

TurboNEWS

The customer magazine of BorgWarner Turbo Systems

Edition 1/2017



INGENIOUS POWERHOUSE

Massive power with impressively low consumption: the R2S® system from BorgWarner delivers high power for Range Rover Sport and Land Rover Discovery

Paving the way

Interview with Frédéric Lissalde, President and General Manager at BorgWarner Turbo Systems

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Quiet & smooth running

Innovative system sets new standards for roller bearings

page 16

Dear readers,

BorgWarner is paving the way for a clean, energy-efficient world. The propulsion systems specialist has been using this ambitious promise for several months in its outward communication worldwide. The company has extended its product portfolio for vehicles with combustion engine to include solutions for hybrid and electric drives – and is now presenting itself as a leading full-service provider for the mobility solutions of tomorrow. Learn more about this in an interview with Frédéric Lissalde, President and General Manager at BorgWarner Turbo Systems, from page 8 in the new TurboNews.

The range of engine projects presented in this edition stretches from exceptionally small to extremely large. Starting with Honda's new 61 cubic inch (1.0 liter) engine and continuing through the new 122 cubic inch (2.0 liter) turbodiesel from Jaguar Land Rover and the Volkswagen Group's 183 cubic inch (3.0 liter) TFSI unit, all the way up to the 402 cubic inch (6.6 liter) turbodiesel from General Motors – a very wide range of drives benefits from BorgWarner's turbocharging expertise.

BorgWarner also achieves its goal of further improving fuel consumption, emissions and performance by constantly optimizing its own products. The best example of this is the new ball bearing technology, which we present on page 16. The innovative bearing increases efficiency by 4 percent and reduces emissions by 2 percent – with excellent NVH characteristics.



Günter Krämer
Director Marketing
BorgWarner

We hope you have fun reading this latest edition of TurboNews

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08

„BorgWarner is playing a key part in driving forward the mobility for today and tomorrow.“

Frédéric Lissalde, President and General Manager at BorgWarner Turbo Systems, spoke to us about the new positioning in an interview.



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Power-packed!

With the new 3.0 TFSI engines developed by Audi, the Group is now presenting a new V6 generation that is equipped with the latest waste gate turbochargers from BorgWarner.

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Compact. Powerful. Economical.

Hondas smallest engine generates its performance using a wastegate turbocharger from BorgWarner



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Ningbo celebrates successes in customer audits



As the expression goes: no pain, no gain. Everyone at BorgWarner is therefore working hard to meet the high expectations of customers. Perhaps the best example of this is the Ningbo facility in China, which received the highest distinctions in three customer audits.

In the VW VDA6.3 audit, the location received the best possible mark of "A" with the highest possible score of 91 points. This award truly represents a massive success, as the audit standards are extremely strict and the performance of upstream suppliers has a strong influence on the result. The facility also received the Platinum Medal 2016 from

Caterpillar for continuous improvements within the scope of the supplier quality excellence process. The award is the highest distinction that Caterpillar presents to suppliers. Ningbo is the first local engine system supplier ever to receive this award. In November 2016, the location also passed the QSB+ audit of DPCA, a joint venture of Dongfeng with PSA Peugeot Citroën in China. With a value of 89 percent, the facility received the highest score among more than 40 suppliers audited in 2016. Ningbo therefore received the QSB+ certificate at the first attempt, although it is typically only presented to a supplier after the second successful audit.

Oroszlány growing with safety

Despite the fact that BorgWarner's facility in Oroszlány, Hungary is constantly growing, employees at the facility have now worked for one million hours without a single accident – not just once, but a total of five times. What an impressive achievement! The facility was presented with the CEO Safety Excellence Award for the fifth time in succession for this excellent performance. Daniel Paterra, Vice President Enterprise Reliability and Sustainability at BorgWarner Turbo Systems, presented the prize at the Oroszlány facility in February 2017. The prize money was donated to various charitable organizations. Many congratulations, Oroszlány!



Daniel Paterra, Vice President Enterprise Reliability and Sustainability of BorgWarner Turbo Systems, presented the award to the Oroszlány facility in February 2017.

Rzeszów receives award for high quality



Marek Zabielski, Plant Manager of BorgWarner Poland receives the Polish Quality Award from the representatives of the Polish Chamber of Commerce, the Polish Center for Testing and Certification and the Polish ISO 9000 Quality Assurance Forum.

Quality is rewarded: BorgWarner's facility in Rzeszów, Poland, won the Polish Quality Award 2016. The award, which is based on the standards of the European Foundation for Quality Management (EFQM), was presented in Warsaw on November 11, 2016, Poland's National Independence Day.

Marek Zabielski, head of the Rzeszów facility, was delighted to accept the award in the royal castle from representatives of the Polish government, as well as the chamber of commerce. The location won the award for its comprehensive portfolio of services and manufacturing operations. The award ceremony, which was held for the 22nd time, is supported by the Department of Trade and Industry.

The Polish Quality Award seeks to honor companies which fulfill and surpass the strict requirements of total quality management (TQM). The award is presented by the Polish Chamber of Commerce in cooperation with the Polish Center for Testing and Certification, as well as the country's ISO 9000 Quality Assurance Forum. BorgWarner has been working to the principles of TQM in Poland for many years. The accomplishments in terms of quality, work processes, health and safety, and environmental protection were honored accordingly by the 71 members of the Polish Quality Award Committee, comprising members from science and industry. Many congratulations to the management team and employees!

Taicang receives award from Volvo Cars

Volvo has strict requirements of its suppliers. Indeed, they must meet the highest demands in terms of efficiency, innovation, safety, environmental friendliness and quality – and only then do they receive VQE status (Volvo Cars Quality Excellence). The BorgWarner Turbo Systems facility in Taicang, China has now been awarded this much-coveted status.

Yuan Xiaolin, President of Volvo Asia Pacific, presented the VQE Award to Ni Guangshan, head of BorgWarner Taicang, on November 25, 2016 during the Volvo Supplier Convention in Sanya. Volvo was keen to emphasize that the facility complies with all VQE conditions and thereby ranks among the best in its sector. The location therefore qualifies as a supplier for the Volvo Car Group. Turbo Systems' second production site in China was established in 2014. Its manufacturing operations are highly automated and structured according to lean production principles. For its high energy efficiency – an important point for Volvo – the facility was awarded an LEED Gold Certificate (Leadership in Energy and Environmental Design). The first turbocharger range for Volvo was launched in Taicang at the start of 2015. Taicang currently supplies CVEP LP/MP/MP+ turbochargers to Volvo's Zhangjiakou location in China and exports VEP-LP turbochargers to Sweden. In May 2017, the facility also began turbocharger manufacturing operations for Volvo's GEP 1.5L program.



Yuan Xiaolin, President of Volvo Asia Pacific (left), during the presentation of the VQE Award to Ni Guangshan, head of BorgWarner Taicang.

A large powerhouse

Large pickups are extremely popular in the US. Vehicles of this kind require high-performance engines that guarantee traction in any situation. A good example of this is the new Duramax V8 turbodiesel from General Motors. BorgWarner supplies an advanced VTG turbocharger and innovative cold-start technology for this engine.

The unit has a displacement of 402 cubic inches (6.6 liters), maximum power output of 438 hp (327 kW) and maximum torque of 910 lb-ft (1,234 Nm). To put these numbers into perspective, the kind of performance you could expect to find in a heavy truck actually powers the heavyweights among the latest US pickups: the Chevrolet Silverado and the GMC Sierra, each available as a 2500HD and 3500HD version. HD stands for heavy duty in this instance. The new engine has absolutely no trouble living up to this name – at very low revs and with fuel consumption and emissions values that are significantly improved over its predecessor.

Power with precision

Close cooperation between the teams of developers at GMC and BorgWarner resulted in a turbodiesel unit that sets completely new standards for diesel engines in the heavy pickup segment. The new power diesel delivers 12 percent more power and 19 percent more torque – the latter of which is now available from just 1,600 rpm. This impressive engine performance is largely thanks to an electronically controlled VTG turbocharger (variable turbine geometry) from BorgWarner.

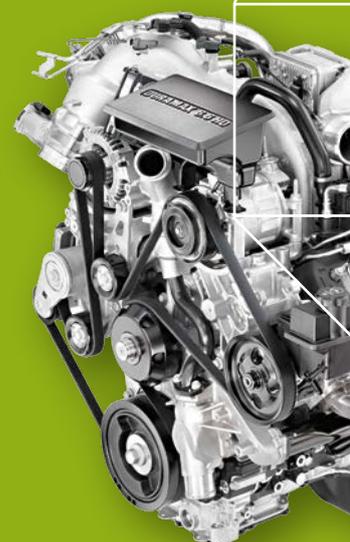
The system in question is a turbocharging system with newly developed impeller wheel and a new turbine vane design which has been dimensioned to handle exhaust gas temperatures of up to 820 °C. The electronic adjustment of the turbine vanes guarantees optimum matching of the exhaust gas stream to the respective operating point of the engine, which significantly improves the

response at low revs and the transient response. During braking, the turbine vanes are closed, thereby increasing the exhaust back pressure and allowing the engine to develop maximum braking force. Overall, the turbocharger was specifically developed to increase the power, control and durability of the drive when transporting and hauling heavy loads and thereby to optimize both efficiency and emission values. The new turbocharging system is produced at an ultra-modern manufacturing facility in Asheville, which has been set up to deliver maximum quality and efficiency while producing in large numbers.

Low cold-start emissions

The cold-start system from BorgWarner makes a contribution to reducing exhaust gas emissions. Even at outside temperatures as low as -29 °C, the ceramic glow plugs reach temperatures of up to 1,000 °C within two seconds. The control module of the glow plugs regulates the voltage separately for each individual glow plug, ensuring that the right temperature is available at all times, thus optimizing the combustion process. The turbodiesel warms up faster, burns less fuel and produces lower emissions.

Besides the turbocharging system and the cold-start technology for the new GM models, BorgWarner also supplies the electronically controlled fan drives for the Duramax engine and friction plates for the Allison 1000 automatic transmission. With the successful completion of the development projects for General Motors, BorgWarner was once again able to demonstrate its full-scope expertise in the drive sector.



Made to handle the rough stuff: the latest Chevrolet Silverado not only impresses with its overall dimensions, but also its very powerful drivetrain.



Gets things moving even from low revs: the VTG turbocharger from BorgWarner.





“BorgWarner is playing a key part in driving forward the mobility for today and tomorrow.”

BorgWarner has now been using its new external communication concept for several months. A lot has also happened within the company – especially in terms of product portfolio alignment. Frédéric Lissalde, President and General Manager at BorgWarner Turbo Systems, spoke to us about the new positioning in an interview.

What is BorgWarner’s core message? What are you trying to get across to the market and your customers?

Our new core message revolves around two key aspects. The first is our vision of a clean, energy-efficient world. The second is our claim of product leadership in the field of propulsion solutions. It makes absolutely no difference whether we are talking about vehicles with combustion engine, hybrid drive or electric motor: BorgWarner is playing a key part in driving forward the mobility of today and tomorrow. This is the reason why we develop propulsion solutions that significantly reduce both energy consumption and exhaust emissions. As product leader with more than 100 years of experience in the propulsion sector, we can provide OEM great support in developing more

environmentally friendly and economical technologies. This applies equally to passenger cars and commercial vehicles, and also the construction and agricultural machinery sectors.

In your opinion, is BorgWarner well equipped to handle the latest trends in the automotive sector?

The automotive industry is currently undergoing a change that is being heavily influenced by trends such as autonomous driving, connectivity and car sharing. Even in future, however, the most important job of a vehicle will still be to move people and products from point A to point B. This will require increasingly efficient propulsion. With our diverse product portfolio, we position ourselves as the preferred partner for our customers in developing solutions for clean combustion engines,

“We will supply the right drive systems, regardless of which drives the vehicles of the future employ.”



Combustion



Hybrid



Electric

and also hybrid and electric drives. We are well known for having one of the most comprehensive portfolios that covers all market requirements. It is important for us to repeatedly remind our investors and customers, yet also our own employees.

What was the reason for the repositioning?

We have recognized that our activities and the progress we have made in the hybrid and electric vehicle segment have not yet been properly understood by the market. Many people inside our company were also not aware of this fact. So we had to realign our communication concept to ensure awareness.

One of the most important trends in the automotive industry is electrification.

How can BorgWarner and, also BorgWarner Turbo Systems benefit from this?

At BorgWarner, we have always engaged in very close partnerships with our customers. So we are excellent at identifying trends right before they translate into actual growth. One example of this is our acquisition of Delco Remy. Our colleagues at Delco Remy complement our portfolio with starters, alternators and electrical motors. There are already promising examples of how we can offer our customers competitive advantages with products in this segment integrating electrical components and BorgWarner mechanical know-how. In the turbocharger business unit, we have our eLine, which includes the eBooster®, eTurbo and fuel cell air supply systems, and are supplementing our current portfolio. Electrification opens up a whole

host of new market opportunities for Turbo Systems.

What other technologies is BorgWarner Turbo Systems working on to meet changing market requirements?

We will launch new gasoline engine VTG turbochargers for mass production and the next generation of regulated two-stage turbocharging systems (R2S). The market launch of the first turbocharger with ball bearing technology for large-scale production is also happening now. This is a unique technology, offering our customers a robust NVH-optimized (noise, vibration, harshness) bearing system. We also introduced our first eBooster® range in December 2016. There is a lot more still to come from BorgWarner in this segment. We are engaged in continuous dialog with customers across the globe

and are developing solutions that are matched optimally to their specific requirements.

What role does Design for Value play in this context?

We launched the Design for Value initiative almost three years ago. Since this time, DfV has developed into a real success story that is applied throughout the entire company and within all

functional areas of our business. We have integrated DfV in our overall processes, we have focused on sharing best practices and are ensuring that our supply base can also generate benefits through participating into the DfV initiative. That way, we ensure sustainability of the initiative. We benefit greatly from the program and are achieving excellent results, which make us more effective day by day. DfV has therefore become an important

foundation for our competitiveness and supports us both in generating new business and securing the leading position in our sector. DfV will also soon be part of our DNA, just like product leadership and cost competitiveness.

Mr. Lissalde, many thanks for taking the time to talk with us today.

“We now offer absolutely pioneering products for all drive concepts.”



ELECTRIC DRIVE MOTOR

- High Voltage Permanent Magnet (PM) Machines



ELECTRIC DRIVE MODULE

- Integrated On-axis
- Integrated Off-axis
- Electric Park Lock



ELECTRIC BOOSTING TECHNOLOGIES

- eBooster® Electrically Driven Compressor
- eTurbos
- eTurbocompounds
- Organic Rankine Cycle Turbines/Pump-Expanders



BOOSTING TECHNOLOGIES

- Wastegate Turbochargers
- VTG Turbochargers
- R2S Turbocharging Systems

Ingenious powerhouse

Ingenium: this is the name of the advanced range of four-cylinder engines which Jaguar Land Rover has been manufacturing in line with the downsizing principle since 2015. A new 122 cubic inch (2.0 liter) turbodiesel is now available for the Range Rover Sport and Land Rover Discovery models. Thanks to the latest R2S® turbocharging from BorgWarner, this new engine combines high performance with low fuel consumption.

In the past, SUVs in the premium segment have traditionally been equipped with large-displacement 6-cylinder or 8-cylinder engines. With the Ingenium SD4 unit, Jaguar Land Rover is presenting an engine that delivers plenty of power in the sporty yet elegant Land Rover models from just four cylinders and a total displacement of just 122 cubic inches (2.0 liters).

The engine generates 237 hp (177 kW). The maximum torque of 369 lb-ft (500 Nm) is already available from 1,500 rpm. This performance is sufficient to catapult the over-two-ton Range Rover Sport from 0 to 60 mph in around 8 seconds. The top speed is 128 mph. Perhaps even more impressive than the performance is the economy achieved by the diesel SUV, which returns just under 38 mpg US (45 mpg UK).

R2S® supplies constant power

A regulated two-stage R2S® turbocharging system from BorgWarner is what makes this performance possible in the sophisticated turbodiesel unit. It comprises one latest-generation compact turbocharger with VTG technology (variable turbine geometry), as well as one larger B03 turbocharger, which are arranged in series.

The smaller, high-pressure turbocharger delivers immediate response from low engine speeds and establishes boost pressure particularly quickly thanks to its VTG mechanism. An electric actuator ensures optimum adjustment of the turbine vanes to the respective operating conditions here. As the engine speed increases, a turbine control flap increasingly

diverts the exhaust gas stream to the larger low-pressure turbocharger, which eventually takes on all of the work at higher revs.

Fuel economy and emissions both improved

The R2S® system delivers consistent high boost pressure throughout the entire rev band and thereby guarantees a powerful, dynamic and pleasurable driving experience. At the same time, it helps reduce fuel consumption and exhaust emissions significantly. With the new turbocharging system, BorgWarner is supporting Jaguar Land Rover in achieving ambitious targets with regard to performance, consumption and emissions.

Collaboration to be further expanded

The market launch of the new turbodiesel is the result of intensive collaboration between the developers at JLR and BorgWarner – which is currently being expanded on a large scale. BorgWarner will also be supplying the booster systems for the launch of JLR's new gasoline engines this year.

The R2S® turbocharging system for the new SD4 unit is manufactured by BorgWarner in Bradford, employing ultra-modern manufacturing systems that comply with the strictest quality standards. At the same time, the start of production marks the launch of high-volume passenger vehicle turbocharger manufacturing in Bradford. The facility has a highly motivated workforce, which is not only responsible for local sales and application development, but can now also offer local manufacturing for JLR.



Visibly dynamic: even with the compact turbodiesel under the hood, the Range Rover Sport truly lives up to its name

Massive power with impressively low consumption: the R2S[®] system from BorgWarner delivers consistent high boost pressure across a wide rev band.



Power-packed

The new units are two direct gasoline injection engines with displacement of 183 cubic inches (3.0 liters) and six cylinders. They are used in various vehicles in the VW Group, but perhaps most importantly in Audi's exclusive S and RS models. The combustion engines were designed from the outset for hybridization, allowing them to be combined with an electric drive. One particular challenge for the developers was to surpass the already excellent transient response of the predecessor generation with mechanical boosting, while at the same time improving both performance and fuel economy.

Pure power in two versions

The entry-level version is equipped with a high-performance Twin Scroll turbocharger with waste gate and delivers 349 hp (260 kW). The maximum torque of 369 lb-ft (500 Nm) is available from just 1,400 rpm. This performance is sufficient to catapult the approximately two-ton Audi SQ 5 from 0 to 60 mph in just over 5 seconds. Even with this impressive power delivery, the vehicle still delivers excellent standard fuel consumption of 28 mpg US (34 mpg UK) with premium grade gasoline.

The more powerful V6 BiTurbo version delivers 429 hp (320 kW). One BorgWarner turbocharger with waste gate is used on each bank of cylinders here. With maximum torque of 442 lb-ft (600 Nm), the drive provides almost limitless power in vehicles like the Audi RS 5, allowing this sporting yet elegant coupé to sprint from 0 to 60 mph in under 4 seconds. The power and torque available make the standard fuel consumption of 27 mpg US (32 mpg UK) even more impressive.

Efficient thanks to the latest turbo technology

The turbochargers replace the supercharger, which was fitted to the predecessor units. Despite the increased drive power requirements, the turbocharging technology from BorgWarner is capable of significantly improving both the torque and transient response of engines over the previous generation, while also reducing fuel consumption. This is an impressive achievement, as the existing engines with mechanical boost already displayed excellent characteristics in this regard.

Another special feature of the new engines is that the turbocharging systems are positioned between the cylinder heads, i.e. inside the engine's „V“. This places very strict requirements on the



*Elegant styling, sporting drive:
the S-models from Audi
offer pure driving pleasure.*

With their powerful sound and incredible power delivery, the VW Group's turbocharged V6 units have been some of the most popular engines for many years among drivers looking for excellent performance in combination with convenience and efficiency. With the new 3.0 TFSI engines developed by Audi, the Group is now presenting a new V6 generation that is equipped with the latest waste gate turbochargers from BorgWarner.

turbochargers used, which must be particularly compact yet also extremely heat-resistant. However, all of the development efforts are now paying off. Thanks to the favorable positioning, the developers were able to optimize the exhaust gas stream and minimize flow losses.

The advanced Twin Scroll technology from BorgWarner has already been proven in numerous applications and guarantees dynamic power delivery from very low revs. It improves the engine's transient response and makes its maximum torque available both quickly and across a very wide speed range. A clever channel design, optimized for efficient airflow using computer-aided simulations, ensures that the exhaust gas stream is fed to the turbine wheel with maximum efficiency on both the Twin Scroll turbocharger and the BiTurbo version.

New collaboration milestone

The new high-tech engines mark another milestone in the longstanding collaboration between Audi and BorgWarner. Employing the latest turbocharging technology, the turbocharger specialist is making a key contribution to further optimizing the performance, consumption and exhaust emissions of engines in the VW Group.



*Keeping up the pressure: the Twin
Scroll turbocharger and the BiTurbo
version from BorgWarner optimize
both the performance and consumption
of Audi's 3.0 TFSI engines.*

Quiet and smooth run

BorgWarner has developed its first turbocharger roller bearing system to series maturity. These new bearings considerably increase the efficiency of turbocharging systems, which in turn improves the response and fuel economy of the engine quite significantly. What's more, the innovative system also sets new standards for roller bearings with regard to NVH behavior.

Modern combustion engines have already reached a high level of efficiency. The challenge therefore becomes even greater when attempting to further optimize these units in terms of fuel economy, power output and reduced emissions. The developers at BorgWarner tackle this task by continuously increasing the efficiency of the turbocharging systems. The best example of this is the company's new roller bearings, which significantly reduce frictional losses over plain bearings of the same size. Further key criteria for the development included noise characteristics at plain bearing level, stable start-stop behavior - in particular in hybrid drive systems - and high resistance to solid and liquid impurities in the oil, also when used with biogenic fuels.

Complex design

Roller bearings offer benefits over plain bearings, particularly at low speeds. To control the rotor dynamics and noise characteristics, however, it is necessary for the outer ring of the ball bearing to be mounted as a „floating“ unit. The developers therefore equipped the system with cartridge-type angular-contact ball bearings. Balls made from silicon nitride, coupled with high-performance materials for the bearing rings, secure excellent system performance and robustness, as they also offer sufficient hardness reserves for the high limit temperatures encountered. Many other design optimizations served to improve the NVH

behavior (noise, vibration, harshness), as this has become a key criteria for the success of roller bearing technology in turbocharger applications.

Excellent efficiency

Comprehensive tests performed by BorgWarner clearly highlight the benefits of the new ball bearings over plain bearings. By way of direct comparison, friction is reduced by up to 50% when using cold oil at low speeds and still maintains a reduction of up to 40% at operating temperature. The friction of the ball bearings also increases more slowly than with plain bearings as the axial thrust and stage pressure ratio rise.

The complex design of the new roller bearing system increases turbocharger efficiency, which in turn has a positive effect on engine response. As boost pressure is built up more quickly at low engine speeds, this significantly improves

dynamic driving performance. The increased efficiency also improves fuel efficiency, while reducing CO2 emissions in the consumption-critical partial-throttle range by around 2%.

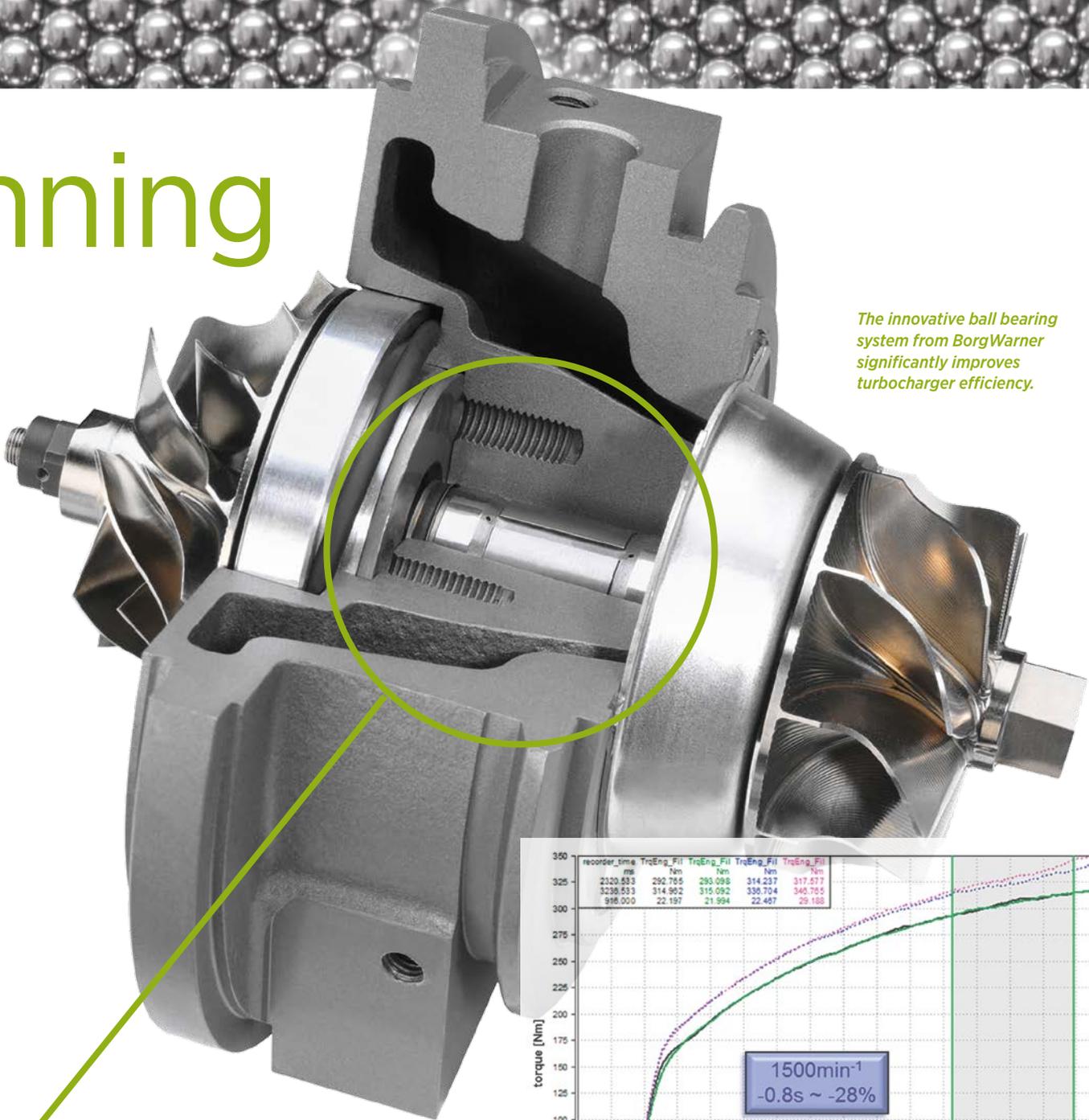
Robust and low-noise

High speeds, dynamic load changes, fast temperature changes, external vibrations, as well as liquid and solid impurities in lubricants are the main causes of wear to bearings in turbochargers. The developers from BorgWarner performed tough tests to assess the robustness of the new roller bearing system. During these tests, turbochargers were subjected to high loads and operated with 200-times the typical amount of filterable, hard impurities. The new ball bearings remained operable, while the thrust bearing of a reference turbocharger with plain bearings was no longer functional following the test. An accelerated endurance test developed in-house that uses the hot chamber and engine test bays, as well as a



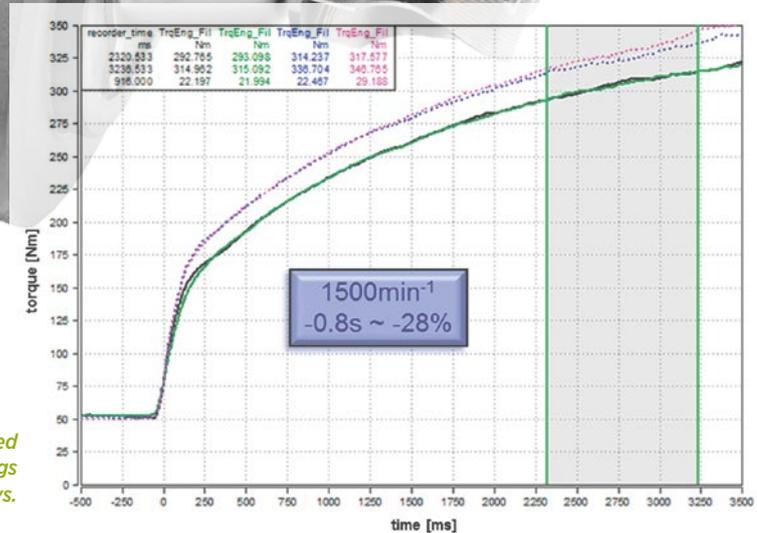
The outer ball bearing ring is floating, so that it can handle rotor dynamics, while maintaining excellent noise characteristics.

nning



The innovative ball bearing system from BorgWarner significantly improves turbocharger efficiency.

In comparison with a turbocharger fitted with plain bearings, the new ball bearings deliver increased torque from very low revs.



vibration endurance test also confirmed the robustness of the new system. Since one of the objectives when developing the new ball bearing technology was to deliver excellent NVH behavior, a whole series of vehicle and endurance tests was then performed. During this testing, it became clear that the new system offers a very low noise level, which was also subsequently confirmed by customers.

Ready for series production start

With the new roller bearings, BorgWarner is offering a high-performance, robust and low-noise solution which is more than capable of meeting the strict requirements of both current and future applications. The advanced technology increases the efficiency of the turbocharger by 4% and thereby contributes to a significantly

improved response behavior. At the same time, the system reduces CO2 emissions by up to 2%. The innovative bearings will soon be available for use in all passenger vehicle sizes.

Compact. Powerful. Economical.

127 hp (95 kW) and 147 lb-ft (200 Nm) of torque – these are the kind of figures you might expect to see from a powerful compact four-cylinder engine. In reality, they come from Honda's latest three-cylinder gasoline engine with displacement of just 61 cubic inches (1.0 liter). This compact powerhouse generates its impressive performance using the latest turbocharging technology from BorgWarner.



Small and extremely small turbocharged engines are in great demand. More and more manufacturers are investing in these mini drives – whether for small cars, the compact class or mid-range models. Manufacturers like Honda are thereby demonstrating that small engines can also offer great driving pleasure – while also delivering impressive fuel consumption and low exhaust emissions.

High power density

With its new 61 cubic inch (1.0 liter) unit, Honda is presenting a direct injection gasoline engine with three cylinders and turbocharging that sets itself apart thanks to its extremely high power density. The turbocharging system used is a particularly compact B01 turbocharger with wastegate from BorgWarner. The turbo significantly improves the engine's power output, response, fuel efficiency and exhaust emission values. In the Honda Civic, this leads to standard fuel

consumption of 49 mpg US (59 mpg UK) and CO2 emissions of just 110 grams per kilometer. The tiny engine powers the Civic from 0-60 mph in around 10 seconds and allows the vehicle to reach a top speed of 126 mph. The maximum torque of 200 Nm is already available from just 1,500 rpm.

Turbo with extras

The BorgWarner turbocharger used displays several special characteristics. It has an NVH-optimized design (noise, vibration, harshness), allows the use of low-viscosity oil and is produced from materials capable of resisting exhaust gas temperatures of up to 950 °C. The low-inertia impeller wheel delivers snappy response from very low revs, reaching a speed of up to 285,000 rpm, and significantly expands the turbocharging system's performance range. For optimum control of the exhaust gas stream based on the engine state, the turbo is also equipped with an electrical wastegate actuator, which reduces boost pressure at higher exhaust gas rates.

First global development project

The innovative turbocharging system was created in the first joint global development project undertaken by Honda and BorgWarner. With the goal of providing customers with the best possible support directly on site, BorgWarner's Yokohama office in Japan was responsible for providing customer service. It was here that the long-planned prototype shop, equipped with the latest technology, was opened in February 2016. This represents an important milestone for the location, as it allows BorgWarner to assemble turbocharger prototypes directly in Japan for the first time – from initial performance samples through to series maturity – and evaluate them on the basis of endurance tests. The turbocharger for Honda's new 61 cubic inch (1.0 liter) engine is produced in Ningbo, China. The small turbocharged gasoline engine will be used in numerous Honda models worldwide.

Modernized across the board: the new Honda Civic was developed to European standards for worldwide sales.



Impressive: the B01 wastegate turbocharger from BorgWarner generates 127 hp (95 kW) from its tiny 61 cubic inch (1 liter) displacement.



The turbocharger for Honda's new 61 cubic inch (1.0 liter) engine is produced in Ningbo, China.

Training the staff of the future

An investment in knowledge gives the best returns. It is with this conviction that BorgWarner has been training young people in a wide range of careers in Kirchheimbolanden since 1961. More than 600 trainees have now started their career here and over 350 of them still work at the facility to this day.

The Kirchheimbolanden site operates its own training department and consistently provides internal training for its specialist personnel. Besides the three technical careers of Cutting Machine Operator, Production Mechanic and Mechatronics Engineer, in which 16 applicants gain places each year, the facility also trains two Industrial Clerks each year. An average of around 60 technical and six commercial trainees are employed in Kirchheimbolanden per year. In addition to this, every year eight further young professionals get the opportunity to complete a dual study program to qualify as Industrial Engineers, Mechanical Engineers or Electrical Engineers.

Training continuously modernized

As the requirements of professionals are constantly changing, the training courses are continually updated and aligned with the needs of the company. The type of training has also undergone pronounced change. While in the past training focused

on specific content, the trainers today see themselves more as learning guides and supporters. Where manual skills used to be the key factor, modern operations require complex automation systems to be set up, processes to be controlled, system faults to be detected and solutions to be developed.

Beside three full-time trainers, trainees also have access to virtual learning environments with networked technology in

At BorgWarner, the trainees have an excellent opportunity to prepare themselves for their later career.

the training center. The young professionals spend almost half of their working hours in Production and accompanying departments, helping them deepen and extend their freshly acquired knowledge. This gives them an excellent opportunity to

prepare themselves for their later career. They are also supported by around 50 employees, who act as training officers.

The importance of personal responsibility

The facility has also had a special training island in place since 1999. The young professionals work on orders independently here and have to overcome various challenges, for example with regard to quality and delivery date. They also engage in productive teamwork. Further training topics include control technology, robotics, PLCs and CNC.

The training offered in Kirchheimbolanden is therefore very demanding. The facility continuously invests in the latest production technologies and concepts, such as the recent solutions for Industry 4.0. This requires a constant flow of qualified junior staff with new expertise, which is derived from the facility itself.



A strong team: the trainers and junior staff at BorgWarner in Kirchheimbolanden.