top engineer

The Elomatic Magazine 1 · 2016

"The Pharma and Biotech industry in India has immense potential to emerge as a key global Lifesciences destination."
– *Abhay Ranjan*

Consulting • Engineering • Design • R & D • Innovation • Technical Solutions

Doing things better

In 2014 my predecessor, Olli Manner, penned a Top Engineer editorial about the eternal quest for optimization. I was tempted to come up with something original for my first Top Engineer magazine editorial. The contents of this magazine and the focus of many of our customer projects, as well as current socio-political events in Finland have, however, convinced me that the topic is well worth revisiting.

In Finland major social and health services reforms have grabbed the headlines for the last year or so. In essence, our political parties and institutions are trying to agree on how to completely overhaul and optimize Finland's social and health services to provide the best return on taxpayers' money and boost the country's competitiveness. Unfortunately, in the world of politics, compromise often holds sway over the most optimal solutions. There is consensus, however, that things need to be improved and that's a start.

Fortunately, in the world of engineering we have methods and tools at our disposal to help us make the most rational and optimal decisions. The intense global competitive situation in many industries has kept optimization goals firmly on the agenda in our customers' organizations. We are improving the efficiency of many of our Finnish customers' operations with e.g. Lean methods. It seems, in fact, that Lean Manufacturing is experiencing somewhat of a renaissance.

In our own organization we also continuously look for ways of improving our way of working. After more than 45 years of operation and thousands of demanding customer projects there is still room for improvement. Even when a project has been completed very successfully and the customer is more than satisfied, it is worth considering where we could have done better, even if just a little bit.

This edition of the Top Engineer contains several articles that support the theme of my editorial. Optimization is discussed, for example, in the context of structural fatigue and the lifespan of welds, in discrete process simulation, in Lean Manufacturing, as well as in R&D processes. The list goes on…

It is imperative for organizations to continuously improve current systems and processes, but thinking out of the box and nurturing innovative thinking is an equally important part of the recipe for success. Finding a good balance between innovation and optimization ensures they we prosper in challenging and dynamic operational environments.

Patrik Rautaheimo
Editor-in-Chief
CEO

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Cover: Abhay Ranjan, Chief Executive Officer at Elomatic Mumbai Office.
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VOC emissions of timber felled for fuel

– a significant energy loss?

Text: Mika Nummila

The strong smell of freshly felled forest and resin is probably familiar to most Finns. It is rarer that anyone thinks where the smell comes from, and even rarer that the share of the timber's heating value lost with the scent to the sky is considered. The matter has scarcely been studied, and a complete picture is very difficult to obtain, based on scattered written sources or experiences. However, it has been observed in practice that volatile organic compounds (VOC) that evaporate off timber are also significant in terms of burning and the heating value of fuel.

As a concept, the burning of fresh woodchips is new and rather heretical. The traditional way to burn woodchips, which many think as the 'right' way, is to store the felled timber for a long time on roadsides and allow them to dry before chipping and burning. Practical issues of logistics have also contributed to this model.

In the autumn of 2015, a new 10 MW grate boiler plant and a modern flue gas scrubber with a heat pump connection were commissioned at Kauhavan Kaukolämpö Oy's Kauhava plant. The concept of the plant and operations is based on the burning of fresh woodchips – from harvesting timber through the logistical chain to burning and heat recovery. Based on the operational experience of the past winter, the concept of using fresh woodchips is working very efficiently, providing significant cost savings in the acquisition of fuel to the plant operator. Despite high moisture, the burning of woodchips can be controlled easily and specific emissions are low.

It can be assumed that the concept of fresh woodchips works efficiently in part because a significant portion of the volatile components contained in timber is included in combustion, rather than allowed to evaporate into air. This article discusses the significance of volatile organic compounds in the heating value of fuel.

Storage and VOC losses

According to research, there is a storage loss of 6–16 % of the heating value of timber as a result of slow combustion during storage, decay due to bacterial activities and fungi, and loss due to material dropping off (a VTT study in 2002). In addition, decaying produces methane, among other things, which is a greenhouse gas significantly more detrimental than carbon dioxide. The storage loss of timber has been studied e.g. at the University of Turku.

The VOC emissions of timber during drying and in its natural state have been studied at the Karlstad University in Sweden. There is significantly less material and actual research data on emissions right after felling the trees. Many kinds of compounds evaporate off trees during their lifetime already, but after the trees are felled, the emissions increase considerably.

According to a study, the monoterpene content of air at a logging site was 1.0–1.5 mg/m^3, while the normal level above foliage is 0.1–0.5 mg/m^3. This means that after felling trees, the terpene content of the surrounding air has been up to 15 times higher than the normal content. The elevated content is visible at logging sites for several weeks.

The chemical composition of wood

Wood consists of thousands of different chemical compounds, with the main groups of cellulose (40–45 %), hemicellulose (25–35 %), lignin (20–30 %) and extractives (2–10 %). Volatile organic compounds (VOC) are mainly contained in extractives. The extractives content varies between wood species. There are also differences between different parts of a tree, and even between individual trees. The bark, branches and foliage contain considerably more extractives than heartwood.

For trunk chips, the share of heartwood is particularly interesting. With spruce, the extractives content of the stem wood varies in the range of 0.8–3.8 % and with pine in the range of 3.0–6.0 %. The share of bark in a tree is approximately 10 %, so the bark also forms a significant source of extractives. For softwood trees, the extractives content of the bark varies in the range of 28–39 %. Some of the extractives are easily water-soluble and slow to evaporate. Some, on the other hand, are not water-soluble and evaporate quickly. The estimate on the volatile compounds in timber varies in the range of 4–10 %, depending on whether the canopy and bark are included.

Volatile organic compounds

The classification of extractives in timber is difficult due to the large number of compounds and compound groups. However, extractives can be roughly divided into three main groups:

- terpenes, terpenoids and sterols
- fats, waxes and their compounds
- phenolic compounds

Especially terpenes and phenols are highly volatile. Terpenes also produce the smell that is characteristic of a felled forest. The evaporation of terpenes has also been studied the most, especially in connection with drying processes. Research is made even more challenging by the large number of compounds included in terpenes; more than 22,000 different compounds have been found in plants.

Diagram 1 shows the development of the amount of terpenes after timber harvesting, according to storage time. A storage time of four months already decreases the terpene content of timber by two thirds. A rough estimate on the amount of monoterpenes in softwood is 0.1–0.6 mass percent of dry matter.

However, the important thing is that, for instance, the heating value of monoterpene is more than twice (approximately 46 MJ/kg) the 'regular' heating value of dry matter in timber (19–20 MJ/kg). Stilbenes, which belong to phenols, appear in large quantities especially in the bark of spruce, up to 10 % of the bark weight. Stilbenes are very interesting in that their heating value is almost equal to terpenes, approximately 40 MJ/kg.

Assessments

Even though exact research information is missing, preliminary assessments can be made on the amount and significance of VOC losses. Let us assume that the amount of volatile compounds is 4 % of the mass of the dry matter in timber. The average heating value of volatile compounds is 40 MJ/kg. The heating value of 'regular' dry matter in timber is 19.5 MJ/kg. Calculated as a weighted average, the heating value of dry matter in fresh timber is, in fact, 20.32 MJ/kg, if the timber is taken quickly to burning. The extra energy from volatile organic compounds is therefore 0.82 MJ/kg.

In addition, the extra energy from volatile organic compounds goes directly into the effective heating value in the burning process. The heating value of woodchips with a moisture of 55 % in their arrival state is approximately 7.1 MJ/kg, but the benefit obtained from volatile compounds can be counted directly as net benefit, making the actual heating value in the arrival state 7.92 MJ/kg. Therefore, the increase in heating value is more than 11 %.

Plant efficiency above 100 %

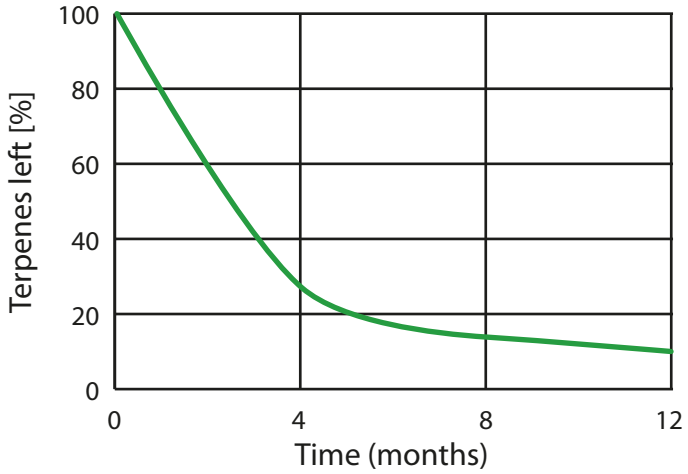
– a perpetual motion machine?

If a heat or power plant has a condensing flue gas scrubber or flue gas condenser, the total efficiency of the plant can rise above 100 %. A perpetual motion machine has still not been invented; this is purely a calculatory matter.

The efficiency of a boiler plant is calculated, based on the effective heating value of fuel, which e.g. for woodchips with a moisture level of 50 % is 8.0 MJ/kg. The heating value of dry matter in the woodchips is 19.5 MJ/kg. The difference between dry matter and effective heating value is spent in the vaporisation of water contained in the fuel in the furnace.

During flue gas condensation, the energy used for water vaporisation is recovered. For instance, a boiler with a thermal power of 10 MW has an efficiency of 90 %, in which case the thermal input is 10 MW / 90 % = 11.1 MW_{pa}. If the heat recovery power is 3.0 MW, the plant's power output to the grid is 10 MW + 3 MW = 13 MW.

This means that 13 MW of power are produced with a thermal input of 11.1 MW. The plant's efficiency is therefore 13 MW / 11.1 MW x 100 % = 117 %.



◀ *Diagram 1. The impact of storage time on the terpene content of timber. (Marutzky, 1979)*

The use of fresh woodchips requires a whole new kind of thinking from the plant and logistics.

Prerequisites for the use of fresh woodchips

The use of fresh woodchips requires a whole new kind of thinking from the plant and logistics. The concept can also be applied to old plants if the structure of the boiler is suitable for burning moist fuel. Fresh fuel also sets some requirements for the fuel storage and fuel supply systems. An essential part of the system is, however, a flue gas scrubber system that efficiently recovers heat from flue gases, condensing the moisture of the fuel vaporised in the boiler. The scrubber should work reliably and efficiently under all conditions, regardless of the variation in the return temperature of district heating.

With a heat pump integrated in the scrubber, flue gases can be cooled efficiently to even below +30°C, making it possible to utilise a significant part of the condensation heat of the water contained in the flue gas. For the purpose of optimising and ensuring the profitability of heat production, a heat pump scrubber has, in practice, been established as the only potential recovery technology for lost heat.

Experiences from Kauhava

Based on the experiences of the past winter, Kauhavan Kaukolämpö Oy is convinced of the excellence of fresh woodchips, compared with regular dried woodchips or bark. According to Ari-Matti Mattila, managing director, combustion is even and steady. The flame is bluish, even though the moisture level of the fuel has been 50–60 %.

The CO content of combustion has also been low, clearly under 10 ppm, even though burning has taken place using a low lambda value, with residual oxygen of approximately 3.0 volume percent. Internal electricity consumption has also been lower with fresh woodchips than with those stored for a longer period of time. Some of the fuel has been felled the same day, and some has been at most a few weeks old. The fuel has also been of uniform quality. However, the system sets its own, new challenges for logistics.

Heat recovery at the Kauhava plant is top class. The average heat recovery during the winter has been more than 35 %, meaning that every third truck load of fuel has been left out, compared to a situation without the scrubber. The total plant efficiency has been over 120 % at its best.

Summary

When considering the entire fuel chain from harvesting to burning and heat recovery, there are several sections in the chain where the energy content of fuel can be saved. These include:

- Decreasing VOC emissions by shortening the time from harvesting to burning. The impact on effective heating value can be expected to exceed 10 %.
- Decreasing storage loss. According to research, the impact is 6–16 % of the energy content of the dry matter of fuel.
- Efficient heat recovery, with the final flue gas temperature even below 30°C. Heat recovery can exceed 35 %.

In total, the burning of fresh woodchips and efficient heat recovery can be used to obtain cost savings of 25–45 % in fuel costs, compared to a traditional plant without efficient heat recovery. The savings potential is so large and complex that the subject deserves further scientific study.

About the Author

Mika Nummila

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Mika Nummila has worked in consultancy and design tasks in process and energy engineering since 1993. From 2005–2012, Nummila worked as a design manager in the process industry at Elomatic Oy, being responsible for the Jyväskylä unit's process department. Since 2013 he has worked as a technology manager at Caligo Industria Oy. Nummila specialises in heat transfer, energy efficiency and flue gas scrubbers.

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Picture © CikerFreeVectorImages/pixabay.com

Engineering the revolution for affordable healthcare

India leading the way

Text: Abhay Ranjan

"Amidst uncertainty and floundering global economic conditions, India continues to stand tall."

– Mr John Rice, GE Vice Chairman

India is currently one of the most talked about emerging markets and widely considered a nation that could decide the future of the world economy. It has become much more than just a "low cost resource pool" for the world. With the advent of the* Make in India *national campaign in the latter part of 2015, the market has seen a renewed surge of interest in the enormous opportunities present in the country.

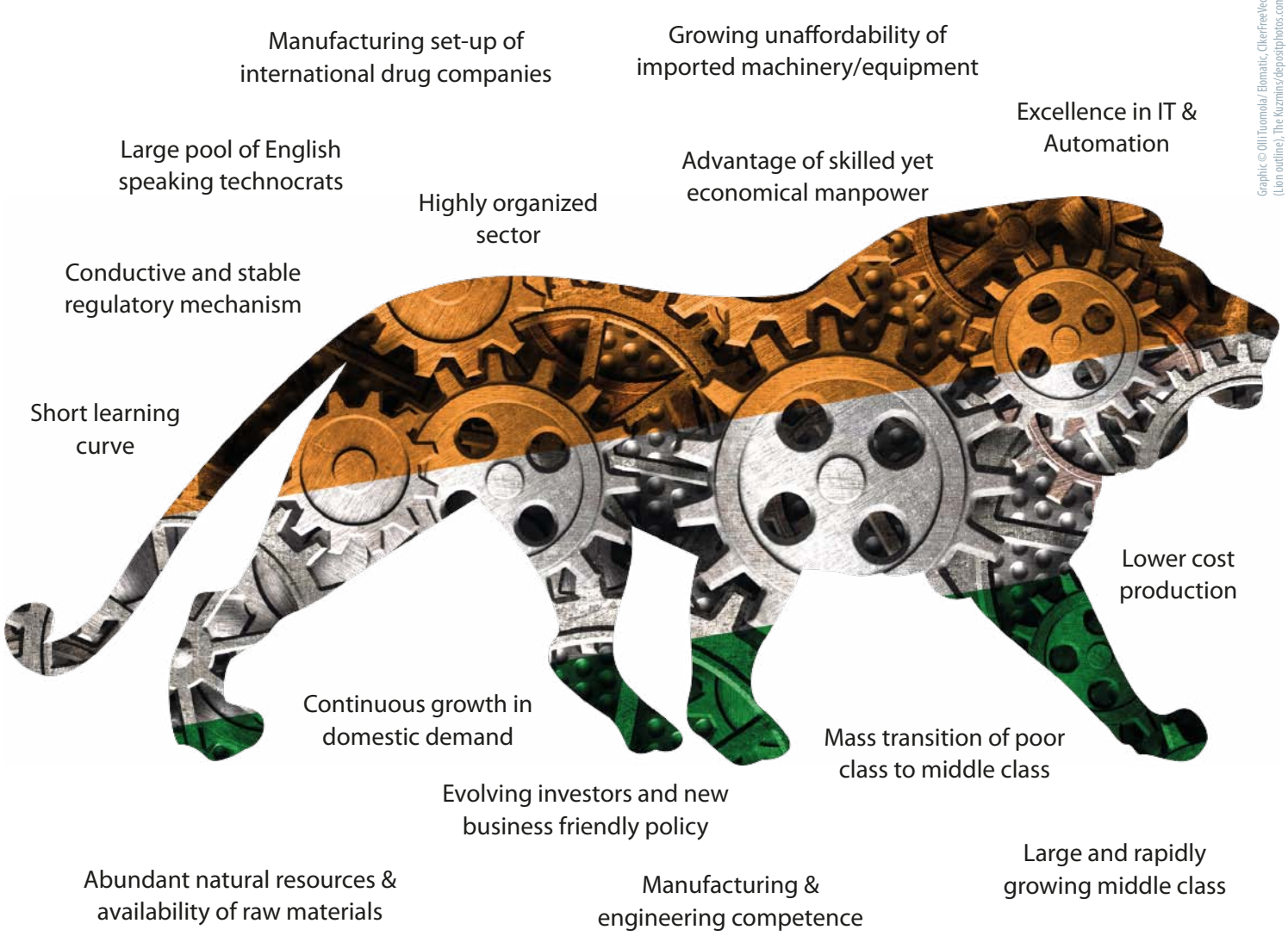
The Indian economy is currently the seventh largest in the world measured in nominal GDP and the third largest in purchasing power parity (PPP). The country is classified as a newly industrialized country, one of the G-20 major economies, a member of BRICS, and a developing economy with an average growth rate of approximately 7 % over the last two decades.

India's economy became the world's fastest growing major economy in the last quarter of 2014 with the potential to become the world's third largest economy in the next decade, as well as one of the two largest economies by mid-century. The outlook for short-term growth is also good. According to the IMF, the Indian economy is the "Bright Spot" in the global landscape.

India has the one of fastest growing service sectors in the world, which contributed approx. 53 % to GDP in 2014–2015 (source: Planning Commission, Government of India). It has capitalized on its large, young, and well-educated English-speaking population to become a major exporter of IT services, BPO services, and software services with revenues of USD 783 billion.

The country has emerged as a leading destination for clinical trials, contract research and manufacturing activities. The Government of India's *Pharma Vision 2020* aims at making India a global leader in end-to-end drug manufacturing.

The business mantra of the new Prime Minister Mr. Modi is *Democracy, Demography, Demand and De-regulation*. He has indicated that India is blessed with the first three Ds, and that he is leaving no stones unturned to add the fourth. His slogan is that *India is not working for incremental growth, but for a quantum jump…* which has been well received and adapted by the local business community.



Engineering sector employs 27 % of Indian workforce

Today, India is a very different country from what it was 15–20 years ago. It has presently become the second largest market for smart phones. Thanks to the Internet, the knowledge, exposure, aspiration and ambition levels of modern youths are vastly different from previous generations.

Engineering is the largest Indian industry segment and contributes about 20 % to total exports. In 2015–2016 engineering goods exports amounted to USD 71 billion. India exports to about 200 countries. The engineering segment employs about 27 % of the workforce and accounts for about 30 % of the total new investments and 63 % in terms of foreign collaborations.

The engineering sector attracts immense interest from foreign players as it enjoys a competitive advantage in terms of manufacturing costs, technology and innovation. India's manufacturing base is the fourth largest among emerging economies.

Volkswagen, Skoda, Toyota, Honda, Nissan, Suzuki, Ford, GM, Hyundai, Yamaha, Kawasaki and many of the world's best known automobile companies have made India their design and manufacturing hub. India ranks second in terms of manufacturing competence in the 2010 global manufacturing competitiveness index and Deloitte Touche Tohmatsu.

Very soon, India will be the second largest producer of steel in world and will be the third largest market for automobiles. At the moment, it is the seventh largest automobile producer in world.

The Make in India campaign has received the attention of several infrastructure and engineering multi nationals including GE and ThyssenKrupp, which are considering investing in the country. Other major foreign OEM investments are from Airbus, Boeing, Lockheed Martin, SAAB, BAE Systems.

India is in the process of globalizing its manufacturing base through the establishment of capital equipment and downstream industries to generate employment as well as boost the Make in India campaign through improved competitiveness of local products.

The US assistant secretary of state, Nisha Desai Biswal, when referring to US-Indian relations, has said that "*much*

Ancient Indian healers discovered energy centres within the body, which they named Chakras (Energy Wheels). Perfectly balancing energy chakras ensures overall health and well-being. If a person suffers from an ailment, health can be restored by rebalancing the energy chakras. Meditation, yoga, visualization, and sonic therapy were also developed to heal the energy flow through the charkas. Today, "Chakra Healing" is one of the most practiced alternative therapy methods.

सत्यमेव जयते

Republic of India

National Emblem:	The emblem of India is an adaptation of the Lion Capital of Ashoka at Sarnath.
Capital:	New Delhi
Government Type:	Federal Republic
Currency:	Indian rupee (INR)
Area:	3,287,263 km^2
Population:	1,276,267,000 (2015 est.)
GDP (PPP)	$8.027 trillion (3rd) 2015 est.
	Per capita $6,209 (124th)
Pharmaceuticals industry of India	
	Third largest (vol.) 13th largest (value)
	USD 20 billion (2015)
	Estimated to grow 20 % p.a. over the next five years.

of the focus has been on the economic partnership and while there continues to be challenges, we have seen a dramatic rise in US investment in India".

Pharmaceutical sector growing rapidly

The Indian pharmaceuticals market is the third largest in terms of volume and 13th largest in terms of value, as per a report by Equity Master. Presently the market size of the country's pharmaceutical industry stands at USD 20 billion.

Branded generics dominate the pharmaceuticals market, constituting nearly of 70 % to 80 % of the market. It is the largest provider of generic drugs globally and accounts for 20 % of global exports in terms of volume.

Pharmaceutical exports have grown at a compound annual growth rate (CAGR) of 68 % over the last decade, while vaccines are exported to 150 countries. Indian pharmaceuticals are exported to more than 200 countries around the world, with the US being the key market.

According to India Ratings, a Fitch company, the Indian pharmaceutical industry is estimated to grow at CAGR of 20 % over the next five years. This growth will outperform the global pharma industry growth, which is set to grow at an annual rate of 5 % in the same period.

India constitutes around 8 % of the total global generics market by volume, indicating a huge untapped opportunity in the sector. Outsourcing is projected to spike after the discovery and manufacturing of formulations.

India is home to about 10,500 manufacturing units and over 3,000 pharma companies. It exports all forms of pharmaceuticals from APIs to formulations to biosimilars. The cost of production is significantly lower (35–40 %) than that of the US and almost half of that of Europe. It accounts for 36 % (3,000) of 8,374 DMFs (Drug Master Files) filed with the USA and has over 500 USFDA approved plants (the highest for any country outside the U.S.).

The pharmaceutical market size is expected to grow to USD 100 billion by 2025, driven by, among others, increasing consumer spending, rapid urbanization, and raising healthcare insurance.

"India can create a new, affordable healthcare system."

– Mr Andrew Witty, CEO GSK

Innovative Biotech sector set to expand at 30% p.a.

The biotechnology sector is highly innovative and is on a strong growth trajectory. The sector is one of the most significant in enhancing the country's global profile as well as contributing to the growth of the economy. At present, India is among the top 12 biotech destinations in the world and ranks second in Asia, after China.

The Indian biotech industry holds about a 2% share of the global biotech industry. It is, however, expected to grow from the current USD 5–7 billion to USD 75–100 billion by 2025, growing at an average rate of 30%. The high demand for different biotech products has also opened up scope for foreign companies to set up operations locally.

Complete pharma and biotech offering

India is one of the few major economics that have a strong worldwide presence in the complete spectrum of Pharma and Biotech engineering, equipment, machinery and other accessories. Its pharma and biotech engineering services, equipment, and machinery etc. are exported to over 100 countries. The continuous growth the Pharma and Biotech manufacturing sector has encouraged the engineering industry to develop local capabilities in product development and advanced manufacturing technologies.

Further boosts are the high capabilities and expertise for drug development, research, tech transfer, dossiers, clinical trials, engineering, turnkey execution, machinery / equipment, quality laboratory set up, skilled man-power, qualification documentation, training, SOP development, validation, instruments, mock testing for regulatory inspections, and audits hand holding till validation batches.

The domestic talent pool is a mix of engineers and pharmacists, biotechnologists and chemists who understand the pharma biotech needs, starting from chemical synthesis or fermentation to the execution of USFDA, EMEA, PIC, ANVISA, WHO and other global regulatory compliant facilities as per cGMP & GAMP design.

Indian machinery is installed and in operation in many FDA approved manufacturing facilities in India and abroad.

The future looks bright

With the offering of numerous differentiating and competitive advantages in terms of R&D, knowledge, skills and cost effectiveness, the Pharma and Biotech industry in India has immense potential to emerge as a key global Lifesciences destination.

Local pharma engineering companies will play a vital role in developing world class equipment, not only meeting the desired quality and regulatory requirements, but also delivering affordable turnkey engineering solutions. In just a few decades, the Indian pharma engineering industry has improved immensely in terms of precision, quality, productivity, automation, accuracy, and validation.

The country can be seen as one-stop-shop for the entire pharma and biotech spectrum, starting from development of pharmaceutical or tech-transfer up to validation batches.

Indian companies are quick to adopt the changes required to make them truly global players. The country's export base of engineering offerings has shifted from low value to hi-tech and from developing countries to the entire globe. The Indian Government is taking all the required measures to make it one of the most investor friendly business destinations around.

With the generous talent-pool in engineering, pharmaceuticals, chemistry, biotechnology and medical sciences, encouraging investments from both Government and Industry and the significant cost-advantage over other countries without compromising on quality; India is set to lead the pack in engineering affordable healthcare for the world.

About the Author

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Abhay Ranjan spearheads the operations of Elomatic, India. As an accomplished visionary- and mission-oriented leader with strong strategic abilities, he has pioneered the growth-story of the company. He holds a bachelor's degree in production engineering and a master's degree in management from IIM-C. He has been closely associated with the pharma and biotech industry for over 25 years. Under his leadership, Elomatic India has with distinction executed numerous projects of various complexities, spanning South East Asia, Middle East, Africa, CIS countries and other nearby countries including India. He is also a member of ISPE and PDA.

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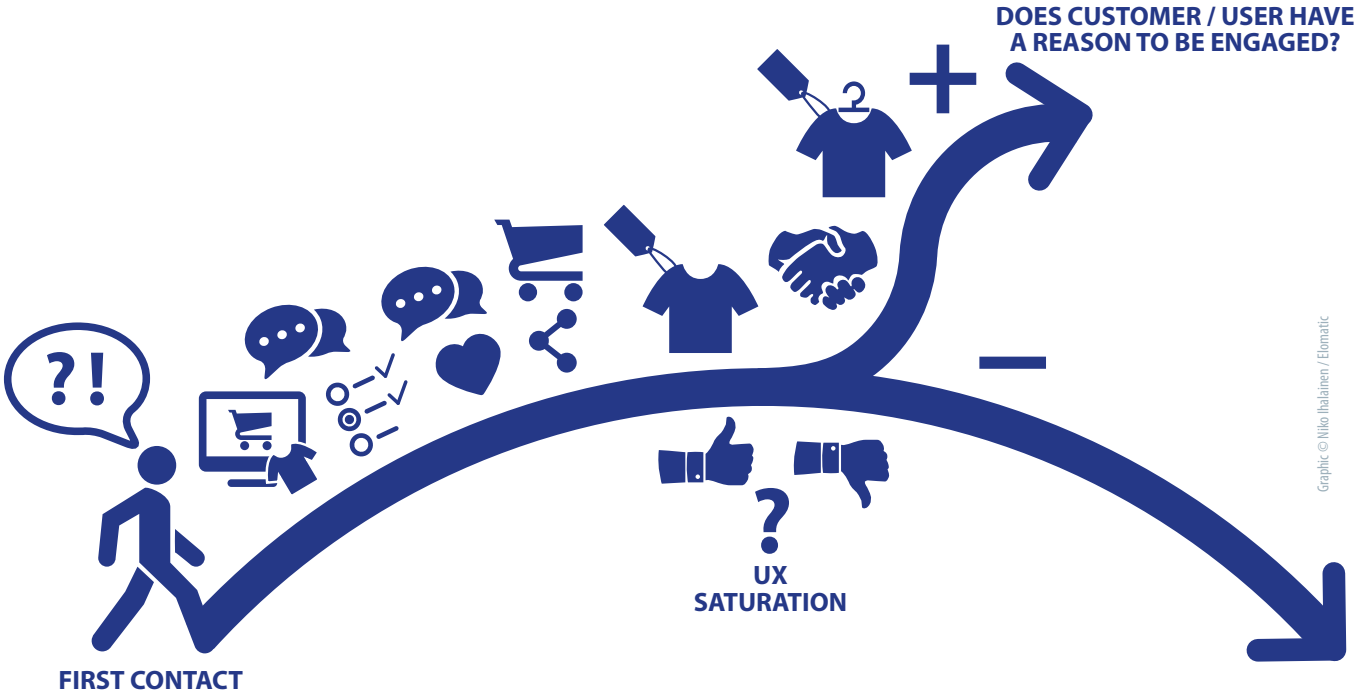


The customer is KING

– *start consciously designing customer journeys*

Text: Sanni Marttinen and Mika Patrakka

Taking customer and user experience into account is crucial in order to extend the lifecycle of customerships to the maximum. The touchpoints where customers and users interact with a product or company present an opportunity to either succeed or fail. Human behaviour has changed since the advent of the Internet and buyer behaviour, in particular, is radically transforming. The challenge for companies is to achieve more meaningful partnerships in the customer value chain or network. This requires transparency and a greater focus on human values. In essence, there is an increasing amount of variables, in addition to pricing, that affect whether companies can achieve and maintain their competitive advantage. It has also become necessary to be involved in the customer journey much earlier. Seamless customer journeys and touchpoints have to be consciously designed to serve and be transparent.

Human beings are at the centre of developing customer and user experience. Humans are the ones who make, for example, purchasing decisions as customers and users. Decision-making is affected by numerous factors, many of which may seem ludicrous. Rationality is not the only basis for decisions and human actions. We, for example, make decisions based on what feels good, right, nice, or because we want gratification, acceptance, to be valued, to fulfil ourselves, to engage with other people, or succeed with the help of a product or service. Human needs have been studied extensively and several theories have been developed to describe the hierarchies and interrelationships of needs.

Empathy is a valuable tool for designers

Successful companies have started taking note what effect feelings have on human behaviour. Emotional Design and Affective Engineering are examples of different design perspectives that focus on humans more closely.

Kansei engineering is well known in the automobile industry. The Kansei notion has several definitions: some describe it as a process, others as the result of a process. It nevertheless deals with feelings, senses, mental states, memory, intuition, interpretation, and personality. Kansei takes the subjective use and value for the user into account, which is then reflected in design.

It is, therefore, important to understand human cognitive processes. The internal model created by humans of a product or service does not perfectly correspond to reality. The afore-mentioned feelings, personality traits, earlier experiences etc. all affect the model. This is why the memory of a product or something is unique.

The subjectivity of experiences and feelings is a challenge for product and service producers and designers. Designers need sensitivity and empathy to put themselves in the user's or customer's shoes. Different user-centric design methods and observation of real use situations assist in this regard. People also associate better with services or products that have or appear to have a personality or a story.

Good customer and user experiences are hard to copy

In industries such as the machine works industry, where benefitting systematically from customer and user experience is new, even small development efforts can achieve large benefits and improvements. Good customer and user experiences are difficult to copy, which protects the company's competitive advantage.

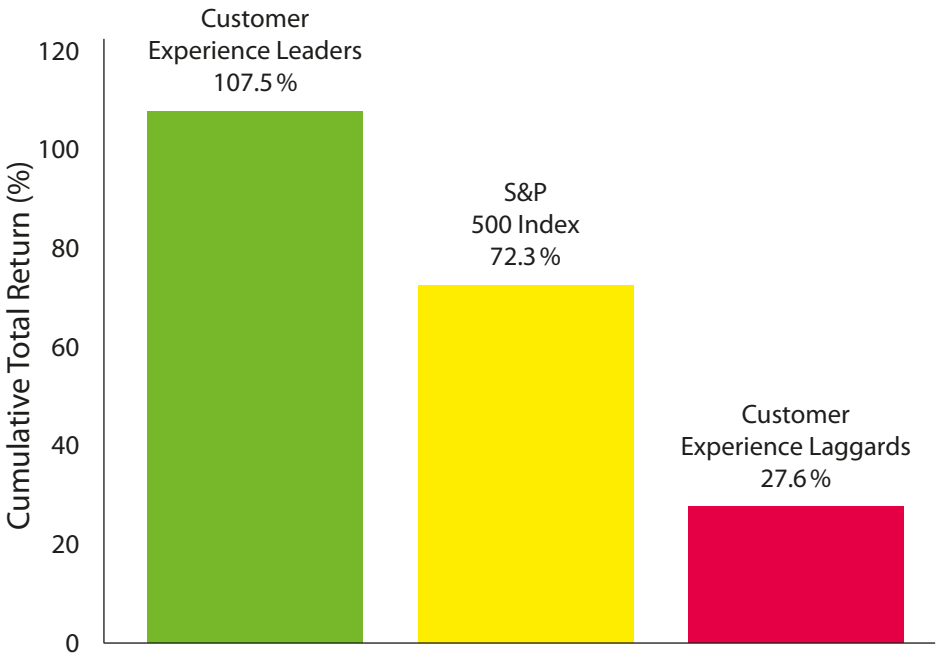
Taking user experience into account at the right time saves both time and money. Costly changes and problems at later design stages can be avoided when users are in some way or another involved in defining and verifying product concepts.

A product's user interface should be modelled and tested for usability at the very start of design. An early user interface prototype is a concrete and effective tool in product development that can identify previously unnoticed needs and user demands.

When user experience is taken into account in design the end result is safe, easy-to-use, and fulfils the user's demands. A user that is satisfied also recommends the service or product to others, trusts the brand more, and is more engaged.

Not all top executives see the benefit

Focusing on customer experience is a given from the customer's perspective, but top executives often see it primarily as a cost factor. This is partly due to the fact that customer and user experience is scrutinised only once



◀ *According to a 2015 Watermark study companies that focus on customer experience are significantly more profitable than other large companies on the S&P 500 index.*

© 2015 Watermark Consulting. Image source: www.watermarkconsult.net/docs/Watermark-Customer-Experience-ROI-Study.pdf

Customer experience is not a separate development area. It should be connected to business operations and requires commitment from the entire company.

most product development and marketing planning has been done and the budget has been exhausted. Customer experience is, however, not a separate development area. It should be connected to business operations and requires commitment from the entire company.

It is difficult to present the benefits of customer and user experience in clear figures to build a business case, but not impossible. One can, for example, measure how often you get return customers or how long customerships are maintained. Customer experience can also be measured via customer feedback, which is an important activity in itself. The Net Promotor Score method is good for regularly measuring customers' propensity to recommend a company, which is also a measure of customer satisfaction.

There are several examples of companies that have successfully invested in developing customer experience. The best have allocated sufficient resources to the changes required and now also fair better in business terms than comparative companies.

The customer journey should be of interest to everybody – not only to salespersons or customer service staff. When customer and user experience drives business operations, development work is focused on delivering added value. Added value is not only reflected in a product's technical development, but in developing a company's own business operations and product and service development. The customer, in turn, receives a better, more effective and more desirable product or service.

Why invest in customer and user experience?

- When two similar products are on offer the customer choses the one that best meets his or her demands, needs and liking.
- Good customer experience is reflected in the amount the customer spends
- Good customer experience builds trust and engagement, the customer lifecycle is extended
- Unsatisfied customers become costly, bad experiences are shared in social media more than good experiences
- Through positive experiences the company receives free publicity
- Reduces insecurity in the company
- Developing business operations becomes more desirable
- Product and service development becomes more efficient
- Indirect costs (e.g. start-up, training, and product support) are reduced. They often include so-called hidden costs.

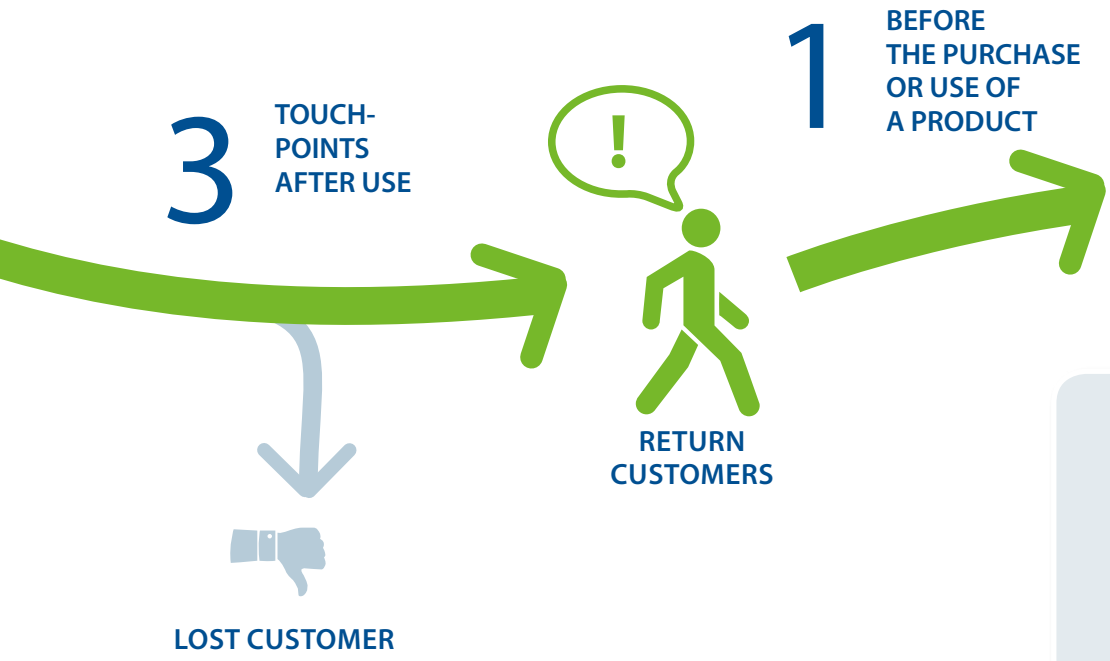
Customer and user touchpoints

The use situation is the most obvious part of the customer journey and where user experience is defined. Factors such as our preconceived ideas about a manufacturer or brand, recommendations, availability, maintainability, and support services also affect the customer and user experience.

The customer journey can be divided into three parts (before, now, and after), which have to be integrated into a seamless entity. To create a good customer experience in every phase of the customer journey, one needs to take account of both the customer and the business model. The figure and table overleaf show the different phases and parts of the customer journey as well as what channels can be used to affect the customer's and user's experience at touchpoints.

Several methods can be used to gain a better understanding of the customer and user. These include, for example, observation, surveys, and interviews. The idea is to get a reliable picture of customers' and users' actions in real life environments.

1 BEFORE THE PURCHASE OR USE OF A PRODUCT		
A) Awareness of a problem or need	**Influencing**	**Channels or touchpoints**
Humans want to associate themselves with something or be bigger than something. We value some things more than others e.g. technology, free time, money, health, friends, etc. We listen to our needs and are prone to newly created needs. In the same way we fulfil our employer's needs, which serve the company, but our selfish needs do not disappear.	Digitalization has created new opportunities for multi-channel interaction and has significantly changed buying behaviour. The following affect the value we give to a product and service: peer groups, colleagues, referrers, brand recognition and reputation, life situation, lifecycle, goals, escapism, problem solving and learning, and inspiration.	Social media, blogs, TV/ videos, podcasts, mobile devices, events, content marketing, advertising, sponsoring, augmented reality, web pages, surveys, etc...
B) Consideration of problem or need		
In this phase a person refers to earlier experiences of companies, products or services. The person prefers to investigate the matter at a suitable time before speaking to the product or service provider. Transferring from one phase to another depends on the person's situation and way of doing things. Some of us are more ready or more impulsive while others want to leave no stone unturned before making a decision.	The point of view should be to share information that deepens understanding and provides answers to the customers' problems or needs. The idea is to get the customer to want more both via rational and emotional thought processes. The content, products, and services need to be visible and available where the customer or user searches for information and compares alternatives.	Social media, blogs, TV/ videos, podcasts, mobile devices, events, content marketing, advertising, sponsoring, augmented reality, web pages, surveys, online shops.
C) Decision-making		
Any deterrents to purchasing should be removed when the customer has found a solution to the problem or challenge and is convinced about it. In this phase the service or product should be made to look as attractive as possible. The customer should be told why your product or service is the best solution.	In this phase the following, among others, affect the purchasing decision: availability, delivery times, financing, pricing, and references.	Customer service, web pages, materials that support sales, promotional events, etc.



2 DURING PRODUCT OR SERVICE USE		
The most obvious part of the customer or user journey is when the service or product is used. The product interface concerns different ways of using the product. All different users and use situations need to be taken into consideration: ■ Installation & start-up ■ Daily use ■ Use under exceptional circumstances (error or emergency situations) ■ Technical support and other support services ■ Transport and storage ■ Maintenance ■ Reclamation Customer and user experience during product or service use can be divided into different parts, for example, usability, safety and desirability.	**Influencing**	**Channels or touchpoints**
	Customer- and user-centric design, engineering- and research know-how, taking care of the customer in all phases (i.a. maintenance and support services), logistics and distribution.	The product or service itself, ordering processes and monitoring, manuals, web pages.
3 TOUCHPOINTS AFTER USE		
Customer experience formation never actually stops; rather the experience is formed and develops continuously in different use situations and customership phases. How can we affect the formation of a positive customer experience after use? Key points in this phase are activity and taking care of the customership lifecycle.	Maintenance and spare parts availability, collecting and responding to customer feedback, recycling, disposal, additional services and information about new possibilities, invoicing, access to customer service, guiding to the next cycle, etc.	Web pages, social media, email and other personalised marketing, maintenance related services and their timely delivery

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Photo © Sauvo Jylhä, Keski-Uusimaa

Innovation and engineering saving the day

Case: Saimaa ringed seal

Text: Martin Brink

The Elomatic Innovation Team has developed an artificial nest for Saimaa ringed seals that has been tested on Lake Tuusula north of Helsinki. The structure is made of common reed found in and around the lake. If the local Centre for Economic Development, Transport and the Environment (ELY Centre) accepts the artificial nest, the goal is to build a similar nest on Lake Saimaa next winter. The Saimaa ringed seal is the most endangered seal species in the world.

According to Metsähallitus, the Finnish State Forest Enterprise, there are only 320 Saimaa ringed seals left in Lake Saimaa. It is the only place the seal subspecies is found in the world. In the early 20th century, there were an estimated 700 seals, but hunting, commercial fishing, and climate change, among others, have contributed to the decline in numbers to the situation where it is currently the most endangered seal in the world.

To breed successfully, Saimaa ringed seals require sufficient amounts of ice and snow as the seal gives birth to pups in a cave-like nest built of snow. Higher temperatures and the lack of snow in recent years have been issues of particular concern and, unfortunately, when the nests melt the seal pups are left without the crucial protection they need during the winter.

Metsähallitus has with success implemented a programme, whereby artificial snowdrifts have been shovelled with snow pushers into high piles to create nesting sites; a process that would occur naturally with the help of the wind, if there was sufficient snow. This has proved useful in creating ideal nesting places, but requires a lot of manual labour and is only a partial solution to the problem.

Pekka Koivukunnas, a member of the Elomatic Innovation Team, volunteered to build artificial snowdrifts, as described above, on Lake Saimaa during the 2015–2016 winter. A seal pup has already been born in one of the nests he helped to build, and has been seen with its mother enjoying the nesting site.

An idea for an artificial nest is born

The Elomatic Innovation Team is used to coming up with innovative ideas to solve their customers' problems, and were keen to put their skills to work in this worthwhile cause too. They used the TRIZ problem-solving and idea generation method and focused particularly on what local natural resources could

◀ *Elomatic's Saimaa ringed seal project team (from left): Pekka Koivukunnas, Jukka Mikkonen, Sebastian Kankkonen*

The process of building a nest

1. *Collecting reeds; bunch length about 2,2–2,3 m.*
2. *Fastening bunches with biodegradable string*
3. *Total of 36 bunches (one trailer load)*
4. *Mesurements: Length about 2.2 m., Width 1.2 m.*
5. *Placing bunches in parallelogram shape*
6. *Adding the roof, interior height about 0,6 m.*
7. *Ready prototype*

We are confident that our concept can be used to make a contribution in saving the seal for future generations.

be used to fulfil the requirements. They quite rapidly identified common reed as a suitable material, that could be accessed close to the nesting site or transported there with ease.

According to Jukka Mikkonen, another member of the Elomatic Innovation Team, it took only about half an hour to design the artificial nest in a cage-like, parallelogram shape, and a further two hours to collect the common reed to construct it.

The reeds were bound with biodegradable string and stacked together to form the structure, which is about two metres long and over one metre wide. The benefits of the nest are shown in the info box.

After consultation with the Metsähallitus it was decided to build the test nest in January on the shore of Lake Tuusula, just over 25 km north of Helsinki. There are no seals in the lake, but the idea has been to expose the artificial nest to the elements to see how it copes and holds up over time under different weather conditions.

During the testing period weekly reports and pictures have been sent to Metsähallitus and the hope is that the local ELY Centre will grant permission to build a similar structure on Lake Saimaa in 2017. At the time of writing this article the testing period was drawing to a close, with a final report still outstanding. By all accounts, however, the testing has gone very well and the structure has passed the test with flying colours.

Much work left to be done

Saimaa ringed seal numbers have stabilised, but much work lies ahead to ensure that the subspecies can be brought off the highly endangered list to relative safety. To achieve this Saimaa ringed seal numbers would have to increase to 400, which means that a whole range of conservation and human intervention measures will be required for the foreseeable future and beyond.

The Elomatic Innovation Team is confident that their concept can be used to make a contribution in saving the seal for future generations.

Benefits of the artificial nest

- Can be built on site from plentiful and local natural resources
- Reduces the need for snow insulation especially during winters with little snow
- Enables independent nest building by locals
- Lasts several years
- Biodegradable material
- Does not sink

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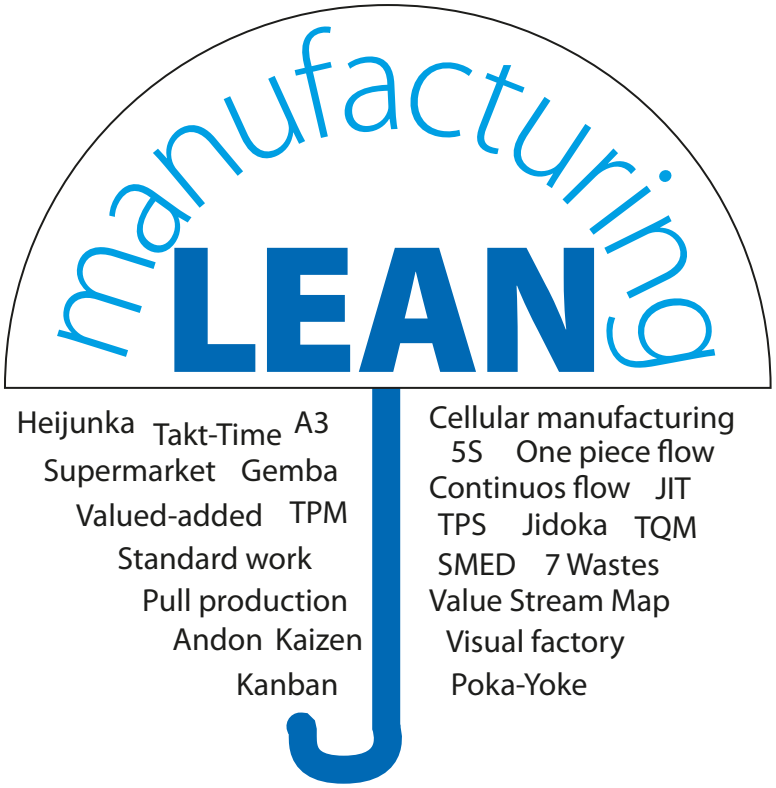

Lean manufacturing is **back**

Text: Mika Kuhmonen

Numerous tools, principles and technologies are available for production development when action is called for. Since the days of Frederic Taylor and Henry Ford, production development has always found new ways to maintain productivity in changing business environments. A large number of principles and approaches have been developed and applied to develop production further. One of the most commonly used is Lean.

The origin of Lean development principles lies in Japanese car manufacturing of the 1950s. After the Second World War, Japan needed to build a competitive manufacturing environment with very limited funding for machinery. Instead of investing in expensive machinery, they decided to focus on the operational aspect of manufacturing.

All this remained a secret to the western world until the 1980s when the US car manufacturing industry started questioning the low cost and high quality of Japanese cars. What they found was a completely new way of developing manufacturing operations where the focus is on effective material flow instead of manpower and machinery utilization rates. They decided to name it Lean, based on a key aspect of the Toyota Production System (as the Japanese called it) – as low as possible material flows in the factory.

Reducing waste at the core of Lean thinking

At the core of Lean thinking is the concept of waste, which can include unnecessary movements, inventories, work in progress, and waiting. Lean provides methods and tools that can reduce this waste.

Success in Lean is measured by lead time, for example, the time when a process is started (value added work to customer) until the last process step. The shorter the lead time is the less waste is involved in the operations and the more productive they are. Lean can be summarized as an operations strategy that prioritizes efficient production flows over utilization rates.

Lean is fashionable again

Lean has recently become fashionable again. It was widely utilized in manufacturing in the 1980s and 1990s, after which it was forgotten, but it has now made a comeback. Industries such as healthcare, banking and construction where operations are based on repetitive processes have also recognized the potential of Lean.

With a relatively small investment a Lean development project can provide a substantial return on investment.

One of the most tempting characteristics of Lean is its cost/benefit ratio. With a relatively small investment (personnel time allocation) a Lean development project can provide a substantial return on investment. Conversely, if the project does not deliver the desired results the loss is minimal. From this perspective the threshold to start lean activities should be low, in theory at least.

Easy to understand, hard to implement

Lean ideas and tools are often easy to understand, but most companies, however, fail to implement Lean in their operations to the extent that they would achieve a noticeable improvement in productivity. This is mostly this is due to a lack of understanding regarding what Lean tools to implement and in which order. The amount of work required is also commonly underestimated. If a company wants to gain a competitive advantage from Lean, it needs to be seen as a permanent activity with allocated resources (create a Lean culture), rather than a time-limited project.

There are numerous different methods, tools and principles that exist under the Lean umbrella. Some of them are easy to understand and very straightforward to implement, while others are rather complex and require a lot of understanding, discussion and development work to be implemented in operations.

In the beginning it is demanding to separate the Lean philosophy (the idea of Lean), from the Lean methodology (used to identify potential and implementation areas), and Lean tools (that you can implement in operations).

It is often challenging to define which Lean tools fit certain operations. Another surprise might be finding out that each Lean implementation is unique. There is no model that can be copied directly or guide that can be followed. In each project one needs to be creative to define a Lean solution for the particular operations and company culture. Companies commonly fail to understand that this creative work should be done by a group that contains representatives from the shop floor all the way to management level executives.

The fundaments of Lean are deeply ingrained in industrial managers' thought processes, even though most do not consciously consider their thoughts to be Lean-based. The concepts of waste or customer demand, which are cornerstones of Lean thinking, are common discussion items in production meeting rooms. This implies that the value of Lean as a development principle is clearly understood, but that there is a capability gap in implementing it.

Key implementation questions are potential stumbling blocks

Even though Lean principles are easily understood, key questions regarding its implementation often prove to be potential stumbling blocks: How should the occasionally vague instructions and guidelines be adapted to suit unique production environments? Where should one start with Lean implementation? What methods should be applied and in what order? How should these methods be linked with each other?

To the inexperienced, these questions often prove daunting or overwhelming. Without previous Lean experience or a Lean company culture, problems may be too extensive or the impact of implementation disappointing. The scale of the project may also be too small, or the improvement in one sub-process may not be enough to show any meaningful measurable benefits.

When implemented correctly and systematically, however, Lean has the potential to optimize processes and add considerable value and competitive advantages.

About the Author

Mika Kuhmonen

Ph.D. (Production Engineering)

Mika Kuhmonen has gained extensive experience in discrete manufacturing development internationally and domestically since his graduation (M.Sc.) in 1993. He has participated in numerous factory development projects in Europe, USA and Asia implementing e.g. Lean manufacturing, Theory of Constraints on shop floors, and order-delivery processes. Mika has held positions from production expert to global development executive and joined Elomatic in 2010.

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Discrete event simulation packs a punch

Text: Risto Hänninen

Discrete event simulation can be a powerful tool to aid companies in understanding their processes better and to produce beneficial information to support decision making. With discrete event simulation, a broad spectrum of data can be obtained, ranging from finding process bottlenecks to the optimization of processing parameters to increase throughput and lower costs.

Discrete event simulation, like all forms of simulation, is a method used to model an aspect of real life on a computer. With discrete event simulation, every change that takes place in the simulation model is its own discrete event. For example, when a processing machine starts processing a raw material, this is one discrete event. The end of processing is another discrete event, after which a new discrete event might follow: the processed raw material begins moving to the next processing machine, for example.

The discrete events in the simulation model can be dependent on each other, or independent, as in real life. Each event happens on its own time as time passes in the simulation, the same way it does in real life.

Discrete event simulation is well suited to modelling production facilities, traffic flows, logistics, and customer service situations. Basically, any situation where a quantifiable amount of anything (raw materials, calls, products…) enters a process and is processed or held up for a definable period of time, after which it eventually exits, can be simulated with discrete event simulation.

Even a relatively small process can be too complex to be fully understood without proper visualisation; how it operates and how all the interdependencies affect the outcomes of the process.

Understanding everything in the finest detail is not, naturally, always needed. Having an unclear picture of how the process works might, however, become a problem when changes have to be made. For example, when capacity is no longer sufficient, or if keeping up with the competition has become more difficult, knowing what to change, and how to do it, is essential.

What can be achieved with discrete event simulation?

Bottleneck identification is quite simple to achieve with discrete event simulation. Once the simulation model has been built and the simulation has been run, the utilisation rates for all activities can be obtained. While there might not be a single activity acting as a bottleneck yet, this can change with increased production or changes in the production plan. This can be easily tested in the simulation. Figure 1 (overleaf) is an example of a simulation bottleneck identification graph.

It is also easy to test different scenarios with a simulation model. For example, when considering a production equipment upgrade, the effects of the upgrade on the whole process are easily tested by changing the parameters for the processing equipment. The effects of changes in the production schedule can be tested by changing the processing parameters in the simulation.

Simulation is commonly used for storage space approximation. The simulation model clearly displays the needed storage space or how the current

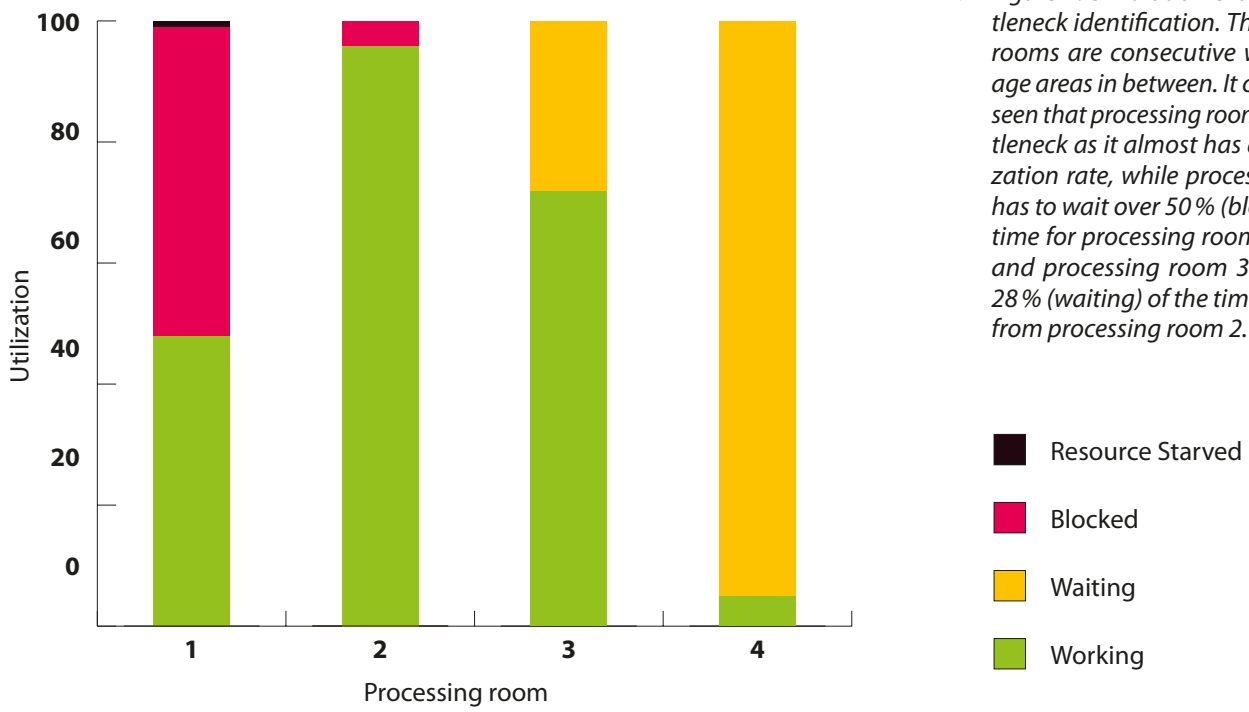


Figure 1. Simulation example of bottleneck identification. The processing rooms are consecutive with no storage areas in between. It can be clearly seen that processing room 2 is the bottleneck as it almost has a 100 % utilization rate, while processing room 1 has to wait over 50 % (blocked) of the time for processing room 2 to be free and processing room 3 has to wait 28 % (waiting) of the time to get work from processing room 2.

storage space can become a bottleneck in the process. Figure 2 is an example graph of storage space requirement simulation results. *Resource needs* and *utilisation rates* can also be identified with discrete event simulation where the resources could be workers, pallets, etc.

A good simulation model can also be a useful aid in decision-making related to process changes. The simulation can clearly display what effects changes would have. This knowledge is particularly important when decisions regarding large investments have to be made.

A simulation model is a representation of the real world and can be simplified very much, or made more complex (closer to real life) by taking into account minor details that affect the real life process.

Why use discrete event simulation?

Dedicated simulation software really excels when the small variations and randomness of the real world have to be taken into account. For instance, the time that a processing room is occupied for the manufacture of a certain product usually varies according to a kind of distribution. This variation can be taken into account, by setting a distribution that represents the real life processing times as the time value for that processing room. The software then randomly selects processing times according to the distribution.

It might seem that the average processing time alone would do much the same as a distribution, but this, however, is rarely the case. If the process upstream depends on the availability of the processing room, or if the process downstream depends on the output from the processing room, it can make a big difference in the simulation model if the average processing time is used as the processing time value, or if a distribution which better represents the real world is used instead.

Another benefit of simulation is how fast it is. Building a simulation model and testing different scenarios is usually so much faster than performing tests in real life that the latter is not really an option. Tests that would take years to complete in real life can be performed within minutes or hours (depending on the complexity of the system) with a simulation model. It is also not usually commercially feasible to conduct experiments on production equipment, as the equipment should be used optimally for production.

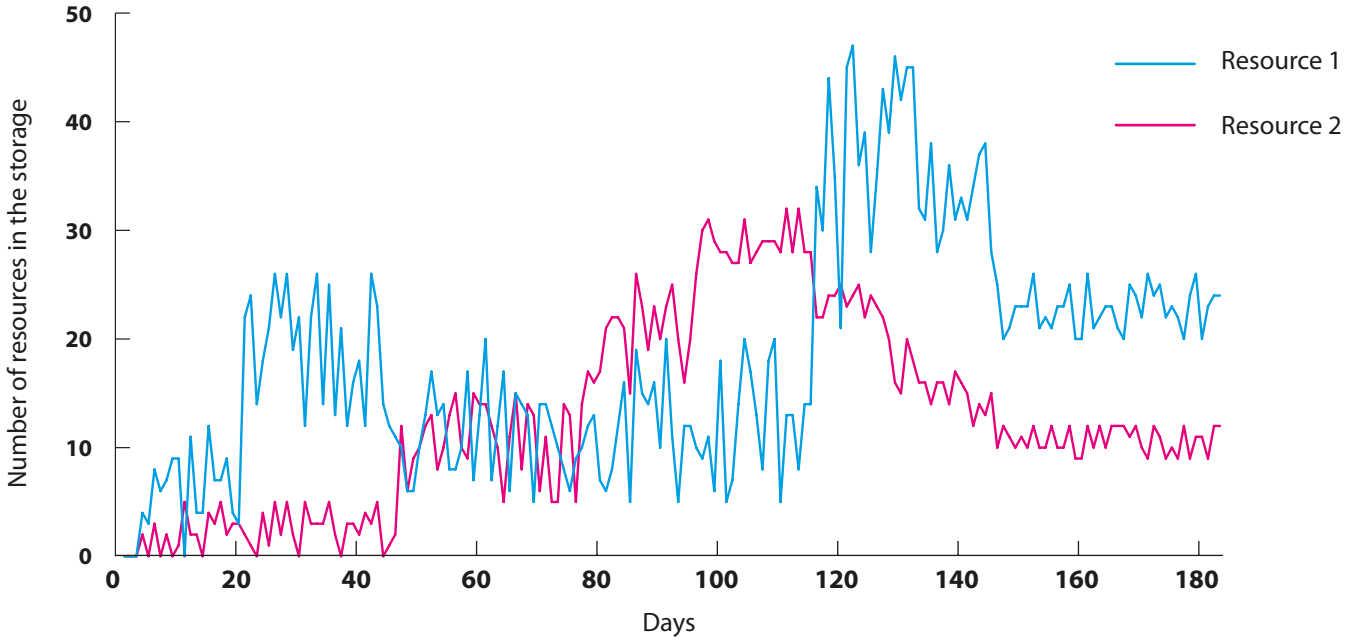
Building a simulation model also takes less time than doing similar calculations with other methods. Barring possibly the simplest models, doing similar calculations with alternative means is, in fact, virtually impossible.

Optimization

Discrete event simulation can be also used for optimization. By varying parameters according to set limits, and aiming to a set a target value, the simulation software can find an optimal solution.

It is not always clear how exactly certain changes affect the process. In these situations optimization can give us results that would be difficult to obtain otherwise. The number of workers working on a part of a process, for example, could be optimized with a simulation model. Having more workers means faster processing, but also

If the data doesn't represent reality closely, neither will the simulation.



▲ *Figure 2. An example simulation of the number of stored resources in a storage area over a six month period. The data can be used to easily evaluate the need for storage space.*

costs more. The optimal number can be quite easily determined with a simulation.

Better data, better results

Good data is really important when running a simulation. If the data doesn't represent reality closely, neither will the simulation. "What goes in comes out" holds very much true in simulation. With bad data, the simulation might initially seem realistic, but might, in fact, represent the reality extremely poorly. This can, of course, be checked by comparing the result data from the simulation with equivalent data from the real world, which is something that should always be done, if possible.

It also has to be taken into account that a simulation is a mathematical model, a representation of the real world, and thus will never perfectly correspond to reality. With good data the model can, however, be made to correspond to the real life situation very closely. It is also possible to do multiple simulation runs with different random number sets and a verified model to get statistically significant results.

Obtaining the required data for a simulation might be as easy as exporting data from ERP-software or other production planning and logging software. Usually, some editing of the data is required, but after editing the data can be imported into the simulation software on a spreadsheet. The time spent on proper data collection and verification is reduced many times over when the simulation represents the real world from the start.

With good data, discrete event simulation can be a powerful tool that gives us useful information that can be used to improve processes and solve problems that would be difficult to do otherwise.

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Risto Hänninen has worked at Elomatic since 2012. His fields of expertise cover discrete event simulation, laboratory design and commissioning, as well as process design. Risto mainly works in pharmaceutical industry projects and chemical industry projects. He has built and analysed results of discrete event simulation models, ranging from small simple simulations to complex models for large factories.

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Structural Fatigue

– the realm of science fiction or something closer to home?

Text: Leo Siipola

It is not uncommon to come across the sentiment that structural fatigue is a very complex phenomenon to explain, and an equally complicated issue to solve. A relatively recent high-profile case in Finland, which involved the Finnish Navy, brought structural fatigue into the national spotlight. In September 2015, when explaining that the vibration induced by the propulsion systems of their Rauma-class missile boats was the source of the structural fatigue on their vessels, the Finnish Navy spokesperson also indicated that "structural fatigue is terribly difficult to explain." But is this the case?

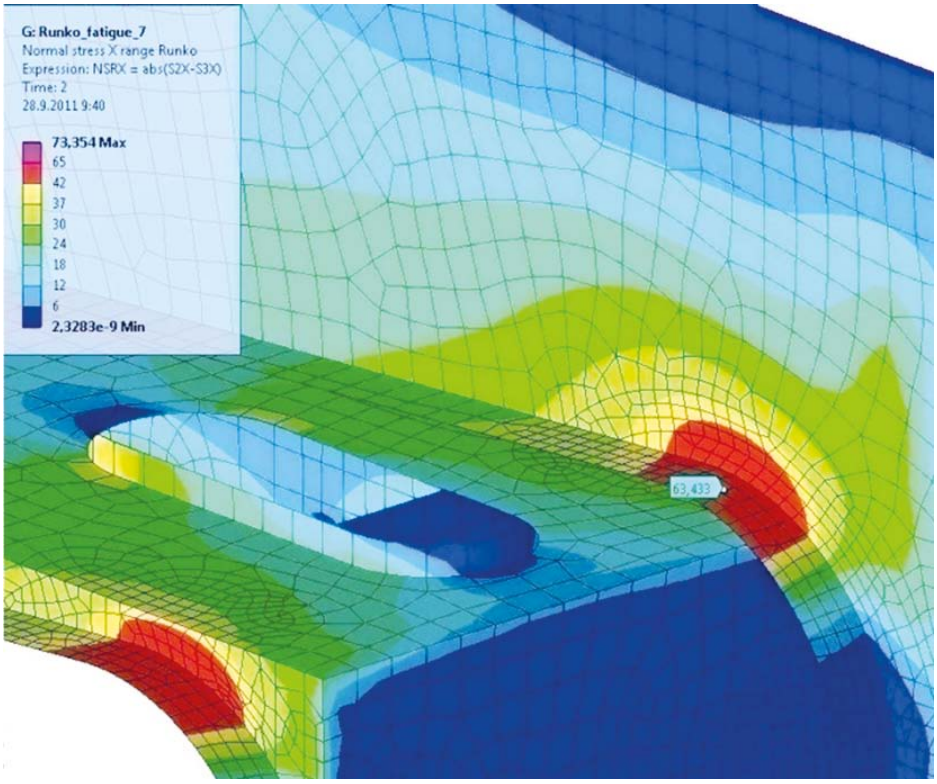
Structural fatigue is not the easiest phenomena to get one's head around, but it is also not the hardest. In essence, fatigue sets in all structures that are exposed to dynamic loads and conditions. These loads may include, for example, temperature changes, wind strength changes, corrosion, and varying weight loads, such as experienced on bridges. This holds especially true for structures manufactured from metal. The welded parts of such metal structures are particularly vulnerable to fatigue.

If the loads are above a certain threshold they can lead to microscopic cracks in the structure, which over time become progressively larger until a tipping point is reached and the structure fractures completely. It is important to note that these loads are individually insufficient to cause a structure to fracture, but their dynamic application over time causes fatigue to set in.

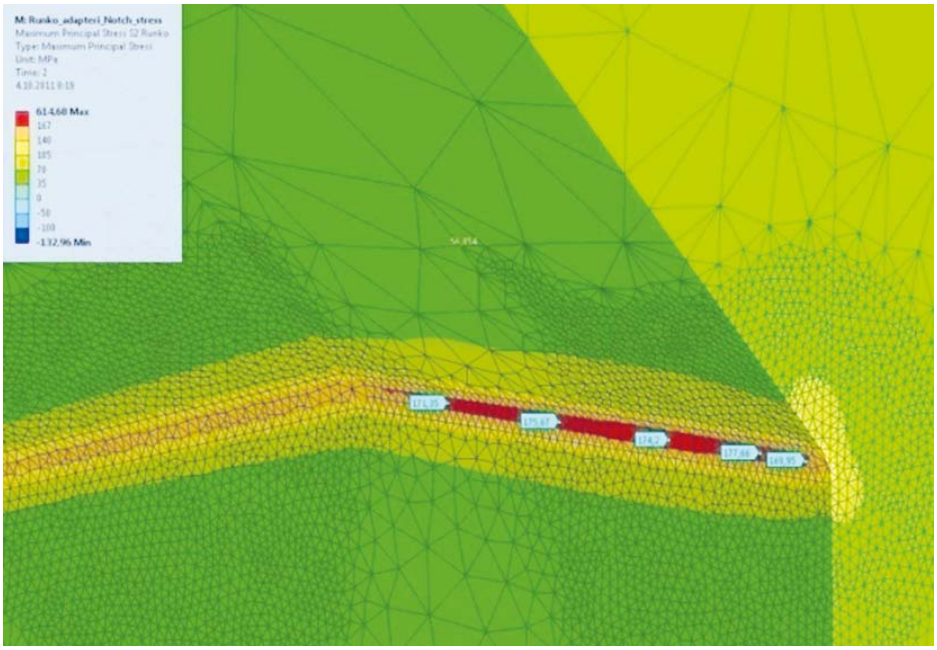
As a phenomenon fatigue is not new. It has, in fact, been studied quite extensively and nowadays, with the help of modern technologies and tools we can with great confidence dimension structures to avoid the associated risks.

Load prediction is the most challenging aspect

The most complicated aspect of fatigue dimensioning is load "prediction". In essence, this means defining the load in such a way that one can be sure that the load will be incurred during the lifespan of the structure. In the best case scenario, there is already an existing or similar structure that can be used to take load measurements over a period of time. If the structure is unique or a whole new concept, however, load definition becomes more challenging. Fortunately, modern simulation technologies allow the simulation of future structural loads. Historical loads can be simulated virtually with multibody simulations (MBS), which produce infor-



◀ *Picture 1. The stress range of a frame in the x-direction.*



◀ *Picture 2. Calculating the stress range on an adapter's weld with the Notch Stress method.*

The location of welds and the type of weld joints significantly affect the structure's life span.

mation that can be applied in fatigue dimensioning. As such, one is not reliant on any guesswork regarding loads.

What significance does the magnitude of loads have? If, for example, there is a 10 % difference in the magnitude of loads that affect a part, this translates to a 33 % difference in life span. If a particular part's lifespan is supposed to be ten years, a larger load can reduce that life span to seven and a half years.

The quality of welded structures a key factor

If the structures in question are welded structures, particular attention must be paid to the quality of manufacturing, in addition to reliable fatigue dimensioning. It can be said that the life span of an individual weld is in many respects dependent on the "hand" of the welder. It is, as such, not sufficient to only ensure that the structure is designed and dimensioned according to reliable calculations. Manufacturing quality and quality control play a critical role in ensuring that structural integrity is maintained as required.

Unfortunately, one poor weld can spoil an otherwise perfectly designed and manufactured structure and lead to serious accidents and loss of life. An equipment weld that has been done in the wrong place can also have catastrophic consequences for structural integrity.

In structures that are exposed to dynamic loads or vibration, the dimensioning of the structure is in most cases a crucial factor with regards fatigue. Structures should be designed and analysed well in order to ensure a sufficient lifespan and at the same time to avoid over-dimensioning, thereby reducing material and production costs. Especially in large welded structures, the location of welds and the type of weld joints used significantly affect the structure's lifespan and costs. An additional benefit of ensuring structural integrity is that one doesn't end up in a situation where you have to prohibit the use of structures, machines, or vehicles while they are being repaired, that is if they can be repaired at all.

Different weld joint types have varying lifespans

What effect does the type of weld joint have? This is most easily illustrated by means of an example where we consider a weld joint that can be welded with either a fillet weld or a full penetration V-weld. There is about a twofold difference between the two weld types' fatigue classifications, but approximately a threefold difference in their lifespans. One can, therefore, say that a fillet weld would last, for example, two years in a structure, whereas a single-bevel butt weld would last six years. For the owner of a digger, for instance, there is a clear difference between having to repair or replace a component every two years as opposed to running a machine for six years without major repair.

Structural fatigue is not in the realm of science fiction, it is, in fact, something much closer to home. We solve fatigue related issues every day and as a result, ensure the safety and operational reliability of an extensive range of structures, constructions and machinery.

About the Author

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Leo Siipola has worked within the Finnish mechanical industry since the early 2000s. His experience covers machine design, structural analysis, vibration and fatigue of welded structures. Leo joined Elomatic in 2011. He currently holds the position of Design Manager, Technical Analysis at the Elomatic Tampere office.

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Optimization, the game changer

– gaining competitiveness and reducing lead-time in R&D

Text: Petri Seppänen

According to Merriam-Webster optimization is a "methodology for making a design entirely perfect, or as effective as possible." This is how R&D personnel also usually understand optimization, but it has a wider application scope than just finding the optimal solution. In this article I present why optimization tools are essential for R&D and why their role is set to grow in the future.

Current day business operations are characterized by high pressures to meet customer demands, the eternal quest to implement cost savings and achieve increased competitiveness, as well as the drive to hit ever-shrinking time-to-market windows. To meet these demands, companies need to change their design paradigms and start using modern product development methods to remain competitive.

The ever-increasing complexity of design (see Figure 1) has made it imperitive for research and development teams to adopt optimization methods, including both parametric and non-parametric optimization and to incorporate large numbers of variables, objectives, and iterations in their R&D processes.

A company's product development strategy is a core success factor in any business and the focal point that drives organizational growth. The effective implementation of the correct product development strategy can make a business successful in the fiercely competitive environment.

Traditional product development approach

The traditional approach to product development starts with the development of an initial design, which is used to develop a prototype for an experimental test. The prototype is usually the best guess for the design problem. The process is iterated until the desired stage is reached.

The effectiveness of the traditional approach is predicated on the experience of the R&D personnel, the development time allocated, and the development budget. The approach is usually based on trial and error and is unfortunately a highly time-consuming process and remarkably costly. The traditional approach to product development allocates relatively little time to the design phase. It focuses, rather, on prototype testing and leaves the required design changes to the product for later.

During economic downturns, companies often start cutting the appropriation of product development to achieve cost savings. This usually reduces product development activities and product quality, which in turn adversely affects the company's competitive position and ability to take advantage of an economic upturn.

Optimization-driven product development approach

Why should companies employ optimization? Studies have shown that product development accounts for 75 % of fixed costs (See Figure 2 over-

leaf). There are, therefore, many possibilities to reduce costs and gain competitiveness through optimization, which reduces the down-time that is needed for research and development in many ways.

With topology optimization, for example, it is possible to start the product development process with an already optimized design. It is a valuable asset for companies if they can balance this multi-objective optimization challenge and have the right product on the market at the right time. See info box 1 for an example or results achieved with topology optimization.

Info box 1

Topology optimization example

A leading automotive OEM manufacturer used topology optimization for engine and gearbox mount castings and achieved:

- Average weight reduction of 15 % compared to non-optimized parts
- Reduction of development time by releasing die-cast tools based on simulation results
- Reduction of material cost

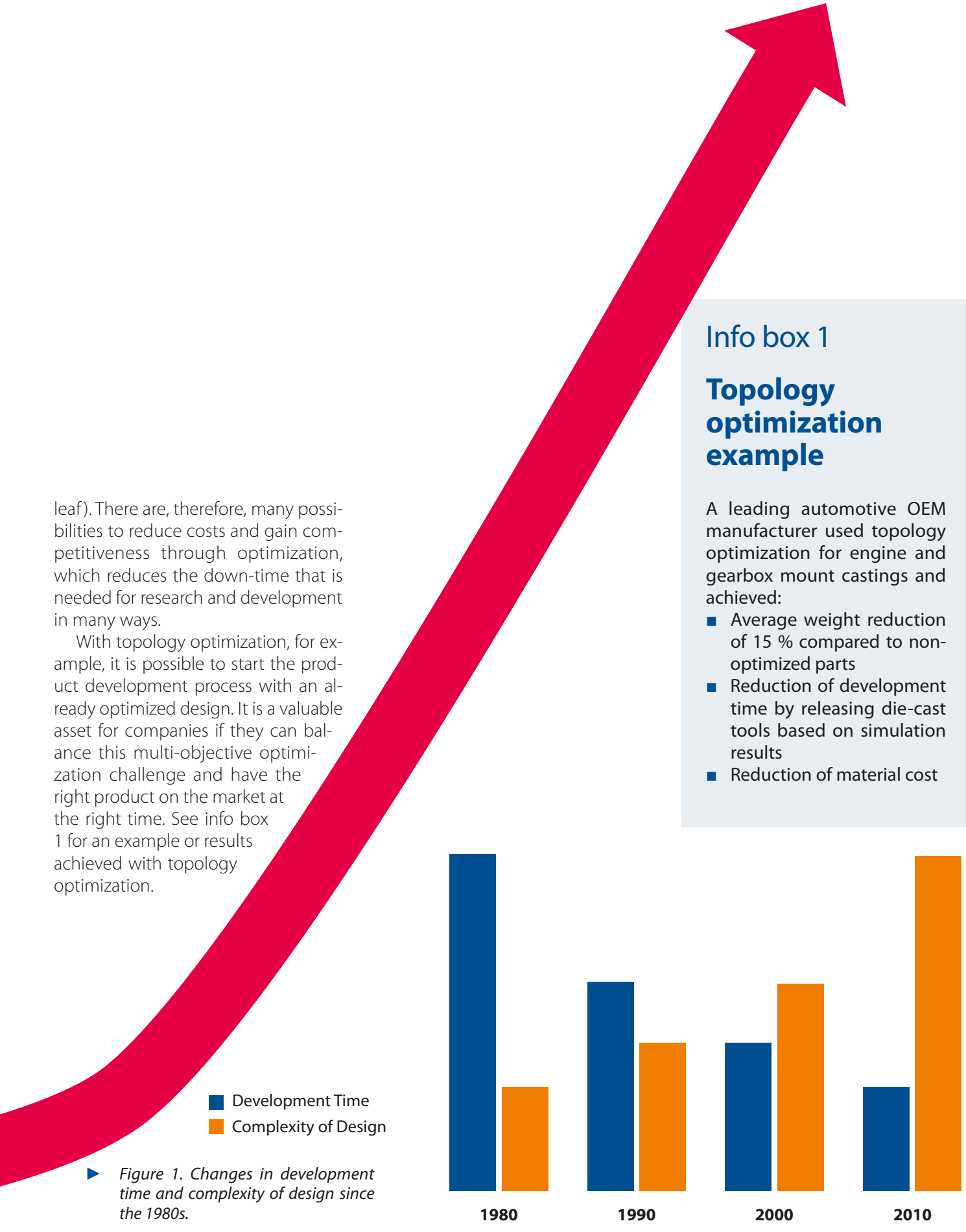
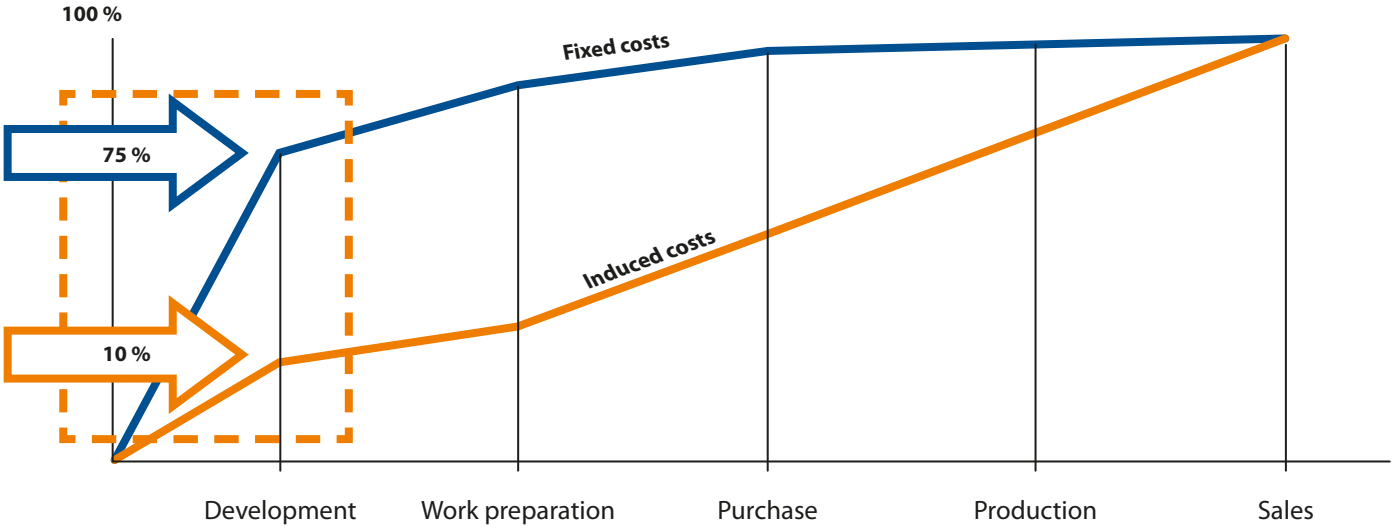
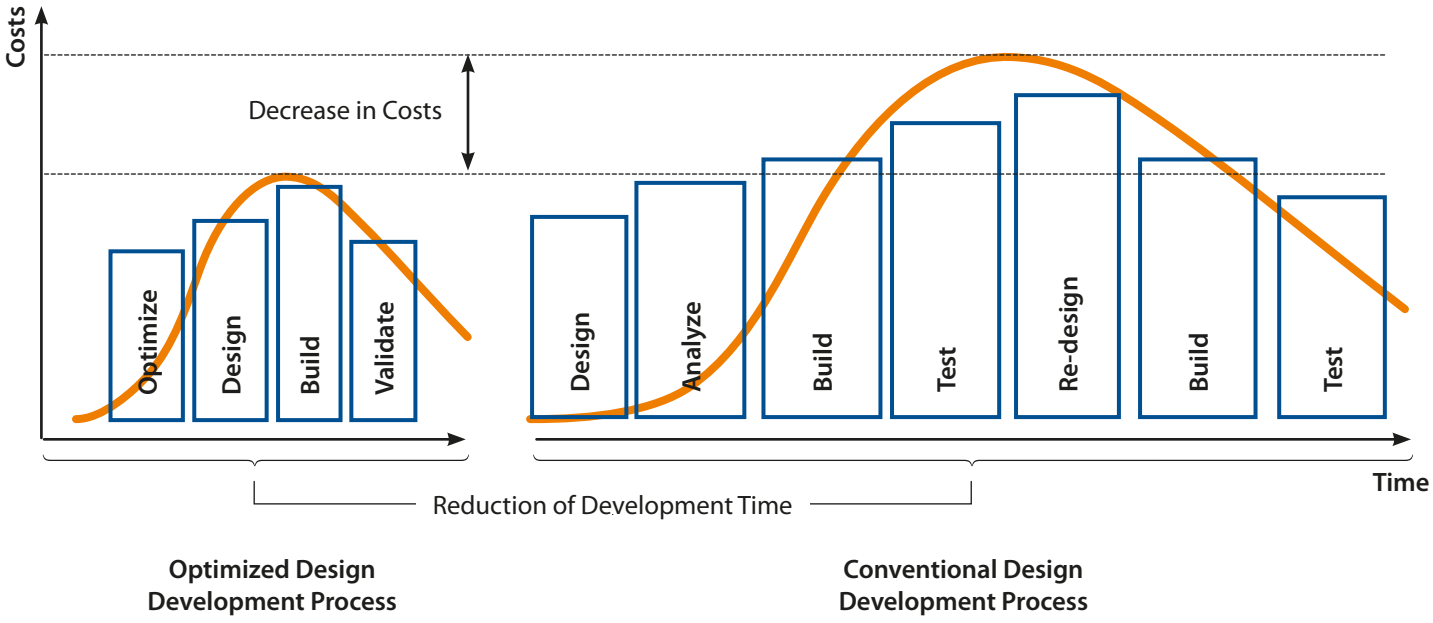


Figure 1. Changes in development time and complexity of design since the 1980s.





Info box 2: **The benefits of optimization**

- Create more reliable and durable products
- Optimize design parameters, honing the understanding of ideal solutions
- Save days or weeks by removing design bottlenecks in the R&D workflow
- Increase early phase CAE capacity to address innovation initiatives
- Eliminate waste
- Get higher quality products to market faster
- Strong return on investment (ROI)
- Reduce
  - time-to-market
  - physical tests
  - prototype builds
  - weight
- Improved
  - product performance
  - fulfilment of high product requirements
  - eco-efficiency
- Streamline complexity
- Increase product efficiency
- Improve durability

The paramount design challenge is getting it right the first time.

◄ *Figure 2. Cost reduction. Research and development accounts for 75 % of fixed costs and 10 % of induced costs. It is, therefore, crucial to use optimization tools in the R&D process.*

◄ *Figure 3. A comparison of optimization-driven design and conventional design development processes with regards development time and cost. The conventional design development process is strongly based on iterations (trial and error). It can produce many bad designs before the "optimal" design is found and is highly time-consuming.*

In addition to reducing costs the optimization-driven approach also increases product quality, reduces lead times and is an excellent tool for solving complex design problems. Optimization with virtual prototypes accelerates the R&D process and enables decisions to be made in the early phases of the design cycle. See Figure 3 for a comparison of optimization-driven design and conventional design development processes.

Optimization also improves manufacturing

Optimization is not only a tool for R&D; it can also be used to evaluate and improve the manufacturing process. It is possible to couple optimization tools with durability analysis programs.

For example, a Tier 1 level automotive component supplier performed a sensitivity analysis for a front cradle part to find sensitive and critical weld seams. As a result, the component supplier succeeded in reducing its manufacturing and warranty costs by increasing the durability of the component and reducing the weld quality for non-sensitive welds.

This article has made the case for the optimization of R&D processes. I have indicated that optimization is crucial in gaining a competitive edge, being able to meet customers' ever stringent demands, and reducing R&D lead-times, now and in the future.

Optimization-driven R&D is superior in many respects to traditional R&D methods, which are highly dependent on funding and experienced research teams, take long to complete, and can be surprisingly costly.

It is no longer a question of whether R&D processes should be optimized, but rather how and when.

Sources

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NAFEMS Simulation Capability Survey 2013.

About the author

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Petri Seppänen started working at Elomatic as a structural analyst in May 2015. He has worked in consultancy, simulation and design tasks within mechanical design since 2008 and is specialized in multibody simulation (MBS) and optimization (parametric and non-parametric optimization). From 2012 to 2015 Seppänen worked as a technical consultant in the automotive industry and consulted OEMS and Tier 1 level component suppliers. He has also performed pre- and post-sale support for an optimization program.

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Combining 3D scanning and 3D printing

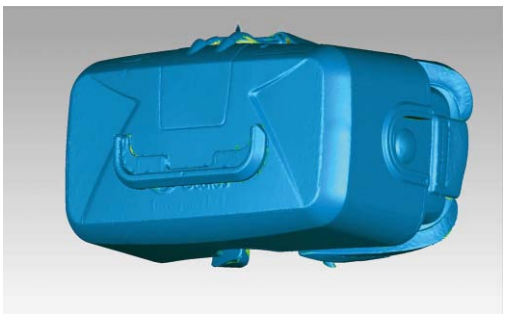
Object

Combining 3D scanning with 3D printing opens up a whole new world of possibilities to create auxiliary and replacement parts. Here a removable marker stand for an Oculus Rift headset was created for use in virtual reality projects.

The information received from scanning an existing part can be used, for example, to 3D-print a component.

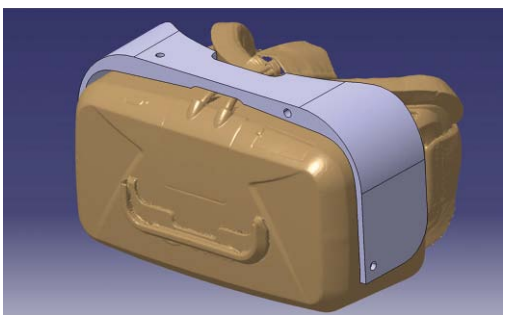
Elomatic's Advanced Technologies team used the technologies to create a removable marker stand for an Oculus Rift headset that is used in virtual reality projects.

After scanning the headset a 3D model was created in which the marker stand was modelled. From there the marker stand was 3D-printed and attached to the headset ready for use.



Scanned Mesh of Object

3D Printed Object



Design Model with Marker Stand

End Result