RHEINMETALL

HEART BEAT

The magazine of Rheinmetall

ISSUE 01/2021

NEW GROUP STRUCTURE

Rheinmetall repositions itself

"IF WE ONLY COULD SEE CO_2"

Interview with Jörg Grotendorst

// A COOL NEW CAT ON THE TRACK

Student team puts the fuel cell through its paces

LIVING DIVERSITY

Ladies and gentlemen,
We've finally put the year 2020 behind us, twelve tumultuous months in which the COVID-19 pandemic turned the world upside down. Around the globe, car sales slumped as never before. Companies closed their factories, and countries their borders. Rheinmetall was hardly immune to these events. In retrospect, however, we've come through the coronavirus crisis in remarkably robust shape. Rheinmetall's defense sales last year witnessed double-digit growth, while the Group's automotive unit succeeded in turning an operational profit in the double-digit euro-million range, the dire circumstances notwithstanding. We're admittedly very proud of this. Besides the pandemic, technological transformation had a profound impact on the automotive industry in 2020. One thing's for sure: The automobile has gained renewed stature due to the coronavirus. After all, there are few places where we are safer from infection than in our own car. Meanwhile, a technological sea change – the electrification of the drivetrain – is once again gathering pace. All these and many more exciting topics such as the new corporate structure are covered in this issue of Heartbeat.

We hope you enjoy reading it and the rest of the articles in this issue. Meanwhile, stay healthy!

Peter Hartung
Head of Corporate Marketing and
Internal Communications
Rheinmetall AG

// **IMPRINT**

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Students from Delft in the Netherlands are currently building the successor to FORZE VIII, one of the world's fastest hydrogen racing cars.

THE WILD WORLD OF ENGINES

HIGHLIGHTS

FOCUS

// **OUR TITLE PAGE** *FORZE VIII is currently the world's only Le Mans-style fuel cell-powered racing car with a monocoque homologated by the FIA.*

// CONTENTS

You can find additional information about these articles by going to

www.heartbeat-online.de/en

// HEROES ON FOUR WHEELS

How the car is helping people through these difficult times

COVID-19 has changed everything. People are looking for new ways to make ordinary things possible in these extraordinary times. The car has been a big help here – and not just as a safe means of going back and forth to work or going shopping. Here are some examples of how important the automobile has become during the pandemic.

Finally! Thanks to the car, it's possible to get out of the house and head for the great outdoors again without worrying about catching COVID-19.

Shaking hands with the birthday boy or girl in the Corona Era may no longer be possible, but humans are still social creatures – and good at improvising: take the "drive-by congratulation", the latest craze in the USA.

In many places, traditional graduation ceremonies have had to be cancelled. Undaunted, high school graduates in Slidell, Louisiana, celebrated on the road instead. Particularly in the USA, young people are making the best of the situation by partying in their cars.

An unexpected comeback for the drive-in movie. Suddenly it was possible to enjoy a movie in the company of others again.

The car has also proved to be extremely useful in the war on coronavirus, especially for testing and vaccinations.

Demand for healthy and delicious food remained as strong as ever. Enterprising people sold food directly from their cars – whether for immediate consumption or, as depicted here, in the form of fresh fruit and vegetables.

In Düsseldorf, a drive-in movie theater was promptly turned into a public registry office. This way, in perfect safety, guests in up to thirty cars could attend civil wedding ceremonies that took place on the stage, listening in on their car radios. When the words “I do” were heard, horns blared!

Picture credit:
D.LIVE/ Anne Orthen

More pictures can be found at
www.heartbeat-online.de/en/wild-world

// RHEINMETALL SUPPLIES DAIMLER TRUCK FUEL CELL

Rheinmetall has been working on fuel cell technology ever since 2004 with various OEMs. Now it continues to widen its technical lead in the field of electrification and green energy: Its subsidiary Pierburg will be supplying hydrogen recirculation blowers to Daimler Truck Fuel Cell. The deal represents a sales volume in the two-digit euro-million range. The blowers return hydrogen not used in the fuel cell reaction back to the stack. This way, the blowers enhance the efficiency of the fuel cells while extending their service life. They also improve cold start behavior. Collaboration with Daimler Truck Fuel Cell will give a further boost to technical advances in the fields of long-haul commercial transport and stationary energy generation.

RHEINMETALL AWARDED PRIZE FOR EXCELLENCE

At the end of 2020, the Berlin plant of Rheinmetall subsidiary Pierburg won the coveted Ludwig Erhard Bronze Prize. The award honors organizations operating in Germany's social market economy that strike a sustained balance between business success and taking due account of the interests of all stakeholders. The ceremony was held online in the presence of Dr. Wolfgang Schirmer, Head of Business Excellence at Rheinmetall.

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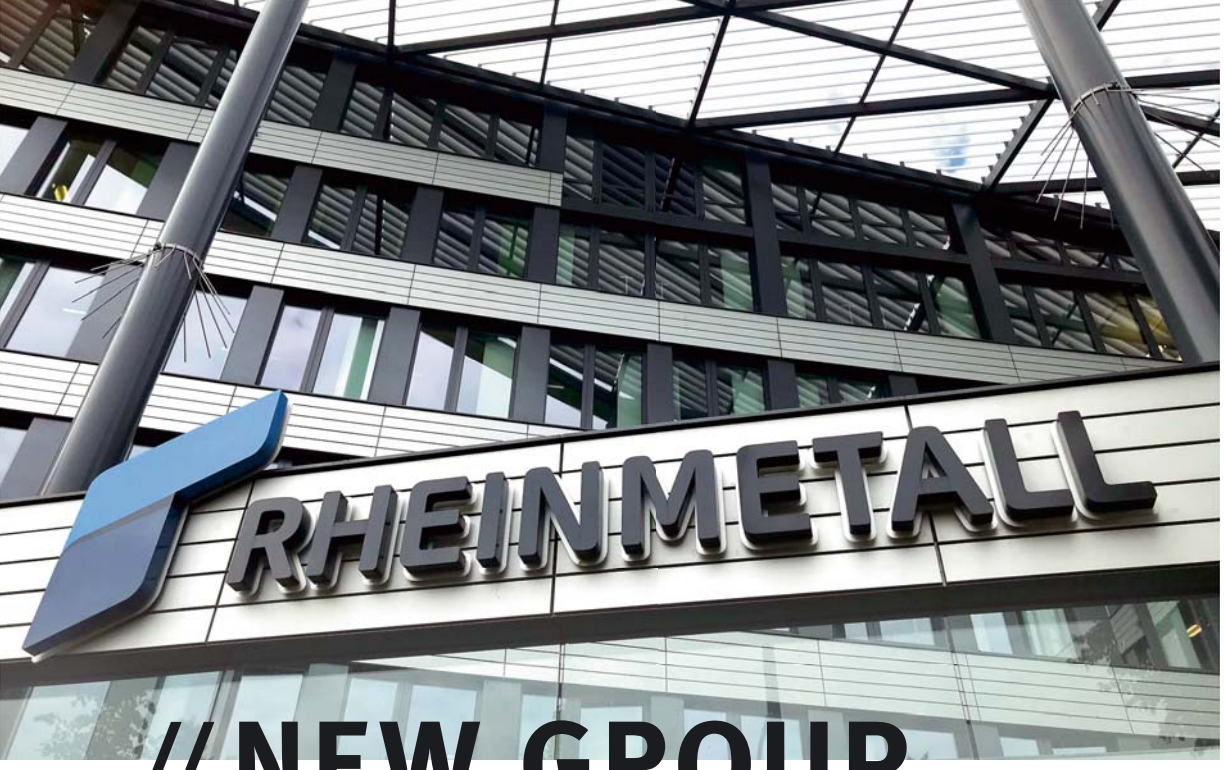
MORE GERMAN CITIES,

among them Heilbronn and Kiel, fell below the limit set by the European Union concerning nitrogen oxide levels in 2020. According to Germany's Federal Environment Agency, this was due to the growing number of modern diesel vehicles on the road and to software updates in older vehicles, and not, as some may have suspected, to the effects of the Covid-19 pandemic.

RHEINMETALL TECHNOLOGY CENTER UP AND RUNNING

Founded in 2020, Rheinmetall Technology Center GmbH (RTC) has commenced operations in the meantime. RTC is focusing on general topics such as automation, sensors, digitization, alternative mobility, and artificial intelligence. Operating in close collaboration with the various divisions of Rheinmetall, its mission is to develop new products and markets, spurring added innovation and creating fresh impetus for growth. Made up of specialists from the worlds of software development, systems engineering, and artificial intelligence, at the operational level the team is led by Jürgen Seuß.



// NEW GROUP STRUCTURE

"Those who do not constantly change, who do not successfully integrate progress and innovations, fall behind and are left behind in global competition."

Armin Papperger

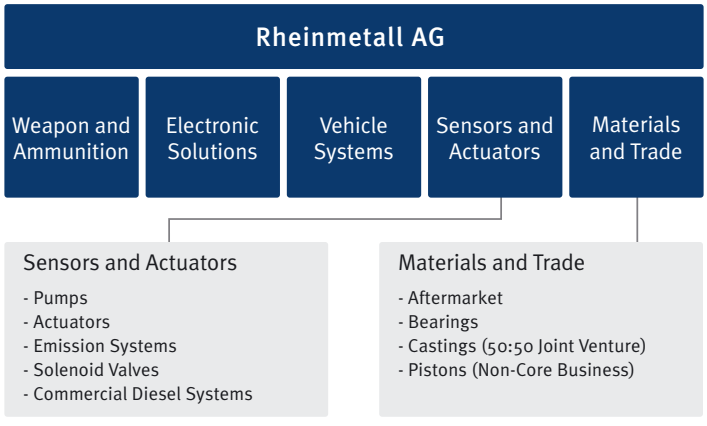
Rheinmetall repositions itself

Rheinmetall is pressing ahead with its strategic transformation into an integrated technology enterprise. This includes a new corporate structure consisting of five divisions run directly by the Executive Board. The previous separation of the Group into two entities, Automotive and Defence, is no longer operative. Rheinmetall Automotive AG, the former intermediate holding company, will be dissolved and merged into the existing Group structure.

From now on, two Rheinmetall divisions will serve the automotive market: Sensors and Actuators as well as Materials and Trade. Sensors and Actuators encompasses the business operations of the former Mechatronics division, i.e. Pierburg GmbH and Pierburg Pump Technology GmbH. MS Motorservice International GmbH, the bearing business, as well as joint venture company KS HUAYU AluTech GmbH will make up the Materials and Trade division.

Following the Group's announcement in summer 2020 that it was reviewing strategic options for the future development of the former Hardparts division – especially the small- and large-bore pistons business – the Group's former pistons organization will be run as a non-core business; a decision on possible options for this part of the Group is expected to be made in mid-2021. "This new structure will facilitate the transfer of technology between different parts of the Group, while simultaneously encouraging a strong focus on future-oriented technologies and business opportunities with clear potential for sustained added value. The Executive Board has identified security technology and electromobility as prime growth drivers. Moving forward, sustainability will form an integral component of our Group strategy," says Armin Papperger, Chairman of the Executive Board of Rheinmetall AG.

THE NEW GROUP STUCTURE



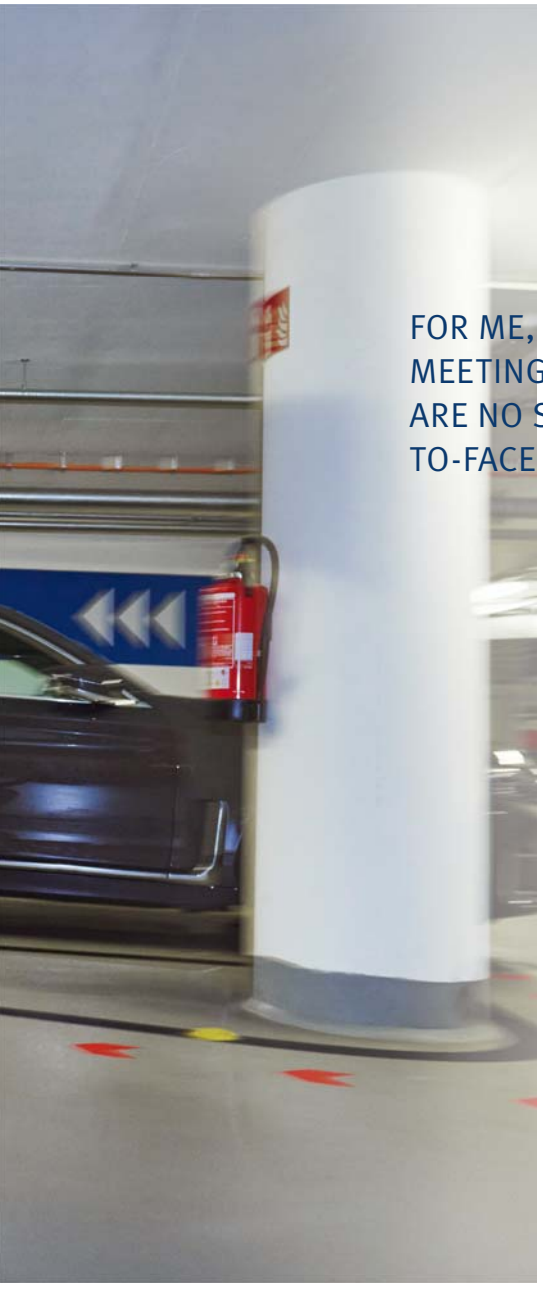
Saving CO_2 – that's easy with the e-bike. But Jörg Grotendorst is also taking on this challenge for the automotive divisions.

// "IF WE ONLY COULD SEE CO_2"

Interview with Jörg Grotendorst

Late last year, Jörg Grotendorst became the latest member of the Executive Board of Rheinmetall, with special responsibility for the automotive divisions. Grotendorst, now 51 and a graduate in Electrical Engineering, has spent his whole life pondering protons and electrons and positive and negative poles, and how to control and regulate them – a subject that has never ceased to fascinate him.

The son of a master electrician from Münsterland in western Germany, Jörg Grotendorst was drawn to electrical engineering at an early age. While still in high school, he set up a workshop in the basement of his parents' home, where he repaired car radios, televisions, and stereos for his neighbors. Given his enthusiasm for electronics, it comes as no surprise that he initially trained as an electrician before moving on to study Electrical Engineering, Regulation, and Control Technology. The practical knowledge he gained during his apprenticeship continues to shape his approach to the subject to this day and has



FOR ME, PHONE CALLS, WEB MEETINGS, AND PRESENTATIONS ARE NO SUBSTITUTE FOR FACE-TO-FACE MEETINGS

clearly influenced his career path. That he still has more than 25 active patent families today attests to his inventive drive and passion for engineering.

Even before he finished high school, Grotendorst had discovered his love of music, too, and played professionally as a drummer with a band that toured the Westphalian county fair circuit, playing in tents – a hobby, by the way, that helped him pay his way through university. A grant led him to the then Daimler group, where they put him to work developing aircraft controls for DASA. It was basically by coincidence that he found his way to Mercedes and thus to the automotive sector. From that point on, he held various positions with Tier 1 automobile industry suppliers, where he was primarily in charge of e-mobility operations. Grotendorst is married, has two children, and lives with his family in Nuremberg.

During the course of his career, he and his family have moved no fewer than eight times. When he's on the road, he always takes running shoes along. A passionate endurance athlete with an impressive collection of medals, he regularly begins his day with a morning run. Together with his family, Grotendorst, an enthusiastic skier and snowboarder, is equally at home on the slopes.

In the following interview, he offers insights into the entrepreneurial course he's charting, his environmental policy credo, and his technological assessment of the divisions that make up Rheinmetall.

// Mr. Grotendorst, how are things working out in your new role?
To be frank, I'm pretty frustrated that I haven't been able to get to know Rheinmetall the way I would normally want to due to the current restrictions. Since joining the Group, I haven't been able to visit a single foreign location. At the moment, I'm spending a lot of time in the office, familiarizing myself with various topics with the help of phone calls, web meetings, and presentations. As far as I'm concerned, though, none of these things can replace personal encounters. I'm always happy when I'm on the factory floor, seeing new developments for myself, and talking to people on location. For the time being, the opportunities for me to sit down with our folks and get a proper feel for our team are very limited. By the same token, people can't find out what Grotendorst is thinking, where he wants to go, or how to work with him. At the moment, this poses a major challenge.

// Despite the current restrictions, what have you locked in on so far?
My first impression is that Rheinmetall is much more broadly based than I originally expected as a former outsider. The total number of technologies we have under one roof here is just astonishing. And when I break this down by sector, I have no doubt whatsoever that there's still additional potential to exploit in the automotive engineering realm. But I also think this process will take a certain amount of time.

// What explains this time factor?
On the one hand, it has to do with the industry's transition from the internal combustion engine to a world of electric vehicles and automated driving. It'll take time for our core businesses to adapt. We got off to a later start here than our competitors, and it'll be a little while till we can catch up. On the other hand, in all of our activities we should never lose sight of trends in the global market. When developing new products, we have to think globally right from the start. Where can we secure the necessary expertise and resources for development and production that we need in order to keep pace with the competition? It happens to be that our customers and competitors operate globally and are present in relevant regions around the world. We need to expand our presence there too.

// Shall we move on to Rheinmetall's international footprint?
Right. It was certainly a very good thing that the automotive divisions focused their attention on China at an early stage. We're really on a roll there, even if our current partnerships mean that we've to find a solution among equals, which usually means making a bigger effort than in joint ventures where we have a majority stake. We could definitely afford to expand our own local presence to make sure our customers always have a local point of contact. This is especially true when it comes to electronics and software development – two areas where we need to become much more international.

// In your new role, which technologies have you turned your attention to in particular?
As far as products go, we're making good headway in electrified auxiliary units and hydrogen components. They are technologies that I personally believe in. Making Europe CO_2 neutral by 2050 is now a set goal. To do this we need more green energy, more ways of storing energy. What we do and how we do it needs to become more sustainable. Rheinmetall has set itself the goal of being CO_2 neutral by 2035. Electric vehicles are poised to play a key role here. I was taken aback by Rheinmetall's R&D expertise in this area. To cite just one example here, in recent years I've developed plenty of batteries, electric drives, and inverters to the point where they were ready to go into full-scale production, and I was astounded by our concept for a new inverter, whose product characteristics are very good indeed. Of course, we're just getting started here and need more products like this one.

// What components are you thinking of here?
I'm not just talking about electric drives here, but about electrification in a broad, deliberate sense, because for the end user this term implies energy on demand, that is to say, energy that adapts to the required level of consumption and whose supply is regulated in terms of time. I'll give you an example: When we enter a room, we turn on a light when we need to, and switch it back off when we leave. In plenty of factories, this kind of economical approach to using energy and resources is lacking, and for a long time wasn't found in cars, either. Even today, many drivers switch off the start-stop system and let the engine run when the vehicle is stationary. I mean, nobody would accept waste like this at home. Electrification and energy on demand are crucial for our society. And this doesn't just apply to automobiles, but to industrial applications too: never make more energy available than you need to use in order to carry out a specific process at a given moment.

// Are there any other major focal points?
A whole bunch. Our general systems expertise in actuators and thermal management is outstanding. We still have untapped potential in electronics and software, but we've identified the gap and we're working on it. I also think we can do a lot more together when it comes to aluminum casting. We're also going to be looking at markets that are completely new to us – computer centers, for example, and smart home applications, plus other applications in vehicles, including for the chassis and sensor systems. We have all kinds of options. We just have to make sure we choose the right ones and are faster and more agile when producing an initial visual example.

// What sort of potential do you see for interdivisional collaboration?
I'm totally convinced that the expertise of our divisions offers plenty of scope for added potential and synergies. Some things have really surprised me. For instance, we're right in the midst of an automotive project that involves real-time data transmission derived from the defense world. Of course, I was also incredibly impressed by the amazing simulation technology in Bremen. I mean, there's really nothing like it in the automotive sector. To cite just two examples, the same goes for our expertise in networking military vehicles like the Boxer or Lynx, not to mention the field of augmented and video reality. We need to bring our teams closer together by introducing enhanced working environments and robust IT solutions. It's a big challenge. But we are actively working on resolving these issues.

// That sounds like quite a handful!
There are plenty of opportunities, no doubt about it. But we also need to decide which card to bet on, which is a pretty tough decision. I think if we had enough time and money, we could make a successful go of all of these things. But obviously we have to keep our shareholders' concerns about the profitability of our automotive activities in mind, all the more so in light of the major opportunities for growth on the Security side of the house.

// The market for e-mobility is exploding at the moment. Do you think this will last?
An explosion is by definition a short-lived event. Electromobility is making strides wherever the right stimuli are found. We're seeing this in Norway, we've seen

WE CAN DEVELOP ADDITIONAL POTENTIAL AND SYNERGIES FROM THE KNOW-HOW OF OUR DIVISIONS

IF WE DO NOT TAKE TOUGH AND DECISIVE COUNTERMEASURES, A POINT OF NO RETURN WILL SOON BE EXCEEDED

it in Holland, and we're seeing it in China too now. But it's also true that the market for electric vehicles contracts as soon as government incentives are scaled back. As far as the shift in the market goes, we're talking about an evolution here, not a revolution.

// So, a rather murky picture?
We need to differentiate between two different things here. In the medium term, there's no alternative to the electric drive, which is simply the most efficient form of propulsion around. We still need to talk about where to store the energy: in the form of hydrogen or chemically in a battery? But there's no getting around the electric drive. Obviously, the question arises as to whether we'll have the necessary infrastructure. The best electric vehicle is useless if you can't charge it up. We need to find the right mix here.

// Does this mean "Depending on the intended purpose"?
Exactly. We already have perfectly acceptable solutions for short- and medium-distance trips by car – and I'm not talking about loading your car onto a train when you're going on vacation. Looking further ahead, we're going to need different energy sources, especially for long-distance truck traffic. A battery big enough to power a truck severely reduces its payload. The question is, do we really want to have twice as many trucks clogging the autobahns just because each truck can only carry half as much? This is why I tend to think that for the rest of the decade, electric vehicles will primarily be used for short- and medium-distance trips, while the internal combustion engine will continue to dominate long-distance travel and heavy truck transport. This, if you will, is the ten-year period of the technology mix and transition. Starting in 2030, there will be a very clear trend in the direction of e-mobility.

// As far as you're concerned, does electrification also have social policy aspects?
Absolutely. After all, if we're going to save the climate, everybody on this planet is going to have to do their part – that much ought to be clear by now. And that's why we all have to ask ourselves the question, do we really want to keep behaving like this in the long run? I mean, we've only got one Earth and there isn't much time left. It's up to governments to establish strict parameters. I completely support the climate accord. Could it be that two degrees are actually too much? If we don't get moving on this very soon, we'll have passed the point of no return and won't be able to stop the climate from changing.

// Would you say that public awareness needs a boost?
Indeed, I would. Two years ago, I held a talk at a university and took bars of chocolate along. A bar of chocolate weighs 100 grams. The emission target for vehicle makers is 95 grams of CO_2 – per kilometer, that is. In terms of weight, a bar of chocolate offers a handy comparison for understanding how much CO_2 is emitted every time we drive a kilometer. And that's just the CO_2 – this calculation doesn't include the water or the other exhaust gases. Just imagine what the world would look like if CO_2 wasn't colorless and you could see it. It would be like a bar of chocolate every kilometer. Or what if you had to load your emissions into a trailer and cart them to the dump?

// It sounds like this will take some serious stamina.
Very true. That's why the delegations that gathered in Paris agreed to 2050 instead of 2030. Look, every part of society has to join in here: industry, energy, agriculture, logistics, transportation. This isn't a 100-meter dash; it's more like a marathon. You don't win it in the first few kilometers – you don't find out if you were successful until the end. We're in on the act!

Mr. Grotendorst, thank you very much for talking with us. ■

The complete interview conducted by Folke Heyer can be found in the online version of Heartbeat at **www.heartbeat-online.de/en/**

// A COOL NEW CAT ON THE TRACK

Student team puts the fuel cell through its paces

Like the Pink Panther series – Blake Edwards' comedy thrillers – the racing car built by university students in Delft in the Netherlands is a gem. In fact, it's the world's first Le Mans-style fuel cell-powered racing car with a monocoque homologated by Fédération Internationale de l'Automobile (FIA).

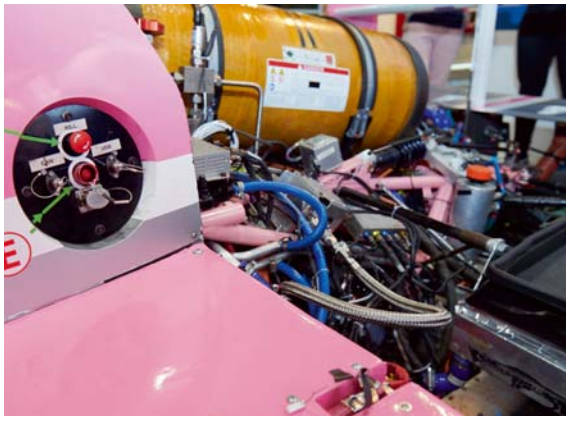
‹3

SECONDS ACCELERATION (0–100 KM/H) WITH FORZE IX

300

KM/H MAXIMUM SPEED OF THE SUCCESSOR MODEL

Fast-paced motorsport action and sustainable drive technology – the two can't be compatible, can they? The FORZE VIII proves that they are.



Pumps from Pierburg are crucial components in the FORZE.

The tank can be filled with six kilos of hydrogen in three minutes.

To date, students at the Technical University of Delft have built no fewer than eight generations of these electrically powered vehicles. In doing so, they soon realized the importance of the fuel cell drive as a means of addressing climate change. Now more than ever, they think the time is right to introduce the public at large to the cold "combustion" of hydrogen and air for producing electric power. As Team Manager Mark Jan Uijl explains: "By developing and fabricating fuel cell-powered racing cars, we've been able to publicize the terrific potential of this technology – especially when the cars are out on the track."

The Delft-based team can already look back at a pretty impressive history. The path to success wasn't an easy one: quite the contrary. The students displayed discipline, drive, and commitment during the multiyear development phase. Things really got going in 2008, when the young hydrogen enthusiasts took part in the Formula Zero championships, the first-ever races with fuel cell-powered vehicles – even if it was just a go-kart. This is the origin of the name "Forze", which the founders picked in 2007.

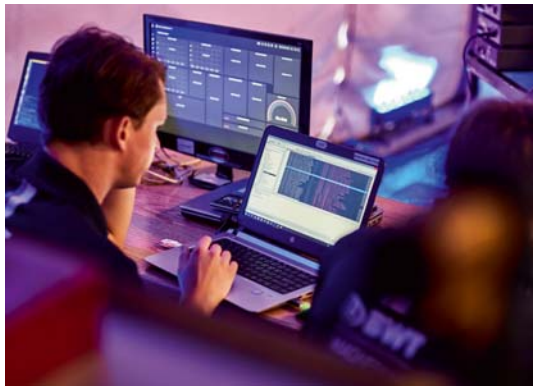
Today, Forze Hydrogen Electric Racing has successfully moved on to racing cars, with monocoques authorized in the FIA's LMP3 class. At the Zandvoort track, for example, the Forze VI held the lap record for electric vehicles for a year and a half in the Supercar Challenge. In the meantime, Forze has been taking on conventionally powered racing cars, too. In recent years, for instance, the team took several spots on the winner's rostrum in the Dutch Supercar Challenge during the Gamma Racing Days at Assen in the Netherlands. Driven by Formula 1 pilot and Le Mans champion Jan Lammers, the car even attained the lap record for fuel cell cars at the famous Nürburgring Nordschleife.

PROJECT FORZE IX

For the students from Delft, the latest generation of hydrogen-powered race car poses multiple challenges during the development phase of the FORZE IX. For instance, the complete high-voltage architecture has to be changed, as does the entire concept of the race car. Everything from new motors to the FORZE IX's safety system.

- 0–100 km/h in three seconds
- Top speed 300 km/h
- 240 kW output

While it's true that their unusual external appearance invites comparison, apart from their speed and agility, the only thing they really have in common is the pink paint job.



The team in the "command post" keeps constant track of the vehicle's data.

Refueling in three minutes
Successes like these naturally require considerable racing ability. In the meantime, the team is supported by professional racing car drivers, who in some cases discovered their love of racing when they joined the team as students. Given the numerous internal combustion competitors, moreover, getting the parameters for racing right is important, too. For example, the current racing car, powered by the six kilograms of hydrogen necessary for sixty minutes on the track, could be refueled during a pitstop in just three minutes.

More than 50 students, 25 of them full-time, are now taking part in the Forze project. A new racing car – the Forze IX – is currently being developed whose fuel cells will feature twice the output of its predecessor. This will put it in the GT3 segment,

THE FORZE IX WILL BE UP AGAINST TRIED-AND-TESTED COMPETITORS IN THE GT3 SEGMENT

alongside such race-hardened rivals as the Porsche 911 GT3 or the Lamborghini Huracán GT3. Jasper van Dongen, the project's Chief Engineer and thus responsible for the racing car's technical aspects, reveals that the ambitious group has a new objective in its sights: "We are in the middle of the development of Forze IX and we can already spot a lot of areas where we expect technology to progress rapidly in the coming years, allowing Forze to step up their game even further than the GT3 class. This advancement could, for example, enable the team to compete in the 24h of Le Mans in future years."

The young racing team is receiving support from a number of sponsors. In some cases, it's simply a matter of making urgently required components available, as Pierburg did with its electric pumps. "We have a long-standing partnership with Pierburg that began with electric oil pumps and now includes electric coolant pumps, which we are installing in the current Forze," explains van Dongen. "In the meantime", he notes, "Pierburg pumps in our racing cars supply coolant and lubricant to everything from the coolant circuit of the fuel cell to the electric motors, the power electronics, the battery, and the transmission."

The most recent support provided to these budding engineers: a 950-watt pump, which Pierburg presented to the team. Commenting on the manufacturer's support for the student group, Thomas Wienecke,

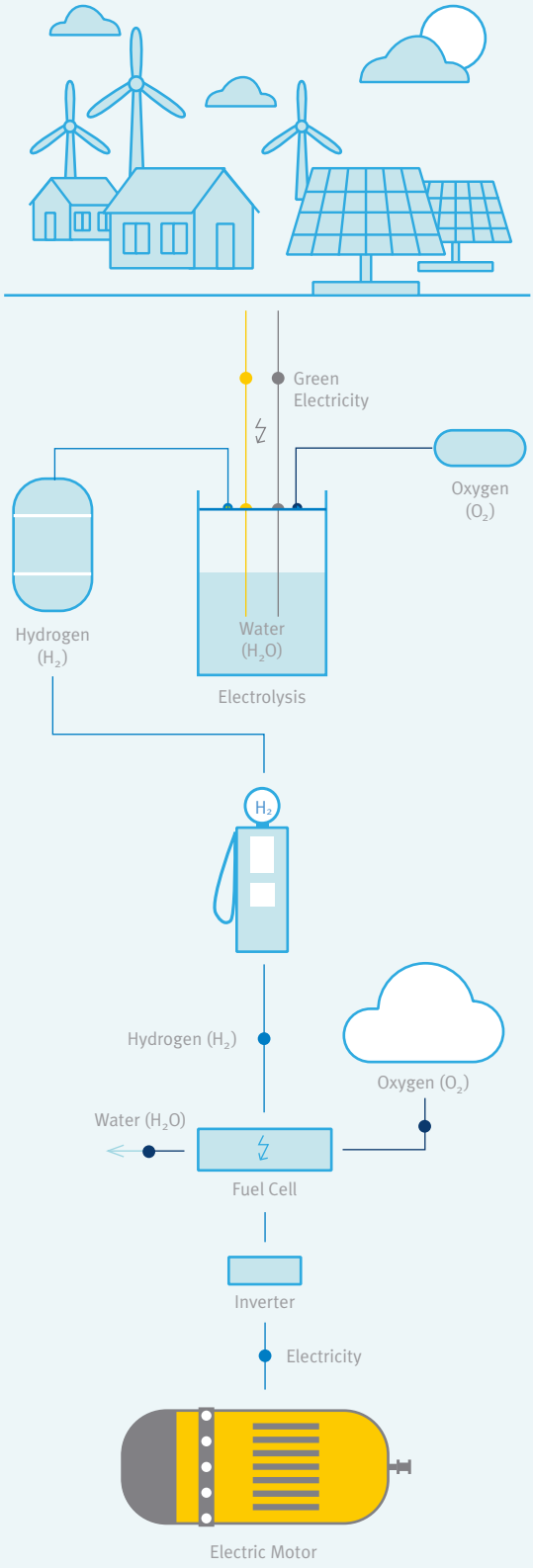
1,500
KG WEIGHT

240
KW (327 HP)
FUEL CELL POWER

600
KW (816 HP)
BOOST POWER

HOW HYDROGEN IS PRODUCED

THE WAY TO SUSTAINABLE FUEL



Director of Product Development Electric Pumps at Pierburg, says that, “Thanks to their professional attitude, the Forze team is making serious headway, which I’m really glad to see. On top of this, these young developers are extremely enthusiastic about what they’re doing. And that’s infectious.”

It’s entirely possible that collaboration between Pierburg and the ambitious young team in Delft will continue to flourish. Just recently, the developers of the pink racing car expressed fresh interest in other fuel cell components from Pierburg. These include a high-voltage pump, a recirculation blower for hydrogen, and a cathode valve. Could it be that all or some of these things will soon be debuting on the racetrack too? ■

In 2019, the Forze team took second place in the Supercar Challenge Sports Division race in Assen, a truly spectacular achievement.

Piloting the pink predator around the track at these speeds requires total concentration.

GAMMA RACING DAY AT ASSEN

According to the organizers, the Gamma Racing Day at the TT Circuit in Assen in the Netherlands is Europe's largest combined auto, motorcycle, and go-kart racing event. Following qualification heats on Saturday, the races on Sunday began with the Dutch Superkart GP, followed by the Supercar Challenge race, the Audi R8 Cup, the Ford Fiesta Cup, the Mazda MX5 Cup, and the NK Historic Touring Cars, and GT – all told, two go-cart races, two motorcycle races, and no fewer than six auto races. Admission is free, meaning that the races, events, and shows always attract a big crowd.

// CALIFORNIAN THINK TANK

New Development Center in Silicon Valley

“Silicon Valley” is inextricably known as a leading global center for innovative companies and start-ups with a focus on electronics and information technology. For the last few decades the region has justifiably ranked as a synonym for high-tech developments.

Since the start of the 1950s, the area nested between San Francisco and San Jose has matured from a research and industrial district close to Stanford University into today's home to 2,000 technology companies, the densest concentration in the world. A disproportionate number of today's leading technology companies such as Apple, Google, eBay, Facebook, Intel, and Tesla can be found in the just under 4,000 square kilometer region. As a globally renowned technology innovation think tank, Silicon Valley attracts researchers, developers, and businesses from all over the world, who are tapping into this innovative spirit for their products and projects and translating it into fresh ideas and start-ups.

Leading solutions for e-drives

Via its automotive divisions, Rheinmetall also has a research center in the City of Santa Clara, located in the heart of Silicon Valley. The mission of the E-Tech Center is to deliver innovative and highly integrated electric powertrain systems. The latest example is the development of a new inverter. Thereby the E-Tech Center is intensively involved in the collaboration with the global teams and their electric mobility research initiatives. According to Dr. Dirk Hunkel, Head of Research & Technology at the Sensors and Actuators division: "Our Silicon Valley Research & Technology Center is primarily focused on research in advanced motor control algorithms and the development of components for power electronics technologies for electric vehicle powertrains."

25 years of professional experience

Head of the E-Tech Center is Mika Nuotio. The Swedish-born engineer is working closely with the Research & Technology department of the Sensors and Actuators division. For 25 years, he has been

RHEINMETALL HAS RECOGNIZED THE SIGNS OF THE TIMES AND IS INCREASINGLY FOCUSING ON ELECTRIC DRIVE SYSTEMS

involved with state-of-the-art research and technology development in the fields of power electronics, semiconductor components, and telecommunications. Nuotio is an inventor of numerous power electronics patents, holds a BS in Computer Science, and is an alumni of the Executive Management Program at Stanford University. He states: "My main fascination with the new opportunity is that the automotive divisions of Rheinmetall, whose historical technology leadership has tended to be focused on products for internal combustion engine drivetrains, has correctly responded to the signs of the times by accelerating its technology and product development initiatives for electrified drivetrains. I believe that this mixture of over a century's track record as a leading supplier of technologically differentiated products to the automotive industry, supplemented by innovative approaches and technologies, will deliver sound and marketable results for our customers." ■

// TURBOCHARGERS AREN'T BRAKE PADS

INTEC France: Making defective turbochargers as good as new

For ten years now, Motorservice subsidiary INTEC France has made a name for itself repairing defective turbochargers. In the process, not only has it carved out a valuable niche for itself, but it has also fostered greater sustainability and helped to conserve resources.

After processing at INTEC in Lyon, the finished turbochargers are absolutely as good as new.

The reconditioned and repackaged turbochargers are waiting in the warehouse for dispatch.

The basic material is hard to estimate: INTEC procures defective turbochargers through a variety of channels, which they then return to mint condition whenever it's worth it.

About two years ago, the specialist company moved to the locations of its parent company, Motorservice France, at Genas near Lyon, systematically expanding its operating radius. "Repairing defective turbochargers is no minor matter. After all, it's a component that's subject to extraordinarily heavy load strains. This requires comprehensive expertise," declares Régis Serrano. The 52-year-old French engineer joined MS France – then known as KS Motorac – in 2007. Meanwhile, he has also been responsible for sales and marketing at MS Motorservice International, its German parent company.

REPAIRING DEFECTIVE TURBOCHARGERS IS NO MINOR MATTER

As far as Serrano is concerned, the brand remains a potent symbol of quality around the globe: "When I'm on the road visiting customers, in North Africa, for instance, they all think of me as 'Mister KS'. They instantly recognize the blue boxes our spare parts come in, and know they can trust them."

Reason enough for the seasoned manager to offer turboloaders in the same trusted packaging. Increasingly, they are destined for the commercial vehicles sector, too. Turbochargers for agricultural and construction machines feature in the program as well, as do others for stationary applications. Conditions in commercial vehicle engines are exceptionally challenging, since turbochargers there are subject to even greater forces. In fact, even in passenger cars, turbochargers reach the speed of a pistol bullet. And if it happens to "shoot" in the direction of the engine, it can cause major damage.

Turboloaders are generally considered to be wear-free components. When problems do arise, the causes tend to be elsewhere in the engine. Defective turboloaders are expensive to replace. This is why it usually makes sense to repair them. But this requires special expertise, as Serrano is quick to note after more than twenty years in the field.

Turbo by INTEC

What made MS France decide to go into the turbocharger business? For Serrano,

2

YEAR OF WARRANTY ON THE REMANUFACTURED TURBOS

3,500

TURBOCHARGERS ARE RECONDITIONED EVERY YEAR AT INTEC

20

YEARS OF EXPERIENCE IN THE RECONDITIONING OF TURBOCHARGERS

An exciting additional activity: besides his duties at MS Motorservice International, Régis Serrano is integrating INTEC's operations into the French subsidiary.

the answer is obvious: "There are 300 engine repair companies in France. All of them source parts from us. Motorservice is at home in the world of engine management. Except for fuel injection, we had everything covered. The one thing we couldn't help them with was the turbocharger."

Then, in 2008, the turbocharger producer Garret approached MS France in search of a sales partner in France. At the time, MS France had already established a training system and had thus the necessary access to customers. The company became Garret's master distributor, with an initial assortment of ten applications. Today, the spare parts specialist enjoys a similar status with Holset, Borg Warner, Schwitzer, Mitsubishi, and VDO. All of them have provided the company with specifications and technical documentation for their turbochargers. In addition, MS France maintains contacts with IHI, whose turbochargers also feature in the program. In the meantime, sales of turbochargers now rank with those of components for exhaust gas recycling, for example: the company now sells some 20,000 turbochargers a year, 80 percent of them destined for passenger cars.

Remanufacturing enjoys a good reputation on the market

However, in addition to the original parts business, the company also wanted to offer an attractive low-cost alternative, though without parting from its premium brand image. This is why the company chose to do its own remanufacturing – and why taking over nearby INTEC, also based in Lyon, was such an attractive proposition. Among other previous owners, INTEC once belonged to Holset, the world's largest maker of turbochargers for commercial vehicles.

Remanufactured turbochargers also come with a two-year guarantee. This is why the major effort and expense is worthwhile only for high-value vehicles. This applies to larger passenger cars, of course, but especially to trucks and marine engines, agricultural machinery, and stationary motors. INTEC now remanufactures 3,500 components a year, including around 1,500 truck turbochargers, at present principally for French customers.

Customers keep coming back for good quality

"Turbochargers aren't brake pads," says Serrano. "When you're a supplier, you've got to make sure that your customers can work with the components. That's why training is absolutely essential – customers need to know what to do during assembly."

And the same goes for INTEC employees. Not even the remanufacturers themselves are supplied with original spare parts or information about the specifications – e.g. the bearing clearance in the impeller – until they've undergone intensive instruction by the manufacturer. This way, the company has access today to all the original specifications. For remanufacturing large turbochargers, moreover, it is 99 percent supplied with original spare part kits from the manufacturers.

In all, the French specialist has 2,800 applications on offer, new turbochargers included. In the heavy-duty segment, the company has 250 different remanufactured models in stock. The remainder are available as new parts. Another special aspect: depending on the supply of used parts, Turbo by INTEC's blue boxes sometimes contain brand new turbochargers, too, in order to keep customers steadily supplied with spare parts. This means that customers occasionally receive a factory-fresh turbocharger for the price of a remanufactured one.

WHEN IT'S DONE RIGHT, A REMANUFACTURED TURBOCHARGER IS NO WORSE THAN A NEW ONE.

INTEC draws its basic supply of defective turbochargers from wholesalers and fleet operators via a deposit system. In

addition, used parts are purchased on the open market or picked up at repair shops, obviating the need to dispose of them.

Thanks to its long-standing experience, INTEC even offers special engineering for turbochargers now. In this special domain, standard turbochargers are upgraded with an eye to achieving heightened performance data – a niche sector dedicated exclusively to rally and racing vehicles. This extends to truck racing, too, which INTEC likewise supports with modified turbochargers. This has developed into an additional sales conduit for the spare parts specialist, since teams often source other components from the company as well. In the meantime, traditional manufacturers are venturing into this market too, offering an upgraded sports series.

Move opens up new possibilities

Today, MS France and INTEC employ a combined staff of seventeen. The prime object of the move was to increase capacity. With a surface area of 4,500 square meters, the new facility gives INTEC the space it needs, while its remanufacturing experts benefit from the logistical possibilities offered by its sister company.

Another reason for the move: INTEC wants to expand its business. Here, the idea is not just to increase the number of remanufactured turbochargers from the current annual figure of roughly 3,500, but to expand into other regions. In addition to Germany, there are promising signs in Spain and Greece, too. Moreover, Serrano is also exploring various other possibilities, especially now that he has the capacity to process up to 5,000 components a year. The company is convinced that the turbocharger business will continue to expand worldwide, especially since truck manufacturers don't always have adequate maintenance and repair networks in the remoter corners of the globe. This means that they're very happy to turn to foreign workshops for practical solutions. It's certainly better for their image than the sight of a broken-down truck. ■

Repairing a turbocharger involves a total of fifteen work steps. The process entails various visual inspections and checks carried out at multiple stations, including disassembly; cleaning and degreasing; alignment; assembly using original parts; balancing; final assembly; testing on the flow test rig; final inspection; and packaging.

The SKYACTIV-X consumes 20 to 30 percent less fuel than the SKYACTIV-G.

// THE BEST OF BOTH WORLDS

New pistons in Mazda's revolutionary new crossover engine

The SKYACTIV-X from Mazda is the world's first serially produced gasoline engine to feature the possibility of compression ignition. It thus combines the advantages of gasoline and diesel engines. This groundbreaking innovation relies on pistons made by Hiroshima-based Japanese Rheinmetall subsidiary Kolbenschmidt KK (KSKK).

Mazda's SKYACTIV-X engine is a true innovation thanks to the SPCCI combustion process.

A crossover design, the SKYACTIV-X combines the advantages of a conventional gasoline-powered engine with the compression ignition of a diesel. Among the specific pluses of a gasoline engine are a larger useful rpm range and lower emissions, e.g. of nitrogen oxide. Compression ignition's virtues

THE SPECIAL COMBUSTION PROCESS SPCCI FROM MAZDA MAKES THIS COMBINATION OF THE BEST OF TWO ENGINE WORLDS POSSIBLE

include its sprightly responsiveness and greater fuel efficiency. Mazda's Spark Controlled Compression Ignition (SPCCI), a special combustion process, makes this combination of the best of two worlds possible. Thanks to continuous operation with spark plugs, it enables a seamless transition from external ignition to compression ignition. This means that the engine can run on an extremely lean, homogenous fuel-air mixture.

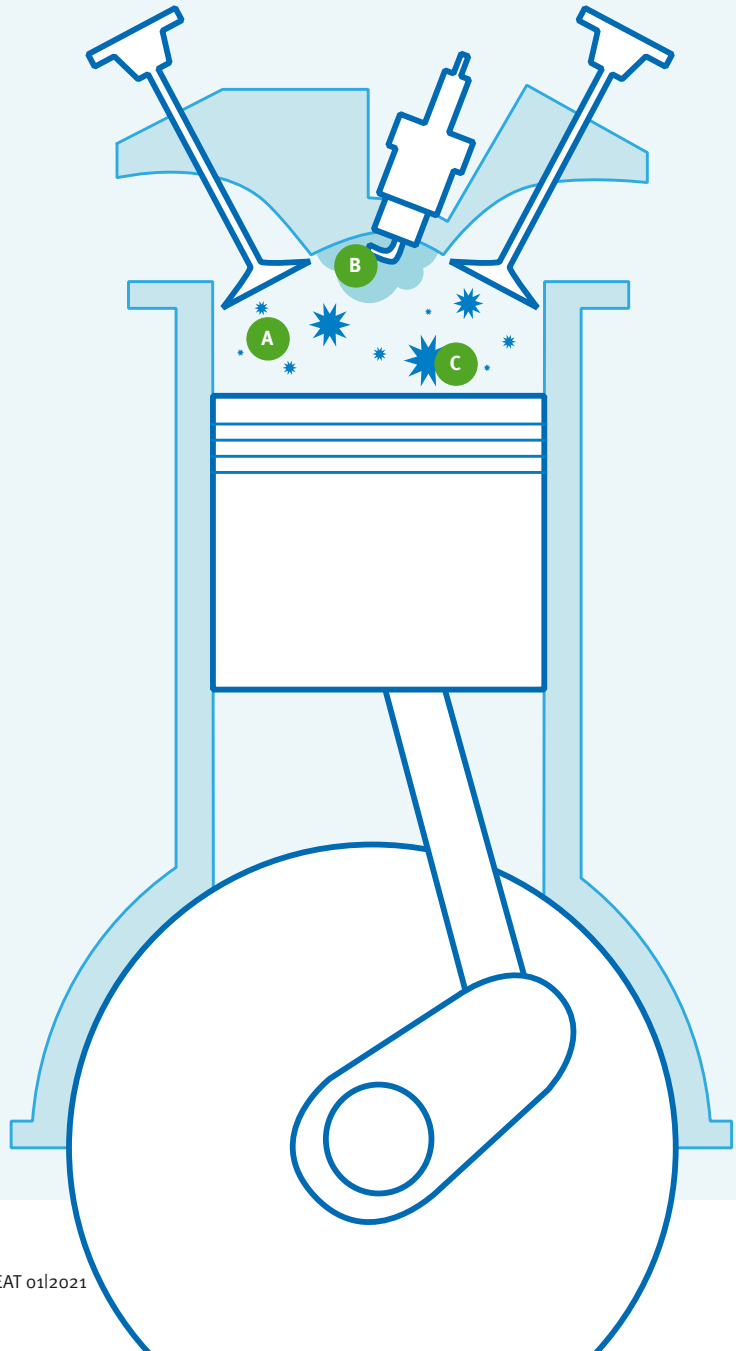
Controlled self-ignition
The SPCCI combustion process has two major advantages over other procedures: Because the compression ignition is triggered by spark plugs, controlled self-ignition always takes place at the optimum point in time. As a result, fuel-saving self-ignition takes place in a broad load and rpm range, which significantly reduces fuel consumption. In addition, thanks to the spark plugs, the system can instantly switch over to external ignition in those rpm and load ranges where compression ignition isn't possible. This makes sure that the compression ratio selected doesn't have to be too high. This inno-

SKYACTIV-X COMBINES SPARK AND SELF-IGNITION

THE MAZDA DRIVE IS BASED ON THE SPCCI COMBUSTION PROCESS

This is how the principle behind Mazda's innovative Spark Controlled Compression Ignition (SPCCI) process works:

1. During the intake cycle, a lean, homogenous gas mixture forms, i.e. with a large air content. This enables lean combustion.
2. At this point a separate injection of fuel occurs during the compression stroke at the spark plug.
3. This leads to a rich mixture in a small area around the spark plug.
4. At the end of the compression stroke, the lean fuel-air mixture is already present in the combustion chamber shortly before compression ignition.
5. An additional increase in pressure in the combustion chamber occurs due to ignition of the rich gas mixture cloud around the spark plug at the corresponding point in time.
6. Ultimately, this additional rise in pressure causes the lean homogeneous mixture in the entire combustion chamber to self-ignite and burn.



A At a compression ratio of 16.3 to 1, the lean mixture is compressed until just before compression ignition occurs.

B Ignition of the rich mixture around the spark plug leading to an additional increase in pressure.

C After this, compression ignition of the lean fuel-air mixture takes place in the combustion chamber.

vative technology enables a significant reduction in fuel consumption: compared to the current 2.0-liter SKYACTIV-G gasoline engine, SKYACTIV-X consumes 20 percent less fuel on average, and up to 30 percent less in the lower load range.

KSKK, a proven partner
For piston developers, this innovative combustion technique poses special challenges. However, Mazda quickly found the right partner, as Tadayuki Kuramoto, President and Member of the KSKK board, reports: "We weren't picked just because Mazda appreciated our technological know-how. It was also because of our long-standing track record with regard to quality, costs, punctual delivery, service, and development. KSKK supported Mazda as early as the advanced development stage, and was ultimately selected to be the series development supplier in 2016."

One of the challenges facing the developers: Self-ignition causes vibrations akin to knocking, a problem that Mazda solved with its Natural Sound Smoother, a vibration absorption system. "Here, a so-called dynamic damper weighing about 50 grams is pressed into the piston pin and moves with the same frequency as the vibrations produced by SPCCI combustion," explains Kuramoto.

Lighter pistons wanted
Because this special structure makes the piston pin relatively heavy, the piston itself has to be as light as possible in order to offset the piston system's heightened inertial mass. "KSKK's LiteKS-Plus piston turned out to be just the right system for this application. Combined with a suitable ring carrier,

THE KSKK PISTON IS ALSO AN IDEAL CANDIDATE FOR GASOLINE ENGINES WITH HIGH COMPRESSION RATIOS

it provides Mazda with a robust, low-weight piston featuring high protection, which makes an important contribution to the overall success of the SPCCI system," declares Kuramoto.

Another challenge relating to an engine concept with a high compression ratio is the need to minimize variation in the compression ratio. For the piston, this meant that variation in the crown volume had to be kept to a minimum. KSKK achieved this through stringent, high-precision control of the crown shape and compression height.

The LiteKS Plus piston system is characterized by low weight and high rigidity.

Tadayuki Kuramoto is particularly proud of the flexibility in production.

Flexibility in production
Kuramoto has special praise for his colleagues on the factory floor: "Just one year before the start of production, Mazda decided to use a ring carrier in order to reduce wear and tear on the part. Despite having no experience in producing pistons with a ring carrier for gasoline engines, we managed to get ready for production in extremely short order, including the casting cell and processing line for manufacturing a piston of this type."

A system with a future
Looking beyond the SPCCI process, Kuramoto sees further applications for the KSKK piston: "It features narrower tolerances in compression height and the crown profile resulting in lower volume vibration than conventional pistons. This makes it an ideal candidate for gasoline engines with high compression ratios that react sensitively to changes in this ratio." ■

// “AS PROUD AS A PEACOCK”

Teamwork can move mountains

Development capacity and high speed were crucial when a team made up of Rheinmetall folks from Berlin, Ústí, and Neuss wondered whether it would be possible to develop a ventilator for intensive care patients with items to hand.

Spring 2020 … the first coronavirus lockdown. People everywhere were genuinely frightened, worried that our healthcare system wouldn’t be a match for the grave challenges ahead. Shocking images from around the world on TV did little to allay these fears. Would there be enough intensive care beds in our hospitals? Were they adequately equipped to cope with a potential flood of incoming patients in urgent need of emergency care? Facing up to this situation, Rheinmetall rose to the occasion, drawing on its international contacts and logistics chains to procure

It just goes to show that actuators from Pierburg can be used in applications no one ever thought of before: the centerpiece of the ventilator is a drive that's also used for exhaust gas recycling in trucks, for example.

desperately needed protective equipment for government agencies. Today, it continues to supply the federal authorities in Germany with FFP-2 respiratory masks and other personal protective equipment.

But that wasn't enough for Rheinmetall's automotive development and prototype specialists, who also saw the worrisome images on TV. They secretly began to wonder if it wouldn't be possible to use existing technology to alleviate the potential looming emergency on the spot. In this atmosphere of general anxiety, all it took was a medical article on simple ventilators published by the University of Göttingen to spark the idea. A team made up of staff members from three different Rheinmetall locations immediately set to work developing a simple ventilator consisting of components to hand.

But there was a further difficulty: How to complete the task in a way that adhered to social distancing and hygiene rules made necessary by the pandemic while still working at top speed. Deep inside, everyone involved in the effort knew

A TEAM FROM THREE RHEINMETALL LOCATIONS IMMEDIATELY SET TO WORK ON THE TASK

from the start that whatever solution they might come up with wouldn't receive immediate official approval, nor would they simply be able to catch up with companies with decades of specialized experience in respiratory technology. But

necessity is the mother of invention. And when Dr. Andreas Müller sounded the starting gun, the team assembled for the task set straight to work.

Looking back, this joint effort goes to show just how resourceful humans can be in an emergency and how quickly new ways and means can be found that previously would have been considered unthinkable. This is also true of this article, which summarizes the team's swift action while respecting the corona restrictions. Even if its use in an actual medical context doubtless lies far in the future, the team in Berlin grouped around Siegfried Güntner wasn't "operating" intuitively. Before embarking on the project, they sought expert advice, including from hospital physicians and first aid trainers. In addition, based on their respective areas of expertise, the colleagues taking part in the project were all able to make their own individual contribution.

Once the necessary components, including the control unit, had been collected, the prototype team led by Akifhan Yurt got to work assembling the device.

Incidentally, the centerpiece of the new device is an adjustable servomotor developed inhouse in Hartha.

Understandably, Güntner was as proud as a peacock once the device had been successfully assembled (though that's not quite how they put it in Berlin!). Even though it will probably never be used in real life, the device goes to show what can be achieved through teamwork and the iron will to succeed. Just realizing this was a huge success in itself. Their joint effort won the Berliners acclaim throughout the entire Group. Necessity is indeed the mother of invention! ■

Marien Baars of Rheinmetall Niederlande recently presented the Mission Master in Neuss.

// MISSION POSSIBLE

The ultimate unmanned ground vehicle operating in autonomous and semi-autonomous fashion

Autonomous vehicles for civilian use are now a hot topic. But whereas numerous manufacturers and service providers are tearing their hair out in the quest for reliable roadworthiness, Rheinmetall's solution for off-road applications has already proved its worth and high reliability on several occasions.

For the Mission Master, operating in follow-me mode is a comparatively easy task.

The vehicle can be steered via various forms of remote control.

We're talking about the Mission Master here, an autonomous unmanned ground vehicle designed for a multitude of different missions. Just under three meters long and weighing in at 1,100 kilos, this four-axle vehicle is powered by two separate electric motors. With its eight all-terrain tires, the Mission Master is thus extremely maneuverable – it can even pivot on the spot.

Award-winning "Mule"

Based on lithium-ion batteries, its electrical charge capacity means that it can operate for eight hours at a stretch, travelling at speeds of up to 30 km/h. Moreover, it can handle steep inclines of up to forty percent and even climb stairs. Nor is this high-mobility mechanical mule afraid of standing bodies of water. Thanks to its encapsulation and special tire treads, the vehicle can cross water obstacles at a pace of up to 5 km/h, while special tire tracks keep the vehicle on the go even through snow.

Its 600-kilo payload makes it perfect to execute a wide array of different missions. One of the Mission Master's major differentiators is its negligible acoustic signature. Like all electric vehicles, it is silent when on the move, and thus relieves the burden on its human companions in more ways than one. Back in 2018, the Mission Master took first prize in the category "Transport/Mule" at the European Land Robot Trial (ELROB) in Lens, Belgium, a bi-annual competition for unmanned vehicles.

Off-road features

The Mission Master owes its autonomous functions to the PATH autonomous kit (A-kit). It provides a wide range of teleoperation options for the Mission Master, including a tablet, smartwatch, soldier system, and single-hand controller. It can also be integrated into digital command and control systems or controlled remotely from inside a vehicle with a computer terminal.

One of PATH's interesting features is the many navigation options it enables for the Mission Master. For instance, the Mission Master can be ordered to follow a vehicle or person at a specific standoff. Or the operator, who incidentally can intervene at any time, can also select a point on the map as the vehicle's destination. Alternatively, a predetermined route of march can be transmitted to the Mission Master. Another option is that it can also be ordered to take the shortest route to a specific location, by following forestry roads, for example, exploiting a preprogrammed network of paths and tracks.

THE MISSION MASTER IS SILENT WHEN ON THE MOVE

Specialties in off-road operation

And if this wasn't enough, the Mission Master can memorize fixed routes between two locations that it can then use over and over again on supply runs, for instance. Thus far, these functions are possible only in an off-road setting rather than in traffic. But here, too, special conditions pertain, as Dr. Marc Lemmermann – responsible for marketing the Mission Master in Germany and some other European countries – explains: "Operating off-road is fundamentally different from autonomous driving in town. This means the vehicle needs a different set of sensors in order to contend with ditches and other obstacles not found in ordinary traffic conditions."

Depending on the task at hand, the Mission Master can, again through the PATH A-kit, rely on different artificial intelligence capabilities. Among other things, object recognition and classification via

Thanks to a laterally mounted carrier, the Mission Master's transport capacity can be readily increased.

the vehicle camera systems allows for improved target and obstacle tracking. In addition, expanded situational awareness algorithms can fuse data from onboard sensors to simultaneously create a map and localize the Mission Master so it can still operate if the GPS signal is lost. Another example is the terrain analysis

WE HAVE TO KEEP UP THE PACE OF DEVELOPMENT. ONE THING IS FOR SURE: ELECTRIC IS UNBEATABLE!

where the Mission Master creates a map and a 3D model of the terrain based on its sensor data, which ensures it navigates challenging terrain safely.

Rheinmetall Canada, the company responsible for developing the system, will be presenting this year a new concept of collaborative work for the Mission Master. Managed by a single operator, the concept consists of multiple Mission Master vehicles efficiently operating as a team in order to accomplish missions of all types. As Dr. Lemmermann notes, "In technological terms, we are way ahead of the competition – but we have to keep up the pace of development. One thing is for sure: electric is unbeatable!"

As far as autonomous driving is concerned, certain aspects of the technology built in Canada will also be used in the development of the automotive field. Many concepts have already been developed together with other Rheinmetall business units. Based on the Group's comprehensive know-how and expertise, we can expect to see a rise of new products and services in this domain.

Packages for every application
The Mission Master can navigate off-road with "level 4" autonomy mode: The vehicle can carry out the mission it is assigned in full autonomy without human assistance in most operations. Nevertheless Rheinmetall is committed to keeping a human in the loop in all kinetic operations.

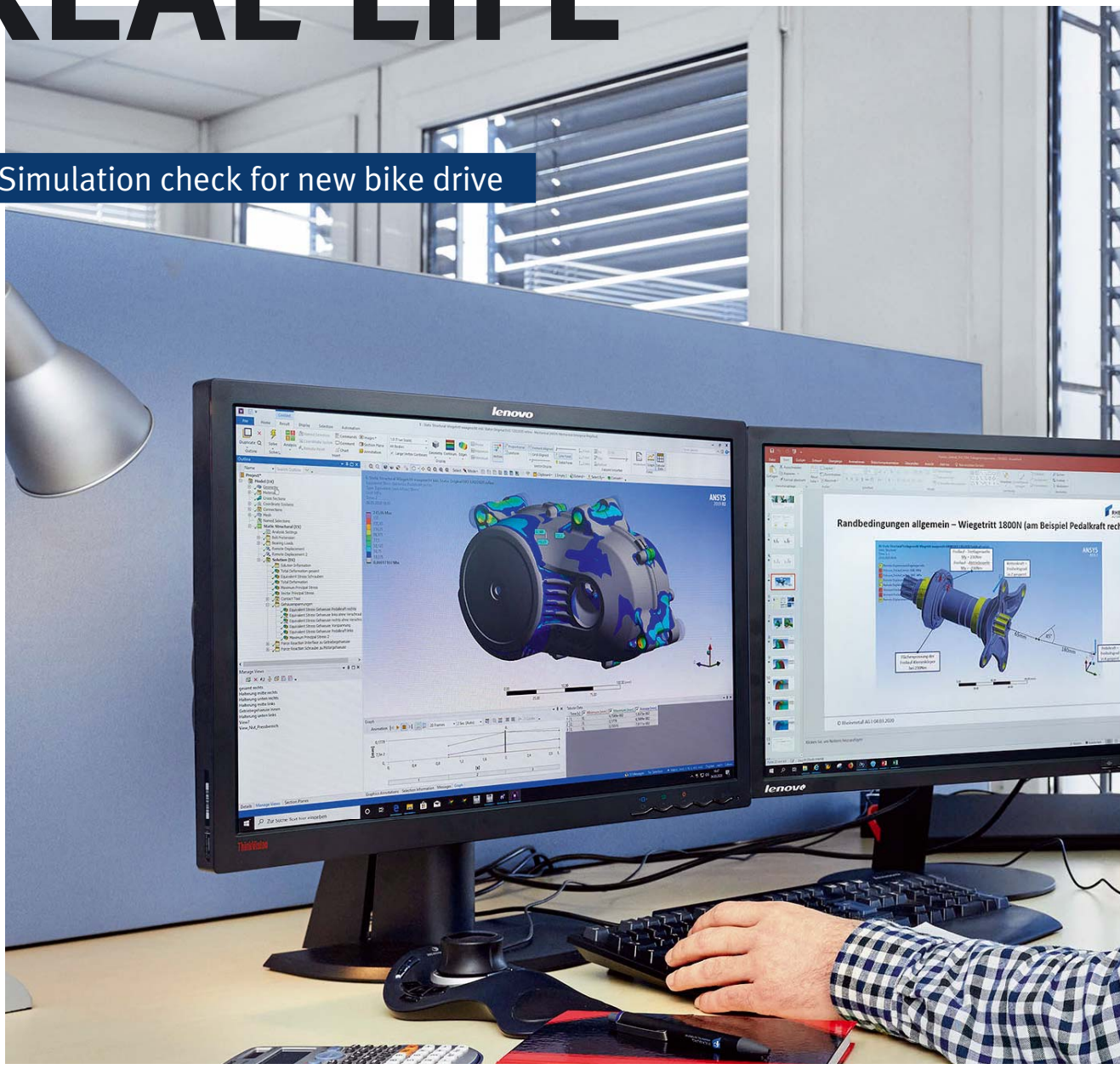
Depending on the specific mission, various equipment packages are available. The scope of applications range from a purely transport role to a medical evacuation system for recovering wounded personnel. The Mission Master can also serve as a mobile surveillance asset or communication relay station, or in a fire support role for troops operating in particularly hazardous situations.

Instantly accepted
The Mission Master was originally conceived as a technology demonstrator that would enable a live presentation of the PATH A-kit, which enables state-of-the-art automated driving. The technology is now being integrated into other vehicles for instance within Rheinmetall's range of military and logistics vehicles.

The fact that it has been instantly accepted as a support vehicle augurs well for the future: Several armies are already testing the vehicle operationally. Perhaps in the medium term it is also suitable for civilian sectors such as agriculture, construction, and mines. The Mission Master is poised to make many things possible. ■

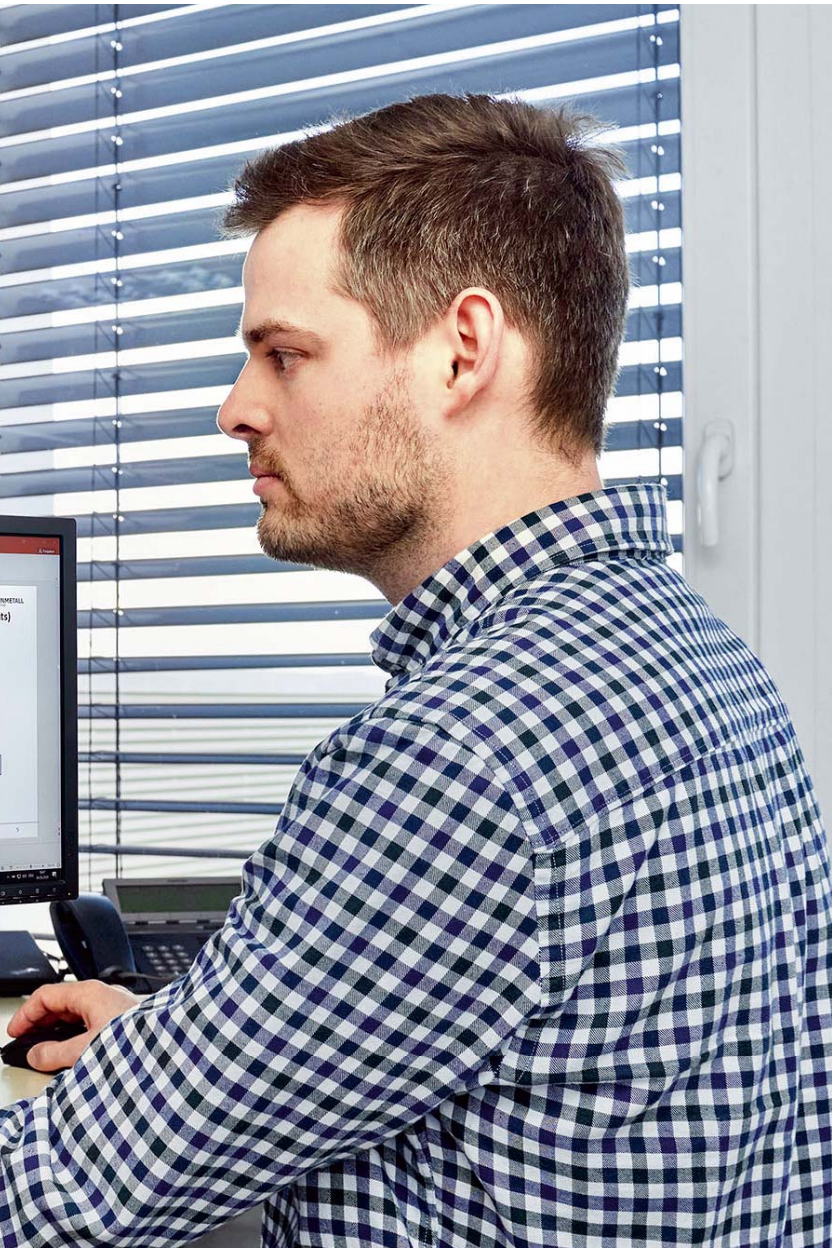
// JUST LIKE REAL LIFE

Simulation check for new bike drive



Technology makes it possible: thanks to advanced simulation programs, the special material characteristics of products can be checked and optimized prior to fabrication of the first prototypes.

A new piston, a new pump design, or even a completely cooled exhaust gas recirculation system: These days, developers use special simulation programs to check many products from Pierburg and Kolbenschimdt during the development process, underscoring the importance of this new tool. This is also true of Rheinmetall's Amprio pedelec drives, which are now in development.



With a furrowed brow, Hendrik Moll stares intensely at his computer screen. The engineer has just initiated a finite element simulation for the latest generation of pedelec drives. This involves a stress calculation in which the future material characteristics are checked for resilience and

THE IMAGE OF THE AMPRIO ENGINE IS COLORED RED IN ONLY A FEW PLACES – THESE ARE THE PLACES THAT NEED TO BE REWORKED

durability. Because he had previously filtered out all irrelevant subassemblies and parameters from the CAD data, the entire process, which once might have taken all night, was complete in a matter of minutes. And it really works: The image of a new Amprio pedelec drive soon appears on the screen. Much to Hendrik Moll's satisfaction, only a few zones are marked in red, which he describes as "critical points that still need a little work." In the next step, Moll sends the results to the drive's developers, enabling the newly gained knowledge to flow into the design.

Acid test, on the double …
A perfectly normal simulation procedure, completed in the space of a single workday. Without this high-tech capability and Moll's expertise, a prototype housing would have to be fabricated and tested, which would take quite some time – precious time that can speed the development process in a

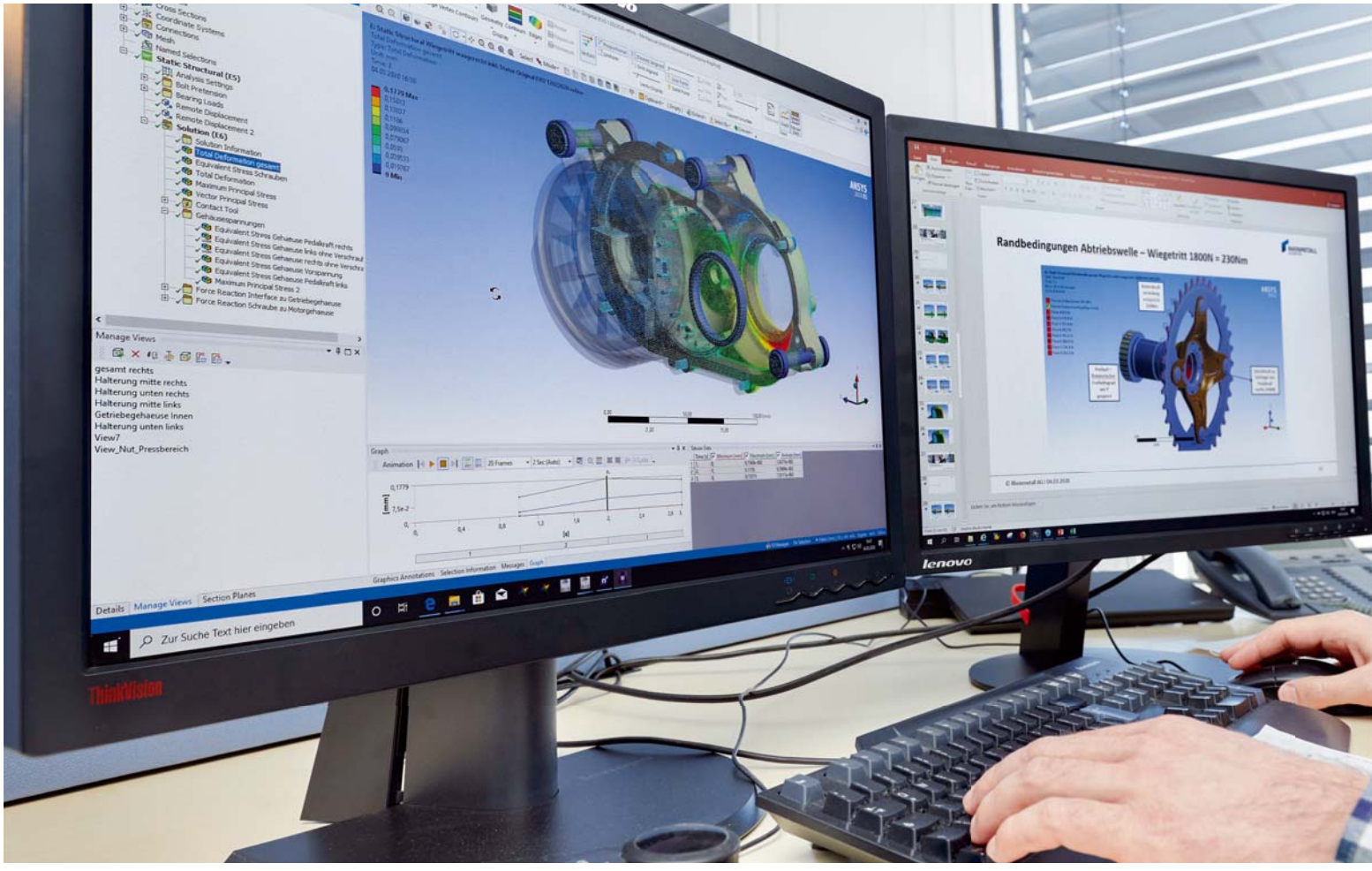
sustained way, yet still enable reliable conclusions to be drawn concerning the future characteristics of a component currently under development. There's also the added benefit of being able to reduce the amount of material used in specific components as well as their weight.

This is music to the ears of company-internal "customers" for simulation: "With Amprio, the high reliability of the simulation-based calculations has been borne out in subsequent practical trials – we definitely trust our colleagues' results," declares Dietmar Greven, who is in charge of innovation management at the Rheinmetall spin-off.

Growing importance

It thus comes as no surprise that Urs Jedrkowiak, Head of the Simulation department, has witnessed a steady increase in incoming orders from various parts of the company. Moreover, he notes, "We've also noticed that the role of simulation in the development process isn't just becoming more important in general, but that our support is being sought at increasingly earlier stages of development." This kind of frontloading means that simulation becomes an integral part of the process right from the start, enabling testing of new products while they're still on the drawing board, as well as investigation of different conceptual approaches. Taking this situation into account, Jedrkowiak walks the design engineers through the simulation and makes the workflows available. This lets his "customers" compare various conceptual approaches during the preliminary stage before making a definitive decision to proceed in one direction or the other.

In the meantime, the simulation possibilities available to Jedrkowiak and his staff have also grown



Finite element simulation lets developers skip the long drawn-out fabrication and testing phases that used to be necessary.

Based on the data collected, Hendrik Moll offers advice on the optimum wall thickness of components, for instance, or the type of alloys to use.

substantially. Today, these range from multibody simulation, finite element method (FEM), and subsequent lifespan analysis to flow simulations, total system simulations, and multi-physical simulation of electronic components, which is increasingly in demand in electronics development. Great importance is attached to machine-supported optimization. This encompasses the physics-related disciplines of structural and flow mechanics, as well as electronics.

Simulation never stops

In the meantime, a tightly woven simulation network has emerged throughout the company, embracing simulation specialists not just in Germany but at subsidiaries elsewhere in Europe, North and South America, India, China, and Japan. This accelerates the organization's output still further, since simulation orders can be executed around the clock, resulting in even faster outcome.

Beautiful landscapes

Meanwhile, Hendrik Moll has forwarded his recommendations to the developers of the pedelec drive. As so often, the initial question was: Can this component withstand the required stress loads? With the help of the multibody simulation, Moll investigates which forces act on which zones, and which interactions develop between different bodies inside the drive housing. The same applies to the components of the bottom bracket bearing, for example, or the support reactions vis-à-vis the housing. In carrying out his calculations, he has to determine whether the planned component can stand up to the stresses it will encounter during its service life. This then flows into an assessment of the component's longevity. In conducting this calculation, he knows he can rely on the German DIN standard for pedelec drives. Moll is categorical here: "If it meets the DIN standard, the component won't break in real life."

An enthusiastic muscle-powered mountain biker himself, Moll draws on his simulation data to advise the motor developers with regard to intended wall strength, the planned radii, possible shifting of the walls, and which alloys to use in the component.

HIMSELF AN ENTHUSIASTIC MUSCLE POWER MOUNTAIN BIKER, MOLL ADVISES THE ENGINE DEVELOPERS ON THE BASIS OF HIS SIMULATION DATA

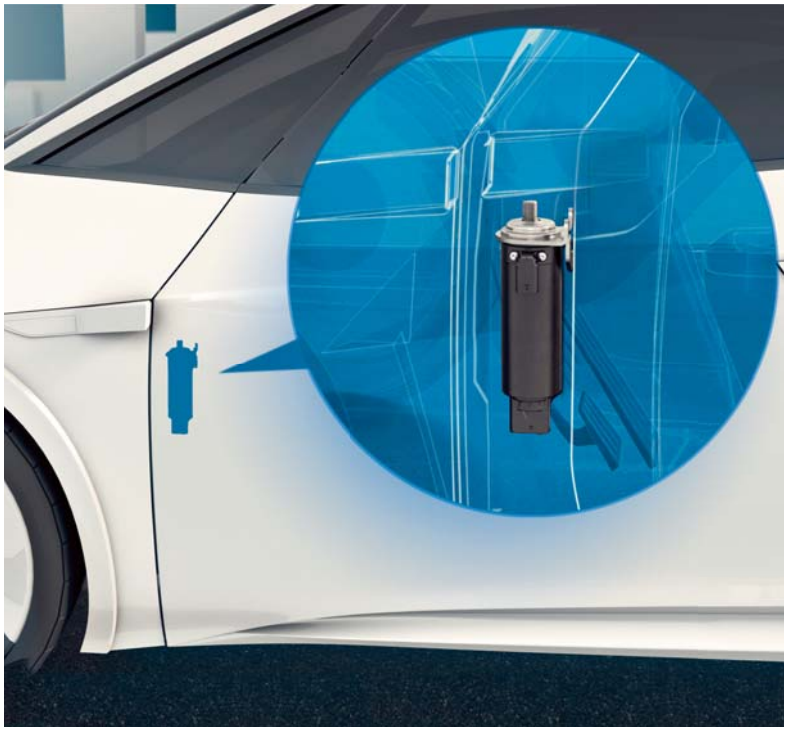
Made up of multiple development stages, a test campaign like this can take several months. The pedelec cyclists who will one day glide effortlessly through spectacular mountain scenery thanks to a dependable and optimized Amprio drive will owe Moll a debt of gratitude. ■

More information at **www.amprio.com**

// OPEN SESAME!

Electric side door openers are conquering the automobile market

A service once largely restricted to luxury hotels or regarded as a courteous gesture has long since become an integral part of our everyday lives. The congenial opening of doors – now no longer performed by a human hand but by special electric motors – is something we encounter everywhere.



A glimpse into the interior. The vehicle door contains an actuator from Pierburg.

Whether in hospitals, public buildings, or even in hotel parking garages, doors open as if by magic as soon as someone – hands full or not – approaches. Why shouldn't passenger car doors open this way too? Pierburg has developed a complete solution to enable just that, and one that doesn't just make life safer for approaching bicyclists and motorcyclists. It doesn't take long for drivers to realize the advantages of doors that open and close automatically, a convenience that they soon wouldn't want to do without. Developed in collaboration with a well-known automaker, the first prototypes of this new door actuator are currently being tested by the customer.

A specialist for this type of actuator, Pierburg was able to draw on its long-standing expertise in the field. The list of specifications for the new product was by no means short. Among other things, the components had to be engineered to save space; display high performance density; and meet lofty expectations with regard to acoustics. Making sure that it couldn't self-lock in

Andreas Köster shows off the actuator – small in size, big on performance.

emergency situations was another key requirement.

"Expectations regarding the actuator's performance were significantly higher than even our own standard," explains Andreas Köster, the responsible Project Manager in Pierburg's Advanced Engineering unit, noting that "a fully equipped car door can weigh thirty or forty kilos, and has to stay in position under windy conditions and on inclines. That's why our actuator is designed with relatively high torque."

A FULLY EQUIPPED CAR DOOR MAY WELL HAVE A WEIGHT OF 30 OR 40 KILOGRAMS

According to Köster, the new actuator differs fundamentally from the conventional drives used for powering electric hatchbacks, for example. The later can operate more slowly and have more leeway when it comes to noise. Conversely, Köster assumes that the side doors need to open and close in just two or two and a half seconds.

A further challenge facing the developers proved to be the required compactness of the components. Because the pilot customers will be offered the electric doors as an extra, the actuator had to be easily installable in the crack of the doors. This characteristic also sets the actuator apart from rival systems. For example, if the actuator isn't installed in the crack of the door, installation space has to be found in the interior of the door instead, without encroaching on other systems located there, e.g. loudspeakers or the windows when lowered. Here, too, the compact design helps.

But this wasn't enough: Pierburg also had to develop the necessary software for the actuator, taking account all of the associated driving maneuvers, including moving forward and backward, stopping under adverse conditions and avoidance of overshooting. As a safety feature, the actuator is connected to the vehicle's sensor suite. This prevents the door from opening when other road users are approaching the vehicle or when a bollard is in the way of the door.

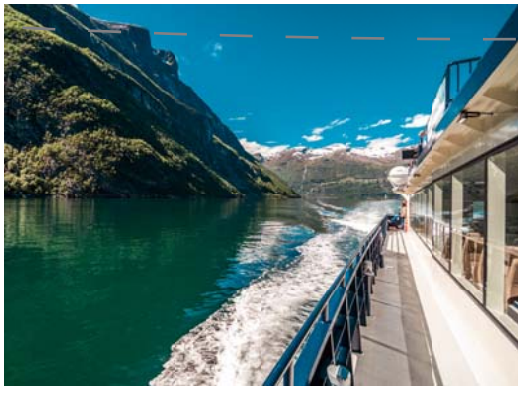
As Köster sees it, this concept offers many advantages, and he envisages a clear trend toward electric doors – and not just in taxis and future autonomous vehicles. Even by themselves, the tendency to have wider opening angles, which make entering and exiting the vehicle easier, and the problem for some of having to push and pull heavy doors, will be an important factor for customer decisions in the future. It will be particularly convenient for drivers of cars that open the door in response to a keyless gesture command after they've automatically driven out of the garage, and then close the door again once the driver is seated. For the time being, of course, the driver will still have to do the driving from this point on. ■

// A NORWEGIAN CLASSIC GETS GREENER

Rheinmetall large-bore pistons on board of the Hurtigruten line

Famous Hurtigruten ships are constantly being modernized. At least six of the Norwegian company's ships will be converted to run on gas – and not just LNG, but also environmentally friendly biogas. Present onboard are large-bore pistons from Rheinmetall.

Right out of a picture book: spectacular Norwegian scenery lines the entire route.



Clear water and green hillsides are signs of a largely intact natural environment.

The famed Hurtigruten line has been a Norwegian institution since 1893. Originally serving as mail boats, today these ships still transport cargo along the Norwegian coastline between Bergen and Kirkenes, though they principally carry tourists now. In doing so, the Hurtigruten AS shipping line attaches great emphasis to environmental sustainability.

The company has set itself the goal of replacing the conventional engines on at least six of its ships with a combination of natural gas-powered motors and electric drives with corresponding battery packs by 2021. These hybrid ships will then be able to operate either on liquid natural gas (LNG), with electric power, or with liquified biological gas (LBG), which happens to be particularly sustainable. The effort and expense involved in making the switch is considerable: In order to install the biogas-capable combustible gas supply systems (FGSS) of the Norwegian engine-maker Bergen Engines into existing Hurtigruten ships, the marine outfitter had to develop and engineer a made-to-measure tank and FGSS system for each ship. These state-of-the-art drive systems feature pistons from Rheinmetall.

A clean alternative to diesel and bunker

Around the world, LNG-powered ship engines are making inroads as an environmentally friendly alternative to diesel motors. While burning LNG produces roughly as much CO_2 as bunker and marine diesel, it doesn't produce soot particles and the ratio regarding NO_x and SO_x is also significantly better. As opposed to other operators, however, Hurtigruten hasn't opted for a dual-fuel option in its gas-operated ships, i.e. motors than can use both diesel and LNG. "Dual-fuel drives are always a compromise solution," notes Ralf Remmler, Head of Rheinmetall's Large-Bore Pistons unit. If, on the other hand, engines are designed exclusively to operate on gas, they can be specially optimized for this fuel. This enables more efficient, and thus more sustainable, operation."

The MS Fridtjof Nansen is powered by ultramodern hybrid drive technology.

The Northern Lights have fascinated people for thousands of years.

Particularly in the far north, sea lions are a common sight.

Climate-neutral gas from organic waste
By contrast, no compromises regarding efficiency are necessary for engines to run on LBG. LBG is considered to be far and away the most environmentally friendly fuel of its kind. The International Energy Agency has declared it to be virtually climate-neutral. LBG is a liquified gas derived from organic waste. In biogas plants, the solid waste is heated first in order to help the bacteria break it down. A controlled decomposition process takes place in the bioreactors, during which the gas is produced. Finally, the gas is cleaned and cooled until it liquifies, after which it can be used in internal combustion engines.

It was very important to Hurtigruten that the entire production and logistics process be taken into account when assessing the sustainability strategy. In Norway itself, the raw material necessary for producing

IN NORWAY, THE RAW MATERIAL FOR BIOGAS – ORGANIC WASTE – IS AVAILABLE IN ABUNDANCE

LBG – i.e. organic waste – is available in abundance due to the fish farming and forestry industries. This enables simple, environmentally friendly production to

ADVANTAGES OF BIOGAS

In the road traffic and transport realm, many experts think that biogas could significantly reduce the harmful emissions produced by trucks and ships. Biogas comes from things that already form part of the carbon cycle: manure, for example, or fish offal and other waste products that would normally be destroyed.

Liquified biogas, or LBG, is an efficient energy source which, thanks to its high energy density, is easy to transport. LBG is therefore ideal for trucks and ships that until now have relied on diesel, while simultaneously keeping large amounts of CO_2 and other pollutants out of the atmosphere.

Liquified biogas is now considered to be far and away the most environmentally friendly fuel of its kind. This has led the International Energy Agency to classify it as nearly climate-neutral after taking all factors into account. Moreover, through its Bio-LNG initiative, the German Energy Agency is also promoting the increased use of liquified biogas in the shipping and trucking sectors.

With a little luck, one might even catch a glimpse of a whale.

take place on location. Moreover, the transport routes from the production sites of the Norwegian gas producer Biokraft to the Hurtigruten ports are short.

It all depends on the pistons

The piston plays a key role in insuring that the motor can operate efficiently on both LNG and LBG. “We adapted the piston cavity to meet the specific requirements of the Bergen engine,” says Remmler. Extensive computer simulations were conducted in the wake of testbed trials of the engine in order to define the optimum cavity design for this special application. This was the only way to make sure that the combustion process in the combustion chamber would proceed especially evenly and thus especially efficiently.

Optimum design of the pistons prevents the development of hot spots, that is to say, those parts of the component walls that become especially hot, in turn leading to uncontrolled ignition of the fuel. Also known as knocking, this kind of ignition causes the temperature and pressure to spike, resulting in further ignitions. The resulting spikes in pressure place a major mechanical strain on the engine.

An important signal for the sector

The pistons from Rheinmetall thus form a small but important element in Hurtigruten AS’s strategic quest for greater sustainability.

As a result, the Norwegians have taken on a leading role in the cruise ship industry: Already in service, two Hurtigruten vessels – the MS Fridtjof Nansen and MS Roald Amundsen – are the world’s first hybrid cruise ships. Retrofitting of further ships with LBG-capable drive technology will likely make the Hurtigruten fleet the most environmentally friendly cruise line in the industry. Operating in a sector that’s come under attack for its lack of sustainability in recent years, Hurtigruten is therefore sending an important signal of corporate responsibility. ■

// TOP TRAINER

Rheinmetall places among Germany's best trainers

Rheinmetall has been recognized once again for its activities in the Human Resources domain. In a survey conducted by the German magazine "CAPITAL", the Rheinmetall Group was awarded five stars, placing it among the best companies in Germany when it comes to training.

Welcoming new trainees and dual study program students at Pierburg GmbH in Neuss.

Future industrial mechanics undergoing training at KS Gleitlager in St. Leon-Rot.

New trainees at Motorservice International in Neuenstadt.

After coming off well in the "trendence-Studie", in which the Group took 41st place among the 100 most attractive employers for engineers, recently Rheinmetall did even better in the "Universum Young Professional Survey 2020", advancing to 34th place in the junior engineer category.

Conducted from March to June 2020, the "CAPITAL" study – the fourth of its kind – was based on apprenticeship and dual study programs. The Group, which has 767 trainees at home and abroad, was awarded 23 points out of maximum total of 25.

"This award is an outstanding confirmation of the commitment our trainers show throughout the Group, day in, day out. It also validates the basic orientation and structure of training at Rheinmetall," declares Peter Sebastian Krause, Member of the Executive Board with special responsibility for HR matters and Labor Director of Rheinmetall AG. In Germany alone, in 2019 the Group invested more than 13 million euros in inhouse training, with a total of 420 trainees nationwide.

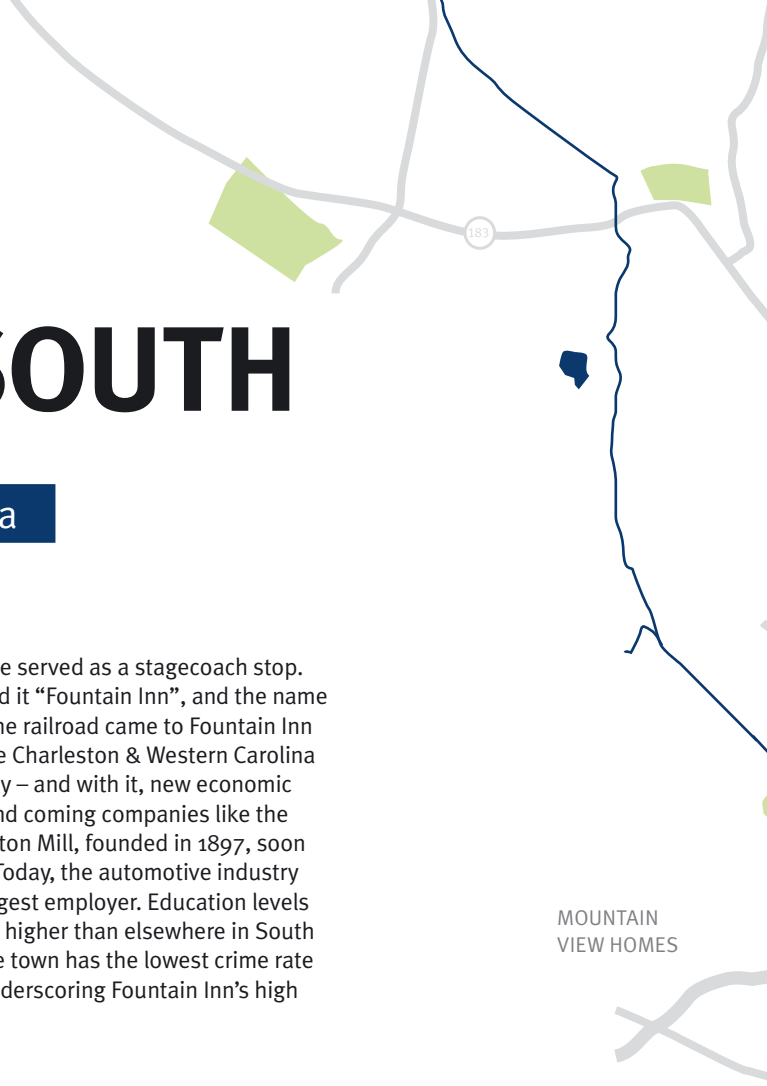
In addition to Rheinmetall's top ranking, a number of Group subsidiaries have also received best trainer awards. Among these are MS Motorservice International GmbH. Located in Neuenstadt in southwest Germany, the spare parts specialist currently has thirteen trainees undergoing vocational training in wholesale and foreign trade management and warehouse logistics as well as eight dual study program students pursuing business administration degrees, variously specializing in commerce, international business, and industrial engineering. Pierburg's Neuss plant was recognized, too. Here, at company headquarters as well as the "Niederrhein" plant, 63 young people are currently undergoing training in a wide variety of administrative, technical, and commercial trades.

THE AWARD IS AN OUTSTANDING CONFIRMATION OF THE DAILY COMMITMENT OF THE MANY INSTRUCTORS AT RHEINMETALL

For the third time, KS Gleitlager GmbH in St. Leon-Rot, also located in southwest Germany, was awarded four out of five stars. Here, 25 trainees are learning to be industrial mechanics, tool mechanics, electronic technicians, and industrial clerks, while three dual study program students are pursuing courses in automation technology and industrial management.

Encompassing nearly 700 companies, the "CAPITAL" survey involves extensive, carefully validated assessment criteria. Questions focus on the quality of the trainers, trainee support, teaching methods, training plans, and success tracking.

But the survey also covers such topics as subsequent hiring, drop-out rates, salaries, interaction with digital media, drawing on the technical competence of the trainees and dual program students, as well as the way companies market their training programs. ■



// WAY DOWN SOUTH

On site in Fountain Inn, South Carolina

Apart from locations in Michigan and Wisconsin, the automotive divisions are also present in the south of the USA. Fountain Inn, near Greenville, South Carolina, is home to another site of the technology group in good automobile company. Besides numerous German suppliers like Bosch or ZF, the largest BMW factory is also not far: The plant in Spartenburg is less than 35 kilometers away. Fountain Inn, population 7,800, was officially founded in 1886, though the town's origins lie deeper in the past. The name is no coincidence: There was indeed an inn by a fountain there, which once served as a stagecoach stop. The drivers called it "Fountain Inn", and the name stuck. In 1886, the railroad came to Fountain Inn in the form of the Charleston & Western Carolina Railway Company – and with it, new economic prosperity. Up and coming companies like the Fountain Inn Cotton Mill, founded in 1897, soon lined the route. Today, the automotive industry is the town's biggest employer. Education levels and incomes are higher than elsewhere in South Carolina, and the town has the lowest crime rate in the county, underscoring Fountain Inn's high quality of life. ■

01
BOB JONES UNIVERSITY MUSEUM & GALLERY

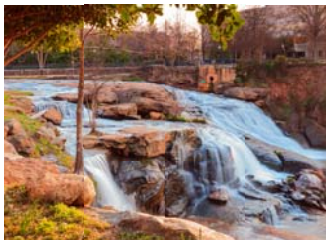
Founded in 1951 in Greenville, this museum boasts the world's largest art collection of religious art after the Vatican. Among other things, it houses Egyptian artifacts and important Renaissance paintings, and even lends works to the Louvre.

1700 Wade Hampton Blvd
Greenville, SC 29614

02
FALLS PARK ON THE REEDY

Located in the middle of downtown Greenville, Falls Park on the Reedy River is a haven of peace and tranquility. Visitors are sure to enjoy the beautifully landscaped gardens, a stroll across the Liberty Bridge, and of course picturesque Reedy River Falls.

206 S Main St
Greenville, SC 29601



03
FLUOR FIELD

The Fluor Field baseball stadium is home to the Greenville Drive, a minor league team, which incidentally also serves as a farm team for the famous Boston Red Sox. Every visitor to Greenville should take advantage of the chance to experience this most American of all sports – the tickets are very reasonable.

945 S Main St
Greenville, SC 29601

04
TRIO RESTAURANT

The Brick Oven Cafe "Trio" has some of the best pizza in Greenville. Toppings include "Cheeseburger" and "Philly Cheese Steak", guaranteeing a memorable, all-American dining experience.

22 N Main St
Greenville, SC 29601

05
ICE CREAM STATION SIMPSONVILLE

The former Simpsonville train station is a treat for ice cream lovers and railroad enthusiasts alike – served up with a generous helping of 1950's Rock 'n' Roll!

125 S Main St
Simpsonville, SC 29618

06
FOUNTAIN INN HISTORY MUSEUM

This small local museum lives up to its slogan: "Where the stagecoach meets the 21st century". The exhibits range from the Cherokees as the original inhabitants to the twentieth century. Here the past is brought to life through numerous artifacts, historical photographs, and documents.

102 Depot Street
Fountain Inn, SC 29644

PIERBURG US, LLC

Site: **Fountain Inn, South Carolina**

Headcount: **150** (2020)

Sales: **110 million USD** (2019)


444
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Bürkert
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