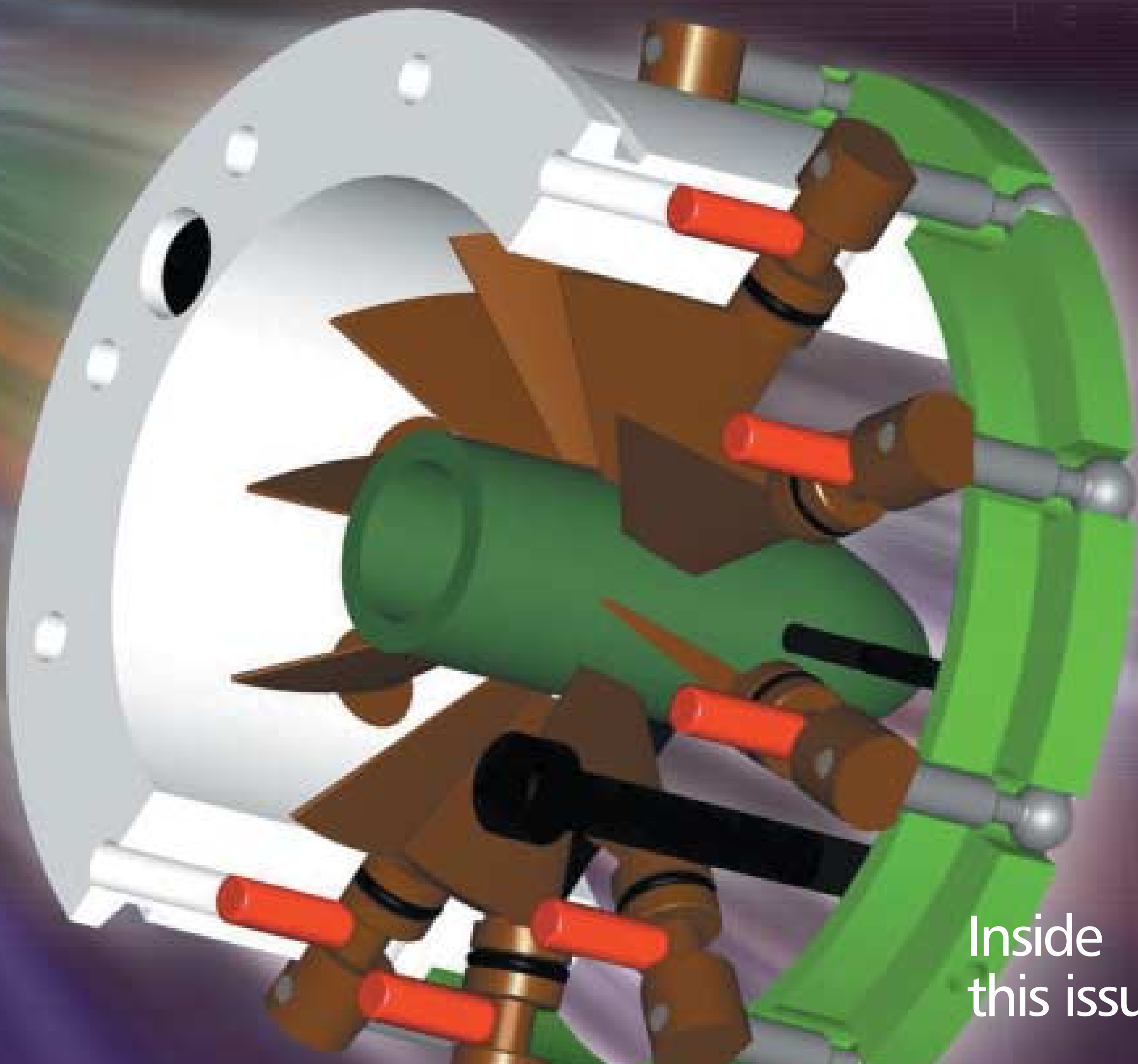
HTi

HOLSET TURBOCHARGERS

The latest news for Holset Turbochargers' customers



Putting VGC to the test

Inside this issue

ISSUE 2

What is the meaning of quality?

The meaning of quality – as well as the content - is a very complex issue. It differs from country to country and within every company.

Quality is defined by everything we do in business, from the processes we use to design and manufacture turbochargers; to the reliability and durability of our products out in the market place; and to the communication systems we are committed to develop to improve information sharing with our customers.

Holset Turbochargers places the utmost importance on achieving high levels of product and service quality and has a strict "Quality Policy" which all entities adhere to. The Quality Policy of Holset ensures that all products and services consistently meet or exceed our customer requirements, on-time and at the lowest cost.

Achieving high levels of product and service quality

Quality is at the very core of the company's business. The function has forged tight links to top management whose commitment to quality is one of the key factors in all business activities.

Continuous improvement is a way of life at Holset and our commitment to quality led to all Holset worldwide plants being accredited to TS16949 in 2003. This is a significant achievement and evidence of our strive for continual improvement which is also supported by our successful 6 Sigma programme. At Holset we welcome all comments and suggestions to further enable us to improve our performance to meet your needs.

Holset Turbochargers is a responsible corporate player who takes its environmental obligations seriously. Our products have an important part to play in helping to improve engine emissions and all Holset sites around the world have achieved environmental accreditation ISO14001. Holset China will follow after its relocation by the end of 2004.

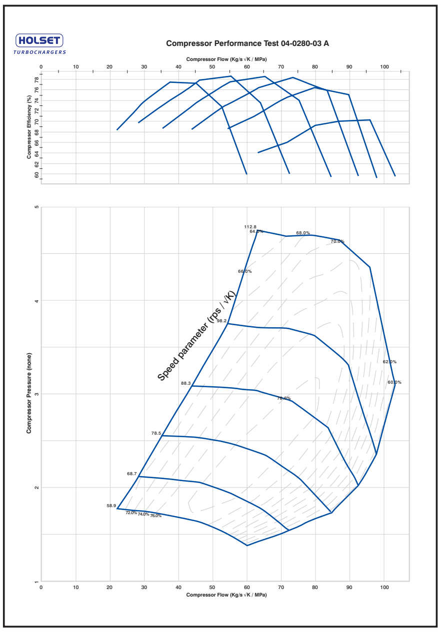
Holset is committed to its customers and to remaining the market leader in the medium to heavy duty turbocharger market.

Paul Ibbotson
Managing Director

HTi is the Holset magazine focussing on the world of heavy-duty turbocharging. It aims to bring you news on the product and market developments.

HTi is produced using an environmentally approved printing process and is printed on fully recyclable and biodegradable paper.

Machined-from-solid compressor wheels



Turbocharger impellers machined-from-solid aluminium, introduced by Holset during 2003, are already being specified by seven OEM customers, in mid-range bus to heavy truck applications; and the portfolio of engine makes and types continues to grow. Holset's machined-from-solid impeller technology has successfully progressed from the prototype stage to volume production at the rate of around 35,000 units a year.

This has been achieved thanks to a dedicated development team at Holset working closely with key suppliers. The end result is a leading-edge but cost-efficient product giving optimum performance and durability under the exceptionally high centrifugal forces experienced in the turbocharger of a modern commercial vehicle diesel engine.

Holset's £1.3 million machined-from-solid development programme began in mid-2001. The aim was to produce an aluminium impeller with substantially better durability than their cast aluminium counterparts. Impeller durability is a key challenge for all turbocharger manufacturers. The drive for greater horsepower and torque per litre of swept volume, has led to the increase in rotational speeds and operating temperature. At the same time, greater engine efficiency is being sought in order to meet ever-tougher exhaust emission limits, with the least possible compromises, especially on fuel economy.

Five-axis milling is now commercially viable

Since 1996, cast titanium impellers have, for Holset, met those higher durability standards – but at a cost. Not all applications need the temperature advantage offered by titanium however, and the cost and wider system implications of titanium has been seen as prohibitive by many customers.

When cast aluminium impellers fail in service it often results from metal fatigue traceable to casting defects such as oxides or other impurities. In contrast, the base material properties of the forged aluminium used for Holset's new machined-from-solid impellers are measurably superior and more dependable. In particular, the forging process breaks down oxide defects.

The subsequent five-axis machining operation - needed to achieve the intricate aerodynamic impeller blade profile and finish - means wheel geometry is not subject to casting surface tolerances and inherent foundry process variability over time. Recent manufacturing technology advances mean that five-axis milling is now commercially viable under volume production conditions. Previously its use was effectively restricted to prototype, one-off and small batch manufacture.

For many years, Holset has enjoyed a technological advantage over its competitors, thanks to the enhanced performance of its sophisticated 'arbitrary' surface blade design. As well as better performance, it brings an inherent service-life improvement over the more simplistic 'ruled surface' methods adopted by competitors. By working closely with five-axis machining suppliers, Holset has developed a cost-effective machining method without compromising its unique blade design.

Even though it has been a step-change in aluminium impeller durability for Holset, through the move from cast to machined-from-solid manufacturing, the company's policy of ongoing development continues. The company's engineers and metallurgists are engaged in programmes aimed at better understanding of the fundamental mechanisms which drive failure, with a view to further evolution involving refinements to the material structure. Academic input from a number of university teams in combination with the practical experience of cutting edge suppliers is helping the aggressive pursuit of new cost reduction opportunities. This technical expertise and sharp commercial focus will bring even greater value to Holset's OEM customers, and to diesel engine end-users, in the next few years.

Holset MFS technology development team. Pictured left to right: Qiang Zhu, Dimitrios Giannis, Luke Hankin, Marie Kerr, David Wescott and John Wesolowski. Not pictured Stuart Mann, Simon Wellings and Duncan King.

Choosing the right turbine for

The job of the turbine inside a turbocharger is to extract energy from the exhaust stream, via the change in momentum of gas through the turbine blades. There are many potential turbine configurations able to perform this 'momentum exchange' role. They include radial, axial, drag and tesla turbines as well as the pelton wheel. Each has its optimum application, where its efficiency is exploited to the maximum. A dossier of design guides has been built up over time, in which hundreds of turbines have been analysed in different applications.

One such piece of work was that of a consulting engineer named Balje, who documented the performance characteristics of many turbines. He presented the turbine data in terms of 'specific speed', from which a designer could pick a machine type likely to give the best efficiency. From Balje's plots of turbine stage efficiency against specific speed, it is apparent that an axial or radial flow turbine is more efficient at higher specific speeds, whereas at lower specific speeds, a drag or tesla turbine would be the best choice.

'Specific speed', of a turbine of a certain size operating at a particular rotational speed, is arrived at via dimensional analysis and similarity considerations. It is a convenient way of expressing the flow and pressure ratio handling abilities.

The gas flow and installation size requirements of Holset's range of turbochargers mean they all operate at a sufficiently high specific speed for the choice of turbine to be effectively limited to radial, mixed flow or axial flow.

For such high specific speeds there is a lot of overlap in the efficiency versus specific speed curves of axial and radial inflow turbines. The fact that the curves overlap and that axials do look better at higher specific speeds may be one reason why mixed flow turbines were originally considered. A mixed flow turbine is just that, the inlet flow is neither radial or axial, enabling it to deliver a good efficiency compromise between the axial and radial at those specific speeds where a normal radial turbine would be less efficient.

So, given the choice between radial, axial and mixed flow, an often asked question is 'why does Holset only use radial inflow turbines for its turbocharger turbines?' As with many aspects of engineering, the answer is not clear cut. But the features of each and hence the reasons for selecting radial inflow can be analysed.

AXIAL FLOW TURBINE

Axials don't get used regularly in 'small' automotive turbochargers - those for engine sizes up about 1000hp (745kW) per turbo – like Holset's HE800 model. At higher engine ratings, a larger unit or multiple turbos are normally used. For turbos larger than HE800, it is quite common for axial-flow turbines to be specified, typified by many designs from ABB, KBB, Napier, MAN and Hispano Suiza.

Axial turbine efficiency is sensitive to rotor tip clearance, more so than with a radial inflow turbine. Consequently for small turbochargers, the efficiency loss through tip clearance would usually make a radial turbine more efficient.

In most axial turbines the gas flow is accelerated into the wheel using a nozzle ring. In a Holset radial, it is done by a spiral 'volute', but without a cost-adding nozzle ring. The axial also needs a 'housing' to collect the exhaust flow, but because it also requires an additional component, namely the nozzle ring, it tends to make the axial turbine more expensive than its radial counterpart.

No distinct efficiency advantage over radials

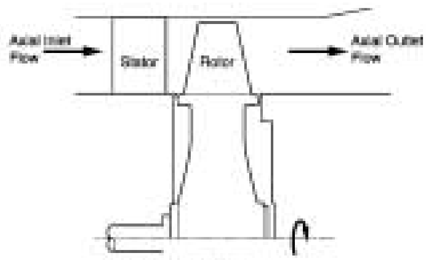
In a Holset investigation into published data for 'small' axial turbines, stage efficiency was plotted against wheel diameter and compared with equivalent in-house radial turbine data. Whilst not totally conclusive, it showed that, for wheels up to about 130mm diameter, axials offered no distinct efficiency advantage over radials.

Another issue with axial turbines is installation bulk. For maximum efficiency, the axial needs a relatively large exhaust diffuser and collector. So, for the same performance, an axial can be more difficult to package, or within the same dimensional envelope, the axial would offer no performance advantage over the radial.

In some cases, irrespective of the efficiency argument at high specific speed, the axial brings both manufacturing and packaging advantages. For the downstream turbine in a diesel engine turbocompound installation, an axial turbine can offer a better packaging solution due to the ability to have a 'rear facing' exhaust.

When the gas flow rate through a radial turbine increases, so inevitably does the size of the wheel. As the wheel is made from inconel, a nickel-based 'super alloy', the large-flow radial becomes correspondingly heavy and costly. The wheel can also be difficult to cast. Here an axial turbine, which for the same diameter can pass more flow than the radial, may well make better economic sense, as well as affording the operational response advantages of lower mass and inertia.

Axial turbine manufacture poses particular challenges. For a large axial, casting its long slender blades on to what is a relatively large hub can be difficult. So instead, individually-made blades are often mounted on to the hub in what is popularly known as the 'fir tree' root arrangement. However such a technique would be too costly for a small



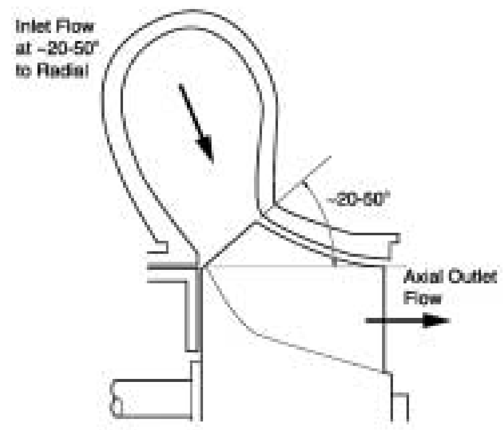
Axial flow Turbine "Axial"

wheel. Consequently, smaller axial turbine wheels are usually of 'blisk' construction that is an integrated, one-piece, blade, disk and hub arrangement. However, it requires complex tooling and limits the designer in his choice of blade shapes more so than with a radial.

With axials, it is also common practice to apply a 'damping wire'. Often long and slender axial blades are prone to forced vibration. Many large turbocharger axial turbine wheels accordingly incorporate a hole in each blade at about 50-75% span, allowing a wire to be passed through all the blades as an anti-vibration damping medium. Such a solution would be impractical, for cost and other reasons, on a small axial wheel being produced in high volumes. Potential vibration issues therefore have to be tackled more fundamentally, through basic blade design. But that in itself can lead to unfortunate compromises. The best axial blade shape from an aerodynamic/turbine-efficiency point of view is often not ideal for resisting vibration modes.

the automotive turbocharger

MIXED-FLOW TURBINES



Mixed flow Turbine 'Mixed Flow'

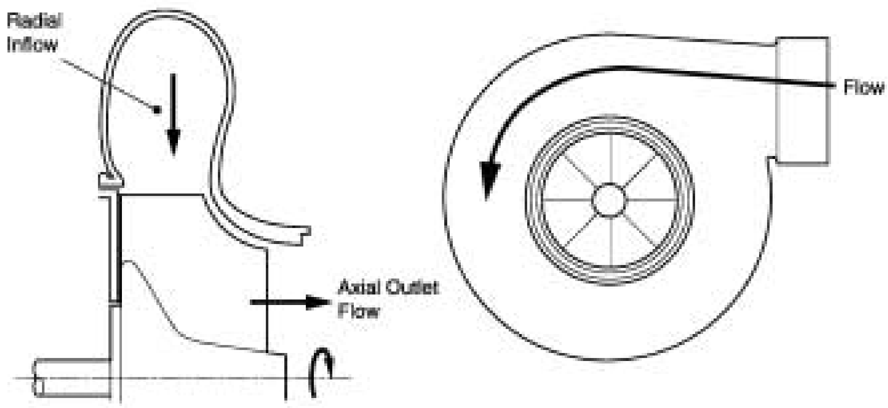
The original motivation for using mixed-flow turbine wheels was that of reducing the mass and inertia of the turbine rotor, so as to improve transient response from the engine, most obviously when the driver of a truck demands immediate maximum acceleration. Inertia reduction could sometimes be achieved without impact on aerodynamic efficiency, most obviously through a reduction in volume and weight of blade/hub material.

Later work tended to show that a mixed-flow turbine may have advantages over a radial design in several respects. The use of a cutback leading edge on the blades of a mixed-flow rotor effectively allows a non-zero inlet blade angle whilst maintaining radial blade 'fibres' for mechanical design reasons. This is said to allow both an improved aerodynamic blade loading – leading to greater efficiency - and the ability to 'adjust' the turbine's peak efficiency point to a higher or lower rpm. That facility comes into its own when the engine manufacturer wants to maximise the pulse energy from the exhaust.

Maximises pulse energy from the exhaust

As a mixed-flow turbine wheel can handle a higher gas flow than a radial of equivalent diameter, it opens up the possibility in a given application to go for a smaller wheel with almost certainly lower inertia. However, the jury is still out on mixed-flow efficiency benefits vis-à-vis an equivalent radial. Mixed-flow merits must, in any case, be set against the more complex tooling required to produce an investment casting mixed-flow wheel. Furthermore, the turbine housing needed to run the wheel may itself need to be of 'mixed flow' configuration, or canted over in a way that could hinder installation in a vehicle's congested engine compartment. Holset's collaborative work with Imperial College, London, on mixed-flow turbine technology has now finished. But there remains a good deal of investigative work still to do.

RADIAL INFLOW TURBINES



Radial Inflow Turbine 'Radial'

In many applications, where cost and simplicity are ever greater influences, radial turbines have significant attractions. In Holset's small flow turbochargers of circa 130mm diameter, for the tip clearance reasons discussed earlier, the radial turbine offers a better performance than an equivalent-flow axial. As the radial also has no need of a separate nozzle ring, manufacture is simplified and cost is reduced when compared with its axial counterpart.

Choosing between radial and mixed flow is less straightforward. But extensive Holset studies still show the radial to offer the best efficiency-cost balance. There is still more work to do to fully understand the potential inertia benefits.

In the future, we might well investigate the use of axials as power turbines in turbocompound installations. Their performance level at these sizes is comparable with a radial and their compact dimensions in such an application could outweigh manufacturing and/or cost penalty. As for mixed-flow, they are likely to be more expensive, take longer to design and develop, while offering no clear advantage over a radial, other than perhaps making for a more compact installation.

Offers the best efficiency cost balance

For the foreseeable future, Holset regards the radial inflow turbine as the best choice for most applications, but developments in axial and mixed-flow technology will continue to be monitored.

Turbocomp

Turbocompounding, of the kind adopted by Swedish heavy truck manufacturers in recent years, is a technique involving use of a second power turbine. Located in the exhaust system, usually downstream of the turbocharger, it feeds additional power from the exhaust gas into the engine crankshaft mechanically, via a reduction gear train. It is also possible to harness the turbocompound's power output in some other form, for example to drive an electrical generator or an air compressor.

In the 1930s the pioneer of diesel engine turbocharging, Alfred Buchi, proposed a system where the engine was used as a gas generator for a downstream power turbine whose mechanical output could be taken independently to power for example, a rail locomotive.

True turbocompound systems (in the sense of the combined power output of the engine and the power turbine being taken from the engine crankshaft) first found favour in aircraft piston engines in the 1940s and 50s to boost performance on take-off and improve cruising fuel consumption.

Well known examples are, from the US, the Wright Cyclone, a spark-ignited 18-cylinder radial engine with a two-speed mechanically-driven supercharger and three axial-flow power turbines. Even more complex was Britain's Napier Nomad engine, a flat 12-cylinder two-stroke diesel with a variable-speed gear connecting the 'turbocharger' – actually a modified gas turbine – to the engine crankshaft. Power could be enhanced by water injection into the inlet manifold and by afterburning between the engine and the power turbine. Unfortunately the relative simplicity and light weight of the emerging simple gas turbine competition put an end to these developments.

Subsequently, marine engine turbocompounding was promoted by Brown-Boveri from Switzerland. A power turbine was installed in the main engine exhaust to drive a free-standing electrical generator. It provided power which would otherwise have needed additional auxiliary generators.

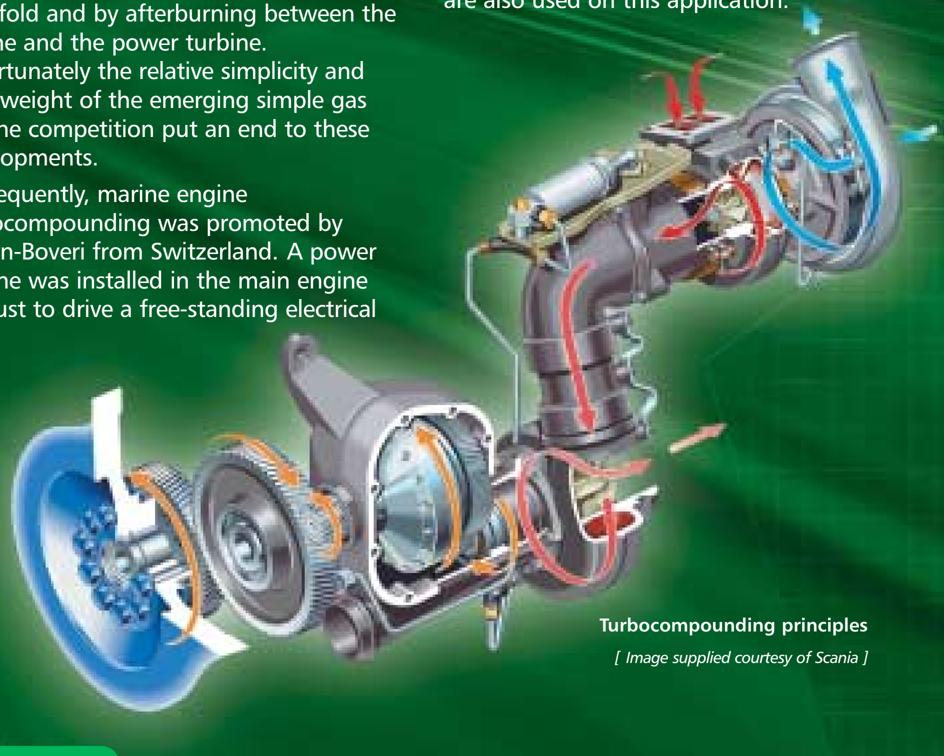
On heavy trucks, various experimental turbocompound engines have been reported, but the Scania 12 litre DTC12 engine was, in 1991, the first production example of a mechanically-connected turbocompound engine. Working closely with Scania, Holset developed the power turbine and the turbocharger for this engine.

Today, Scania customers can specify its 11.7 litre 470hp Euro 3 DT12 engine, and the new R Series truck also uses Holset turbocompound technology for its Euro 4 engines.

Boost's thermal efficiency

Volvo recently introduced a turbocompound engine, the 12.1 litre 500hp DT500, using a Holset turbocharger.

The Cummins-Compair 5.9 litre 6BTTAA engine is an example of an industrial turbocompound application where the power turbine is used to drive an air compressor for supercharging an industrial air supply through the engine-driven screw compressor. Holset turbochargers are also used on this application.



Turbocompounding principles

[Image supplied courtesy of Scania]

pounding

In simple terms, the object of turbocompounding is to boost thermal efficiency – that is to maximise the energy recovery from the fuel burned. In modern highly-turbocharged engines designed for the best possible fuel economy, significant energy remains in the hot exhaust gas after it has done its work in the turbocharger.

At full load the exhaust gas is typically at a temperature of 500 to 600°C at the outlet from the turbocharger. With typical exhaust mass flows of at least 0.5 kg/sec for a heavy-duty engine, there is the potential for significant downstream energy recovery. On stationary engines this is very often done in combined heat and power installations through the use of water boilers to provide heating capability, often in addition to the electric power from an engine-driven generator. But for a vehicle engine the prime demand is for 'crankshaft power' which can be turned into vehicle performance. Turbocompounding is therefore directed to augment that crankshaft power.

Scania 12 litre 470 turbocompound engine, D12

[Image supplied courtesy of Scania]

Just how much power can be recovered by the power turbine is in practice limited by the back pressure which the power turbine expansion-ratio imposes on the engine. Four-stroke engines can work effectively against considerable back pressures. But the positive work gained from the turbocompound power turbine can all too easily be offset by the work the engine has to do in pumping air against the exhaust back pressure. A balance has to be found where the positive work exceeds the pumping work loss over a wide range of engine operation. Typically a net gain in power of around 4 to 5% is achieved at rated conditions. For a given power level this results in a reduction of specific fuel consumption of about the same percentage.

Increased power and lower emissions

Power turbine back pressure has another effect on the air handling side of the turbocharger installation. The flow characteristic of the turbocharger turbine has to be altered to account for the much higher exhaust gas pressure at its inlet. A smaller volume flow turbine is therefore needed – for example if a power turbine expansion ratio of 2:1 was to be used, the turbocharger turbine would see its own inlet pressure doubled. It would then need half the volumetric flow capacity, compared with its non-turbocompound counterpart. A different design of turbocharger turbine is therefore likely to be needed, to ensure that efficiency is not lost by a poor turbine-compressor match.

However, the small turbocharger turbine in itself gives another system advantage to a turbocompound installation. At low engine speeds the downstream power turbine contributes little power, creating minimal back pressure resistance to the turbocharger turbine. The engine "sees" only a small turbocharger turbine. This has correspondingly low mass and inertia, helping to give better transient response as well as higher boost pressure for improved low speed torque. The behaviour of the two turbines in series – turbocharger and turbocompound power turbine – is a dynamic one across the engine speed and airflow range which can be exploited by good matching of the turbines.

Mechanical design of a turbocompound power turbine must receive special attention from a durability point of view. The power turbine bearings have to cope with the torque loads transmitted back through the vehicle gearbox. In the Scania and Volvo turbocompound engines now in production, the fluid coupling in the drive train 'cushions' the power turbine and high speed gears against crankshaft torsional vibrations and gives some protection to the system during engine start-up and shut-down.

Turbocompound progress over the years is a fascinating example of the quest for engine systems giving better efficiency, increased power and torque and lower emissions, which has characterised engine and turbomachinery development from its early days.

Increasing compressor map width - the best approach?

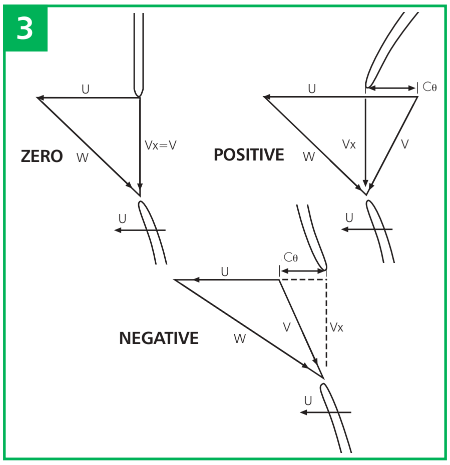
Variable geometry compressors (VGCs) – as opposed to turbines - for automotive engine turbochargers are not common. The basic technology for VGCs is not new however. It is applied routinely in gas turbines and process compressors for example. So why are VGCs not routinely used in automotive turbochargers?

And why are they not used by Holset in preference to the compressor range improvement technique used today, namely Map Width Enhancement (MWE)?

There are several ways of making the compressor geometry variable. Each technique aims to vary the angle of the airflow into the compressor – that is to control the incidence of flow on to the blades – or to vary or to alter a particular flow area somewhere in the compressor stage, effectively varying the compressor size. Configurations that vary the compressor diffuser area are much more common than those which change the actual compressor cover throat area.

Figure 3 shows the effect of pre-swirl on inlet velocity triangle.

3



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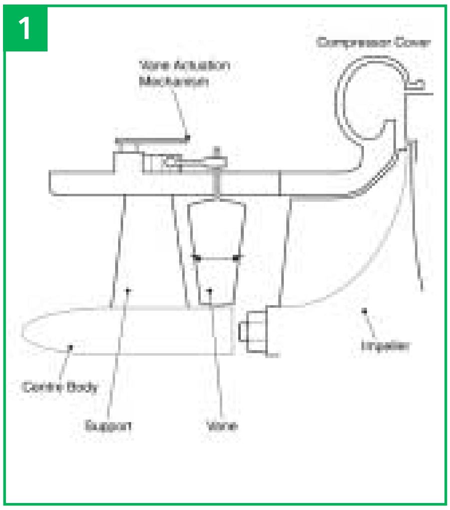
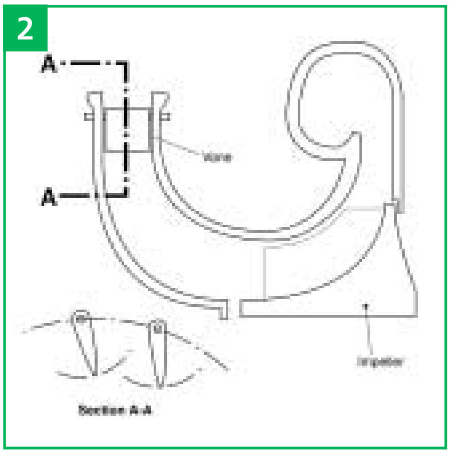


Figures 1 and 2 show diagrams of axial inlet guide vanes and radial inlet guide vanes respectively.

2



Varying the inlet flow angle to the compressor usually involves a row of small vanes whose angle can be controlled. The vanes can be positioned axially upstream of the compressor inlet, or radially upstream ahead of a radial-to-axial inlet - that switches the flow from a radial to an axial direction – ahead of the compressor inducer.

An analogy can be made with an aircraft wing under stall conditions. In level flight the air hitting the leading edge of the wing does so roughly at the same angle the wing is at. That is to say there is little 'incidence'. But if the aircraft is then put into a steep climb, that incidence difference - between wing angle and the oncoming airflow would be large. Eventually, the incidence angle reaches a point where the airflow will not stay attached to the upper surface of the wing.

The basic technology for VGCs is not new

It will 'separate' from the wing, losing lift and creating a stall condition. In the case of a compressor inlet blade, the role of the inlet guide vanes is to change the flow incidence angle on to the blade at low flow levels so as to reduce the onset of inlet blade stall and 'surge', that is compressor instability at low air flows caused by flow separation or reversal in the impeller inducer or diffuser.

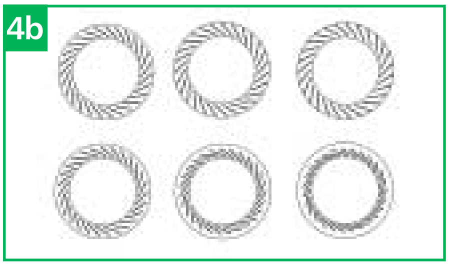
By building in a mechanism capable of varying the diffuser vane angle, the throat area of the diffuser can be increased or decreased, allowing the map width – or breadth of flow difference between 'choke' and 'surge' – to be increased. Choke is the 60% efficiency point at any given operating speed. Intake air delivery to the engine can thus be more readily optimised. Other strategies for varying diffuser throat area have been proposed from time to time. These include a moving-sidewall version with

Figure 4a shows a typical vaned diffuser arrangement with the compressor cover removed.

4a

Figure 4b shows vane setting angle changes on individual prototype diffusers to simulate, when tested, the operating range of a variable vaned diffuser.

4b



some similarities to Holset's successful VGT turbine geometry specified by Iveco and others. Moving the diffuser sidewall changes the diffuser throat area.

Holset has to date built and tested in experimental form the three main varieties of VGCs. In each case the main aerodynamic features of the device have been tested, though actuation mechanism have yet to be refined. Inlet guide vane testing was done by setting vane angles manually and then producing a performance map of each setting angle. Similarly, variable-vaned diffuser experiments have been undertaken with fixed vanes machined at a selected variety of angles.

In the radial inlet guide vane (RIGV) tests, the results were disappointing. Some movement of the surge and choke lines were achieved. But in MWE terms, the results showed little advantage over fixed geometry compressors with map width enhancement.

Figure 5 shows the Holset RIGV hardware and fixed vanes used for the variable vaned diffuser tests.

However, the axial inlet guide vane (AIGV) tests proved much more successful. The surge and choke lines could be manipulated significantly. When compared with existing fixed geometry maps, improvements in surge margin are significant although, when they are set in any position other than purely axial, the vanes detrimentally affect the operating speed and efficiency of the compressor.

Holset's experiments with variable-vaned diffusers showed that overall map width can be varied significantly, mainly by modifying the 'choke' flow of the compressor map. 'Overall range' defines the difference between the surge flow with the vanes in their most closed position and choke flow when the vanes are fully open.

Figure 7 shows the effect of the RIGV on the compressor map.

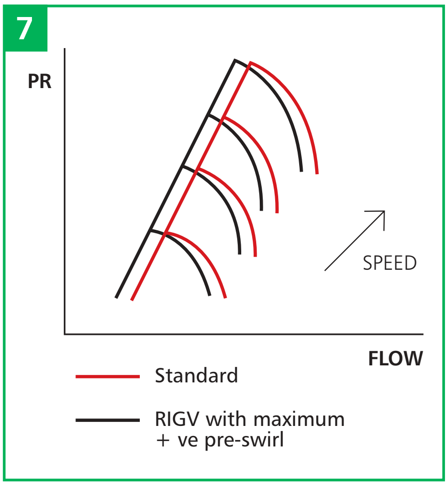
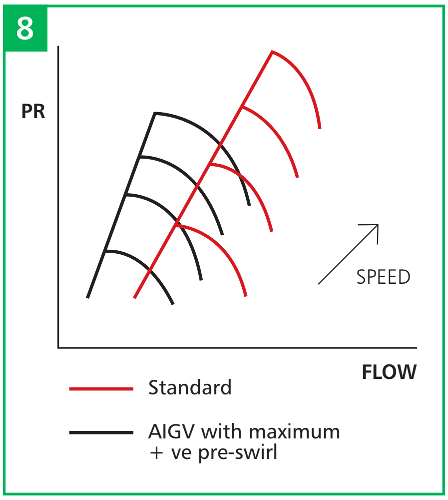
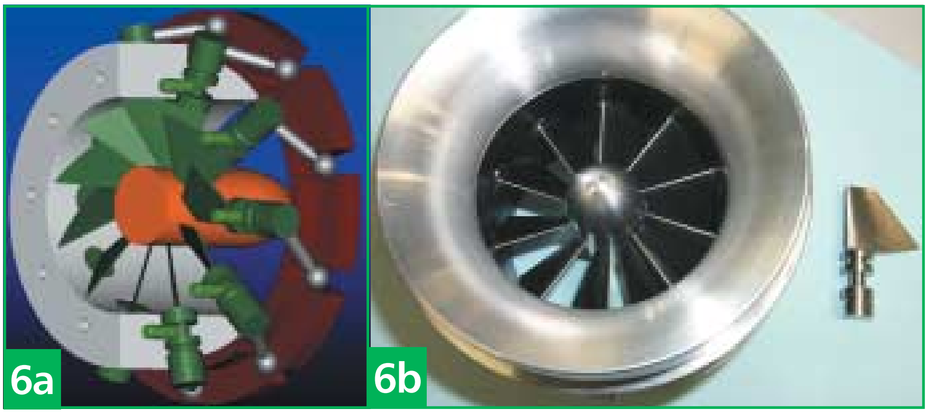


Figure 8 shows the effect of the AIGV on the compressor map.



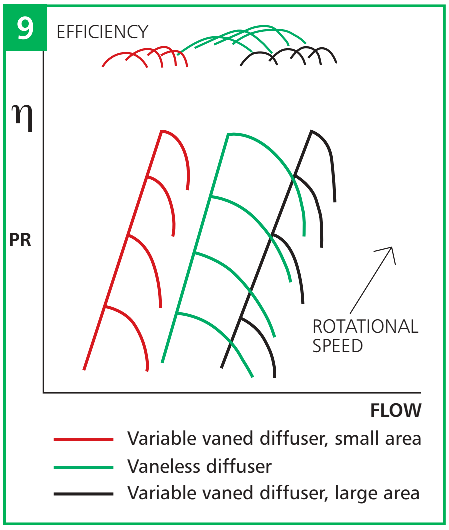
Figures 6a and 6b show the Holset AIGV hardware.



For any set vane angle, the compressor map looks very narrow. This is simply due to the presence of the vanes, which is why Holset uses a vaneless diffuser for standard non VGCs. It was found in testing that the incidence angle on to the leading edge of the vanes can result in a major loss of efficiency when operating away from the design point.

In the test programme, machined-from-solid vanes which effectively had no hub and shroud clearance were evaluated. In a real-world VGC, the vanes would need clearance so they could rotate to change the vane angle. Efficiency is significantly affected by this clearance. Experiments using fixed vanes at different angles (with no movement clearance) will inevitably record optimistic efficiency levels.

Figure 9 shows the effect of vaned diffuser setting angle on the compressor map.



Although a moving sidewall vaneless diffuser has yet to be subjected to specific testing by Holset, regular experiments with diffuser width optimisation provide a good understanding of its effects. The surge line movement is not as great as with a variable vane diffuser or inlet guide vanes and again there is a trade-off between efficiency and map width. Typically, a narrow diffuser width gives good map width with low efficiency, and vice versa.

Holset's experiments to date show that VGCs can result in some map width advantage over existing map width MWE techniques. But this is generally at the expense of speed variation and reduced efficiency. The speed variation effect could affect compressor wheel durability.

Recent advances with MWE, or super MWE as its becoming known, make the marginal benefits of current VGCs, when compared with established MWE methods, now seem doubtful. Together with the obvious added cost and complexity of the VGC they cast doubt on its practical and commercial viability. As with other turbo machinery technologies though, Holset will continue to watch developments closely.

Global Excellence

Holset wins ISO/TS quality approval

All Holset turbocharger manufacturing plants worldwide have been accredited to ISO/TS 16949: 2002. This replaces QS9000 as the recognised global standard in automotive quality systems. The manufacturing sites in UK, China, India and USA, were audited by Lloyds Register of Quality Assurance (LRQA). The Holset plant in Brazil has quality approval from Det Norske Veritas (DNV).

whole range of business indicators and the audit process is geared to implement positive change.

One of the key initiatives for improving the company's business processes is the Holset 6 Sigma programme. Continuing to build on the success of the last three years, it complements the requirements of TS16949 and provides a structure to improve processes. The outcome is lower costs and improved quality, sustainable through the disciplines that 6 Sigma brings.

The new ISO/TS16949: 2002 approval demonstrates the commitment of the company to its customers and its intention to achieve ISO/TS approval for all its production facilities during 2003 and met the target with a month to spare - well in advance of the timescales set by our major customers.

ISO/TS16949: 2002 requires companies to develop and implement a quality management system that provides for continual improvement, emphasising defect prevention and the reduction of variation, while striving to minimise waste in the supply chain.

It provides a framework for the identification of customer requirements and those processes which are key to the organisation's ability to satisfy them.

External certification bodies like LRQA and DNV are adopting a rigorous approach to TS16949 assessments. They look for evidence of continual improvement during surveillance visits. Systems for setting objectives and monitoring performance against those objectives are examined in detail and action plans are expected to correct any off-target measures. Maintaining the status quo is no longer an option on a determination to remain leader in the increasingly competitive turbocharger market.

Lower costs and improved quality

Andrew Ireland, Holset's Worldwide Quality Leader, says 'This is a significant milestone on our journey of continual improvement and a stamp of approval that an increasing number of our OEM automotive customers are demanding from their suppliers'. Holset declared its

Manufacturing and material handling processes are then closely managed for performance against set targets, as a means of ensuring that the business is working effectively and efficiently.

One of the most important measures mandated by the new standard is achievement of perceived and demonstrated customer satisfaction on which business success increasingly depends.

Setting world manufacturing standards in China

This year marks a new chapter for Holset's turbocharger business in the world's largest market for key engine components. A Joint Venture with Wuxi Power, Holset China's all new production facility has come on stream, as an integral part of a company strategy to expand its worldwide turbocharger manufacturing capacity.

In January, operations at the existing Holset plant were finished and manufacturing began at the new facility in Wuxi National High and New Technology Zone. The new facility, officially opened on the 11th May 2004, is a purpose-designed plant equipped to world-class manufacturing standards. It is supplying the growing number of engine manufacturers now being established in China as well as OEMs in other Asian countries.

Adjoining the plant a new, expanded Holset technical centre has been built. It employs engineers whose role is to tailor and refine proven turbocharger models and components to suit specific Asian market applications, before testing and subsequent approval sign-off as well as perform tests and approval work for regional as well as other Holset operations in the world.

On the same site is an expanded aftermarket parts distribution centre geared to provide an enhanced service and parts business offered to OEM and end-user customers. The offices project Holset's corporate image and are in line with its increasingly high-tech product portfolio. Meanwhile there are longer-term plans for the installation of additional equipment in the Wuxi plant, which will expand capacity, embracing new Holset turbocharger models, while providing a further assurance of global quality standards.

Holset is in China for the long term and will continue to invest through the Wuxi Holset organisation, a joint venture with Wuxi Power. With its enormous potential for growth, China is a key market for Holset turbochargers and the company is committed to long-term development in the world's largest country.

Online to get closer to the customer

The internet revolution has affected everybody over the past 15 years, businesses and individuals alike.

Internet start ups like Amazon and Lastminute.com have revolutionised where consumers purchase goods and have stimulated the high street stores to follow suit. Latest figures indicate that e-business accounts for over 6% of total retail sales in the UK[1] and 1.5% of all US retail sales[2]. These percentages may sound small, but in monetary terms, e-business is huge and growing at a tremendous rate. It is estimated that by the end of 2004, global e-retail sales will be worth USD$38billion, up by over 48% from 2003[3].

It seems that the business to consumer (B2C) sector is fully embracing the internet revolution, but what about the business to business (B2B) sector?

Individual companies have greatly improved internal communication through better IT integration and to some extent how they communicate with customers, but there is still too much inefficiency in the system. Teams of people are employed at customers and suppliers to check on delivery status and delivery requirements; too much time is taken extracting data from one computer system and then sending this in a readable format to the partner company. The next stage of the B2B internet revolution is to integrate two companies' different business operating systems to allow real time access to information… a Corporate Portal.

A Corporate Portal is an online application that allows companies to share internally and externally stored information through a single gateway providing the focal point for conducting day-to-day business. Portals combine a rich, declarative environment for creating a portal Web interface, publishing and managing information, accessing dynamic data, and customising the portal experience, with an extensible framework for J2EE-based application access.

Using Portals, e-businesses have the power to connect employees, partners and suppliers with the information they need and the flexibility to create views tailored to each community. Portals will provide the preferred access route for mission-critical confidential applications and must therefore authenticate against a wide variety of security systems, while providing extensive search and classification accuracy.

At Holset we are pursuing this next step of the internet revolution by creating individual customer internet portals. These customer portals will be central communication hubs which will revolutionise the relationship Holset has with our customers. Via the portal both Holset and the customer will be able to see into each other's operating systems using web enabling software to get the information required. The aim will be to eliminate non-value added telephone calls and data extraction allowing Holset to concentrate resources on product and system improvements. Holset will be able to see customer engine build programmes, customers will be able to see Holset production planning figures, if warranty data and failure modes are needed for analysis then it is available to both parties immediately.

Once we integrate different operating systems the possibilities for extending into true partnerships are endless.

> Holset's new business to business ('B2B') Portal structure is designed to become the preferred access route.

> Web enabling software to 'see' into each others' operating systems

[1] Source: UK Office of National Statistics
[2] Source: USA Department of Commerce
[3] Source: Gartner Research Inc.

What can a Portal contain?

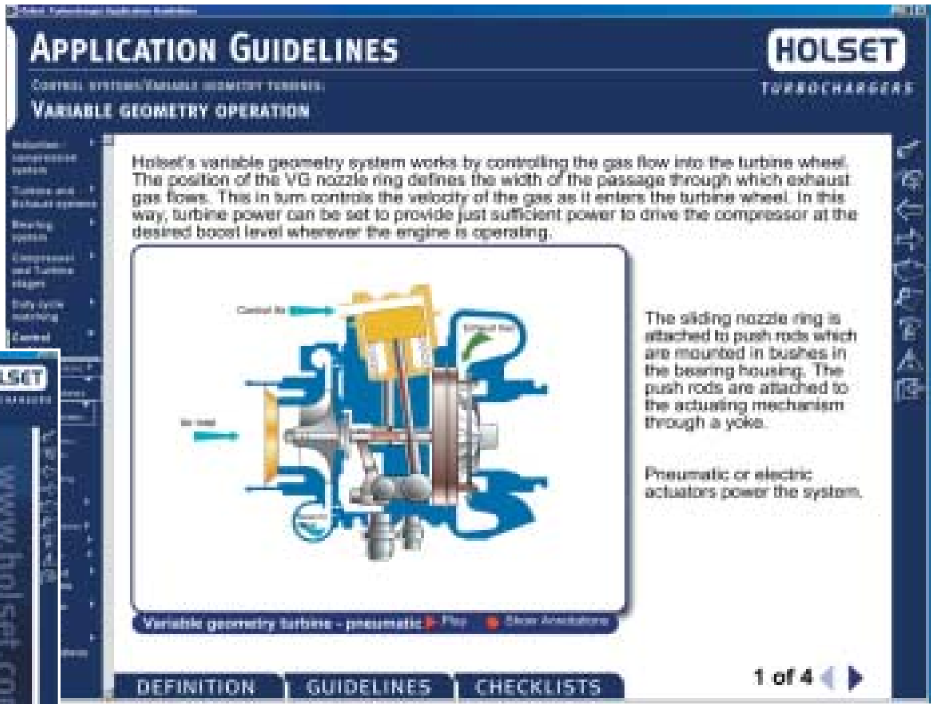
- **Contact Management Suite or CRM System** - maintain relationships with your customers and suppliers.
- **Email Accounts** - send and receive emails from multiple accounts.
- **E-Business** - mailing lists, broadcast emails and capture responses.
- **Market Data** - analyse, report and extract data from your data warehouse.
- **File Sharing** - store and share documents and business information to anyone you authorise.
- **E-Commerce** - allow your customers to shop and order online.
- **Notice Boards & Forums** - Leave messages for your users, keep them updated with newsflashes and host opinion polls or discussions.

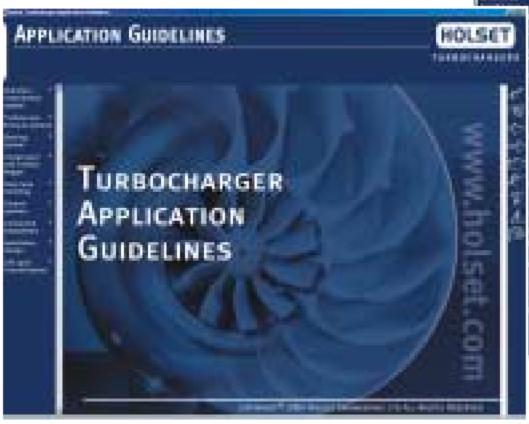
Advantages of a Corporate Portal for B2B Communications

- **Single Gateway** - single point entry of inter-company content and data.
- **Effective & Efficient** - deliver information to the appropriate employee, client or supplier quickly, cheaply and effectively.
- **Easy Setup & Maintenance** - reduce the need to buy and install new software for each and every computer your company owns.
- **Improved Relationships** - improve inter-company processes and communications and create stronger relationships with employees, suppliers and customers.
- **Mobile Office** - take your office with you around the world. All you need is an internet connection and your login details.

Application Guidelines published

The relationship between an engine and its turbocharger is becoming more and more complex. It is very important therefore that the best possible advice and information is available to our customers' Air System Engineers.





Communicating important technical data rapidly

In pursuit of our initiative to improve customer relationship and information sharing, is the publication of the third edition of Holset's 'Application Guidelines Manual'. Unlike the previous editions published in hard copy and CD format, this edition will be fully internet-compatible, though working from initial CD-provided baseline data.

Those accessing the revised manual will benefit from its easy menu-driven format. It is divided into nine chapters, each of which has a visual map of its contents for easy navigation and the user is encouraged to use internal links to follow topics further.

The manual's content has been extensively updated since the second edition, driven largely by changes in engine air/gas management due to more stringent emissions legislation around the world. There are accordingly, new sections on VGT, EGR and electronic turbocharger controls.

Contained within the database is a fully downloadable Application FMEA worksheet. Use of this allows the customer to completely evaluate a turbocharger application against a series of engineering criteria, which, if followed, should ensure problem free operation in the field. Although these evaluations can be carried out independently, Holset recommends that they are carried out in conjunction with Holset Application Engineers.

The Guidelines provide Holset's best thinking in all aspects of the installation, use and maintenance of their turbochargers. Special attention has been given to identifying the limits of use which ensure reliable, safe and efficient use of the product. It gives Holset a platform allowing the dissemination of real time information on product use. This information comes directly from component analysis, in-house testing and field feedback sources.

The Guidelines also include many new and improved illustrations and for the first time includes animations to illustrate certain principles of operation.

The Application Guidelines database platform provides Holset with a means of communicating important technical data rapidly. It also provides a way of communicating to our customer the information they need to be able to use our products to best advantage. We shall expand the database based on these needs, and will listen closely to what they suggest as additions.

Plans for additional sections on turbo nomenclature and a chapter on turbocharging theory are already in process.

Holset will be discussing with all its customers their views and requirements relating to the applications manual. You can make contact on this subject through emailing turbo.applications@holset.com

Speed to Market

In response to the ever-increasing quality standards and technical requirements for the Dodge Ram Heavy Duty 600, Holset commissioned a new assembly line at their Charleston Manufacturing Plant, South Carolina as part of the MY04.5 product launch.

Mark McGovern, Holset Program Team Leader said "The MY04.5 program launch has meant introducing new technology and commissioning a new assembly facility on a very tight timescale. Competition in the truck & SUV market in the US is such that speed to market is of the essence and the MY04.5 program has emphasised Holset's ability to do this".

The 5.9 litre Cummins 600 OHV Inline 6 cylinder is fitted with the Holset HE351 turbocharger which allows the engine to deliver more power and more torque than its MY03 predecessor despite having the same turbocharger envelope size. This is the first Holset turbocharger to utilise the compressor cover mounted 'Command Valve' wastegate technology.

Cummins Inc credit heavy reliance on computer analytical tools for the new Cummins 600's placement as front-runner in power/torque and refinement categories tending to both the numbers and noise-vibration-harshness concerns in the same development phase. The new name reflects the class-leading torque rating of 600 lb.ft.

Holset was set some very challenging targets which were achieved through hard work in the design, manufacture and assembly of the turbocharger and engine air handling system - a true team effort from Holset, Cummins and Chrysler.

SPECIFICATIONS

- Holset HE351 Turbocharger
- Engine type: 5.9L OHV inline 6-cyl. turbodiesel
- Displacement (cc): 5,883
- Block/head material: cast iron/cast iron
- Bore x stroke (mm): 102.1 x 119.9
- Power (SAE net): 325hp @ 2,900 rpm
- Torque: 600 lb.-ft. (813 Nm) @ 1,600 rpm
- Specific output: 55 hp/L
- Compression ratio: 17.2:1
- Application tested: Dodge Ram Heavy Duty

Boosted to Paris-Dakar victory by Holset

[Image supplied courtesy of Kamaz]

Once again the Kamaz-master team, driving trucks powered by Holset turbocharged engines, has carried off the victor's laurels from the Paris-Dakar rally.

Three specially-built speed-tuned Kamaz trucks took 1st, 2nd and 4th places in their class of the 2004 Paris-Dakar rally. Vladimir Tchaguine notched up his 4th victory in the gruelling 17-day, 6500 mile event (adding to those in 2000, 2002, 2003). His team mates Firdaus Kabirov and Ilgizar Mardeev finished in 2nd and 4th places.

Engineers from Holset in the UK worked closely with the Kamaz-master team to supply and install high-performance turbochargers able to maximise truck power and speed without compromising engine or component durability. Holset engineer Will Kerins, who led the project, said 'after working so closely with the Kamaz team it was great news when we heard that all three entries had such an excellent race, and that Holset turbochargers had helped to power them to victory in one of the toughest events of its kind in the world.'

The 26th Paris-Dakar, which claims to be the world's toughest rally, opened the sporting calendar for 2004. Between 1st to 18th January 2004, covering over 11,000 kilometres and starting in Paris, it took the drivers through Europe, Morocco, Mauritania, Mali, Burkina Faso, finishing in Dakar, Senegal.

Kamaz-master is the national team representing Russia and the Republic of Tatarstan in auto sport events and is supported by Kamaz, the major Russian truck manufacturer. Such consistent successes in the event show all too clearly that Kamaz-master has become one of the strongest world teams in truck-based sporting events.

MAN D20 Common Rail

[Image supplied courtesy of MAN]

Holset would like to congratulate MAN on the launch of their new 10.5 litre "D20 Common Rail" engines.

After four years of development, MAN has presented its newly developed D20 Common Rail engine range, a completely new generation of diesel engines designed to meet future Euro 4 and Euro 5 emissions legislation. The new engines have many benefits over the outgoing D28 engines. They are more compact, yet they deliver more power, weigh 10% less, and are quieter and more efficient, giving a 5% reduction in fuel consumption.

Holset has been working with MAN on the turbocharging for this engine from the beginning of the development program. Using 3D computer modelling techniques and internet data links, Holset was very much an integrated part of the MAN development team. The virtual engine transformed into reality with the minimum of effort, the new turbo hardware performing exactly as designed first time. The turbocharging system uses HX40 technology which has been tried and tested by MAN and found to be robust and reliable.

A spokesman for MAN said, "We had good experiences on the development work with Holset for the MAN D08-engines. Due to these positive experiences, a HX40 turbocharger was developed and applied to the new D20-Common-Rail engines for the 310 hp and 350 hp versions."

Holset looks forward to working with MAN to provide successful solutions for Euro 4 and Euro 5 engines.

The new Scania R Series

Scania recently launched a new truck range: the R Series.

The new range is an important extension of Scania's global truck offering, with the trucks featuring innovations and improvements in many areas: Quality, operating economy, driver appeal and their first ever Euro 4 engine.

Scania took the best components from its existing range, while innovatively renewing other components and systems to create an exceptionally competitive new global truck range.

The Scania R Series offers a 16 litre 500 and 580hp V8 engine, 12 litre straight six 420 and 470hp engine, 12 litre 420hp Euro 4 engine and an 11 litre straight six 340 and 380hp engine.

Scania's first Euro 4 engine, the 420hp engine, features 30 percent lower emissions. To achieve these emissions levels, the Euro 4 engine uses several technologies such as; engine management, high pressure fuel injection, Holset's turbocompounding and Exhaust Gas Recirculation (EGR). Available from this autumn, a Scania customer will be able to choose a truck with especially high environmental performance.

More details on the Holset turbocompounding system can be found on pages 6 & 7.

[Image supplied courtesy of Scania]


Performance Partner
Breathing Life into the Machine
By setting the pace, Holset is your perfect partner for a world-class performance.
We deliver industry-leading technology – Variable Geometry Turbocharging (VGT), Turbocompounding and the world's first production cast titanium compressor - for commercial diesel engines.
The focus and commitment of our people ensures that we design and develop innovative products that meet the special needs of these engines.
We have people and systems in place to work with you at all levels to deliver this technology on-time wherever in the world you are. Our partnership approach is a proven winner time and time again.
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