



**Turbo
Technologies**



The Latest Turbocharger News

New Holset Turbochargers for Small Diesels



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Executive Comments

Welcome to our fifteenth edition of HTi. The big news from Cummins Turbo Technologies is our new family of small turbochargers for diesel engines between two and five litres. Our move into the small diesel market responds to the needs of our customers who require our technology in smaller sized turbochargers. The range also opens up new opportunities for Cummins Turbo Technologies such as in the light commercial vehicle engine market. For the first time our customers can harness the benefits of the unique technology in our Holset VGT™ for smaller sized turbochargers. Our heritage of expertise with turbochargers for larger diesels will give us a great launching point in these new sectors.

Here at Cummins Turbo Technologies we are accustomed to following a green agenda. Our turbochargers achieve optimal performance for minimal fuel consumption and exhaust emissions. We extend that environmental concern into how we do business, cutting waste and reducing energy consumption, for example. In this edition of HTi we recount how our work with a manufacturer of biomass energy generators opens up another way of applying our knowledge to benefit the environment.

Our useful Turbocharger Application Guidelines has been around for 13 years in one form or another. It will be available from early 2011 on the internet, giving engineers easier access to its valuable guidance. In a similar vein, our new model naming system makes it easier for customers to understand our product line up. Learn more about these developments on pages two and seven respectively.

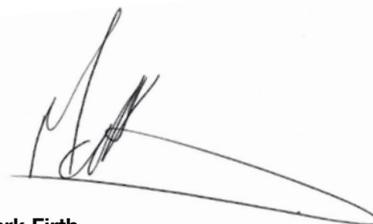
Elsewhere in HTi we describe our new two-stage offering for the Cummins light-duty 3.8 litre ISF engine. Its first application is in Brazil where it will help the little ISF pack a powerful punch. We also introduce our M²™ series sequential two-stage



Mark Firth

system and its ability to provide good boost pressure across a broad range of engine operating conditions. A clever, versatile valve is at the heart of the design.

Like many companies, we appreciate the value of training. Sharing our knowledge in an open dialogue with our partners also gives us a keen insight into their requirements and cements long-term relationships. It is all part of delivering one of Cummins' mission statements: "Partnering with our customers to make sure they succeed."



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HTi is the Cummins Turbo Technologies magazine focusing on the world of turbocharging. It aims to bring you news on product and market developments.

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Best Practice Guide Gets Even Better: Turbocharger Application Guidelines Moves Online

Written by John Clark; Applications Manager Europe

The key to really successful turbocharging is achieving the optimum match with the engine and its application. That means integrating the turbocharger functions in the best way possible, managing the influence of the different engine systems and having a thorough understanding of how the total machine will influence the operation of the turbocharger.

Cummins Turbo Technologies' Turbocharger Application Guidelines, first issued in 1997, was written as a best practice guide, helping turbocharger engineers, engine customers and end users work through the application process. Over the years it has proved to be a very effective and widely used document, with over 200 registered users among our customers.

Turbocharger Application Guidelines started life in book format. The pace of technological development dictated that it needed updating within two years of publication, so a second edition was released in 1999. The document moved to CD-ROM format in 2000, with further updates incorporated at the same time. Then, in 2004, a fully functional CD version was released, giving the end user access to remote updates. Since then, Turbocharger Application Guidelines has been updated annually.

Now comes the next step in the evolution of Turbocharger Applications Guidelines: it will be available on the World Wide Web from early 2011. Making access easier, faster and truly global, this is the latest part of our initiative to make our relationship with customers and the way in which we share information with them the best in the business.

Taking the guide online provides all the benefits of the Internet that we now take for granted. The information is always at our fingertips, anywhere in the world. There is a search function and specific pages may be bookmarked. Updates are made automatically, so end users always know they have all the latest revisions. As engine systems the world over become more complex to meet increasingly stringent exhaust emissions legislation and the advent of carbon dioxide (CO₂) limits, the ease and speed of updating Turbocharger Application Guidelines on the Internet is sure to become even more valuable.

If you wish to discuss Turbocharger Application Guidelines and its content, e-mail: turbo.applications@cummins.com.



New Applications for Two-Stage Systems

Written by Rafael Marsiglia; Applications Engineer and Owen Ryder; Principal Engineer – Engine Air Systems

The rising cost of fuel and a growing focus on limiting carbon dioxide emissions means no stone can be left unturned in the search for better vehicle fuel economy. One proven solution is engine downsizing, the technique of using smaller but highly efficient engines with good specific fuel consumption.

Downsized engines have to develop higher power densities and that means more boost pressure across a wider speed range. The turbocharging solution is often compromised by using only one turbocharger and in this article we highlight a couple of examples of how Cummins Turbo Technologies have developed two-stage turbocharging solutions to meet particular customer requirements.

Reaching new heights

Downsizing is well advanced in the car business but is slower to take a hold in the world of commercial vehicle engines. However, that is not the case in Brazil where diesel engines with relatively small displacements are already proving their worth. A local OEM Euro V truck, rated at up to 54 tonnes gcw will use a Cummins ISL (with a Holset VGT™) with a displacement of just 8.9 litres, while competitors' engines are at least 13 litres. Similarly, Euro V 9 tonne gcw truck in Brazil is to use a Cummins ISF 3.8 litre engine instead of the ISB 4.5 litre engine used by competitors in this weight class.

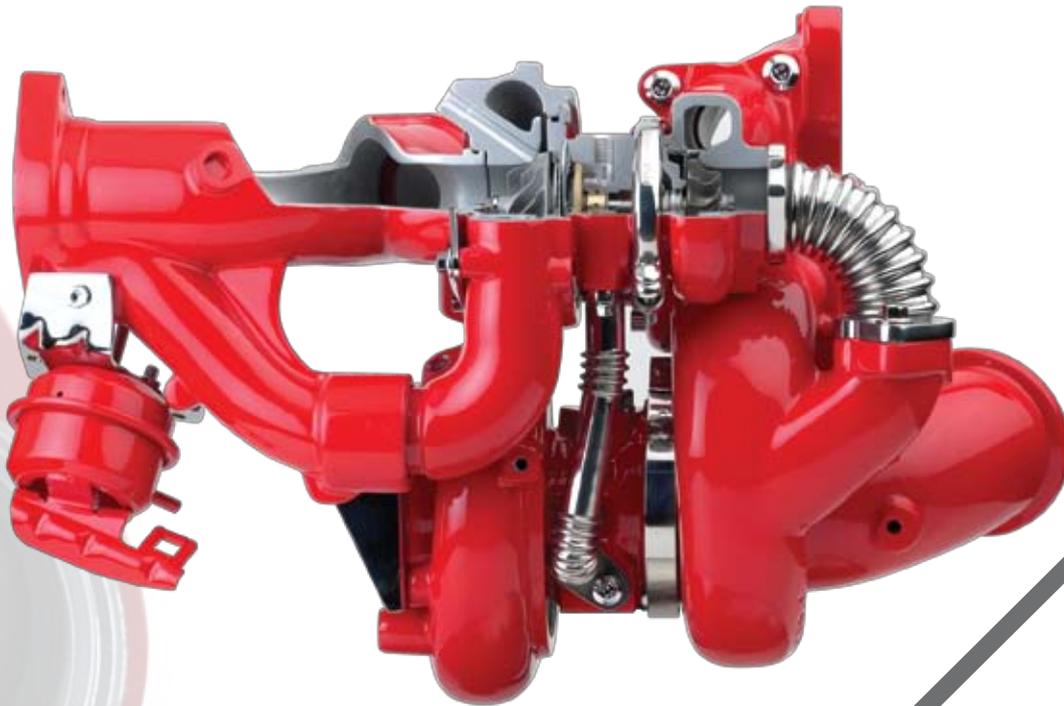
A sophisticated turbocharging strategy is one of the key factors that enables a small engine like the Cummins ISF 3.8 litre to deliver the blend of performance, fuel consumption and durability needed for this demanding application. The ISF is intended for use in small city buses and light urban delivery trucks, both of which are particularly severe applications because of the stop start nature of their duty-cycles. Customer requirements on

altitude capability without compromising durability could not be met with a single-stage turbocharger strategy, so this ISF engine is to use a wastegated two-stage turbocharging system from Cummins Turbo Technologies. Although the system may sound complex, because it comprises two separate turbochargers, the cost of replacement parts is lower than that of two-stage systems based on a single casting. As an added bonus, two-stage turbocharging will provide fuel consumption improvements of between 0.5% and 2.0% at full load.

Local knowledge – global resources

The 3.8 litre ISF engine for Brazil is the first Cummins engine for light-duty on road applications to use two-stage turbocharging. "I feel this two-stage turbocharged engine will be a success and sell well in the Brazilian market," says Rui Barbieri, Engineering Supervisor, Cummins Turbo Technologies Brazil. "Competitors' turbochargers used on city buses in South America have very high failure rates."

Cummins Turbo Technologies Brazil is proud to have carried out much of the engineering work. This includes many of the validation tests such as performance, oil leakage, thermal surveys, vibration, cold starts, duty cycles and durability tests. Working in collaboration with production engineers in China, technical experts in the UK and engine performance engineers in the US and Brazil, this turbocharging system is a truly international team effort. However, none of this would have happened without the Brazilian local market knowledge and passion to tackle the work.



Holset M² - modulating series sequential system

The multi-tasking M²™ system

A turbocharger configured to work well at low engine speeds is different from one designed for high engine speeds. A series sequential turbocharging system, involving two differently sized turbochargers, effectively gives you a small turbocharger for low air flow requirements and a large turbo for high air flow. The small turbo also provides the advantage of good transient response due to its low inertia. The difficulty with series sequential systems is the control and switching of the bypass valve that allows the individual turbochargers to be switched in and out. The packaging of two turbochargers and a bypass valve may also be difficult where space around the engine is limited.

One Valve

The new M² system from Cummins Turbo Technologies incorporates a novel new rotary valve to open ports that perform the bypass or wastegate functions. By means of a clever patented design, this single rotary valve not only works as a high pressure turbine bypass and a low pressure turbine wastegate, but also provides exhaust aftertreatment thermal management and an engine braking function, all from the one actuator!

At low engine speeds, the rotary valve is positioned so that all the exhaust gas passes through the small turbine. The gas passes through the second, larger turbine afterwards, but as the flow is small and the second turbine is big, only a small amount of energy is extracted here. As engine air flow increases with engine speed and load, the electrically actuated rotary valve modulates to allow an increasing amount of exhaust gas to go directly to the large turbine. This large turbine increases its work contribution whilst the work done by the smaller turbo stays relatively constant. At high engine speeds, the rotary valve diverts most of the exhaust gas directly to the large turbine, leaving the small turbo contributing very little.

In this condition, the compressor bypass valve is opened to avoid the small compressor becoming a restriction to the incoming air. At this point the system is now working as a high flow single-stage turbocharger.

Not only does M² provide a variable turbine flow but the two compressors also deliver variable compressor functionality, with a flow range wider than can be achieved with a conventional compressor map.

Although good fuel economy demands high turbocharging efficiency, there are instances where it is useful to deliberately reduce efficiency. For example, it may be necessary briefly to make the engine work harder in order to raise the exhaust temperature to regenerate a diesel particulate filter in the exhaust aftertreatment system. Positioning the rotary valve to restrict the exhaust passage produces the necessary increase in exhaust back pressure to make the engine work harder, and therefore hotter. If the rotary valve is closed completely, the exhaust passages are blocked providing an engine brake without needing any extra hardware.

The example shown in the photographs is a prototype suitable for mid-range engines of between four and six litres. Cummins Turbo Technologies would work with an OEM to provide a bespoke package for its specific engine. Our new range of small turbos will also be ideal for use in two-stage systems such as the M².

Big News for Smaller Engines: Introducing Our New Family of Holset Turbochargers for Small Diesels

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

Long known for its expertise in the medium and heavy-duty diesel engine market, Cummins Turbo Technologies is set to extend their scope with a new range of Holset turbochargers for smaller engines.

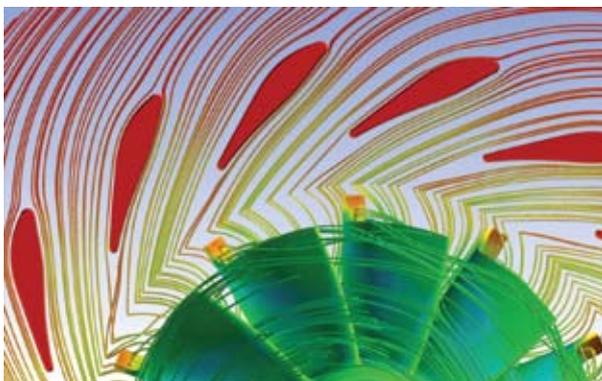
Designed specifically for diesel engines with displacements of between two and five litres, the new turbochargers were launched in September at the IAA in Hannover, Germany, the leading European trade show for the commercial vehicle industry.

"These new products combine the best knowledge gained from our experience and heritage in the commercial diesel market, with strong market research and customer collaboration to ensure that they have been designed specifically to meet the needs of the smaller engine market," said Jim Lyons, Cummins Vice President and President of Cummins Turbo Technologies, speaking at the IAA. "The turbochargers meet customer size and weight requirements while providing the durability and reliability that is the Cummins Turbo Technologies hallmark."

Why small turbochargers?

The new range has been developed in response to the increasing focus on fuel economy and engine downsizing of our existing customers and to meet the needs of the global diesel engine market across a range of applications worldwide.

With this increased focus on small turbos, Turbo Technologies are now able to offer current customers in current markets smaller VG turbos for both twin turbo and single-stage solutions and also to instigate growth into other areas, notably the light commercial vehicle (LCV) market. After the passenger car market, the LCV sector is the second largest turbocharger market in the world (Source: PSR 2009).



Computational Fluid Dynamic (CFD) modelling image showing gas flow through the variable geometry nozzle into the turbine wheel

Combining experience with innovation

The Holset product brand has been synonymous with turbocharging and aerodynamic excellence for more than 50 years. During that time we have developed an enviable reputation for the pursuit of efficiency, durability and emissions reduction. Independent market research commissioned by Cummins Turbo Technologies confirms that there is a gap in the LCV market for a small turbocharger that is more durable than those currently available. Our new turbochargers, developed by an international team of Cummins Turbo Technologies engineers from China, India and the UK, can now fill that gap.

The right technology matters

Cummins Turbo Technologies has a long history of working in partnership with our customers and as a subsidiary of a global engine company, we are proficient in working as part of an integrated team to ensure optimum technology selection.

Our expertise and application of analysis led design tools enables comprehensive accurate, right-first-time turbo selection and engine performance prediction, ensures long service life and optimises thermodynamic performance.

The new range features our class-leading compressor technology. Compressors are sized to cover a wide flow range with the best available efficiency and provide options on performance characteristics like pressure ratio capability. Map width enhancement and impeller tip treatment extend the operating range and provide optimum efficiency and pressure ratio characteristics.

The innovative oil sealing technology in our rotor system design extends the 'leak-free' operating envelope and provides ultimate performance and reliability on high pressure applications. Lead free bearing materials are utilised in line with the move to eliminate hazardous materials.

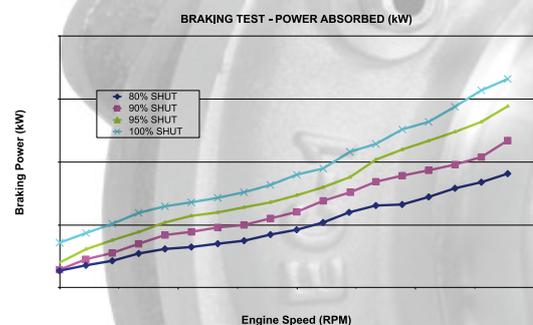


Fig 1 - Graph showing braking power enhancement by use of the variable geometry turbocharger



“These new products combine the best knowledge gained from our experience and heritage in the commercial diesel market”

Holset VGT™

Variable geometry turbochargers provide optimum power output with efficient fuel consumption.

The new range of Holset variable geometry turbochargers for small engines uses our proprietary market-leading sliding-wall design. The Holset VGT design has been enhanced specifically for smaller engines and its features include:

- World class, robust performance owing to low number of moving components
- High resolution and precise regulation
- Can be combined with speed sensors to feed data to engine management system
- Electric actuation with on board controls and diagnostics reduces load on the engine control unit.

Increasing system integration requires every component within the vehicle to contribute to overall cost-effective performance. The proprietary sliding wall design of Holset VGT offers additional benefits to the entire vehicle system.

- The Holset VGT can be used to raise the temperature significantly in the exhaust system at engine idle, thereby regenerating the diesel particulate filter without the need for additional dosing systems
- Exhaust manifold pressure can be strategically raised to drive exhaust gas recirculation (EGR) and help meet emissions targets
- Braking mode capability can replace additional downstream exhaust brakes and extend wheel brake service life (Figure 1).



Holset 200 Variable Geometry Turbocharger (HE200VG)

Wastegate turbochargers

Wastegate turbochargers are most suited to applications with mid to low power densities. Our wastegate products offer a reliable, durable and cost effective solution. Their features include:

- High bypass flow capability optimised by use of computational fluid dynamics (CFD)
- Actuator mounting developed with the customer for optimal packaging
- Simple boost feedback system or electronic valve control for more advanced shaping of the boost curve
- Compressor wheels are available either as castings for a cost effective solution on light and moderate duty-cycles or machined from solid (MFS) for enhanced fatigue life in arduous duty-cycles.

Our new range of turbochargers for two to five litre diesel engines will be available globally from 2011. For further information, please email smallturbo.enquiries@cummins.com.



Holset 200 Wastegate Turbocharger (HE200WG)



What's in a Name?

Introducing Our New Model Naming System

Written by Joanne Worthington; Senior Marketing Coordinator

Part of being a customer focused organisation is the ability to see ourselves from our customers' point of view. So when feedback from a recent Six Sigma project told us that customers found our model naming system rather complex we concluded that this was an issue that we should tackle.

Sophisticated technology delivers clear benefits but a straightforward and clear naming system that our customers can easily refer to is also needed. Our aim was to establish a straightforward and logical approach to model naming that makes it easy to relate each turbocharger product to the technologies it uses. Cummins Turbo Technologies implemented the new model naming system on 1 October 2010 and it will be used in future for new releases of Holset products.

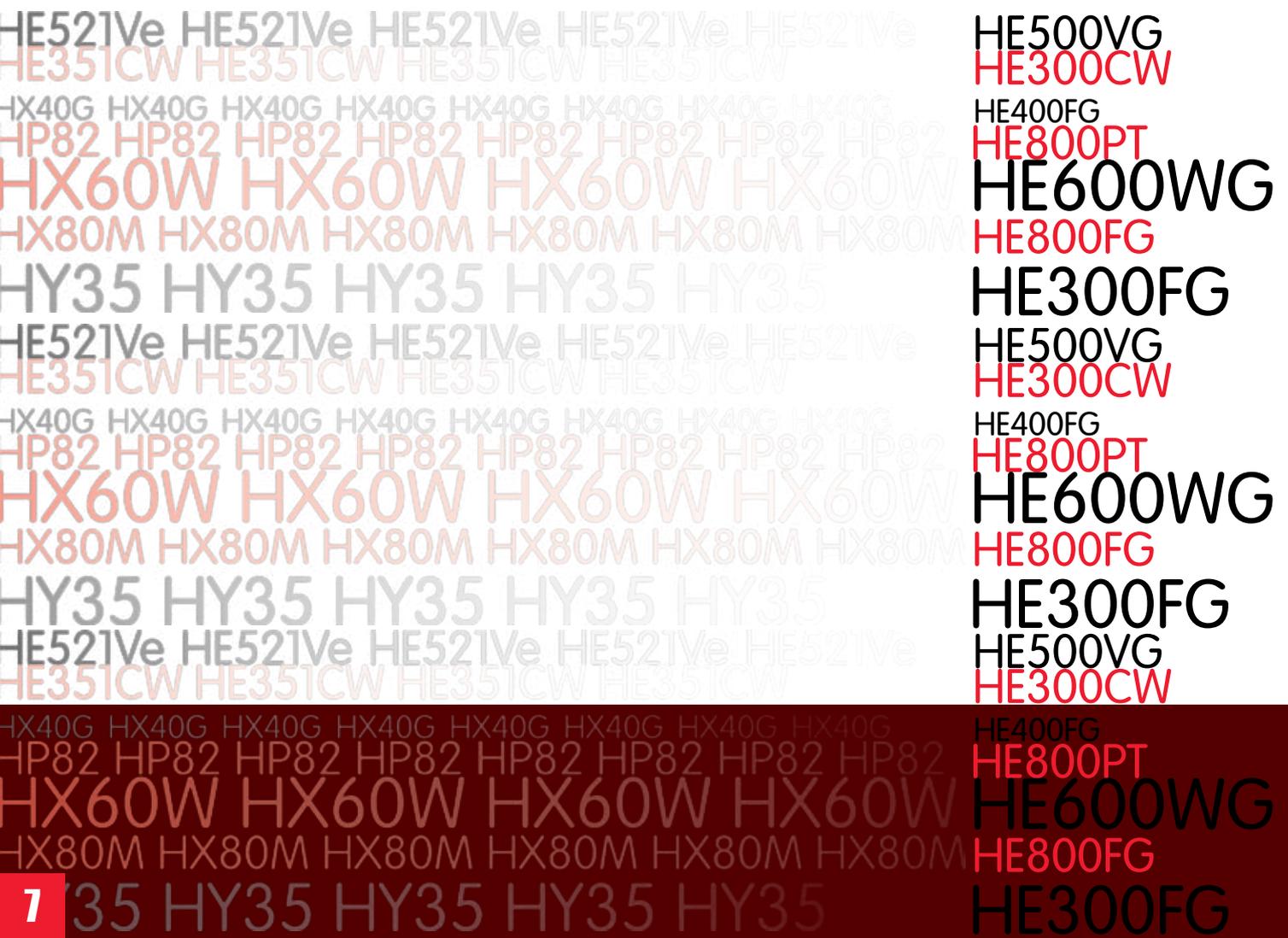
The new naming system brings many added benefits, both to our own employees and to our customers. The model designation includes series and platform details, making it simple to correlate the model name with the product. We provide a

clearer indication of product size and type of technology. The new system is also adaptable for naming future products. At the same time it allows us to present our large and diverse product range in a market friendly manner. At an engineering level, product specifications will still use the same nomenclature.

Preparing Cummins Turbo Technologies for change

To ensure we communicate a consistent message about our new naming system to our customers, employees are participating in training delivered online or via local site briefings. This was the first time Cummins Turbo Technologies used online training to roll out uniform, consistent training to employees right across the world. The goal is a seamless transition to the new naming system with minimal disruption to the business. Quick reference cards are also available for cross referencing.

Given the nature and complexity of our industry, adopting this new naming system is one more way in which we can contribute to business success by bringing Holset products to market with as much clarity as possible.



Prepared to Share:

An Open Approach to Knowledge and Training

Written by Owen Ryder; Principal Engineer – Engine Air Systems

Knowledge is power, so the saying goes, perhaps explaining why many companies guard their technical knowledge so closely. Why give away what they have worked so hard to learn?

At Cummins, one of our mission statements is “Partnering with our customers to make sure they succeed.” Another is “Creating wealth for all stakeholders.” The implication of these two statements is that we are not in the business of keeping our customers and suppliers in the dark. We believe that by sharing knowledge and talking with our partners on a highly technical level, we improve the knowledge base of all concerned. This continuous circulation and improvement of technical knowledge raises the level of discussion, making it more likely that we arrive at better solutions and develop better products.

A company with a key piece of know how has a competitive edge, but only until its rivals catch up, as surely they will do. What gives an enduring business advantage and really differentiates a company from its competitors is the rate at which knowledge is gained. As a diverse collective, the value of Cummins Turbo Technologies and its partners with a common goal is stronger than the sum of its individual parts. We believe this synergistic strategy makes Cummins Turbo Technologies **the** technology partner for any air handling needs.

Training is a two-way street

Turbocharger machinery theory and practice is not taught in many universities and although textbooks cover the theory of turbocharger component design, there is little material available on the holistic application of turbochargers. We train our own people at Cummins Turbo Technologies, using in house resources and teaching staff, constantly updating the material to keep pace with the rapid rate of development. This training has also been delivered to our customers, partners and distributors.

During the last year we have delivered turbocharging training at three different engine manufacturing sites, at our distributor conferences as well as at our own facilities around the world. This means engine manufacturers do not have to develop their own turbocharging training for new starters. In return, the questions asked during these training sessions allow Cummins Turbo Technologies staff to learn more about the engine manufacturers’ requirements. Running a training seminar with an experienced audience brings learning to both parties. Similarly, delivering training to our distributors is an equally valuable two-way exercise. Distributors appreciate that they are improving their understanding of how our products work; we are opening another channel to learn more about issues encountered in the field.

We believe that this open approach and willingness to share our knowledge is one of the key strengths of Cummins Turbo Technologies, helping us to succeed with our partners. Our technical experts are ready and waiting to help you tackle your turbocharging challenges.



Growing our Green Routes:

Working with Talbott's Biomass Generators

Written by Lucy Bywaters; Engine Air Systems

Holset turbochargers have impeccable green credentials, improving diesel engine fuel efficiency and playing a major role in enabling engines to comply with today's strict exhaust emission limits. As a company too, Cummins Turbo Technologies demonstrates a strong commitment to the environment. We work to reduce waste, minimise pollution from our processes and cut energy consumption. More recently we have taken a third route to a greener, more sustainable environment by helping a company involved in renewable energy generation.

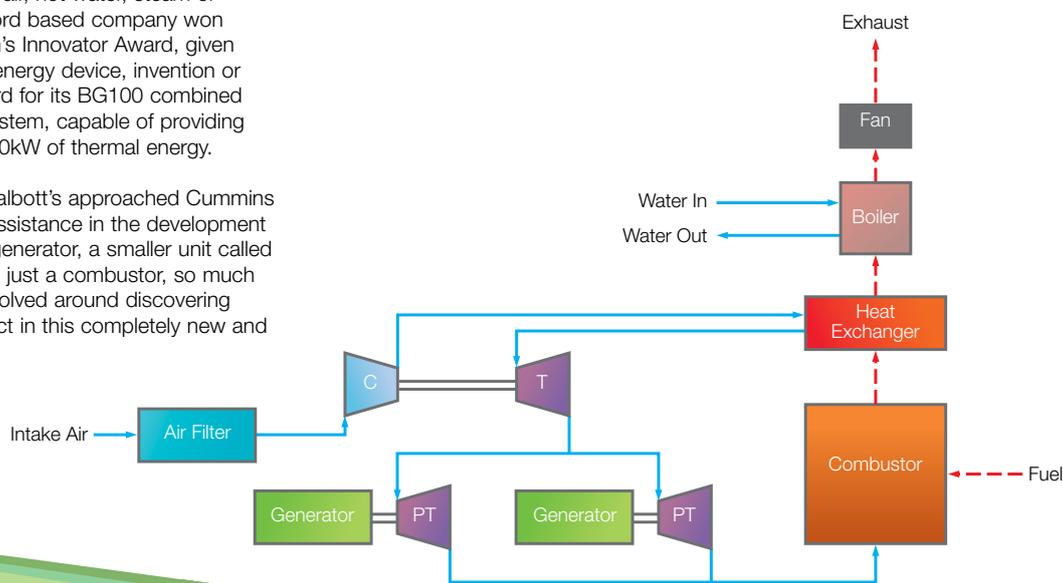
Talbott's Biomass Generators is the UK's largest manufacturer of energy generators that burn waste products from renewable sources (biomass) to generate hot air, hot water, steam or electrical power. In 2007 the Stafford based company won the Renewable Energy Association's Innovator Award, given for the best innovative renewable energy device, invention or application. Talbott's won the award for its BG100 combined heat and power (CHP) biomass system, capable of providing 100kW of electrical energy and 200kW of thermal energy.

After the success of the BG100, Talbott's approached Cummins Turbo Technologies for technical assistance in the development of its next generation of biomass generator, a smaller unit called the BG25. The unit has no engine, just a combustor, so much of our work on this project has revolved around discovering how our products work and interact in this completely new and exciting application.

How does it work?

The generator burns biomass fuel, usually either wood chips or pellets, in a stepped, moving grate combustor. The heat is extracted from the combustion gases in two ways. First, the hot gases pass into an air-to-air heat exchanger where they flow over compact stainless steel pipes containing compressed air from the compressor. Then the combustion gases are passed through an air-to-water heat exchanger in a boiler. This extracts the heat that remains in the gases, using it to produce hot water. The gases, now cooled, finally are exhausted to atmosphere with the help of an induction fan.

The hot compressed air exiting the air-to-air heat exchanger is directed through the turbine side of a Holset 500 series fixed geometry unit turbocharger, driving the intake of ambient air into the turbocharger's compressor. After leaving the turbine the air then passes through two 700 series power turbines set in parallel, each of which drives its own electric generator via a reduction gearbox and beltdriven system. This flow of expanded air is then recycled back to the combustor in order to recover its residual energy.



Talbott's BG25 system diagram

Operating automatically with computer control, the BG25 is capable of producing 25kW of electricity and 80kW of thermal energy. If the site does not consume all the electrical energy that is generated any surplus can be fed to the grid via a metered connection, earning additional income. Buyers of the units may be eligible for Carbon Trust subsidies and interest free loans as an incentive for using carbon neutral energy production. According to Talbott's, the installation of one of the units could save up to 160 tonnes of carbon dioxide (CO₂) per annum when compared to energy produced by burning fossil fuels.

Technology partner

In our role as a technology partner we have worked to assist Talbott's in every aspect we can. That has meant adapting our primarily engine based skills and tools to the new application of biomass combustors. The whole process has been an enormous learning exercise for everyone involved in the work. Cummins Turbo Technologies has supplied Talbott's with prototype turbo builds and carried out extensive system modelling and simulation work. Supported by an on-going dialogue and site visits, our contribution has enabled Talbott's to develop and refine the BG25 using methods that would otherwise not have been available to the company. "We have received all round support from Cummins Turbo Technologies," says Paul Firth; Managing Director, Talbott's. "We haven't just been given information on the turbocharger; we've also had help with oil systems, speed sensors, materials, etc. It has made a massive difference to our company and we have been offered a lot more help than expected."

The future

The market for the BG25 generators includes hotels, farms, schools and industrial units, both in the UK and overseas. For example, the company has recently received an order from an Italian farming co-operative that wants to assess the BG25's potential to help its members turn their waste into profit. Another international application is a major port development project in South Africa, whose developers are looking at using 18 of the units to aid their renewable energy generation. These generators would run mainly on agricultural residue, showing how they can remove waste from local trades and businesses and use it to benefit the local community's economy. Talbott's reports that the interest in the generators is phenomenal and includes enquiries about forthcoming larger units based on the same technology.

Cummins Turbo Technologies and Talbott's Biomass Generators have built up a great relationship while working together on this project. Work is currently underway to continue the project by developing similar units with larger power outputs. Dr. Sunil K Omar; Talbott's Technical Director, commented, "The development of units with larger power output involves investigation into new areas involving turbomachinery, which is only possible thanks to the supportive relationship with Cummins Turbo Technologies."



Talbott's BG25 Biomass Generator



**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.