DESIGN AT ATOMIC LEVEL • "There's market share to gain"
Additive tool manufacturing • **THE SMASHPROOF GUITAR**
FLYING ON LESS FUEL • On-the-job training in China

MEET SANDVIK

#1-2019

SANDVIK GROUP MAGAZINE

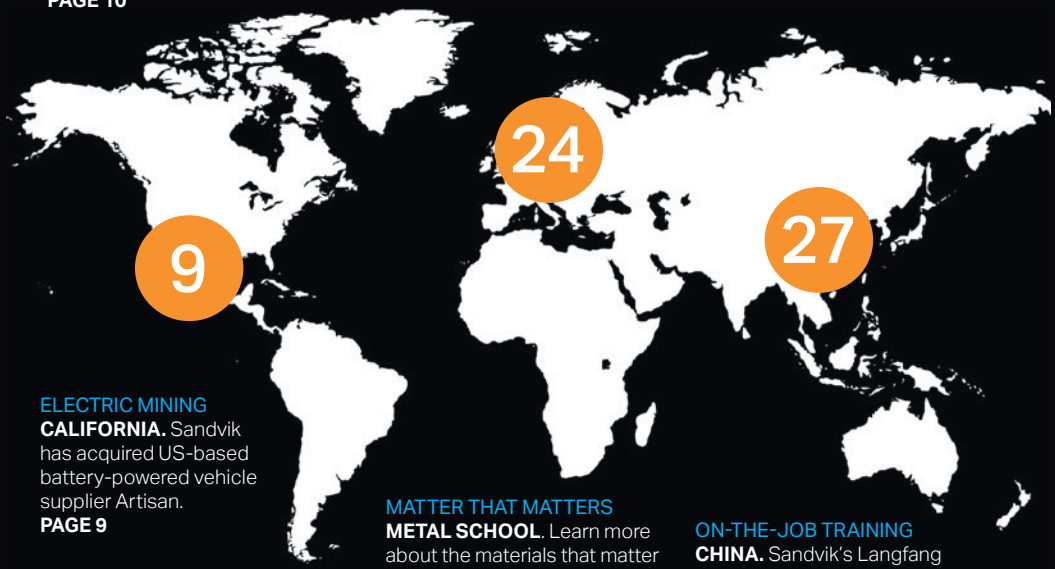
TOMORROW TAKES OFF

By developing lighter, stronger and more durable materials, Sandvik shapes the world of tomorrow and makes it more sustainable.
PAGE 10

TOMORROW'S MATERIALS
FOCUS. Materials build civilizations and shape our world. Tomorrow's materials are designed at atomic level by Sandvik.
PAGE 10

LET'S CREATE!
BRANDING. Sandvik has built a smashproof guitar.
PAGE 4

INTERVIEW
GÖRAN BJÖRKMAN. The president of Sandvik Materials Technology can look back at a good first year.
PAGE 24



ELECTRIC MINING
CALIFORNIA. Sandvik has acquired US-based battery-powered vehicle supplier Artisan.
PAGE 9

MATTER THAT MATTERS
METAL SCHOOL. Learn more about the materials that matter most.
PAGE 20

ON-THE-JOB TRAINING
CHINA. Sandvik's Langfang plant offers vocational training to support recruitment and community image.
PAGE 27

CONTENT #1-2019

Follow us on social media and find more stories at: home.sandvik/sandvikstories

MEET SANDVIK: The Sandvik Group magazine
PUBLISHER RESPONSIBLE UNDER SWEDISH PRESS LAW: Jessica Alm
EDITOR-IN-CHIEF: Marita Sander **PRODUCTION:** Spoon Publishing AB
WRITERS: Danny Chapman, Susanna Lidström, Jonas Rehnberg
PRINT: Falk Graphic **DATE OF PRINT:** April 2019
Published in Swedish and English, in printed form and at our website home.sandvik
EMAIL: marita.sander@sandvik.com.
PHOTO: Samuel Unéus, Alamy, Getty Images

UNIMAGINED POSSIBILITIES WITH THE MATERIALS OF TOMORROW

THE DEVELOPMENT OF materials with new properties is highly significant for society. Materials knowledge is required to produce safe, clean and efficient energy systems and to develop new materials that make airplanes and cars lighter and more fuel-efficient. If the Eiffel Tower had been built using today's advanced high-strength steel, four towers could have been constructed with the same amount of material.

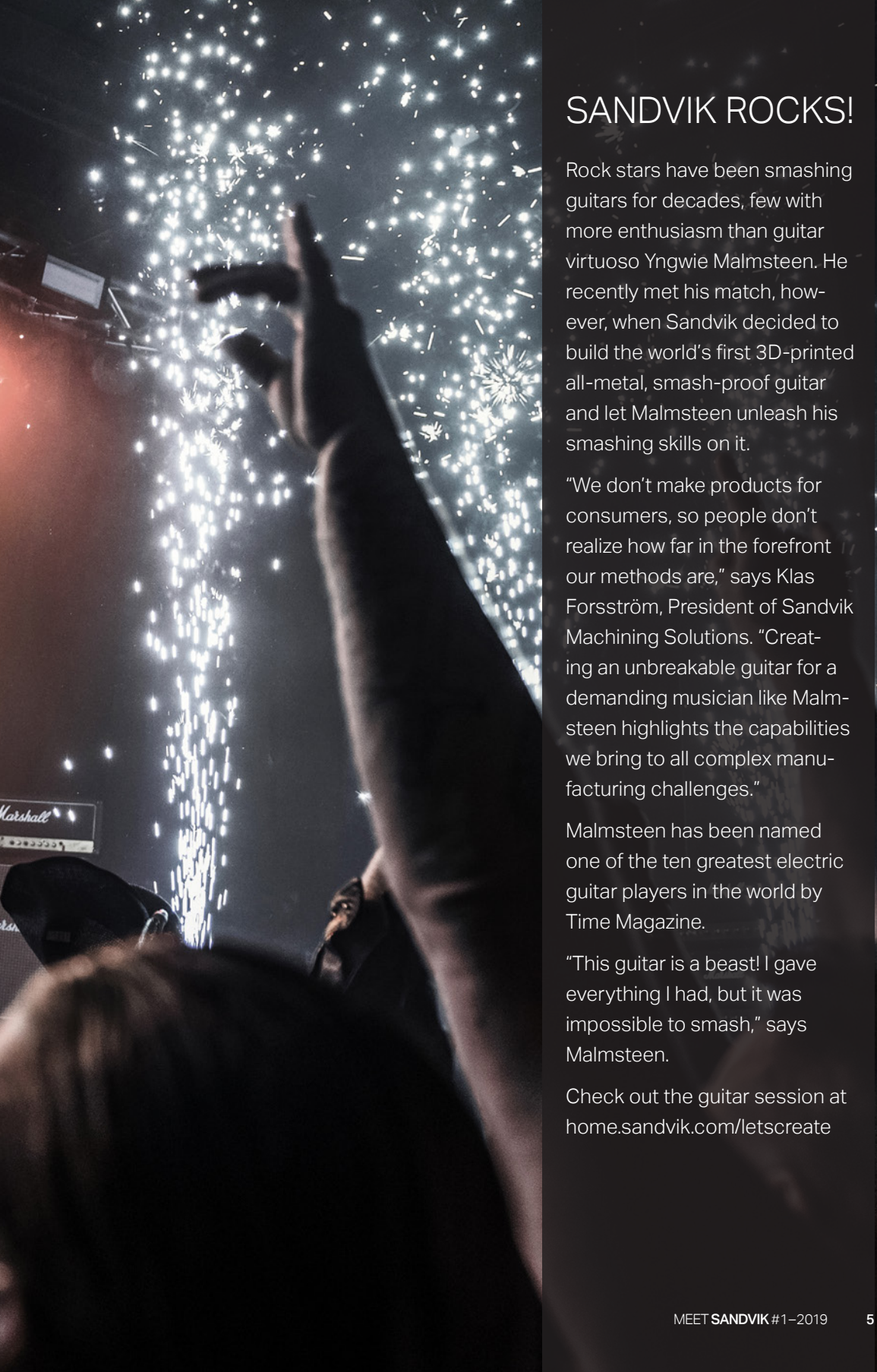
Sandvik has been developing new materials for more than 150 years, and we are world leaders in this field. The demands for new solutions are rapidly increasing, not least from a sustainability perspective, and there is significant future potential. It is of central importance to continue optimizing materials so that they weigh less, are stronger and can withstand higher temperatures and more corrosive environments.

Through additive manufacturing (3D-printing) and computer-based integrated material design, materials are optimized to have specific desired properties. We work at the atomic level when we design materials, moving atoms around to create new compounds based on existing materials.

Materials knowledge is and will continue to be a key skill, and increasingly the industry needs young engineers who are interested in the subject. To that end it is important to explain what materials development actually involves and how it affects the world around us. Read more on pages 10–23.

Björn Rosengren, President and CEO


Marshall



SANDVIK ROCKS!

Rock stars have been smashing guitars for decades, few with more enthusiasm than guitar virtuoso Yngwie Malmsteen. He recently met his match, however, when Sandvik decided to build the world's first 3D-printed all-metal, smash-proof guitar and let Malmsteen unleash his smashing skills on it.

"We don't make products for consumers, so people don't realize how far in the forefront our methods are," says Klas Forsström, President of Sandvik Machining Solutions. "Creating an unbreakable guitar for a demanding musician like Malmsteen highlights the capabilities we bring to all complex manufacturing challenges."

Malmsteen has been named one of the ten greatest electric guitar players in the world by Time Magazine.

"This guitar is a beast! I gave everything I had, but it was impossible to smash," says Malmsteen.

Check out the guitar session at home.sandvik.com/letscreate

NEWS

NEW AND INSPIRING ONLINE PRESENCE. Visit our new web site "Meet Sandvik – our stories". Where technology, ideas and innovation intersect to create a better tomorrow. Articles, features, podcasts, videos and much more at home. sandvik/meetsandvik.

6 **In the past 10 months**, Sandvik has implemented six acquisitions, a historically high number:
Inrock (rock drilling tools), Metrologic (measurement technology), Custom Electric (heating elements for industry), Dura-Mill and Kunshan (solid carbide end mills/round tools) and Artisan (battery-powered equipment for mines).

SMART STEEL **WINNERS**

SMARTSTEEL INNOVATION Challenge is an initiative from Sandvik and steel maker SSAB aimed at developing new ideas of how to trace steel throughout its life cycle. An identifying mark, like a fingerprint, should act as a quality label and provide useful information about the material – its safety and durability among other things.

Twenty-six teams submitted ideas ranging from laser and direct part markings, digital twins, blockchains, algorithms and image-based microstructure identification to noise analysis and a global platform. The jury selected Mikael Sjödahl from Luleå University of Technology, Sweden and Tobias Schmid-Schirling from Frauenhofer Institute for Physical Measurements Techniques IPM, Germany as winners based on their marker-free tracking solutions.

Sjödahl's proposal is based on a three-level optical solution in which each level identifies the product through a unique pattern saved in a database.

Schmid-Schirling's solution, called a Track and Trace Fingerprint, captures the structural pattern of a product with a standard industrial camera and encodes the high-resolution image into a numerical code for later identification.

Together with Sandvik and SSAB, both winners will start pilots to further develop their ideas.

Mattias Klockars (Sandvik jury member), Mikael Sjödahl (winner), Niko Korte (SSAB jury member) and Tobias Schmid-Schirling (winner) at the awards ceremony.

ACQUISITION OF **DURA-MILL COMPLETED**

SANDVIK COMPLETED THE acquisition of U.S.-based Dura-Mill, a manufacturer of precision solid carbide end mills on December 3, 2018. As part of Sandvik Coromant, Dura-Mill will add even stronger capabilities for managing customized end mills.

ADDITIVE MANUFACTURING REINVENTS TOOLING

SANDVIK TAKES MACHINING solutions to the next level by applying additive manufacturing technology to CoroMill® 390, a tooling system with shoulder milling cutters for mixed production. Additive manufacturing is excellent for complex shapes and allows the product to be topologically optimized. As a next step the material has been changed into a titanium alloy, using the additive technology of powder bed fusion laser as the manufacturing method.

The result is a new lightweight version of CoroMill® 390, in which the milling cutter body weight has been reduced by more than 80 percent without compromising strength. The design limits vibration and smooths cutting performance, increasing customer productivity by up to 200 percent.

Sandvik's leading expertise in metal cutting and additive manufacturing, including powder technology, has enabled the reinvention of an existing product, with increased end-customer value.

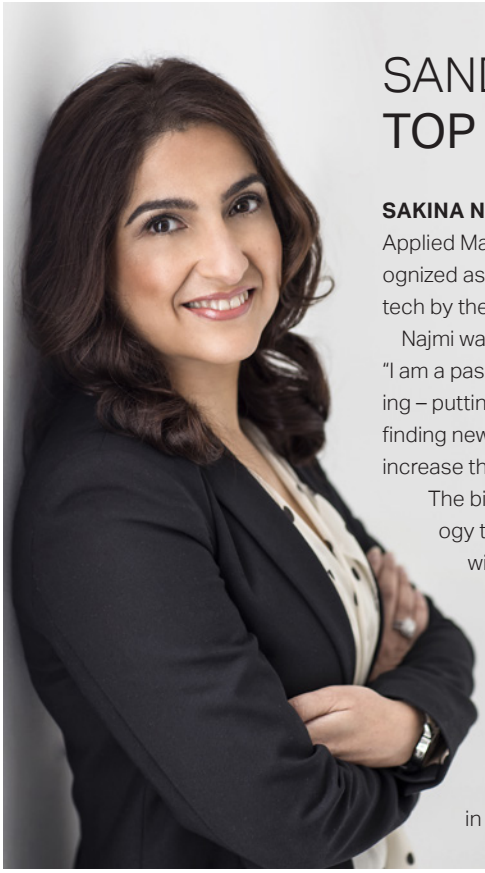
Outcome:
Optimized design, 80 percent lower weight and up to 200 percent increased productivity.

Designers:
Per Viklund, Johan Lindström, Einar Leo Ottesen and Anna Nordstrand

Material:
Titanium alloy, Ti6Al4V

Additive technology:
Powder Bed Fusion Laser

Post processing:
Heat treatment and machining



SANDVIK HOME TO TOP TECH INFLUENCER

SAKINA NAJMI, Vice President Marketing at Sandvik's Applied Manufacturing Technologies division has been recognized as one of the top 20 most influential women in B2B tech by the B2B Marketing thinktank.

Najmi wants to align marketing with commercial ambitions: "I am a passionate advocate of customer-centric marketing – putting customers at the heart of any campaign – and finding new, innovative ways to engage and inspire them and increase the level and longevity of their loyalty to a brand."

The big challenge, she adds, is finding the right technology to create meaningful and relevant conversations with the customers. "There are so many continual advances in technology it can be difficult to keep up and be confident of your marketing technology investment. AI and machine learning are potent tools, but the challenge is how to introduce these 'hot ideas and technologies' to transform the way we market our products and solutions in an industry where things are still done in a very traditional way."

NEW PRESIDENT FOR SANDVIK MINING AND ROCK TECHNOLOGY

SANDVIK HAS APPOINTED Henrik Ager, previously President for the Rock Tools division in Sandvik, as President of the business area Sandvik Mining and Rock Technology and member of the Sandvik Group Executive Management.

"Ager is committed to further strengthening Sandvik Mining and Rock Technology's market position, reinforcing customer relations, driving aftermarket sales, leveraging further on a decentralized way of working and ensuring our forefront position within automation, electrification and sustainability," says Sandvik's President and CEO Björn Rosengren.

Ager has more than 16 years of experience from the mining industry, out of which an extensive period has been spent living in South Africa. Additionally, he has worked in Australia, South America, India and other important mining markets.

Henrik Ager

UNDERGROUND BATTERY VEHICLE SUPPLIER ACQUIRED

SANDVIK HAS COMPLETED the acquisition of Artisan Vehicle Systems, a U.S.-based supplier of battery electric vehicle solutions for underground mining. Artisan will be a business unit in the Load and Haul division within Sandvik Mining and Rock Technology.

In 2017 Artisan, a start-up company, had revenues of 12.3 million USD and approximately 60 employees.

WEF RECOGNIZES SANDVIK

THE WORLD ECONOMIC FORUM (WEF) has recognized the Sandvik Coromant production unit in Gimo, Sweden, as an advanced Industry 4.0 facility. The plant was added to a network of "Manufacturing Lighthouses", state-of-the-art facilities that serve as world leaders in how to successfully adopt and integrate cutting-edge technologies, including automation, Internet of Things, Artificial Intelligence and cloud computing. WEF points out how Sandvik has created a digital thread throughout its production processes that has significantly raised productivity.

Sandvik's plant in Gimo is hailed as an advanced Industry 4.0 facility.

Nadine Crauwels, President of Sandvik Coromant, says: "Having our Gimo production unit listed as a lighthouse not only demonstrates true performance and increased competitiveness but, just as importantly, it shows sustainability at the heart of innovation."

SANDVIK INCLUDED IN SUSTAINABILITY YEARBOOK 2019

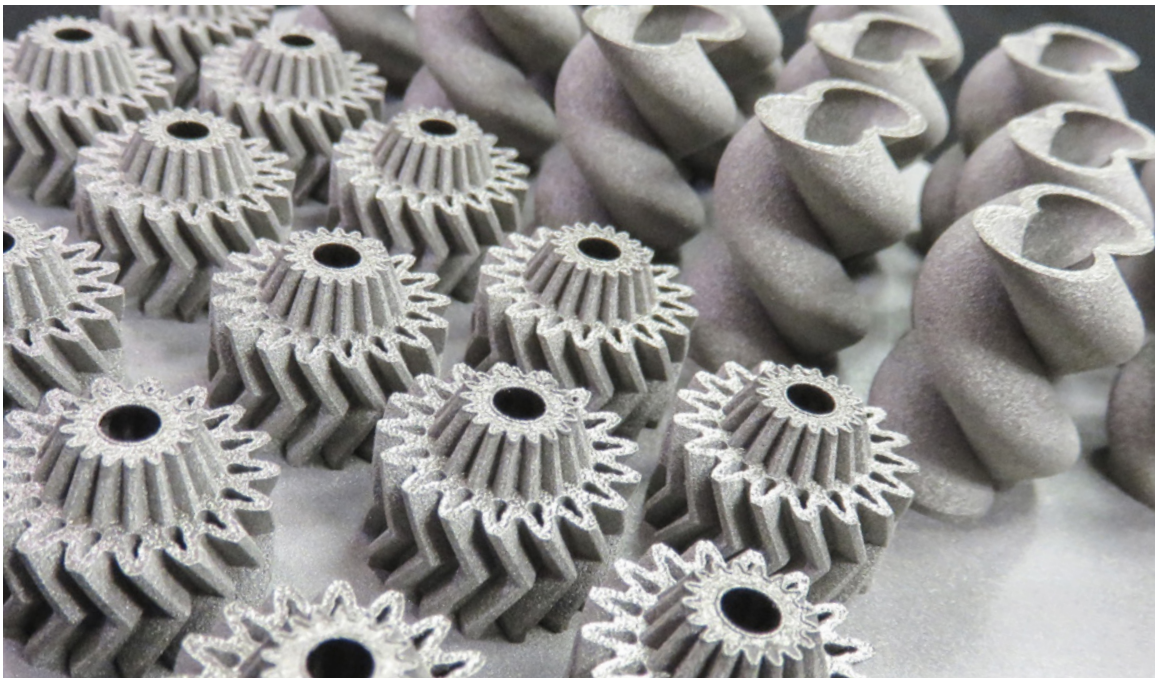
SANDVIK HAS QUALIFIED for inclusion in the RobecoSAM Sustainability Yearbook 2019, proof of its successful sustainability performance. To be listed in the yearbook, companies must be within the top 15 percent of their industry and must achieve a score within 30 percent of their industry's top-performing company.

"We congratulate Sandvik for achieving a place in the Sustainability Yearbook 2019, a showcase of the world's best-performing companies among industry peers and in terms of financially material ESG [Environment, Social, Governance] metrics," says Daniel Wild, Ph.D., Co-CEO of RobecoSAM. "Launched this year under the SAM brand and now with increased public access to the percentile rankings of all companies, the yearbook remains a highly credible source of corporate sustainability insights."

FOCUS

MATERIALS SHAPE CIVILIZATIONS

Rather than looking for brand new materials, material scientists today are focusing on developing existing materials through revolutionary new processes. The results of their work will undoubtedly change the world around us – and possibly help to save it.



Additive manufacturing has opened up completely new ways of using the same types of materials that we have today, by building in certain properties and allowing products to be topologically optimized.

THE DEVELOPMENT OF new materials is perhaps one of the most important endeavors of humanity, defining historic periods and changing the way the world around us looks. After all, the stone, iron and bronze ages were so named because of the materials that were most in use during those times.

When it comes to thinking about tomorrow's materials today, the biggest focus is on sustainability. And material science is key to making secure, clean and efficient energy systems possible as well as making a whole range of industries, from transportation to manufacturing, sustainable.

ANNIKA BORGENSTAM IS professor at the Department of Materials Science and Engineering at Stockholm's KTH Royal Institute of Technology. She uses the Eiffel Tower as an example of how material science can lead to a more sustainable world.

"If we used the advanced high-strength steels that we have today, we could build four Eiffel Towers with the same amount of material that was used originally," she says. "Building lighter constructions will mean that less transportation of material is necessary and less material needs to be produced. Both factors lead to less CO_2 emissions. Stronger steel also means that aircraft and cars and such will weigh less, which means less CO_2 emissions."

Material scientists are searching for materials that are lighter and can withstand higher temperatures and more corrosive atmospheres.

But rather than looking to actually develop brand new materials, today the big push within the industry involves the (often radical) restructuring of existing materials, using revolutionary new processes such as additive manufacturing, also known as 3D printing, and computational modeling.

"Additive manufacturing will open up completely new ways of using the same types of materials that we have today, by building in the properties that we need," says Borgenstam.

One of the reasons why the focus in materials science is now on new processes and the development of existing materials is because the development of brand new materials can take many years. And while there is a push to replace certain scarce materials such as cobalt, which is used in cutting tools and electric car batteries, material scientists are also increasingly focusing on recycling materials.

Borgenstam cites steel as an example of an existing material for which there is no need to find a replacement. "Steel is fully recyclable, cheap and abundant, and we can produce it with a large spectrum of different properties," she says. "It is difficult to compete with that. There is still room for improvement with steel. We are far from reaching its theoretical strength."

PERHAPS ONE OF the biggest issues facing the development of new materials is a shortage of young people with the right competencies to undertake the relevant research. "It is not that easy to recruit young people into materials," says Borgenstam. "It is not as well known, as physics and chemistry are, and aspects of it, like the steel industry, are sometimes presented negatively in the media."

But, she adds, this is an area in which young scientists and engineers can have a huge impact on the world around them. "I would advise young people that going into material science is a way to save the world, because you can really have an impact on sustainability and saving the environment. There are so many positive effects from using better materials, and we need to show them that." ■

Annika Borgenstam
Professor at the Department of Materials Science and Engineering at Stockholm's KTH Royal Institute of Technology.

DESIGNING MATERIALS AT ATOMIC LEVEL

To develop the materials that customers and society will demand tomorrow, companies need to think radically and collaboratively. With its world leading materials expertise, Sandvik is well positioned to help create tomorrow's world.

SANDVIK HAS BEEN developing new materials for more than 150 years. Today it is one of the world's leading developers of new materials. The company knows that staying ahead of current trends is essential to meeting customer as well as societal demands.

Marco Zwinkels, Director R&D Technology Platforms at Sandvik Coromant, says industry demand for new materials is driven primarily by the aerospace and automotive sectors and the push for more sustainability across manufacturing.

This demand, Zwinkels says, presents similar challenges for the development of new materials by Sandvik to be used in products across industry and manufacturing as it does for the development of Sandvik's cutting tools.

"The trend for weight reduction in all forms of transportation is resulting in an ever-increasing use of fiber composite materials and lightweight materials such as titanium," he says. "We are seeing an increase in aluminium components, driven by the development of electrified vehicles. At the same time, more advanced heat-resistant superalloys are now being used for turbines in the aerospace industry. These are often very tricky to machine, which puts higher demands on our tools."

ANOTHER DRIVER FOR the development of new materials in the machining solutions area comes from several issues associated with cobalt, one of the key constituents of cemented carbide, the main material used in metal and rock cutting tools.

Cobalt is becoming more problematic, Zwinkels says. "Cobalt has been reclassified as more hazardous than before, and occupational exposure limits have been lowered," he explains. "In addition, it is mined at or close to conflict areas. Furthermore, it is used in car batteries, so with the electrification of cars there is a risk it will become scarce."

Zwinkels says that Sandvik has both a challenge-driven and an opportunity-driven perspective when it comes to developing new materials.

"From the opportunity side we drive long-term research in-house, often in cooperation with institutional and academic partners," he says. "We probe and track the development of new materials in academia. The need side comes from customer requests, market trends and industry developments. The essential input comes from our global sales, engineering and specialist network as well as from the business intelligence function. We try to understand from this what kind of material development will be necessary for the future."

SUSANNE NORGREN, Group Expert Materials Design at Sandvik, is also an associate professor in Applied Materials Science at Uppsala University. For her, the most exciting development in materials science comes from revolutionary new processes.

"Additive manufacturing and the further development of integrated computational materials engineering are methods where materials are digitally optimized in order to achieve certain desired properties. We can also develop and design materials and components in new and faster ways," she says. "The 3D-printed spacecraft

"We are now at atomic levels in designing our materials, allowing us to create new compositions of existing materials."

The 3D-printed landing gear for SpaceX was developed using integrated computational materials engineering where materials are optimized digitally.

landing gear for SpaceX is an example where this method is used in proceeding from atomic level to finished product."

Zwinkels agrees. "Materials science has become very mature," he says. "We are now at atomic levels in designing our materials, allowing us to move atoms about to create new compositions of existing materials. Computational modeling allows us to see what kind of new compositions could be possible and what would be needed to realize those."

ANOTHER KEY ADVANTAGE of additive manufacturing, Norgren points out, is that it allows engineers to remove waste materials from the process, making materials lighter and therefore more sustainable. "I think all of Sandvik's customers will benefit from this," she says. "And Sandvik will benefit internally too in terms of efficiency. Sandvik is very well equipped when it comes to 3D printing machines and know-how."

Perhaps the only way that a sustainable world can really be achieved, though, is through recycling. And this is also something that material scientists are increasingly exploring more, helped by the new computational processes.

"Driven by the increasing scarcity of cobalt and many other materials, as well as the need to reduce our carbon footprint, we must move toward 100 percent usage of recycled raw materials in our products," Zwinkels says. "Sandvik is the leading global player when it comes to recycling cemented carbide. A significant amount of the materials that we sell comes from recycled tools, which we buy back and convert into new material. We have done that successfully for many years, and this will become increasingly important." ■

POWDER POWERS SMART DEVICES

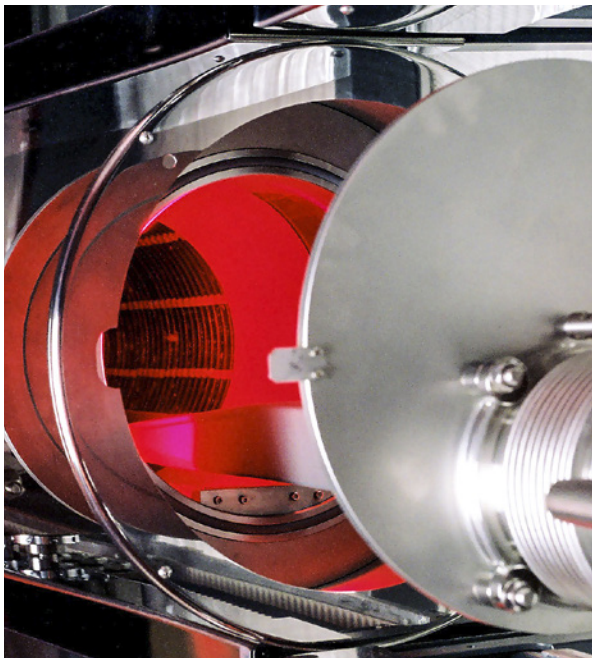
Semiconductor components for smartphones and other digital gadgets are processed in industrial furnaces with extremely precise demands for dimensional stability and purity. Sandvik's powder metallurgical materials stand up to these challenges and boost productivity and sustainability in the electronics industry.

IN OUR DIGITALIZED society, more and more people are using increasingly sophisticated technology built into a growing number of smart devices for both utility and entertainment. Demand for hardware is increasing, and at the same time the requirements for sustainability and resource efficiency are becoming more stringent.

"Our materials are used in, for example, heating systems for industrial furnaces, where silicon-based semiconductor components are treated with various coatings before being assembled into PCBs, which end up in smartphones and computers," explains Dilip Chandrasekaran, Head of Research and Development at Sandvik's Kanthal Division in Hallstahammar.

"The processes are extremely demanding, with high temperatures of up to 1,300 degrees Celsius, meaning that all components passing through the furnaces must withstand the harsh gas atmosphere without changing shape or giving off any particles. Otherwise, a whole production batch of expensive silicon wafers could be destroyed."

Kanthal supplies a product that forms the core of these furnace applications, the heating element itself, which comprises a helical metal wire embedded in a ceramic fiber module. When power is connected to the wire it heats up,



Semiconductor components are treated with various coatings in industrial furnaces where temperatures can reach 1,300 degrees Celsius.

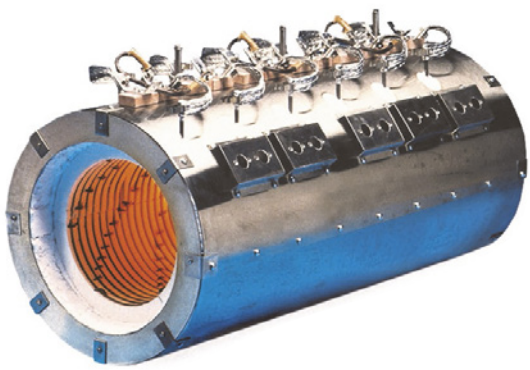
"The powder metallurgy process creates unique properties in the wire, thanks to an optimal microstructure," explains Dilip Chandrasekaran, Head of Research and Development at Sandvik's Kanthal Division.

warming whatever is to be processed in the furnace.

"To make the wire, we start with a metal powder," says Chandrasekaran. "The powder is then compressed under high pressure and high temperature into a solid body for further processing, via hot rolling and drawing, into its final form. The powder metallurgy process creates unique properties in the wire, thanks to an optimal microstructure that cannot be achieved in conventionally produced rolled wire."

THE PRODUCTION PROCESS is based on advanced powder metallurgy

INDUSTRIAL FURNACE FOR the manufacturing of silicon wafers used in, for example, electronics and solar panels. The spiral-shaped heating coil from Sandvik can withstand extreme heat thanks to the unique microstructure of the wire. This technology is based on advanced powder metallurgy that adds billions of nanoparticles to the metal, which dramatically improves the mechanical strength of the wire.



"With powder metallurgy we go one step further."

that makes it possible to structure the metal with billions of small particles, dramatically boosting its strength. Otherwise, a common problem in this type of heating system is that structural components become deformed at high temperatures over time.

For a material to function properly at extremely high temperatures, it must demonstrate both high dimensional stability and resistance to oxidation and corrosion.

"The special iron, chrome and aluminum alloy that our products are based on delivers excellent oxidation properties in a conventionally produced form," says Chandrasekaran. "With powder metallurgy we go one step further, offering a premium material that also maintains its shape extremely well at high temperatures. That means a lower maintenance requirement and higher productivity for industrial customers who use the furnaces."

Alongside the semiconductor industry, Chandrasekaran identifies a large and growing market among manufacturers of solar panels that also use silicon as their starting material and need to heat-treat their components in the same type of demanding furnace applications. ■

POWDER POWERS ADDITIVE MANUFACTURING

EVEN MORE FUTURE applications are emerging for metal powder used as a base material in additive manufacturing. "With metal powder and 3D printers, it is possible to customize a unique form and function, totally in line with the customer's wishes, and with minimal material wastage," says Dilip Chandrasekaran.

"This is already in commercial use today, for example in producing small runs of certain components in airplanes, but major volume production is still some way off. What we need is to get production costs down and ensure that the final product meets the same requirements for precision, strength, etcetera that apply today."

SANDVIK IS INVESTING heavily in the area and has developed leading expertise throughout the additive manufacturing value chain - from concept to serial production. The company has a leading position in the production of fine-particle metal powder that is offered not only as stainless steel, but also as a range of alloys based on metals such as nickel, cobalt/chrome and titanium.

MEET THE METALS

From the lightest lithium to the densest osmium, metals are such an integral part of everyday life that we rarely think about them.

TUNGSTEN (W)

A rare, heavy steel-gray metal with a density comparable to gold. It has the highest melting and boiling points (3422°C and 5930°C, respectively) of any metal and is most often found in compounds with other elements, where this originally malleable and soft metal becomes very hard and difficult to work. More than half of extracted tungsten is used in what are termed "superalloys." Sandvik inserts for complex metal-cutting operations, such as in the aerospace industry, are made of various combinations of tungsten carbide and cobalt. After use, 95 percent of a Sandvik insert can be recycled.

NICKEL (Ni)

A hard, silvery, lustrous, slightly magnetic and ductile transition metal that generally occurs in combination with other materials. Nickel is essential in the iron and steel industries, for example in the production of austenitic (including the most common stainless steel, Type 304, also known as 18/8) and duplex stainless-steel alloys. Nickel-based alloys have good toughness, tensile strength and corrosion resistance, particularly in high-temperature applications such as in jet engines in the aerospace sector. Nickel is also used for electroplating and in coinage, batteries and alnico magnets.

COBALT (Co)

A hard, lustrous bluish-gray ferromagnetic transition metal. In nature, it is combined with other elements and is often a by-product of copper or nickel production. Some 80 percent of cobalt in use is in high-performance alloys to improve temperature stability, wear-resistance and strength, such as in jet engines and gas turbines. It is used as pigment (cobalt blue) in paints and glass as well as in cutting tools, prosthetics and electroplating. It is also used in lithium-ion batteries, and there are concerns about potential availability of cobalt as a result of the growing demand for such batteries.

TITANIUM (Ti)

A gray-white light and non-magnetic transition metal. It is ductile and has a high strength-to-weight ratio and a low density. It is used in many alloys, such as aluminum and tin alloys, which are as hard as steel and very corrosion-resistant and thus increasingly used in the aerospace, marine and nuclear industries and other low-weight, high-strength applications. Titanium oxide, TiO_2, is a pigment used in everything from toothpaste to sports equipment. Titanium nitride (TiN) and titanium carbide, because of their superior characteristics such as extreme hardness, are often used to coat metalworking tools.

CHROMIUM (Cr)

A steely-gray, lustrous transition metal, chromium is the third-hardest element and highly resistant to tarnishing. It is primarily used in iron alloys such as stainless steel to increase hardness, strength and resistance to corrosion and discoloration. Superalloys with nickel and cobalt, such as Inconel 718, keep their mechanical properties even at high temperatures and are used in applications such as jet engines and gas turbines. Kanthal® (FeCrAl) alloys are mostly used in heating elements. Electroplated chromium is used to give automotive and motorcycle parts a high-gloss sheen.

MOLYBDENUM (Mo)

A rare metal that in nature only occurs as a part of chemical compounds. In February 2019 molybdenum was valued at roughly USD 25,000 per ton. In its pure form, it is a silvery-gray metal with a high melting point. In this form it is used in electric and electrochemical components, but it is chiefly used in steel alloys, superalloys and coatings to improve hardness, strength and corrosion resistance. Superalloys with molybdenum can be used in temperatures up to 1000°C. The use of molybdenum compounds has increased in various applications such as as catalysts and lubricants, and to improve flame resistance.

ZIRCONIUM (Zr)

In its pure form, a lustrous transition metal. A self-healing oxide layer forms on the surface, making zirconium highly resistant to corrosion by alkalis, acids, saltwater and other agents. The chemical and mechanical properties are changed by adding non-metals, and it is possible to tailor the properties. Zirconium is used as fuel cladding in the nuclear industry. The compounds zirconium carbide and nitride are used for cutting and drilling tools. The principal source of zirconium is the mineral zircon (ZrSiO4), which is used directly in high-temperature commercial applications.

TAKING FLIGHT WITH TITANIUM

By supplying the aerospace industry with materials that are so light and strong that they can literally be described as out of this world, Sandvik is helping humanity explore the edges of the planet and makes air travel more sustainable.

Sandvik contributes to the aerospace industry through its core business of machining and tooling solutions. Sandvik helps manufacturers produce various aircraft body and engine parts to the highest specifications and tolerances. The company is also helping to transform the aerospace industry by providing lighter and stronger materials that help aircraft fly more sustainably.

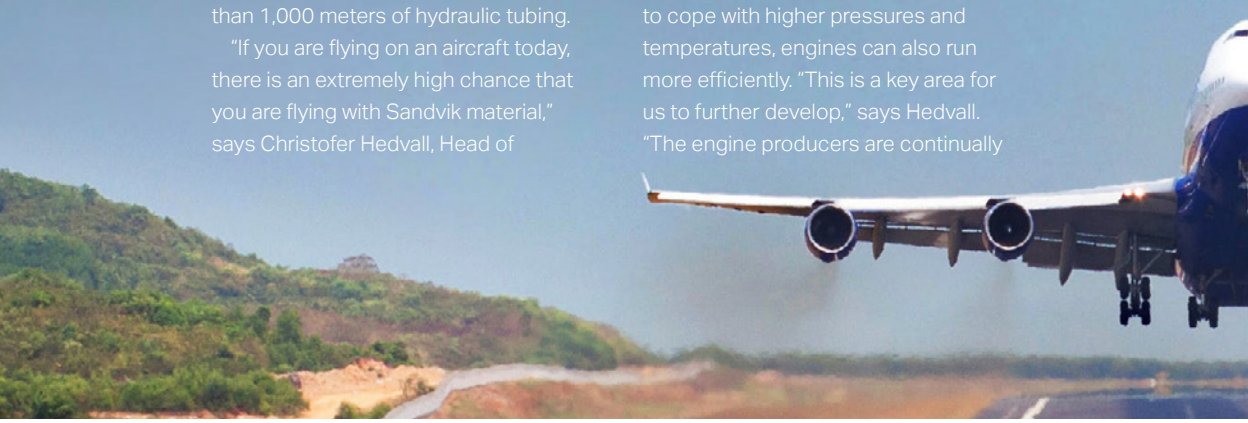
Specifically, Sandvik is developing advanced stainless steel and titanium alloys that are used in the pipes and tubes that make up aircraft hydraulic systems.

Hydraulic systems are used in aircraft for various purposes, including the operation of wheel brakes, retractable landing gear, flight control surfaces, wing flaps and doors. Larger types of planes are typically equipped with more than 1,000 meters of hydraulic tubing.

"If you are flying on an aircraft today, there is an extremely high chance that you are flying with Sandvik material," says Christofer Hedvall, Head of Business Unit Specialized Products at Sandvik. "We sell the tubes that are used in some aircraft engines to move the fuel from A to B and the tubes that are used in most aircraft hydraulic systems."

THE TUBES THAT Sandvik supplies to the industry are made from titanium and special grades of stainless steel. "The key advantage of titanium is that it is much, much lighter," says Hedvall. "But you have to make sure that it can withstand the same pressures. And for us, it is equally important to make sure that we develop the stainless side as well, because there will be parts that are not suited to titanium."

By using materials that are lighter, aircraft weigh less and therefore need less fuel to fly. And by being able to cope with higher pressures and temperatures, engines can also run more efficiently. "This is a key area for us to further develop," says Hedvall. "The engine producers are continually



promising airlines that they will make sure the engines are more efficient. And they need more and more complicated material for that."

SANDVIK'S WORK IN this area, however, goes beyond the airline industry. It also supplies tubes for space applications. "This is very interesting from a material development point of view," says Hedvall. "For these materials to leave the planet they need to be even stronger and lighter and also cleaner and more precise. The good thing for us is that if you are good in aerospace, you will be good in other segments too, because when it comes to developing stronger and lighter materials, this is the highest class. This is where the materials need to be the best."

The aircraft industry presents one of the biggest sustainability challenges to humanity that there is. Hedvall says he is proud that Sandvik is helping make it more efficient. "It has a filter-down effect too," he says. "What you see in aircraft today, you will see in cars tomorrow, so our work in developing more efficient materials for the aerospace industry will also help make land transportation more efficient in the future." ■

Take off!

Sandvik contributes to the aerospace industry in a number of ways. Here are some of them:

- Sandvik contributes to the manufacture of various aircraft parts, including landing gear beams, central wing boxes, wing ribs and vertical tails.
- Leading airplane manufacturers use Sandvik's broad range of aerospace tubular products for fuel lines, hydraulic lines, instrumentation systems and pressure gauging.
- Sandvik provides top-end stainless steel tubing for the trailing edge of helicopter rotor blades.
- Sandvik supplies the highest-grade stainless alloy and titanium tubing material for some of the world's leading space programs.
- Sandvik Coromant is a member of the Advanced Manufacturing Research Centre in the UK. Through working with the Center's partners, Boeing, Rolls-Royce and the University of Sheffield, Sandvik shares research and support in areas of assembly, composite materials, structural testing and advanced machining for the aerospace industry.

"I TELL IT LIKE IT IS"

Sandvik Materials Technology has been steadily on the up since Göran Björkman took charge in late 2017. A strong economy and a focus on driving improvements in the mix, prices and productivity are some of the reasons, he says.

The Sandvik Materials Technology business area exceeded expectations in 2018, with a growth rate of 13 percent for sales and an operating margin of 9.2 percent for the full year. What's the secret?

There are no secrets. The point is that everyone knows what's required if targets are to be met, and how they can contribute. We have a clear follow-up structure for both activities and results, and a strong economy makes it easier to raise prices and make changes to the product mix. We've been able to afford to turn down low-profitability deals.

What gives you most satisfaction about 2018?

That we succeeded in increasing our invoicing by 13 percent without having to bring in more resources. We got more out of what we have, and that's a success. I still believe that there's room for continuous improvement.

One of your targets is that every factory and unit should improve cost productivity by 1 percent a year. What does that mean?

If inflation is 1.5 percent, we have to improve our cost efficiency by 2.5 percent, excluding costs of materials. We must absorb inflation and at the same time slightly increase competitiveness.

How do you achieve that?

By being careful with costs, and by making sure that everyone is familiar with the targets. When I'm out meeting our employees, I make sure that everyone knows what the targets are, and what each and every individual can do to become a little more efficient every day. You need an efficient structure to create a culture of continuous improvement.

You joined Sandvik 29 years ago as a process developer in a pipe factory. You were appointed as factory manager as a 27-year old and as a production director a few years ago. What has made you loyal to Sandvik?

Sandvik is a fantastic company with so many different businesses, and it offers excellent opportunities to develop into new jobs without changing employers.

What do you enjoy most about your current job?

I find most of it fun, and I get a kick out of change. I like being out where the business is, and would like to do that more.

Göran Björkman
Age: 53
Title: President, Sandvik Materials Technology
Education: Master of Science in Mechanical Engineering
Lives: Row house in Villastaden, Gävle. In the summer, I like to spend time with my family in our holiday house at Finnharsfjärden, Axmar.
Interests: Fishing, skiing and travelling. I like cooking, too.
Who are you like as a person and as a leader? "I don't see any difference in my roles; I try to be myself, at home and at work. I think that I'm seen as clear and transparent, and I tell it like it is."
Strengths: "My ability to involve people and create a culture of commitment. I expect a lot from people when it comes to delivering on their targets. I'm good with figures, stubborn and tenacious."
Weaknesses: "Strengths and weaknesses can be the same thing, depending on who you ask, and when. Stubborn may be perceived as bull-headed, ask my wife!"

Energy producers are an important customer segment to Sandvik Materials Technology. How's that business being affected by the energy transition in society?

This is an existential issue to me, both professionally and personally. As a business owner, I see the energy transition and the ambition of increased sustainability both as a necessity and a major opportunity. The transition brings demands, which is great news for materials technology companies like Sandvik, since we are good at products that improve energy efficiencies for users. Many of the renewable energy sources depend on the ability to store energy, for example, in fuel cells, to which we provide parts. Energy efficiency often means demands for lightweight, high strength, good corrosion resistance and high heat resistance, in which our materials are world class. The transition from gas to electricity, for example, in industrial heating is a good example of an area in which we are well-positioned. We also have several applications in solar energy and hydrogen.

How do you see the outlook for 2019?

It's difficult to speculate. We're watching developments closely and have made preparations for any decline, but my feeling is still that the future is relatively bright. The part of our business that is associated with big projects, where customers undertake large investments, comes late in the economic cycle, and it is in this area that I believe an improvement will emerge in 2019. But, if and when there is a decline, we know what we have to do.

Where would you go on the offensive?

There is market share to gain – both geographically and in various segments. Our market shares show a rather uneven pattern; we are much bigger in Europe than in Asia and North America. That means potential to grow. We are big in energy, but not quite as big in the aerospace industry and medical technology. Potential to expand there, too, in other words.

Göran Björkman likes being out on the floor, where the action is.

You're very often first in the office at half past six. Why's that?

It's not about "The captain should be first on board", just that I operate better in the morning than in the evening. Also, I can be at home in time to have dinner with the family.

How important is diversity to you?

It's very important. In my management group, 40 percent are women. But we need more members with a non-Swedish background.

Fengxin Li is a student from the Langfang Technician School for vocational training: "Sandvik has a good work environment," he says. "I'm happy here every day."

TAPPING LOCAL TALENT

Securing future talent and building a pipeline of skills are the objectives of the trainee program at Sandvik in Langfang, China. "It's a great place to learn."

LANGFANG IS A city of 4.5 million people in the Hebei Province in eastern China. Here Sandvik Coromant operates a production plant. The region is dynamic, with strong economic growth, and is home to a range of industrial manufacturing companies. Sandvik must compete with other local employers to attract the best candidates for its workforce.

To that end, Sandvik operates a trainee program for students from technical schools in the region. The program draws trainees from occupational schools and colleges and runs for six or twelve months, depending on the age and school level of the trainee.

"Recruiting for qualified candidates in the local labor market is not easy," says Ice Zhang, Human Resources Business Partner at the Langfang plant. "The program is a great opportunity to promote our brand and reputation in the local community, particularly in the schools, in order to attract potential future candidates."

Zhe Li studies at the Langfang Polytechnic Institute and says he enjoys learning according to an individual plan.

ACCORDING TO LOCAL regulations, companies are not allowed to hire students before they have finished school. The trainees normally have one or two semesters left before graduation, when they can join Sandvik.

"Having the students onboard for an extended period of time offers Sandvik the opportunity to evaluate their performance and to offer some a permanent employment at a later date," says Zhang.

The program also provides tangible benefits from a production perspective. "By adjusting the number of trainees we take in at any given time to the actual volume demands in production, we gain a lot of flexibility in manning the production and handling swings in demand," she says.

The total number of trainees taken in a year varies between 10 and 40, aged 18 and up. Most are boys, but there are a number of girls too.

WHAT DO THEY think about the program? "The feedback we get is that they find Sandvik a great place to learn more about production as well as contemporary management methods," says Zhang. "Young people today want to feel that they are in focus and receive attention at work."

At Sandvik they do so, since each trainee is assigned his or her own mentor plus an individual development plan with specific goals and tasks.

What do the longtime staffers think about the trainees? "Most of our employees have worked at Sandvik for decades and find it refreshing to host a new generation of colleagues," Zhang says.

"The trainees find Sandvik a great place to learn," says Ice Zhang, Human Resources Business Partner at Sandvik in Langfang.

PREPARED FOR THE FUTURE

Three questions to Sandvik CFO Tomas Eliasson.

How well prepared is Sandvik for a possible weakening of the global economy?
The best way to deal with any kind of scenario, market growth or market decline, is to have a truly decentralized organization where accountability and authority are as close as possible to the customer. In that way, those who first feel changes in markets and customer behavior are the ones who can take action immediately. This is where Sandvik is today, so I would say we are well prepared.

What are the most important aspects of a good contingency plan?
The responsibility of the management teams in the business units and the divisions is to have a plan for all scenarios. How to deal with revenues, costs, priorities and so on. If everyone is well prepared, action can start immediately.

Many have heard you talk about scorecards. What do you mean?
In a decentralized organization you need a tight financial control system so that everybody understands and knows their numbers. Our goal is to make everybody his or her own controller. If something is wrong, the line manager should see it immediately and take action. At the same time, we keep an eye on it from the group level. This is what the scorecards system is. Simple, straightforward and similar for everyone.

2018 HIGHLIGHTS

- Strong development in all customer segments and geographical regions.
- Record-high adjusted operating profit.
- Strengthened balance sheet enables growth.
- Several strategic acquisitions completed, including the metrology software company Metrologic Group.
- Sandvik Hyperion and the wire operations (welding wire and stainless wire) were divested.
- Investment in manufacturing plant for titanium and nickel powder.
- Inclusion in the 2018 Global 100 Most Sustainable Corporations Index and the 2018 Dow Jones Sustainability Index.

SANDVIK AT A GLANCE

Sandvik is a high-tech and global engineering group offering products and services that enhance customer productivity, profitability and safety. In 2018, the Group had approximately 42,000 employees and sales of 100 billion SEK in more than 160 countries.

BUSINESS AREAS

SANDVIK MACHINING SOLUTIONS

A market-leading manufacturer of tools and tooling systems for advanced metal cutting, expanding in additive manufacturing and digital manufacturing.

SHARE OF REVENUES **40%**
SHARE OF ADJUSTED OPERATING PROFIT **53%**

SANDVIK MINING AND ROCK TECHNOLOGY

A leading supplier in equipment and tools, service and technical solutions for the mining industry and rock excavation within the construction industry.

SHARE OF REVENUES **43%**
SHARE OF ADJUSTED OPERATING PROFIT **39%**

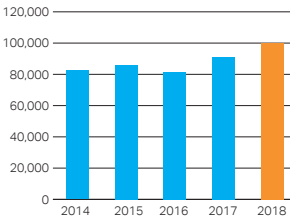
SANDVIK MATERIALS TECHNOLOGY

A leading developer and manufacturer of advanced stainless steels, powderbased alloys and special alloys for the most demanding industries.

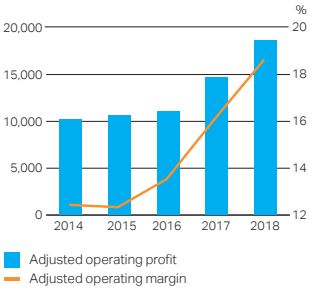
SHARE OF REVENUES **15%**
SHARE OF ADJUSTED OPERATING PROFIT **7%**

THE GROUP

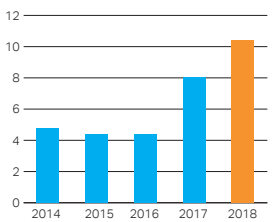
REVENUES, MSEK



ADJUSTED OPERATING PROFIT, MSEK AND ADJUSTED OPERATING MARGIN, %



ADJUSTED EARNINGS PER SHARE, GROUP TOTAL, SEK



RECOGNITION AND MEMBERSHIPS

MEMBER OF Dow Jones Sustainability Indices In Collaboration with RobecoSAM

FTSE4Good

THE GLOBAL COMPACT WE SUPPORT

Figures refer to Group total 2018.

MAIN CUSTOMER SEGMENTS

MINING

We deliver drill rigs, rock-drilling tools and systems, mobile and stationary crushers, load and haul machines, tunneling equipment, continuous mining and mechanical cutting equipment, as well as various solutions to increase automation, safety and customer productivity.

SHARE OF REVENUES **34%**

ENGINEERING

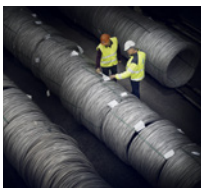
Our tools and tooling systems for metal cutting as well as advanced materials and components are used in engineering industries worldwide, improving productivity, profitability, quality, output, safety and environment. Sandvik is also a global leader in high-alloy metal powder for different applications.

SHARE OF REVENUES **23%**

AUTOMOTIVE

Our tools and tooling systems for turning, milling and drilling in metals raise productivity when manufacturing e.g. engines and transmissions. Our stainless and high-alloy products are found in, for example, airbags and air conditioning.

SHARE OF REVENUES **12%**



ENERGY

Sandvik offers solutions for all forms of energy production, including clean and renewable energy. We supply high-alloy products, such as seamless stainless steel tubes as well as tools and tooling systems to satisfy the industry's metal-cutting needs.

SHARE OF REVENUES **11%**

CONSTRUCTION

We offer products and services that increase safety and customer productivity in the breaking, drilling, tunneling, crushing and screening niches of the construction industry.

SHARE OF REVENUES **9%**

AEROSPACE

Sandvik works closely with the world's aerospace companies. As they apply new materials to manufacture airplanes that are lighter, safer and more fuel efficient, advanced tooling solutions and light-weight materials from the Group are critical.

SHARE OF REVENUES **6%**

Figures refer to Group total 2018.

THE OBJECT | The smashproof guitar

Sandvik has created a smash-proof, 3D-printed all-metal guitar to demonstrate how advanced, precise and sustainable the company's techniques are. Rock legend Yngwie Malmsteen was invited to smash the guitar on stage but failed.

Several different divisions of Sandvik collaborated to make the instrument, relying on its expertise in the areas of additive manufacturing, powder metallurgy, materials technology and precision machining.

Learn more about how the guitar was made and watch the movie on home.sandvik/letscreate.