vacancies and many other topics relevant specially for them

› Invitation to major company events (Summer party, Regional family days, Christmas concert, Free University by MOL)

› Company newspaper sent by post

› New mothers’ coordinator, correspondence list

› Up to date information about allowances, benefits, rights and obligations of employees on parental leave.

After returning to work, atypical employment (i.e. part-time work, telework, job sharing) is also available upon demand but it also depends on the type of job. As mentioned before, currently these opportunities are not wide-spread throughout the company.

Going further on a universal career path, assuming that the personal ambition is to step forward, the next phase is about getting to the next level of the career ladder.

The coming part introduces those corporate practices that aim to develop and promote more women in senior positions. Since there are no specific initiatives known to serve such objectives at MOL Group, those best practices are described where companies keep gender diversity among the top priorities on the strategic agenda.

“No program or initiative can be the ‘silver bullet’ to advance women into senior roles. Rather, the whole organization must change. This goal requires a serious commitment from busy leaders. And it required real engagement up and down the line, including engagement from women. Efforts to advance women must be integrated into the organization’s daily work” (McKinsey 2011).

The Women matter global survey (McKinsey 2010) studied the implemented measures related to the retention, promotion and development of women at more than 1,500 companies. The most frequently mentioned action is the option for flexible working conditions. Among the three most popular measures the second is the visible and credible commitment of the CEO and the executive team including regular monitoring of the progress in gender diversity related programmes. Then initiatives follow which encourage female networking and role models. Thus there is a common platform for women to share the experience and also to publish biographies, make the success stories transparent.

Among these initiatives, programmes are also mentioned like skill building specifically for women, mentoring and sponsorship by senior executives.
Interestingly, gender quota is the last one of the top ten list indicates that it is not the regulation that changes the trend. It is the approach, the values embedded in the corporate culture that makes the difference hence turns the trend around.

In MOL Group further analysis is required to map the trends and collect the already existing practices. Only then can a global, comprehensive diversity strategy be introduced throughout MOL Group where one focal point should definitely be the gender.

CONCLUSIONS
After looking through the global trends and industry specifics, it can be declared that companies, even governments treat the topic of gender diversity really differently. For the future the EU initiative is quite clear with the objective to increase women’s participation in the active workforce and in the highest governing bodies of listed companies.

Companies benefit from other advantages as well while complying with the EU principle. Namely those companies are proven to perform better in financial terms and happen to be the employer of choice where gender diversity is high on the strategic agenda.

MOL Group is still on the way to create the fundamentals of a Group level diversity strategy. This common platform should respect global corporate values while reflect on local specifics because it truly means competitive advantage to retain, develop and promote women.

Keywords: sustainable development, gender diversity, employment patterns, senior women, leadership, equal opportunity

Reviewed by Beáta Nagy, Dr. and Pál Kapusy

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Respective company websites 2012, including
Since Timea Hadházy joined MOL 18 years ago, she gained various experiences in different HR positions, as HR associate, then recruitment and selection specialist and HR partner. Recently, since she returned to work from maternity leave, as a part-time worker, she is responsible for equal opportunity issues of MOL Plc. and also works as recruitment and selection expert. She has a Master’s degree of Psychology from the University of Debrecen and Work- and Industrial Psychology from the Budapest University of Technology and Economics.

Szilvia Hanti joined MOL Group in August 2011, and work at Human Resources. She prepared and presented the study ‘Career according to Her’ with Judit Kormos at Business Education and MOL Free University. Szilvia as sociologist participated in several social science researches before such as surveys on public attitudes, on financial awareness or on population trends of disadvantaged areas. She published an economic sociological study on ‘The relation of e-banking and trust in Hungary’ in 2011. She graduated from Corvinus University of Budapest in 2010. Her specialisation was Sociology of Organisations and HR, Industrial Relations.

Judit Kormos joined the company as a participant of the Growwww program in 2011. Recently she has been working on the foundation of a comprehensive diversity strategy at MOL Group. She graduated from Corvinus University of Budapest. She also holds a degree of CEMS Masters in International Management.
HISTORY OF THE 60 YEARS OLD ZALA OIL REFINERY

László Gelencsér, Dr.
Ret. Director of Bitumen Business
MOL Plc.

ABSTRACT
The author summarises the main events of the 60 years Zala Refinery starting from its establishment till the present day. Changes in the processing units, product development and marketing, and environmental developments are detailed.

THE BEGINNING: DISCOVERING THE NAGYLENGYEL CRUDE OIL FIELD AND ESTABLISHING A REFINERY
Zala Refinery celebrating its 60 years anniversary in November 2012 had been established in 1952 under the name of Zala Asphalt Production Company. Its successor companies were Zala Mineral Oil Company (1953), Zala Crude Oil Company (1954), MOL Plc Zala Refinery (1991).

The overview of Zala Refinery now being part and under the management of the Refining and Marketing of MOL is shown in Figure 1.

Establishment of the Refinery had been facilitated by the discovery and exploration of the Nagylengyel crude oil field in the years 1950 to 1951 within the Nagylengyel, Gellénháza, Barabásszeg region (Hungary). Starting from the autumn of 1951 exploration, drilling and development of production wells had been accelerated (Nagy, B 1972; Nagy, S 1987A; Nagy, S 1987B; Gelencsér, L 1993; MOL 1997; MOL 2002). In addition to its significant economic role the discovery of the Nagylengyel crude oil field had an impact of high significance to the area – to the life of the nearby county seat Zalaegerszeg (Nagy, S 1987B).

Fig. 1. Overview of Zala Refinery in the early 2000s

Properties of the Nagylengyel crude oil are high density, low pour point, a paraffinic intermediate nature, high (12 to 17 %) asphaltene content, high (approx. 3.5%) sulphur content, high viscosity, low light fractions and high (approx. 60%) bitumen residue yields. The delivery by pipeline of this low pour point crude oil – based on the engineering conditions of that time – could be solved economically to a short distance only.

The location for establishing the Refinery had been defined with consideration given to the close location of Nagylengyel crude oil field, the existence of Zalaegerszeg to Rédecs railway line (product transport by rail), the stream flow and vicinity of Upper Válicka brook (process water intake), the direct connection to the services available at Zalaegerszeg railway station, the possibility of quickly constructing a railway network, the beneficial utilisation of the sloping terrain conditions (draining process wastewaters, rainwater run-off, installation of storage and process tank farm).

In its letter dated 17th May, 1952 the Secretariat of the National City Planning and Emplacement Committee set the location of the Refinery South of the Zalaegerszeg railway
station and East of the Zalaegerszeg to Rédics railway line (Nagy, S 1987B). In addition to the engineering and economic considerations, the political aspects of that time for establishing industry were also justifying the location of the Refinery close to Zalaegerszeg which had no significant industry.

Established on a 74 hectares area as a green field project the activities of Zala Asphalt Company were: processing crude oil produced by Nagylengyel Crude Oil Production Company, and selling its products. With its high bitumen content the Nagylengyel crude oil was suitable for processing economically into bitumen – in line with the needs of the time - into heating oil with the proper use of the distillates mainly as transport fuels.

Until the 1950s the Hungarian refineries have processed light oils with high white product content. Economic processing of the Nagylengyel crude oil required and made the foundation for designing and establishing a refinery of a special process technology – with bitumen as the target product. The main profile of the new Zala Refinery had been bitumen production.

The outcome of the proper installation concept of the Refinery and its optimal geographical location – the logistical nearness of the countries in the region, the satisfaction of the just in time bitumen delivery conditions – represent competitive advantage in bitumen marketing even today.

**THE PRODUCTION UNITS OF THE REFINERY, MAJOR INVESTMENT PROJECTS, REVAMPS AND UPGRADES**

**CRUDE OIL PROCESSING**

The implementation of major projects, revamps and upgrades during the 1952 to 2010 period had practically been characterised by the systemic approach.

Figure 1 illustrates the process units, infrastructure and level of development of Zala Refinery in the 2000s.

The construction and erection of the Refinery started in June 1952. In October 1952 a DN 250 mm crude oil transport pipeline between Nagylengyel and Zalaegerszeg was commissioned.

The actual production was commenced on 15th November, 1952 in the first atmospheric distillation unit A1 of the Refinery, and wide range distillate and high viscosity fuel oil were produced at the beginning. Following an upgrade in 1953, gasoline, gas oil and soft bitumen appeared among products. In the early years the basics necessary for a continuous operation, incl. infrastructure, power supply system, tank farm, bitumen discharge and loading system, storage yards, bitumen packing metal drum (of 20 to 250 litres volume) production, railway loading system, wastewater treatment system, process water intake unit, and network of side railway tracks were gradually implemented with the uninterrupted upgrading of the process equipment (Nagy, B 1972; Nagy, S 1987A; Nagy, S 1987B; Gelencsér, L 1993; MOL 1997; MOL 2002).

The increase in the production of the Nagylengyel crude oil field and the ever rising demand for crude oil products especially for bitumen substantiated the construction of the 610 tonnes per day capacity atmospheric and vacuum distillation unit (A2V) and the 50 thousand tonnes per year capacity bitumen blower unit in 1954. As a result of the efficient process upgrades throughout the 1960s – intensifications, modernisations, revamps – the conditions for high volume production of bitumen with a high utilisation value were established.

In addition to the domestic supplies the export sales of the bitumen products, competitive in the international markets, made of the Nagylengyel crude oil, were also started at a significant rate from 1955. The dominant rate of the bitumen exports was provided by the products packed into metal drums in compliance with the set of packing and rail loading requirements for exported bitumen products.
The bitumen production and sales were dynamically rising from 1957 on. Figure 2 presents the bitumen sales of Duna and Zala refineries in a clear and purposeful manner.

In 1952 the Refinery employed 87 persons. In 1960 Zala Crude Oil Company was offering jobs to 626 employees. Because of an increase in the proportion of the more labour intensive bitumen products the headcount of the Refinery was increasing on a continuous basis until 1968. At that time it had reached 738 persons, however since then it has been dropping significantly – due to engineering upgrades, modernisations, activity outsourcing, rationalisations and organisational measures.

Despite the continuous upgrades Unit A1 established first was less and less able to comply with the requirements. In 1969 a modern Unit A1 was constructed and the further upgrading of the unit, the construction of the vacuum flash unit was completed in 1971. For the purpose of motor gasoline production Unit A1V was revamped and upgraded in 1973 so the processing of the relatively light South-Zala crude oil become feasible. Due to changes made in both the international and Hungarian product standards the motor gasoline production was discontinued in the Refinery in the early 1990s.

The proportions of feedstocks processed in the Refinery during the years between 1952 and 2001 are presented in Figure 3 (MOL 2002).

The feedstocks having a dominant effect on the structure of the Refinery crude oil processing are: the Nagylengyel crude oil (high bitumen
crude, its properties have been addressed earlier), the South-Zala crude oil: crude produced in the Budafa, Lispe, Lovássy, Bázakerettye region (high white product, low sulphur light crude of a paraffinic nature), Sávoly crude oil (high paraffin heavy crude oil, unsuitable for bitumen production), Sávoly South-East crude oil (medium bitumen and white product crude oil), HBR (diluted vacuum residue of the Russian Romaskino origin, high bitumen feed), imported feed (high bitumen or white product crude oils at a varying volume) and others.

For the purpose of keeping and improving the domestic and foreign market positions the intense upgrading in the bitumen packing and the packaging process to satisfy the varying customer needs was continued. The Refinery experts developed processes for the bitumen packing first into polyethylene bags in the 1960s and 70s, and into polyamide bags in the second half of the 1980s. The significant market demands required further developing the packaging and cooling processes and implementing the engineering upgrades of the complete mechanisation.

As a result of the market-oriented developments the fast cooling, packing, storing and environment-friendly packaging process of bitumen products with a higher softening points (bitumen grades 100/25, 105/25, 95/35, 95/40 for the building industry) was also implemented.

Figure 4 is presenting the changes and trends of the market areas targeted by the benchmark countries in line with the market requirements in the bitumen packing and packaging processes to meet the European standards on a continuous basis. Produced only in Zala Refinery in Hungary, the high volume building industry grade bitumen products of various packing and packages represent a dominant segment of the complete bitumen product range.
The production capacity of the bitumen products which have a priority importance in the product structure development was completely revamped. In 1979 a bitumen oxidising (blowing) unit with a high technical standard suitable for producing the total blown bitumen product range was constructed using a World Bank loan scheme, with a capacity dominant in terms of its size even within Mid-Europe (see Figure 5). The 200 thousand tonnes per year bitumen blowing unit consists of two production lines which can be operated in parallel and which allow the simultaneous production of two bitumen product types.

During the years between 2003 and 2006 the bitumen blowing production process technology was further improved, a modern micro computerised distributed process control system (DCS) was implemented. The bitumen blower is still the main processing unit of the Refinery at present – the bitumen product range made is: 70/100, 50/70, 35/50, 85/25, 85/40, 95/35, 105/25, B-25.

Following the shutdown of the crude oil distillation activity, bitumen blowing feed (vacuum residue) of some 150 thousand tonnes per year volume is being supplied in rail tanker cars to Zala Refinery from Duna and Slovnaft Bratislava refineries since 2001.

In addition to the upgrades in the bitumen blowing production process technologies significant environmental investment projects have also been implemented: treatment, incineration and caustic scrubbing of blower off-gases. The process equipment of the flue gas scrubber is presented in Figure 6.

Commissioned in 1984 the new 400 thousand tonnes per year capacity atmospheric-vacuum distillation (A2V) unit, due to its high rate of flexibility, was suitable for processing both heavy and light crude oils. In Unit A2V the complete distillation bitumen product range was produced (B-15, B-25, B-45, B-65, B-80, B-200, KM-90, KF-120 and BB-75).

During the complete revamping of Unit A1V in 1993 the upgrading of the unit process technology was implemented. Before the revamp the Unit was performing the distillation of crude oils with high white product content. Following the revamp the state-of-the-art process equipment is able to produce high softening point bitumen grades. In details, as a result of the revamp project in the atmospheric and vacuum distillation unit A1V:

› The flow of vacuum distillates was increased, their proportion had been changed

› The flow of more valuable gas oils was increased at the expense of fuel oils, which in summary resulted in an increase in the white product yield

› For the South Zala and Sávoly crude oils the yield of vacuum gas oils was increased, the sharpness of cut improved significantly
In processing the Nagylengyel crude oil the sharp separation of vacuum gas oil and paraffinic distillate became possible.

As a result of the vacuum tower construction with structured packing the separation sharpness between paraffinic distillate and bitumen was improved significantly.

Unit A1V became able to produce the total distillation bitumen range.

The specific power consumption dropped significantly.

The water and oil load on the wastewater treatment system was reduced.

A distributed process control system (DCS) was implemented.

Furthermore, important upgrades were implemented in the Refinery units, including:

- Modernising the power supply system
- Revamping the boiler feed water treatment system
- Improvement in the electric power supply system
- Railway loading and discharging systems
- Revamping the process water and wastewater management
- Constructing a storm water basin
- Water re-cooling through recycling
- Improvement in the process water channel
- Constructing a modern bitumen analysis laboratory
- Revamping the industrial side track rail network
- Constructing LPG and auto gas discharge gantry.

WASTE OIL PROCESSING

As a significant step in rationalising the refinery activities MOL Plc. shut down the crude oil distillation in Tisza and Zala refineries in 2001 (MOL 2002). This measure was in line with the international trends. In Zala Refinery the fact that despite an intense crude oil exploration effort the crude oil production in Zala (Nagylengyel crude, South-Zala crude, Sávoly crude) was dropping significantly also contributed to the discontinuation of the local crude oil distillation activity.

Between years 2001 and 2007 the Refinery was storing the Nagylengyel and South-Zala crude oils delivered to Zala Refinery by pipeline, loaded them into railway tanker cars and transported them to Duna Refinery.

Since the early 1990s Zala Refinery has been processing the total quantity of waste oil collected by MOL Plc. The waste oil residue is utilised in producing blown-fluxed bitumen grades.

The vacuum equipment of Unit A1V revamped in 1993 was shut down in 2001. Taking the efficiency and environment protection requirements as a basis, the unit has been revamped and upgraded for the purpose of processing waste oil. The volume of the waste oil was sharply dropping and has now levelled out at 7 to 8 thousand tonnes per year. Its processing takes place in properly scheduled weekly cycles, 4 to 5 times a year.

As a result of the process technology and environment upgrading of the waste oil processing the following have been implemented:

- Improving the efficiency of spent oil treatment
- Modernisation of storage tanks (side agitator, heating system, layer sampling)
- Even distribution (homogenisation) of the hydrocarbon content in the spent oil
- Efficiently operating 3-phase (water phase, oil phase, solids / sediment phase)
centrifuge installed in the system for de-watering prior to processing reduces the water content below 2% in the waste oil to be processed

› Internal structure (tower structure, mesh tray structure) of the main distillation tower has been revamped

› Water cooling equipment fitted with a modern control system

› Purposeful upgrading in the DCS computerised process control system

› Making the head product storage tank a closed system

› Utilisation of the processed waste oil (waste oil residue) in producing blown / fluxed bitumen grades

› Discharging, treating and incinerating the decanter off-gases.

BITUMEN / BITUMINOUS PRODUCT UPGRADES
Based on their market-oriented nature and up-to-datedness the bitumen / bituminous products made or developed in the Refinery can be arranged into several blocks (Gelencsér, L 1995).

PRODUCTS IN THE FIRST GROUP
The first group includes the quality bitumen products of a high volume. These are in compliance with either the applicable domestic and international standards and codes, or with specific contracts and specifications in respect of some parameters. They represent a complete range of the distilled and blown bitumen products packed in various ways for road construction, building, paint, power, or briquette industries.

The blown / fluxed bitumen products satisfying special needs are ranked into this group. In that case the quality of the blown bitumen grades is defined by several factors: quality of feed, composition of the oil distillate / waste oil residue used for fluxing, number of steps in fluxing and oxidising, and the selection of the process parameters used.

In bitumen grades of a nearly similar softening point, produced with traditional oxidation and in one or two fluxing steps, a significant difference can be experienced: the penetration of product will increase and the Fraass breaking point will drop to a significant rate.

In 2001 MOL Plc Refining and Marketing Division reviewed the bitumen product range (MOL 2002). As a consequence, based on the market demands and with consideration given to the analysis of the competitors the emphasis in the future should be placed on the production of high volume quality bitumen grades (road construction, building industry), as well as of the modified bitumen products. In 2001 the company produced 42 different bitumen products, and a significant proportion of these were marketed in several types of packaging. In 2002 only 18 grades of bitumen products were produced and packed on a continuous basis. Specific products of a small volume went into production and packaging with a suitable schedule based on more significant market demands.

Bituminous products packed for the building industry were gradually replaced by modern bitumen-based insulation plates and roofing sheets (Gelencsér, L 1995) (see later).

ACTIVITIES CLASSIFIED IN THE SECOND BLOCK
For activities that can be classified into the 2nd block the research and development, the production and the marketing are forming a continuous chain. The intense research and development of bitumen products with a structure modified with plastics to improve the application properties of the bitumen can be dated to the second half of the 1980s (Nagy, S & Horváth, Z & Gelencsér L 1988).
As a combined result a modern product family of the modified bitumens was developed under the brand name ZALAPLAST: ZALAPLAST modified road construction bitumens, ZALAPLAST-FM modified bitumen filler products, ZALAPLAST-E emulated modified bitumens (Gelencsér, L 1995; Nagy, S & Horváth, Z & Gelencsér, L 1988; Pallós, I 1994).

In addition to the development in products and production processes new testing methods were also introduced. Using a state-of-the-art fluorescent microscopic method the procedure of production, the dissolution and integration of the modifier into the bitumen can now be monitored on a continuous basis (homogenous dispersion system).

In the category of modified asphalts the hot deformation resistance of the asphalts made by using modified bitumen marked ZALAPLAST-8 is good and their cold behavioural properties are outstandingly advantageous (Pallós, I 1994).

The thin asphalt overlays produced using bitumens modified with polymers, the drain asphalts having also a noise reduction effect and the wear layers with open pole structure and bigger void content, as well as the modified bituminous mastics used advantageously as components of bridge insulation / coating systems have become important components of the road construction and maintenance processes.

As a result of developing a filler system of high requirement standard the modified bituminous filler product ZALAPLAST-FM has also been introduced for the road construction industry.

The road construction technologies using modified bitumens are providing excellent possibility for several asphalt road construction, motorway construction and maintenance solutions.

Figure 7 is illustrating a road structure with thin asphalt wearing layer made using modified bitumens.

Fig. 7. Asphalt road with modified bitumen ZALAPLAST-8 wearing layer on motorway M1, Győr bypass section (1994)

To prevent deterioration of the road surfaces the thin asphalt renewing process is used mainly for the reconstruction works of roads and motorways suitable in terms of load bearing.

The increase in use of roads and motorways and their longer life, the traffic of vehicles with 40 tonnes of total weight, with 11.5 tonnes of load on axle, the frequency of vehicles with an increasing tire pressure (0.3 to 0.9 MPa), the impact of global warming, the significant and varying increase in vehicle traffic (traffic composition) have changed demand for road bitumens. As an outcome of the developments executed on the basis of user market demands and of research and development works aiming at providing a product quality as required by both the development of a modern modified bitumen product family modified with polymers – basically elastomers – and competitive with the West-European products, an up-to-date production process have been implemented successfully in Zala Refinery.

A plant section producing the modified bituminous products is presented in Figure 8.

As a result of both the market-oriented research and development, and the production improvement, and further as a result of the single channel end user marketing system, the sales volume of the road construction modified
bitumens has increased in recent years. For the construction of speedways, high load roads and for road surface renewal works the use of modified road construction bitumens basically varies in the range of 37 to 70 thousand tonnes per year.

In 2012 following the 10 year common research work by MOL Plc and Pannon University of Veszprém a rubber bitumen pilot unit of 5,000 tonnes annual capacity has been constructed in Zala Refinery. The process has been patented. The first batches have been made and test roads have been constructed in Duna Refinery and next to Zala Refinery, and the commercial sales have commenced.

During the design and construction a priority attention had to be paid to handling the gases and vapours generated during the production which has proved to be a success from both safety (formation of an Ex zone) and environment protection (avoid unpleasant odours) points of view. At present the priority task is to increase the market sales quantity of the product.

**PRODUCT MARKETING**

Today the Refinery markets its products primarily in foreign markets. In the early years mainly bitumens and fuel oils were marketed, from 1980s on gas oil was also sold.

**CHANGE IN THE PACKAGING METHODS**

1955: The first export bitumen sale – in year 1955 – was delivered to Finland, followed within the same year by the delivery of several thousand tonnes – by ship overseas – to Burma.

1958 to 1963: In this period the domestic and export bitumens were delivered packed in plywood and metal drums, small packages and paper bags, then the plastic bag packing appeared with an increasing volume.

1960: From this year the Refinery was marketing – in an increasing volume – bitumen and fuel oil hot loaded into road tanker trucks (see Figure 4) mainly to Austria and Yugoslavia.

1968: In this year the domestic road transportation started with modern insulated tanker trucks and from then on the tanker truck capacity and the quantity transported in one trip were increasing, and by now it represents a net 25 tonnes of bitumen delivery to the markets of the region.

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**Fig. 8.** A section of the modified bitumen plant of Zala Refinery

**The asphalts made** using the modified bitumens produced in Zala Refinery (7 to 27 thousand tonnes per year) and in Duna Refinery (20 to 44 thousand tonnes per year) have an excellent hot deformation resistance at higher temperatures, are less susceptible to wheel caused rutting, show a good fatigue strength under repeated pulling and bending stresses at medium and lower temperatures, are less rigid – due to their good elongation capability – under winter weather conditions and have a very low cracking sensitivity.

**Considering the international** benchmark developments, tests, norms and specifications the bitumens modified with elastomers have become dominant also in Hungary – in line with the trends in Europe.

The marketing of the bitumen products by the Refinery was established in the territories of nearly 20 countries (Nagy, S 1987B).

CHANGES IN MARKETING

Up to 1992 the Mineral Oil Supply Company and – on a commission basis – Mineralimpex Foreign Trading Company, with Zalabit Ltd in the years between 1990 and 2000 were performing the bitumen sales to the domestic and export markets, respectively.

Integrated into MOL Plc’s Refining and Marketing Division (RMD), the functions of the Bitumen Business between 1994 and 2000 included the co-ordination and management of the complex refinery activities in Zala Refinery, along with the sales of bitumen products made in MOL Plc’s Duna and Zala refineries. The bitumen sales were implemented in a single channel system, typically under an end user contract.

From 2000 to date MOL Plc’s RMD Marketing organisation has been performing the sales of the bitumen products made by MOL Plc’ and MOL Group, basically for road construction industry and building industry target areas.

During the years between 1990 and 2009 bitumen was sold from Zala Refinery in the varying volume of about 130 to 180 thousand tonnes per year (Figure 2). In recent years the sales of building industry, road construction and modified road construction bitumens have been performed at a high rate (Figure 4) in the market areas of the following countries: Croatia, Serbia, Slovenia, Austria, Bosnia-Herzegovina, Romania, Slovakia and Poland. While the sales formerly had been based on market demands in the first place, today the quality and quantity to be produced are defined by an approach based on the procurement-production-sales modelling method.

BITUMEN USER TARGET AREAS, CUSTOMER RELATIONS

Presentations of the process developments, the product improvements, the bitumen researches and the services, together with trade conferences and customer meetings, are held on a regular basis to obtain a direct knowledge about the needs of the users – the bitumen user target areas.

Since year 1993 MOL Plc organises the MOL Bitumen Days at an annual regularity.


MOL is playing a priority attention to have the customer and user groups acquainted with the latest bitumen product handouts and the application technology publications, to organise application technology presentations, to make the process and product developments of its bitumen production units widely known.

MOL’s experts attend the programmes of the bitumen user target areas: Road Days, conferences of Hungarian Asphalt Pavement Association (HAPA). The changes in the bitumen product demands by the market segments and user target areas – mainly the road construction industry and building industry (insulating plates, roofing sheet production) were directly fed back to the bitumen product and process development. The knowledge of the bitumen
market environment and the direct end user customer relations laid the foundation for the developments.

**ENVIRONMENTAL DEVELOPMENTS**

Complying also with the system of requirements for a market-oriented operation first the Quality Management System of Zala Refinery was accredited (1994) followed by the Environmental Management System of the Bitumen Business (1999) (MOL 2002; Gelencsér, L & Durgó, R 1994).

The environment protection conditions and the emission limits for the operation of MOL Plc’s Zala Refinery have been set forth in Integrated Pollution Prevention and Control (IPPC) permit No. 781-8/12/2010/1 set in a uniform structure.

In the previous parts of the article some environmental protection measures have already been mentioned. Additional more significant environmental developments implemented have been:

- Revamping the fire water supply, 1980
- Constructing condensate systems, process oil traps, separating process effluents and rainwater, between 1986 and 1998
- Improving the flotation in bitumen blower, treating the scrubber effluents, 2000
- Removing the process water channel and the 10 thousand m³ process water storage, implementing a closed system for effluent discharge from wastewater treatment unit, between 2003 and 2004 (since the crude oil distillation activity discontinued in year 2001 the process water consumption of 250 to 550 m³/h in previous decades has dropped to a rate of 30 m³/h)
- Installing a biological wastewater treatment (WWT) unit, increasing its capacity, discharging the treated effluent into the city’s WWT Plant, between 2003 and 2010.

The gases emitted from the process equipment of the Refinery are sent to incineration (fuel: natural gas) in fired heater (FH) and / or thermal boiler (TB) for heat recovery:

- Blowing gases taken from Bitumen Blower Production line No. 1 and / or No. 2 (FH and TB; FH / TB)
- Vapours recovered from road tanker loading gantry of a closed system (FH)
- Protection of the space in bitumen tanks with a nitrogen blanket in bitumen tank farm – gases removed from a closed system (FH) (see Figure 9)
- Gases removed from the flotation equipment of bitumen blower (TB)
- Decanter gases from the spent oil processing unit (FH).

Fig. 9. Use of nitrogen blanketing for bitumen storage tanks

The incinerated gases are treated with caustic in the process equipment of the flue gas scrubber.

As an outcome of upgrades and projects of a significant rate and as a result of the environmental conditions for the Refinery operation and the high efficiency treatment process – gas discharge in a closed system, incineration and caustic scrubbing of the air pollutants generated during the production process
technology – the measured concentration of the emitted components is below the limit at a significant rate.

Values of the components emitted via a steel stack from the flue gas scrubber – standard emission point source – constructed in the Bitumen Blower are illustrated in Figure 10.

The measurement of air pollutants emitted via stacks (emission point sources) from other process equipment of the Refinery – fired heaters, heat...
transfer oil thermal boilers, steam boilers - is also made on a regular basis. The measured values of the components are significantly below the limits.

The values of measuring results (the rate of air pollution) from the performed immission measurements – diffuse sources (spent oil storage, process effluent treatment) – are also significantly below the limits (see Figure 11).

As a result of 60 years of continuous design, construction, modernisation and efficiency improving efforts Zala Refinery is now a valuable component in the organisation and installations of MOL Group RMD from both process and economic and HSE points of view by the end of year 2012.

Keywords: bitumen blowing, modified bitumen, rubber bitumen, waste oil

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László Gelencsér, Dr. was director of Zala Refinery from 1991 till 1994 and director of Bitumen Business Unit of MOL Ltd. from 1994 till 1999. Earlier, he was chief mechanist and afterwards, chief technologist of Zala Refinery. Dr. Gelencsér is member of Board of Trustees of Hungarian Oil Industry Museum and lecturer at University of West Hungary. He graduated at Miskolc Heavy Industry Technical University in 1968. Between 1987 and 1989, he attended economic engineering education at Budapest Technical University.
NEW PHOTOACOUSTIC SPECTROSCOPY-BASED INSTRUMENT FOR MEASURING EMISSIONS OF GLYCOL REGENERATORS

Veronika Hanyecz (28)
Predoctoral fellow
University of Szeged, Department of Optics and Quantum Electronics
hanyeczv@titan.physx.u-szeged.hu

Árpád Mohácsi, PhD (38)
Research fellow
University of Szeged, Department of Optics and Quantum Electronics
mohacsi@titan.physx.u-szeged.hu

Sándor Puskás, Dr. Univ. (52)
R&D senior expert
MOL Plc. Exploration & Production Division, IFA New Technologies and R&D
spuskas@mol.hu

Árpád Vágó (58)
R&D senior expert
MOL Plc. Exploration & Production Division, IFA New Technologies and R&D
avago@mol.hu

Gábor Szabó, DSc (57)
Full professor, member of HAS
University of Szeged, Department of Optics and Quantum Electronics
gszabo@physx.u-szeged.hu

ABSTRACT
An instrument determining benzene and toluene concentrations in natural gas and ethylene glycol samples on quasi-continuous way to estimate aromatic emission of natural gas dehydration plants is introduced. A more advanced version of a previously made prototype is presented. In one respect the instrument must be explosion proof, on the other hand it is required to provide accurate sampling that is reliable under field conditions in long-term. Therefore, a new pneumatic sampling unit was built which is discussed in detail. Test measurements indicated that this new sampling unit is appropriate. Finally, the plan of the explosion proof version of the instrument is given.

INTRODUCTION
We published earlier a paper (Hanyecz, V & Mohácsi, Á & Puskás, S & Vágó, Á & Szabó, G 2011) on an instrument measuring benzene and toluene concentration in natural gas and liquid samples produced in natural gas dehydration unit. This instrument consists of the following main parts: handling systems for gas and liquid, a measuring unit with a preconcentration adsorbent, a chromatographic column, a photo-acoustic detector (PAD) and an electronic unit. It can measure only gas samples, therefore bubbling extraction is used in case of liquids. The
flushing air and the gas (during gas sampling) stream goes through the adsorbent which absorbs benzene and toluene. Afterwards nitrogen flows through the heated adsorbent and washes benzene and toluene on the column where they separate in time. The PAD detects photoacoustic signal (in volts) which plotted against time and creates a chromatogram. The areas under the peaks are proportional to concentrations. Detection limits are 2.5 μg/l of benzene and 4 μg/l of toluene in gas samples (sampled volume 1 l), while 1.5 mg/l for benzene and 3 mg/l for toluene in liquid samples (sampled volume 1.5 cm³) and these values meet the requirements of the application.

Basically, the instrument is a gas chromatograph (Scott, R PV 2003) combined with a PAD. The photoacoustic phenomenon (Bozóki, Z & Pogány, A & Szabó, G 2011) can be described as follows. If a sample is illuminated with modulated light and the sample absorbs at least a part of light, sample emits sound with the same frequency as light modulation frequency. Consequently, the main parts of PAD are the following: a light source, which is a diode laser radiating around 1,669 nm at a wide absorption band of benzene and toluene; a microphone to detect sound; a photoacoustic cell in which the signal generation takes place; and an electronic unit to control laser and microphone and to process signal (besides it carries out the control of the whole instrument). PAD is preferable to other, generally used chromatographic detectors like FID (flame ionization detector) or MS (mass spectrometer) because it does not require special gases or vacuum and its sensitivity is suitable. Moreover, it is a spectroscopic method, consequently it provides excellent selectivity.

We found that the instrument fulfils all requirements (selective measurement of benzene and toluene contents with appropriate detection limit, measurement of gas and liquid samples, compact design and automatic operation), except one, the ability to be used in potentially explosive area. We introduce a further developed version of the instrument.

THE DEHYDRATION OF NATURAL GAS

One method of natural gas dehydration is glycol contacting (see the schematic flow sheet of technology of one of MOL’s plant in Figure 1). Natural gas from wells flows to a pre-separator where free water and heavier hydrocarbons are removed from gas at a given temperature. Then regenerated (lean) glycol is vaporized into the outgoing wet gas flow and gas enters the ammonia cooling system where its temperature decreases to -5°C (glycol keeps the condensed water in liquid state at -5°C). In the following cold separator rich glycol and condensate (containing mainly heavier hydrocarbons) are removed from dry gas. Rich glycol enters the regenerator where water is boiled out of glycol. Glycol leaving the regenerator (so called lean glycol) is again vaporized into the wet gas. Dry gas from the cold separator goes to the following plant and used as heating gas for the regenerator. Vapour from the regenerator enters the cooling unit and cools down as it reaches the end of the outlet tube. A part of it condenses and is collected in a tank and the other part is released to the atmosphere.

Dehydration units have been identified as important emission sources of benzene and toluene. Natural gas contains aromatics in μg/l range. A part of these separates as condensate during dehydration but since they are very well soluble in glycol they accumulate in it. Benzene and toluene are very volatile at working conditions so during regenerating they goes to the vapour phase and thus to the atmosphere. This emission causes a high background immis- sion of benzene and toluene that is harmful to health and the environment. Our goal was to develop an instrument which can measure benzene and toluene concentration in gas and glycol samples and, consequently, it allows us to estimate the aromatics emissions of the dehydration unit at working parameters.

In Figure 1 materials printed in italics are generated or circulate in the process. In order to determine material balances for benzene and toluene it is necessary to know their concentrations in all streams. In raw material (natural
gas) and therefore in wet gas their concentrations are roughly constant. Nevertheless, as working parameters of contacting and regenerating alter the benzene and toluene contents of lean and rich glycols, as well as dry gas change. Four streams, wet and dry gases as well as rich and lean glycols (marked by blue) are required to be monitored by the instrument introduced here. Natural gas, condensates from pre-separator and cooling unit and the water condensed from vapour (marked by red) are to be analysed by MOL gas chromatography quarterly. Concentrations of benzene and toluene in condensate (marked by violet) can be calculated. To determine benzene and toluene material balances the flow rates of (lean and rich) glycols should be known.

**PROBLEMS TO SOLVE**

According to European Standard on equipment for explosive atmospheres (ATEX) (European Parliament and the Council 1994) the prototype of the instrument is qualified as electrical equipment and dehydration plants are potentially explosive areas. Therefore, the instrument has to meet standards and an ATEX licence is required to install it to the plant.

The accurate volume sampling is one of the most important requirements. The instrument determines photoacoustic signal which is proportional to the amount of analyte. It is independent of the volume of the sampled gas or liquid but it can be converted to concentration if the volume and pressure of samples are constant. In the prototype, gas sampling was made by a mass flow controller (MFC). MFC operates on the basis of thermal conductibility, what depends on natural gas composition changing continuously. Therefore, it leads to large inaccuracy in gas sampling. Consequently, it is necessary to implement a sampling method which is independent of gas composition in the explosion proof version.

Glycolic acid derived from glycol is a very aggressive medium thus all parts which contact with it must be inert. It is particularly important in case of the circulating pump.

**THE NEW SAMPLING UNIT**

Glycol is transmitted by piston pumps at natural gas plants therefore it is obvious to circulate it in the instrument. Furthermore, it makes possible accurate gas sampling due to the volume of sampling cylinder, so the volume of the transmitted gas is constant and depends only on pressure. Therefore, gas sampling is made at atmospheric pressure. Besides, one of the most important steps to accomplish explosion-proof equipment is to minimise the number of electrical parts which are potential spark sources. Pneumatic pump is not electrical equipment; it needs only instrument air to work.

In Figure 2 a uniquely built pneumatic sampling unit can be seen. The two sampling pistons move together. The gas and liquid sampler cylinders are 410 ml and 75 ml, respectively. So the volume of samples is 820 ml and 150 ml during one cycle. The pistons are moved...
by two slave cylinders which are operated by instrument air. One cycle, i.e. one back and forth movement of the pistons, is started by a pressure impulse, turned and stopped by the end switches. After one cycle the sampling is stopped until it gets another starting impulse. There is two speed rate of piston movement which rates can be controlled by valves. Changing between the two rates can be carried out by a pneumatic switch. In case of gas sampling slow movement is justified to absorb the components properly. Nevertheless, in case of liquid sampling streaming is used for refreshing which does not require slow moving.

The pneumatic pump draws the samples through the instrument therefore occasional contaminations in the sampler cylinder do not cause measurement errors. To operate automatically, solenoid valves control the start switch and the switch to change speed. On the (2) end switch (see Figure 2) there is a pressure sensor to register the end of the cycles.

Since the liquid and gas sampler pistons move together it is necessary to provide free flow of gas during liquid sampling and free flow of liquid during gas sampling.

MEASUREMENTS WITH PNEUMATIC PUMP

The pneumatic pump was tested with the prototype sampling unit in the laboratory and in the field. Minor changes were made to the gas and the liquid sampling unit of the prototype, but the principle of operation remained the same. Parallel measurements of the gas and liquid samples were unrealisable because different transformations of the gas and the liquid sampling units were necessary for the gas and the liquid measurements.

The instrument was calibrated with samples containing known amount of components.

Both the gas and the liquid treatments could be divided into two phases; there are refreshing and sampling.

Fig. 2. The pneumatic sampling pump
In case of gas, refreshing was made by using an accelerating line through that gas streamed outside with 1 l/min flow rate. The sampling was performed by the pneumatic pump with slow piston movement meaning that one cycle lasted 1.5 min. The above mentioned flow rate is appropriate because the pump is sampling with a flow rate of about 0.5 l/min (taking the mentioned 0.82 l in 1.5 min) of gas. During the sampling about 0.5 l/min of gas is flowing through the accelerating line and therefore sampling would be carried out from the gas and not from open air. In this solution besides refreshing sampling is always carried out under quasi-atmospheric pressure.

In case of liquid, the pneumatic pump was used for refreshing, and sampling was performed by trapping (see below). One piston movement cycle lasts about 20 sec (at fast piston movement) and four cycles have to be done. During four cycles 600 ml of liquid (4x150 ml) is moved, which volume is equal to the volume of an about 50 m long and 4/6 mm diameter tube. The connecting pipe between the instrument and glycol regenerator was shorter, so the measured sample could be regarded fresh.

In summary, pneumatic pump has different tasks in gas and liquid measurements: it provides sampling for gas, and refreshing for liquid.

Figure 3 shows the results of continuous laboratory measurements carried out on indigenous natural gas. The average concentrations were 95 μg/l of benzene and 60 μg/l of toluene. During this measurement inner temperature (temperature inside the instrument box) was also tested. Temperature changed between 17 and 31 °C during the testing period, but there was no correlation found between the temperature and the measured concentrations.

In Figure 4 and 5 measurement results in field (at one gas plant of MOL) are shown. Figure 4 reflects measurements carried out on heating gas of the glycol regenerator (i.e. dry gas). Daily cycles of the measured concentrations could be noticed: the measured values follow the outer temperature. The inner temperature was controlled by a heating cable which did not allow it to decrease below 24 °C. However, at dawn of 14th October the outer temperature was so low that the inner
temperature control did not work properly. An experience in laboratory and field shows, that concentration follows the outer temperature and not the inner one. This confirms that the efficiency of the cooling technology depends on the outer temperature. For instance, the efficiency of ammonia cooling is better at lower temperature, when higher amount of heavier hydrocarbons can be removed from gas. Thus the average concentrations were 560 μg/l of benzene and 260 μg/l of toluene, higher than they were measured in indigenous natural gas (see Fig. 3).

The measurements results shown in Figure 5 were obtained on rich glycol. The average concentrations were 295 mg/l of benzene and 195 mg/l of toluene. The temperature control of the instrument was not appropriate, minor temperature dependence was noticeable. In order to improve temperature control in the future, additional use of a Peltier thermocouple in the glycol-gas contactor is planned.

These measurements indicate that pneumatic pump is suitable equipment for sampling of gas and circulating of liquid.

**THE PLAN OF THE NEW, EXPLOSION PROOF INSTRUMENT**

In Figure 6 the schematic view of the instrument can be seen. The minimisation of the number of electrical parts seems to be a rational step when building an explosion-proof instrument. However, this prototype contains several requisite electrical devices (solenoid valves, MFC, adsorbent and column heaters, diode laser, microphone, controlling and signal processing unit). One possible solution is the application of overpressure protection system what means that inside the box overpressure (20 mbar) of instrument air prevails, preventing infiltration of inflammable gases. This box can accommodate all non-EX parts. It is embedded in a doubled walled, waterproof, and heatable by an EX heater outdoor box in order to protect the parts from weather adversities.

Two different liquid samples can be measured. To select one a 3/2 solenoid valve is applied. Filters with 100 μm pore size are used to protect the instrument from solid contaminants. The gas sampling part can handle two gas pipes. To choose between them a 3/2 solenoid...
Development

As it was mentioned earlier the two sampling pistons of the pneumatic pump move together. Liquid can flow unimpeded during gas sampling. A three-way valve before the gas piston cylinder represents a feedback ensuring that during liquid refreshing the gas piston cylinder draws itself.

The liquid sampler is a short tube (connected to two solenoid valves) which has constant volume therefore volume of the trapped liquid is constant. Bubbling is carried out by nitrogen and its flow is controlled by a needle valve. The glycol-gas contactor is made from copper and temperature controlled.

In gas pipes after each reductor there is a pneumatic valve. They are opened if voltage is applied to the whole instrument, and closed if the current is cut off. In the explosion proof box methane detector is placed to determine gas escape which indicates anomalistic working (is not shown in Figure 6). If this detector gives signal, the current is cut off and therefore pneumatic valves are closed.
The overpressure venting and control of the pneumatic parts (pump and valves) are performed by the instrument air line which is not shown in Figure 6.

The electronic unit calculates concentrations from raw data and sends them to the centre of the gas field. The communication port meets the requirements of RS-485.

CONCLUSIONS, OUTLOOK

The new sampling unit and the further developed version of the instrument measuring benzene and toluene concentration in gas and glycol samples was introduced. The new sampling unit ensures accurate sampling which applicability was verified with test measurements. The instrument needs to be explosion-proof, consequently transformation of the instrument including overpressure protection, methane detector, pneumatic pump and valves.

After completing the explosion-proof instrument calibration, test measurements in laboratory and in field will be performed. Our aim is to estimate the benzene and toluene emissions of the gas dehydration plant.

Keywords: photoacoustic spectroscopy, sampling, natural gas, emission

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Veronika Hanyecz is a pre-doctoral fellow in environmental science at Department of Optics and Quantum Electronics of University of Szeged, Hungary. Her current research interests include photoacoustic spectroscopy and its application in trace gas detection and industry. Veronika received her MS degree in environmental science at University of Szeged, in 2008.

Árpád Mohácsi, PhD is a research fellow at Department of Optics and Quantum Electronics of University of Szeged, Hungary. His current research interests include photoacoustic apparatus and external cavity diode laser development. Árpád received his MS and PhD degrees in physics at University of Szeged, in 1998 and 2002, respectively.

Sándor Puskás, Dr. is employed by MOL as a petroleum engineer MSc since 1985. He is a petroleum engineer and holds R&D senior expert position at the New Technologies and R&D Department of the Exploration and Production Division of MOL in Szeged, Hungary. He has 27 years of experience as a field, research and development engineer in the crude oil production. He is the author and co-author of several technical papers. Sándor holds a dipl. eng. degree in petroleum engineering from Moscow State Gubkin Oil and Gas University and a Dr. Univ. degree in colloidchemistry from József Attila University in Szeged, Hungary. He also holds a postgraduate degree in R&D management and human management from Budapest University of Economic Sciences and State Administration, Management Development Centre.
Árpád Vágó started to work at the Research Institute of Heavy Chemical (Veszprém, Hungary). Now he works for the New Technology and Research and Development part of the MOL EPD as a R&D expert. He has over 25 years experience in this field. He manages different R&D projects from financial and professional point of view. His area of expertise includes development of hydrate inhibitors, inert gas separation technologies from natural gases, development of EOR technologies. Árpád graduated as a chemical engineer specialised in hydrocarbon and coal processing and organic chemical technology at University of Chemical Industry, Veszprém in 1985.

Gábor Szabó, DSc has been working at University of Szeged starting from 1978 to the present where he has been a full professor in the Department of Optics and Quantum Electronics since 1994. He has also visited scientists at both Max Planck Institute, Göttingen, Germany, and Rice University, Houston, Texas. Professor Szabó is a member of the Hungarian Physical Society and SPIE, and has been a corresponding member of Hungarian Academy of Sciences since 2004 and full member since 2010. His research activities include photoacoustic spectroscopy, ultrafast laser spectroscopy, generation of femtosecond pulses, nonlinear optics, optimum control of quantum systems, medical applications of lasers. Gábor received his MS and PhD degrees in physics from JATE University, Szeged, Hungary, in 1978 and 1981, respectively.
FUEL FORMULATION FOR FUTURE DRIVE TRAIN DEVELOPMENTS

Máté Zöldy, PhD (34)
Automotive & fuel quality expert
MOL Group, Downstream Development
mzoldy@mol.hu

András Holló, PhD (42)
DSD Product Knowledge Centre manager
MOL Group, Downstream, Product Development HU

Zoltán Szerencsés (53)
CAPEX and Project Management thematic leader
MOL Group, DS Development

Ferenc Kovács (36)
Fuel Development expert
Downstream Hungary, Development Product Development

Róbert Auer
Head of Research & Innovation
Downstream Hungary, DS Development Research and Innovation

ABSTRACT
Nowadays fuel quality standards provide clear instructions for both automotive industry and oil industry to produce vehicles and fuels for transportation. In midterm time horizon it will be changed. Fuel mix in the world but mainly in Europe will be much more inhomogeneous as it is now. Fuels will be developed more heterogeneously; different regions will have different energy pathways. Fuel producers have to be prepared for these times: they should have fuel development methodology leading to new fuel grades based on new recipes, components and additives for new uncommon engine and drive train solutions.

In the continuous fuel development more and more focus has to be put on the different market segments. This is a key success factor of retailers in the European strong market competition. Segmentation could be based on utilisation conditions, market size or also fuel availability and specifications. Engines could be used at near optimal parameters when they run on fuels specific to their conditions. MOL Group’s recent goal was to set up new development methods that allow development of customer oriented fuels for special user segments. In our paper we give an overview about the heavy duty fleet testing as an important element to meet the customer expectations. A dual-driven – technology push and market pull – development is presented.

Recently a carefully organised development process was carried out by MOL Group together with the internal (refinery, supply chain, logistics, wholesale, retail) and external partners. Based on the already used application testing methodology and analytical background we introduced a new method for fuel development for specific market segments. In the paper we outline our results and work in the example of heavy duty market segment. We present the development goal established on the basis of customer value creation, method to find and built up the new test environment and the creation of the new product from the idea to the market introduction. We share our experiences in the example of an already implemented product development process.
Method was developed and tested against the current European fuel market needs. It has to be proved taking into account great challenges, special engine / drive train and energy supply needs, e.g. fuel cell, pure butanol fuel usage.

Petroleum industry can remain the primer energy supplier of the transport sector if it is able to diversify its fuel portfolio based on the customers’ and vehicle producers’ needs. The presented method and product are good examples on how to create synergy between automotive developments and petroleum industry opportunities.

INTRODUCTION
The main challenge of the transport sector is the reduction of its greenhouse gas (GHG) emissions. One possible solution from refinery point of view is the promotion of low carbon fuels, like biofuels. Recent studies showed higher GHG emissions for bioethanol compared to conventional (crude oil based) fuel, when taking into account the effect of indirect land use change (ILUC) (Searchinger, T et al. 2008). However, crude oil based fuels are especially important in the aviation, freight, and marine sectors where good alternatives are hard to find and get approved for daily use. From automotive industry point of view, the GHG emissions reduction is achievable through downsizing and hybridization of engines in the short-term (till Y2025).

Crude oil dependency is also raises concerns about the future security of energy supplies while climate change concerns drive energy efficiency improvements and the replacement of fossil fuels with renewable or alternative fuels. The degree to which fossil fuel replacement or decarbonisation should take place depends on many factors, such as vehicle compatibility, fuel efficiency, sustainability of alternative fuels on a well-to-wheels basis, the pace of development of and investments in alternative fuels, the demand for alternative fuels in other sectors, cost of CCS (carbon capture and storage) technologies, change in demand (e.g. increased mobility, alternative fuel penetration in community transport), etc. By 2020, the joint study (JEC 2011) of the European Commission’s Joint Research Centre, EUCAR and CONCAWE (JEC) expects fossil fuel dominancy in European road transport sector.

Thus, the total supply of non-renewable fuels is unlikely to keep pace with the growing global demand. Renewable and alternative energy and fuels will be required and work is already in progress to accelerate these developments. Due to regional differences in fuel infrastructure, imports, climate, water supply, prevailing winds, available crop lands, and many other factors, the best alternative for one country or region may not necessarily be the best alternative for another. For this reason, a coherent and cost-effective transition from non-renewable to renewable energy and fuels will be a significant challenge (Ricardo 2011).

The recent economic downturn will have had an impact on private technology investments but will be largely overcome by public intervention. Public-private partnerships and policy will contribute to the recovery of technology developments needed to meet the demanding objectives for GHG emissions reductions and sustainable road transport. The need for trained engineers and scientists to create and implement these developments will have been recognised.

FUEL MARKETS IN THE NEXT DECADES
Customer value proposition in specific markets with special products will be based on three pillars in the 21st century. Although diesel and gasoline seems to be remaining the main products of the refining industry in the next decades some other energy carriers and usage modes will have increasing role. Secondly, product quality standards allow giving the same product for broad customer sectors. Thirdly, the 21st century technology allows great variation in refinery and additive production.

Main fuel market premises could be summarised in the following bullet points.

› By 2025, crude oil and natural gas will still be available in significant volumes and represent more than 80% of the transport en-
ergy demand. The primary sources for these products will continue to shift to politically unstable regions. Thus, most of the customers will utilise conventional diesel and gasoline fuelled vehicles (Holló, A et al. 2011).

Electric vehicle (EV) options, driven by CO₂ emission reduction targets, will be growing in urban regions and in some densely populated corridors, for both passenger and freight transport; the EV market share of the total new vehicles sale will not reach 15% up to 2025. Most stakeholders assume (e.g. Shell 2011; Clark, N & Conley, J & Jarrett, R & Nennelli, A & Tóth-Nagy, Cs 2001; Gács, I & Bereczky, Á & Török, Á 2011) that the realistic market share for new, electrically chargeable vehicles will be in the range of 2 to 10% by 2025. For Europe, especially in Middle and Eastern Europe lower penetration rate is expected in connection with the economic environment (Holló, A et al. 2011). EV vehicles will have a definitive niche market with high entry barriers.

The EU climate and energy package will change the fuel quality; blends containing more biofuels (E10-15, B10-15 and E85, B100) will be on the market by 2025. Alternative fuels, like LPG, CNG, DME (dimethyl ether), HVO (hydrotreated vegetable oil) and XTLs (x-to-liquid type fuels, where x defines the feedstock), as low carbon fuels would gain market share. By 2020, in the European passenger car market, the LPG-driven cars sales and stock sizes would account for 2% (0.4 million) and 2% (5 million) respectively; the same figures for CNG-driven cars would be 4% (0.8 million), and 2% (5 million); additionally HVO and XTLs appear in diesel pool, according to JEC Biofuels Programme Report (JEC 2011). Use of high biofuel containing diesels in modified, developed engines will have local role in high potential agriculture zones. Liquid gases will forge ahead in the favourable economic environment and gas producing countries.

Road transport will further increase in Europe. Long-term freight transport could be handled as an independent market segment based on its volume and its refuelling demand focusing on motorways. Fleet management systems, low operational cost and high availability are key factors of this sector (Zóldy, M & Holló, A & Thernesz, A 2011).

Vehicles for daily trips only could be handled as a further specific segment characterised by systematic and recurrent transports, mainly between household, workplace, shopping and service centres. Short distances are very usual, daily average is between 50 and 75 km. Expansion of new energy sources and drive train variations is expected in this segment.

NICHE MARKET FUEL DEVELOPMENT

DETERMINATION OF MARKET SPECIFICATIONS

Fuel formulation to meet specific market needs is presented in the example of heavy duty market segment. The users of the heavy duty vehicles include different subgroups as freight transport over long distances, public passenger transport, agriculture, mine, industry, etc. The common feature of this market the customers are very price sensitive and the yearly average procurement volume is large. Typical vehicle fuel consumption is 25-50 litres/100 km, and the diesel engine volume is at least 5 litres.

During the fuel development, application tests are to be done. Engine and vehicle test methods are prescribed by CEC (Co-ordinating European Council) and ASTM (American Society for Testing and Materials). Application technology and test-driven development of diesel fuels mainly focus on small and mid-size engines in engine bench development. The most commonly used and approved by CEC test methods are DW10 and XUD-9 that help distinguishing diesel fuels in the automotive and refining industries. These tests give essential information on fuel behaviour in the fuel supply system, combustion chamber and after treatment system, but they can not include the specialities of compression ignition engines used mainly in the freight transport and in coaches (Harrington, W & Krupnick, A
Clark et al. (Clark, N & Thompson, G & Delgado, O 2009) present results of their work on modelling heavy-duty fuel economy on dynamometer test: the “results of the application of the black box neural network model and the commercial software model produced average percentage errors of the order of 10% and 4%, respectively”.

Table 1 summarises the main parameters of the three most commonly used fuel development tests for diesel. All of them are designed for passenger car (PC) size engines and cannot be used for developing fuels for heavy-duty (HD) engines. Firstly, the HD engines are much larger; their piston diameter for example could be 150% of the PC engines. The friction surfaces are larger based on the size increase requiring higher friction reduction by precise formulation and addition of the fuel. Secondly, the HD engines are mainly used in different conditions as presented in Figure 1 (see on the next page).

Figure 1 shows that passenger car engines are usually used at very different driving conditions. By contrast, heavy-duty engines are typically used in well-localisable torque and engine speed ranges. Armed with this knowledge, the diesel engine components can be optimised for the quasi-stationer combustion. Since engine bench tests for PC engines are available we focused our attention to the field tests that could give more real life-based results, although they need more organisation and energy to deliver the nearly same data accuracy.

### DEVELOPMENT OF FLEET TEST METHOD

Dual-driven product development is very effective tool to specify fuel submarket needs and develop special products. The dual-driven process bases on two pillars: technology push and market pull. Possible sequence of the executable actions is shown in Figure 2.

- **Heavy duty fleet test: development steps**
  - Literature overview
  - Market research
  - Key customer survey
  - Laboratory tests
  - Fuel formulation
  - Engine bench test
  - Internal truck fleet test
  - External truck fleet test

Fig. 2. Dual-driven product development (Zöldy, M & Holló, A & Thernesz, A 2011)

A carefully organised fleet test with well-chosen test vehicles, test parameters and collaboration with additive supplier partners is a crucial element for collecting application technology information directly from the field. The main factors of the tests are test fleet selection and data acquisition / evaluation; refuelling facility and the product under development.

**Test vehicle selection** has to be done very accurately to have comparable results with different fuel recipes. Test vehicles should regularly be driv-
en on the same route with the nearly same load/unload ratio. Truck delivery helps also to provide similar load conditions on the same route with different fuels. Test truck should have one refuelling point only, and it is prohibited to tank in other locations. If refuelling facility is electronically controlled the fuel amount could be also measured with refuelled volume; it can be a valuable control data. When determining the test truck number it is beneficial to have the trucks at least duplicate (minimum two trucks with very similar technology) for reducing measurement errors. In the other hand it is advantageous to extend the tested vehicles technology level (i.e. Euro class, engine type, etc.) as broad as possible.

**Fleet test on** heavy-duty vehicles requires special refuelling facility. The amount of the used fuel is large, since the HD vehicles fuel consumptions could be five times more than of PCs. Thus a large fuel tank should be dedicated for the tests. The exact amount depends on the number of the test vehicles, on the estimated average fuel consumption based on historical data, and the planned length of the test. This is very closely connected to the wished mileage. Some developments on fuel quality have immediate effect; others need time to build up. If refuelling is electronically controlled and measured and it is connected into an account network then it provides very useful data to control the fuel consumption of the test vehicles. In the test done in MOL DS Development we locate a 20,000 litres tank in a refuelling station connected into its account network. We calculated the volume of the tank \( V_{\text{tank}} \) based on the test vehicle number \( n_{\text{veh}} \), estimated average fuel consumption \( FC_{\text{avg}} \), and necessary mileage to control the expected changes \( d \) as presented in **Equation 1**:

\[
V_{\text{tank}} = \frac{n_{\text{veh}} \times d}{100} / FC_{\text{avg}}
\]

(Eq. 1).

**Test batch quality** and quantity were frequently monitored, and not only in the fuel change period. We let only the test vehicles to be refuelled. The internal fleet test was followed by external test, when customers were involved into the test of the fuels with their vehicle fleet on their own running parameters.

**During the development** the third main parameter, of course, was the fuel, itself. It was the key factor that had to be reformulated and tested. In the first stages of the development batches on specification of EN 590 were investigated, new recipes were developed, according to the customers need. These fuels were used without

![Fig. 1. Passenger car (left) and heavy-duty (right) engine speed-torque variation (Zöldy, M & Holló, A & Thernesz, A 2011)](image)
any special permission in vehicles requiring fuels of EN 590 specifications. Later other fuels were tested with increased degree of freedom. From production point of view the tested fuels should be reproducible, blendable and additivable in low volume batches at MOL Group refineries.

**FLEET TEST DATA ACQUISITION AND EVALUATION**

In the case of fleet testing a key factor is the test data acquisition. There are lot of parameters that could influence an investigated parameter. Vehicle acceleration, top torque, emissions or fuel consumption could be affected by route, wind, temperature, driver, truck load, traffic situation, etc. (Miller, T 2010). On the other hand the goal is not to have a special fuel that could show its effect in a special vehicle or in special application environment. In order to check the expected changes fixing of some vehicle parameters is beneficial, such as:

- Different vehicle types (Euro classes, manual / automatic gear etc.), but at least two similar test vehicles are used
- There is no consumption during loading / unloading operations
- Testing trucks should have routes to fixed delivery places and they run over 80% on the same route.

Test data acquisition accuracy is based on the test duration and the type of data acquisition system. During our test we used at least two parallel data sources. For example, in the case of fuel consumption we got data from the vehicle fleet management system, GPS, drivers log block and retail network refuelling data. It enabled cross-checks among the similar data types.

**TEST RESULTS FOR NICHE MARKET DEVELOPMENT**

To develop special fuel quality for the presented niche fuel market segment (heavy duty vehicles) fleet test is the special method were the customer expectations and fuel development results should be matched. During the fuel development process more than 15 different fuel recipes were tested with the presented fleet test method and the best rated (technically and economically) batch was selected for external partners. Some of our results are presented in Figure 3, proving that development of special fuel qualities for market segments needs special development methods.

The first bar in Figure 3 presents the theoretically estimated fuel consumption expectation based on the changes of C/H ratio, blending component characteristics, effects of special additives, etc. The second column shows the external control engine bench test results on the developed fuel. The third column indicates the results of the internal fleet tests and last the results of the external fleet tests are presented. The 0 level is the fuel consumption with the reference fuel. The columns show the estimated and measured fuel consumption reduction. The estimation was the highest, but the three engine-, internal fleet and external fleet tests resulted nearly the same effect in fuel consumption.

Results showed that based on the theoretically calculated maximum values the internal and external fleet tests are good tools to check the fuel consumption improvement and modifying effects and create new fuels to meet special market needs.

**SUMMARY**

In our paper the tendencies of the expected fuel quality changes were presented that are mostly based on the engines requirements. The esti-
mated changes in the vehicle drive trains, legal environment and vehicle utilisation behaviour can be followed only with specified energy carrier forms for the special market segments. Development of new fuels for niche markets / special segments requires improvement of the development facilities and methods to create new fuels for the special demands. In our paper as an example for a special market fuel and method development we presented heavy duty segment fuels and the developed fleet test method. Our results show that exact market requirements, fuel development with special investigation methods can result in new fuel qualities meeting the special market needs and increasing customer satisfaction.

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Keywords: diesel, niche market, heavy duty

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Máté Zöldy, PhD, the correspondent author is an automotive expert. He worked for Ford Motor Company Engine Development Centre at Cologne and for AVL in Remscheid. Since he works for MOL Group he deals with automotive development relevancies on oil industry, leads engine and vehicle testing facilities at Százhalombatta. He graduated at Faculty of Transportation and finished his PhD studies at Budapest University of Technologies and Economics in 2007.
ARGUS – NEW TRENDS IN ON-LINE ANALYSERS TECHNIQUES

Gábor Bereznai (39)
Department of Control & Electrical Engineering
MOL Plc., Duna Refinery
gbereznai@mol.hu

Róbert Zomborszki (27)
Department of Control & Electrical Engineering
MOL Plc., Duna Refinery
rzomborszki@mol.hu

ABSTRACT
Due to the internal organisational changes at Refining MOL, significant organisational changes also occurred in the field of quality control, in the course of which the importance of on-line analysers continued to grow, and a requirement was raised to use the values provided by the analysers in quality control. As a result of the changes, the relation between the laboratory and the on-line analysers was reconsidered, and thus at places where on-line analysers function reliably, laboratory will primarily play a role in providing continual validation of those instruments.

It was raised as a recurrent question about on-line analysers whether their availability meets the requirements, and whether their measurement accuracy and stability are suitable.

This paper describes both the method elaborated to find answers to the above questions, and the software developed for such purposes in PI AF (Asset Framework), which we implemented on the basis of a real-time comparison of on-line analysers with the values measured in the laboratory.

INTRODUCTION
Refineries’ struggle to squeeze out every marketable drop enforces operators to maximally exploit their available technologies in order to increase efficiency. Several technologies are available to us for optimisation, whose capabilities have not yet been utilised completely: one of them is the on-line analysis technique or, in other words, the application of analysers.

Their application is indispensable in petrochemical and oil industrial processes where quick change-overs between products may occur, as a laboratory measurement process is unable to keep up in a timely manner with technological change-overs for the delays resulting from the taking and transportation of samples.

BACKGROUND
Today’s analyser specialists are responsible for a wide range of devices. Duna Refinery deals with more than three hundred analysers of different types, compared to a small plant with a handful of various analyser types.

Analysers are heterogeneous. Different communication standards, operation philosophies and maintenance procedures are in use. As this is a very widespread situation, a common look and feel is vital for at least some basic functions. Analysers are delivering results and status information to the control system at any time. High quality is a must for this data.

Initially, analysers were used in refineries to follow the changes in processes, i.e. for trend tracking, accuracy and precision in metrological sense were secondary criteria.
Today applications require innovative use of analysers, not only support operational decision-making, but to be used as an underlying asset, of course, endowed with greater responsibility on the operator and maintainer.

It is true especially in areas where we do frequent-switching in operations, or when the key indicator is the measured property (key operating index). Thereby we can provide a KPI (key performance indicator), such as energy minimisation, yield maximisation, setting of the finished product quality, and by all these can reduce the quality giveaway and ensure the reliable operation management, based on analysers.

Today, however, the reliable analysers with improved capability of repetition can be expected to produce 95% availability (Sherman, RE (ed) 1996).

As for availability, the entire analytical system needs to be taken into account, meaning all the partial elements from the sampling probe through the multi-stage sample preparation system up to the analysers, including any other elements that have an impact on measurements. The 95% availability means that an analyser can be unavailable for maintenance reasons for less than 18 days in any one year. Considering the complexity of analysers and the current practices of spare part supply it can be easily understood that it is an extremely high requirement and can only be met with a well-formulated maintenance strategy. Taking into consideration the general cycle time (10 minutes / analysis) of a gas chromatograph, nearly 50,000 measurements can be made annually with the above parameters. Such an amount of data enables continuous optimisation, in every mode of operation, including particularly unit start-ups, shutdowns and extreme operating conditions.

Of course, the question arises: with what level of accuracy can it be achieved? As was said, trend tracking used to be the main priority and measurement accuracy was a secondary criteria. Thus, analysers were in general tasked to track given parameters and to provide feedback to operators about how quickly and to what extent the technological process can follow the changes. Confirmation in the form of an accurate measurement was given in each case by the laboratory, and that is what they still do today.

**FOUNDATIONS FOR DEVELOPMENT**

The analysers marketed over the last ten years can even be expected to achieve a 1-2% measurement accuracy projected to the final scale (FS) of measurement range. An obvious question is whether the availability of a high accuracy analyser changes the practice of the operating laboratory?

Before giving an answer to that question, it is worth thinking over how we can assure and sustain such measurement accuracy in function of time. The classic practice was to calibrate the analyser in regular intervals (e.g. once in every three months). If the unit indicated some inaccuracy compared to the last laboratory measurement (!) between the calibrations, the analyser was set to the last laboratory measurement value. Obviously, from the viewpoint of accuracy requirements, such a practice can only serve for trend tracking what does not impose high demand. To be able to make use of the inherent capabilities of the analysers, we need to change the operational and maintenance practices!

Instead of traditional calibration and setting methods, such new approaches should be deployed as quality tracking on statistical basis (Siemens 2011, ABB 2004). The essence of that method in use is the following.

Laboratory and analyser measurements, with times stamps, can be retrieved from the Refining PI system as historical data. Assigning the respective laboratory / analyser measurement values and accepting laboratory values as a reference, the repetition accuracy of the analyser can be followed in time, and it can be identified whether the analyser meets the expected accuracy requirements. This process is called validation. **Figure 1** shows that if we want to track changes with the laboratory, we
Development

would need to order 5 or 6 laboratory measurements a day. In the current situation, it would impose an unacceptable burden on the lab. In the following example the laboratory makes one measurement a week while the analyser keeps sending data to the operator once in every 10 minutes.

That sounds very simple but how to implement it? You can find below a step-by-step description of how we implemented the validation process of analysers. The first action is to include analysers and laboratory data into the same system. MOL’s Duna Refinery has excellent opportunities in this respect, as all analysers are connected to a DCS (distributed control system) from where all data can go to the PI (historical database). The laboratory information and management system (or LIMS – laboratory information management system) also has a PI connection, which allows us to handle process and laboratory data in the same system. We have used the AF (Asset Framework) subsystem of the PI for programming the validation application. The validation process is illustrated in Figure 2. Products of several famous manufacturers are available on the market, but programming and configuring PI AF exempt us from significant expenditure of Euro 20-50 thousand. The necessary software and hardware building elements are at our disposal, thanks to previous projects:

› There was no need for the procurement of new software or for a modification because the SQC (Statistical Quality Control) module in the 2009 release of OSI PI fully supports our access to the required functions

› In the NICE framework system on the computers running PI client the ARGUS validation application is accessible.

Summarising, the configuration actions performed were:

› Specification of the technical scope of the evaluation platform,

› Combining LIMS laboratory values + .LA and PI analyser + .PV data,

› Calculation of the acceptance limits,

› Programming, configuring and testing PI AF, and

› Testing the evaluation environment and the graphical displays.

For measurements to be considered as suitable for validation as per the standard, the following criteria have to be met:

1 Both laboratory and analyser measurements have a normal distribution

Fig. 1. Laboratory (blue) and analyser (green) measurements assigned to each other. (The values of laboratory measurements are shown by the ‘blue trend’, as discreet values after rising edges, remaining constant for 6 to 7 days after every measurement)
Laboratory and analyser measurements are independent of each other.

Reproducibility of laboratory measurements does not change significantly within the timeframe under scrutiny.

**TURNING THE STANDARDS INTO LIVE**

The first task is data collection in the course of which the values of the last 15 laboratory measurements and the related analyser values are deducted from each other. This is called 'bias', the bias of 'i' number of samples will be $\Delta i$ while and the sample number will be 'n' (ASTM D3764-01 8.3.3.6).

Firstly, we calculate the average ($AVG$) of the related laboratory and analyser values (Eq. 1), then their statistical deviation ($StDEV$) for every sample, if $T_{crit} > T_{\text{crit}}(n)$, then sample no. ‘i’ will be the outlier (Eq. 2-3). The $T_{\text{crit}}$ values are defined on the basis of the related standard (ASTM E178-02). The outliers are excluded, and the test is continued with the remaining data until all outliers have been excluded. The critical values $T_{\text{crit}}(n)$ are the critical values used at 2.5% significance level for one-sided testing. As we perform testing on two sides, it means 5% in our case. Then, with the Chi square test, we use the filtered samples having passed the outlier test, to check if the analyser has been able to produce the reproducibility that we expected of it ($R$) (ASTM D3764-01 8.3.3.9). We calculate the expected variance (ASTM D6299-02 3.2.10) from the expected reproducibility (Eq. 4).

$$AVG = \frac{1}{n} \sum_{i=1}^{n} \Delta_i$$

(Eq. 1).

$$StDEV = \sqrt{\frac{\sum_{i=1}^{n} (\Delta_i - AVG)^2}{n-1}}$$

(Eq. 2).

$$T_i = \frac{|\Delta_i - AVG|}{StDEV}$$

(Eq. 3).

The value 1.96 is coming from the normal distribution two-sided 95% probability. So from 100 differences only 5 can be greater than the expected reproducibility.

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![Laboratory measurements combined in one system](image)

**Fig. 2.** Laboratory (.LA) and analyser (.PV) measurements combined in one system.
Using the Chi square test, we compare the estimated precision with the expected precision (ASTM D6299-02 A1.7.1). We calculate the value of the Chi² parameter (Eq. 5).

\[ \text{Chi}^2 = \sum_{i=1}^{n} \frac{(\Delta_i - \text{AVG})^2}{\sigma^2} \]  
(Eq. 5).

As we have not calculated the value of Chi² from a moving range (MR) but from the square sum of deviations from the average, the number of degrees of freedom will be \( n-1 \). If \( \text{Chi}^2 < \text{Chi}^2_{\text{crit}} \) \((n-1)\), then our analyser is capable of producing the expected reproducibility.

The critical values refer to one-sided, upper 95% significance level and to the given degree of freedom. We have performed paired \( T \)-test for the samples that have passed the outlier test (Eq. 6). The hypothesis is that the real bias value is 0 (ASTM D3764-01 8.3.3.10).

\[ T = \frac{|\text{AVG}|}{\text{StDEV}/\sqrt{n}} \]  
(Eq. 6).

If \( T < T_{\text{crit}} \) \((n-1)\), then there is no regular bias between our analyser and laboratory values, meaning that our analyser is precise.

The screenshot (Figure 3) shows the details about ARGUS. On the left side in tree view we can see analysers integrated in the system. In the middle we can follow up the correlation between the pair of analyser and lab values. In the upper right corner we can check the difference between the lab and the analyser in function of time and there is a histogram about the differences. Of course we can follow lab and analyser trends in the right bottom part of the screen. If the analyser meets the above mentioned criteria based on ASTM standards we can see the validation is done in the bottom of the screen. During the calculation ARGUS takes into account the status of the unit (running / not running) and the status of the analyser.

**SUMMARY**

One of the strategic objectives of Refining is to make better use of the resource reserves in our existing IT systems. To this end, a dedicated software module (ARGUS) has been created in PI to run the analysers of key importance and to evaluate availability on statistical basis. By means of ARGUS, we can ensure, with the utilisation of minimal resources, a real-time monitoring of the correlations between the data from on-line analysers and laboratory data, the measurement of availability indicators and the validation of analysers.

We believe by the change in the operating philosophy and with more trust on the reliable analysers we can earn greater benefits such as load decrease only in the laboratory. Decision-making without any delay, keeping the limits of the critical properties, optimisation of the energy consumption and decrease of the quality giveaway carries tremendous business opportunities.

Currently we have 15 analysers in ARGUS. They are multiparameter measurement analysers so they have 35 independent output parameters. ARGUS can validate every independent output. Our target (25 analysers should be integrated into ARGUS by the end of year) means around 50 parameters to be validated.

**Keywords:** quality control, on-line analyser, validation

Reviewed by László Szirmai, Dr.

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Gábor Bereznai began his career at MOL in 1998 as a process analytical engineer in the Instrumentation and Control Department. He later joined the newly-formed Engineering Supervision Department as a process control specialist. He has worked on several major MOL projects including ultra-low sulphur motor fuel production, SIL, ATEX and maintenance system development. He also worked as a technical advisor to MOL Group Maintenance Management assisting in the development of PDM and PM systems and RCM. Gábor holds an automation engineer (BSc) degree from KKVMF, Budapest and an environmental engineer (BSc) degree from Széchenyi University in Győr. He is also a TÜV Functional Safety engineer.

Róbert Zomborszki started his carrier at Process Information department in 2009, responsible for real-time and material balancing systems development, where he took part in material balancing and refinery information system upgrade both in Duna and Rijeka refineries. Now he is supporting various applications of monitoring refinery assets and seeks further opportunities to improve production excellence. Róbert graduated as chemical engineer at the Budapest University of Technology and Economics.
DIRECTIONS OF VEHICLE AND ENGINE DEVELOPMENT FOR CARBON DIOXIDE EMISSIONS REDUCTION

Lajos Kisdeák (60)
Head of Technical Service
MOL Group, MOL-LUB Ltd.
likisdeak@mol.hu

Máté Zöldy, PhD (34)
Automotive & fuel quality expert
MOL Group, Downstream Development
mzoldy@mol.hu

ABSTRACT
The extremities of weather indicate that climate change inducing carbon dioxide emissions must be reduced. Results achieved up to this point are far from satisfactory, global carbon dioxide emissions are increasing dynamically.

The European Union bodies issued numerous acts and legislations aiming carbon dioxide emissions reduction, many of them concerning vehicle manufacturing industry. One of these directives has been promoting the use of biofuels in the transport sector but now it is concerned by sustainability issues.

In the current circumstances decreasing carbon dioxide emissions of vehicles has extreme importance. According to different studies, there are substantial reserves in the field of decreasing vehicles energy losses such as aerodynamical losses, losses from road-wheel contact, losses from the power train of the vehicles, and other losses. Vehicle weights must be decreased and alternative fuels must be developed.

Engine development also addresses carbon dioxide reduction. Intensive research is conducted on burning process improvement. By decreasing mechanical losses engine efficiency can be dramatically improved; downsizing and downspeeding are important tools to reach this goal.

Along with current developments of today’s vehicles OEMs have to search for future solutions that enable us to safely use hydrogen as engine fuel. Nanotechnology has also got leading role in this field.

DRIVING FORCES OF VEHICLE DEVELOPMENT
The climate of our Earth is changing. Day by day we watch the weather getting more and more extreme and incalculable. In 2012 in the Carpathian basin spring freeze damaged orchards, early summer hail-storms destroyed plants then the nature’s vengeance was completed by a long-term drought. Things are not better anywhere else. Lately Australia was suffering from frequent floods, in England and Wales there was an average 1,340 mm rain in 2012, while in the first half of 2010 their drinking water supplies were endangered by drought.

“According to IPCC (Intergovernmental Panel on Climate Change) based on observations and scientific analysis we can state with certainty that the currently developing global climate change can be put down to the changing composition of
the atmosphere mainly caused by human activities. Compared to pre-industrial revolution times the atmosphere’s carbon dioxide concentration has increased by 39%, methane concentration by 258% and dinitrogen oxide concentration by 20%, and the increasing is continuous, slightly growing” … “According to climate models it is almost certain that the increasing frequency of warm side weather extremities will continue in the future” (IPCC 2011).

**Increased average temperature** aggravates instability in the atmosphere resulting is quick weather changes and frequent extremities.

The **conflict between** civilisation and nature often becomes apparent. This is demonstrated by **Figure 1**, which shows the last launch of the Space Shuttle Programme (Space Shuttle Atlantis, Cape Canaveral, 8th June, 2011). Not resolving this conflict would lead to the end of human civilisation.

**Fig. 1.** Are there real antagonism between technological advancement and nature? (ESA, European Space Agency 2011)

**Carbon dioxide emissions** reduction is the central topic of all climate conferences. Press release from the November-December 2012 Doha climate change conference published on the European Union website was titled “Doha Climate Conference takes modest step towards a global climate deal in 2015” (European Commission 2012A). A new binding climate agreement is planned to be achieved by 2015 and substituting the expiring Kyoto Protocol.

**Authors of article** ‘IEA CO₂ Emissions Update 2010 – Bad News’ compare the actual carbon dioxide emissions (unpublished data of IEA (International Energy Agency)) with the estimations of IPCC Year 2000 Scenarios (see on **Figure 2**) (Nuccitelli, D & Abraham, J 2011).

**Fig. 2.** Observed carbon dioxide emissions vs. IPCC Year 2000 scenarios (Nuccitelli, D & Abraham, J 2011)

Data in **Figure 2** are backed up by other sources as well: in 2011 worldwide carbon dioxide emissions have exceeded 34 billion tonnes. As the main source of the emissions, China is responsible for 29% of this quantity. But efforts of the economically developed countries are not totally wasted. In the European Union and in the United States of America carbon dioxide emissions have decreased compared to year 1999 (Oliver, JGJ & Janssens-Maenhout, G & Peters JAHW 2012).

Unfortunately, up to this time one thing seems to be the most effective to reduce global carbon dioxide emissions: global economic recession. Biofuel applications have not provided the results expected earlier. Increased demand for biofuel base stock has caused tremendous damage. Rain forests and savannas have been victims of agricultural production: their area has been occupied by palm and maize plantations. The early optimism has been ended by the study of Timothy Searchinger and his research team from Princeton University titled ‘Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions
from Land Use Change’ published in Science Express in 7 February, 2008. Searchinger has introduced the concept of Indirect Land Use Change, and has proved that the collateral effect of biofuel production is additional carbon dioxide emission. This study has generated conflicts and arguments for years, but proved to be basically correct.

The European Union first reaction took place in 13th July, 2011, when legislation on indirect effects of biofuel application was postponed based on a proposal by Günther Oettinger, Commissioner for Energy and Connie Hedegaard, Commissioner for Climate Action. A press release in 17 October 2012 stated that European Comission gave a new proposal on minimising the effects of biofuel production on climate. This proposal states that the European Union targeted share of renewable energy sources used in transport remains 10% by 2020, but the quantity of foodstock based biofuels and liquid biofuels remains on the current level (5%) (European Commision 2012B).

The EU intends to encourage production of second and third generation biofuels made from non-food base stock such as kelp, straw or different wastes therefore does not need additional fieldlands. They wish to tighten limitations on greenhouse gases (GHG) as well: new biofuel production establishments have to ensure at least 60% GHG reduction (European Commission 2012B).

In the latest years biofuel production has led to a considerable rise of food prices. This effect is the worst in those underdeveloped countries which – due to their cheap workforce – contributed considerably to base stock production. For example, in Guatemala prices of corn and sugar have doubled, the price of eggs has increased three times, while approximately 50% of the children are undernourished. These unfavourable effects caused warning sounds increased, even in the USA, that 2020 goals and policies should be reconsidered (Energiacentrum 2012).

The European Union regulation No. 443/2009/EC sets the average CO₂ emissions for new passenger cars supplied by the same manufacturer starting in 2012 at 130 g CO₂/km, by means of improvement in vehicle motor technology and requires additional measures corresponding to a reduction of 10 g CO₂/km (European Parliament and Council 2009). Each manufacturer of passenger cars shall ensure that its average specific carbon dioxide emissions do not exceed its specific emissions target calculated according to the following value:

\[
\text{Specific CO}_2 \text{ emissions} = 130 + a \cdot (M - M_0), \text{ g/km}
\]

where:
- \(M\) is the weight of the vehicle in kgs,
- \(M_0\) is 1372.0 kgs,
- \(a\) is 0.0457.

The row weight of the vehicle (M) means the weight of a completely equipped, ready to go vehicle, as stated in the vehicle documents. \(M_0\) value shall be reconsidered in the following years; a modified value is expected to have to be used after 2016.

The European passenger car manufacturers shall fully comply with the regulation starting from 2015. New passenger cars with lower than 50 g CO₂/km emissions get super-credits, however, excess emissions are to be penalised. Between 2012 and 2018 the following fines should be payed:

- For the first gram of excessive average CO₂ emission: 5 Euros per new vehicles
- For the second gram of excessive average CO₂ emission: 15 Euros per new vehicles
- For the third gram of excessive average CO₂ emission: 25 Euros per new vehicles
- Above the third gram for every further gram of excessive average CO₂ emissions: 95 Euros per new vehicles.
The European Union is planning to lower the 130 g/km specific CO₂ emissions of passenger cars to 95 g/km, after 2020.

An amendment of the regulation 443/2009 introduces legally binding emissions limit of 175 g CO₂/km for light vans up to 3.5 tonnes (2014: 70% of the fleet, 2015: 75%, 2016: 80%, 2017: 100%). Non-compliance will be penalised. By 2014, Commission may propose to extend CO₂ emissions limits to minibuses and vans up to 12 tonnes (Council 2011).

Carbon dioxide emission has to be measured according to New European Driving Cycle (NEDC).

This way the EU car manufacturers are driven to take regulation No. 443/2009/EC into consideration when creating their portfolio. If they produce large SUVs (sport utility vehicles), they should balance their high carbon dioxide emissions by selling low CO₂ emission light cars.

What is the foregoing conclusion? Global carbon dioxide emissions are dynamically increasing, biofuels have not come up to expectations. Fundamental scientific-technical breakthrough in concerning vehicle construction has not been reached yet. Conventional vehicle constructions should be further improved, as there are reserves in them. In the next two decades internal combustion engines are prognosed to be dominant in the field.

CENTRE POINTS
OF VEHICLE DEVELOPMENT

According to a MIT study (Massachusetts Institute of Technology 2008) fuel consumption of lightweight commercial vehicles can be reduced by 30-50% in the next 30 years. In short-term the results will be due to gasoline and diesel engine developments, modern gears and gasoline hybrid engines. Decreasing weight and aerodynamic resistance of vehicles will contribute as well. Widespread use of plug-in hybrids is prognosed for the second half of the next 30 years. Mass application of hydrogen fuel cells can be expected afterwards. Nevertheless, these changes will lead to significant increase in vehicle prices.

Making predictions for decades is adventurous nowadays, but thinking over the possibilities has definite advantages.

REDUCING PARASITIC LOSSES

The expression ‘parasitic loss’ covers practically all kind of losses. Operating a turbocharger, for example certainly consumes energy, but the increase of engine performance due to the turbocharger use should not be forgotten. Thus the energy used for operating the turbocharger does not deserve to be treated the same as for example the tyres’ resistance of rolling. From this perspective we try to classify ‘losses’ more correctly, as follows.

Reducing aerodynamic resistance
Researchers have paid great attention to aerodynamics of aeronautical vehicles and have achieved great results; just think about rapidly ascending combat aircrafts capable of flying at extremely low speed.

Ground vehicles got less attention so far. That is why MIT researchers’ prediction of reducing aerodynamic resistance by 25% in 25 years is not an exaggeration.

Reducing tyres’ resistance of rolling
Modifying the material and design of tyres gives a possibility to reduce fuel consumption. According to MIT 10% reduction of resistance of rolling is possible with our current state of knowledge. Further research can increase this percentage up to 33% in 25 years.

Reducing losses of power train
Power train consists of the engine and the different gears, so reducing their losses is a complicated task with numerous possibilities. Loss reduction of internal combustion engines will be discussed later. Some other possibilities are listed in a few points.
Improving gear performance
As it can be seen in reference (Massachusetts Institute of Technology 2008) gearboxes of light commercial vehicles transmit engine performance towards the wheels at 89% efficiency. This improvement will be due to not only the wider application of efficient designs – for example automated mechanical gearboxes – but development of metallic and non-metallic construction materials and gear oils as well. Hydrodynamic and hydrostatic drives are expected to remain only for extremely high performance applications.

Improving hybrid drives
As development of hybrid vehicles is amply covered in literature we will not deal with them in detail. The hybrids of different types show considerable advantages over conventional constructions on two areas: they provide possibility to recuperate braking energy, and are capable of zero emissions operation in cities.

Despite these advantages their share in public operations is not high and their high price is only partly an explanation. The electric motors and accumulators of current technological level increase the vehicles weight, therefore part of their fuel-saving capabilities are lost. Lifetime of the accumulators is relatively short and this fact contributes to the high upkeep. We should not forget the larger environmental footprint of hybrid vehicle manufacturing compared to that of a conventional model. Plug-in hybrids can bring a real breakthrough, when serious deficiencies in the field of electric power accumulation are solved.

Fuel cell hybrids or fuel cell electric vehicles are in their experimental state at best. In their case not only electric power accumulation must be solved at higher technological level and at lower costs than today, but reliable fuel cells for everyday use and safe hydrogen tanks are needed as well. Of course mass production of hydrogen in an efficient and environmentally considerate way must be solved as well.

Today’s unresolved and partially resolved problems have become fields for hunting for nanotechnology.

Developing construction material of the power train
Today’s known construction materials are not optimal for modern internal combustion engines or gears. We need materials with low adhesive surface providing low friction coefficient in the state of boundary or mixed lubrication. Further requirements are improved resistance to high temperature and low heat expansion coefficient. These points shall be covered in our last section.

Of course researchers do not limit their attention on power train construction materials. U. S. Department of Energy sums up construction material development in two points:

› Lightening’, contributes to reducing vehicle weight

› Developing power train materials to achieve higher efficiency (U. S. Department of Energy 2011).

As a matter of curiosity: development of materials science has been boosted by nanotechnology as well.

Let us see an example. In the eighties NASA got out an old technology known since 1931 in order to produce aerogel. Aerogel is a type of gel in which the liquid component has been removed leaving its quasi-solid structure intact to maintain gel structure. The advanced version of this material was used to produce a dust sampler equipment of Stardust space probe. Nowadays different types of aerogels are available commercially, they are used as heat insulating materials in construction industry (see Figure 3), as ultra-light material for the best tennis rackets, and they have medical applications as well.

And here is the more advanced one: aerographite. Its structure is similar to that of aerogel, but its frame structure is made of carbon tube network
as a product of nanotechnology. It is solid, with a density of 0.2 kg/m³, but capable of withstanding big elastic deformation. It is an excellent electric conductor. They are highly expected to make construction of excellent electric charge accumulators, more advanced than today’s ones, possible.

Developing surface coatings and surface-forming technologies
This area of manufacturing technology has also been boosted by nanotechnology. Today numerous researchers are working on surface modification technologies, even a new expression was created and established: ‘surface engineering’. Surface coatings and modification technologies are often used in vehicle construction, in order to reduce frictional losses.

Developing lubricants
Lubricants are auxiliary materials essential in machinery operations. Considering frictional losses generated by lubricants, well, we have to optimise. Should we have a liquid with no internal friction, it was useless as a lubricant. Of course, there is no such liquid. High viscosity lubricants (with high internal friction) in turn cause high frictional loss.

Nowadays manufacturers seem to recommend lower and lower viscosity engine oils for their modern engines. This process was started many years ago by trying to assure fuel economy. Development of hybrid drives and fuel-economy start-stop systems has boosted the process. Internal combustion engines are often stopped in both cases – at least in cities – so they are often cold. In order to decrease lubricant-related loss low viscosity oils are needed.

Considering all this we should not be surprised that SAE (Society of Automotive Engineers) will soon introduce SAE 16 viscosity class, so SAE 0W-16 can be created for vehicles with hybrid or start-stop systems (Van Rensselar, J 2013).

Current lubricant development does not end in lowering viscosity. Further objective is reducing frictional loss in the state of boundary and mixed lubrication. An interesting and potentially successful field of this research is application of solid additives (IF, Inorganic Fulleren-like particles) produced by nanotechnology which can allow us to change from the old antiwear additive zinc-dithio-phosphate that has been in use for more than 70 years, and has numerous adverse effects. Under the aegis of the European Commission’s 7th framework programme a new consortium led by Infineum Ltd. has been formed with the name of AddNano (AddNano 2009).

Engine oils have to contribute to decreasing classical harmful emissions (mainly solid particles emitted by diesel engines), too.

Reducing other losses
Reducing power absorption of the vehicle’s accessory equipments
They also increase fuel consumption. Two types of them worth a closer look:

› Coolers and air-conditioners
Due to global warming air conditioners are less and less for comfort and are becoming more important tools of driving security. Despite this their power absorption and their impact on the environment are important factors. Cooling agents are known greenhouse gases. Defects or failure of
air-conditioners, or their incorrect repairment can cause cooling agents released into the atmosphere. Introduction of a new, less environmentally dangerous cooling agent (R1234yf) has been attempted for years, but so far it has not happened, because of its ambiguous inflammability.

Generators
The biggest electricity consumers of generators are lighting fittings. Manufacturers are looking for energy saving solutions on this field, too. This is the reason of worldwide spreading of LED lighting. LEDs are more controllable than light bulbs, so they can offer other advantages as well.

Reducing idle time: start-stop operation
To reduce fuel consumption it is convenient to stop the engine while waiting at red light, or in traffic jam we stop and go. If the driver switch the gearbox into neutral position and remove his leg from the clutch pedal, the engine stops. When the driver engages the gearbox again the engine restarts. This solution seems easy, but it is not. Start-stop systems require special accumulators, starting engines and generators. In addition, heat balance of the engines deteriorates, and should be balanced by advanced temperature control (thermal management).

Reduction of harmful emissions (classical harmful emissions: nitrogen oxides, carbon monoxide, unburned hydrocarbons)
In the European Union introduction of Euro 6 norm for heavy commercial vehicles and buses on 1st January 2013 closes the legislative emission control process (Dieselnet 2012A). Euro 6 norms for the approval of passenger cars and light commercial vehicles will come into force on 1st September 2014, for some types of light commercial vehicles this date is postponed by a year (Dieselnet 2012B). Further restriction for passenger cars and light commercial vehicles are not under preparation. Of course development will not be stopped. Current technological solutions can be improved, for example reducing energy consumption of regenerating diesel particle filters would be definitely advantageous. Further restriction would lead to increased power consumption of emission systems resulting in higher carbon dioxide emissions.

Reducing vehicles’ weight
Lightweighting is an important field of vehicle construction. To achieve this, development of new construction materials is required. Application of carbon composites in vehicle construction is increasing. Application of high tensile steel, magnesium and aluminium alloys will be increasing, while conventional steel usage will be decreasing. New materials require advanced construction principles as well (Massachusetts Institute of Technology 2008).

According to Massachusetts Institute of Technology prognosis the total weight of a fleet with representative combination of vehicles will be able to be reduced by 20% in the next 25 years. This may result in 12-20% reduction in fuel consumption (Massachusetts Institute of Technology 2008).

Developing alternative fuels
To achieve the 10% rate of renewable energy sources among engine fuel consumption while keeping the rate of first generation biofuels below 5% till 2020 according to the European Union policies is a real challenge. Fuel producers and distributors have to find the best solutions for themselves while fulfilling the requirements stated by fuel standards.

In the latest years utilising industrial and agricultural waste accessible in large quantities as base stock for fuels and developing the necessary technologies has come to the front. Interesting example is the so called black liqueur, which is dimethyl-ether produced from paper mill waste and used as diesel engine fuel. This programme was carried out in Sweden, and was backed up by the European Union.

While working on her proposal on biofuels Connie Hedegaard, the European Union Commissioner for Climate Action expressed plainly, that the
European Union will not ban first generation bio-fuel production, but indicates, that in the future, the increasing rate of biofuels must be reached by more advanced biofuels, as they represent the only sustainable solution. In connection with the proposal the Commission has defined the difference between first generation and advanced biofuels as well. Biofuels made from vegetal base stock, such as sugar, starch, vegetable oil, which, like foodstock, require separate cultivation area, are qualified as first generation biofuels.

Alternative fuels can come from other sources than renewable ones. In this spirit the European Commission proposed a new strategy for ‘clean fuels’, including electricity, hydrogen, biofuels, natural gas (LNG, CNG), and LPG. This strategy does not deal with fuel quality, but with the European level development of the alternative fuels infrastructure, and common standards for developing and operating these stations.

According to the proposal, till 2020 7,000 electric recharging points for plug-in hybrids must be provided in Hungary (European Commission 2013).

Improving driving safety
Improving driving safety is also part of the European vehicle development strategy.

RESEARCHING MODERN SOLUTIONS
During the discussion about hybrid drives, we have already mentioned nanotechnology, as a possible answer to unsolved problems. Let us see a brief list of those vehicle development areas, where nanotechnology is intensively used in research.

› Construction material development with composite components produced by nanotechnology

› Tyre material development

› Catalyst development to aid more complete combustion of conventional fuels

› Developing solid lubricant additives capable of surface modification

› Developing accumulators and supercondensers for hybrids and electric cars

› Developing fuel cells for hybrids and electric cars

› Developing hydrogen containers for fuel cell applications

› Hydrogen production with the help of photocatalysis using solar energy.

It is difficult to forecast, when the above mentioned areas will result in practical solutions (Nanoconsulting 2010).

ENGINE DEVELOPMENT FOR INCREASED EFFICIENCY

COMBUSTION PROCESS DEVELOPMENT
Combustion process development has three main objectives.

› Improving combustion efficiency
More complete combustion leads to reduced fuel consumption, therefore reduced carbon dioxide emissions.

› Reducing losses caused by performance control of gasoline engines (losses from flow control or pumping)
During intake especially in case of partial performance the pressure is low in the cylinder reducing engine performance. This is one of the reasons gasoline engines are less efficient than diesel engines. The other reason is the necessity to avoid autoignition: high compression in Otto-engine, like in diesel engines cannot be achieved.

› Reducing classical harmful emission
The most effective way of reducing harmful emissions is prevention. Not an easy task! Harmful combustion materials are mostly produced in the flame front. Temperature in the flame boundaries is high, contributing to nitrogen-oxide formation, and oxygen deficiency may occur in certain points even with adequate fuel-air mixture. This later process is responsible for particle formation.
Depending on the engine construction there are three types of solutions.

› Improving fuel supply system of diesel engines
We aim to vaporize fuel to form smallest possible droplets in order to maximise air contact surface. In today’s engines vapour pressure has reached 250 MPas.

High vapor pressure alone is not enough. Due to the strict emission requirements, modern diesel engines are operating with direct injection. This leads to fast combustion and consequently high combustion pressure and temperature. Elongated combustion can be ensured by vaporizing fuel in multistep. To accomplish this controllable fast acting injectors are needed. This is the reason Common Rail fuel supply systems are used everywhere: they are fitted with piezocrystals and solenoid-operated injectors.

› Direct fuel injection
For gasoline engines direct fuel injection is the solution. The injectors inject fuel directly into combustion area in quantities needed for the required engine performance. Choke valves are unnecessary even at low power level, therefore engine efficiency is improving. Nevertheless, the situation is complicated. At low engine power levels injected petrol may form a low concentration mixture with air, and combustion stops. Injection, ignition, gas movement in the combustion chamber, and combustion itself must be carefully synchronised and precisely designed. Direct fuel injection ensures engine operation at low fuel concentrations. Higher compression ratio can be applied, therefore efficiency is improving. The only disadvantage is high level of nitrogen oxide emissions.

› CAI-HCCI engines
More complete combustion leads to reduced fuel consumption, therefore reduced carbon dioxide emissions.

There is one problem both of the above mentioned solution share: they do not eliminate flame front. The intent to eliminate flame front has led to development of CAI (Controlled Auto Ignition) and HCCI (Homogenous Charge Compression Ignition) engines. One of them is for petrol, and the other is for diesel approach towards operation without flame front.

Basic principle of CAI-HCCI engines is simple. Take a homogenous fuel-air mixture, and compress them until the mixture is ignited by the increasing temperature caused by the compression. The main advantage is that multiple ignitions happen simultaneously; therefore flame front is not formed. This is the reason why CAI-HCCI engines have low emissions. These engines combine the low emissions of gasoline engines with the high efficiency of diesel engines. The only difficulty is precise timing of ignition, and to solve this highly advanced process control is required.

To control ignition time CAI-HCCI engines have precise temperature control that is adjustable during operation. Combustion processes of conventional gasoline engines and HCCI engines are shown in Figure 4.

Fig. 4. Combustion processes of conventional gasoline engines (left) and HCCI engines (right) (MotorTrend Magazine 2008)
**IMPROVING ENGINE CONSTRUCTIONS**

Constructions of internal combustion engines can be improved by a few simple modifications. We do not say these modifications could not be done earlier, but they have a definite cost-increasing effect, so some pressure was needed to introduce them. The most important possibilities are as follow.

- **Variable compression ratio (VCR)**
  Thermal efficiency of internal combustion engines is known to be improved with increased compression ratio. Increasing compression ratio is limited by structural strength of engine parts, and, in case of gasoline engines, the danger of autoignition.

  If maximum power of an engine is not needed, compression ratio can be increased. As a result, its efficiency will not be decreased, or suffer only a slight decrease.

  In case of CAI-HCCI engines variable compression ratio is required for operation. To achieve variable compression ratio numerous construction has been developed. Widespread use of VCR engines is hindered by their complex structure and high price.

- **Flexible valve control**
  Speed (rpm) change of engines creates gas vibrations in intaking and exhaust systems. Opening and closing process of valves should be adjusted to these vibrations in order to ensure optimal charge at any speed. Fixed connection between crankshaft and camshafts should be released and flexible connection should be established.

- **Variable turbocharger geometry**
  Operational characteristics of internal combustion engines and turbochargers are different. To ensure their optimal co-operation in a wide speed range of the engine, turbocharger operation should be modified to optimise blast air quantity and turbocharger pressure. Meanwhile attention should be payed that the turbocharger should not cause higher loss in the exhaust system than absolutely necessary.

**REDUCING FRICTIONAL LOSS BY MODIFYING ENGINE CONSTRUCTION PRINCIPLES**

Reducing frictional loss has been getting special attention lately. Engine construction principles have been fundamentally modified; ‘downsizing’ and ‘downspeeding’ are the expressions for these new principles.

**Downsizing**

Downsizing means decreasing size and weight, and it is applicable in case of both gasoline and diesel engines. Essentially engineers intend to achieve the same engine power by developing smaller and lighter engines. Reducing engine parts’ weight means reducing mass force, consequently friction caused by them. Reducing frictional loss improves engine efficiency – moderates specific fuel consumption – therefore a smaller and lighter engine is capable of providing the same power. Further advantage is that the auxiliary equipments (such as coolant and oil pumps) of a smaller engine require less power.

Of course, possibilities of downsizing are not unlimited. Smaller size means smaller cross-section for gas flow (intaken air, exhaust gas), this means faster flow and consequently increase in frictional loss in gases.

Lighter engines mean lighter vehicles and the reduction of fuel consumption is not negligible.

**Downspeeding**

After reducing engine size original power level could be easily recovered by increasing engine speed, but this way advantages gained from downsizing would disappear because higher speed means higher mass force. Instead of increasing engine speed should be decreased. To recover original power level or even improve it strong charge is needed.

Let us see an example for an engine constructed based on downsizing and downspeeding principles. Ford Motor Company has introduced its three cylinder 1.0 litre engine produced with two power levels (73.5 kW
and 92 kW) in 2012 (see Figure 5). Main characteristics of the ‘92 kW’ version are as follow:

› High pressure direct fuel injection
› Maximum power speed: 6,000 rpm
› Engine weight: 97 kgs
› Cylinder head material: cast aluminium alloy
› Cylinder block material: cast iron alloy
› Maximum speed of turbocharger: 248,000 rpm
› Variable conveying oil pump with electronic control
› Double thermostat, double pump thermal management system
› Specific carbon dioxide emissions built in a five door Ford Focus with six speed manual gearbox are 114 g/km (Birch, S 2012; Media.Ford 2012A).

Fundamental modification of engine construction principles

Engine constructors sometimes try to set usual construction principles aside. Wankel engine was born from this type of mind game. It is not widely used, they can be found in few types of cars nowadays. Nevertheless, this kind of ideas worth attention, one of them is described below.

Engineers of MCE-5 Development SA have designed a new engine intending to eliminate substantial frictional loss between pistons and cylinders. Kinematic chart of their engine is shown in Figure 6.

Piston rod is firmly connected to piston. New part of the engine is a disfigured gear connected to piston rod on one side, to compression-modifying piston rod on the other side and to the connection rod in the middle.

The modified piston, connection rod and the connecting machine parts are shown in Figure 7, cutaway of the engine can be seen in Figure 8.
It is a complicated engine design, but engine characteristics are convincing:

- Displacement: 1.5 litres
- Maximum speed: 6,500 rpm
- Downsizing-downspeeding technology
- Charge pressure: 0.4 MPa
- Maximum power: 180 kW
- Specific carbon dioxide emissions built in Peugeot 406 passenger car: 128 g/km (MCE-5 VCRi 2012B).

**Thermal management**

**Fuel consumption** of internal combustion engines is high for a few minutes after starting. There are two reasons for this:

- Incomplete combustion due to low combustion chamber temperature
- A significant part of intaken fuel condenses on cool surfaces and getting into engine oil.

**Engine design helping** fast warm-up is useful. That is why electronically controlled multiple thermostat and multiple pump cooling systems are built.

Thermal management plays key role in case of vehicles with hybrid and start-stop system.

**Construction material of engines**

Construction material development has multiple purposes. Downsizing alone is capable of boosting construction material development, because workload on smaller machine parts is only partially decreased. Mass forces are reduced, but so called gas forces (forces originated from high pressure combustion gases) are increased. New construction materials with higher resistance and loadability are needed. Lower thermal expansion coefficient of these new construction materials is a definite plus, because non constant warming leads to unwanted size distortion and consecutive...
mechanical tension. Further purpose of new construction materials are wear resistance and low friction coefficient.

Unsurprisingly many car manufacturers stopped using aluminium and prefer application of high tensile cast iron or cast steel. Main advantage of aluminium is lower density, but aside from this, there are only disadvantages: low resistance, high thermal expansion coefficient, high friction coefficient, etc. Return to cast iron has not stopped efforts towards weight reduction.

Decreased lubricant viscosity means new requirements for construction materials. Due to low viscosity, low bearing play should be applied. If engine parts suffer big elastic deformation bearing plays are distorted leading to serious wear. Construction materials with high coefficient of elasticity are useful. In the absence of this kind of materials engineers have to ensure necessary machine part strength.

**Nanotechnology based** composite material development aims to solve this type of problems.

**Keywords:** climate change, CO₂ emissions, biofuels, vehicle development, lightweighting, engine development, downsizing, downspeeding, nanotechnology

Reviewed by András Holló, PhD

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*Workshop*
Lajos Kisdeák was working for Budapest University of Technology as a lecturer until 1994. Since 1995 he has been working for MOL Group. His fields of expertise include different lubrication applications, technological development and its effect on lubrication and lubricants. In his work he puts great emphasis on warnings on negative impacts of climate change and on importance of moderating these effects. Lajos is mechanical engineer graduated from Budapest University of Technology in 1977.

Máté Zöldy, PhD is an automotive expert. He worked for Ford Motor Company Engine Development Center at Cologne and for AVL in Remscheid. Since he works for MOL Group he deals with automotive development relevancies on oil industry, leads engine and vehicle testing facilities at Százhalombatta. He graduated as mechanical (automotive) engineer and finished his PhD studies in Budapest University of Technologies and Economics in 2007.
IMPACT OF CHANGES IN TEMPERATURE OF THE COOLING WATER AND STEAM FLOW THROUGH THE CONDENSER TO THE EFFICIENCY OF CONDENSING TURBO GENERATOR PLANT

Ivan Jakovljević, PhD (41)
Manager of Energy Department and energy nets
INA, Lubricant sector
ivan.jakovljevic@ina.hr

ABSTRACT

Internal power of the condensing steam turbine depends on the inlet and outlet steam parameters, such as flow, temperature and steam pressure. At constant inlet steam parameters and internal losses changes in the operating characteristics of steam in the condenser will cause a change in the internal power of the condensing steam turbine.

This paper presents an overview of changes in the internal power of the condensing steam turbine connected to the changes in the cooling water temperature and steam flow.

INTRODUCTION

Condensing steam turbines (Figure 1) are used to produce electricity. Except these plants, in industrial plants are installed condensing turbo generator plants with extraction of steam for technology needs (Smajević, I & Hanjalić, K 2007; Bloch, HP 1996; Prelec, Z 1994; Woodruff, EB & Lammers, HB 1977). Extraction of steam can be regulated and unregulated. In case of regulated extraction, steam is discharged to heat consumers after an exactly calculated heat drop with constant pressure. In case of unregulated extraction, after a defined heat drop steam is released to the consumers. An increasing in the steam flow increases the steam pressure and vice versa.
These turbines exhaust excess steam in a partially condensed state to the steam condenser. Liquefied steam or condensate is delivered by the condensate pumps via the piping system into the feed water tank. Expansion of steam in this concept of plants is done to a pressure lower than atmospheric.

In non-condensing or back pressure steam turbines the exhaust pressure is regulated by a valve; they are typically used for process steam applications.

Basic parts of the condensing turbo generator plants are:

› Steam turbine
› Steam condenser
› Generator to produce electricity
› Vacuum system
› Lubrication system and
› Cooling system.

Additionally, plants should be installed with auxiliary equipment and devices, all the necessary armatures, and control and monitoring system with management system for safe and reliable operation.

VARIABLES IN THE CONDENSER OPERATION

Steam condenser, as one of the fundamental parts of condensing turbine plant has a very important role in the operation of the whole plant. It is a heat exchanger in which the exhaust steam from the turbine condenses and turns into liquid aggregate state (condensate).

The condenser is a shell and tube heat exchanger (see Figure 2). Condensing steam flows over the tubes and transfers heat to the cooling medium (e.g. water) running through the tubes. The tube surface temperature is below the saturation point of steam at a pressure in the condenser. Condensing steam passes heat to the cooling medium that had previously received during evaporation.

The most frequently used cooling medium is water but air and some other liquids can also be used.

Improper operation of the condenser directly affects the efficiency of the plant. Main causes of improper work of condenser which result with lower efficiency of the condensing turbo generator plant include:

› Condenser fouling
› Inadequate cooling water temperature
› Inadequate temperature of exhaust steam
› Condenser leaks.

It is important to define the optimal conditions of the condenser operation in order to reach the maximum possible efficiency of the entire plant. For this purpose, a mathematical model (Staniša, B 1980) and (Shchegliaev, AV 1967) can be used with the operating parameters projected for the nominal load of condenser. Decision variables in the model are the steam flow through the condenser and the cooling water temperature change.

Input data for mathematical modelling include parameters listed in Table 1. Symbols are explained in Table 2. Figure 3 illustrates the scheme of steam condensation.

RESULTS OF THE MODELLING

Results of the mathematical modelling were obtained for the different operating modes of the steam condenser. They involve changing of the condensing pressure depending on the cooling water temperature and of flow rate of steam through the condenser.

Table 3 summarises the results, and Figure 4 shows graphical presentation of the results.
Fig. 2. Steam condenser (Wikipedia 2007)

Fig. 3. Schematic view of the steam condensation
The obtained results show that with increasing of the steam flow through the condenser and of cooling water temperature condensing pressure is growing. When we increase the condensing pressure at constant conditions of steam at the inlet of the turbine it will lead to a reduced heat drop, which directly results in power level reduction of the steam turbine and of the entire turbo generator plant.

The mathematical model for internal power of steam turbine (Staniša, B & Prelec, Z & Jakovljević, I 2010) showed the dependence of a steam turbine power change on changing the condensing pressure.

Input data for the mathematical model are given in Table 4.

**Figures 6A, B, C, D** present the change of internal power of steam turbine more precisely at a constant flow of steam through the steam condenser.

**ANALYSIS OF THE RESULTS**

In this paper we analysed the results of four different steam flows through the steam condenser of the steam turbine. Each steam flow was analysed in five modes, i.e. at five different temperatures of the cooling water.

### Table 1. Input data for mathematical modelling

| $m_k$  | 1.53 | kg/s |
| $W$    | 440.64 | m3/h |
| $h_k$  | 2,508 | kJ/kg |
| $p_k$  | 0.3 | bar |
| $t_{w1}$ | 27 | °C |
| $z$    | 1 | - |
| $Q_k$  | 3,395 | kW |
| $m$    | 80 | - |
| $\Delta t_w$ | 6.62 | °C |
| $k$    | 11,621.14 | kJ/m²h°C |
| $A$    | 34 | m² |
| $w$    | 2 | m/s |
| $d_1$  | 17 | mm |

**Table 2. Used symbols in mathematical models**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_k$</td>
<td>steam factor</td>
</tr>
<tr>
<td>$W$</td>
<td>quantity of steam for condensing, kg/s</td>
</tr>
<tr>
<td>$h_k$</td>
<td>enthalpy of condensate, kJ/kg</td>
</tr>
<tr>
<td>$h_0$</td>
<td>inlet steam enthalpy, kJ/kg</td>
</tr>
<tr>
<td>$k$, $k_1$</td>
<td>coefficient of heat conductivity, kJ/m²h°C</td>
</tr>
<tr>
<td>$m$</td>
<td>water factor</td>
</tr>
<tr>
<td>$m_k$, $m_{k1}$</td>
<td>quantity of steam for condensing, kg/s</td>
</tr>
<tr>
<td>$P$</td>
<td>internal turbine power, kW</td>
</tr>
<tr>
<td>$p_k$</td>
<td>pressure at condensing, bar</td>
</tr>
<tr>
<td>$p_0$</td>
<td>inlet steam pressure, bar</td>
</tr>
<tr>
<td>$s$</td>
<td>entropy, kJ/kgk</td>
</tr>
<tr>
<td>$t_{w1}$</td>
<td>temperature of cooling water, °C</td>
</tr>
<tr>
<td>$t_0$</td>
<td>inlet steam temperature, °C</td>
</tr>
<tr>
<td>$z$</td>
<td>number of water streams</td>
</tr>
<tr>
<td>$W$</td>
<td>quantity of cooling water, m³/h</td>
</tr>
<tr>
<td>$w$</td>
<td>water speed, m/s</td>
</tr>
<tr>
<td>$Q_k$</td>
<td>heat load of condenser, kW</td>
</tr>
<tr>
<td>$\Delta t_w$</td>
<td>cooling water temp. difference, °C</td>
</tr>
</tbody>
</table>

**Table 3. Results of the mathematical modelling**

<table>
<thead>
<tr>
<th>$m_k$ [kg/s]</th>
<th>$t_{w1}$=20 °C</th>
<th>$t_{w1}$=25 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_z$ [°C]</td>
<td>$p_k$ [bar]</td>
<td>$t_z$ [°C]</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1.530</td>
<td>72.37</td>
<td>0.345</td>
</tr>
<tr>
<td>1.147</td>
<td>59.48</td>
<td>0.1945</td>
</tr>
<tr>
<td>0.765</td>
<td>46.46</td>
<td>0.1033</td>
</tr>
<tr>
<td>0.383</td>
<td>33.33</td>
<td>0.0512</td>
</tr>
<tr>
<td>$t_{w1}$=27 °C</td>
<td>$t_{w1}$=30 °C</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1.530</td>
<td>78.29</td>
<td>0.4418</td>
</tr>
<tr>
<td>1.147</td>
<td>65.67</td>
<td>0.2577</td>
</tr>
<tr>
<td>0.765</td>
<td>52.89</td>
<td>0.1424</td>
</tr>
<tr>
<td>0.383</td>
<td>40.03</td>
<td>0.07375</td>
</tr>
</tbody>
</table>

### Table 4. Used symbols in mathematical models
Table 4. Input data for calculation of condensing turbine power

<table>
<thead>
<tr>
<th>$p_0$</th>
<th>$t_0$</th>
<th>$h_0$</th>
<th>$s$</th>
<th>$m_{k1}$</th>
<th>$\rho_k$</th>
<th>$h_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 bar</td>
<td>440 °C</td>
<td>3,308 kJ/kg</td>
<td>6.9064 kJ/kgK</td>
<td>1.147 kg/s</td>
<td>0.1945 bar</td>
<td>2,607.9 kJ/kg</td>
</tr>
</tbody>
</table>

Fig. 4. Graphical presentation of the modelling results

Fig. 5. Change of the internal power of the steam turbine as a function of the cooling water temperature

Fig. 6. 6A, B, C, D. Change of the internal power of steam turbine at constant flow of steam through the steam condenser as function of the cooling water temperature
Based on this modelling, we investigated the dependence of the pressure in the steam condenser on the quantity of steam for condensation, at five different cooling water temperatures. Since the saturated vapour pressure varies with the temperature, pressure has been determined by the temperature of saturation for each of the studied operating modes.

Condensing steam turbine power depends on the quantity of steam and the difference of the enthalpies of the entering steam and outgoing condensate; changing one of these variables impacts on the power of turbine.

The results revealed that a 5 °C increase in the cooling water temperature at the same quantity of steam reduces the internal power of the turbines by about 1%. A 15 °C decrease in the cooling water temperature improves turbine efficiency by about 3%. This would mean a 3% increase in the extracted steam volume.

CONCLUSIONS

Cooling water temperature has an impact on the steam turbine efficiency; temperature reduction would lead to not negligible savings in long-term.

Methodology of the mathematical models can be applied for similarly designed turbo generator plants, condensing turbo generator plants with extraction and for condensing turbine for all power range.

Keywords: condensing turbo generator plant, cooling water, steam, power, efficiency

Reviewed by Professor Staniša, B, PhD

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Ivan Jakovljević, PhD has been working for INA since 1993 in various positions in the energy departments. Currently, Ivan is the manager of energy and energy networks in the lubricant sector. Furthermore, he has spent year and half on the construction sites of HPC (Syria) as a supervisor of the engineering works. Ivan graduated as mechanical engineer at University in Rijeka and received PhD in process energy engineering.
EXPERIENCES WITH OPERATOR TRAINING SIMULATORS IN DUNA REFINERY

Tibor Szabó (46)
Process automation expert
MOL Group, R & M, Százhalombatta
tibszabo@mol.hu

ABSTRACT
Plant operator training simulators can provide high level training all over the industrial areas. Simulation-based vocational trainings together with visualised unit processes are one of the fastest and most obvious forms of staff qualification improvement.

After implementation of eight individual systems, currently a well-established and solid training background is provided in Duna Refinery (Százhalombatta).

This article is going to introduce elements of this system in detail. Statistical summary is presented about the increasing number of simulator users in the last years and the utilisation figures of systems. As a result, time for reaching the aimed higher qualification of board operators and shift foremen has been shortened.

INTRODUCTION
The appearance and gradual dissemination of training simulators will make simulation-based vocational training increasingly important. This critical role no longer prevails only in aircraft simulations, but it is also becoming more and more widespread in the operation of power plants, oil refineries, nuclear power stations and other industrial process technologies. First principle simulation software applications used nowadays are enabled to provide not just fundamental training, but are also capable of generating complex drills and exercises encompassing the broadest spectrum of operations. They contribute to significant learning time reduction and greatly increase operators’ skills in terms of control. At the same time they can substantially boost operational reliability and reduce process risks next to improved efficiency and profitability. Optimal and energy efficient operation is one of the most pressing tasks in a refinery. In this regard one can state that High Fidelity priority simulation software available nowadays (e.g. Hysys®, UniSim®, PRO/II) also truly do have this kind of potential. Today’s high level advanced process automation environment makes it possible to purchase certain simulation training tools or tool systems with a broad spectrum and capacities. Such tools may constitute an asset particularly for companies which have high expectations and aim for efficient operational priorities. Such simulation training tools not only make it possible to conduct high standard simulation-based training courses, but they also serve as a fundamental guarantee for them. They may be used – in conjunction with written training materials, instructions, available documentation and process diagrams – to ensure that plant control personnel are confident, dedicated and well skilled.
In 2005 MOL launched the first Operator Training Simulator (OTS) Project. The first two UniSim based training simulators were implemented in 2007 (at Duna Refinery’s Fluid Catalytic Cracking and Reforming units). Now there are eight High Fidelity simulators in operation at Duna Refinery in Százhalombatta. These systems were installed in four training rooms, each close to their respective technologies. It is a very important criterion for training attendants to be close to their workplaces thus making possible for them to practice using simulators at any time their work allows. Another experience was (again, as expected) that high standard training can only be attained through whole plant simulation. If process control, plant startup, plant shutdown or even operational interruption situations are exercised with plant modelling it can significantly boost operator capabilities and deepen their know-how about technological processes.

**TRAINING SESSIONS, EXPERIENCES**

In order to provide the reader with accurate and comprehensive impression, it is important to present the fundamental components of training system (Figure 1) whose existence, function and operation are indispensable conditions for efficient and high standard training.

A well-prepared specialist with high standard technological knowledge is one of the fundamental guarantees for the operation and use of Operator Training Simulators. The full-time instructor can be considered as the system’s owner. There are 4 full-time OTS instructors employed at Duna Refinery. Their main duties include compiling training exercises and developing them to the level of efficient training tasks. In addition, they are also responsible for preparing, organising and conducting training sessions. Continuous use of the system contributes to refining of the implemented model, making it even more accurate (with the participation of the maintenance group).

One of the full-time instructors’ critical tasks, which at once also carries the greatest responsibility is the implementation and evaluation of yearly OTS examinations for every operator and shift manager. In addition, they also make recommendations and remarks to improve efficiency of the system operation. Using specified KPIs (key performance indexes) they draft yearly reports about the system’s operability and accuracy, efficiency of training sessions, as well as the maintenance process.

**SCHEDULING**

Scheduling of training sessions is an important action. Without scheduling operating the system would be incomprehensible for the users, and it would be impossible to keep track of utilisation indicators.

A preliminary schedule (drafted by the instructors) is created every six months. It contains all information that guarantees full utilisation of the system and conducting of training sessions. They use 6 different colour codes to identify the activities and provide useful framework for utilisation of the systems.

**SCENARIO**

When an exercise is created on a conceptual level, in many cases it is not enough just to upload it to the training simulator and drill it. Instead, operators and shift managers should receive these tasks in a detailed form. This is

![Fig. 1. Components of training system – ‘Value pyramid’](image-url)
necessary because education, rather than testing is the most important goal of the training sessions. In other words, knowledge transfer should deepen skills and lay the appropriate foundations for a highly efficient operator staff pool. This is why it is important to generate more complicated, complex exercises in written form as well, and make them available at the instrument room and on MOL's intranet site to everyone interested.

EVALUATION

An examination period follows exercises and training sessions. According to refinery practice, these are linked to on-the-job training session examinations. In practice, during the usual autumn on-the-job written and oral examinations OTS examinations are also held (wherever an OTS operates). OTS system provides on the one hand an automatic evaluation software report (which is part of the OTS system) and on the other written feedback that assesses examinations in a complex way.

The automatic evaluation software (Trainee Performance Table) provides percentage result of a training participant’s performance at the end of the exercise. This software, however, is only strictly enabled to calculate results based on technological interventions, i.e. by monitoring limits that are set in advance. Besides electronic evaluation, a written assessment form is also used. It delivers a much more complex, comprehensive and broad scope performance assessment. This comprehensive impression is important because it allows making an inference how incidents occurring during real operation would be managed.

Categories evaluated in writing include:

- Information collection (shift handover / take-over procedure)
- Accurate and unequivocal identification of the situation that arose during the exercise
- Communication during the execution of the exercise
- Abiding by HSE considerations, safety engineering requirements, operating requirements
- Efficiency, accuracy, diligence of interventions effected during the exercise
- Execution of task, elimination of simulated event, the occasional restoring of normal operational conditions.

These two forms of evaluation guarantee the accurate, unbiased and comprehensive percentage score that serves as the basis for the various employees’ performance assessment, influencing their future salary and bonuses.

MAINTENANCE

Nature and efficiency of maintenance is the alpha and the omega of our work, they strongly influence the usefulness of OTS system. The properly functioning, efficient and successful system can be sustained on the long run only by appropriate maintenance and support thus improving or at least maintaining the usefulness of OTS system.

This is why we continuously track every activity related to maintenance and repair that is conducted on any of the OTS systems. Currently all completed operations are entered in the appropriate ‘drawer’ of the electronic shift log after they are completed. At the same time, such entries also entail approvals by the instructor. Such maintenance tracking is beneficial for several reasons. In that way we can collect appropriate information for the more successful conducting of subsequent projects. In addition to that, we have an accurate understanding of issues and problems, and we can make recommendations to the vendor’s developers for their elimination.

WORKSHOP

On Figure 1 it is the basic item that means the most for all of us who deal with operator training simulators. A full day workshop is organised every year affording us an excellent opportunity to shed light on jobs from the
preceding year, completed tasks, evaluations, and everything else that happened in the OTS framework. Representatives from every plant that has an OTS, from other refineries in MOL Group, and Duna Refinery’s management usually attend the event. The presentations, discussion and sometimes debates at the event all contribute significantly to the success of OTS.

**TRAINING PROCESS**

Training is a complex process made up of many stages. The exercise has to correspond perfectly to situations that occur during real plant operations. Another critically important part of the various exercises is that the task should never be too simple or overly complicated. They always need to be aligned with the capabilities of personnel and should carry extra content that can be the key to improving and deepening staff’s skills. Figure 2 shows the chain of activities that need to be completed before the implementation of the training sessions.

Since the appearance of the simulators, substantial emphasis has been placed on which subjects ought to be exercised during various training sessions. At Duna Refinery we continuously strive to leverage the opportunities the model provides, and the knowledge that has been accumulated in the life of the instructors and plants.

Based on these assets, we are in the process of developing a system with the main elements already in-use since go-live. However, continuous improvement is required in order to broaden operators’ skills and create interesting, efficient exercises that also provoke thinking. The training method called ‘WHOM’, an acronym based on the first letters of its four components, is the next stop of this development (see Figure 3).

**WHAT IF**

This part of the ‘WHOM’ training sessions is about exercises that occur very rarely at the given plant or have not occurred at all. They include the types of incidents have been discussed on multiple occasions in theory, but never happened before. However, they may occur at any time. Compiling such exercises is the instructor’s task. Recommendations from operators and shift managers are welcomed. The following exercises can be listed here:

- Redundant pump stop
- Sequence of transmitters failures
- Heard but not experienced unit failures, etc.

![Fig. 2. Preparation for exercises, training sessions](image1)

![Fig. 3. Elements of ‘WHOM’ training method](image2)
HAPPENED
This is the category that assumes the execution of exercises which occurred at the given plant some time before. These are the typical exercises for which scenarios are drafted. This is important because there were colleagues, who did not go through the incident at the real plant. These colleagues need to be well informed about processes, fully understand the series of actions that were executed, and they have to learn about the possibly incorrect interventions. The following exercises can be listed here:

› Unit upset
› Failures
› Mistreat
› Instrument failure
› Pump upset
› Compressor upset, etc.

OPTIMISATION
This is the training category, for which improvement and perfection is currently under way. Energy consumption optimisation and production efficiency improvement are among the most important requirements for refineries. OTC offers an excellent opportunity for operators to improve their related knowledge. Using training simulators optimisation exercises can be repeated at any time and training attendees will be able to leverage know-how acquired during simulation training in real operational circumstances. Furthermore, they will be able to learn how to abide by the ever more stringent energy efficiency parameters and stricter quality requirements.

As it was mentioned, the introduction of this kind of practice is currently in progress. For the sake of the greatest possible complexity and efficiency of the system, a few modifications had been made. They impact Honeywell’s UniSim® operation and DCS (distributed control system) interfaces. Allow for the traceability of optimal function, efficient operation or energy efficient
intervention, the display of some parameters (e.g. density, composition) found in the model on the HMI (Human-Machine Interface) is indispensable. In this way attendees in training can see parameter and quality changes they cause through their interventions in efficient and less efficient operations of the various processes. The transparency of such parameters represent a challenge to the burnt out operator staff practices – ‘Stay on the safe side’ or ‘From father to son’ training – that are present in many places and do not always entail efficient operations. The following exercises can be listed here:

› Unit startup

› Unit shutdown

› Heater startup / shutdown

› Compressor startup, etc.

**STATISTICAL DATA**

Activities and evaluations that are summarised every year (see subsection ‘Workshop’ above) constitute the basis of any assessment. Utilisation is one of the most important metrics for us, as well as for anyone interested. Charts are produced about these indicators for the period of 2008 to 2011 (see Figures 4 and 5).

**Figure 4 illustrates** the OTS systems’ utilisation for training sessions and free exercises (i.e. done without an OTS trainer, during afternoon and night shifts).

According to our assessment utilisation rate of the various OTS systems calculated as the ratio of used time to the available total accounted for about 75%. In 2011 a major upgrade lasting several months took place on FCC plant’s OTS system, and this decreased utilisation indicators significantly.

**Figure 5 shows** the number of those engaged in training.

**Figure 5 shows** that number of people engaged in training has been increased from 2008 to 2010. Year 2010 was outstandingly successful in this respect. Decline in 2011 can be explained by the FCC plant’ OTS system’s extend-

![Number of examiners + Number of trainees](image)

*Fig. 5. Number of involved trainees*
Workshop

From Enrolment to Panel Operator 2

![Chart showing impact of OTS on time elapsed between enrolment and Panel operator 2 position.

**Fig. 6.** Impact of OTS – Time elapsed between enrolment and Panel operator 2 position

Ed maintenance work. It is important to note that in 2011 and 2010 all operators and shift managers were intensively engaged in training at every plant where an OTS system operates.

**Besides these statistical data,** different kinds of other information received about exercises, examination topics, trainers’ work and system reliability are likewise assessed. All of our data shows that although we have achieved significant improvement since the start, we still have a lot of potential not only in terms of training quality or quantity, but also in that of the level of our organisation. Shortcomings are corrected or eliminated continuously.

**DEVELOPMENT EFFORTS**

When we discuss maintenance or improvement of a company’s stability, efficiency or operability, components that are the key to higher performance – e.g. properly trained, highly qualified plant personnel at hand – must be treated as critical criteria. Every tool enabling the given employee to do – as it is expected – high standard work as soon as possible must be treated as critical. **Figures 6 and 7** compare the induction periods of personnel of plants with existing and planned OTS systems.

**Figure 6** indicates number of years elapsed since employee’s enrolment until the ‘Panel operator 2’ position without and with OTS systems. It illustrates shorter induction times at plants where an OTS is already in place (red line). This period can be compared with data of the period before introduction of OTS (blue line). In addition, the chart also displays the induction time of Duna Refinery Mild Hydrocraking Unit’s (DMHCK) workers (green line) – this is the plant where we intend to deploy an OTS during the next stage of the project.

**Figure 7** also shows that induction times have significantly shortened between Operator 2 and Operator 3 positions since OTS use started (the red line shows statistics for the period after OTS implementation, while the blue line those for induction duration before the OTS was installed).

These figures were cleaned, thus some outstandingly long and abnormally short (due to various constraints) induction periods were removed. Reasons include reorganisation, retirement, leaving the plant, and enrolment of new employee churns. Judging on the aver-
age induction periods that HR deems acceptable, generally the induction duration became shorter by using OTS systems.

Furthermore, shifts of a given plant show different preparedness to meet operational challenges. Figure 8 produced on the basis of DMHCK plant cumulated shutdown, startup and operational failure occurrences between years 2009-2012 indicates how many times the various shifts were ‘given the opportunity’ to participate in this kind of activity demanding significant skills and experience of the operators. A single incorrect intervention can result in damage running into millions e.g. in case of the reactor catalytic converter.

The figure clearly shows that there are years when a given shift does not encounter such a highly stressful situation demanding a lot of attention at all or does so on only a few occasions. For instance, the shift marked ‘C’ only encountered the previously mentioned situations on just 6 occasions all in all, in contrast e.g. with shift ‘D’, which did so 11 times. The question therefore is how we can equalise risks resulting from employees’ qualifications, readiness and any inequalities at the various plants.

The answer is that Training Simulators must be given quite a significant role next to the several available training topics.

**SUMMARY**

Increasing the utilisation of training simulators used at Duna Refinery could be one of our priority goals. This could be achieved not only through even more training sessions for shift staff already subject to mandatory training, but also by engaging colleagues from other refineries within MOL Group. Additionally, ‘promoting’ training could also be a priority goal. This means that involving colleagues who would like to improve technological knowledge and experiences is also a possibility. In addition, engaging workers from plants that use similar technology could also be a goal for future training courses.

It would be an important step to create competence survey for each and every colleague. We have already taken steps pertaining to this. Plant management, the instructor and the affected operator would work together to develop a training structure in order to meet the targeted capability of the operator during designated training session in the given year.
In addition, properly distinguishable training tasks and competences are to be developed for each individual employee. Thus everyone could reach an identical level in a short time through personalised exercises and using these for practice. The current system is already suitable for this. In addition – based on preliminary information from vendors and what was presented at previous User Conferences – not only will upcoming simulation version updates make individual competence surveys possible, but even fundamentally demand their application from users.

**Keywords:** training, simulation, development, effectiveness, practices

Reviewed by László Lázár

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**Fig. 8.** Participation frequency of DMHCK unit’s shifts in shutdown, startup and operational failure handling operations

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**Tibor Szabó** is a process automation expert for Production Excellence Department at MOL Duna Refinery. He is the OTS System Administrator in the Refinery, supervising and managing OTS operation, giving advices and supporting the instructors and liaising between the instructors and the supplier. Tibor has been working for MOL since 1994. He worked in FCC unit 13 years. Beside OTS system administration he has contributed to more projects. He has led the expert team in the preparation of the Electronic-logbook system and has been contributing to alarm management project in Duna Refinery. In addition, he is also a member of the project team to control energy efficiency and energy consumption all over the Downstream segment. Tibor received a bachelor’s degree from University of Gödöllő (Hungary).
2012 could be a remarkable year for Viktor Dank, DSc, former chief geologist of the Hungarian oil and gas industry, and later President of the Central Office of Geology, retired university professor and holder of many other, social-professional titles. In November 2012, during the Hungarian Science Days he was rewarded at the Hungarian Academy of Science (HAS) when Mr. József Molnár, Chief Executive Officer of MOL Group handed over MOL Scientific Award for laying the theoretical and practical foundations of successful exploration of the very important oil and gas reserves in the Hungarian Lowland. This recognition followed the ‘Cross Order of Merit of the Hungarian Republic (Civilian)’ as the retired professor Dank of Eötvös Loránd University of Budapest received this distinction in March 2006 for his scientific and educational achievements.

Mr Dank was born in 1926 in Veszprém (Hungary) then his family moved to Szeged (South-East Hungary). He is listed among the famous students of Piarist Grammar School of Szeged where he passed his final examinations in 1944. With regard to his former pilot and paratrooper experience he was immediately enrolled in the Pilot Academy later evacuated to Berlin due to the military events. In 1945 he was captured by the US Army as a prisoner of war and in the following two years he was forced to work in a Belgian coal-mine as a cutter. During this period he got acquainted with and developed a taste for mining. In 1947 he returned to the ‘new’ Hungary with changed political orientation.

Despite this handicap he succeeded to enter University of Szeged and following the Hungarian higher education reorganisation he graduated in 1951 at Eötvös Loránd University of Budapest as geologist.

He started his professional carrier at the Geological Institute of Hungary. From 1954 to 1960 he was the chief geologist of Budafa Oil Pro-
duction Company (West Hungary). Under his management as a result of geological activity oil production reduction of the aging local oil field was moderated. They discovered new hydrocarbon traps and developed the geological model of the water injection production method. At his initiative significant carbon dioxide reserves were found under the already known production layers thus opening room for the practical application of carbon dioxide enhanced oil recovery. Water injection and carbon dioxide enhanced oil recovery resulted in major additional local oil production.

In 1960 Mr Dank was invited to Budapest to the newly established Hungarian Oil and Gas Trust where he spent near a quarter-century. He held various positions starting from the head of Exploration Department (1960) to the chief geologist of the Trust (1965-1984). Between 1969 and 1975 he was the deputy general director with responsibility for exploration operations. Here he prepared country-wide predictions, exploration programmes and planned the areas, sizes, directions and rates of geophysical and drilling activities. He had to rank the exploration areas. The basis of the ranking was the prognostic reserves of hydrocarbons revised every five years (the first prognosis was prepared in 1959). Updates were made on the basis of new information gained in the last period for the given stratigraphic-tectonic history about formation, migration and trapping of hydrocarbons. Taking into account the prognosis, operative (long-term, medium-term and short-term) exploration plans were elaborated, and as a result more than 200 subsurface hydrocarbon-containing formations were identified. Additionally, Dr Dank also supervised the current field exploration works.

As professor Dank states “preparation of prognosis for industrial exploration is the most beautiful and challenging task of a geologist”. The geological model-based hydrocarbon prognosis always contains potential reserves, quantities already produced and possible reserves for each geological exploration unit. As he emphasises, hydrocarbon exploration is a formidable inter-disciplinary team work of various specialists and characters and he was the geologist planner and the responsible geologist manager of this team during 1964-1984 in Hungary. In 1973 Dr Dank received a shared State Award for industrial activity.

Regarding the period between 1937 (the first oil field discovery in Hungary) and 1984, 70% of the total newly discovered hydrocarbon reserves were found by Dr Dank’s team. The most striking and disputed result of their first prognosis was the declaration of the most promising exploration areas of Hungary, i.e. the new hydrocarbon reserves findings in the Hungarian Lowland (eastern Hungary). The most important exploration findings in Lowland include Úllés (1962), Szank (1964), Kiskundorozsma (1964), Algyő (1965), Szank-West (1966), Kiskunhalas (1967), Ferencszállás (1969), Kisújszállás (1969), Endrőd (1970), Szeged (1971), Hódmezővásárhely (1971), Sarkadkeresztúr (1976), Zsana (1978), Kiskunmajsa (1978), Rúzsa (1979), Szeghalom-North (1982), Úllés-Deep (1982), Kiskunhalas-North (1983), Ásotthalom (1985), Zsana-West (1988), Szeghalom-West (1989). Dr Dank emphasises that the most significant hydrocarbon field of Hungary (Algyő) and other major fields (Úllés, Szank, Kiskundorozsma) were discovered in the period when the Hungarian oil industry was isolated from the more developed western oil industry achievements.

While in 1965 the Transdanubian area (western Hungary) provided 80% of the oil production and 20% of the gas production of Hungary, in 1970 the Lowland deposits gave 68% of the domestic oil and 96% of the domestic gas production. According to the oil industry statistics, between 1937 and 2007 the estimated Hungarian hydrocarbon production accounted for 92 million tonnes oil and 202 billion m$^3$ natural gas (or HuF 18,000 billion at 2007 prices). Between 1960 and 1990 the Hungarian Oil and Gas Trust discovered 53 million tonnes of crude oil and 192 billion m$^3$ of natural gas as proved reserves (worth of
HuF 15,000 billion at 2007 prices) and 56 million tonnes of oil and 146 billion m$^3$ of natural gas have been produced (worth of HuF 12,000 billion at 2007 prices).

From 1984 to 1990 professor Dank was the president of the Central Office of Geology (COG). In this position he also supervised the implementation of the projects connected to the 1984 hydrocarbon prognosis (prepared under his management). He retired from COG in 1990.

A strong and up-to-date scientific knowledge base is one of the traditional key assets of successful hydrocarbon exploration activity. Mr Dank, among others received a ‘doctor of university’ degree in 1957, and the a CSc (PhD) degree in 1963 on ‘Crude oil – geological relations and perspectives of hydrocarbon exploration in South-Lowland’, then a DSc degree in 1988 on ‘Earth science basics of the Hungarian crude oil and natural gas exploration’. He is the author of numerous publications (maps, books, articles) in German, English and Russian.

From 1966 to 1974 Dr Dank was the chairman of the Crude Oil-, Natural Gas-, Water-Production Committee of HAS Section of Earth Sciences. Between 1974 and 1980 he was the member of the HAS Section of Earth Sciences and the Hydrocarbon Subcommittee. From 1981 to 1985 was the chairman of the Crude Oil Geology Sub-Committee of HAS Section of Earth Sciences.

Dr Dank served as elected and then three times re-elected chairman of the Hungarian Geological Society between 1972 and 1986, and the Hungarian Society of Natural Science from 1990 to 2005. He is the member of the Croatian Academy of Sciences and Arts (from 1968), and corresponding member of the Austrian Federal Geological Bureau (from 1986).

In 1982 Dr Dank received the Award of the Hungarian Academy of Sciences ‘for the scientific improvement of the Hungarian geological – crude oil geological – model, for the further improvement of scientific cognition of the Hungarian deep geologic conditions, for the elaboration of conception in support of operative exploration’. As he explains, this is a good description of his full scientific activity.

Starting from 1960 till 2009 (from 1988 as a university professor) Mr Dank was the lecturer of subjects of crude oil geology, planning of hydrocarbon exploration, calculation of hydrocarbon reserves, etc. at Eötvös Loránd University of Budapest. He prepared the proper lecture notes for the students. He also delivered lectures at universities of Austria, the former Yugoslavia and the former Soviet Union. Many of his former students work for the hydrocarbon industry worldwide and some of them benefited from Dr Dank’s contributions to their academic carrier.

One of Dr Dank’s favourite research topics is the history of hydrocarbon exploration in Hungary. Dr Dank has been the president of the Board of Trustees of the Hungarian Oil Industry Museum since 1996 and an enthusiastic participant and contributor of jubilee meetings of the oil industry. He (alias Dénes Vidos) is also the author of a book with several oil industry stories.

His daughter is an oncologist, an associate professor of Semmelweis (Medical) University of Budapest, already decorated with the Hungarian Order of Merit. His wife, Veronika Szentgyörgyi retired from MOL Hungarian Oil and Gas Ltd. where she served as the Chief Financial Officer.

Dr Dank’s significant industrial, scientific and educational achievements are accompanied by a colourful personality and wide local and international recognition. We congratulate him on his latest award.
To think is to be human.

To create is to make one’s dreams come true.

To move forward continuously is to develop oneself, every waking moment.