Honeywell

GARRETT

booster

MAGAZINE

September 2003

Driven By Technology

Focus On Smart Roadster

Moving Global

Supporting Customers Worldwide

On Track

Shanghai is the location for Honeywell's turbocharging engineering globalization program and is already providing the company with 24 hour working capability on behalf of customers.

Garrett's® AVNT™ technology has helped a US customer develop a diesel engine for the light truck sector that has been voted among the world's Top Ten.

India is home to one fifth of all humanity, has an economy growing at 5% and a highly skilled workforce – no wonder 13 global auto manufacturers have set up base.

There's a new global quality standard that's recognized across the world by auto manufacturers, but Honeywell is looking beyond ISO TS16949:2002 to continuously drive up performance.

Investment in the latest manufacturing technology in Europe is pushing up quality, cutting lead times and adding real value to the company's rapid prototyping operation.

The durability of Garrett's boosting technology is being proven time and time again in partnership with racing teams around the world.

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LISTENING AND LEARNING

Dear Readers

Many people think that it is technology that binds us together. In many ways, of course, this is true. We share technological innovation with our customers, communicate with all our stakeholders using the common language of the internet and celebrate the remarkable engineering achievements of auto manufacturers and engine makers.

But we need to look beyond technology to find the real strength of any organization – its people. It is they who create the technology, they who make partnerships work and they who deliver true value.

Increasingly these relationships are global in their scope. At Honeywell, our customers operate worldwide and expect support from their supply partners that doesn't just cover the world but is world class in its quality.

Globalization is becoming an increasingly common feature of doing business in the 21st century – and we, in turn, need to organize in a way that really does add value.

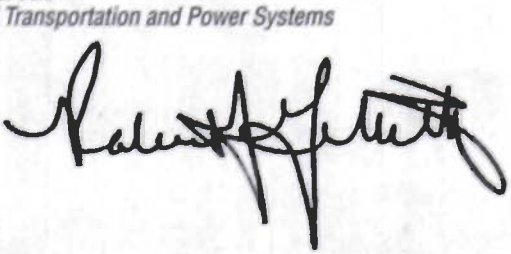
As a way of reflecting this, Garrett® Booster magazine has been expanded to cover the developments of Honeywell and its turbocharger customers across the world.

In this first global issue of Garrett® Booster, we look closely at our own globalization program, celebrate the successes of many of our customers in different parts of the world, focus on key developments in manufacturing and quality and share our plans in China and India.

We live in exciting and challenging times when the pace of technology appears to be ever quickening. At Honeywell though, we constantly remind ourselves that is only through harnessing this technology to augment those singularly human capabilities of listening and learning that we can help our customers realize their goals.

It gives me great pleasure to introduce this first global edition of Garrett® Booster – thank you for your continuing support.

Rob Gillette
President & CEO
Honeywell Transportation and Power Systems



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What are the main business drivers for Honeywell's turbocharging business globally and where do you see the greatest opportunities?

Our global business should grow at an equal rate in Europe, Asia and the US, though we anticipate differing business drivers in each market.

In Europe, the business will continue to grow with the increased penetration of diesel-powered passenger vehicles and I'm proud that our VNT™ technology is contributing to diesel's reputation for enjoyable driving. Simultaneously, European OEMs are increasing the use of turbo gasoline engines to meet the voluntary CO_2 goals set for 2008.

In the US, we have leveraged our VNT™ technology to help commercial vehicle customers meet increasingly stringent emissions regulations. On the passenger car side, we are seeing the first signs of US auto manufacturers following Europe's lead by introducing diesel and turbo-powered gasoline engine vehicles.

Our Japanese customers are focusing on getting into the European market with diesel passenger cars.

The Chinese automotive market represents a tremendous opportunity for Honeywell too, as its economy continues to grow rapidly.

We also expect to see significant export growth out of Korea, led by Hyundai's export of diesel passenger vehicles.

How do you believe that boosting technology will evolve over the next decade?

Honeywell will continue to serve as the driving force behind the technological evolution of the turbocharger to match the needs of our customers, whether it be for performance, to meet emissions regulations or for fuel efficiency. As vehicles become more and more electronically driven, turbochargers will need to become electronically integrated in the engine, which is an area where we can draw on Honeywell's experience in sensors and controls.

What is it that gives Honeywell the edge over its competitors and how will the company maintain this advantage?

The simple answer is that we are more global than any of our competitors. We rely on top people and premiere technology worldwide to keep us a step ahead of our competitors.

In order to maintain that edge, we have placed the best minds in every region where our customers need us to be and have used that regional knowledge to help ourselves and our customers grow. Furthermore, we have committed ourselves to pursuing technology-driven solutions that provide our customers with what they want to buy.

The Ar

lization

w with Bob Gillette

Honeywell is investing considerable resources in globalizing its turbocharger business. What is the vision for the company that overarches this business strategy?

The move to a truly global operation is a reflection of the 21st century way of competing in the auto market – an industry where projects are delivered across continents by maximizing skills, technology and advanced processes.

Honeywell is responding to this environment through fully operational global customer teams, by establishing advanced manufacturing and engineering standards that operate across continents, and by creating a supply base that's worldwide and world class.

Our vision is to supply global solutions to global challenges – to provide our customers with a support structure that views the bigger picture, identifies issues more quickly and delivers results.

How will you ensure that you can respond to regional market opportunities if the focus is on globalization?

My philosophy is that you can't effectively run anything from 3,000 miles away. We manage our business regionally and even though we provide solutions to our customers at the local level, we use that local knowledge to benefit each other globally by staying connected. That's the challenge we have given ourselves. When done right, it will provide the resources necessary to establish a true partnership with our customers on both a global and local level.

Is it important to communicate the benefits of boosting technology to end users or OEMs to boost demand?

Communication to both consumers and OEMs is essential in creating demand for turbo technology. The key difference is the message communicated. End users in the US and Asia need to be educated about the emissions reduction, fuel economy and performance benefits of boosting technology, while OEMs need to be exposed to tangible evidence and trends that support the fact that turbo-powered vehicles can help them sell cars. In more established regions like Europe, OEMs and consumers are already familiar with the turbo technology and the Garrett name and there is less need for education.

How does being part of Honeywell add value to the turbo business and its customers?

Cliff Garrett founded the company that bears his name as an aerospace supplier in 1936. From those first jet engine turbines to the cabin pressure systems produced and manufactured by Honeywell Aerospace today, our automotive applications have benefited from the commitment made to share knowledge in order to improve technology. That tradition continues today as we leverage the technological advances of our peers within Honeywell, whether it be Aerospace or the Sensing and Control Group. Our ability to expand our resource pool makes us more valuable to our customers and, in the end, provides the solutions and technology that they demand.

Boosting

Customer Su
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Toyota Avensis 115 D-4D

Engine Specification
- Engine Layout - Cylinder 4
- Displacement - 1995cm³
- Maximum Power - 116hp @ 3600rpm
- Maximum Torque - 280Nm @ 2000rpm
- Diesel direct injection common rail

Turbocharger Features
- Garrett® GT17 VNT™ 2nd Generation
- Water cooled center housing
- Thermo-decoupled turbine housing

Turbocharger Key Benefits
- Superior aerodynamics
- Component design optimization for weight reduction
- Lower thermal inertia

Boosting One Of The First Euro IV Compliant Engines

Alfa Romeo 156 MJTD 2.4 20V

Engine Specification
- Engine Layout – 5 in line
- Displacement - 2387cm³
- Maximum Power - 175hp @ 4000rpm
- Maximum Torque – 385Nm @ 2000rpm
- Diesel direct injection common rail

Turbocharger Features
- Garrett® GT22 VNT™ 2nd Generation
- Use of new turbine housing materials

Turbocharger Key Benefits
- Optimized aerodynamics package for improved torque and maximum output

Optimizing Turbo Matching For Superior Driveability

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- Creating technology-driven solutions
- Listening, responding and planning for the future

Garrett® turbocharging technology is specified by auto manufacturers around the world. Global customer teams forge partnerships focused on helping manufacturers meet the challenges of engine downsizing, emissions control, fuel efficiency, performance and driveability. Here is a selection of recent passenger cars benefiting from Garrett® turbochargers.

Audi A8 4.0 TDI

Engine Specification
- Engine Layout – V8
- Displacement - 3936cm³
- Maximum Power - 275hp @ 3750rpm
- Maximum Torque - 650Nm from1800 to 2500 rpm
- Diesel direct injection common rail

Turbocharger Features
- Garrett® Twin Turbo GT17 VNT™ 2nd Generation
- Controlled by Rotary Electronic Actuator (REA)
- Very compact turbo design

Turbocharger Key Benefits
- Optimized low end turbo response
- High temperature compliant

Achieving Superior Performance With Optimum Fuel Efficiency

Jaguar S-Type 2.7l V6 Diesel

Engine Specification
- Engine Layout – V6
- Displacement - 2700cm³
- Maximum Power - 207hp @ 4000rpm
- Maximum Torque - 435Nm @ 2000rpm
- Diesel direct inject common rail

Turbocharger Features
- Garrett® Twin Turbo GT15 VNT™ 2nd Generation
- Controlled by Rotary Electronic Actuator (REA)

Turbocharger Key Benefits
- Optimized aerodynamics and compact twin turbo design along with specific bearing features allow better transient response and high performance

Boosting The First V6 Jaguar Diesel Engine

Renault Velsatis 2.2 dCi

Engine Specification
- Engine Layout – 4 in line with particulate trap
- Displacement - 2188cm³
- Maximum Power - 150hp @ 4000rpm
- Maximum Torque - 320Nm @ 1750rpm
- Diesel direct inject common rail

Turbocharger Features
- Garrett® GT18 VNT™ 2nd Generation
- Use of high temperature materials

Turbocharger Key Benefits
- High temperature capabilities

Enabling New Generation Particulate Traps Through First High Temperature Diesel Application

BMW 530d

Engine Specification
- Engine Layout – 6 in line
- Displacement - 2993cm³
- Maximum Power - 218hp @ 4000rpm
- Maximum Torque - 500Nm @ 2000rpm
- Diesel direct injection common rail

Turbocharger Features
- Garrett® GT22 VNT™ 2nd Generation

Turbocharger Key Benefits
- New turbine wheel design allows higher rpm and improved performance
- New nozzle material accommodates higher temperatures

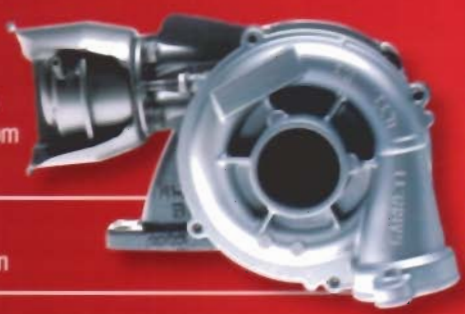
Making Driving A Memorable Experience

Peugeot 307 1.6 HDi 110

Engine Specification
- Engine Layout – 4 in line
- Displacement - 1560cm³
- Maximum Power - 110hp @ 4000rpm
- Maximum Torque – 240 Nm @ 1750rpm
- Diesel direct injection common rail

Turbocharger Features
- Garrett® GT15 VNT™ 2nd Generation

Turbocharger Key Benefits
- Latest aerodynamic package helps to address challenges linked to downsized engines (from 2.0l to 1.6l)



Enabling Engine Downsizing

Focus On Smart Roadster

Interview with Rüdiger Herzog

Overall Coordinator for Smart Engine Powerplants

What were Smart's requirements from Honeywell at the start of the Roadster program?

Our vision was to create an engine that would combine maximum fuel efficiency with impressive torque in order to deliver the highly responsive performance demanded by our customers.

What were the major technological challenges presented to Honeywell?

The lengthy development work undertaken jointly with Honeywell led to the introduction of numerous improvements which influenced both the responsiveness and the durability of the turbocharger. These developments helped to cut fuel consumption still further.

The ultimate goal was to develop a turbocharger that would operate at high temperatures (1050°C) and offer our customers the impressive levels of driving performance that they have come to expect. Working closely with Honeywell, we came up with a solution that included reduced aerodynamics clearances for better engine performance – technology that was the subject of stringent testing and validation.

How did Smart and Honeywell work together to address these challenges?

The program was clearly one that was technology driven but as is the case with all successful partnerships, what really underpinned our success was the trust that defined our close working relationship.

The improved driving dynamics resulting from engine enhancements and the driveline management were achieved only by close collaboration with the development partners. The agility and pull of the "SMART for fun" are impressive but the standing-start acceleration of the "SMART for fun" is especially convincing.

What does the turbocharger deliver in terms of performance?

For engines below 1000 ccm displacement, the turbocharger is one of the most important components in achieving the required levels of performance, fuel efficiency and driveability.

The cylinder capacity of the turbocharged engine was increased from 600 to 700 cc by changing the bore and stroke. For the basic 37 and 45 kW versions, the torque was significantly increased but for the 60 kW variant, it was increased still further to 110 Nm. This was achieved with a new turbocharger design.

This puts the specific power output of the 60 kW version at 87.5 kW/l, which is amongst the market leaders. The brake mean effective pressure of 19.8 bar is in the sports car league over a broad speed range from 2250 to 4500 rpm. These very impressive figures could only be achieved with the development of an innovative turbocharger, which markedly improves the agility of the new cars in comparison to their already excellent predecessors.

What has been the response of Smart Roadster drivers to the performance of the car?

We have received extremely positive feedback from our drivers. They have been really surprised by the engine performance – they are amazed at the responsiveness of this 'small' engine. What this means is that the engine is helping to make our vision a reality: "SMART for fun".

Smart Roadster 82hp

Engine Specification

- Engine Layout – 3 in line
- Displacement - 698cm³
- Maximum Power - 82hp @ 5250rpm
- Maximum Torque - 110Nm @ 2500rpm
- Gasoline electronic multi-point injection with two spark plugs per cylinder

Turbocharger Features

- Garrett® GT12 with Integrated Exhaust Manifold
- Technology carry over from racing applications drives 1050° C capability

Turbocharger Key Benefits

- Compact design along with high temperature and advanced aerodynamic features deliver high performance and low emissions

Delivering High Performance With The First 1050° C Gasoline Application

Driving L
Of Gaso

Fuel economy and emissions control set the downsizing agenda

Boosting technology enhances performance and driveability

Martin Verschoor, VP Worldwide Turbocharging Engineering and Technology, assesses the state of the gasoline engine marketplace – and points to the boosting technologies that will help auto manufacturers deliver the dynamic but fuel efficient vehicles of the future.

What is driving the development of gasoline turbocharging technology in each region?

There is an acknowledgement across the world of the need for engine downsizing to improve fuel economy and to meet CO_2 emissions standards. The challenge for auto manufacturers and for companies like Honeywell is to develop the technologies that will deliver these goals but that ultimately continue to satisfy the demands of the marketplace.

What we must always keep in mind is performance and driveability – these are the common denominators that underpin the marketplace and what consumers are looking for in the vehicles they drive. Turbocharging is a vital element in this proposition.

Are the issues the same across the world for OEMs?

There are common issues in areas such as emissions but the characteristics of various regions do mean that the approach will vary.

In Europe, for example, it is very clear that for OEMs to meet the CO_2 emissions targets they need to do something significant with the gasoline power plant. In theory, the targets could be achieved with close to 100% penetration diesel engines – but there is clear market evidence that this just cannot happen. The most affordable way of meeting these targets is through engine downsizing, because this approach can easily deliver in excess of 15% improvement in fuel economy while still offering the high performance demanded by the consumer.

In the US, while there is a trend towards greater fuel economy there is also much greater emphasis on power and low engine speed torque to accommodate the heavier mainstream vehicle weight – that's why there is a preference for bigger gasoline displacement engines. So the US requires very high torque density to make engines very responsive, particularly in light trucks and SUVs.

As a consequence, in Europe, OEMs are looking to downsize from say 2l engines to 1.5l or even smaller; in the US it is more likely to be from 5.5l to say a 4l engine or from 3l to 2l – it's a different level of downsizing.

In Asia, particularly Japan, OEMs are very much focused on meeting emissions targets and are actively working on new advanced turbocharged engines in combination with gasoline direct injection technology.

What will be the key technological developments in gasoline boosting?

There are two critical elements in gasoline engine turbocharging – turbo response times and the emissions capabilities. For gasoline turbocharging to be successful, vehicles must feel and drive like a much bigger naturally-aspirated gasoline engine

So the biggest area of development is in continuous improvement of the low engine speed

he Future
line Boosting

performance of the turbocharger – and there are various development scenarios. Response performance at low speed can be improved through greater turbine efficiency and through enhanced compressor efficiency. We are looking carefully at both areas.

As far as the emissions issue is concerned there are two key points to consider – the first relates to cold start emissions and the second focuses on how clean an engine is under full load. The first area could be tackled by using smart exhaust manifold/turbine housing arrangements for fast catalyst light off prior to heating up the turbocharger.

The other part of the challenge – high speed, high load, emissions control – signals a move towards high temperature-capable materials in turbos. Traditional gasoline turbochargers operate in temperatures in the 950°C range – going forward all Garrett® turbos will be capable of handling 1050°C or more.

Much of our experience in this area has been gained through our successes in gasoline turbocharging in endurance and rally racing, such as at Le Mans and WRC. These technologies are now being applied in our mainstream activities.

With different regions having differing priorities, can there be a truly global approach to gasoline boosting?

Our OEM customers are all globally active manufacturers and producers and the truth is they cannot afford to have technologies that apply in one region and not in another. Regardless of the engine philosophy in each region, the technologies will be the same – European manufacturers will release the same vehicles in US; Japanese OEMs will release the same technologies in Europe and the US. From our own experience we know that our global customers are looking for global technological solutions.

Where does Honeywell see the greatest opportunities for gasoline boosting?

The most immediate opportunities exist in Europe, and in Asia, in the small car and family sedan segments where vehicles are currently using naturally aspirated 1.5-2.0l engines. With engine downsizing, the only way to significantly improve vehicle dynamics while still meeting the requirements of customers in terms of performance is by applying turbocharging.

In both these regions, gasoline engine downsizing and CO_2 emissions programs are already a reality and we will see high volume applications hitting the market over the next few years.

In the US, I believe the biggest opportunities exist in the compact Sports Utility Vehicle segment – where the need to improve fuel economy and enhance the dynamic experience will drive the adoption of turbos. Additionally, the passenger vehicle market, which is currently dominated by Japanese imports, is an opportunity for US OEMs to differentiate themselves by developing exciting, yet fuel-efficient vehicles.

How well is Honeywell placed to maximize the opportunities?

Where we lead the way is in the scale and nature of the production capabilities that already exist on a global scale. We currently produce almost eight million turbochargers each year – we have the infrastructure, the supply networks and the technological know-how to work at the same pace as our customers.

Where Honeywell will also demonstrate its advantage is in the development and application of the sophisticated breakthrough turbocharger technologies that will help auto manufacturers deliver on the emissions agenda. This experience and know-how will be vital in supporting our customers in the gasoline turbo marketplace that, by general industry consent, is expected to double in size every four years.

Moving Global

The Right Approach, Right Across The World

Global accountability ... regional delivery

There's a new impetus to the way in which Honeywell supports its customers on a worldwide basis. The move to a truly global operation is a reflection of the 21st century way of competing in the auto marketplace – an industry where projects are delivered across continents by maximizing skills, technology and advanced processes. Customer service led by customer requirements.

Honeywell is responding to this environment through fully operational global customer teams, by establishing advanced manufacturing and engineering standards that operate across continents and by creating a supply base that's worldwide and world class. Global solutions to global challenges. Providing customers with a support structure that views the bigger picture, identifies issues more quickly and delivers results.

Closer to customers through global account management

For customers, globalization translates into service that is more responsive and better able to meet emerging opportunities.

Honeywell's global account management initiative is now fully operational and provides customers with a service structure that shortens lines of communication and is able to react more quickly to issues as they arise.

"Effective and regular dialogue is at the heart of our move global," says Calogero Morreale, Customer Warranty Service Director. "The global account program came out of a customer excellence initiative which showed that we could add significant value to our customers' operations by working with them more closely to meet their global requirements.

"The process we have set-up enables us to address issues and to pursue opportunities much more quickly than was previously the case. All customers have a dedicated customer team, whose responsibility it is to tap into the company's global resources to deliver solutions. Application engineering support may be provided in one region (i.e. Asia) and turbocharger production may be undertaken in another region (i.e. Europe) but the team in charge remains the same."

The global account management program is supported by business managers and team leaders across all functions, including engineering, quality, manufacturing, finance and supply chain management.

Manufacturing standards defined by worldwide initiative

"Variation is the enemy". This is the thread that runs right through Honeywell's Six Sigma program – now the company is extending the concept to deliver a truly global approach to manufacturing.

The Advanced Manufacturing Engineering (AME) initiative takes the best of Honeywell's regional expertise and captures it in a global program that sets the standards and processes governing every element of manufacture ... wherever in the world it takes place.

The result will be better customer service founded on product consistency, common quality systems and universal procedures built on a platform of worldwide functional excellence.

At the heart of the program are cross-functional teams that have been formed with the ultimate aim of removing any variation from the manufacturing process, from the earliest stages of specification through to the finished product. "AME starts from a position of recognizing excellence across a wide range of manufacturing engineering functions wherever this expertise resides – and then sharing it across the whole organization," says Adriano Palma, VP European Operations, who is heading the program.

In time, the AME program will address all existing manufacturing engineering functions and will be instigated on all new product lines.

Major performance gains result from supply base strategy

Honeywell is unlocking the power of partnership to deliver benefits to customers through the development of its supply base.

Leading the strategy is Jerry Rockstroh, VP, Worldwide Supply Base Management, whose focus is fixed unerringly on delivering competitive advantage to customers. Put simply, for Jerry this means creating the strategic partnerships in each of the company's three operating regions in order to help meet or exceed customer expectations. The objective is for the supply chain to be as lean, flexible and short as possible.

Part of this approach includes rationalizing the supply base – but more importantly identifying and working with world class supply partners who share Honeywell's business ethos and who can add real value to the company and its customers.

The tangible outcomes of this approach include dramatic improvements in both quality (rejects down from 3000 ppm to 650ppm with a target of 250ppm next year) and delivery reliability (currently averaging around 95%). "What this means is that we are working with suppliers as true partners in a global enterprise," says Jerry. "They share our vision not just in terms of quality, flexibility and cost – but in delivering what is required of us by our customers."

"Close collaboration with suppliers is about so much more than cost. It's about sharing common values, helping supplier partners find new and better ways of working, through programs such as Six Sigma, and helping them to implement the lean manufacturing techniques that will drive up quality and efficiency."

Partnership is also about communication and Honeywell's turbocharging business has begun to use the common language of the internet where we can communicate the latest production scheldules, exchange quickly the quality performance an create uniform documentation application. Further expansion is underway for communicating the supplier assessment and other applications.

"Underpinning all of this activity is quality, flexibility, technology and commitment – and always with the customer in mind."

The Indian Ad

- Emerging opportunities create global interest

- Honeywell targets world class supplie

Eastern Europe and Asia have long featured in global manufacturing strategies ... but now there's an emerging industrial powerhouse that's winning worldwide recognition for its world-class credentials. India is experiencing economic growth of 5% per annum, has a booming automotive sector – and is attracting significant investment as a result of its industrial know-how, skills base and quality culture.

Sanjay Sondhi is Honeywell's Director for Business Development in South Asia and he sees enormous opportunities opening up for the turbocharging business. "At a macro level, India is the second fastest growing economy in the world after China – and is set to grow even more rapidly over the next decade.

"With such growth comes greater economic wealth and this will lead to opportunities for Honeywell's turbocharging business to support a flourishing passenger car and commercial vehicle market, particularly with diesel fuelling 40% of India's commercial and passenger vehicles and more stringent environmental legislation in the pipeline (Euro 3 standards by 2005).

"Indeed, India is already home to 13 major auto manufacturers which have recognized the domestic market opportunities and the added value that can be delivered to their businesses through the local supply base. The implications for Honeywell's engine boosting technology are self-evident."

A period of sustained investment has seen the country transformed from a low volume, fragmented, industrial facility into a truly world class manufacturing base, producing world class products using world class systems and technology. Suppliers are very strong in product development, CAD CAM capability and speed in tooling, with highly sophisticated lean techniques delivering impressive lead times.

Honeywell's turbocharging business involvement in India began 18 months ago and already new partnerships have been formed on the supply side. It is estimated that in three years time, up to 10% of the company's direct spend could reside within India's world class manufacturing facilities.

"India is fast emerging as a world leader in many areas of relevance to Honeywell's turbocharging business," says Pasquale Abruzzese, European Director Supply

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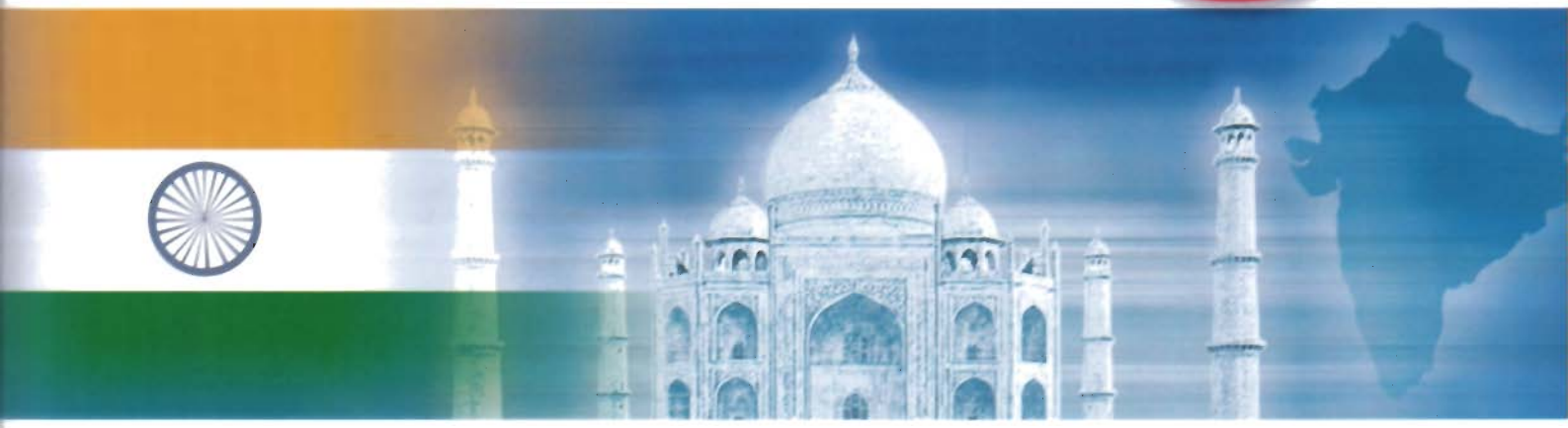

Management, who is leading the company's supply chain development in the country.

"This is a country brimming with highly skilled suppliers which share a quality culture in line with our own and I am sure that they can assist us in delivering competitive advantage to our customers."

Honeywell is building a team of supplier development and commodity managers, tasked with working with Indian companies initially to support established products going into the European marketplace – but with an eye on extending this to include the US and Asia and, in the future, to investigating engineering, testing and 'back office' opportunities.

India Fact File:

- Services account for 51.2% of the economy, agriculture for 26.8%, and industry for 22%
- India is a leader in the IT and ITES services domain, with 2002 revenues of $8 billion growing at 30% per year and expected to reach $50 billion by 2008
- Automotive component exports grew by 30% in 2002 to $800 million
- There are 400 automotive components suppliers in India, of which:

  - 244 are accredited to ISO9000
  - 11 to ISO1400
  - 107 to QS9000
  - 4 to ISO TS16949
  - 2 hold a Deming prize for Quality

Models Of Co

Breakthrough 1

Investment in the latest manufacturing technology is delivering significant quality and productivity gains at the Honeywell plants in the UK and in Ireland.

An automated manufacturing cell is driving up productivity for the company's Exhaust Gas Recirculation (EGR) coolers; a new 3D printer is dramatically improving the rapid prototype process; and advanced foundry technology is delivering optimum consistency in turbocharger wheel production.

Honeywell created a multi-functional team to work on delivering an automated solution to the assembly and testing of EGR coolers. Working closely with a partner supplier, manufacturing engineers used Six Sigma tools to develop an automated manufacturing cell that would significantly improve on the previous manual process by driving up product consistency, quality and productivity.

The result is a remarkable reduction in cycle time that enables 102 units to be produced each hour, compared to just 24 under the old system.

"By applying lean manufacturing principles and focusing upon ergonomic design, our engineers have achieved a number of benefits aimed specifically at improving service to our customers," says Bob Fenton, Manufacturing Engineering Leader.

The plus points include:

- Greater consistency and repeatability in applying the braze alloy to each cooler type
- Improved quality - the machine has mistake-proofing built in to each stage of the process to ensure that any non-conforming product is rejected immediately
- Change-over set up times reduced by 60%
- Cycle time cut by 75%.
- Improvement in first time rejects to 0.8%.
- A 16% reduction in waste alloy
- Better floor space utilization

"We now have a process that is better controlled and deliver significant gains in terms of output and quality," says Bob. "We are receiving excellent feedback from our customers."

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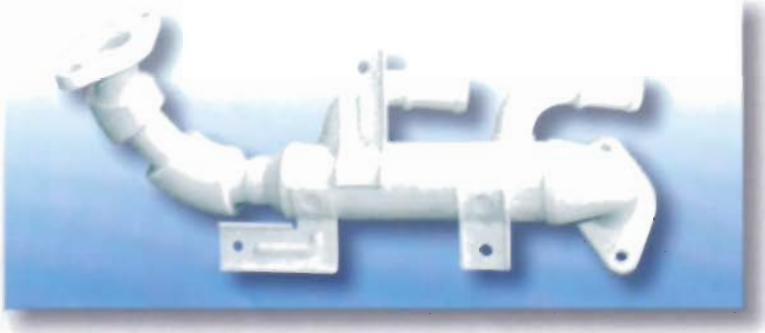
Breakthrough 2



Honeywell's investment in the latest 3D printer is revolutionizing the design cycle time involved in Birmingham's rapid prototyping facility.

A process that took days, sometimes weeks, to move from design to stainless steel model is being radically improved as a result of the company's ability to create a solid bonded 3D mock-up in a matter of hours direct from CAD input.

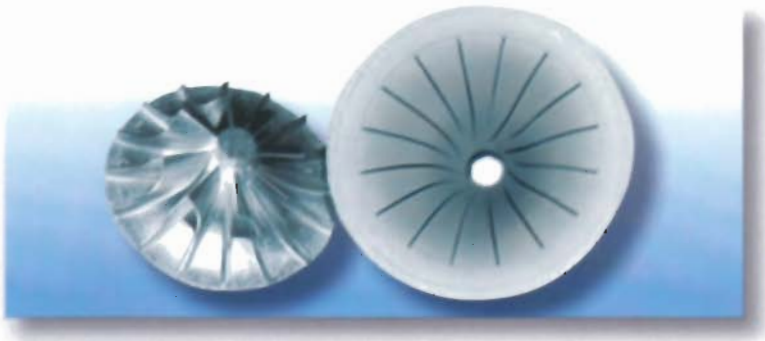
Matt Stonehouse, Manager, Engineering Services, says that the 3D printer is already proving its worth in shortening the time from conceptual design through to production tooling.

One of the first projects involved creating a 3D working model of an EGR by-pass valve in support of an on-going customer program. Within a matter of days from initial discussion, a 3D model was presented to the client engineer at his desk.

"The new resource reduces the design cycle time by minimizing the likelihood of future problems and helps to clarify complicated component/assembly designs with the supply chain.

"This is proving to be an essential prototype tool - enabling us to produce scale down models or built-up assemblies and to test the feasibility of components both faster and at lower cost," says Matt.

Breakthrough 3



Investment in the latest automated manufacturing technology is moulding a new dimension in quality and safety at Honeywell's turbocharger foundry at Waterford in South East Ireland.

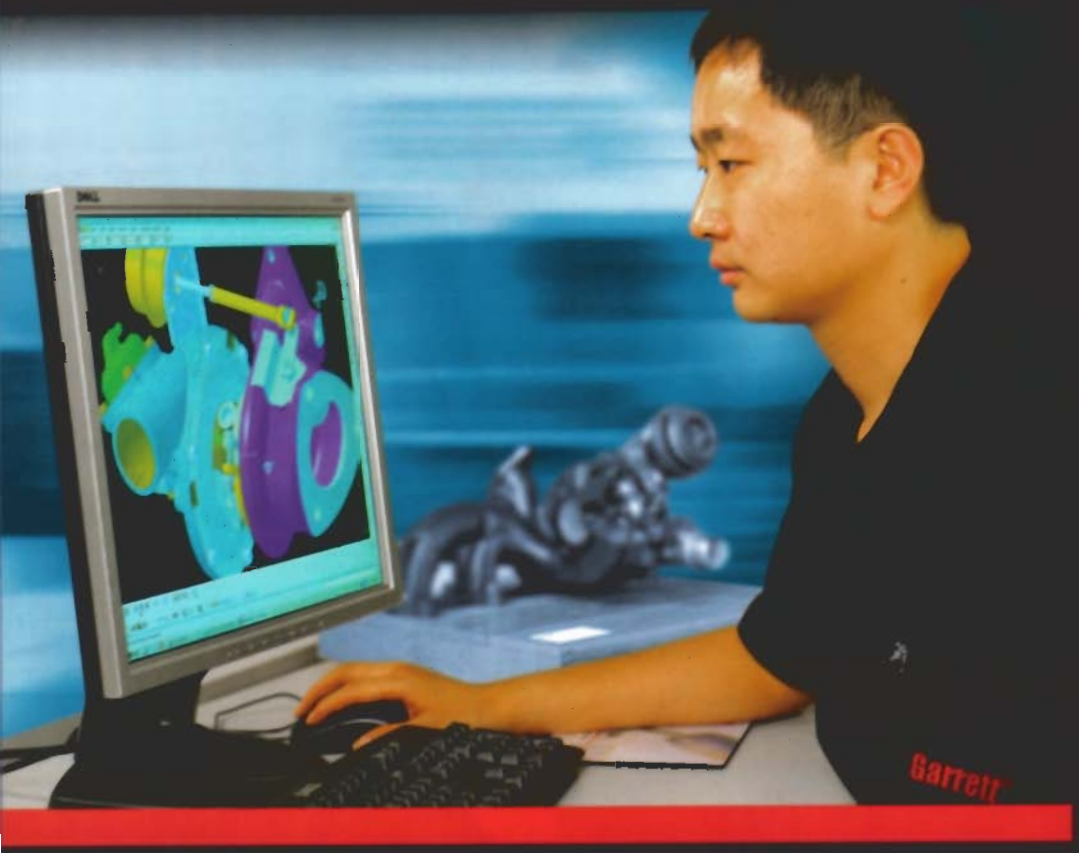
Waterford is the company's major producer of turbocharger wheels, manufacturing aluminum compressor wheels and super alloy turbine wheels for all Honeywell turbocharger sites worldwide.

Now computer-controlled technology has been introduced for casting aluminum – a new process that eliminates the risk of oxide inclusions by taking a pre-determined amount of metal from beneath the metal surface and pouring this automatically into the mould. The result is a process that minimizes waste and variation and improves quality. This investment has led to a 50% reduction in product cycle time, which has enabled us to increase capacity.

Says Michael Morrissey, Engineering & Technical Manager: "Mechanical integrity of wheels is critical in meeting the ever more exacting demands of today's engine environments. This investment ensures that we deliver the quality and consistency required by our customers while at the same time creating a safer operating environment for our employees."

Shanghai Engineering The Future

- **World class resource supports global customers**
- **Asia's first design center completes worldwide network**



Honeywell's investment in the new Shanghai Turbocharging Technology Center completes a global Engineering network capable of delivering round-the-clock working ... around the world.

For Honeywell, the Shanghai Center is much more than a world-class engineering facility for Asia, but also a resource for Europe and America. Through the engineering globalization program, it is playing an important part in harmonizing engineering standards right across the company.

Dennis Thoren, Director of Global Engineering Services and Core Technology, is heading the globalization activity.

"We considered a number of potential sites in our push to drive growth through global engineering. In particular we wanted the site to be able to provide high quality engineering support to our existing technical centers in Europe and America. Shanghai was selected for two reasons: the significant market growth opportunities in China; and a large pool of productive and talented engineers is readily available."

Initially, the center will be serving primarily as an additional resource pool for Honeywell's customer programs in Europe and America. As the Asia market develops, the center will increasingly support customer projects within the region – indeed, engineers at the center are already working with application engineers in China and will soon take in Japan and Korea.

The Shanghai Center gives Honeywell the engineering capacity and capability to work round-the-clock. Indeed, customers in Europe and America have already benefited from 3D modeling and stress analysis projects that were commissioned at the end of one working day and turned round to share with customers at the start of the next.

"Our investment in the Shanghai Technology Center is significant for many reasons," says Dennis Thoren. "Not only is Shanghai providing additional engineering resource to Honeywell's turbocharging business worldwide, the center is also playing an important role, as part of the global design standards team, in harmonizing critical engineering data in areas such as design drawings, tolerances and modeling. The Shanghai team has also demonstrated its ability to deliver very high quality 3D modeling and FEA stress analysis thanks to outstanding training and teamwork with engineers in America and Europe."

Currently, 65 people work at the Shanghai Center, 45 of whom are design engineers, representing the single largest design team within Honeywell. With active, ongoing recruitment, the total number of staff at the center is expected to hit 80 by the end of this year.

Looking ahead, the Honeywell Shanghai Technology Center is expected to also become an important resource for Testing and Development – a turbocharger test laboratory is due to come on stream in the first quarter of 2004.

Meeting Japan's Future Emissions Standards

Honeywell's engine boosting technology looks set to play a key role in helping Japan meet the world's toughest diesel emissions standards.

In March, the Japanese Ministry of the Environment announced that the most stringent regulations in the world governing heavy vehicles would be introduced in 2005 – with even stricter controls planned for 2007.

The new regulations will severely limit, in particular, both nitrogen oxide (NOx) emissions and particulate matter (PM) in heavy commercial vehicles (over 3500 kg). From already tightened 2002 limits, by 2005 NOx will need to be reduced by an additional 41% to 2.0 g/kWh, and PM reduced by 85% to 0.027 g/kWh.

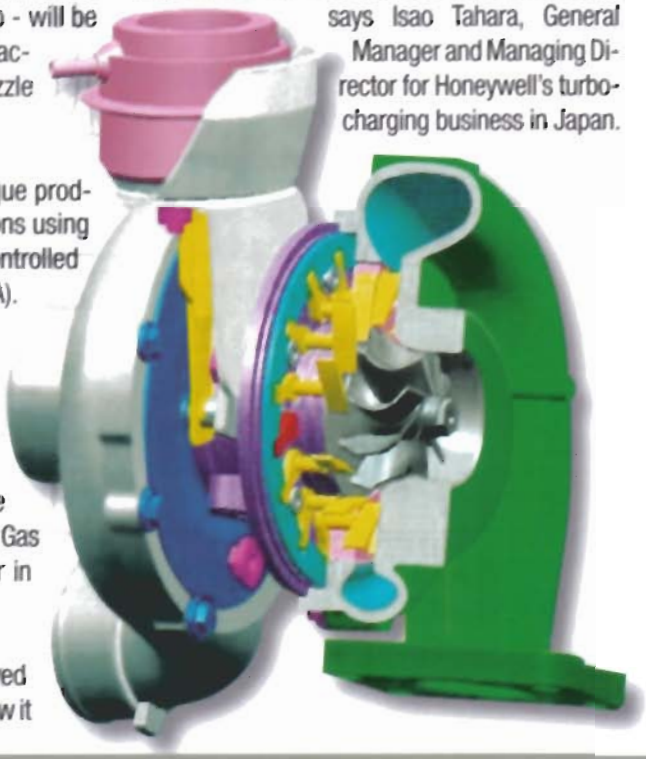
Even more stringent long-term emission regulations are likely to take effect in the 2007 timeframe.

To meet these new standards, Honeywell – which has a turbocharger factory in Kodama, 70 miles north-west of Tokyo - will be working with diesel engine manufacturers to apply Garrett® Variable Nozzle Turbine (VNT™) technology.

The company has developed a unique product for commercial diesel applications using double-axle VNT™ technology controlled by a Rotary Electronic Actuator (REA).

The double-axle VNT™ helps limit PM by boosting air-fuel ratios at lower engine speeds. The REA, meanwhile, works directly with the truck's engine control unit to optimize boost level and aid precise Exhaust Gas Recirculation control, a critical factor in lowering NOx emissions.

"In the past, turbochargers were viewed just as a high-end component, but now it is one of the critical factors in clearing emissions regulations for commercial diesel vehicles," says Isao Tahara, General Manager and Managing Director for Honeywell's turbocharging business in Japan.



Successful Debut For VNT™ In Korea

Honeywell has introduced its ground-breaking Garrett® variable geometry turbocharger into Korea, supplying the boosting technology for the Hyundai D2.0l diesel engine found in the Santa Fe and Trajet models.

The initial development of Garrett® VNT™ turbocharger for the Hyundai D2.0l engine began in August 2000.

Very interested in the sample VNT™ turbos and impressed with the dedication and teamwork of engineers and sales managers, Hyundai decided in January 2001 to develop an upgraded version of its D2.0l engine to be equipped with Garrett® VNT™ technology.

From project start to mass production took only 24 months – a period characterized by frequent meetings that lasted until daybreak. Engineers worked around clock to keep the project on schedule, with regular conference calls between France, Japan and Korea, and excellent team work between application engineers and sales teams in Korea.

The result is a high performing turbocharged engine which, in comparison to the original, delivers more power (126hp vs. 115hp at 4000rpm), more torque (29.5kgm vs. 26.5kgm at 2000rpm) and 10.4% better fuel efficiency.

The Hyundai Santa Fe has become one of the best selling SUV models in Korea.

Steve Peterson

Moving global creates opportunities and challenges. One of the key drivers at the top of the agenda is quality ... ensuring that the improvements achieved over the last 12 months are further augmented through a global approach to business. In this interview, Steve Peterson, Worldwide Director of Quality for Honeywell's turbocharging business, tackles some of the big issues that are driving the quality culture within the company.

Quality

Cascading A Cultur

- **Worldwide approach defines quality commitment**
- **Competitive advantage founded on values shared with customers**

In such a complex marketplace, how does a business ensure true worldwide consistency in its own quality operation and through its global supply chain?

The approach to quality for the automotive industry has become common worldwide as competition has become global. There may be some subtle differences in application based on local cultures, but conceptually everyone follows the same disciplines.

As a global automotive business serving global customers, we strive to deliver world class quality wherever we operate. We have the same standards and the same approach in every plant and with every supplier.

Businesses tend to define quality by reference to internationally recognized standards - does the achievement of such standards automatically create a quality culture?

I wish creating a world class quality culture was as straightforward as creating processes and procedures and becoming certified to a quality standard. Achieving certification must be seen as necessary but not sufficient. A quality culture is more about how each individual acts every day and what they do to make sure the customer's needs are met each and every time. And to be clear, this culture must permeate the entire enterprise. The factory is only the last link in the quality chain that serves our customers.

We ask that all our managers and supervisors keep the customer in mind and encourage the necessary behaviors to make quality a dynamic competitive advantage both for our company and, more importantly, for our customers.

A quality ethos should be reflected in service to customers - how does your quality approach support the technological innovation that auto manufacturers seek?

One thing is very clear; people expect their cars to always work as expected, to last longer than the last one, and they expect convenience and performance not dreamed of a few years ago. Improving quality and reliability on more complex products working in tougher environments is a daunting challenge, but it's the one that keeps many of us excited to come to work every day.

It is a great advantage that we have been using Six Sigma for so many years because now everyone understands what we mean by "variation is the enemy."

Design For Six Sigma (DFSS) is the starting point to clearly define what is Critical To Quality (CTQs) and how to translate them into successful designs with the full knowledge of and respect for manufacturing process capability. It can be a long path, but our product development and introduction program and the industry's Advanced Product Quality Planning process are employed to ensure new technology is delivered on time and with Six Sigma quality. We can't claim we always achieve that goal, but the target is always directly in sight, and each time we get a little closer.

Of Success

Do quality issues vary in different regions - are all regions at the same stage in the achievement of standards?

In today's global automotive world, it is unacceptable but also unnecessary to accept lower standards from any region in the world. Sometimes we can see that the emerging countries are less mature in understanding global standards, but from my own experience, they compensate by working harder to improve, so the gap is not so big in practice.

I see some healthy competition between our plants, with each one wanting to be seen as "the best" – so this tends to create a lot of momentum for continuous improvement.

If we look at our supply base, we actually experience more problems with some long-term suppliers who have not kept up with rising expectations, while some newer ones in the emerging economies are fully competent to meet our expectations. We have been successful in raising our expectations of suppliers – after all they deliver 60% of what goes into our product. It is certainly more true today than ever before that if you are not moving forward, you are falling behind.

What are the benefits of the new quality standard ISO TS16949?

I see benefits both in terms of uniformity as well as resource conservation.

The ultimate goal is for a global quality system that can best be viewed from the top of the organization, with each key management process cascading throughout the regions and sites. Until now, each plant has created its own unique set of quality procedures.

With the new version ISO TS16949:2002, we take a process-driven approach, better reflecting how the business is really managed. The ultimate result will be fewer procedures and better-documented and controlled processes. The quality system will be maintained regionally and globally, and cascaded throughout our network.

A Global Standard For A Global Business

The global nature of the automotive business is driving a new quality standard that will be recognized within the industry in every corner of the globe.

ISO TS16949 has been developed by auto manufacturers through the International Automotive Task Force to accredit quality management systems within OEMs, first tier suppliers and second tier companies.

Director Quality Europe, Karl-Heinz Westhoff comments: "In the future, this standard will effectively be the entry card to the marketplace. It is particularly valuable because it focuses on the way in which we meet objectives that relate to the needs of our customers. It looks at processes rather than departments embracing many of the principles already evident in Six Sigma."

Utilizing the culture embedded in Six Sigma has delivered significant improvements in quality performance over the last 12 months – including a 50% reduction in parts per million rejects. This result has been made possible by a quality system that focuses on prevention rather than detection.

Turbocha

Whether it's on asphalt, snow, gravel or rocky dirt; on a road course, a racing oval or a grueling off-road circuit; whether it's cold or blazing hot – Garrett®-boosted racing machines have proven to be winners once again in 2003 in all the racing series in which they compete.

At the top of the honors list is a fourth consecutive first-place at the prestigious Le Mans 24 Hour endurance race in France. The winning performances of Bentley and Audi teams meant a 1-2-3-4 finish for Garrett®-boosted entries.

Overall, six of the top nine finishers were equipped with the company's turbochargers, which deliver a cooler and denser compressor charge, reduced back pressure on the engine exhaust, improved boost response, lighter weight and smaller, enhanced packaging.

On the US side of the Atlantic, Honeywell has taken the opening three rounds of the 2003 American Le Mans Series, with Garrett®-boosted Audis claiming the opening races at Sebring, Florida, and Braselton, Georgia and MG/AER winning the race in Sonoma, California.

In the 2003 World Rally Championship, defending series champion Marcus Gronholm is the only multiple winner after seven events, setting the pace in his Garrett®-boosted Peugeot 206 WRC in New Zealand, Argentina and Sweden. Garrett®-boosted cars have won 7 of the first 8 events on the 2003 schedule.

On the open-wheel racing front, all CART Champ Cars are equipped with Garrett turbochargers in the spec Ford-Cosworth engine for the first time this season. After 11 of 19 events, the Championship is led by Paul Tracy in a Lola-Ford.

ging To The Checkered Flag

Turbocharged Racing Engines Are More Durable

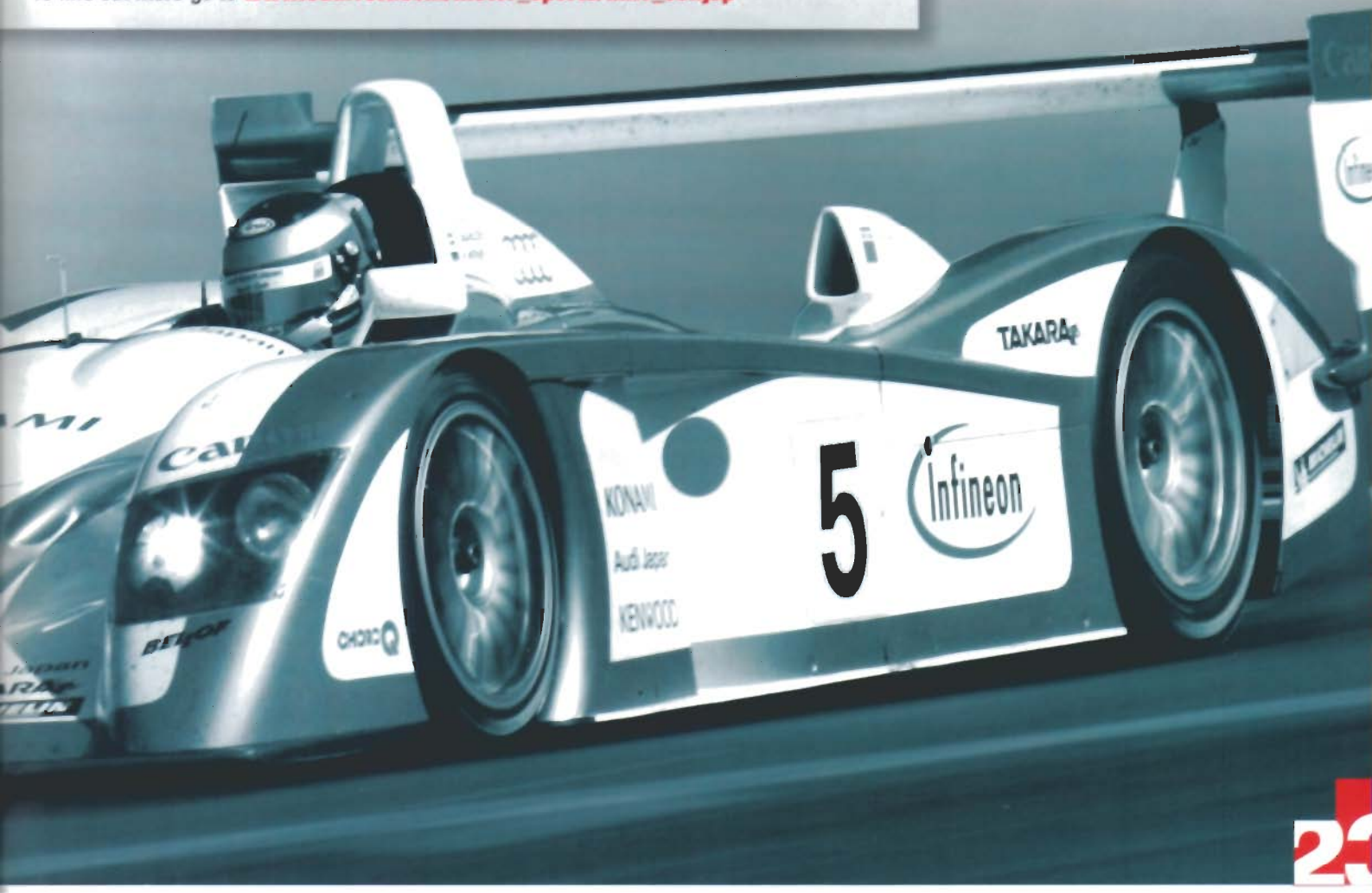
Some advantages of a turbocharged racing engine are well understood. Smaller displacement leads to reduced fuel consumption. In addition, smaller, lighter engines help to deliver improved vehicle handling and better body aerodynamics. But what about durability of a turbocharged racing engine?

Doug Milliken, Motorsports Manager, examined the dynamic characteristics of typical engines of varying displacement, cylinder count and induction type at the Le Mans race.

The analysis explains the reason that turbocharged engines have had a significantly better durability record than naturally aspirated engines in the LMP900 and GTP classes at the Le Mans 24 Hour endurance race in recent years.

According to Doug Milliken's SAE paper on the subject, "Turbocharged racing engines can achieve equal performance with significantly lower internal inertial loading because of smaller and therefore lighter reciprocating components operating at lower speeds." Little surprise, therefore, that Bentley and Audi chose turbocharged engines to compete at Le Mans.

To find out more go to **www.eGarrett.com/motor_sports/innv_sol.jsp**



Winning A

- **Garrett® AVNT™ technology sets the pace in the US**
- **Diesel boosting platform supports award-winning customer**

A three-year development program with a leading engine manufacturer is heralding the rapid expansion of turbocharger technology for commercial vehicles in the US … and winning critical acclaim for customers along the way.

Honeywell's ground-breaking Garrett® AVNT™ technology has been adopted by the International Truck and Engine Corporation for its light pickup truck sector – and demand is rising fast as users see the benefits of impressive performance on the road, lower emissions and optimum fuel efficiency.

For International, Garrett® AVNT™ technology has played an important part in its Power Stroke® diesel engine being named one of the world's top 10 in 2002.

"International saw Garrett® AVNT™ technology as a means of winning market share in a

ll The Way

highly competitive marketplace", says Doug Reithmeier, Customer Team Leader at International.

"International recognized that the air management system was critical in the development of an engine for the future – a diesel engine that would deliver greater power ratios than their competitors while at the same time offering improved fuel economy and superior emissions control."

The Garrett® AVNT™ boosting technology enables International's Power Stroke® 6.0 liter V8 diesel engine to develop 325hp in contrast to the earlier 7.3 liter that delivered 265hp.

While Garrett® AVNT™ technology has been adopted by International in the light truck sector, there is also significant potential for the boosting technology in medium and large trucks over the next few years.

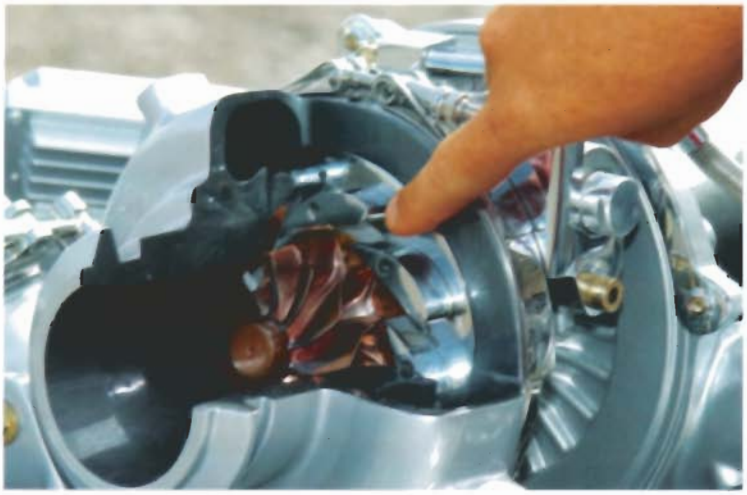
"And not just in the US," says Michael Cirone, Director, Worldwide Commercial Diesel.

"The common denominator across the globe – whether it's the US, Europe, or Asia – is the need among commercial diesel manufacturers to meet ever more stringent emissions regulations. We already have the proven technology to help our customers deliver the competitive advantage that they seek – as evidenced by International."

Garrett® AVNT™ – How The Technology Works

The Garrett® AVNT™ turbocharger is a multivane VNT™, where the unison ring is in the exhaust flow path and controls the vanes through tabs mounted on the vanes.

"This is accomplished by the use of a proportional solenoid combined with a 4-way hydraulic spool valve. This spool valve is connected to a double-acting piston that drives



the VNT™ crank mechanism through a rack and gear. The gear also has a cam, which provides VNT™ position feedback to the closed loop hydraulic servo."

The vanes are metal injection molded and have a "chubby" cross-section, allowing the pivot to be a fixed pin pressed into the turbine housing, with a hole in the vane for the pin. The actual VNT™ mechanism consists only of nine vanes, nine pins, and one unison ring.

"One of the unique features of the Garrett® AVNT™ is its electro-hydraulic actuation that utilizes the bearing system oil feed as the hydraulic source, integrating the bearing system and actuation system into one housing," says Steve Arnold, Director, Innovation and New Concepts.

The Garrett® AVNT™ provides customers with a high performance, cost effective, VNT™ with self-contained actuation that has excellent packaging. The AVNT™ improves engine transient response, provides optimized air/fuel control, and can be used to drive Exhaust Gas Recirculation and to improve engine braking.

International's Power Stroke® Diesel engine, which features Garrett's® AVNT™, was named one of 2003's "10 Best" engines by Ward's AutoWorld, a premier automotive industry magazine.

US 'Ride and Drive

Showcasing the Latest Turbo Technologies

■ Production cars from US, Europe, Australia and Brazil demonstrate benefits of engine boosting to the US market

Turbocharged cars deliver great performance, excellent fuel efficiency … and are fun to drive!

These were the messages that Honeywell delivered to US auto manufacturers and the media at a special 'Ride and Drive' event in Detroit in May, 2003.

At the event, executives from DaimlerChrysler, General Motors and Ford Motor Co. and media representatives got the chance to drive a wide variety of turbocharged vehicles and to test them against their non-turbo counterparts.

"We were demonstrating to the US marketplace what is already evident in Europe - that turbos give consumers great performance and increased fuel economy compared to larger, non-turbo- powered vehicles," said Rob Gillette, President and CEO of Honeywell Transportation and Power Systems. "Plus, turbocharged cars are incredibly fun to drive."

He added: "One percent of gasoline passenger vehicles in the US are turbocharged, while in Europe the number is 10% and growing. If you also look at the wide acceptance of turbo diesels in Europe, it's clear that they are far ahead of the US in taking advantage of the benefits of turbo technology."

The vehicles driven at the event included two Ford Falcons from Australia, the Euro-only Ford Focus RS, two versions of the Saab 9-3 (same engine, different turbos), the VW Parati (Brazilian wagon), two Jeep Liberties (one turbo, one without), the Volvo XC90 and three turbo diesels: the BMW 530d, the Jeep Grand Cherokee and Volvo S80.

Latest News

Honeywell's Transportation and Power Systems CEO Rob Gillette Speaks to Top Detroit Auto Industry Executives

Drawing on Honeywell's turbocharging experience in Europe, TPS President and CEO Rob Gillette told 700 automotive executives that technology can help US auto manufacturers profitably sell cars. Rob spoke at the Management Briefing Seminars, an annual event in Traverse City, Michigan, where leaders throughout the auto industry gather to network and learn about market trends.

In his remarks, Rob discussed how technology, including turbocharging, is used in Europe to make popular vehicles that provide both fuel efficiency and performance. He went on to state that the smaller turbocharged engines common in much of Europe, can provide the same power as the much larger and fuel-thirsty engines that are typically used in the US.

New Vice-President and General Manager for Europe

lexandre Ismail

Bert Snijders is retiring after serving as Vice-President and General Manager of the Europe region for Honeywell's turbocharging business for the past six years.

Alexandre Ismail is taking over this position as of September 1st, 2003. He brings a strong global perspective to his new role having held strategic functions within Honeywell both in the US and Europe regions over the past four years. In his most recent position, Alexandre Ismail served as Vice President, Turbocharger Sales and Customer Management, Europe. He began his Honeywell career in 1997 and has held several roles within the automotive consumer products and aerospace businesses.

Said Rob Gillette, President and CEO, Honeywell Transportation and Power Systems: "Bert's enthusiasm and vision has been an essential part of our continued success in Europe over the last six years. We are grateful to him for his leadership in the region and appreciative of the strength of the organization he now hands to Alexandre."

Honeywell Plans Regionalization

Honeywell will shortly begin a regionalizan program that will centralize European turbocharging maneement activity in Switzerland. e company aims to consolidate umber of its business functions one central location as a means of enhancing efficiency and improving still further communication with customers and suppliers.

"We will be keeping our customers, supply partners and staff fully informed of developments, but in essence this move will deliver significant advantages to the business," says Alexandre Ismail, newly appointed Vice-President and General Manager of the Europe region.

"We decided on Switzerland because it is right at the heart of Europe and benefits from an excellent infrastructure. Moving our administrative functions to a centralized location has long been a goal of ours. With our rapid growth over the past few years, it has become increasingly critical to look for ways in which we can operate as efficiently as possible."