

TurboNews

1/09 Issue

The Info Magazine of BorgWarner Turbo & Emissions Systems

Super sports car

WITH THE NEW FOCUS RS, FORD PRESENTS A NEW SPORTS CAR
IN KEEPING WITH THE RICH RS TRADITION



Power plus environmental protection

BorgWarner supplies VTG turbochargers to John Deere

Gas-powered turbos

Opel and Volkswagen with turbo-charged natural gas engines

Technology in action

The "ring°werk" at the Nürburgring shows turbos from BorgWarner

Efficiency is the key

Dear Readers,

Whether compact or medium-sized vehicles, luxurious sedans or thoroughbred sports cars – efficient use of fuel today plays a central role in the development of new engines. And we can observe two different approaches emerging here.

Many manufacturers are employing “downsizing” and developing ever smaller engines with higher power density. The turbocharger is an integral part of this strategy, as it allows compact units to achieve the performance characteristics of larger engines while significantly reducing fuel consumption. Some excellent examples of this include Renault's 1.4 16V TCE and K9K engines, which we report on in this edition of TurboNews. The K9K is the world's first engine to employ a 4th generation VTG turbocharger.

Yet downsizing is not only limited to small displacement engines. It also works with high-performance units. Innovative turbocharging systems also form the key technology here, with which entirely new levels of dynamic performance can be tapped while maintaining moderate fuel consumption. With the Volvo D5, Audi TT RS and Ford Focus RS we also present several interesting examples of this here.

Efficiency is also the keyword in our articles on the VW Passat 1.4 TSI Ecofuel and the Opel Zafira ecoFlex Turbo, which combine natural gas with turbochargers – and on BorgWarner's Bradford site, which was able to significantly increase its productivity using a TPM system. In addition to these fascinating reports, you can also read about other exciting topics such as the “test°center” at the Nürburgring or news from our facilities in Campinas, Bradford, Pyongtaek and the new manufacturing facility in Rzeszów, Poland.

Best regards,

The editorial team

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BorgWarner opens manufacturing facility in Rzeszów

Campinas supports school projects for children

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BorgWarner and BERU present themselves at Automec 2009

BorgWarner gets involved in the Action Museum at the Nürburgring

Quo vadis, automobile?

Alongside the financial and economic crisis, which has caused an unprecedented global collapse in the automotive business, the central topic in the automotive industry remains the lasting reduction of fuel consumption and CO₂ emissions. Reading articles in the press, it is easy to get the impression that the internal combustion engine's glorious era is soon to come to an end, heralding the beginning of the reign of the electric vehicle. However, if we look at the facts with the necessary realism, the only real conclusion to be drawn is that the internal combustion engine will remain the dominant form of drive in 10 to 15 years, despite the fact that electric vehicles and battery technologies are making progress. If we look at the global figures, electric vehicles will only have achieved a small market share by this time and not have emerged from the niche market. Hybrid drives, on the other hand, will significantly increase their market share, whereby the micro-hybrid and mild-hybrid versions are likely to take the lion's share of this business. Yet even these new drive versions will rely on further-developed, highly efficient internal combustion engines.

A key technology for further improving the efficiency of diesel and gasoline engines lies in downsizing – i.e. reducing engine displacement while simultaneously increasing power density by using boosting technology. We are on the verge of witnessing a real triumph of turbocharged engines here, in particular gasoline engines, which will be significantly more fuel efficient and offer at least the same level of driving pleasure as larger displacement drives. And the end is also not even close to being reached in the development of diesel engines. In this edition of TurboNews you can learn about the kind of contribution BorgWarner is making to lowering fuel consumption without sacrificing driving pleasure. The 4th generation of

our VTG range of BV turbochargers, for example, represents significant progress in terms of efficiency and controllability, and will open up new opportunities for engine developers. Our regulated, two-stage turbocharging technology is also allowing more and more BorgWarner customers to launch high-performance, low-consumption diesel engines in the market. In the gasoline engine sector, we can demonstrate our downsizing expertise with the optimized KP39 for the Renault 1.4 I Turbo. And thanks to its BorgWarner turbocharger, the high performance 5-cylinder unit from Audi proves that sports car performance and efficiency are not mutually exclusive. Added to these success stories are the first turbocharged natural gas engines, which rely on our broad know-how and our tried and tested K0 turbocharger range.

These are challenging times – not only due to the economic crisis, but also the ever increasing technological demands and expectations of customers. Yet despite all the hurdles we face, BorgWarner will continue to help shape the future of the internal combustion engine with innovative solutions.



Ulli Fröhn, Vice President
Sales & Marketing Passenger Cars
at BorgWarner Turbo & Emissions Systems.



WITH THE NEW FOCUS RS, FORD PRESENTS A NEW SPORTS CAR
IN KEEPING WITH THE RICH RS TRADITION

Super sp

The 40-year history of the sporty RS models from Ford has reached a new high. Some six years after production of its limited edition predecessor was ceased, the new 2nd generation Ford Focus RS is ready to tear up the asphalt. Equipped with a BorgWarner K16 turbocharger, the Focus generates peak power of just over 300 bhp. This makes the high-performance vehicle the most powerful model ever to have left Ford's production line in Europe.

Whether Escort RS 1600 or RS 2000, Ford Capri RS or Sierra RS Cosworth – for around 40 years, the abbreviation RS has stood for breathtaking performance and amazing wins across all

racing and rally circuits in the world. And with the new Focus RS, Ford is now presenting a worthy successor to the long line of RS ancestors which sets new standards in terms of performance and driving dynamics.

Aggressive styling

From the very first glance, it is clear that the Focus RS has been trimmed without compromise for sports driving. The Ultimate Green paintwork and the "Ford Kinetic Design" with a huge air intake and the air conveying element at the rear give a clear indication that this is an ultimate high-performance vehicle.



Green and envied! From the first glance, the styling of the Focus RS conveys a sense of aggressive sportiness.

orts car

Incredible torque

At the heart of the Focus RS sits a 2.5 liter (153 cubic inch) Duratec turbocharged engine, which allows the Ford to easily keep up with significantly more exotic competitors – whether on the daily commute or closed racing circuits, such as the legendary 20.8 kilometers (12.9 miles) of the Nürburgring's Nordschleife.

The five-cylinder unit generates maximum power of just over 300 bhp at 6,500 rpm from a displacement of just 2.5 liters (153 cubic inches). Perhaps even more impressive is its torque, which reaches an amazing flat line peak of 440 Nm (325 lb-ft) between 2,300 and 4,500 rpm. With performance figures of this magnitude, the Focus RS accelerates from 0–62 mph in just 5.9 seconds and reaches a top speed of 163 mph.

When developing the engine, the engineers' goal was to significantly increase the delivery of both power and torque – without compromising the engine's durability and service life. Comprehensive measures and modifications to the internal workings of the engine were needed to meet these ambitious targets. These included a modified cylinder head gasket, a special coating for the cylinder walls to offer greater stability, reworked

valves, and the particularly precisely shaped profile of the camshafts and piston rods, which employ larger bearings at the upper end.

A turbo for extremes

The most distinctive modifications affect the air intake system, the exhaust manifold and the K16 turbocharger from BorgWarner Turbo & Emissions Systems. With a maximum boost pressure of 1.4 bar, the unit provides twice the boost of the model used in the Ford Focus ST (0.7 bar) and allows a power increase of 35%. To ensure spontaneous response of the engine, even from very low revs, the turbocharger had to be optimally dimensioned and integrated in the exhaust manifold, while flow losses also had to be reduced on both the intake and exhaust side.

Thanks to its optimized intake side with minimized frictional losses, the turbocharged engine in the Focus RS can breathe particularly freely. It also benefits from a newly developed airbox with twin intake and cylindrical air filters, which operate with low air resistance. The supply and exhaust lines of the turbocharger and the generously proportioned, incredibly effective charge cooler also display extraordinary efficiency. Developed specifically for the new RS, the cooler lowers the temper-

ature of the intake mixture from 160°C to a maximum of 60°C. The key advantage here is that the cooler air increases the efficiency and thereby also the performance of the engine.

Further special technological features fitted to the RS include the complex sports exhaust with integrated catalytic converter, which helps the vehicle meet the latest emissions standards and improves the exhaust gas stream while simultaneously reducing the exhaust gas back pressure.

Top fuel consumption performance

Despite its immense engine output, the Focus RS uses only 9.4 liters of 98 octane gasoline per 100 km (25 mpg US, 30 mpg UK). It therefore ranks as one of the most economical models in the engine class above 300 bhp. The CO₂ emissions are also limited to just 225g per km (0.79 lb per mile).

Following successful cooperation on the Ford Focus ST (see TurboNews 2/05), the developers at Ford and BorgWarner have once again created an engine with impressive performance figures. And despite comparable fuel consumption figures, the power unit in the Focus RS impresses with noticeably more power and an even more dynamic driving experience.

BORGWARNER PROVIDES VTG TURBOCHARGERS FOR POWERTECH PLUS™ DIESEL ENGINES FROM JOHN DEERE

Power plus enviro

The US agricultural and construction equipment manufacturer John Deere relies on turbochargers with variable turbine geometry from BorgWarner in getting its engines fit for ever stricter emissions standards. The turbocharged PowerTech Plus™ diesel engines are to be fitted in agricultural and construction machinery, in machines for forestry applications and in OEM applications.

The background to the collaboration between John Deere and BorgWarner Turbo & Emissions Systems includes the new Interim Tier 4/Stage III B emissions standard for “off-highway applications”. This new standard stipulates 50 % lower nitrogen oxide emissions than former standards. The booster technologies from BorgWarner will help ensure that John Deere equipment can meet the new standard.

Many years of successful cooperation

“BorgWarner VTG turbochargers are the first to prove their reliability under the extreme conditions of off-highway applications, while meeting next-level emissions standards and achieving best-in-class fuel economy”, explains Roger Wood, President of BorgWarner Turbo & Emissions Systems. “We are pleased to work with John Deere to develop solutions for InterimTier 4 emissions standards.” Indeed, the collaboration between John Deere and the turbocharger specialist started back with the development of Tier 3 compliant engines. The two companies are now keen to set new standards in the off-highway segment with the use of the cooled exhaust gas recirculation (EGR) and VTG turbocharger technology.

With cooled exhaust gas recirculation, the exhaust gases are initially cooled and then fed back to the fresh air feed to reduce the amount of nitrogen oxide. Compared to the turbocharging systems

of other manufacturers, BorgWarner’s VTG turbochargers offer more accurate control of the exhaust gas recirculation. Precise opening and closing of the turbine vanes allows the exhaust gas pressure and inlet pressure to be optimally balanced.

With the start of the development of Interim Tier 4-compliant engines, all VTG BorgWarner turbochargers are now also being equipped with the compact brushless actuator that is specifically designed for use in highly stressed turbochargers and EGR valves.

John Deere tractor sets new records

The VTG technology from BorgWarner has already allowed John Deere Power Systems to significantly reduce fuel consumption over Tier 2/Stage II engines – even in the toughest of operating conditions. A good example of this is the PowerTech Plus™ 9.0L engine, which employs a BorgWarner S300V VTG turbocharger. Equipped with this high-tech engine, the John Deere 8430 Tractor was able to achieve an 8.8 % improvement in diesel economy, making it the most fuel efficient row crop tractor ever tested by the famous Nebraska Tractor Test Laboratory.

Economical and reliable

BorgWarner not only focuses on fuel consumption and exhaust emissions when developing its turbochargers and



exhaust gas recirculation systems. The turbocharger specialist’s commercial vehicle turbochargers with VTG technology are uncompromising designs geared to handling extreme environmental and operating conditions in tough off-highway applications and also offer

Environmental protection



The John Deere 8430 Tractor with BorgWarner VTG turbocharger has been awarded the title "Best Row Crop Tractor" by the Nebraska Tractor Test Laboratory for its high performance and low fuel consumption.

the excellent reliability that customers in the commercial vehicle segment demand. We can all look forward to hearing which new records the coming generations of John Deere engines will break with regard to performance, efficiency and reliability.

AUDI TT RS WITH TURBOCHARGER HARKS BACK TO THE TRADITION OF THE ORIGINAL QUATTRO

Welcome back qu

The massive potential that lies in the combination of turbocharging and all-wheel drive was first tapped back in the 80s. Alongside countless individual victories from 1981 to 1985, the Audi quattro also secured two manufacturer and driver world championship titles. With the new 2.5 liter TFSI engine, Audi opens a new chapter in its rich history of five-cylinder turbocharged engines. In a joint venture with quattro GmbH, the auto manufacturer developed a high-performance power unit that tops the range in the TT RS.

Fulminant performance

The high-tech engine generates a massive 450 Nm (332 lb-ft) of torque. This is a truly outstanding figure, made even more impressive by the fact that this maximum torque is available constantly over a range from 1,600 to 5,300 rpm. As such, the TT Coupé is catapulted from 0-62 mph in just 4.6 seconds, with the roadster taking just one tenth of a second longer. The specific output is 100.8 kW (137 bhp) per liter of displacement.

This astounding performance is made possible by combining gasoline direct injection with an exhaust gas turbo-

charger from BorgWarner, who also supplies the entire camshaft drive system alongside the turbocharging system. The efficiency of this engine technology is also reflected in the fuel consumption. The transversely mounted five-cylinder engine in the TT RS Coupé delivers impressive consumption figures of just 9.2 liters per 100 km (25.6 mpg US/30.7 mpg UK), while the Roadster consumes just slightly more at 9.5 liters per 100 km (24.8 mpg US/29.7 mpg UK).

A real challenge for the developers

The special geometry and the need to keep component weight as low as possible placed great demands on the forming and casting technology at BorgWarner. The cast steel manifold of the exhaust gas turbocharger is attached to the cylinder head using the clamping flange technique tested at Audi. Using this approach allows the turbocharging system to compensate for the thermal expansion that occurs. The K16 turbocharger is fitted with a relatively large impeller wheel and offers a high degree of efficiency over a wide operating range. Under full load, the turbocharger can theoretically compress 335 liters of air per second with a relative boost pressure of up to 1.2 bar.

The turbocharger has a separate oil supply and is cooled by a dedicated water pump. Under full load, the charge air cooler lowers the temperature of the compressed air and ensures efficiency of more than 80 percent. To guarantee the necessary boost at low revs, sufficient turbine power is always available – even with minimal exhaust gas flow. The specialists from Kirchheimbolanden achieved the best possible utilization of the output pulse onto the turbine wheel by adjusting the cross

sections of the manifold and turbine. In conjunction with Audi's efficient combustion process, the turbocharging system guarantees a consistently high average pressure level with excellent thermodynamic characteristics in the mid rev band. The engineers at BorgWarner also adjusted the two-stage camshaft drive system to the chain forces of the turbocharged engine, which are higher than in a normally aspirated engine. As such, the system guarantees non-wearing and low-noise operation.

Consistent utilization of turbocharging technology, direct injection, inlet and outlet camshaft adjustment, as well as careful matching of the infeed and output side, allowed an extraordinarily responsive high-performance engine to be created. When coupled to the permanent all-wheel drive system, this makes the compact Audi TT RS a superlative sports car.

Vorsprung durch turbo

Audi already got together with BorgWarner to break new ground in the sports car segment with the four-cylinder diesel engine in the TT 2.0 TDI (see TurboNews 1/08). This 170 bhp power unit employs a 3rd generation BV43 exhaust gas turbocharger with variable turbine geometry, which allows torque to be significantly improved. With impressive fuel consumption of 5.5 liters of diesel per 100 km (42.8 mpg US/51.3 mpg UK), the engine easily meets the requirements of the Euro5 standard.

And the 272 bhp 2.0 TFSI engine in the TTS also benefits from an advanced BorgWarner turbocharging system. The K04 turbo with waste gate is equipped with a pulse muffler and milled impeller wheel. It is also used by Audi in the S3.



The K16 turbocharger generates 450 Nm (332 lb-ft) of torque from just 2.5 liters (153 cubic inches) of displacement in the new TFSI engine.

attro!

Some 30 years after the premiere of the original quattro in Geneva, Audi is once again presenting a thoroughbred sports car with turbocharged inline five cylinder engine and all-wheel drive: The Audi TT RS. At the heart of the most powerful TT sits an entirely new 2.5 liter (153 cubic inch) power unit that generates 250 kW (340 bhp), has an excellent torque curve and weighs in at just 183 kg (just over 400 lb).



Sporty design, immense power: The Audi TT RS with BorgWarner turbocharger.

BORGWARNER DEVELOPS 4TH GENERATION VTG TURBOCHARGER

Next generation turbo

Exhaust gas turbocharging is a key technology for lowering fuel consumption and emissions in internal combustion engines. Turbocharger specialist BorgWarner Turbo & Emissions Systems therefore works continuously on further improving its technologies. And the company is now presenting its latest generation of turbochargers with variable turbine geometry (VTG) for use in diesel engines.



The latest VTG generation from BorgWarner is characterized by its innovative S-vane design.

BorgWarner has been using variable turbine geometry for many years, in particular to optimize the response of turbocharged diesel units while also reducing fuel consumption and emissions values. VTG turbochargers employ adjustable turbine vanes which are arranged in a circle around the turbine wheel on a vane ring. This system allows the boost pressure to be adjusted flexibly to the engine speed. By varying the angle of the rotating vanes using an adjusting ring, the cross section exposed to exhaust gas flow can be adjusted based on the amount of boost pressure required. At low revs the cross section is smaller, and it then increases at high revs – offering optimum back pressure of the exhaust gas.

Optimized design, optimized materials

In developing the latest BV generation, the engineers at BorgWarner in Kirchheimbolanden were faced with the task of fulfilling the even stricter requirements of VTG turbochargers for future

engines – without sacrificing the well-respected key features of the 3rd generation units. This meant finding ways of further improving the thermodynamics, response and controllability while also lowering costs without compromising reliability.



Unlike the previous generation, whose turbine vanes were straight in shape, the engineers employed a patented S-vane design for the new 4th generation VTG units. These vanes are curved at both ends, with each end cambered in the opposite direction to its counterpart. This is what gives the vanes their characteristic S shape. The S shape offers both improved thermodynamics and controllability. Due to the innovative design, the turbine vanes open independently at a certain angle (specified by the actuator) when needed using the force of the exhaust gas. The new VTG turbocharger is designed for use with both pneumatic and electrical actuators, depending on the requirements of the engine manufacturer. The new VTG generation significantly improves the response of the engine and increases efficiency in the low rev band. This allows auto manufacturers to develop engines which offer greater driving pleasure and improved consumption figures and environmental friendliness.

Another new feature compared to the previous generation is the use of wear-optimized and heat-resistant materials.

BorgWarner thereby guarantees that the turbochargers offer both durability and reliability in the face of ever-increasing power density.

First series application

The first engine to be mass produced with a 4th generation VTG turbocharger is Renault's 1.5 liter (91.5 cubic inch) displacement K9K diesel engine. Since what is currently Renault's smallest turbodiesel was launched in 2000 as an EU3 version, BorgWarner Turbo & Emissions Systems has been the sole supplier of all the respective turbocharging systems. Following the EU4 version, which celebrated its premiere in 2008 in the Renault Laguna (see TurboNews 1/08), the engine is now being produced as the K9K EU5 unit.

The improvements in the 1.5 dCi unit in terms of fuel consumption, environmental friendliness and dynamics are thanks to a BorgWarner BV39 turbocharger with 4th generation VTG. The 109 bhp turbodiesel generates its maximum torque of 240 Nm (177 lb-ft) from just 1,750 rpm and consumes a mere 4.6 liters of diesel per 100 km in the Mégane (51 mpg US, 61 mpg UK). At the same time the engine, which is manufactured in the Spanish city of Valladolid, emits only 120g of CO₂ per km (0.42 lb per mile) and complies with the Euro5 emissions standard.

Other auto manufacturers are also currently developing engines with the latest generation of VTG turbochargers. Further series applications are set to follow later in the year.

BORGWARNER AND BERU PRESENT THEMSELVES AT AUTOMECC 2009

Let's get ignited!

This year's Automecc, held in São Paulo, Brazil, in April, focused on spare parts, accessories and services in and around the passenger vehicle and light commercial vehicle sectors. BorgWarner's Campinas site presented itself together with BERU for the first time at the trade fair. The specialist in ignition technology, diesel cold start technology, electronics and sensor technology is also part of BorgWarner.

As the most important automotive fair in the southern hemisphere, Automecc attracts suppliers from across the globe every year. This year, some 968 Brazilian companies and 426 exhibitors from 23 other countries showcased their products and services in the 50,000 square meter (538,200 square foot) exhibition area.

An important highlight at Automecc for many visitors was an introduction to the innovative products from BERU in Brazil, which are to be marketed by BorgWarner in future. The presentation was organized by Aftermarket Sales Manager David Patrício, the Brazilian Aftermarket Sales Team and Thorsten Irion, BERU's Sales Manager. Both the press and the public showed great interest in BERU's leading technologies in and around the field of ignition and cold starts. The turbochargers from Turbo & Emissions Systems and the fan systems of Thermal Systems also enjoyed a high level of interest among the visitors.



BorgWarner's Aftermarket Sales Team.

The South American customers also took the opportunity to meet with General Manager Arnaldo Iezzi Jr., hold personal discussions with Global

Aftermarket Director Sergio Veinert, and chat with Dirk Polte, Thom Miles and Dave Kirkley from the Independent Distribution Service.



OPEL AND VOLKSWAGEN OFFER TURBOCHARGED NATURAL GAS ENGINES

Gas-powered

With the Passat TSI EcoFuel and the Zafira ecoFlex Turbo, Volkswagen and Opel are demonstrating that it is possible to combine environmental friendliness and driving pleasure. Both the 1.6 liter (98 cubic inch) engine from Opel and the 1.4 liter (85 cubic inch) engine from Volkswagen impress with excellent performance and low running costs. Both units employ tried and tested BorgWarner K03 turbochargers, which only had to be adapted minimally to run on natural gas.



The engine in the Zafira CNG is extremely quiet and impresses with fuel costs of around € 5 per 100 km (under 10p per mile UK and 12 cents per mile US).

Natural gas gaining in popularity

Just under eight million vehicles worldwide are today equipped with engines that can run on CNG (compressed natural gas). And this figure is set to increase, as natural gas is not only more economical, but also better for the environment than conventional fuels. Natural gas engines produce 70% less nitrogen oxide than diesel engines and 25% less CO₂ than gasoline engines. Another advantage is that the exhaust

gases contain virtually no soot particles. With 130 octane, natural gas also offers significantly better anti-knock properties than conventional gasoline and is particularly suitable for boosting with a high compression ratio. As such, turbocharged natural gas drives not only overcome their previous performance disadvantage compared to gasoline engines, caused by the lower degree of combustion, but also offer impressive performance at low revs and under heavy loads.

Attractive alternative

With their turbocharged natural gas engines, Volkswagen and Opel are now offering their customers particularly attractive alternatives to traditional engines with power output of 110 kW (150 bhp). On both units, the mix is formed in CNG mode through port fuel injection. While the TSI engine from Volkswagen is set up as a dual-fuel system in the Passat and will also be available in the Touran from mid 2009,

d turbos

the gasoline mode in the Opel unit with its 14 liter tank is designed purely as an emergency backup.

Opel: Focus on natural gas operation

The turbocharged 1.6 liter (98 cubic inch) four-cylinder engine in the Zafira consumes a mere 5.1 kg of natural gas per 100 km (0.18 lb per mile). As such, it gives the Opel a range of up to 250 miles in natural gas mode, which is extended by the 14 liter (3 US gallon) reserve gasoline tank. And the maximum torque of 210 Nm (155 lb-ft), which is available constantly from 2,300 to 5,000 rpm, ensures powerful pickup. To save weight and guarantee fast response of the turbocharging system, Opel got together with BorgWarner to optimize the water-cooled K03 turbocharger. The turbocharger casing has been integrated in the cast outlet manifold and impresses with its improved flow geometry and extended service life. The results of these measures mean that the engine is just 15 kg heavier than the normally aspirated version.

Passat: Impressive torque, low fuel consumption

The EcoFuel version in the Passat is the world's first turbocharged direct injection engine developed for natural gas operation. It is based on the 1.4 TSI Twincharger from Volkswagen with twin boost from both a supercharger and a turbocharger. This meant that various modifications to the engine technology were necessary. Due to the high pressures involved, the valves, piston rings and pistons themselves had to be additionally strengthened. The engine also employs a K03 BorgWarner turbochar-

ger, which has been fitted with a smaller impeller to allow higher boost pressure in natural gas operation. An air choke regulates the air mass that the turbocharger requires based on the respective operating point of the engine. Above 3,500 rpm, the supercharger is then deactivated and the turbocharger generates the entire boost pressure by itself. However, at the same boost pressure the level of air supplied is lower in natural gas operation, as the natural gas displaces a portion of the air when being blown into the intake. The boost pressure must therefore be increased to achieve the same torque as gasoline powered operation. Thanks to the smaller impeller on the turbocharger, BorgWarner was able to achieve 0.25 bar greater boost pressure in CNG mode, meaning that the engine generates an identical torque curve as in gasoline powered operation. The TSI EcoFuel generates torque of 220 Nm

(162 lb-ft) in the Passat variant. This torque is available continuously across a rev band from 1,500 to 4,800 rpm. The turbocharged direct injection engine in the Passat, modified for natural gas operation, also offers impressive consumption figures of just 4.5 kg of natural gas per 100 km (0.16 lb per mile).

Added value from exhaust gas turbocharging

With their innovative CNG engine concepts, Opel and Volkswagen have not only demonstrated what is possible with natural gas, but also that exhaust gas turbocharging has not even come close to exploiting its full potential. The technologies of BorgWarner are also making a decisive contribution to significantly improving the performance characteristics of alternative drives, while reducing both their fuel consumption and exhaust emissions.

The Passat TSI EcoFuel offers an impressive range of over 550 miles and generates only around 120 g of CO₂ per km (0.42 lb per mile).



VOLVO'S FIVE-CYLINDER DIESEL ENGINE COMBINES
DRIVING PLEASURE WITH ENERGY EFFICIENCY

Clean performance!

The Swedish auto manufacturer Volvo has been setting standards in the field of safety for years. And with the new D5 five-cylinder diesel engine, the manufacturer is now also assuming a leading position in the market in terms of driving pleasure and energy efficiency. The secret of the ultra-modern diesel's success is the R2S two-stage turbocharging system from BorgWarner.

The S80 is Volvo's top model. The discerning buyers in this vehicle class today expect extremely smooth running and dynamic driving performance – coupled with the lowest possible fuel consumption. In developing the new D5 engine, the main focus of the engineers was therefore not on increasing specific output. Instead, the developers concentrated on significantly improving

the delivery of power available while simultaneously lowering fuel consumption and emissions. Exhaust gas turbocharging was a key technology here.

Economical thanks to R2S

With the ambitious D5 development project, Volvo relied on the experience and know-how of BorgWarner Turbo &

Emissions Systems. The turbocharger specialist contributed its regulated two-stage boosting system (R2S) to the five-cylinder diesel engine. This consists of two turbochargers arranged in series which provide consistently high boost pressure. The result of the close collaboration between Volvo and BorgWarner is an agile and efficient diesel unit with maximum torque of 420 Nm (309 lb-ft)



The new D5 turbodiesel fits in perfectly with the dynamic styling of the Volvo S80.

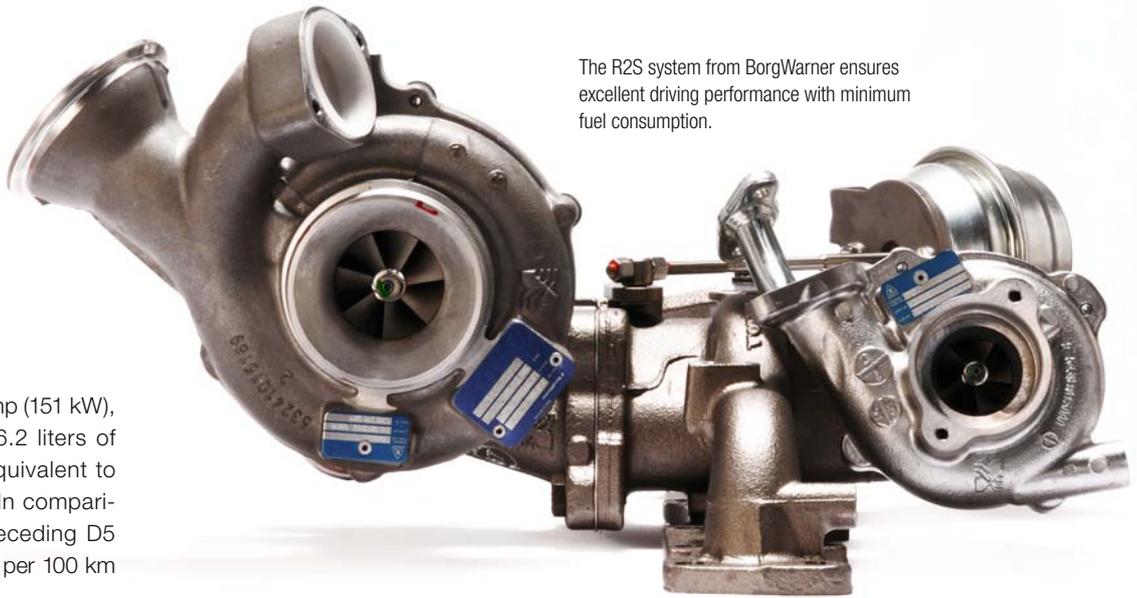
and power output of 205 bhp (151 kW), which consumes merely 6.2 liters of diesel fuel per 100 km (equivalent to 38 mpg US/45 mpg UK). In comparison, the less powerful preceding D5 generation required 7.1 liters per 100 km (33 mpg US/39 mpg UK).

Impressive dynamics

The new five-cylinder turbodiesel has a displacement of 2.4 liters (146 cubic inches) and an excellent torque curve across the entire rev band – thereby also offering an extremely dynamic driving experience. The secret to this

dynamic performance and the low fuel consumption lies in the two exhaust gas turbochargers arranged in series. At low revs, a compact KP35 high-pressure turbocharger provides spontaneous engine response and eliminates starting weaknesses. As the revs

The R2S system from BorgWarner ensures excellent driving performance with minimum fuel consumption.



increase, this small turbo is supported by a larger K16 low pressure turbocharger, which then takes over responsibility for full boost pressure above a certain engine speed and provides exhilarating performance. As the boost pressure is generated so quickly, starting torque is improved, which in turn has a positive effect on acceleration from a standing start. The S80, which weighs in at almost 1.7 tonnes (3750 lb), is therefore able to accelerate from 0-62 mph in just 8 seconds. Yet it is also when accelerating in the speed range from 50 to 75 mph, a situation frequently encountered in real life driving conditions, that the unit offers excellent elasticity which makes driving such fun.

Fit for Euro5

Alongside optimization of dynamic driving performance and energy efficiency, reducing harmful emissions and particles in the exhaust gas stream also ranked among the most important development goals at Volvo. Thanks to the R2S turbocharging, greater volumes of exhaust gas can now be recirculated – which is a key prerequisite for keeping emissions to an absolute minimum. And despite its impressive performance characteristics, the new D5 engine only produces 164 g of CO₂ per km (0.58 lb per mile) and thereby complies with the strict Euro5 emissions standard.



BRADFORD FACILITY INTRODUCES TPM SYSTEM TO IMPROVE MACHINE AVAILABILITY

Totally productive

Today more than ever, efficiency and quality are key competitive factors for automotive supply companies. The turbo-charger assembly and maintenance departments at the Bradford facility have therefore introduced a Total Productive Maintenance concept to look after their most important production equipment. This has resulted in an impressive 74 % increase in machine uptime.

Holistic quality assurance

The basic premise behind “Total Productive Maintenance” is to continuously and systematically improve all areas within a company. The goal here is primarily to track down problems in production to reduce defects, down-times, quality issues, accidents, etc. to their lowest possible level.

Improved teamwork

The TPM initiative is being implemented at BorgWarner in Bradford in close cooperation between staff members in the assembly and maintenance departments. Production personnel are responsible for daily cleaning of the machines and daily functional checks on the most important equipment.

are also responsible for implementation of planned, preventive and predictive maintenance activities.

TPM charts create transparency

The TPM concept was developed and introduced by a cross-functional team, consisting of a manufacturing technician, senior maintenance engineer and manufacturing engineer, to deal with the TT core balancing machines, which were proving unreliable and requiring high maintenance. An open discussion was carried out with the team members, the Assembly Business Team Manager and maintenance management, with agreement being reached that the con-



The TPM team standing in front of a TT core balancing machine, with large charts to visualize check points and any concerns.

TPM is being implemented as a company-wide solution at BorgWarner to optimize the efficiency and availability of manufacturing. The company's objective here is not so much to fix machinery or processes following a failure – but rather to define and maintain high quality standards throughout the production process as a whole.

These staff members also document their inspections, including all malfunctions and any concerns they have. Staff working in maintenance train production staff, giving them the knowledge they need for the daily inspections, and also introduce counter measures when problems or malfunctions have occurred. In addition to this, the maintenance staff

This resulted in the team developing a 3 document chart system, to be located at each machine and including:

- A key care point **CHECKLIST** that precisely specifies which functions are to be checked, which criteria are to be met and the frequency of inspections/ checks
- An **OVERVIEW** with photos of all machine parts to be checked
- A **FAULT LIST**, used to record identified concerns or faults

BRADFORD SPONSORS THE ENGINEERS OF THE FUTURE

Tomorrow's talents

Finding talented future engineers is an important competitive factor for industrial nations. This is one of the key reasons why BorgWarner's Bradford site (Great Britain) is working with a local school on two projects within the scope of its Engineering Education Scheme (EES).

The EES was established in 1984 to help Year 12 students gain in-depth experience in real life engineering/science or technology related projects. With close industrial links, the scheme promotes challenging and stimulating objectives in the real world of industry, allowing students to gain transferable practical skills and hands-on experience in a professional engineering environment.

EES – a program of success

The experience gained by the young people helps enrich their knowledge of the wide arena of engineering careers and equips them with essential skills they will need at university and in their future career. Since 1984 the scheme has introduced more than 17,000 young people to the world of engineering, and continues to go from strength to strength with ever increasing numbers of participants.

BorgWarner also benefits from the commitment to young people, as it for example allows the company to assess the availability of young talent with a view to future sponsorship through university. With the help of talented participants, the company can also execute projects affordably and establish a positive image among future engineers.

Over the past 6 months, Simon Harrison and Rob Daniels from the Bradford facility have acted as mentors for two teams, which consisted of 4 students and their teachers from Greenhead College. Each team worked on a real industrial problem for which BorgWarner needed a solution. The scheme consisted of a launch day, a project development workshop at a university, an assessment day, visits to the Bradford facility and lots of hard work.



cept was to be highly visible at the point of use, clear and easy for all personnel to understand.

74% less downtime

To ensure that staff members working in production would be able to successfully apply the new TPM system, they were trained in how to perform the daily checks, which include visual checks and checks for unusual smells or sounds. Any item that does not meet the specified standards is entered into the fault list. The maintenance team then view the lists on a regular basis and address the faults, as well as carrying out the weekly planned maintenance activities identified in the TPM checklist.

The concept was rolled out by the team to all operators who work on TT core balancing machines, who embraced the initiative very positively, not least because it soon became clear that it was resulting in significant improvements in equipment uptime and availability – in turn reducing unplanned machine stoppages by 74%.

The TPM initiative has now been in operation for 4 months with very successful results. And with the proven success of the initiative, the decision has now been taken to roll out the TPM format to the other key equipment within the machining departments of the Bradford facility.



Eight students were able to demonstrate their practical skills at BorgWarner in Bradford.

Projects with a practical flavor

The assessment day was held at the University of Huddersfield and consisted of 16 teams presenting their projects to an assessment panel made up of specialists from the engineering industry. The two BorgWarner projects focused on development of a lubrication device for assembly of a turbocharger insert and on development of an error-proofing device for an impeller wheel locknut. These projects stood out among the massively diverse range of projects being shown.

On May 13, the two teams then presented their projects again at the Bradford site. The impeller wheel locknut error-proofing device developed by one of the teams proved so effective that it is now the first of the 16 projects that is actually to be used in production.

RENAULT INVESTS IN ENGINE DOWNSIZING AND TURBOCHARGING

Créateur d'ef

In the development of new engines, the goal is not always to improve output and performance. Auto manufacturers are today concentrating more on finding solutions to make their tried and tested drives more economical and more environmentally friendly, while maintaining excellent driving characteristics. One interesting approach here is “downsizing” in connection with exhaust gas turbocharging. For example, with its new 1.4 liter (85 cubic inch) turbocharged unit, Renault is presenting a highly efficient low displacement gasoline engine that offers the response of a 2.0 liter (122 cubic inch) unit.



Excellent response coupled with low consumption – the new Mégane 1.4 16V TCE.

Turbocharging is the key here. It was with the help of this technology that Renault developed the new 1.4 16V TCE, which offers the kind of power and torque figures normally associated with significantly larger displacement units. At the same time, fuel consumption is lower than that of a 1.6 liter (97 cubic inch) four-cylinder engine. The key to this high degree of efficiency is the compact KP39 turbocharger, which BorgWarner Turbo & Emissions Systems developed for the engine. The

additional aspiration of the combustion chamber allowed fuel consumption to be reduced by up to 16% over Renault's 2.0 liter (122 cubic inch) normally aspirated unit, while maintaining virtually identical performance figures.

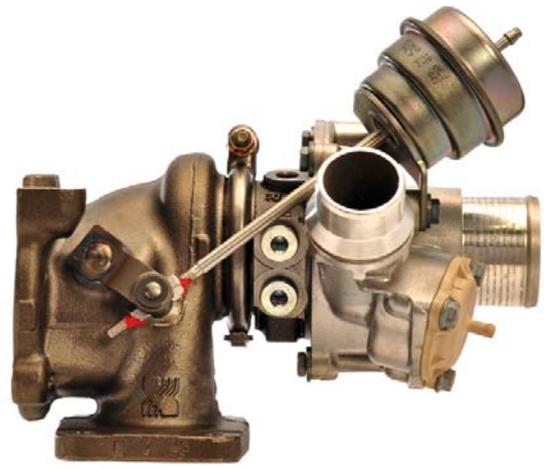
High specific output

The turbocharged 1.4 liter (85 cubic inch) 16V TCE 130 achieves its maximum torque of 190 Nm (140 lb-ft) at 2250 rpm and generates peak power

of 96 kW (130 bhp) at 5500 rpm. This represents a high specific output of 69 kW (93 bhp) per liter of displacement. Thanks to these excellent performance characteristics, Renault has decided that the new engine (which is manufactured in the Spanish facility in Valladolid) is to replace the larger 2.0 liter normally aspirated engine.

The modern 1.4 liter turbocharged gasoline engine of course also complies with the Euro5 emissions standard. It

efficiency



is used in Renault's compact class models – initially in the Mégane and Scénic. In the Mégane, the engine consumes just 6.5 liters of gasoline per 100 km (36 mpg US/43 mpg UK) and emits just 153 grams of CO₂ per kilometer (0.5 lb per mile). And with fuel consumption of 7.1 liters per 100 km (33 mpg US/39 mpg UK) and 168 g of CO₂ per kilometer (0.6 lb per mile), the Scénic consumes only slightly more.

The future is "TCE"

The 1.5 liter (91 cubic inch) and 1.6 liter (98 cubic inch) gasoline units co-developed by Renault and Nissan form the basis of the lower displacement engine. The new power unit is the second of the so-called TCE range at Renault. TCE stands for "Turbo Control Efficiency" and underlines the central role played by turbocharging in the design of the new engine by the French auto manufacturer. Instead of conventional normally aspirated engines, Renault is investing in smaller engines with modern booster technology across the board. In addition, the lower frictional resistance of reduced displacement and the move toward greater loads offer better efficiency, which in turn leads both to lower fuel consumption and lower emissions.

Perfectly tailored boost

Renault's development partner is turbocharger specialist BorgWarner, which also supplies the turbocharger for the "K9K" 1.5 liter (91 cubic inch) common-rail diesel engine in the Laguna (see TurboNews 1/08). The engineers at BorgWarner developed a specially

adapted version of the KP39 turbocharger for the new 1.4 liter (85 cubic inch) turbocharged gasoline engine. Thanks to a small impeller diameter, the turbocharging system engages virtually instantly and ensures that the small Renault engine delivers spontaneous response and performance. Indeed, due to the thermodynamic design of the engine, the charger has such good response that the engineers were able to do without a costly Twin Scroll turbocharger that only combines the exhaust gas streams of the individual cylinders

just before the turbine wheel. The boost pressure of the KP39 is controlled via a so-called waste gate, which diverts excess exhaust gas away from the turbine when the impeller is spinning fast.

With the 1.4 16V TCE, Renault and BorgWarner have impressively demonstrated the advantages of gasoline engine downsizing. And the new engine only represents the beginning of the trend toward compact turbocharged gasoline engines.



Renault Scénic

PYONGTAEK FACILITY CROWNED CENTER OF EXCELLENCE
FOR VTG CARTRIDGES

Korea takes off

SeohanWarner Turbo Systems, in which BorgWarner owns a majority stake, opened a manufacturing facility in Korea in September 2007 (see also TurboNews 2/07). And the facility, located in Pyongtaek, has now developed into a key pillar for turbocharger production.



The staff members in Pyongtaek celebrate their first delivery of VTG cartridges to Kirchheimbolanden.

Variable turbine geometry is increasingly becoming the state-of-the-art technology for modern turbocharging systems. However, with ever greater penetration of the market and the corresponding growth in volume comes increased cost pressure. The decision has therefore been taken to expand the Pyongtaek facility, creating a "Center of Excellence" for the manufacture of VTG components. Indeed, the site made its first shipment of 3rd generation VTG cartridges for BV43 turbochargers to Kirchheimbolanden (Germany) in June 2009.

Sound cooperation

Intensive collaboration was needed between the specialists in Germany and the staff members in Korea before production could be started up. But the efforts of everyone involved paid off, and the close, cooperative exchange between the teams made it possible to establish productive and profitable manufacturing in Korea in line with the highest quality standards. By bundling the activities in Korea and localizing material procurement, BorgWarner expects to gain lasting competitive advantages in production. And the VTG cartridges, which are required across the entire globe, are expected to be produced in large volumes in Pyongtaek by the second quarter of 2010.

The facility's next goal is to get ready for production of 4th generation VTG cartridges. Pyongtaek will then be the central manufacturing facility for global VTG cartridge requirements. Alongside the VTG cartridges, other turbochargers – in particular with VTG – are also produced in Pyongtaek for the local market. Examples include units for the Hyundai models Veracruz and Grand Starex, as well as for the Kia models Sorento and Grand Carnival.



The Korean facility is soon to manufacture large quantities of VTG cartridges.

BORGWARNER IN BRADFORD RECEIVES OHSAS 18001 CERTIFICATE

Safety first

Health and safety at work is an issue affecting all businesses across the globe. And implementing an occupational health and safety system to protect their staff is now a requirement of customers in many businesses throughout the world. BorgWarner is meeting this requirement head on in Bradford (Great Britain) with OHSAS 18001 certification.

BorgWarner has already been committed to the health and safety of its staff members for some time. The Kirchheimbolanden (Germany) site, for example, was certified to OHSAS 18001 (Occupational Health and Safety Assessment Series) back in May 2008, and the Bradford site has been working intensively for years to continually improve standards for its employees. With the certification to BS-OHSAS 18001, these efforts have now been rewarded.

Three certificates, one common goal

OHSAS 18001 makes a contribution towards introducing key elements and guidelines which correspond with leg-

islation and help protect BorgWarner's interests as an employer. This system will help reduce the risk of accidents, litigation and downtimes. The facility is also certified to TS16949 for excellent quality and to ISO14001 for high environmental standards. Together with the new OHSAS 18001 health & safety standard, this will simplify the integration of all three standards and help reduce duplication of policies and procedures.

Creating awareness of safety

Bradford has recognized the importance of continuous improvements and, with the help and cooperation of all

employees, will continue to make every effort to ensure a safer and better working environment. Indeed, the site already introduced the "safety first program" in 2008 to get a better feel for staff perceptions of risk and behavior. And although still in its infancy, this system has already helped improve awareness and behavior, encouraging employees in Bradford to take ownership and responsibility, to stop and think – as safety will always require every single person to get involved.



Staff members in Bradford are proud of their joint commitment and the OHSAS 18001 certificate they have been awarded.

BORGWARNER GETS INVOLVED IN THE ACTION MUSEUM
AT THE NÜRBURGRING WITH A HANDS-ON EXHIBITION

Technology in action

On August 15, 2009 the day finally came. After long preparations, the keenly anticipated “ring°werk” museum was finally opened at the Nürburgring (Germany). The most legendary racing circuit in the world now boasts another unique attraction that is sure to entice thousands of visitors, even when no racing events are being held. BorgWarner is involved with a permanent interactive exhibition in the test°center of the ring°werk.



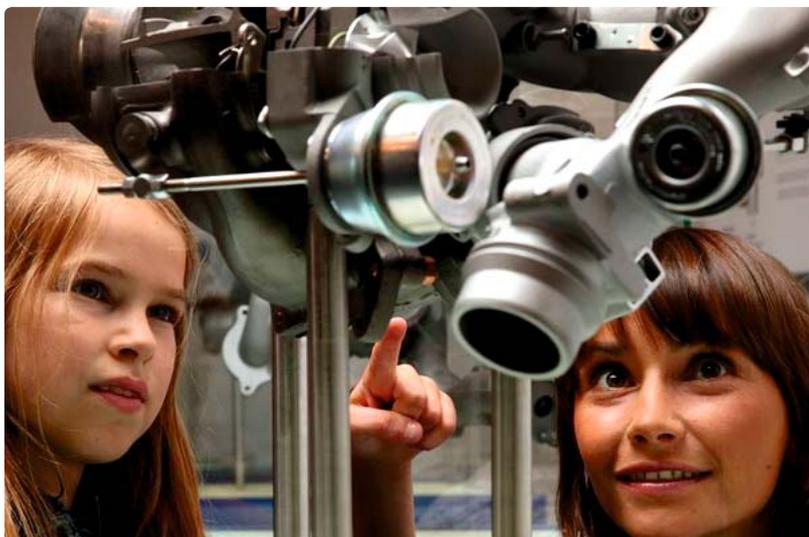
Everything in the 15,000 square meter (161,450 square foot) arena of the new fun park focuses on legend, motor sport and mobility. Visitors can learn all about both the history and future of the “Green Hell”, as the Nürburgring is often called. They can take a peek behind the scenes of Formula 1 or be catapulted from 0 to 135 mph in less than 2.5 seconds on the world’s fast-

est rollercoaster. Alongside 3D cinemas, driving simulators and many more attractions, visitors can also enjoy the test°center, which offers exciting insights into the latest vehicle technologies.

Walking through the engine that forms the entrance to the test°center, visitors can discover a whole world of information, in which BorgWarner Turbo &

Emissions Systems also shares its interesting knowledge in and around the field of exhaust gas turbocharging at various interactive stations. How does a turbocharger work, what does it do and what are its advantages? What hellish environmental conditions must it be able to withstand? How is an engine with a turbocharger designed? What has happened to the turbocharger since it was developed a hundred years ago? There is a lot to see, discover and try out in and around these questions in BorgWarner’s discovery area. Phrases like “I never knew that!” and “Now I understand!” are par for the course here – for children and adults alike.

The ring°werk museum is open all year round every day from 10 am to 6 pm. You can find further information on the internet at www.ring-werk.com.



There is a lot to discover with BorgWarner’s interactive terminals, showpieces, glass cabinets and display boards.

BORGWARNER OPENS MANUFACTURING FACILITY IN RZESZÓW

Start of production in Poland

BorgWarner Turbo & Emissions Systems takes a stand against the crisis: Just one year after laying the foundation stone, the automotive supplier officially opened its new turbocharger production site in the Polish city of Rzeszów on June 22, 2009. Up to 500,000 turbochargers for European auto manufacturers are to be manufactured every year at the modern facility.

Marshal Zygmunt Cholewinski, district administrator Jozef Jodlowski and Mariusz Bledowski, head of the Mielec special economic area, attended the opening celebrations for the new site. "After laying the foundation stone in March 2008, we are proud of the fact that series production at our new site is already up and running at full speed", said facility manager Marek Zabielski in his address. "From the planning phase, through construction of the production halls, commissioning of the machines and training of the staff members, right up to the final acceptance test – we needed less than a year to implement this important project."

Turbos for Fiat

The first customer of the new facility is Fiat Powertrain Polska, for whom BorgWarner previously produced turbochargers at its Hungarian site in Oroszlány. The first turbocharging systems were sent to Fiat as early as

December 2008. These were KP35 turbochargers for Fiat's 1.3 liter (79 cubic inch) diesel engine that is used in various models. Relocating production capacities to Poland means that BorgWarner is now able to offer an optimum supply of these turbochargers for Fiat's facility in Bielsko-Biala in the south west of Poland.

Rzeszów site

BorgWarner Turbo & Emissions Systems chose the Podkarpackie Science and Technology Park, located south-east of Krakow, as its site. This was deemed the ideal production location, as it offers excellent transport connections. The new facility in Rzeszów employs over 100 staff members and has a total area of 5,500 square meters (59,000 square feet). It has been designed as a so-called "green building", which means that the building and systems give special consideration to the environment. For example, the roof and



Up to 500,000 turbochargers can be produced every year in Rzeszów.

wall designs incorporate building materials which significantly reduce energy consumption in the building. Sensor-controlled lighting systems also ensure that the lighting is only ever switched on when people are actually working in the respective area.

Equipped for the future

With the new European manufacturing facility, BorgWarner is well equipped to handle future challenges and capacities. And Europe is today the key market for exhaust gas turbochargers due to the large proportion of diesel engines sold here. Added to this is the fact that more and more European auto manufacturers are now looking toward turbocharged gasoline engines with reduced displacement, which will also cause the percentage of vehicles with intelligent booster concepts to continue increasing.



Facility manager Marek Zabielski at the opening celebrations of the new facility.

Making learning fun

CAMPINAS SUPPORTS SCHOOL PROJECTS FOR CHILDREN

BorgWarner's Campinas site (Brazil) has been fully committed to social issues in the region for many years. Indeed, the facility has already supported the most diverse of aid campaigns together with the local communities and authorities. This year, three projects in the field of education are being supported.

The first project involves the production of a book, which helps children learn important basic values for life. The book has been distributed to 2,000 children and also recorded on 50 audio CDs for donating to organizations that help and support blind children.



The other two projects involved organizing theater plays on topics of environmental protection, such as saving resources and recycling. More than 1,300 children aged between six and ten who attend state schools near the plant enjoyed a performance that not only conveyed knowledge and information, but was also great fun.

The play was an absolute premiere for the majority of the children, who were clearly excited by the event. The beautifully designed books were also very well received by the young readers – many of whom cannot otherwise afford their own books.



The chance to experience a "real" play – a first for many children in Campinas.

Publishing Information

TurboNews – 1/2009 Issue

Publisher

BorgWarner Turbo Systems
Worldwide Headquarters GmbH
Mannheimer Straße 85/87,
D-67292 Kirchheimbolanden

Editing and coordination

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Photographs

BW Turbo & Emissions Systems, Audi, Ford,
John Deere, Opel, Renault, Volkswagen, Volvo

Concept, design and lithograph

schulze, reister, grözinger, werbeagentur ag, Germany
www.srgwerbeagentur.de

Printing

WDW Druck GmbH, Leimen-St. Ilgen, Germany

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