Turbo Technologies

HTi

The Latest Turbocharger News

Advances in Global Engineering Capabilities

Edition 16:

Executive Comments

Welcome to the sixteenth edition of HTi. At Cummins Turbo Technologies we demonstrate our commitment to research and development through the increased investment in our technical centres in China, India, the UK and the USA. These technical centres provide global capability coupled with local expertise, designed to innovate and optimise our technology, which in turn positions us with a number of advantages. One example is the recent expansion at our technical centre in Wuxi, which will allow us to keep pace with growing demand in China.

Likewise, an innovative new test facility, designed in-house at our UK technical centre, is ready to help customers develop the waste heat recovery systems that hold so much potential for the next generation of fuel efficient, low CO_2 engines. We are also increasing the capabilities of our Advanced Engineering team, which consists of engineers tasked with developing the technology of the future and bringing it to market. In this edition of HTi, we explain how new fuel efficiency and GHG rules for trucks and buses in Japan, the USA and soon in Europe are changing our customers' requirements for turbocharging solutions. One size does not fit all, so our array of solutions makes us an ideal development partner.

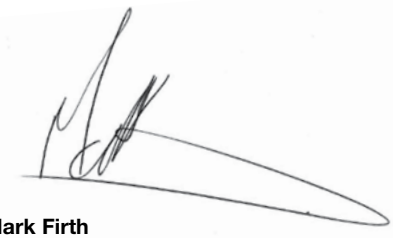
Our commitment to research and development is also about recruiting and developing talented engineers. In these pages we describe how our numerous links with universities have already proved to be beneficial, with many new exciting projects underway.

As we push ahead with evolving technology, we take care to keep our customers informed. One of the ways we do this is through Technology Days. Recent events held for some of our major customers in China and India have showcased our technology and forged stronger partnerships.

Brazil is implementing its next tier of exhaust emission legislation in January 2012. We are meeting the challenge by introducing the Holset VGT™ for the first time on a Brazilian application. This involved our engineers from Brazil, the UK and the USA, working in collaboration with the Cummins Engine Business Unit and Cummins Emissions Solutions. Read how they went about this, including testing at altitudes of almost 5,000 metres.

Mark Firth

In the last edition of HTi, we introduced our new family of Holset turbochargers for small diesels. This new range of turbochargers was designed in response to customer demand for reliable, durable turbochargers that meet the specific requirements of the 2-6 litre diesel engine market. In this edition find out how we made an impact at the Supercharging Conference in Dresden when we presented a technical paper about the benefits of our new range of small turbochargers.



Mark Firth
Executive Director; Research and Engineering

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It aims to bring you news on product and market developments.

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Showcasing
Our Technology

Written by Zhang Yanyan; China Marketing Specialist and Preetika Thakur; India Marketing Communications Coordinator

Holset modulating two-stage series-sequential system

Working in partnership with our customers is of the utmost importance to Cummins Turbo Technologies, as we believe this is an ideal way to provide practical solutions to meet current and future demand. It is for this reason that our Technology Days have been so popular.

The Technology Days are jointly arranged between Cummins Turbo Technologies and our customers and bring account managers, technical leaders and engineering employees together from both sides. This forum provides an ideal opportunity for the exchange of knowledge and the forging of stronger partnerships with our customers.

Two excellent examples of our Technology Days include our Advanced Engine Technology forum in China and collaboration with our customer Ashok Leyland in India. The Technology Day held in Beilhai, Guangxi, China was organised for our customer Yuchai and attended by many of their engineering and technical employees. Jonathan Wood; Director Asia Engineering, presented slides on our global technical capabilities as well as covering particular projects currently in progress with Yuchai. The day provoked lively debate and generated positive feedback from attendees. Wuxi Cummins Turbo Technologies also hosted similar events in April and May of this year with China National Heavy Duty Truck Corporation (CNHTC) and the DongFeng Motor Corporation (DFM) respectively.

The Ashok Leyland Technology Day was held at the customer's technical centre in Chennai and was attended by Cummins Components Group. It presented an ideal opportunity to bring our business units together at the event as 'One Cummins'. Each business unit displayed a range of their products. The Cummins Turbo Technologies exhibit included our turbocompound system, modulated two-stage and our new Holset 200 series of turbochargers for diesel engines between 2 and 6 litres.

These events focus on technology and provide a comprehensive level of technical detail, which is a great draw for engineering personnel. The chance to engage at these events has opened the door for discussions on forthcoming projects and also for general debate between like-minded engineers, whether newly recruited or with years of experience in the industry. The positive feedback received has secured the Technology Days as a 'must do' event in all parts of the world.

Achieving Fuel Efficiency
Through Air Handling

Written by David Sudall; Engine Air Systems

The international scientific community agrees that climate change caused by emissions of greenhouse gases (GHG) is likely to be the biggest threat facing humankind over the next 100 years. It is hardly surprising then that Japan, the USA and Europe have all introduced legislation designed to reduce emissions of the most common GHG, carbon dioxide (CO_2), from passenger cars and more recently from light commercial vehicles.

Heavy-duty commercial vehicles have previously been left untouched by such legislation. This is partly because it is difficult to design legislation that makes truck manufacturers responsible for complying with CO_2 limits if they have no control over their vehicles' final configuration. The specification of semi trailers or bodywork clearly has a major influence. However, with heavy commercial vehicles accounting for 19% and 26% of CO_2 transport emissions in the USA and Europe respectively, there is now a commitment to address the issue.

First Japan, now the USA and then Europe

The first legislation of its kind was drafted by Japan in 2005 and is to be implemented in 2015. It sets fuel efficiency standards, expressed in km/litre, for all diesel powered commercial vehicles over 3.5 tonnes gross vehicle weight (GVW). There are four specified vehicle groups: transit bus, non-transit bus, trucks and tractor vehicles. Each group is sub-divided by GVW. Trucks with gross weights of between 3.5 and 7.5 tonnes are divided into four groups, based on their payload capacity. There are further refinements, such as gear ratio, applied to the simulation modelling used to evaluate fuel consumption. This uses Japan's JE05 drive cycle (which simulates city driving conditions) and an inter-urban drive cycle.

In August this year, the US Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) announced the final rules for the introduction of GHG legislation for heavy-duty commercial vehicles in the USA. The limits are to be phased in, starting in 2014 and running through to 2018. Although the legislation is not comprehensive, it is intended as a foundation for future targets.

2005
Japan HDV legislation first drafted

2009
EPA propose draft HDV legislation

2010
EC study into potential HDV legislation

2011
February: Lot 1 of 2-part study by EC released.
August: EPA announce final rule-making of HDV legislation

The US legislation includes CO_2 standards for engine manufacturers, while there are whole vehicle standards for the chassis manufacturers. Within the vehicle standards, there are three categories of heavy-duty vehicles:

- Combination tractors (articulated vehicles)
- Heavy-duty pick-up trucks/vans (with gross weights of 8,501-14,000 lb)
- Vocational vehicles (rigid chassis buses, fire trucks, refuse trucks).

Each category is further divided into relevant sub-categories, chiefly dependant upon their gross vehicle weight. The combination tractors are also sub-divided by the height of their cab roof because this is used as an indicator of trailer height. Turning to the engine standards, CO_2 emission limits have now been added to the current limits for emissions such as particulates or oxides of nitrogen and will be measured on the same test cycles. Compared with current engines, these limits will produce CO_2 reductions of 6% and 5% by 2017 for tractors and vocational vehicles respectively. Japanese legislation focuses only on fuel consumption, whereas the EPA is directly legislating CO_2 emissions, measured in gCO_2/ton-mile. The equivalent NHTSA requirements translate these into fuel efficiency standards, measured in gal/1,000 ton-miles. In both cases, the ton part of the measurement unit refers to payload, not gross weight.

The European Commission (EC) is also investigating how to implement limits for truck and bus CO_2 emissions and/or fuel consumption. Commercial vehicle manufacturers favour a global standard but it is unlikely to come to fruition in the short-term with the USA and Japan already going their own way. All eyes are now on the EC to see if it will follow either of the others or adopt its own unique approach.

One size does not fit all

Irrespective of whether there is ever a single global CO_2 standard, the huge variety of heavy commercial vehicles means there will never be a one size fits all solution for minimising CO_2 emissions. For long distance applications, where air resistance is the biggest force to overcome, reduction in aerodynamic drag could improve fuel efficiency by around 10%. In urban applications with stop-start duty cycles, the EC believes improvements in powertrain efficiency have the greatest potential to reduce CO_2. In either of these two scenarios, improvements could be achieved through a variety of engine measures such as down-speeding to reduce frictional losses, greater component efficiencies and the recovery of waste heat.

Turbocharging solutions

There is a range of turbocharging options to suit each of these applications and duty cycles. For example, turbochargers with wastegated turbines are a compact and cost effective solution for vehicles that do not place many demands on the turbocharger. When used in conjunction with a turbocompound system, even more energy can be extracted from the exhaust gases, delivering a power boost at high engine loads.

In contrast, urban duty-cycles demand more from the turbocharger. Our customers need quick response and high efficiency across a wide range of engine speeds. The Holset VGT™, with its accurate and reliable sliding vane mechanism, allows a broad range of engine conditions to be achieved with high efficiency. Alternatively, our modulated two-stage system can offer a wide range of compressor and turbine flows, with peak efficiency focused for low load conditions or transient duty cycles.

Prompted by growing interest in hybrid commercial vehicles, particularly in the urban distribution market, Cummins Turbo Technologies has been researching electrically assisted turbochargers. These not only offer high boost pressure at low engine speeds, but can also work in reverse by regenerating waste exhaust energy and turning it into electrical energy. This can be used to supplement battery charging or to power electrical auxiliaries.

Meeting future GHG emissions

As part of our continuous development process we are striving to make incremental gains in turbocharger efficiency. For example, we are improving the aerodynamics of the turbocharger and reducing bearing system losses. A more radical solution is waste heat recovery, featured in edition 14 of HTi. This technique utilises the Rankine cycle to capture waste heat from the exhaust, engine block and the charge air cooler, extracting its useful energy via a power turbine. This feeds power back through a transmission to the engine's crankshaft or to an electric generator. Such systems have already shown to improve fuel consumption by up to 8%.

Cummins Turbo Technologies' ability to provide such a broad range of turbocharging solutions is helping commercial vehicle manufacturers meet future GHG emissions legislation, no matter how diverse the application or how tough the duty-cycle.

2012/13
EC final HDV rulemaking expected

2014
EPA HDV regulation phase-in through to 2018

2015
Japanese mandatory Implementation of HDV legislation

2016/17
Expected EC HDV legislation implementation

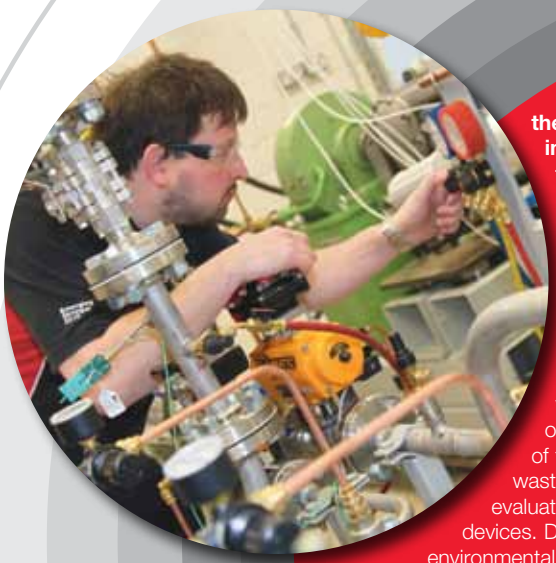
Timeline of Events – Heavy-Duty Vehicle (HDV) Legislation

Advances
in Global Engineering Capabilities

Cummins Turbo Technologies is committed to research and development, facilitated by our technical centres in China, India, the UK and the USA. These centres enhance our global capabilities whilst meeting the needs of local markets. We are actively expanding these technical centres to increase our capacity to develop current and future technologies; reinforcing our position as a global technology partner.

Waste Heat Recovery Test Cell

Written by Dave Clay; Director - Prototype and Test Operations



As pressure grows to improve vehicle fuel consumption and thereby curtail carbon dioxide (CO_2) emissions, there is a demand to investigate more radical ways of increasing engine efficiency. One of the most promising technologies is waste heat recovery, a method of drawing energy from a number of waste heat sources on an engine. Adding a secondary heat recovery system using organic fluids allows this energy to be turned into useful mechanical or electrical work.

A turbine expander is a compact and efficient means of converting the energy from the vaporised organic fluid into useful output. Our turbine expertise puts us in a strong position to explore this exciting concept and we are currently working with a number of customers to develop turbine expanders for a range of applications. In order to support the design, validation, testing and optimisation of these we have invested more than US$1.5 million in the installation of a dedicated waste heat recovery test cell at our technical centre in Huddersfield, UK. It allows us to evaluate the thermodynamic performance and durability of these high speed micro-turbine devices. Design of the facility involved a number of challenges, such as the safe handling and environmental impact of using organic fluids, measurement of power from small high speed turbines, dynamic control and operational safety.

The test rig includes a three stage pump to initially raise the pressure of the working fluid up to 30bar gauge. A 250kW electrical heater is then used to simulate heat energy rejected from the engine. This energy is transferred to the working fluid via a two-stage oil heat exchanger that converts the working fluid from liquid to a super heated vapour to drive the turbine expander. Output from the turbine shaft is coupled to a high speed gearbox with engine loading simulated using an eddy current dynamometer. Dynamic control of the test rig is achieved via a real time control and data acquisition system that can control all the rig's running parameters. This allows test cycles to be run automatically for evaluation of the product under different operating conditions. Safety and environmental control is a critical feature of the test rig, so it includes a gas detection system designed to shut down the rig safely in the event of any leak of vapour from the organic fluid.

This comprehensive test facility, designed in-house, means Cummins Turbo Technologies is ready to help our customers develop waste heat recovery systems that are likely to be part of the forthcoming generation of fuel efficient, low CO_2 engines.

Technical Centre Expansion in China

Written by Jonathan Wood; Director - Asia Engineering

Cummins Turbo Technologies is currently experiencing continued worldwide growth, with China playing an important role within this expansion. The Wuxi Cummins Turbo Technologies joint venture business was established in 1996, a partnership that has successfully developed a strong technical presence within the country.

A growing market, China is starting to adopt stringent emission limits, which brings with it the need for products and technologies that can meet these standards. Cummins Turbo Technologies is meeting these challenges through the introduction of a wide range of products into the China market and the expansion of our engineering teams within the Wuxi technical centre.

Our engineering rotation programme enables the sharing of knowledge and skills between our UK and Wuxi technical centres. This collaborative work is developing our capability to design and fully approve components in China for the China market.

In support of building our engineering resource in China, the Wuxi technical centre has been extended this year. This provides us with a high quality environment for our engineering teams to develop new products and to reinforce Wuxi's role as one of our four global technical centres.

China became the lead market for Cummins Turbo Technologies when the Holset 200 series was launched. This platform has been developed by a team in the UK and China collaboratively.

The Advanced Engineering Group

Written by Pierre French; Director - Advanced Engineering

The engineers in our Advanced Engineering group are always working ahead of market needs with development projects commencing years before actual production. The group is highly specialised and currently operates from our Huddersfield, UK technical centre. Planned expansion of the team means that, in the future, there will also be some members based at our US technical centre in Columbus, Indiana.

Technology Development

Partnering with our customers' Advanced Engineering projects; we produce ground breaking technology for future markets. The types of products we look at range from a technological enhancement of a component to the complete thermodynamic design of a power delivery system. The overall objective is to produce market leading products that deliver improved fuel consumption, enhanced performance and increased capability.

The Advanced Engineering process develops product ideas and turns them into demonstrators to prove their viability. Many of these ideas are beyond our current product offerings and have the potential to take us into entirely new markets. Where a business need is identified by Cummins Turbo Technologies, a product is moved into the Value Package Introduction (VPI) process and ultimately into production.

Exploratory Research

The Advanced Engineering group's exploratory research approaches ideas and concepts that are futuristic. These concepts come from a multitude of sources including collaboration with universities, institutes and other agencies. Engineers study these ideas and concepts for feasibility, and a critical part of the work is separating the viable from the non-viable. This is important to get right, because ultimately these decisions can influence the products of the future.

Wherever they work, members of our Advanced Engineering group liaise closely with the Technology and Program Management groups. Together we are developing more effective ways of identifying promising technologies and bringing them to market without delay.

Brazil's First
Holset VGT™ Application

Written by Marcos Schiesari; Application Engineer

Brazil's diesel engine technology is advancing rapidly, particularly with the onset of new emissions legislation.

Clean Brazilian air

Currently, Brazil's emissions legislation is Conama P5, similar to the Euro III level of legislation in Europe. Keen to achieve higher air quality, Brazil's government is skipping the Euro IV equivalent, Conama P6 and on the 1 January 2012 will jump straight to the more stringent Conama P7, similar to Euro V legislation currently in place in Europe.

This represents a big reduction in both Nitrogen Oxides (NOx) and Particulate Matter (PM) and most engine manufacturers are utilising Selective Catalytic Reduction (SCR) technology in exhaust aftertreatment systems to meet the emissions limits.

NOx primarily consists of Nitric Oxide (NO) and to a lesser extent, Nitrogen Dioxide (NO_2). SCR depends on a supply of urea aqueous solution called ARLA 32 in Brazil, equivalent to AdBlue in Europe and Diesel Exhaust Fluid (DEF) in North America. When the urea solution is injected into the hot exhaust system the urea is converted into Ammonia (NH_3). It is this ammonia that drives the SCR process by reacting with the nitrogen oxides on a catalyst to form harmless and naturally occurring Nitrogen (N_2) and water vapour (H_2O). Whilst this all occurs downstream of the turbocharger, the turbo solutions are not necessarily simple as air flow control and exhaust temperature control are both essential for the correct operation of the SCR system.

Cummins engines for Conama P7 will use SCR emissions systems; different applications require different turbocharging solutions.

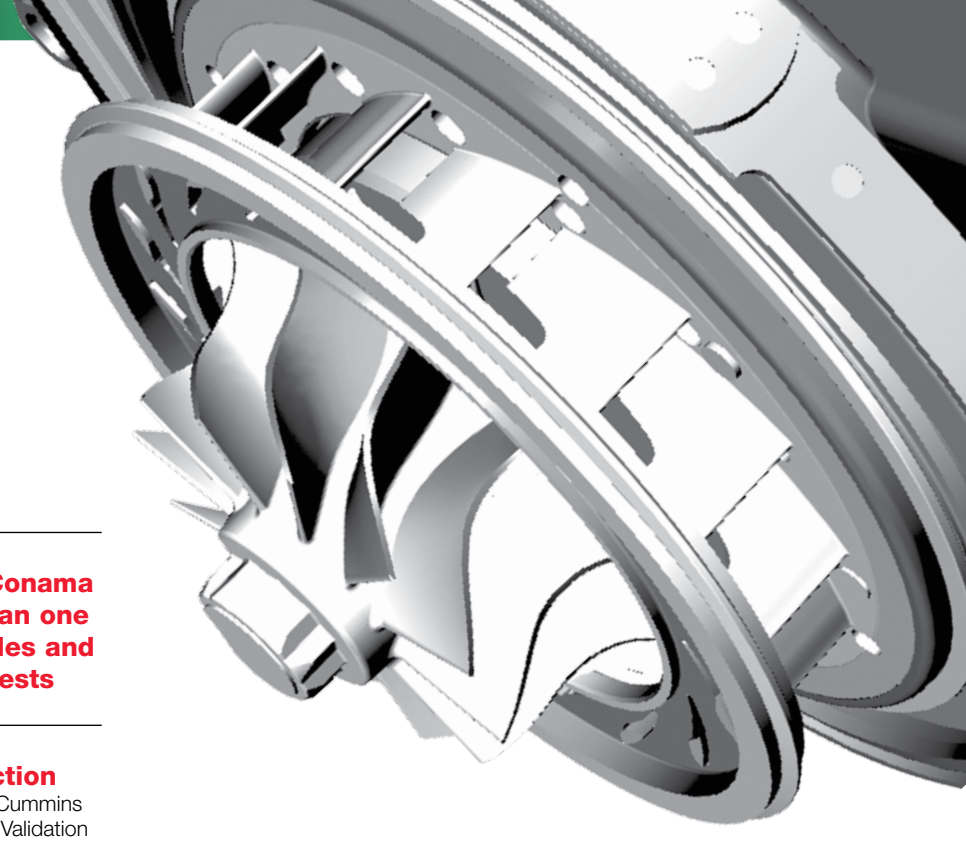
The ISBe 4.5 litre and ISBe 6.7 litre engines have already been released with wastegate turbochargers and the ISF 2.8 litre engine will join them soon. The ISF 3.8 litre engine will use a Holset modulated two-stage system, as covered in HTi edition 15 and now the ISL 8.9 litre engine is ready to be introduced at Conama P7 level with a variable geometry turbocharger.

Why a Holset VGT?

One of the largest customers of Cummins engines in Brazil presented a challenging set of requirements for the development of the ISL 8.9 litre engine. These included:

- High power density from the 8.9 litre to compete with existing 12 or 13 litre engines. The ISL develops 400HP at 2100rpm and 1700Nm at 1100rpm
- High level of engine braking performance for descending hills
- Good transient response
- Best-in-class fuel economy
- Altitude capability of 2000 metres without de-rate for sale throughout South America
- High durability for minimal downtime
- Suitable for gross vehicle weights of up to 57 tonnes
- To comply with the Conama P7 emissions regulations.

The best product to provide all of these capabilities in the smallest package size is the Holset VGT.



Currently, the Cummins ISL 400HP Conama P7 engine has accumulated more than one million kilometres in prototype vehicles and more than 8,000 hours in bench tests

Testing to ensure customer satisfaction

In addition to conducting customer durability tests, Cummins Turbo Technologies' engineers created a full Design Validation Plan and Report (DVP&R) for the Holset VGT on this application. They drew up an extensive program of testing to validate the turbochargers' reliability, robustness and durability under such demanding conditions, including:

- Checking nozzle loading and actuator load
- Test for oil delay at low ambient temperatures (-22°C)
- Check shaft sealing of oil under a wide range of operating conditions
- A thermal survey to verify internal temperatures
- Bending moment calculations and vibration and strain measurements to verify component stress
- Low-Cycle Fatigue (LCF) tests applicable for use in Brazil and Chile at altitudes of up to 4,800 metres.

Currently, the Cummins ISL 400HP Conama P7 engine has accumulated more than one million kilometres in prototype vehicles and more than 8,000 hours in bench tests, confirming the robustness of the turbocharger. The learning curve is not limited to the turbocharger's mechanical components. The development program and testing also covers the Holset VGT's electronics, the interface with the engine's Electronic Control Module (ECM) and its communication with the emission system's On Board Diagnosis (OBD).

A global team with a local presence

A multi-functional and global team was created to provide the customer with an engine capable of meeting this tough set of requirements. The turbocharger development had engineers from Cummins Turbo Technologies in Brazil, UK and the USA working on the development, allowing local knowledge and personal customer relationships to benefit from the global resources and experience of Cummins Turbo Technologies.

University Challenge:

Cummins Turbo Technologies Working with Universities

Written by John Allport; Talent Development Leader - Asia

Cummins Turbo Technologies has a long history of working with universities and in recent years has expanded this involvement to the point where we now have links with over 30 universities in the UK and around 15 more across the world. Both parties benefit from this type of close association.

For Cummins Turbo Technologies the benefits are threefold: universities are a prime source of talented people; university research projects are a cost-effective way of developing new technology; and we believe there are a range of staff development benefits derived from working with universities.

Stuart Kitson; Director - Technology meets graduates and PhD students at the launch of the turbine blade vibration project at the University of Bradford

Recruitment

Working with universities is an excellent way of further raising awareness of Cummins and engaging with students, highlighting some of the opportunities that we can provide. Working on real world projects in collaboration with a global business puts the students' studies into context and shows them how they could utilise their skills in the future. This can help them make the transition from students to potential employees who already have an understanding of some of the company's operations. Some of these trainee engineers will come into the company on a year-out or summer placement. As well as providing useful work experience, these placements serve as extended assessments that give both parties the opportunity to see whether there is a good fit between student and company.

Research

Research projects carried out in partnership with universities are an effective way of developing new technology and are often supported by grants from other organisations. Funding for Masters and PhD level projects has been obtained from a range of sources, such as the European Union, the Engineering and Physical Sciences Research Council, Regional Development Agencies and Knowledge Transfer Partnerships.

Staff development

Personal development for staff is a valuable aspect of our involvement with universities. Sharing best practices helps both organisations to improve. Our senior engineers are invited to give lectures to students; when doing so they can provide alternative viewpoints or a different slant to the academic coursework. They also serve on professional advisory boards, helping to shape the structure of courses and by assessing the quality of university courses for professional accreditation. This liaison between industry and academia is vital to ensure that courses remain relevant to changing technology and that new engineers are prepared for the modern workplace. The same principle also works in reverse. We may use university consultants to advise on a technical issue and we can learn from the viewpoints of people outside of our organisation.

Current projects

Among the current university research projects in which Cummins Turbo Technologies is involved, is a study into methods of measuring vibration in turbine blades. This is a US$2m project part funded by the European Union, supporting the work of two PhD students at the University of Bradford in the UK. This project has links to another at Cambridge University, studying variability in turbine blades. This US$200,000 PhD project is supported by the Engineering and Physical Sciences Research Council. In another project, this one at the University of Bath, Cummins Turbo Technologies is part of a consortium in a US$1.5m study researching engine matching, installation effects and turbocharger optimisation. In all, we have links with around 45 universities across the world, a number that is still growing as we seek to expand Cummins Turbo Technologies' global footprint.

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Academic track record

Involvement with a university is a process that works best when the relationship is built over time and grows as a partnership. Our breadth of contacts within the academic world allows us to match projects to the most appropriate university, so that their abilities and facilities maximise the chances of success. The projects are managed much like any other, first laying out a detailed project plan and then seeking approval for the plan and the necessary resources, maybe with an application for external funding. Then we put together a suitable team and execute the plan. Once a first project is completed, any future work is usually much more straightforward; a track record in the academic world opens the door to many other opportunities.

In future editions of HTi we will be exploring some of our university projects in more detail.

Small Turbos

Make Impact at 16th Supercharging Conference

Written by Helen O'Regan; Organisation Improvement Leader, Small Turbo Group

The annual Supercharging Conference, organised by Dresden University, took place at the International Congress Center Dresden on the 29 and 30 September 2011.

Cummins Turbo Technologies presented a technical paper to highlight the significance of our new range of small variable geometry turbochargers, known as the Holset 200 Series, to the worldwide light commercial vehicle (LCV) market.

Speaking at the conference, David Green; Director - Engineering at Cummins Turbo Technologies said: "The need to improve fuel economy, reduce emissions and increase engine performance means that vehicle makers are increasingly looking towards turbocharger technology to help them achieve their goals.

However, independent market analysis has highlighted that reliability and durability are equally important to the LCV market and existing variable geometry turbochargers serving this sector fall short of customer expectations – something which was verified when we undertook a 1000 hour durability test on a competitor's product that failed after just 300 hours. This failure was due to wear on the pivots of its swing vanes which led to jamming. The sliding wall design available from Cummins Turbo Technologies has less moving parts and 85% fewer wear sites delivering clear benefits."

To support David Green's address at the conference, Cummins Turbo Technologies exhibited variable geometry and wastegate models from the Holset 200 series alongside our other key technologies such as two-stage, turbocompounding and waste heat recovery. Our products and technologies attracted lots of attention with the event providing an ideal opportunity to promote our capabilities in developing optimum solutions for vehicle, application and market requirements.

Holset 200 series variable geometry turbocharger (HE200VG)

Cummins Turbo Technologies

Our Philosophy

We enable our customers' success through our expertise, dependability and responsiveness.

Our Goals

Cummins Turbo Technologies places the utmost importance on achieving high levels of product and service quality.

Our people are the single most valuable asset we have to ensure we meet your requirements. Through structured training development programmes we encourage our employees to spend approximately 5% of their working time in training and personal development.

Our operations worldwide are certified to TS16949 quality standard and we welcome suggestions as to how we can further improve our performance to meet your needs.

We take our environmental obligations seriously and all our worldwide sites have achieved ISO14001. Our products have an important part to play in helping to improve engine emissions.

Our goal is to provide the lowest total cost solution for your turbocharging needs.

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