

ESSENTIAL

FREUDENBERG SEALING TECHNOLOGIES
THE MAGAZINE – ISSUE #1 2015

INNOVATION – PROCESS OR ACCIDENT?

With its award-winning Innovation Management System (IMS), Freudenberg Sealing Technologies is leaving nothing to chance.

INDUSTRY IN INDIA

Interesting facts about the partner country to HANNOVER MESSE

INDUSTRY 4.0

Into the fourth Industrial Revolution with digitization

OPEN INNOVATION

Interview with Prof. Dr. Frank Piller on web-based innovation techniques

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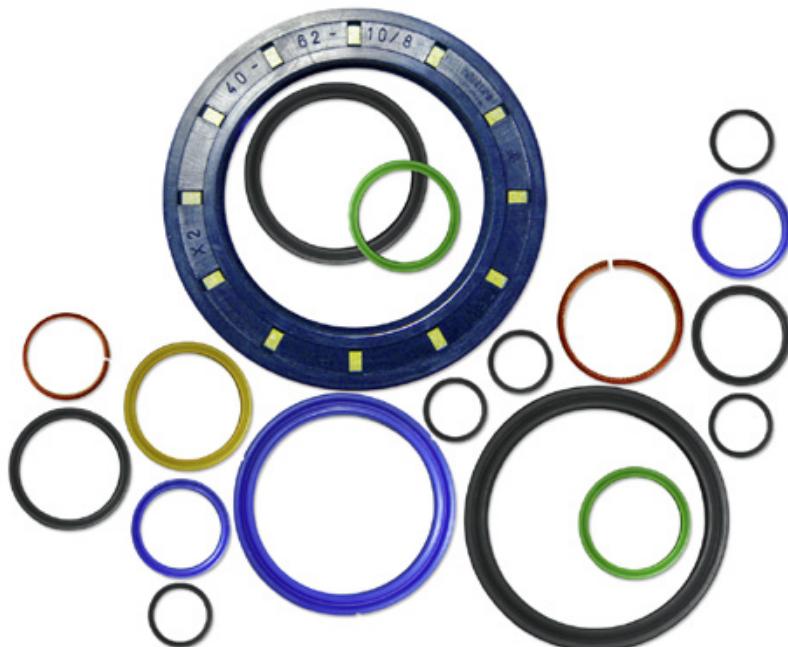
MEGAFACES

The MegaFaces project, designed by London-based architect Asif Khan for the 2014 Winter Olympic Games in Russia, combines digital, sculptural and architectural innovation. The kinetic façade of the MegaFaces Pavilion in Sochi replicated three-dimensional objects and presented human faces in three dimensions, each resembling a gigantic, moving pin cushion.

Measuring 18 by 8 meters, the installation consisted of 11,000 telescoping cylinders. Like pixels on a giant screen, each represented an image point of the overall façade, could extend hydraulically up to two meters out or in as part of a three-dimensional form, and could change color. 3D photo booths, specially developed for the project and placed inside the pavilion and at various locations in Russia, created 3D facial scans of visitors.

The image data generated were converted into control data and sent to the individual actuators. So that no one missed their own face being shown, participants were notified of the exact time of their appearance by SMS. As many as three portraits, each up to 8 meters high, were visible simultaneously on the façade of the MegaFaces Pavilion – and were larger than the face of the Statue of Liberty.

For several seconds, MegaFaces made it possible for anyone to be the face of the 2014 Winter Olympics.





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INTERVIEW WITH DIETER SCHÄFER

The Chief Operations Officer (COO) of Freudenberg Sealing Technologies on the challenges of Industry 4.0.



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INDIA – FACTS AND FIGURES

What's exciting and inspiring about the subcontinent's society and economy.



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A SYSTEM OF INNOVATION

The Innovation Management System (IMS) at Freudenberg Sealing Technologies is designed to systematically develop the potential for innovation. And that's exactly what it has done.



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INDUSTRY 4.0

What is behind the fourth Industrial Revolution?



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OPEN INNOVATION

You don't have to invent everything by yourself. Dr. Frank Piller, an expert on open innovation, on how the Net has changed the process of innovation.



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ENGINE SUMMIT

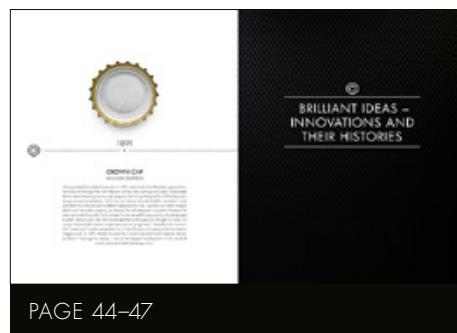
The International Motor Symposium, the global summit for engine developers, comes around every other year at Vienna's Hofburg. Freudenberg Sealing Technologies will be there with LEVITEX®.



PAGE 28–31

LIFE IN INDIA

What life is like in the partner country for this year's HANNOVER MESSE. ESSENTIAL visited with an Indian engineer amid his daily routine.



PAGE 44–47

BRILLIANT IDEAS

Sometimes the products that will have an impact on our daily life emerge accidentally. ESSENTIAL presents the curious origin stories of some ground-breaking innovations.



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AN INDUSTRY ELECTRIFIED

The electrification of the drivetrain is on the march, presenting seal manufacturers with new opportunities as well as challenges.

#1

MACHINES AMONG THEMSELVES

Machines are communicating with machines, changing production processes, triggering orders and assembling shipments to customers. People are only called in when disruptions occur. In its execution, the vision of Industry 4.0 not only relates to the way we fabricate things, but it also reflects the way we are changing society as a whole.





INDUSTRIAL TREND THE INTERNET OF THINGS

#2

Whether this in fact marks a fourth revolution or the consistent evolution of our digital world, the effects can already be felt. Flexibility and efficiency – in development, production and logistics – are the crucial benefits. If you turn your back on this trend, you could find yourself among the losers tomorrow. Machines no longer just provide assistance; they make decisions. The Internet of Things will rearrange our lives in many areas – in the smart home, the smart grid, the (self-driving) smart car or the smart factory. It is a vision with many challenges and risks – but even more opportunities.



#3

SUBCONTINENT OF EXTREMES

Nowhere else in the world are modern and archaic traditions likely to collide as forcefully as in India, this year's partner country to the Hannover Messe. No nation has as many highly qualified programmers – while the bulk of the population can only dream of an education and the participation of the rural populace in the country's social progress remains a distant goal.





INDUSTRIAL TREND INDIA

#4

By the middle of the century, at the latest, India will be the most populous country on the planet, with more than 70 percent of its inhabitants of working age. By contrast, China – as a consequence of its rigid family policies – will have to live with an increasingly aged society. The prospects for India are outstanding if it manages to improve its education and health care systems on a sustained basis, and if bureaucratic obstacles or social structures no longer stand in the way of foreign investment and continued industrialization.

#5

OUTSIDE THE BOX

Every company lays claim to being an innovator. But innovations require a break with tradition. And here it gets complicated. That's because it becomes necessary to call things into question and do things differently than in the past.



INDUSTRIAL TREND OPEN INNOVATION

#6

As a result, most innovations emerge neither in R&D departments nor within the framework of research contracts. Instead, the most fertile sources of innovative impulses are frustrated users of inadequate products. They mostly stay behind the scenes and often cook up their own solutions. On occasion, their concepts lead to products that we can hardly imagine doing without in our daily life today. The Internet and global networking are now giving companies the opportunity to engage in dialogue with creative users and to learn from them. There are a couple of key conditions if they want to derive innovations from these potential external ideas – intensive listening and an openness to new thoughts coming from outside their own box.

6

QUESTIONS
to

DIETER SCHÄFER

Chief Operations Officer (COO),
Freudenberg Sealing Technologies



1 MR. SCHÄFER, EVERYONE IS TALKING ABOUT INDUSTRY 4.0. WHAT IS YOUR VISION OF THE FOURTH INDUSTRIAL REVOLUTION? Not only have we been watching this development with great interest for years, we have already introduced various elements of Industry 4.0. For example, we already have self-management processes at our Schneegans subsidiary. Here, machines communicate with one another and optimize their respective parameters, but networking within the process still takes place internally. We use open interfaces only for communication with the tool setter. Status information or problem reports are sent directly to his smartphone.

2 IS INDUSTRY 4.0 CREATING SMART PRODUCTS IN ADDITION TO SMART FACTORIES? Industry 4.0 is changing products and services, too. A Simmerring® with condition monitoring can detect possible malfunctions or disruptions in advance, before a machine comes to a stop. This is of major importance, especially for wind turbines, offshore parks and crucial systems that are hard to access.

mutual language for the machines. But this will happen gradually and certainly not based on a schedule for the entire company. With our diversified and decentralized production, we have excellent options for introducing something in one location and learning from it at other facilities. In the end, the competitive strength of a company will increasingly depend on its capacity to network closely with all the market participants involved in its production process.

5 IN YOUR VIEW, WHAT BARRIERS MUST STILL BE OVERCOME? The demands for greater speed, flexibility and individuality, all the way down to batch size 1, are naturally a huge challenge for a company that produces about 400 million seals a month and offers more than 300,000 different products with delivery times of up to six weeks. Above all, absolute data security must be guaranteed. With open interfaces, you are relinquishing access to your innermost workings – you have to ensure ahead of time that your data are just as well protected against misuse as in a purely internal process. In addition, the data network

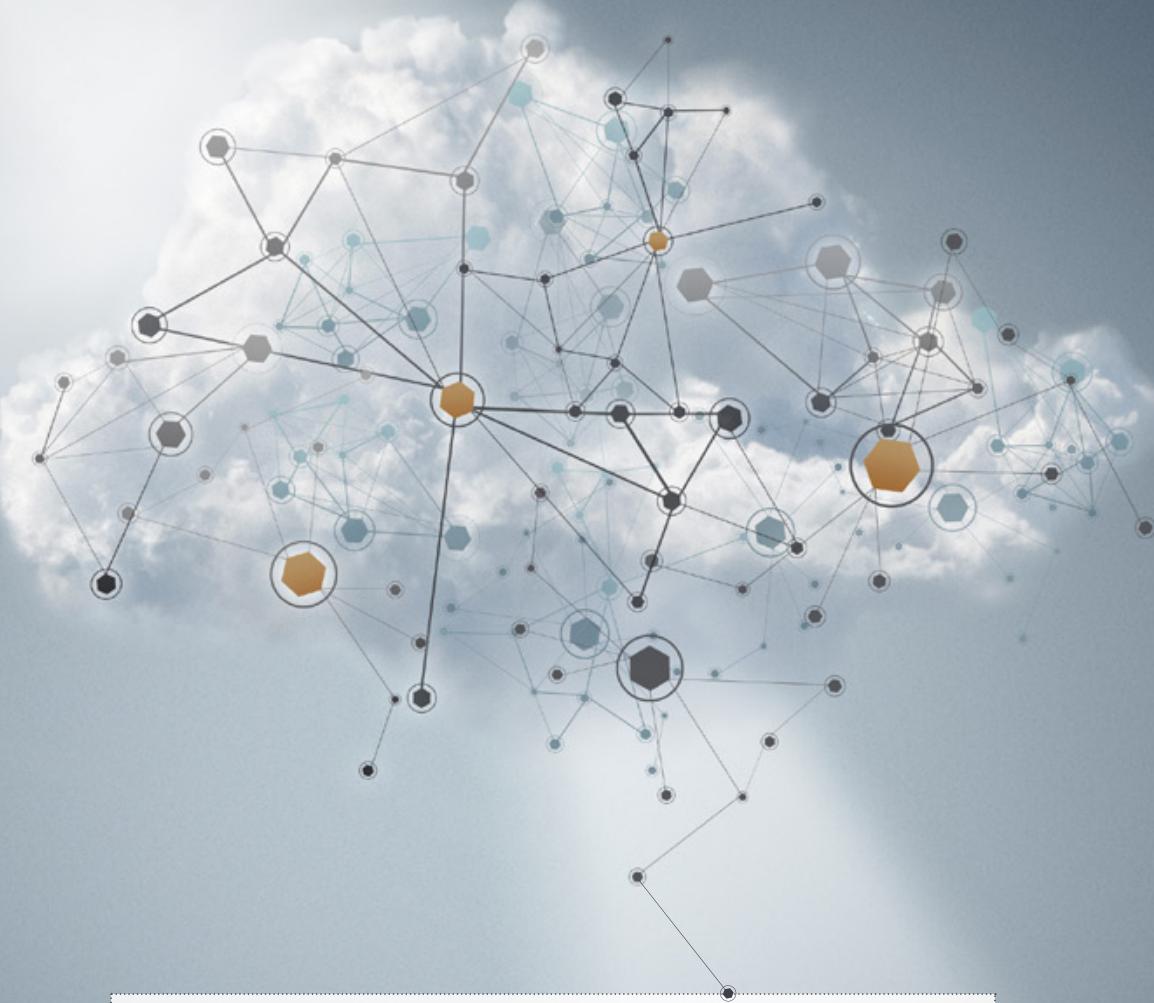
"NETWORKING ACCELERATES INNOVATION"

3 IT'S GOOD TO HAVE THE RIGHT PART IN YOUR INVENTORY. That's correct in principle, but it's our job to achieve maximum flexibility instead of relying on costly warehousing. Freudenberg Xpress is our answer to the situation. We are in a position to offer our customers highly individualized, specific product solutions and manufacture them precisely to their requirements without any loss of quality and in the shortest possible time. Manufacturing of the future will generally be subject to stringent requirements. They must be intelligent, alterable, efficient and sustainable. We can already execute this very well at Freudenberg Xpress and thus provide customers with ideal support.

4 WOULD YOU ACTUALLY TALK IN TERMS OF A REVOLUTION? We see Industry 4.0 rather as an evolutionary process. A high degree of automation and stable processes are the basic prerequisites. If both are present, we can implement self-management. For the next step, which is networking with customers and suppliers, the prerequisite is a standardized,

must be faster and more stable overall. The more communication takes place over the network, the less we can afford breakdowns. The trend is unstoppable. According to experts, the number of devices and machines networked with one another will face rapid growth by 2020.

6 IF INNOVATION CYCLES ARE SHORTENED DUE TO NETWORKING, WHAT EFFECT WILL THIS HAVE ON FREUDENBERG SEALING TECHNOLOGIES? We are relying on continual, systemic and efficient innovation management, which helps to set us significantly apart from the competition – across all industries. We do not consider innovation to be a selective snapshot. Instead, it involves ongoing optimization and development. We are also putting all our processes and procedures to the test again and again. Innovation is our core competency. We are very confident in this respect. And we have already been practicing one of the main requirements of Industry 4.0: close cooperation with all partners. We see ourselves as a solutions provider that meets new challenges and makes changes in concert with its partners.



INDUSTRY 4.0

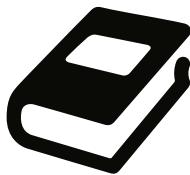
SINCE AT LEAST HANNOVER MESSE 2011, THE PHRASE
ON EVERYONE'S LIPS HAS BEEN "INDUSTRY 4.0"

The digitization of classic production is expected to bring a decisive increase in value creation and serves as a catchword for the fourth Industrial Revolution. But as prevalent as the issue is in the media and as clearly as numerous studies have documented it, the path to implementation is still long and rocky. Here ESSENTIAL attempts to pin it all down.

How far are we from Industry 4.0?



ON THE EVE OF THE REVOLUTION



Over the centuries, people's lives hardly changed – and within an individual lifespan, they barely changed at all. Agricultural techniques and artisan skills lasted whole eras, as did social structures. But that has changed. When an 80 year-old today looks back on his life, it seems the face of the world he lives in is hardly comparable in many aspects with what he knew from his childhood. Mobility, media and personal circumstances: nearly everything has been subjected to rapid change that sometimes seems hard for the individual to grasp. Education and enlightenment have been the decisive impetus for profound change.

IN THE BEGINNING THERE WAS THE BOOK

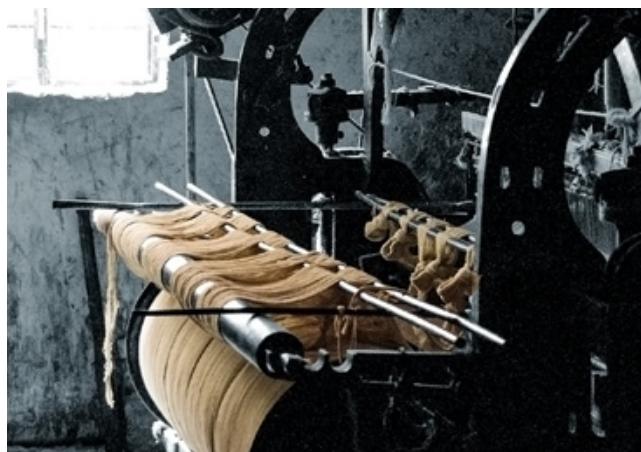
The beginning of a massive social revolution can be dated to the mid-15th century. Johannes Gutenberg of Mainz invented printing with movable type – a prerequisite for producing and distributing writings in large numbers. In 1997, the famous American maga-

zine "Time Life" called Gutenberg's invention the most significant discovery of the past millennium. In late 1998, American journalists even bestowed the title "Man of the Millennium" on Gutenberg in their book "1000 Years - 1000 People".

In 1517, without the new communication technology, it would have been virtually impossible for Wittenberg monk Martin Luther to publicize on a large scale the contradictions between the contents of the Bible and social conditions. Starting in the 16th Century, the Reformation cleared the way for the Enlightenment – the spiritual and social reform movement that changed mainly Europe between 1650 and 1800, but altered North America as well. The core idea of the Enlightenment was to overcome all the structures hindering progress by thinking rationally. Education was a central element. And it was not only rationality – reason – that became increasingly important; so did the rationalization of value-creating processes. This was an absolute necessity in view of the rapid population growth as well as the growing size of cities, with all their associated problems of supply and disposal.

THE FIRST INDUSTRIAL REVOLUTION – WATER POWER AND WEAVING LOOM

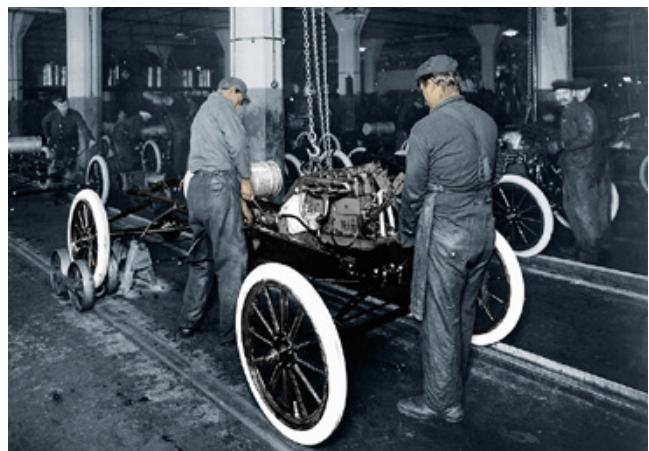
Historians agree that, in the time since the 10th century before Christ, during the transition from nomadism to sedentary life, people's lives did not change as much as they did during the first Industrial Revolution. It took hold in the second half of the 18th century and developed massive momentum during the 19th century. Water and steam power replaced many aspects of physical work. Mechanization allowed division of labor and thus the start of industrial production, the symbols of which are the steam engine and mechanical loom. The textile industry went through a massive upheaval at the start of the 19th century, with manufacturing in numerous small workshops increasingly transferred to large factories. Social unrest was one consequence of this development: 250,000 English handweavers bitterly resisted the introduction of mechanical looms and even burned down factories.



THE MECHANICAL LOOM –
the epitome of the first Industrial Revolution

SECOND INDUSTRIAL REVOLUTION – ELECTRICITY AND RESEARCH

The second Industrial Revolution, which began around 1880, bears the stamp of the chemical industry and electricity. Company-owned research laboratories emerged for the first time. They transferred their physical and chemical findings – including new substances and materials – directly into development and production process. If the first Industrial Revolution basically made familiar items such as textiles less expensive for the most part, the second Industrial



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ASSEMBLY LINE PRODUCTION AND ELECTRIFICATION were typical of the second Industrial Revolution

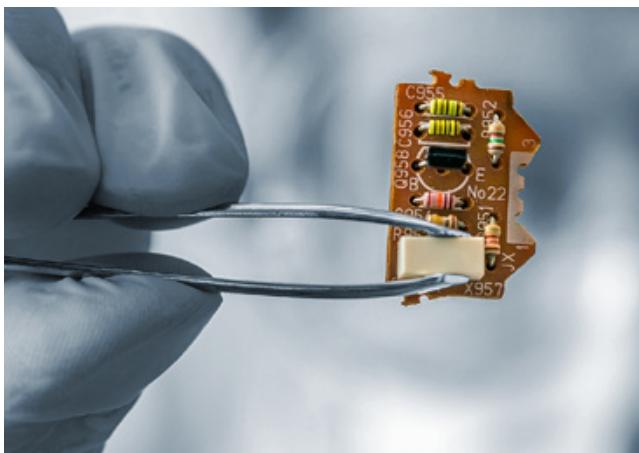
Revolution created entirely new products thanks to the systematic implementation of newly acquired expertise. Furthermore, modern mechanical engineering enabled the production of complex systems such as the first automobiles. Even the production process itself increasingly became an object of research. The introduction of the assembly line and thus mass production gave many people access to products that had earlier seemed beyond their reach.

In addition, the second Industrial Revolution introduced unprecedented growth in the world's population. Between 1750 and 1920 – that is, within 170 years – it grew from 1 to 2 billion people, and it has surpassed another billion mark roughly every 12 years since the 1960s.

THE THIRD INDUSTRIAL REVOLUTION – THE MICROCHIP MAKES ITS DEBUT

The third Industrial Revolution is also known as the digital revolution, the symbol of which is the microchip and its steady increase in output based on Moore's Law*. Steady improvements in microchips have enabled the growing automation of production, the establishment of global communication networks and the digitization of all information available worldwide. In 1993, only about 3 percent of all information storage capacity was digital. The assumption today is that it is nearly 100 percent. Since the start of the third Industrial Revolution – roughly the mid-1980s – computers have not only continued to gain importance in the professional arena, it is no longer possible for people to conceive of their personal lives without them. The proliferation of computers has led to completely new approaches in entertainment, science and consumption.

* This law, formulated by Gordon Moore in 1965, stated that the computing power of newly developed microchips doubles every 18 months.



ELECTRONICS MADE THEIR WAY into the third Industrial Revolution

Within just a few years, completely new industrial sectors and companies have emerged. It is not unusual for their share prices to surpass those of old, established companies many times over.

Phenomena such as globalization or a globe-spanning youth and pop culture would be inconceivable without the achievements of the third Industrial Revolution. But even political processes have changed due to digitization. Without social networks, there would have been no Arab spring. But the positive aspects are countered by the negatives: worldwide networking quickly leads to an undesirable transparency – and it has nearly made the threatening vision of the transparent human being or the transparent company a reality.

INDUSTRY 4.0 – THE SMART FACTORY

The term "Industry 4.0" made its debut at Hannover Messe 2011. It stands for the concept of an intelligent factory that stands out for its interactivity, capacity to transform itself, resource efficiency and ergonomics. It is accompanied by greater complexity in the entire value creation process, from development to delivery, including the incorporation into the process chain of customers and partners. What mainly differentiates Industry 4.0 from conventional processes is that products and production systems become intelligent and networked.

To this end, the smart factory incorporates the Internet. All the machines and people involved in the production of a product communicate with one another. Smart products can – thanks to embedded microchips – exchange information with production facilities and suppliers. They also know their current processing status as well as the production steps and additional components that are needed before they achieve their final form. Smart production systems know their capabilities and can plan their capacity based on the current order situation. In a smart factory, the "Internet of Things" is more than an improvement of existing IT support processes, it takes advantage of huge data quantities ("Big Data") that are available on the Net and analyzes sequences and effects – which previously could not be captured – with highly complex algorithms. This results in a self-learning system that continually optimizes the decisions of largely autonomous subsystems. Industry 4.0 creates the conditions for individualized, self-governing decentralized production.





SMALL BATCHES – AND ENORMOUS FLEXIBILITY

In a practical example at Hannover Messe 2014, Festo Didactic and SAP jointly presented an 8.6-meter-long production facility where workpieces told machines how they should be processed. Two completely different product groups were assembled – a remote control unit and electronic smart-meter components. A number of product variations were also possible. The workpieces communicated with the equipment via RFID, or radio frequency identification. This consistently enabled them to move to the right station, identify themselves as a certain part or version and communicate the right processing order. In this way, it was possible to produce various versions in any given sequence and volume on a single production line. The example demonstrated that batch-size 1, meaning the production of precisely one product with an individualized customer configuration, has moved into the realm of the feasible.

The smart factory combines the most advanced equipment technology with a cloud-driven system for order administration and production control. This ensures a high level of flexibility for order changes, a mix of variations or the required process adjustments.

Regular self-tests increase equipment availability. In the event of a disruption, the system automatically notifies a service technician by SMS and simultaneously cites its cause.

INDUSTRY 4.0 – ALSO A SERVICE ISSUE

In addition to production facilities that are fit for the future, Industry 4.0 enables “smart service” – proactive maintenance and repairs. Normally, machines or production facilities are maintained at regular intervals or when a disruption occurs. Unplanned disruptions or equipment breakdowns lead to huge costs. For a facility operator, it would be hugely advantageous to be able to calculate predictions for equipment breakdown. This is possible with the complete vertical integration of measurement data into the machine cloud and into service processes. A multitude of collected data – from similar machines under similar conditions of use – can be analyzed in the cloud in real time. If the machine reaches critical values, a specific repair or service order is generated. Thus, an integrated system reduces both unplanned machine breakdowns and maintenance costs.

The example shows that Industry 4.0 is more than just a smart factory – it also

means smart products. That’s because a machine component built according to Industry 4.0 principles not only knows when it needs maintenance. Since it knows the history of its production and its prior use, it also knows what replacement part the technician has to provide when it is needed. In any case, the notion of networking makes the smart factory an important component of future intelligent infrastructures. The “Internet of Things and Services” also includes the smart grid, smart mobility, smart logistics and the smart home – the intelligent, networked house.

NEW BUSINESS MODELS

New cooperation and business models are emerging within the framework of Industry 4.0. They will make it possible for small and medium-sized companies to use services and software systems that are currently barely affordable due to existing licensing and business models. Industry 4.0 scenarios, such as “networked production”, “self-organizing, adaptive logistics” and “customer-integrated engineering”, require concepts implemented by a highly dynamic network of various partners, not generally by a single firm as in the past. The main requirement is integrated engineering that encompasses both production as well as the manufactured product and that in-



termeshees seamlessly within the digital as well as the physical world. This tends to reverse the centralizing structures of the first Industrial Revolution. Networking enables decentralization – with all its associated advantages.

HOW FAR ALONG IS INDUSTRY?

On the eve of the revolution, a question arises: What role will people and companies play in this? In a study by Staufen AG, which surveyed 140 industrial companies for the "German Industry 4.0 Index" during August of last year, it became clear that many firms still cannot precisely assess their role in this field. More than two-thirds of the companies have either not yet dealt with the issue or, at best, find themselves in an observer role. 14 percent of the surveyed firms have started individual projects – but only one percent says they have comprehensively implemented Industry 4.0.

Of the companies dealing concretely with the implementation of Industry 4.0 concepts, more than 90 percent are focusing on manufacturing. Research and development as well as logistics and warehousing are also priority fields. All other fields hold little importance to the companies. Logistics in particular are presumed to offer great

potential, especially when it comes to flexibility and deadline performance – even ahead of costs and product quality.

BUILDING SKILLS FOR COMPETITIVE ADVANTAGE

Many studies have shown that the number of uncomplicated jobs that exclusively involve routine activities has been in decline for years. Industry 4.0 will accelerate this trend – that is the assumption at least. In fact, 85 percent of the companies surveyed assume that the number of highly skilled jobs in their company will grow in future. While small and medium-sized companies are calculating a net increase in jobs, 61 percent of large companies are assuming that the number of jobs overall will decline in the course of Industry 4.0. In particular, there will no longer be a need for low-skilled workers.

But there is a need to catch up. The companies only give themselves mediocre grades when it comes to preparing their employees for the transformation. According to their employers, only about 45 percent of employees in manufacturing know what will be asked of them in the future. In the logistics and warehousing areas, the figure is just 14 percent. So far, 70 percent of companies are not even offering training on

Industry 4.0. A mere 11 percent of companies are dealing with the issue in existing continuing education programs, and just 5 percent offer special training on it.

Active engagement with Industry 4.0 issues is urgently needed to prepare individual companies for the future. This is the conclusion drawn by the Industry 4.0 working group of the German Ministry for Research and Technology. Its final report recommends that, in light of a looming shortage of skilled workers, it is important to maintain the productivity of older employees over the course of a long working life. In the work processes of the fourth Industrial Revolution, it is true that employees can focus on creative, value-adding activities and that they are unburdened from routine tasks due to smart assistance systems. Flexible work organization also makes it possible to better combine a career, private life and continuing education. A harmonious work-life balance is the result. In addition, Industry 4.0 makes it easier to manage demographic shifts.



WHAT IS EVERYONE ELSE DOING?

Germany is one of the most competitive industrial centers and German companies lead the world in the field of factory equipment. Not least of all, this is related to a specialization in the exploration, development and manufacturing of innovative production technologies as well as the capacity to control complex industrial processes. Other crucial factors are its strong equipment and plant engineering, its considerable IT expertise and its know-how in embedded computer systems and automation technology. Germany has an excellent foundation to expand further its leading position in production technology.

But the global competition in this field has grown as other countries have recognized the trend toward the use of the Internet of Things and Services in industrial manufacturing.

UNITED STATES

The United States is trying to counter its deindustrialization with promotional programs for the Advanced Manufacturing Partnership (AMP). The AMP steering committee, consisting of presidents of the country's top engineering universities and CEOs of leading U.S. companies, has initiated the National Network of Manufacturing Innovation (NNMI). The network, conceived as a series of public-private partnerships, has the goal of making U.S. companies more competitive and increasing investments in U.S. production facilities, functioning as regional centers for manufacturing excellence. In addition, the National Institute of Standards and Technology, which is responsible for standardization processes, handles the Advanced Manufacturing Portal. It was set up at the Advanced Manufacturing Partnership's recommendation and is designed to ensure the networking of governmental, university and private initiatives in this area.

CHINA

China is also striving to expand its machine-tool sector. According to its 12th five-year plan (2011-2015), the country's dependence on foreign technologies is supposed to be reduced in seven "strategic industries", including high-end equipment



WHAT NEEDS TO HAPPEN?

All the studies and surveys suggest that industrial production is facing a paradigm shift. But – on the eve of the revolution – is not clear to everyone where the journey is headed. Industry 4.0 needs the right general conditions to support implementation. The final report of the Industry 4.0 working group identifies eight areas that may be crucial factors determining whether people and companies are among the winners or losers.

Standardization of the reference architecture

Networking across companies requires common, uniform standards. A reference architecture is needed for their technical description.

Mastery of complex systems

Since products and production systems are becoming more and more complex, engineers must have special methods and tools at their disposal to develop adequate planning and explanatory models.

A comprehensive broadband infrastructure for industry

High-quality, fail-safe and comprehensive communication networks are an indispensable prerequisite. For this reason, the broadband Internet infrastructure must be massively expanded.

Security

The risk of unauthorized access also rises with networking's growth. Integrated security architectures and explicit, counterfeit-resistant proofs of identity are therefore critical to success. But operational security is also an enormously important aspect.

>/ACCESS GRANTED

Work organization and structuring

Real-time-oriented control is changing job content, processes and environments. The participation of employees in work structuring and reference projects designed as models are important keys to success.

Training and continuing education

Along with job-related continuing education, appropriate employee training strategies and a work organization that promotes learning are necessary to accommodate changes in jobs and competency profiles.

Legal framework

The legal challenges largely involve the protection of company data, but there are also issues relating to liability, trade restrictions and the handling of personal data.

Resource efficiency

Processes based on Industry 4.0 must provide proof of improved resource efficiency.

If a systematic approach succeeds with the solidarity of all participants, the available base technologies can be adjusted and innovative solutions to new facilities and markets can be developed. The revolution requires an evolutionary process, the potential of which should rapidly become transparent with reference and demonstration projects. Industry 4.0 can only be implemented if society and technology advance hand in hand – on the way to a sustainable and humane industrial future.

manufacturing and new-generation information technology. At the same time, the country is supposed to take the technological lead in these sectors.

To accomplish this, Chinese leaders are making a total of 1.2 trillion euros available and are stimulating supply and demand with subsidies, tax relief and other incentives. The share of expenditure on research and development (R&D) should rise from 1.2 to 2.0 percent of gross domestic product. In machine-tool manufacturing, the focus is on the development of smart production equipment, smart control systems and digitally controlled machines. Efforts in the IT area are centering on the Internet of Things and its applications, among other topics.

An "Internet of Things" conference has been held annually in China since 2010; China's first IoT center was opened at its start. Promoted with 103 million euros, the center is devoted to the exploration of basic IoT technologies and the associated requirements for standardization. Wuxi in Jiangsu province is considered China's "IoT" innovation zone. It is home to 300 companies with more than 70,000 employees. In all, the Chinese government intends to invest 705 million euros in the IoT industry.

INDIA

India's five-year plan (2012-2017) focuses on the promotion of innovation and predicts an increase in governmental and private R&D spending to 2 percent of the country's economic output. In 2011, its Cyber-Physical Systems Innovation Hub was launched under the backing of the Ministry of Communication and Information Technology, which, among other things, conducts research on humanoid robotics. In November 2011, Bosch founded its Centre for Research in CPS in Bangalore. Top Indian research centers and the Fraunhofer Society are participating in this project in a consulting role. The goal of the collaboration is to create the optimal research and work environment for the IT specialists of the future. A total of 22.8 billion euros has been made available for it. In future, research contracts are expected to support industry and science. In an international comparison, a current study by the Zebra Tech firm found that Indian firms are in the lead in the introduction and application of IoT technology.



FROM THE FOG INTO THE CLOUD

INDUSTRY 4.0 IS AN EXCITING AND FORWARD-LOOKING TOPIC FOR FREUDENBERG SEALING TECHNOLOGIES. ESSENTIAL SAT DOWN WITH ED BORGER, GLOBAL VICE PRESIDENT, LEAN/GROWTTH*, AND DR. JAN KUIKEN, DIRECTOR OF ADVANCED MANUFACTURING TECHNOLOGY IN WEINHEIM, TO FIND OUT THE ROLE THAT THE FOURTH INDUSTRIAL REVOLUTION IS PLAYING AT THE TECHNOLOGY AND MARKET LEADER IN THE FIELD OF SEALING.

The diversity could hardly be any greater: the Freudenberg Sealing Technologies portfolio ranges from a Simmerring® measuring just a few millimeters, produced in huge volumes, to an individually fabricated seal for a tunnel boring machine with a diameter of several meters. These products would seem to require completely different production strategies and equipment. A general approach to a value-creation philosophy such as Industry 4.0 would seem out of the question from the outset.

But this is a view that Jan Kuiken and Ed Borger do not entirely share. To them, the future of both areas lies in networked production – the differences are primarily in the time horizon, they say. "In some areas, we have already reached the point where we are meeting the key criteria for Industry 4.0," explained 47 year-old Kuiken. For example, a system that handles self-managing processes is in use at Freudenberg Schneegans. A wide variety of environmental parameters are continually measured in the production of high-value 2K components – from the external temperature to the consistency of the raw material. Based on this information, control parameters such as the heating time and injection speed of the material are adjusted to ensure the

absolutely consistent quality of the final product at all times. "Previously, a setter had to check these parameters constantly and undertake the changes himself," said Kuiken, a native of the Netherlands who has worked at Freudenberg since 1993. "In the best case today, he gets a text message on his smartphone, informing him about any deviations. But the adjustment itself takes place fully automatically."

The system at Freudenberg Schneegans is on the brink of interactive manufacturing. As a next step, the machine's capacity to complete its own data analysis is expected to increase, by determining, for instance, the load level and the timing for the next required maintenance, based on previously processed orders or by using an algorithm supplied from the quality assessment. It calculates the likelihood of a disruption and compares the machine's current status with upcoming orders. For example, the machine is capable of pulling a maintenance interval forward to ensure the smooth handling of the next major project. With a text message saying "I need cleaning tomorrow, so I can carry out a job the day after tomorrow", the setter knows what he is supposed to do, and productivity is improved as well.

*Get Rid Of Waste Through Team Harmony – "GROWTTH"



FREUDENBERG XPRESS

UNIQUE RAPID SERVICES FOR RE-
PLACEMENT PARTS, PROTOTYPES AND
SMALL PRODUCTION RUNS

Freudenberg Xpress is impressive in its
speed, quality, reliability and flexibility.



Instead of the cloud, Kuiken and Borger prefer to talk about the fog. Networking will initially play out on the machine level, before wholesale major networking with the Internet becomes a reality. "It will be such a densely webbed network of information and communication that we think this image is appropriate," said Borger, who, like his colleague, hails from the Netherlands. Although this involves communication over the Internet, networking with external partners will initially have a secondary priority. "As a first step, we must induce the machines to tell us their needs. Here the focus is more on the capacity to communicate than on data engineering and storage," said the 51 year-old engineer, delving into the Freudenberg philosophy. But ever more costly sensors and ever higher computing power will herald the age of Big Data as well.

The work is now a matter of mastering increasing complexity with automated processes to reduce the complexity experienced by the user. Borger likens the situation to an automobile. "Cars were previously designed much more simply. But if you wanted to start a cold motor and get rolling in the winter – you could not make a single mistake, by pressing the gas pedal too far, for example, or pushing the choke in too early. These were the only variables you had. Today, we have networked systems in our cars, ranging from injection systems to anti-slip controls and ABS, which simultaneously process hundreds of variables and are many times more complex. These systems can only be controlled automatically – without the driver noticing anything. From his standpoint, everything has become simpler."

The two engineers are convinced that Industry 4.0 will have a similar effect in manufacturing. The machine will report to the setter: "My job is almost over. Start on the new tool and think about producing the next mixture because I'm going to need it for the next day." Thus, the capacity to communicate optimizes the supply chain and reduces inventory.

But a main requirement for communication is that all the machines speak the same language – or at least have a secure translation option available. This is where improvements are still needed, because plants have many machines functioning in closed systems. Their operation is indeed excellent and they can communicate among themselves, but this will not be enough in future – all the machines and equipment must be able to have contact with their environment.

FULLY AUTOMATIC
INFORMATION
INTERACTIVE PRODUCTION
COMMUNICATION
SMART PRODUCTS
SELF-MANAGING
PROCESSES
DATA SECURITY

Borger sees, above all, stable processes as the basic precondition for the introduction of Industry 4.0. He sees "lean production" as a necessary step in that direction. "I can only benefit from the flexibility of Industry 4.0 if my processes are absolutely stable – if I know that the raw materials are available and the machines are set up the moment I want to run job XY. If the specific controls between output and what I need as input work smoothly, then, with the increased flexibility, I can benefit from the advantage in efficiency that comes from smaller batches," he said, describing the benefits of more targeted production controls.

Industry 4.0 is most likely to be introduced in fields where a high degree of automation and great process security already exist. In Pinerolo, Italy, for example, where valve stem seals are produced with a high degree of robotization, material parameters and scrap rates were included in the controls. The development times to implement these processes now can be as long as several years, but they are becoming shorter with the increasingly simple intermeshing of systems.

In Kuiken's view, the benefits will be even greater where high flexibility instead of large volumes is expected. Smart products are ushering in new prospects for service. In fields such as wind power, for example, it is conceivable that an analysis can be undertaken, either with sensors or the capture of certain load parameters, to indicate when a seal has to be maintained or replaced. Temperature deviations can also point to problems with frictional elements. It is possible to respond to these situations. Freudenberg Xpress offers a highly flexible production system capable of producing a seal within 24 hours.

Borger and Kuiken are absolutely in agreement on the fact that data security remains a key precondition for Industry 4.0. If production processes are controlled via the Internet, there must be absolute guarantees that no-one outside these processes can intervene inside them, they say. The reason is that, in future, the capital of a seal manufacturer will not only include material competency, but also the data and algorithms that control all its processes from development through production to delivery, whether for O-rings measuring just millimeters in diameter for dental drills or for a seal measuring 10 meters in diameter for a tunnel borer.



JAN KUIKEN

CONSISTENT
QUALITY
LEAN PRODUCTION
INDEPENDENT
DATA ANALYSIS
AUTOMATION
ADVANTAGES IN EFFICIENCY
BIG DATA
STABLE PROCESSES
COMMUNICATION CAPABILITY
COMPLEXITY
HIGH FLEXIBILITY
SUPPLY CHAIN
PROCESS SECURITY





HUGE POTENTIAL, HUGE PROBLEMS

IN THE PUBLIC'S PERCEPTION, INDIA OFTEN STANDS IN CHINA'S SHADOW, YET THE PARTNER COUNTRY FOR HANNOVER MESSE 2015 IS ONE OF THE WORLD'S MOST VIGOROUSLY EXPANDING ECONOMIES. WITH A CURRENT POPULATION OF 1.2 BILLION, IT IS PROJECTED TO BE THE MOST POPULOUS COUNTRY IN THE WORLD BY MID-CENTURY AND ADVANCE TO THIRD PLACE – BEHIND CHINA AND THE U.S. – IN GROSS DOMESTIC PRODUCT (GDP).

The internal contradictions could hardly be greater. On the one hand, no country has as many millionaires and billionaires. On the other, India is significantly below the level of many African countries based on many social indicators. The country's average annual income per capita is less than 1,000 euros. About 30 percent of the population lives below the poverty line of one U.S. dollar per capita per day. And on the United Nations Development Program's Human Development Index, India is in 135th place out of the 187 countries covered.

Even the mostly double-digit economic growth through 2011 has not evened out the differences in regional development and the growing income gap between the expanding urban middle class and the predominantly poor rural population. Instead, it has been thrown into sharper relief. The hoped-for effect on employment has failed to materialize.

The disparity between the share of GDP and employment in agriculture and services is typical of India. About 70 percent of Indians live in rural agricultural

structures, yet the share of agriculture in India's economic output is only about 14 percent (2013/14). The agricultural sector has been marked by a lack of capital, farming acreages that are too small, stagnating earnings and the absence of sales structures. Only about 8 percent of all employees are in a contractually regulated labor relationship. The remaining 92 percent are assigned to the "informal sector". They have no safeguards in the event of illness or accidents at work. Nor do they have retirement benefits or access to social services.

India owes its growth and prosperity primarily to its services sector, which accounts for about 60 percent of its GDP. But only a small portion of the population fits the typical image of an Indian software programmer. To overcome the country's mass poverty, new jobs would have to be created, especially for unskilled or low-skilled laborers. In the government's view, it would be most likely for this to occur in the industrial sector – particularly in manufacturing, which held a share of just 10 percent of India's economic output in 2013/2014.

Furthermore, the country's bureaucracy is proving to be an obstacle. A range of sectors – especially oil, gas, coal, heavy industry, transportation, banks and insurance – are in the hands of governmental or semi-governmental companies. In recent

years, a number of governments have failed in their attempts to break up the structures, at least in small steps.

The sheer size of India's economy, its demography and its comparatively high growth rate still make the subcontinent an important market for the future. In a key difference from China, domestic demand drives development in India. The optimistic projections are based mainly on its "demographic dividend". In 2026, nearly 70 percent of the population will be of working age, between 15 and 59 years old – an ideal base for sustained growth. But the necessary jobs still need to be created. Massive public investments in education, training and health care are also needed, since just 5 percent of all the people available to the labor market have an occupational skill. So far, there

are only about 4.5 million training positions on offer for the more than 12 million young people entering the labor market each year, and most positions are of rather poor quality.

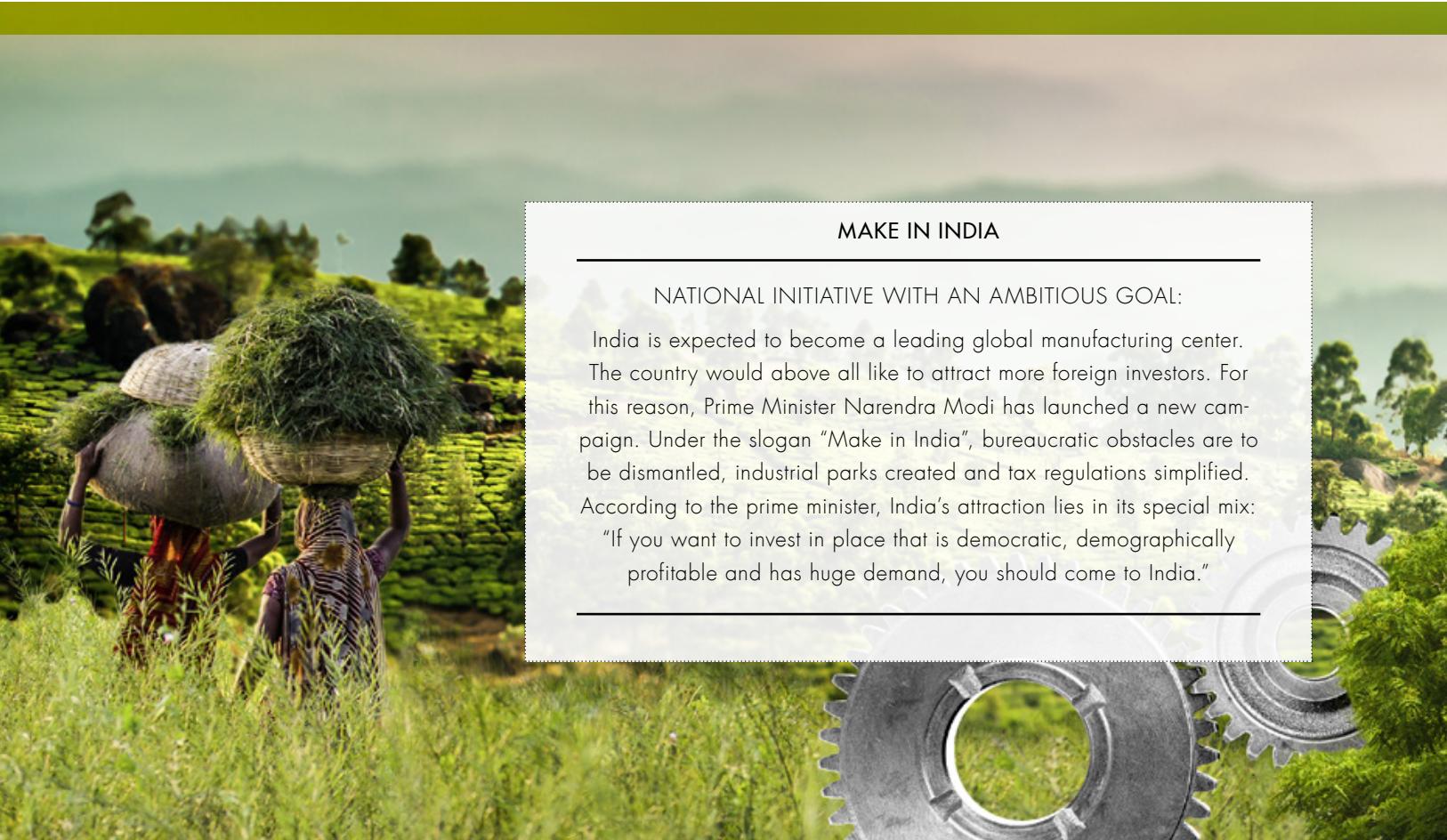
The Indian government has recognized the problem. In its 12th five-year plan (April 2012 – March 2017), it set the goal of doubling expenditure on academic and professional education to 6 percent of GDP. At the same time, the government decided to create a training strategy and formulate a national employment policy to target the phenomenon of economic growth without the addition of jobs. It is clear that the country's severe deficit in human capital is endangering its potential for growth.

MAKE IN INDIA

NATIONAL INITIATIVE WITH AN AMBITIOUS GOAL:

India is expected to become a leading global manufacturing center. The country would above all like to attract more foreign investors. For this reason, Prime Minister Narendra Modi has launched a new campaign. Under the slogan "Make in India", bureaucratic obstacles are to be dismantled, industrial parks created and tax regulations simplified. According to the prime minister, India's attraction lies in its special mix:

"If you want to invest in place that is democratic, demographically profitable and has huge demand, you should come to India."



INDUSTRIALIZATION AS A GOAL

India wants to press ahead with massive industrialization. In late September 2014, Prime Minister Narendra Modi launched the "Make in India" campaign and called on foreign investors to manufacture there under improved investment terms. Industrial production's share of GDP is supposed to climb from the current 15 percent to 25 percent. The amount of direct foreign investment in India has grown sharply in recent years, although hopes for the equivalent of nearly USD 21.6 billion were not met in 2013/2014.

Meanwhile, India has increasingly opened up to the world in recent years. In most areas of the economy, direct foreign

investment is now permitted and the upper limits for foreign participation have been entirely dismantled in some cases. Until now, these barriers were significant and kept non-Indian investors from pursuing their business goals. Administrative processes have been tightened significantly to ease foreign involvement in India and brisk competition has emerged among India's states. IT and electronics, services, the vehicle industry and the energy sector are benefiting from extensive investment from abroad.

Without massive injections of cash in labor-intensive sectors, India will not be able to free itself from poverty and underdevelopment. Infrastructure deficits are clouding the prospects for growth. But the government is proceeding with gigantic projects here as well. A new route for high-speed

trains is planned between Mumbai and Delhi, along with a transportation and industrial corridor, the "Delhi-Mumbai Industrial Corridor", with modern, ecologically well-thought-out city developments. Other corridors are expected to connect Delhi and Calcutta from west to east through the Ganges plain, as well as Mumbai with the economic centers of Bangalore and Chennai in the South.

Many Indians hope that the high-speed trains are a symbol that their country is on its way to becoming an industrialized society, where as many people as possible can benefit from economic growth and an improved standard of living.





AN ENGINEER IN INDIA – A GUARANTEE OF UPWARD MOBILITY



THROUGHOUT THE WORLD, TECHNICAL PROFESSIONS PLAY A KEY ROLE IN THE CREATION OF A WELL QUALIFIED LABOR MARKET. ON THE INDIAN SUBCONTINENT, THE OPTIONS FOR TECHNICAL TRAINING HAVE BECOME MORE AND MORE MULTIFACETED IN THE LAST FEW DECADES. MILLIONS OF INDIAN ENGINEERS IN AN EXTREMELY WIDE VARIETY OF FIELDS ARE HIGHLY REGARDED AND SOUGHT-AFTER TODAY. FOR MANY INDIANS, ENGINEERING STUDIES ARE A TICKET TO A SECURE, WELL PAID JOB. ESSENTIAL SPOKE WITH AN INDIAN ENGINEER ABOUT HIS CAREER.



The youngest of nine children, Venkatraman Thiagarajan was born in the small village of Nachiyar Kovil in the south Indian state of Tamil Nadu. Thiagarajan, a mechanical engineer, now works as the chief engineer at a power plant near Chennai, the capital of Tamil Nadu. His company runs a three-shift operation – 24 hours a day, 365 days a year. The power plant generates a maximum output of 420 megawatts per day. "We often have to overcome problems to achieve 100 percent capacity utilization," said 57 year-old Thiagarajan. "My job is to make sure that we quickly recognize and solve the difficulties so we can achieve maximum energy production."

The village of Nachiyar Kovil is known primarily for its famous Vishnu temple and its agriculture. Thiagarajan's father owned

VENKATRAMAN THIYAGARAJAN

Education and knowledge have largely shaped his life

some land and was able to earn a few extra rupees leasing it to other farmers. "With so many hungry mouths and such a meager income, you could hardly talk about a comfortable youth," Thiagarajan recalled. But despite all the limitations, his parents managed to give each of their nine children an education – something that could not be taken for granted. Thiagarajan's parents often told him how important a good education was for a better life as an adult. From today's perspective, he is impressed by his father's farsightedness on the importance of mastering English to open up opportunities in education and careers. "This is where the cornerstone was laid for everything I achieved later," he said.

In India, a large portion of the population live in rural villages, where farming and handcrafts are nearly the only source of income.



EDUCATION IN INDIA HIGH DEMAND – LIMITED OPTIONS

Even after Indian independence, the structure of the education system introduced by Britain as the colonial power was largely maintained. Four years of secondary school follow a total of eight years of primary school. This system opens up access to universities.

India currently has about 620 universities and nearly 33,000 associated colleges. The number of college-level students is about 25 million. The goal is to increase this number to more than 40 million students by 2020. The regional concentration of universities is expected to be countered and new institutions created in outlying districts, while existing institutions with the potential for excellence are developed. The biggest problem, however, is the lack of university lecturers. Even today, 40 to 50 percent of positions are not filled. Massive emigration to the West plays a key role in the shortage of well-trained scientists and engineers in India. In addition, many students do not return after their education abroad.

Village life certainly lacks the stress and noise of India's pulsating major cities, but villagers pay a price – they barely participate at all in the country's economic growth and their circumstances have hardly changed over the centuries. That is why many families send their children to school in the cities, in the hope that the next generation might have a more comfortable life than they themselves have had. Above all, it is their performance in their final school exams that determines the opportunities available to them. Their grades in high school are the admission ticket to universities, with the technical universities among the most sought-after.

Thiyagarajan benefited from the fact that his older sister already worked as a teacher during his school years. In his final years, as school grades became more important for entry into a technical university, she used her network of contacts and arranged additional tutoring for him on weekends. The result was that Thiyagarajan achieved the highest score for his final school project in the entire state of Tamil Nadu. He found mathematics and scientific subjects particularly easy, which is why an engineering education seemed obvious. In fact, his academic performance earned him a scholarship to one of the leading Indian engineering schools, ensuring financial support for his entire education. Thiyagarajan settled on mechanical engineering as his field of study because he expected it to provide good prospects for employment and relatively high pay.

Right after his university studies, the state electric company in Tamil Nadu offered him a position as an engineer in a boiler plant. The ease with which he acquired his first job confirmed the wisdom of his choice of studies and especially pleased his family in his home village. He was now in a position to support himself financially.

In his professional life, Thiyagarajan has worked at three different energy suppliers in India, devoting himself to technical responsibilities, the scope of which increased with each new position. His ambition to advance professionally also carried him far from his native village to other Indian cities and regions – with other languages, foods and

cultures. He invariably saw these new experiences as enriching and, looking back, he wouldn't have missed them, despite their initial strangeness. After all, the variety of India's cultures and languages is often compared to the diversity of Europe – to the point that every Indian is a stranger nearly everywhere in his own country.

His track record continued to open up new opportunities for him. He ultimately found his current position, which made it possible for him to return to the city where he began his professional career.

Thiyagarajan is married and has a 28-year-old daughter, a trained computer engineer who lives in Chennai, the city where he and his wife reside. Thiyagarajan says his experience in extremely diverse locations made him more self-confident and mobile. He says this has rubbed off on his daughter, who adapts to new situations naturally and apparently without any qualms. She even speaks Hindi like a native speaker, although Tamil is her mother tongue.

After her graduation as an engineer in computer science, she followed in her father's footsteps. As was the case for Venkatraman Thiyagarajan, her most important criteria was the professional prospects for her course of studies – in this case, computer engineering. The course of her life has likewise been set by her education – and

by the open attitudes of her father. Thiyagarajan's wife actually graduated with a degree in English literature, though she has remained a homemaker.

Most parents in India hope that their children will marry and start a family before the age of 30. Since the marriage of their daughter, the Thiyagarajans are alone in their household and look forward to the weekend visits of their daughter and son-in-law. Life is quite hectic for both of them during the week, and Venkatraman Thiyagarajan spends nearly three hours a day commuting by car. So he especially enjoys being able to relax in front of the television or listening to music.

He often travels into the countryside to visit his family. He still finds life there much as it was during his childhood, and he experiences a world that is completely different from the hustle and bustle of cities with populations in the millions. He becomes nostalgic when he nears his native village, and on the 300 kilometer trip back to Chennai, he is regularly overcome by homesickness. But only briefly – a short time later, he starts making plans for his first days back home. During these trips, Thiyagarajan often ponders his life and the distance he has traveled. But it is not a distance measured in kilometers, for he can hardly imagine a greater distance than the one between the life into which he was born and the life he now leads.



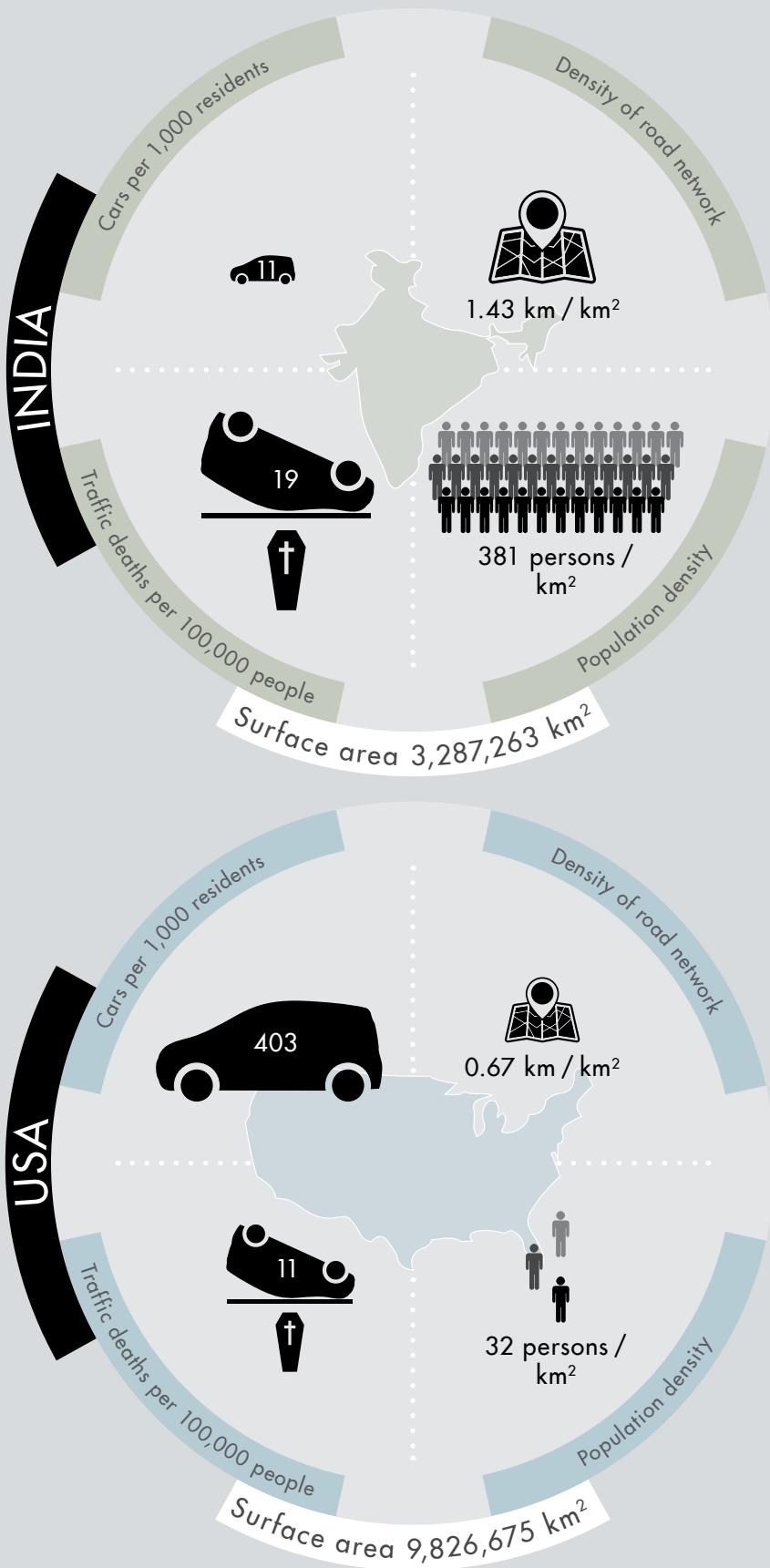
FACTS & FIGURES

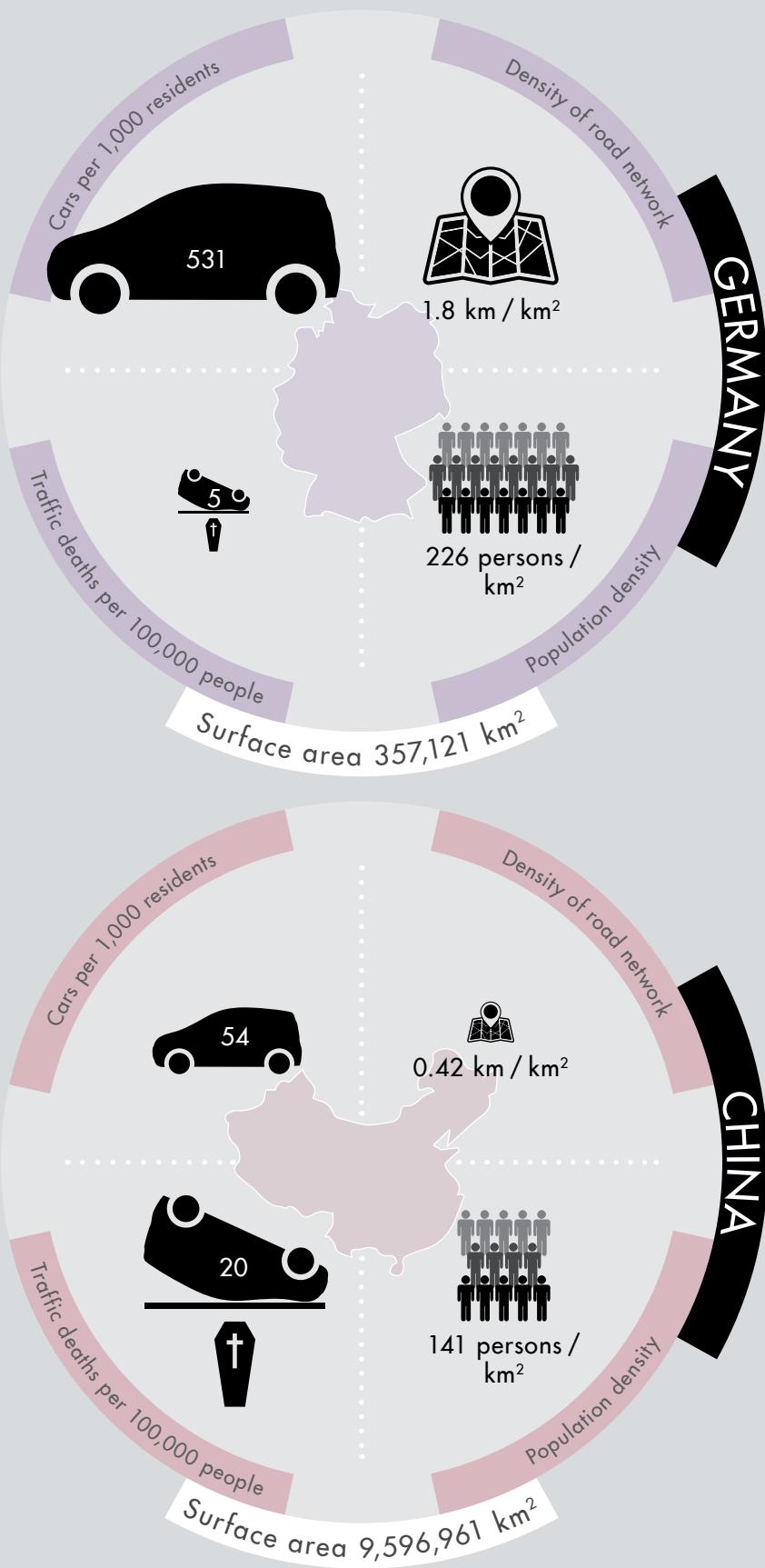
DENSE NETWORK MOBILITY IN INDIA

A comparison of various industrial countries shows how differently mobility has developed in each case. India, for example, currently has just 11 cars per 1,000 inhabitants. In China, the figure is already five times as high. The chasm is huge between those nations and two first-world countries – Germany and the United States. Here the rate of car ownership per capita is 40 to 50 times greater.

India and China invite comparisons despite their great difference in population density. The surface area of the subcontinent is only about one-third that of China or the U.S. In India, for example, 381 people share a square kilometer. In the U.S., the figure is just 32. And with 141 inhabitants per square kilometer, the Chinese on average live in less crowded circumstances than Indians do. India's road network is also denser – 1.42 kilometers of roads criss-cross each square kilometer of Indian land. In terms of surface area, that works out to twice as much as in the U.S. and three times more than in China.

At 1.8 kilometers for each square kilometer, Germany's road density is even greater





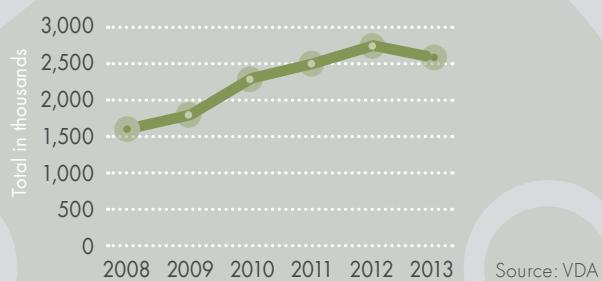
than India's. With an average of 226 inhabitants per square kilometer, the Federal Republic is only about 60 percent as densely populated as India – but that close-knit network characterizes one of Germany's crucial strengths as an economic center: its good infrastructure.

Despite its low automobile density, the risk of traveling on India's roads is extremely high. With 19 traffic fatalities per 100,000 inhabitants annually, India joins China in the upper reaches of the comparison. Among other reasons, this is due to a large share of two-wheel motor vehicles, which often make up a third of the total traffic in major Indian cities. Other causes include high traffic volume in close quarters – often without standardized rules – and frequently only rudimentary driver training, along with the poor condition of roads and vehicles. Good traffic discipline and high vehicle safety standards make roads significantly safer, as the example of Germany shows: despite extreme vehicle and traffic density, by far the fewest fatal accidents occur in this country. From a statistical standpoint, more than twice as many accidents take place in the U.S.

PARADISE FOR SUBCOMPACTS

Subcompacts define the street scene in India. But they have to be somewhat larger – and more prestigious – than the Tata Nano, which was introduced in 2009. The favorite of Indian car buyers is the Maruti Alto, which competes as the Suzuki Alto in Europe. The Mahindra Bolero, an authentic SUV, takes sixth place in the registration statistics, while a microbus, the Maruti Omni, is in ninth position. In cities, however, cars provide only 15 percent of personal transportation. Motor scooters are the preferred option here.

CAR SALES TREND IN INDIA

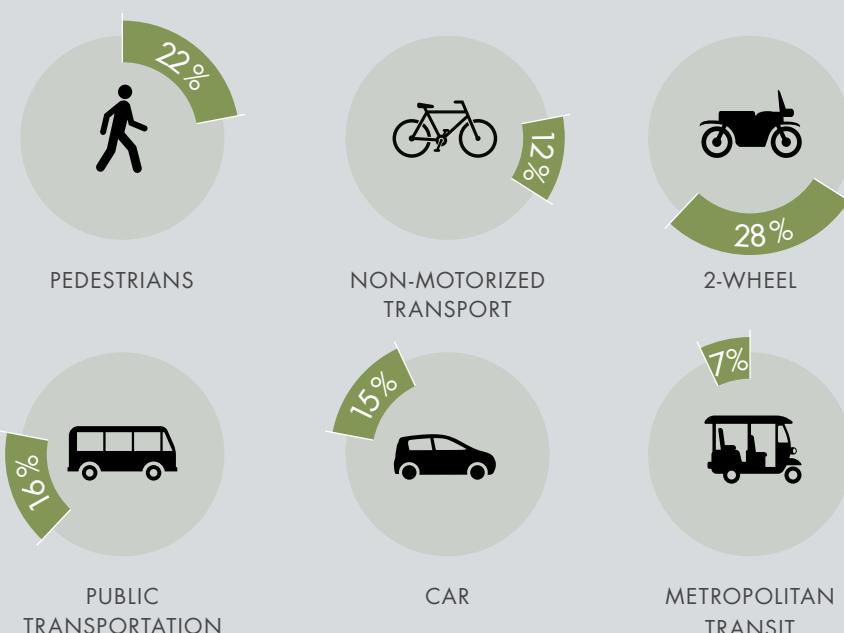


THE 10 TOP SELLERS

	1	Maruti Alto	196,604 [10.5 %]
	2	Maruti Swift Dzire	161,721 [8.6 %]
	3	Maruti Swift	155,556 [8.3 %]
	4	Maruti Wagon R	119,076 [6.3 %]
	5	Hyundai Grand i10	78,743 [4.2 %]
	6	Mahindra Bolero	76,907 [4.1 %]
	7	Hyundai Eon	60,737 [3.2 %]
	8	Honda City	58,945 [3.1 %]
	9	Maruti Omni	54,888 [2.9 %]
	10	Honda Amaze	53,535 [2.8 %]

MOBILITY IN INDIA

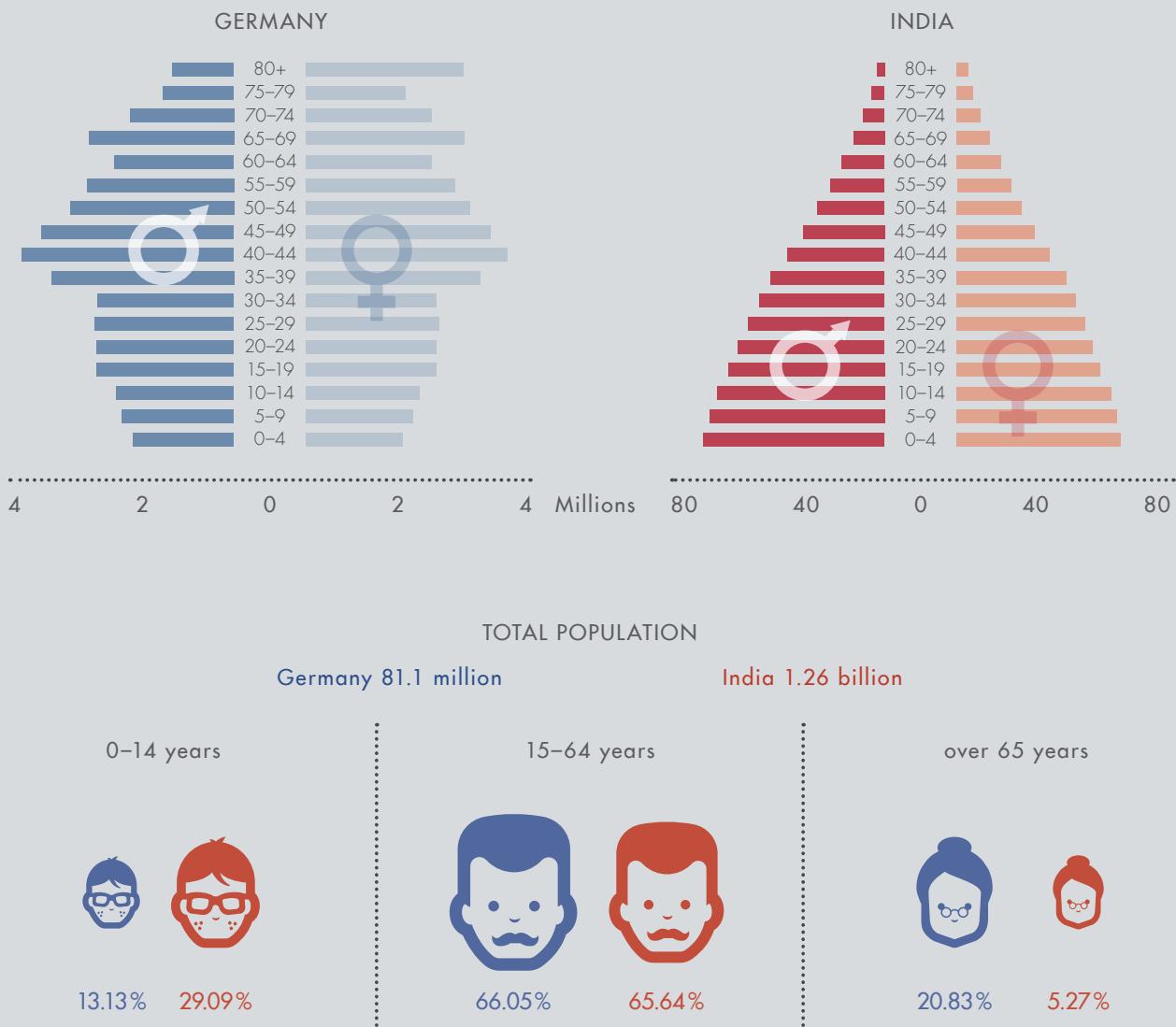
With Ahmedabad (6.36 million inhabitants) as an example



Source: Indian Census (2011) and iTrans (2009)

Source: Auto Zeitung (January-February 2014)

DEMOGRAPHIC COMPARISON



Source: German Federal Statistical Office (2012-14), IMF (2014), World Bank, DSW, CIA, UN Desa

THE DEMOGRAPHIC DIVIDEND

The difference could hardly be greater – India is an extremely young country. Only 5 percent of the population is older than 65 years of age; the corresponding figure for Germany is nearly 21 percent. Indians call their population structure a demographic dividend. Its large number of working-age people is expected to

generate economic growth for the subcontinent, and that number is only expected to grow significantly in coming decades. Unlike the situation in China, the demographic dividend is generating one thing above all – high domestic demand.



NEW FACTORY FOR THE MARKET LEADER IN SEALING



FREUDENBERG SEALING TECHNOLOGIES HAS BEEN ACTIVE IN THE FAST-GROWING INDIAN MARKET SINCE 2001 THROUGH ITS JOINT VENTURE SIGMA FREUDENBERG NOK (SFN). SFN HAS LONG ESTABLISHED ITSELF AS THE MARKET LEADER ON THE SUBCONTINENT. A COMPLETELY NEW FACTORY OPENED IN BASMA, PUNJAB, EARLY THIS YEAR. MORE THAN 2,000 EMPLOYEES, 50 PERCENT OF THEM WOMEN, WILL PRODUCE SEALS FOR A WIDE VARIETY OF SECTORS.



Production facility in the new SIGMA FREUDENBERG NOK plant in Basma, Punjab

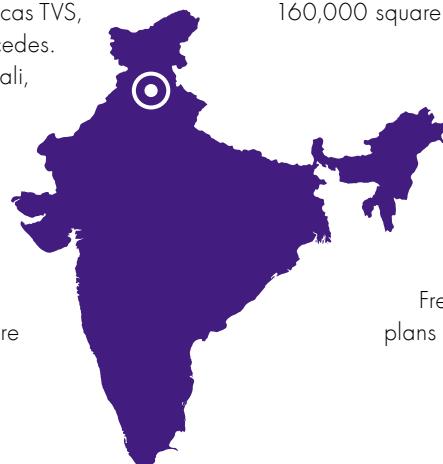
The opening on February 4, 2015 marked a new phase in the Freudenberg commitment to India. In attendance were Ministers Sukhdev Singh Dhindsa and Parminder Singh Dhindsa of the Punjab region, NOK Chairman Mosato Tsuru, Claus Möhlenkamp, CEO of Freudenberg Sealing Technologies, Dieter Schäfer, Chief Operations & Technology Officer and Chief Financial Officer Ludger Neuwingen-Heimes. A highly advanced production facility covering more than 23,000 square meters was erected, representing an investment of more than 20 million euros. It is planned to produce primarily radial shaft seals and O-rings for the auto sector and general industry.

SFN is thus reinforcing its position in India. The best known customers of the joint venture include Maruti Suzuki, Honda Siel, Tata Motors, Toyota, Ford, Ashok Leyland, Lucas TVS, Eicher, Escorts Hyundai, Volkswagen and Mercedes. The company has had a production facility in Mohali, a little less than 35 kilometers away, since 2001.

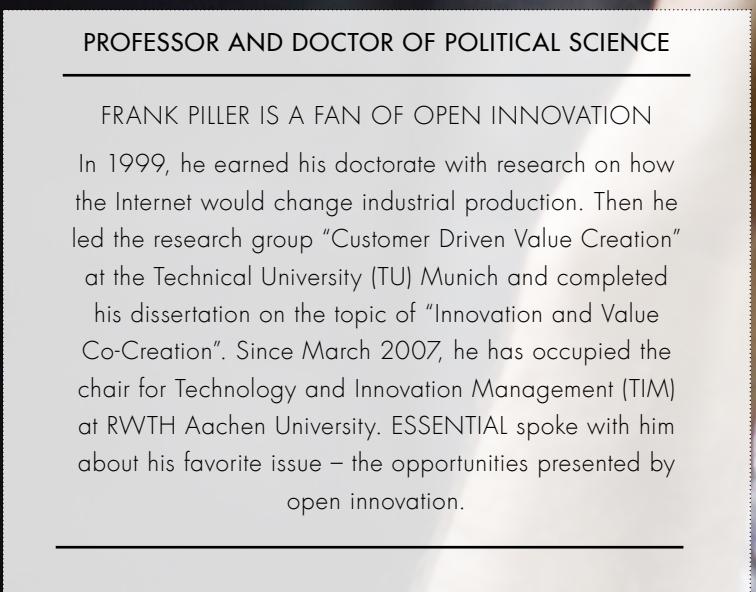
The core team spent six months in Germany familiarizing themselves with the Freudenberg Sealing Technologies quality philosophy. The company owes its strong position in India to its uncompromising execution. All the seals developed and manufactured there are

subject to intensive testing – both in the laboratory and in the validation of completed products. At the same time, the requirements in customer specifications are being increased by a factor of two. Sigma Group Chairman JD Singh points to the extremely well equipped test stands, which alone can handle 240 different test processes. The company is certified under numerous international quality standards (TS 16949:2009, OHSAS 18001:2007, ISO 14001:2004 ISO 9001:2008) and pursues a strict zero-defect philosophy.

Demand has risen in the automotive, mining, power plant, steel manufacturing, agricultural and construction machinery segments, making a second production facility essential. In Basma, Punjab, SFN acquired property for the new plant covering more than 160,000 square meters.



Freudenberg Sealing Technologies and Japanese company NOK have been cooperating for decades in various markets. The Sigma Corporation India in Delhi has been in existence since 1964. With the signing of the cooperation agreement in August 2000, Freudenberg chalked up its 28th country and plans for its 46th production facility.



PROFESSOR AND DOCTOR OF POLITICAL SCIENCE

FRANK PILLER IS A FAN OF OPEN INNOVATION

In 1999, he earned his doctorate with research on how the Internet would change industrial production. Then he led the research group "Customer Driven Value Creation" at the Technical University (TU) Munich and completed his dissertation on the topic of "Innovation and Value Co-Creation". Since March 2007, he has occupied the chair for Technology and Innovation Management (TIM) at RWTH Aachen University. ESSENTIAL spoke with him about his favorite issue – the opportunities presented by open innovation.



DEVELOPING MARKETS WITH OPEN INNOVATION



PROFESSOR PILLER, HOW DID INNOVATION BECOME YOUR SPECIALIST FIELD?

PILLER: A project with Adidas played a major role. We had a research field that emerged from my doctoral work that we called mass customization – meaning a way to manufacture individualized goods just as efficiently as mass goods. We later helped Adidas establish a program allowing customers to buy an individualized gym shoe. With its help, consumers suddenly had direct access to the company and they were making use of it. I can still remember receiving a call for help: "Mr. Piller, we have a huge problem. Customers are calling us with ideas. How can we stop this?" We of course had no intention of stopping it, but wanted to steer it into orderly channels. So, in a project at TU Munich in 2002, we launched Germany's first Internet-based idea competition. It was a true pioneer in open innovation.

CAN YOU EXPLAIN TO US WHAT OPEN INNOVATION IS?

PILLER: The best way to do this is by differentiating it from the classic understanding of research and development (R&D). The idea of the innovative entrepreneur or engineer has left its mark on Germany's small and medium-sized companies and made them strong. Innovation is understood to be what the R&D department does. This is also the best protected location within the company. We naturally know that we have to involve suppliers and our direct customers, particularly in the industrial sector. We talk here about the "obvious others". Companies affiliate within

associations and jointly conduct basic research. Germany has a large industrial family. People know each other and mostly stay among themselves.

By contrast, open innovation is a formal, systematic process to capture the discoveries of "unobvious others". I don't involve them by resorting to contractual commitments. Instead, I build informal relationships with them. This is something entirely different from classic contract research. It is a matter of achieving significant increases in efficiency via the "unobvious others" with the help of new platforms.

SO THE "UNOBlOUS OTHERS" ARE NOT CUSTOMERS?

PILLER: Usually not. Ultimately, it is my best customers who are apparently satisfied with what I am already doing. And customers mostly want the same thing as before – only cheaper and better. Frustrated users, for example, are more interesting for open innovation. From the history of innovation, we know that 60 to 70 percent of all innovations can be traced back to a single user. New camera equipment features can often be traced back to photographers who were irritated by the inadequacy of their equipment. Among them are a few who have some technical aptitude and they optimize things – and, at some point, a camera or equipment manufacturer sees them and reverse-engineers the solution. Or take an example from the machinery field. Imagine a field representative who encounters a machine that the customer has rebuilt. The first reaction is,





A PROFESSOR KEEPS HIS EARS OPEN
Frank Piller during a discussion with students at one of his lectures on technology and innovation management at RWTH Aachen

"The warranty is terminated". But, in fact, an ambitious tradesperson was forced to further develop the machine because it couldn't do something that he needed. These people are the "unobvious others", the Holy Grail that we are seeking. They are especially progressive users who have arrived at innovative solutions due to extreme requirements or a shortage of resources.

BUT HOW YOU FIND THEM?

PILLER: Until now it was very labor-intensive. But thanks to the Internet, I can find these "lead users" much more easily, or – and this is the core thought – they find me. For example, this happens with open idea competitions. A problem is publicized as widely as possible and anyone with a solution gets in touch with you. A prize, an award, a development partnership or a job – whatever – is given out for it.

This kind of innovation competition also works in the B2B area. Consider the example of Reifenhäuser, a manufacturer of plastic extruders in Troisdorf, near Bonn. Here, an open Internet competition for new products and concepts in manufacturing brought in 200 ideas. The winner was a Polish master's student who previously didn't even know the manufacturer existed. His solution led to improvements in energy efficiency. A job offer soon followed as a result of his work.

One other possibility: You specifically target and evaluate communities on the Internet where problems are frequently discussed and lead-user innovations are often already documented. This works more easily in the consumer goods area, but we have carried out several projects in the B2B area as well. It's surprising how often purportedly unsolvable problems have already been thoroughly discussed and solved in Internet communities.



PERSONAL STYLE

Using the online service "mi adidas", customers can even create an individual look when they order their sports shoes



OPEN INNOVATION?

IDEA!

IS OPEN INNOVATION ALSO SOMETHING FOR SMALL AND MEDIUM-SIZED FIRMS?

PILLER: This tool is actually especially interesting for small and medium-sized firms in the industrial sector, since there is an increasing demand for people to offer solutions rather than products. This requires a broad knowledge base – even in areas that are not part of a company's core competency. The beauty is that open innovation is a relatively inexpensive tool. We had an example where a material with certain properties was sought. Millions of euros had already been spent on the associated basic research – without success. It proved possible to find a solution in six weeks with 20,000 euros using an open innovation platform.

The real problem is the implementation, however. In small and medium-sized firms, things often fail when they come up against the pride of German engineers. People in large companies are more used to cooperation. But "not invented here" is a classic cultural phenomenon and one of the great obstacles to innovation management. And it is especially pronounced in successful German, engineer-driven small and medium-sized companies. There you have either to work extensively on the culture or make open innovation one of top management's chief concerns. Otherwise, engineers fear they will seem incompetent – because they did not find the solution on their own. After all, in their education, we send our engineers out into the world with this message: You're the best – no problem is too difficult for you – instead of teaching

them to find out first whether there might not already be a solution before they pursue one themselves.

HOW DO YOU INITIATE AN OPEN INNOVATION PROCESS?

PILLER: First I have to know whether I am looking for concepts and ideas or a technical solution. There are various tools and other intermediaries for mediation between task assignment and the "unobvious others". There are about 150 platforms, from which you can choose a suitable one. Then you start the competition. The responses come back quite quickly, which is why a process should be set up in parallel to regulate how the incoming solutions are handled. There are in fact closed platforms for technical innovations. In some circumstances, you can draw competitors' attention to a problem – and thus a potential market.

ARE THERE OTHER STRIKING EXAMPLES?

PILLER: Two years ago, Beiersdorf launched a deodorant that's now making a very strong contribution to the Nivea brand's revenues – Nivea Invisible. It's a deodorant stick that leaves no flecks on white shirts or T-shirts. The starting point was research in the Internet communities: what do people talk about when they exchange information on deodorant? There are more than 80 forums and communities by customers for customers, where people discuss deodorants. The classic development priorities for the deodorant were normally a number of properties: "skin compatibility", "sweat blocking", "good value" and "good scent". On the Net, however, deodorant flecks on clothing was a very



central theme. Naturally, people at Beiersdorf knew that deodorants cause flecks – but they tended to see it as a problem for detergent producers. But on the Internet, there was a whole repertoire of recipes from frustrated users for do-it-yourself deodorants without flecks. With this finding, the issue became a higher priority. For the solution, however, Beiersdorf needed textiles expertise. In a classic open-innovation process with a textile research institute, the company mounted a search for substitute ingredients to replace the substances causing the flecks. The result was the most successful new product introduction in Beiersdorf's history.

IS OPEN INNOVATION ONLY POSSIBLE WITH OUTSIDERS?

PILLER: No, I can carry out the same processes internally as well and include employees in the brainstorming beyond the classic suggestion-program instruments. Something like a campaign: over six weeks, we're going to look for the best idea to counter product piracy. This way, the approach involves more than just the three individuals who normally take part. Even the janitor can contribute a good idea on an equal footing. There are companies that do this with an internal network of 50,000 people. When someone has a problem to solve, he can put it on the platform. It doesn't go to everyone – this part is controlled

think big
teamwork
 new. imagination
risk inspiring
creative business
 communication **solution**
 performance planning works
key innovate
ideas concept
brand
brainstorm plan
 strategy **success**
 global process
 OUToftheBOX **excellence**
reward
 leadership
efficiency
 workflow information marketing best
 organization network social
 research analysis green
 advertising positive vision
 development refresh ads
goals

by an algorithm – but it's still sent to many employees throughout the entire company, to the "unobvious" co-workers as well. This kind of project sometimes takes just a little more than an hour. By then, the solution has already arrived, often in the form of a phone call, such as: "I'm familiar with the problem. We've already had it here." With internal processes, there are fewer problems with implementation since everything stays in the family.

SO THIS DOESN'T JUST INVOLVE INNOVATION BUT ALSO THE FACTORS THAT PROMOTE IMPLEMENTATION?

PILLER: Exactly. It's relatively simple to get input – whether internally or externally. It's more difficult to evaluate what the best solution is. We, as innovation-management researchers, look after the cultural issues such as the innovation culture or organization. Engineers, as a rule, do not. And as methodology researchers, we try systematically to promote techniques of creativity and liberate thinking from tunnel vision. Of course, the other people that I reach out to also have tunnel vision, but it's through another tunnel. We have to position ourselves more broadly, so we can think in a more multi-colored way and be more innovative. You could describe our task accordingly: engineers create the solutions and we solve the problems with problem-solving.



1891



CROWN CAP WILLIAM PAINTER

He was a true Gyro Gearloose and, in 1891, after more than 80 patent registrations, he finally hit the big time, with the spirit of the times coming to his aid. Carbonated drinks were becoming increasingly popular, but transporting bottles of the fizzy beverages proved problematic. Either the tiny carbon dioxide bubbles were lost – and with them the popular prickly effect – because the cork, porcelain or metal stopper didn't seal the bottle properly, or the top flew off because it couldn't withstand the pressure inside the bottle. This is where Painter sensed his opportunity. He developed a small, throw-away item that distributed the bottle pressure through 24 (later 21) crimps. A cork disk inserted inside it ensured an airtight seal. He called the invention the "crown cork" and it catapulted him to the Olympus of invention that he had so long pursued. In 1893, Painter founded the Crown Cork and Seal Company, known as Crown Holdings Inc. today – one of the largest manufacturers in the world of crown corks and other beverage items.

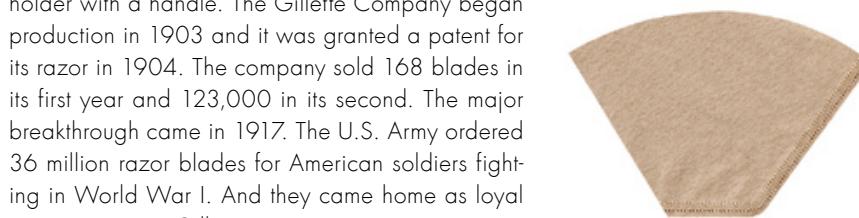


BRILLIANT IDEAS –
INNOVATIONS AND
THEIR HISTORIES

RAZOR WITH REPLACEABLE BLADES

KING CAMP GILLETTE

King Camp Gillette wanted to get rich from an idea. He was a bottle cap salesman in William Painter's company and he was envious of the success of its owner, the inventor of the crown cap. Painter gave Gillette a bit of advice: he, too, should invent something that is thrown away after use and would have to be repurchased again and again. When Gillette became annoyed with a dull razor blade one morning in 1895, a brilliant idea came to him – a replaceable blade, sharpened on both sides, in a holder with a handle. The Gillette Company began production in 1903 and it was granted a patent for its razor in 1904. The company sold 168 blades in its first year and 123,000 in its second. The major breakthrough came in 1917. The U.S. Army ordered 36 million razor blades for American soldiers fighting in World War I. And they came home as loyal Gillette customers.



1903



COFFEE FILTER

MELITTA BENTZ

Coffee grounds in the bottom of your cup aren't the most appetizing thing to look at as you drink your morning coffee. Melitta Bentz's two children were inadvertent helpers in her search for grounds-free coffee enjoyment, when their mother repurposed the blotting paper from her sons' school notebooks. When used as inserts in a perforated brass pot, the paper retained the undesired grounds, thus keeping them out of the coffee cup. Thus, the basic principle of the first coffee filter emerged. On July 8, 1908, the imperial patent office in Berlin granted the invention legal patent protection. After a few refinements, the family-owned company M. Bentz began manufacturing filter paper in 1912 and Melitta filters in 1937.

1908

EAR PLUG

MAXIMILIAN NEGWER

Noise levels were rising massively in the 20th century, with industrialization and urbanization to blame. People sought relief by plugging wads of cotton, wooden balls or hard rubber into their ears. Berlin pharmacist Maximilian Negwer had a better idea. It supposedly came to him during a conversation about Greek mythology. Beeswax plays a key role in Homer's epic, *The Odyssey*, where it was used to block out the singing of the bewitching sirens. After testing, Negwer recognized that a cotton ball dipped in Vaseline and paraffin produced the desired effect. The first Ohropax ear plugs went on sale in pharmacies in 1908. The name Ohropax comes from the German word for ear (Ohr) and the Latin word for peace (pax).



1908



ADHESIVE BANDAGE

EARLE DICKSON

Josephine Dickson was a klutz. As a cook, she was constantly getting small cuts or burns that her husband had to treat at home. One day, to make the daily care of his wife a little easier, Earle Dickson glued a strip of gauze onto a broader stripe of surgical tape and wrapped everything up with crêpe paper to protect it all. If necessary, Josephine could now cut off a strip herself and, after removing the wrapping, stick it onto her wounds. At the time, Earle Dickson was working as a cotton buyer for the U.S. firm Johnson & Johnson. A colleague of Earle's heard about his invention and convinced him to tell his boss about it. The result was the industrial production of the adhesive bandage, which came to market under the name Band-Aid. Initially, business was sluggish, but the distribution of free samples to butchers and Boy Scouts ultimately led to quite a huge success.



1922



1929

GUMMI BEAR

HANS RIEGEL

The highlight of the Weimar Republic! It was with these words that Kaiser Wilhelm II heaped praise on gummi bears while in exile. Since the invention of snacking, growing numbers of people have been paying the invention the same imperial compliment. The gummi bear was born in 1922 in the kitchen of sweets-maker Hans Riegel in Bonn. Its most important raw material is food gelatin. The dancing bear made from Haribo fruit gum, and its cousin made from licorice, first found wide acceptance at carnivals. You could buy two of the rubbery sweets for a penny. With the German economic miracle of the 1950s, the gummi bear changed form. It was transformed from a rather skinny creature into a proper little fellow in the most dazzling colors. As artificial dyes went out of fashion, the gummi bear became paler – which in no way hurt its popularity. Now colored solely with fruit extracts, it is still making children happy worldwide. And adults, too.



1926

POCKET TISSUE

OSKAR ROSENFELDER

By the time Oskar Rosenfelder stepped into the German patent office in Berlin on January 29, 1929, humans had been blowing their noses into cloth handkerchiefs for centuries. But with his visit to the office, the paper manufacturer ushered in the end of an era. What the office registered under No. 407752 changed the daily life of the human race. Rosenfelder had invented the pocket tissue out of pure pulp – "satin soft, absorbent and hygienic", as promised by the first advertisements in the *Berliner Illustrirte* newspaper. The co-owner of the Vereinigte Nürnberger Papierbetriebe quickly came up with a name for his revolutionary product: "Tempo". It was the perfect term for an era when things keep turning faster and everything that is brand-new today may end up in the wastebasket of history tomorrow.



1929



SIMMERRING®

WALTHER SIMMER

Walther Simmer had worked at the Carl Freudenberg leather factory in Weinheim since 1919. During the development of a splitting machine, a problem arose involving the sealing of roller bearings. They were inadequately sealed by felt rings and were thus quickly destroyed. Following many attempts, Simmer conceived an idea of a sleeve ring lined with leather scraps. It was embedded in a sheet metal casing ring and pressed against the machine's operating shaft using a screw tension spring. The invention worked so well that the tannery began offering it to other companies in 1929. In the 1930s, it won acceptance in the auto industry. The oil traces left behind by parked cars quickly became a thing of the past. The use of a new material, Buna rubber, began in 1936 when leather scraps were no longer considered sufficient. The invention went down in the history of technology under the name Simmerring.



1929



VELCRO

GEORGE DE MESTRAL

Even as a child he was interested in technical processes. Swiss inventor George de Mestral was only 12 years old when he filed a patent for a fabric-covered model airplane. After his studies at the École polytechnique fédérale de Lausanne, he began working in an engineering firm. The avid hunter came up with the idea for Velcro one day when he found the fruit of the greater burdock on his pants and on the fur of his dog after a hunting excursion. As he looked at the objects through a microscope, he realized why the hedgehog-like balls adhered so well. At their tips, the barbs of the seeds had tiny elastic hooks that became fixed when they came into contact with fur or woven material. This led him to develop a fastening system to bind two materials in a simple manner.

In 1959, de Mestral founded Velcro Industries, now the world market leader in the field with USD 260 million in annual revenue.

1941

TETRA PAK

RUBEN RAUSING

It was Ruben Rausing's wife who led him to his ingenious packaging idea. According to legend, it all started in 1943 with a sausage. Elisabeth Rausing was filling small sausages – the mass was fed into the skin, tied off – and it's done. Ruben Rausing, a Swedish cardboard box manufacturer and inventor, was inspired by the sausage principle – inexpensive packaging that closes up around precious goods cleanly and airtight. He tinkered with it for years and finally it worked. In 1952, he folded his first cardboard box into an equilateral pyramid (tetrahedron), filled it with 100 milliliters of whipping cream and pressed the flaps tightly together. The result was the first Tetra Pak – a revolution in beverage packaging.

1952



1953

SCREW ANCHOR

ARTUR FISCHER

Wood screw anchors have been around for centuries. But the world had to wait until 1956 for the kind of anchors that held screws securely in a wall. This is when Arthur Fischer's former instructor asked his pupil to make a special screw anchor. Fischer exceeded the expectations of the master craftsman with the invention of the expansion anchor. Fabricated from weather-resistant nylon, the small attachment component had what it takes to guarantee a secure hold. Due to the absence of a block, the anchor is suited to all hole depths. As the screw is rotated, the anchor spreads out and its distinctive mini-tails prevent the attachment plug from turning with it. A stroke of genius that delivers what it promises and has been employed many millions of times worldwide.

**Art
Fry**

1974

1958



POST-IT

ART FRY

Art Fry, a U.S. employee of the Minnesota Mining and Manufacturing Company (3M) and a member of a church choir, was irritated that his bookmarks were constantly falling from his music book as he stood and sang. In 1974, he recalled a mothballed idea that a 3M colleague had come up with. It was a special adhesive that could be applied to any surface, and objects could be removed from the surfaces just as easily as they were attached. He retrieved a sample from the laboratory, coated small scraps of paper with the adhesive and tested the result the very next Sunday at church. And lo and behold! The treated bookmarks stayed in place and could be removed easily without damaging the music book. The Post-it was born and began its triumphant march into the world's offices.

IKEA

INGVAR KAMPRAD

Ingvar Kamprad didn't invent the shelf or the studio couch – but he revolutionized an entire industry with a process innovation. The Swede from Småland first made his money in matches and ballpoint pens and then in furniture starting in 1947. In 1952, he began selling furniture through his mail-order business. The catch: Customers had to assemble the pieces on their own. In 1958, Kamprad opened his first IKEA furniture store in Älmhult in southern Sweden. There the customers could indeed look at the finished furniture, but they could only buy it packed up as individual parts for assembly at home as a "do it yourself" project. Thanks to the low prices, the concept proved to be a great success. Kamprad opened his first foreign furniture store in Oslo, Norway, in 1963, and the first IKEA branch outside of Scandinavia opened its doors in Spreitenbach, Switzerland, in 1973. Today, IKEA has 315 furniture stores in 27 countries.



A SYSTEM OF INNOVATION

DR. EBERHARD BOCK, DIRECTOR, STRATEGIC PRODUCT DEVELOPMENT, FREUDENBERG SEALING TECHNOLOGIES, DOES NOT DISPUTE THE FACT THAT GROUNDBREAKING INNOVATIONS OCCASIONALLY OWE THEIR EXISTENCE TO ACCIDENTS. BUT A GLOBAL TECHNOLOGY COMPANY CANNOT WAIT FOR ACCIDENTS TO HAPPEN. ABOVE ALL, IT NEEDS TO BE SENSITIVE TO THE IDENTIFICATION OF TRENDS AND CUSTOMER NEEDS AND TO BE OPEN TO NOVEL CONCEPTS, SO IT CAN TAKE THE LEAD IN NEW IDEAS – AGAIN AND AGAIN. SINCE 2012, THE COMPANY HAS GIVEN STRUCTURE TO ITS BRAINSTORMING. ITS INNOVATION MANAGEMENT SYSTEM (IMS) CAN NOW POINT TO ITS FIRST SUCCESSES – AND IT IS ALREADY AN AWARD-WINNER.

Innovations are a common thread in the company's history. In the 1930s, Freudenberg Sealing Technologies wrote a chapter in the history of technology with its Simmerring® – and, along the way, made the once-inescapable oil spots under parked cars a thing of the past. Within a few years, the shaft sealing ring established itself as a standard component and was the start of the transformation of Europe's largest tannery into a seal manufacturer. With encoder technology, the crankshaft Simmerring added sensor

capabilities in 1995 – another quantum leap that marked its evolution from a simple sealing element to a multi-functional module.

For Freudenberg Sealing Technologies, the capacity to innovate is not just one of a number of characteristics. Jens Trabert, Director, Future Technology, is convinced that it is the very foundation of the technology company. "Innovations create added value for our customers and ensure our financial success." And because innova-

tions can only emerge from our employees' knowledge and experience – individually or as a team – a culture that promotes innovative thinking and action is essential for the company's long-term success.

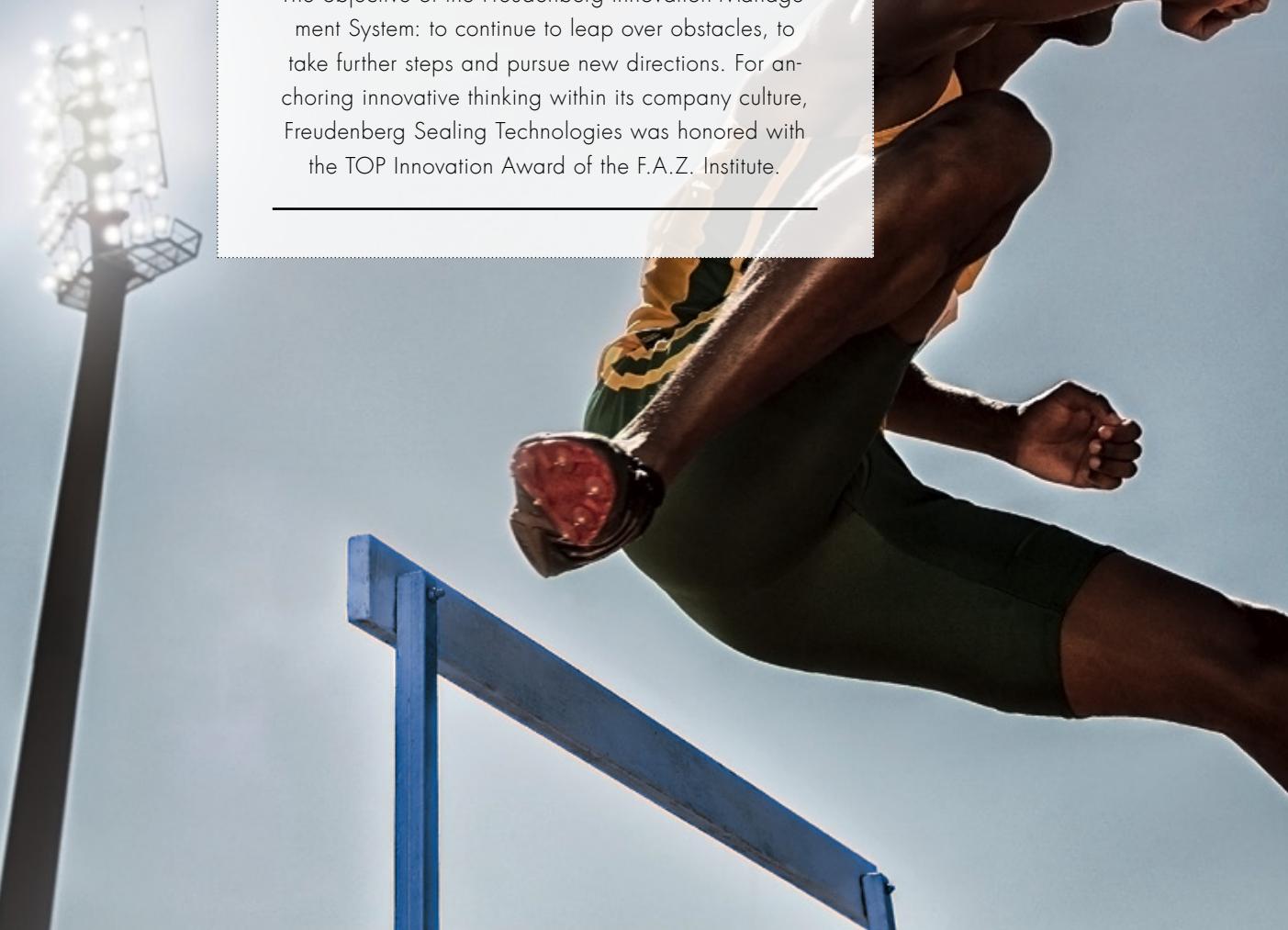
Introduced in 2012, the Innovation Management System (IMS) is the framework for achieving this. With its help, the innovation process is being incorporated into standard company practice – so that valuable ideas are not lost and existing potential is not overlooked.



TOP INNOVATION AWARD 2014

LEAP OVER OBSTACLES

The objective of the Freudenberg Innovation Management System: to continue to leap over obstacles, to take further steps and pursue new directions. For anchoring innovative thinking within its company culture, Freudenberg Sealing Technologies was honored with the TOP Innovation Award of the F.A.Z. Institute.





INNOVATION IN FIVE STEPS

The IMS process consists of five key components: The first step is a **strategic orientation** and includes all the relevant areas of the company. On a kind of oversized chess board, 32 market segments are assigned to the company's 23 Lead Centers, which are the source of an extremely wide variety of sealing concepts. The segments that have been identified jointly with Freudenberg management as strategically significant are specifically marked. More than 700 fields have emerged. The Lead Centers undertake a classification of the segments they consider to be relevant to them commercially. The fields are supplemented by a traffic light system indicating whether or not an innovation project currently exists for the particular segment. If the analysis by the Lead Center, sales and

management ultimately sees a field as strategically important – but no or insufficient projects are underway – it is highlighted in red. This is where action is needed.

The next step is the **definition of the opportunities**. In this process, the red fields on the matrix are subject to an in-depth analysis, which can reach as far down as the application level. Here the primary goal is to build up expertise, and the main tool is the product innovation process (PIP), an important IMS component. All the technical requirements are first clarified within the PIP. Other issues are discussed as well: are there successful products from other segments that could be used here? Are customers from other areas active here? What are our competitors supplying? In the subsequent concept development, a search is mounted for potential solutions – for example, determining whether it would make sense to create completely new ideas with a creative workshop.

With 32 market segments and 23 Lead Centers, an **evaluation of potential projects** is essential. This occurs in the third IMS step. The criteria are the possible market entry, expected sales, development costs and necessary investment. Each potential project must undergo a stringent feasibility analysis. This involves technical and business considerations in equal measure – and the assessment of opportunities and risks. An individual project assessment is developed with results of the analysis. It concerns not only the quickest possible commercial success, but it is also important to assess whether the project is in a strategically important segment. This assessment is based on firmly defined criteria that have different weights in the evaluation.

In **prioritization** – the fourth step – the projects are compared against one another. This involves categorization: "pearls" are highly likely to be techni-



4

Prioritization

5

Advanced Product Development

INNOVATION

cally feasible and promise huge commercial potential. Freudenberg Sealing Technologies innovators describe the "bread & butter" projects as feasible. But they only represent incremental evolution and thus offer low potential for added value creation. This stage is the end of the line for "white elephants". They offer few prospects for new profitable markets but run high risks during their technical execution. In prioritization, it is important to strike the right balance – a healthy distribution of projects heading into the next round across various segments minimizes the entrepreneurial risk.

All the information gathered to this point is ultimately verified with management, developers, controllers and sales. If there are still positive signs after the endurance test, the product innovation process (PIP) continues and **advanced product development** begins – the first step on the path from the market gap to the completed product.

The project's progress is also analyzed repeatedly during the product's advanced development. A continuous exchange of information takes place among all the participants: Did any of the assumptions change? Are there new developments in the segment that are relevant to the assessment? Or will the production of the new technical solution prove to be impossible at the originally planned costs? At this point, it is definitely possible for a "pearl" to become a "white elephant". In that case, the project is very likely to be halted.

The innovation process, even though it was only introduced in 2012, has already led to concrete results. A thermoplastic thrust washer has successfully made it through all the stages and went into series production in fall 2014. It represents an alternative to axial roller bearings or simple spacer assemblies.



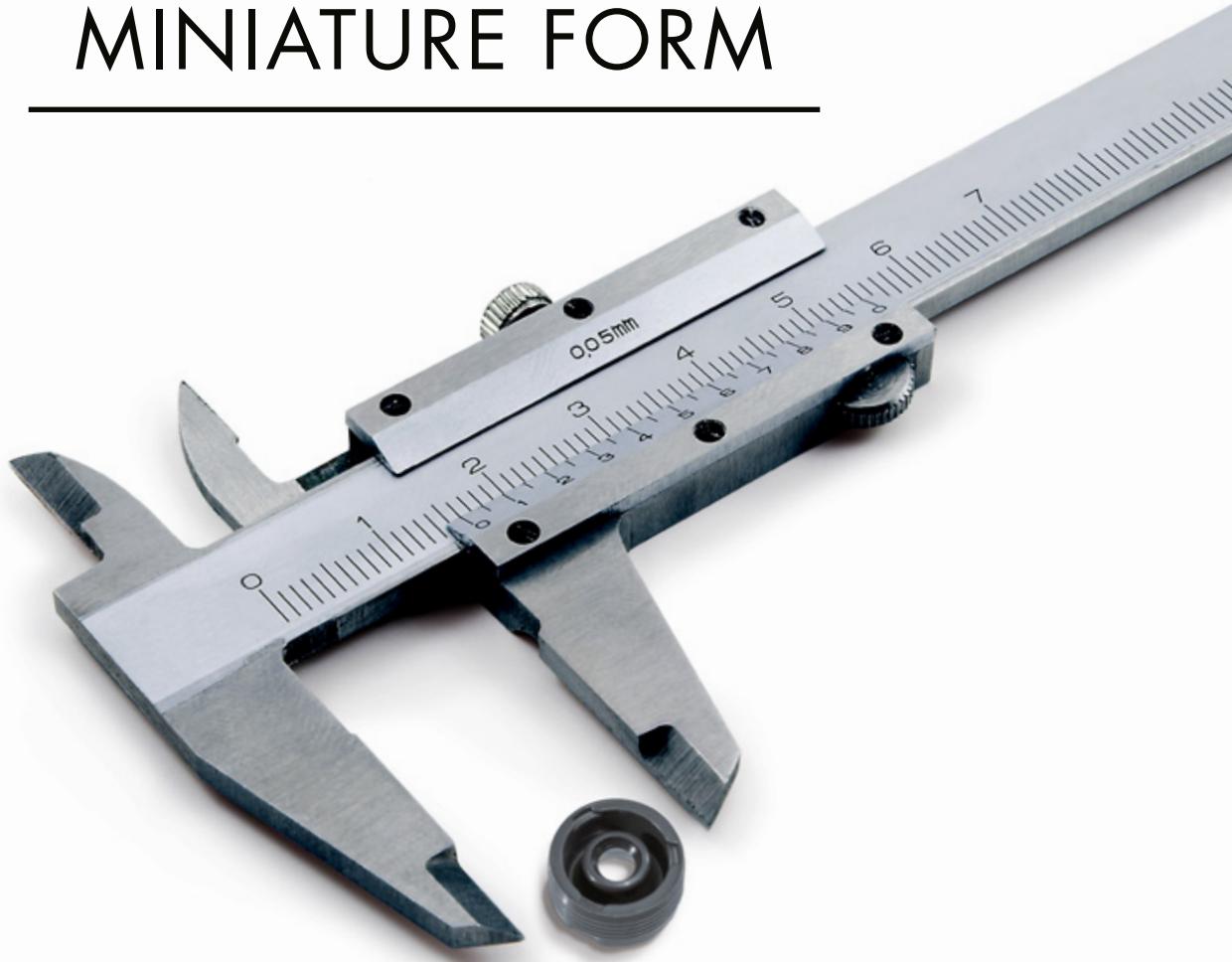
f. l. t. r.:

Dr. Peter Kritzer, Dr. Arman Barimani,
Marcel Schreiner

It is gratifying that others can benefit from the innovation practices that Freudenberg Sealing Technologies firmly established and lives and breathes. Interested companies are learning about the approach at FST Academy seminars and at best-practice events – and an outside institution has recognized the process with an award. In fall 2014, the F.A.Z. Institute gave Freudenberg Sealing Technologies its TOP Innovation Award for the development and presentation of its Innovation Management System.



HIGH TECH IN MINIATURE FORM



THE PRODUCT DEVELOPERS AT A SWISS MANUFACTURER OF HOT DRINKS VENDING MACHINES ACTUALLY HAD NO TIME FOR ROLF SCHÄPPI, SALES ENGINEER, GENERAL INDUSTRY, AT FREUDENBERG SEALING TECHNOLOGIES. THEY WERE BUSY TACKLING AN URGENT QUALITY PROBLEM. IT WAS CONSIDERED MORE IMPORTANT THAN A BUSINESS DEVELOPMENT APPOINTMENT WITH A SUPPLIER THAT HAD NO BUSINESS RELATIONSHIP WITH THE MANUFACTURER AT THAT POINT. BUT THEY TOOK TIME TO MEET WITH SCHÄPPI ANYWAY AND TOLD HIM WHAT THEIR PROBLEM INVOLVED.

AND HE WAS IMMEDIATELY ABLE TO OFFER A SOLUTION –

THE WORLD'S SMALLEST SIMMERRING®.



THE MICRO-SIMMERRING® seals rotating shafts ranging from one to three millimeters

With a few pointed questions from both sides, it was possible to isolate the cause and develop specifications. The hypothesis was that the material in the competitor's seal was not up to the task in the coffee machine due to the manufacturing tolerances of the material being used for small dimensions. The proposal from the Freudenberg Sealing Technologies sales engineer was to use a micro shaft seal ring made of an elastomer. The approach was already moving from advanced development into regular production at the time.

Then everything happened quickly. The requirements were precisely specified and several materials checked for their suitability. The Micro-Simmerring had to withstand gear temperatures of 150 degrees as well as oils and food-grade cleaning agents. The material known as Fluoroprene® XP 41 fit the bill. Using a sample tool, Freudenberg Sealing Technologies created several prototypes that the customer could test in real-life on its own machines – with impressive results. The leak-tightness problem was solved shortly before the launch of regular production. In less than nine months, the Micro-Simmerring made it from an advanced development concept to customer approval – for a six-figure volume per year.

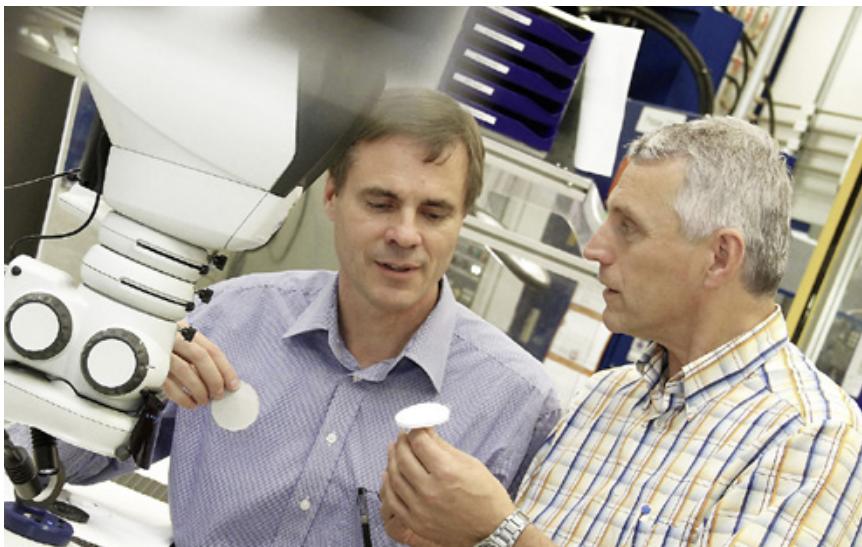
The concept for the Micro-Simmerring emerged in the advanced product technologies (APT) area in Weinheim. Uwe Müller has been in charge of the project from the outset. "Tests showed that the product series reliably seals rotating shafts with diameters ranging from 1 to 3 millimeters at more than 18,000 rpm," he said. The greatest challenge was to design and manufacture vulcanization tools that can shape the ma-

terial in these micro-dimensions. The milling tools used for the metalworking have diameters smaller than a human hair.



UWE MÜLLER
Advanced Product Technologies,
Weinheim

The Micro-Simmerring is produced in Freudenberg Sealing Technologies' Lead Center Special Sealing Industry in Riechelsheim. It is used inside miniature devices and motors equipped with elaborate electronics and sophisticated mechanical elements. For example, micro-pumps must often dose extremely small quantities of liquids very precisely and convey them to their point of operation. The extra-fine dosing of adhesives is another area of application. Micro-seals also play an important role in pharmaceutical and chemical production, biotechnology, the aerospace industry and vehicle technology – in extremely small blowers for LED lamps, for instance. Freudenberg Sealing Technologies' Micro-Simmerring is being introduced to a wide-ranging audience at the Hannover Industry Messe.



ROLF SCHÄPPI/SWITZERLAND (left), STEPHAN BEGLE/AUSTRIA (right) and UWE MÜLLER/GERMANY are jointly taking the Micro-Simmerring to production readiness



2015 VIENNA MOTOR SYMPOSIUM

A "Who's Who" of the auto industry is gathering for the 36th International Motor Symposium at Vienna's Hofburg Palace on May 7 – 8, 2015. The renowned conference gives experts from around the world the chance to exchange ideas, strategies and trends in powertrain technology, discuss legal requirements and report on their latest developments.





ENGINE SUMMIT FOR EXPERTS WORLDWIDE



The focus is on increasing efficiency and reducing fuel consumption and emissions – without impairing drivability and driving pleasure. The work involves complex requirements, and Freudenberg Sealing Technologies has supported the auto industry in these areas with its expertise and productive innovations for many years.

The International Motor Symposium always draws a crowd. This year, more than 1,000 participants are again expected at this star-studded mecca for powertrain experts. In 2015, the Motor Symposium, organized by the Austrian Society of Automotive Engineers (ÖVK) and the Institute for Powertrains and Automotive Technology at the Vienna University of Technology, is attracting visitors to the home of the Prater Park with more than 40 technical presentations. In two parallel sections, they offer information and insights on a range of exciting topics: new gasoline and diesel engines, RDE (real driving emissions, the measurement of emissions during real-life driving instead of test stands), trends in development, exhaust treatment, fuels, engine management, commercial vehicle engines, the plug-in drivetrain, high-performance engines for Le Mans and engine processes. After the presentations,

REMARKABLY LOW FRICTION:
The new LEVITEX® mechanical face seal from Freudenberg Sealing Technologies is gas lubricated, employing a structure that creates an aerodynamic effect during the shaft's rotation.

there is plenty of shop talk – a venerable tradition at the event.

Automakers and suppliers are continually being challenged by ambitious CO₂ emissions limits worldwide. They have to further exploit the potential of internal combustion engines while pressing ahead with alternatives, including powertrain electrification.

A key role also falls to suppliers. Freudenberg Sealing Technologies is flying the flag in Vienna, presenting the expert audience with a selection of the innovative sealing solutions in its portfolio that can help make a significant contribution to demanding development goals. Experts from Freudenberg Sealing Technologies will be ready to field questions on-site at the exhibit. The highlight will be LEVITEX®, the gas-lubricated – and thus especially low-friction – mechanical face seal. Its use can lead to reductions in CO₂ emissions of 0.5 to 1.0 grams per kilometer, without appreciable adjustment to the installation space. This is an enormous reduction from a single component. Declines of this magnitude can generally only be achieved with changes in the concept or the system. This is a major contribution in the automotive

field, in particular, where every gram of fuel consumption counts. The financial considerations are significant as well: if average CO₂ emissions from a particular automaker exceed the limit specified by the EU, fines of 95 euros per gram over the limit, multiplied by the number of new vehicles sold, can be a massive cost factor.

The first LEVITEX seals are already running on test stands and undergoing tough prototype trials with vehicle manufacturers. Series production is planned for 2017.

The innovative seal is especially suited to crankshaft sealing in compact installation spaces. In the process, the primary ring rides on a cushion of air in interaction with the mating ring, leading to a 90 percent reduction in frictional losses compared to a conventional crankshaft seal. There is no solid-to-solid contact during operation and the frictional losses are significantly less due to the low viscosity of the air. Besides the reduction in CO₂ emissions and fuel consumption, LEVITEX offers yet another advantage – reduced wear leads to a longer operating life.

At the Motor Symposium, it is traditionally only a short step from the details of a highly effective innovation to an over-arching perspective. At the grand finale on May 8, three high-caliber figures from the automotive world will take a look into the future.

- **Prof. Dr. Thomas Weber**, Member of the Board of Management of Daimler AG responsible for Group Research and Mercedes-Benz Cars Development, is reporting on "**PLUG-IN Hybrids – Efficiency Meets Performance**"
- **Klaus Fröhlich**, Member of the Board of Management of BMW AG responsible for Technical Development, is presenting "**Power eDrive – the Joy of Driving for Tomorrow**", another chapter in powertrain electrification.
- **Prof. Dr. Martin Winterkorn**, CEO of Volkswagen AG, is addressing the topic "**Turning Point for the Automobile? The Challenges as Volkswagen Sees Them**".

And what's next? Fortunately, it is only one year until the next summit of the powertrain elite rolls around again in the Austrian city, in May 2016.



The LEVITEX® mechanical face seal comes very close to the vision of a friction-free seal.





NEW SOLUTIONS FOR THE MOBILITY OF THE FUTURE



THE AUTOMOTIVE WORLD IS BEING ELECTRIFIED. TO REDUCE THE CONSUMPTION OF FOSSIL FUELS AND THUS THE RELEASE OF CLIMATE-DAMAGING CO₂ EMISSIONS, MANUFACTURERS ARE INCREASINGLY RELYING ON THE ELECTRIFICATION OF POWERTRAINS IN ADDITION TO THE OPTIMIZATION OF INTERNAL COMBUSTION ENGINES AND TRANSMISSIONS. A FEW YEARS AGO, NEARLY EVERYTHING REVOLVED AROUND PURELY ELECTRIC CARS, BUT NOW PLUG-IN HYBRIDS ARE INCREASINGLY IN THE SPOTLIGHT. NEARLY EVERY AUTO SHOW FEATURES THE DEBUT OF A VEHICLE WITH THE POWER OF TWO HEARTS UNDER THE HOOD. WHETHER HYBRID TECHNOLOGY OR PURELY ELECTRIC DRIVE, FREUDENBERG SEALING TECHNOLOGIES HAS THE RIGHT SOLUTIONS ON HAND TO MEET NEW CHALLENGES IN THE SEALING FIELD.



≈ 600
Freudenberg
seals per
vehicle

© General Motors



THE CHEVROLET VOLT IS ONE OF THE PLUG-IN HYBRIDS
As with the current model, several hundred Freudenberg seals are employed in the next-generation Chevy Volt.

Legislative requirements for cuts in fleet CO₂ emissions are ambitious. They may vary from region to region around the world, but they all have something in common: automakers have to mount major efforts to achieve them. As they do so, a high share of electrified powertrains in their fleets promises to be part of the formula for achieving the greatest possible impact.

The spectrum of e-concepts is wide. They range from part-time e-cars to purely electric versions. Hybrids fall into the part-time category, relying on the combination of an electric motor and an internal combustion engine as the sources of propulsion. If its battery can be charged externally from the grid, the twin-hearted vehicle carries the "plug-in" suffix. The fully electric category includes vehicles that produce electricity with the help of onboard fuel cells, as well as cars with a high-voltage battery – usually the lithium-ion variety – providing the electric current for the e-drive.

The leading markets for electric mobility are the U.S., Japan and China, where government subsidies play a major role in shaping consumer demand. In the United States alone, more than 100,000 electric cars and plug-in hybrids hit the road for the first time in 2014. More than half a million electrically or partially electrically propelled cars are now being driven worldwide. The rate of increase for full-time and part-time e-cars is impressive: their number

has doubled every year between 2012 and 2014. But compared to annual new-car registrations in the double-digit million range and a global inventory of more than a billion cars, the absolute figures still seem vanishingly small. Since purely electric cars have so far not met the market's expectations, automakers are increasingly betting on plug-in hybrid technology. Even with all the growing pains, the trend seems irreversible – electricity is powering the future.

INNOVATIVE SEALING SOLUTIONS ENSURE HIGH EFFICIENCY

But for electric mobility suited to everyday use, a variety of innovative components and systems are needed – and automotive engineering must often venture into new territory. For example, operating voltages range up to 600 volts – the normal starter battery is 12 volts and not sufficient for propulsion. And the complexity of the systems, especially in the hybrid field, is enormous.

"Due to the high-voltage components and the specific thermal management requirements alone, there are entirely new and to some extent very complex challenges in seal applications," said Dr. Peter Kritzer, innovation leader in Freudenberg's Advanced Product



FREUDENBERG SEALING SOLUTIONS FOR BATTERY SYSTEMS



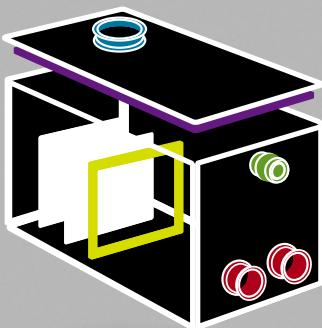
PLUG CONNECTORS FOR COOLING CIRCUITS

Plug connectors (Plug & Seals) are provided for the interfaces within an electric vehicle's thermal management system. The carrying tube executed in 2-component technology offers a range of advantages: secure, inexpensive assembly, acoustic and mechanical decoupling, eccentricity compensation and relatively wide installation tolerances.



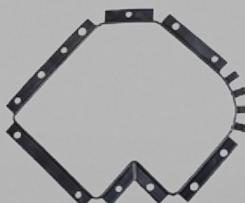
SEALS FOR CELL FRAMES

Cells in a lithium-ion battery can be the prismatic variety or the round or pouch cells. The particularly lightweight pouch cells, with their flexible cell envelope, pose the greatest challenges for mechanical fixing, especially since the thickness of the cell varies with the charge condition. The frame seal that Freudenberg is developing for pouch cells combines the fixing and sealing of the individual cells. It is also possible to integrate additional functions, such as thermal management or discharge channels for emitted gases.



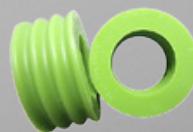
OVERPRESSURE VALVES

Elastomer overpressure valves guarantee reliable system sealing for batteries in a closed state. In the course of regular pressure fluctuations (+/- 0.2 bar), the valves remain closed. In the event of overpressure due to malfunction, Freudenberg's solution ensures the efficient discharge of the resulting gases, thus preventing the potential bursting of the battery housing.



FRAME SEALS FOR HOUSINGS

Large-format, profiled frame seals (flat gaskets) represent the bulk of applications in this area and are tailored to particular requirements, both in their form and in their material. They are especially suited for medium-to-large production runs, starting at 5,000 units, and are easy to assemble.



PLUG SEALS

High-current plug connectors in electric vehicles require special sealing technology. The Plug Seal is a high-voltage insulator developed especially for electric vehicles and can be used at up to 1,000 volts.

Technology division. "Here we can fully play out our know-how and provide manufacturers the best support with innovative, made-to-order sealing solutions."

Freudenberg Sealing Technologies has long experience in sealing applications for the auto industry and this know-how pays off. Its experts are familiar with the varying requirements in different powertrain concepts. The advanced development team of the Weinheim-based seals specialist has been working for some time on new made-to-order solutions for electric vehicles, among other projects. They come into use in batteries and inverters, electric motors, electric axle drives, coolant circuits and various connections within the system – including special seals for lines and plugs. Investigations are also underway on seals for completely novel drive concepts involving wheel hub motors integrated into the wheel. In their work, the engineers' focus is always on reliability, safety, ease of maintenance and, above all, ensuring no loss of efficiency – the reason being that range is the top priority for electric cars. Low-friction, dynamic seals can make an important contribution to minimizing their limitations.



ENERGY BOOST FOR HIGH-VOLTAGE BATTERIES

The grid is the power source for plug-in hybrids and electric cars

Another crucial difference compared to conventional powertrains involves thermal management. While the primary objective for internal combustion engines is cooling, the focus here is on good housekeeping with heat energy and its transport with minimal loss. The reason is that, due to its much greater efficiency, an electric car generates far less heat. And it is imperative to lead this small amount of heat as efficiently as possible from its origin to the vehicle interior so it can be used for climate control.

In addition, due to their higher system complexity, electric cars and hybrid vehicles have more temperature-critical components,

where heat and cold have to be controlled. Due to safety concerns relating to high-voltage and high-current products, the requirements for seals are much more stringent – and more complex. A battery system's modular construction alone involves a wide variety of sealing points. Specially calibrated sealing components can thus make an important contribution to improving thermal management circuits in electrical systems and increasing their safety.

The mainstays of every electric vehicle are its high-voltage battery and electric motor. Freudenberg Sealing Technologies has developed a range of sealing solutions for both of these core components and for numerous connections within the entire system.

SEALING SYSTEMS FOR HIGH-VOLTAGE BATTERIES

Advanced high-voltage batteries require sophisticated thermal management to ensure homogeneous temperature control. Therefore, the deterioration of the various battery cells at different rates – and thus the loss of performance and capacity in the entire system – must be prevented. Furthermore, efforts are made to counter batteries' reduced power output at low temperatures using targeted heat input. Engineers have put emergency protections into their specifications in case of overcharging – along with the avoidance of condensation and penetration by dirt or moisture (risks of corrosion and short circuits). In the event of malfunctions in individual battery cells, the safe discharge of blowout gases must be ensured. Reliability over the entire lifecycle is also one of the core requirements, as is ease of assembly and maintenance. It must be straightforward to open the battery housing and close it completely tight again.

SOLUTIONS FOR ELECTRIC MOTORS

Designing seals for electric drives involves a particular challenge: avoiding loss of performance in pursuit of the highest possible efficiency. But it is also important to cool electric motors adequately, and it is crucial to guarantee sufficient pressure equalization to avoid condensation (risks of corrosion and short circuits) and the reliable sealing of the drive unit against the penetration of moisture and dirt. Moreover, there are strict requirements on noise and vibration (NVH – noise, vibration and harshness) and on electromagnetic compatibility.



FREUDENBERG SOLUTIONS FOR ELECTRIC MOTORS



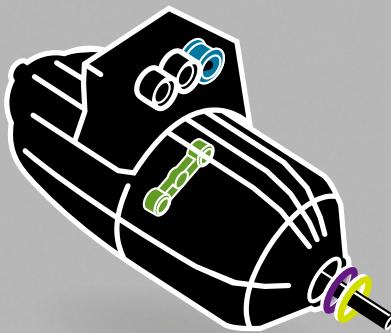
PLUG CONNECTORS FOR COOLING CIRCUITS

Plug & Seals with an EPDM (ethylene propylene diene monomer) seal stand out for their effective resistance to coolants. In plastic carrier tubes, they feature low thermal conductivity – unlike metal versions. The Plug & Seal with an integrated temperature sensor offers an additional benefit: it provides smart monitoring of the cooling temperature in the circuit. This requires neither additional seals nor bores, and assembly is straightforward.



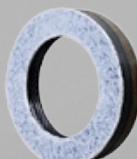
ENCODERS

The rotational angle of the driveshaft is an important operating parameter for the efficient control of electric powertrains. In Simmerrings with an absolute value encoder, the position of the shaft can be exactly determined up to high rotational speed ranges – and even from a standing position, without rotational movement. No additional component is required and assembly complexity is reduced.



TORQUE SUPPORTS FOR ELECTRIC MOTORS

Torque supports, in the form of elastomer composite parts for integrated motor generators (IMG), are a customer development at the Lead Center Special Sealing Automotive. They offer high rigidity in the circumferential direction, as well as soft, compensating characteristics in the radial and axial directions. Thus, they fulfill their task perfectly – controlled vibration compensation.



SIMMERRING® WITH AN OPTIONAL, ELECTRICALLY CONDUCTIVE PTFE-GRAFITE NONWOVEN

Numerous conventional versions of Simmerrings can be found in series-production electric vehicles. Low friction, even at high shaft rotational speeds, is vitally important, although this must not be at the expense of the seal's reliability. The integration of a conductive PTFE-graphite nonwoven permits an additional benefit: in axle drives in an electric car, the input shaft can become

electrically charged, which can lead to damage of the motor mount. With the help of this nonwoven, the electrical charge can be fed from the shaft to the housing, effectively eliminating the danger of damage to the mount.



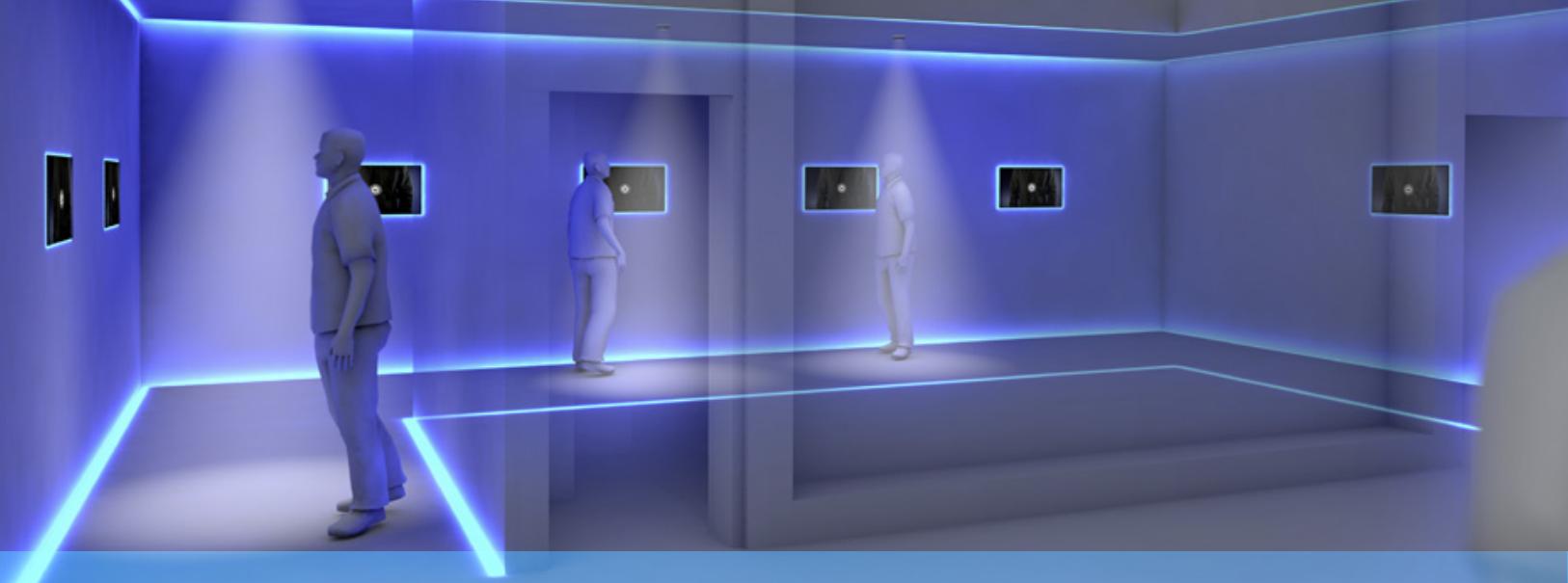
GETTING TO THE HEART OF DIVERSITY



HANNOVER MESSE 2015
April 13-17

DOING JUSTICE TO THE COMPLEXITY OF THE TECHNOLOGY COMPANY'S LINEUP ON A TRADE FAIR STAND IS NO EASY TASK, ESPECIALLY IF THE COMPLEXITY EXTENDS ACROSS 32 INDUSTRIAL SEGMENTS AND INVOLVES A WIDE ARRAY OF SEALING PRODUCTS MADE FROM 1,800 COMPOUNDS AND MORE THAN 1,000 RAW MATERIALS. SO THE FOCUS IS ON HIGHER-LEVEL ISSUES THAT ARE IMPORTANT TO MANY SECTORS. FREUDENBERG SEALING TECHNOLOGIES HAS SELECTED **FIVE AREAS** TO DEMONSTRATE ITS SPECIAL EXPERTISE AND DIVERSITY AS THE MARKET AND TECHNOLOGY LEADER AT HANNOVER MESSE.





INNOVATION TUNNEL AT HMI - SOMETHING TO EXPERIENCE
Freudenberg Sealing Technologies is presenting the latest developments
in sealing technology in the Innovation Tunnel at HMI

BE DRIVEN

1 Freudenberg's patented **Curve Gasket** supports the trend toward new lightweight drive modules. With greater stability, lower reactive forces and broader compression ranges, the Curve Gasket decreases the quantity of form-stabilizing plastic required in engine covers. To accomplish this, the seal features a combination of straight and wave-shaped interfaces that reduce stress. The wave-shaped sections of the seal use the same design principle as the arched waves used to stabilize sheet metal. At increased temperatures, which often lead to expansion problems in seals, this unique design prevents the seal from exceeding the groove's optimal fill level. The Curve Gasket also offers greater stability in smaller grooves, which is ideal for the thermoplastic covers of many new engine designs.

In combination with the right sensor, **multi-pole encoders** allow precise measurement of rotational speeds and angles. They are used in applications in the automotive sector and in general industry, including crankshafts, transmissions and camshafts. With the help of sensors, a magnetizable elastomer layer encoded alternately with north and south poles provides control systems with precise information on rotational speeds and angles. The applications range from gears to crankshafts and camshafts, even all the way to transmissions. With an upgrade to an absolute encoder, the position of a shaft can even be identified at a standstill, without the need for rotation. This is possible with a second identifier, which calculates how many degrees the shaft has already rotated.

CLEAN SOLUTIONS

2 The more sensitive systems are exposed to contamination, the more important it is to seal reliably against outside influences. On farms, modern tractors reduce their tire pressures to less than one bar to spare the soil as much as possible during their work. However, higher air pressures are needed for safe handling on the road, and are duly provided by on-board pneumatic systems. In these applications, seals must be absolutely resistant to dirt and reliably separate oil and air. The **CTI (Central Tire Inflation) seal** from Freudenberg Sealing Technologies was designed for precisely these requirements. As a result, downtime is minimized and efficiency increased.



INNOVATION TUNNEL,
FREUDENBERG STAND, HMI 2015
Innovations in products and materials

HANDLE THE PRESSURE

3 The low-friction LF 300 seal is a single-action rod seal composed of polyurethane with an asymmetric profile and grooved contact surface at the inner diameter. It was developed for light to medium applications (e.g. lift trucks, farm equipment and hydraulic presses), where low friction and shock-free movement are the key criteria, along with excellent leak tightness and reliability.

The grooves on the inner diameter reduce the contact surface and thus the frictional force of the seal. As a result, positioning processes at low speeds can be carried out with particular precision (low propensity for stick-slip). In addition, the overall friction in the system is reduced. Combined with the new high-performance material 94 AU 30000, the new LF 300 offers a unique range of performance and sets new standards for energy efficiency and the ability to withstand chemical and mechanical stresses.

RESOLVE CONFLICTS

4 The use of conventional, non-EHEDGE-compliant flat washers runs the risk that fluids can become established under the screw head. Especially in the food industry, dangerous microbial formations can be the result – with unforeseeable consequences. This is because even the most thorough equipment cleaning cannot reach and clean the soiled areas beneath the screw heads. The **Hygienic Usit®** is the solution for these difficult applications. In accordance with hygienic design, this seal ring makes it possible for the first time to seal off screw heads reliably against external influences. Germs don't stand a chance.

SMOOTH AND STEADY

5 The new polymer **thrust washer** demonstrates the success of close cooperation during development – in this case with Solvay Specialty Polymers and General Motors. In the eight-speed 8L90 transmission, it combines outstanding frictional and wear characteristics at increased pressures and speeds. The plastic uses features with the highest possible stability and rigidity up to a temperature of 275 °C and outstanding resistance to wear, yield strain and chemicals.

The **Duo Forseal** is an extremely wear and heat-resistant seal that is ideally suited for use in modern high-pressure injection pumps. Their piston rods move at a frequency of more than 200 Hertz – a load that the Duo Forseal can handle, even after more than a billion strokes. Thus, high-pressure pumps can function efficiently and trouble-free during the long operating life of a commercial vehicle.

LEAK-TIGHT UNDER ARCTIC CONDITIONS

They must withstand the most adverse weather conditions in the most remote areas, whether they are a means of transportation in Alpine or Arctic regions, recreational vehicles or impressive racing machines on professional circuits – Polaris snowmobiles set the standard when it comes to reliability, quality and performance. Freudenberg Sealing Technologies has developed nearly maintenance-free diaphragms in cooperation with this American leader in its field. They now last as long as the snow machines themselves.

Snowmobiles are frequently powered by two-cylinder/two-stroke engines, in which diaphragms use the cylinder pressure to activate variable outlet valves. If a diaphragm fails, the engine can no longer deliver its maximum performance. If diaphragms in both cylinders fail, the loss of power is especially dramatic. Developed by Freudenberg with its longtime partner Polaris, the new diaphragm is nearly maintenance-free, very robust and stands out for its high durability.



Four measures are crucial here:

- The installation of reinforced high-temperature meta-aramid fabric (Nomex®) enabling the diaphragm to withstand high temperatures in the exhaust system over a longer period. Even on very cold days, exhaust temperature can often exceed 150 °C.
- The addition of an RFNTM (Reduced Friction by Nanotechnology) coating, which reduces friction by up to 70 percent, allowing the diaphragm to move effortlessly along the surfaces of the intermeshing fixtures.
- A design change from a dome-like to convoluted form to facilitate mounting and to allow the effortless movement of the diaphragm.
- The incorporation of small rubber ribs on the fabric side to protect it from abrasion.

"Freudenberg is proud to collaborate with an industry leader like Polaris," said Vinay Nilkanth, Vice President, Mobility Sector, Freudenberg Sealing Technologies. "We are establishing successful business relationships with companies that set technological standards and supporting their success with the best available sealing systems."

In this way, even snowmobile drivers can benefit from Weinheim's material and sealing expertise when they ride their snowmobiles under extremely severe conditions.

POWERFUL TRIO



FOR THE PHARMACEUTICAL AND CHEMICAL INDUSTRIES

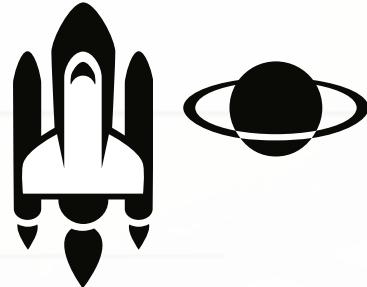
The pharmaceutical and chemical industries place tough demands on flat gaskets. The flange connections must withstand rising surface pressures and high temperatures, and seal reliably even with variable loads and changes in internal pressure. Freudenberg Sealing Technologies currently has three types of products in its portfolio that cover all these requirements.

The white **FG-180** flat gasket to DIN 28091-3 consists of PTFE with structured silicate as a filler material. The FG-180 is mainly designed for the pharmaceutical industry and conforms to the specifications of TA Luft and FDA CFR 177.1550. The use of silicate provides improved stability values compared to flat gaskets with a barium sulfate filler. FG-180 flat gaskets can be used from **-200 to +210 °C**.

The white **FG-360** is made from 100-percent pure, expanded PTFE (ePTFE) to DIN 28091-3. It can be delivered either as a stamped flat gasket or a self-adhesive sealing band (FG-360 Joint Sealant). The special feature of PTFE material is its unique flexibility. The FG-360 flat gasket fulfills all the requirements of FDA CFR 177.1550, TA Luft and USP Class VI - 121 °C. It offers the best stability values among all the options in this product category – and in nearly all media. Both the sealing band and the sheets are distinguished by their extraordinarily high stability in the temperature range from **-270 to +310 °C**. The self-adhesive flat sealing band can be tailored individually on-site and seals complex forms, joints, lids or frames quickly and reliably.

The blue, tried-and-tested **FG-120** to DIN 28091-2 is a graphite seal reinforced by aramid fibers. It meets the specifications of EC Regulation 1935/2004 as well as TA Luft. It also stands out for its good mechanical characteristics as well as its high chemical and thermal resistance. Due to its graphite filling, the seal is suited to operating temperatures from **-100 to +300 °C**.

All the requirements of the pharmaceutical and chemical industries can be covered by the powerful **trio** of **FG-120**, **FG-180** and **FG-360**.



FROM SPACE FLIGHT TO THE ROAD

Freudenberg Sealing Technologies now applies a stamped metal seal made from a high-temperature alloy (HTA), originally developed for the aerospace industry, to the auto industry as well. Compared to the traditional stainless steel materials, the new seal offers higher stability and better resistance to corrosion and fatigue.

The **HTA alloy** is made from a metallic material with high nickel content and offers extreme temperature stability. This quality makes it extremely suitable for turbocharged engines. "The adaptation of HTA materials to the automotive market makes sense, because turbocharged engines mean considerably more heat is produced in the engine compartment and especially in the exhaust system," said Scott Anderson, Freudenberg Sealing Technologies Product Marketing Manager. HTA's strength increases over the course of time and under heat exposure. As a result, the aging resistance of a catalytic converter's inlet seal can be increased by a factor of three compared to the current standard, without deterioration in performance. Other advantages are reduced material thickness and stamping widths. The new HTA seals are manufactured in Neenah, Wisconsin, in the United States. Materials, products and coatings can be tailored to the requirements of specific applications.



FEEDBACK & CONTACT

UP-TO-DATE, COMPREHENSIVE INFORMATION

Would you like to know more about Freudenberg Sealing Technologies, our products, solutions and services? Then go to www.fst.com and take a look at our extensive portfolio. You can also go to our website to download back issues of our customer magazine in PDF format or to register for a free subscription to the magazine.

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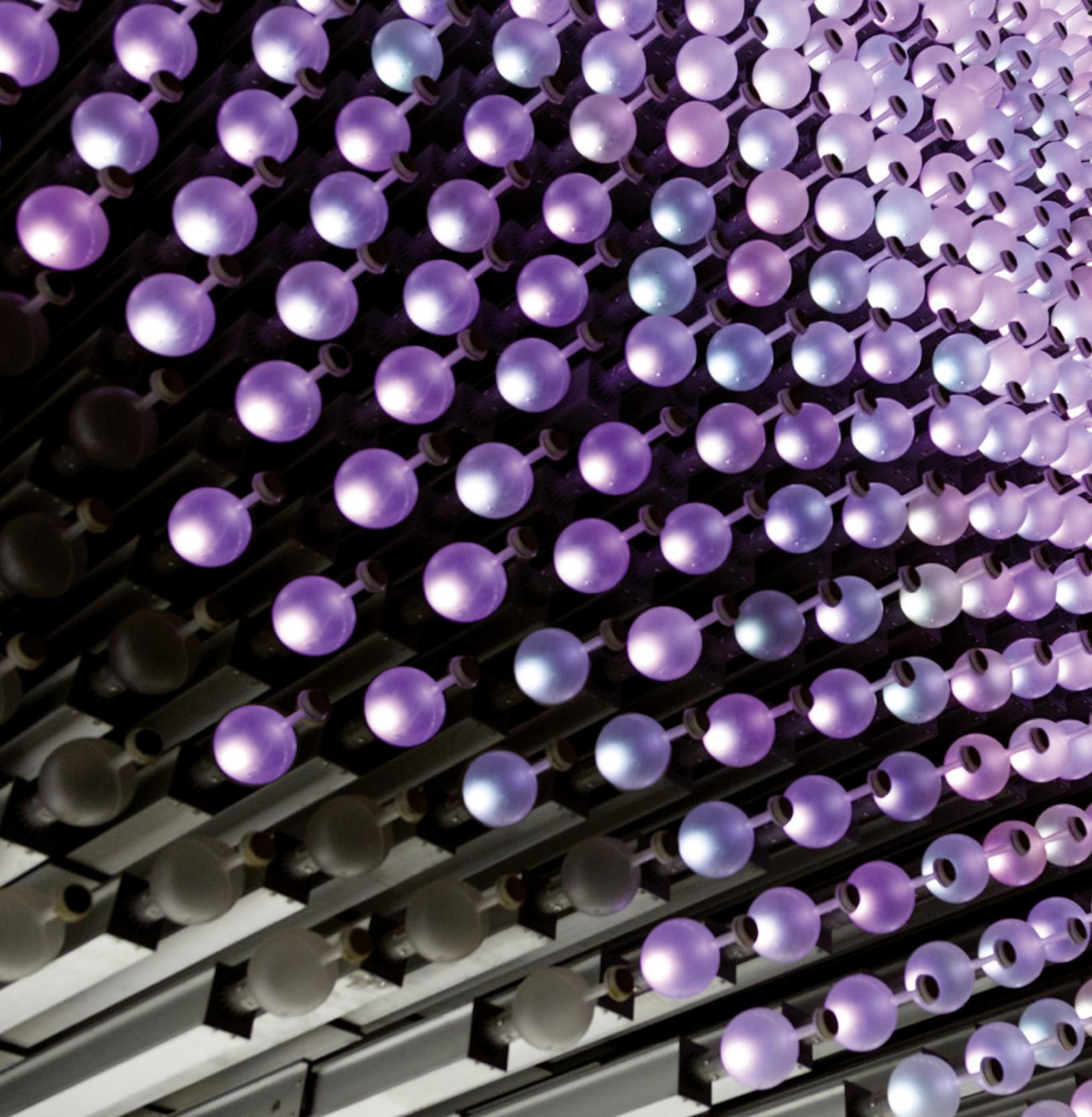
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