Honeywell

Booster

May 2004

The VNT™ Dimension
13 Million Garrett® Turbo Solutions

Pole To Podium
Turbocharging Across The Winning Line

On Track

Honeywell's third generation VNT™ turbocharger makes its debut this year – adding to the 13 million VNT™ units that have already been shipped to customers since the ground-breaking technology was unveiled in 1989.

Honeywell's manufacturing and assembly facility in Bucharest is ramping up quality and output on the back of a major development program involving plant and people. The investment mirrors increasing interest in Eastern Europe in the automotive industry.

Emissions regulations being introduced in the US in 2007 are shaping the next generation of commercial diesel engine platforms. Engine manufacturers are increasingly looking for turbocharger solutions that can drive engine boosting into the light truck and SUV segment.

A major partnership program has resulted in a step change in outboard engine technology. The Mercury Marine project has created what is believed to be the most sophisticated marine propulsion unit in history.

Sustainability is the watchword at Honeywell's Waterford plant in Ireland, where 80% of all waste is either recycled or reused.

Race teams supported by Honeywell turbo technologies made a clean sweep in 2003 of constructors' titles in the FIA World Rally Championships, CART Champ Cars and the American Le Mans and The 24 Hours of Le Mans (France) series.

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LISTENING AND LEARNING

Dear Readers,

Technological excellence, a commitment to quality and dedication to customer service – these are the cornerstones of the Honeywell approach to business.

One of the best examples that combines these three elements is the story of VNT™, the ground-breaking engine boosting technology that changed the nature of turbocharging in the automotive industry.

The VNT™ story began more than 15 years ago, but its success and the customer benefits it brings continue to evolve to this day. Indeed 2004 will see the rapid take-up of the third generation of VNT™, a development that will strengthen our customer partnerships as we seek to take passenger car engine boosting to a new level.

Technology, of course, is only part of the equation in the way we support our customers. The other critical element is quality – and quality will be the major focus this year of the entire Honeywell turbo technologies business: in every region and across every function throughout the organization. This is an area where we can – and will – do better.

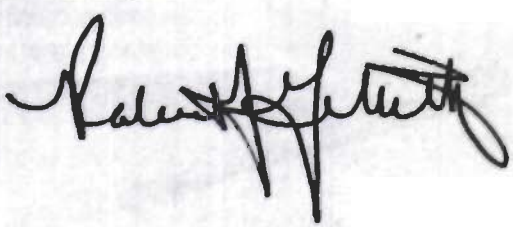
We have developed a comprehensive global plan that will ensure that we take the necessary steps to create the world-class quality culture that is a pre-requisite of our partnerships with our customers.

A good example of the progress we are making can be found in the development of our new manufacturing and assembly facility in Bucharest, where we are recording extremely high customer ratings. This success demonstrates the standards we set ourselves going forward.

I would also like to take this opportunity to inform you about a change in our company name from Garrett Engine Boosting Systems to Honeywell Turbo Technologies. Garrett® will still appear as a product name, but we are now aligning ourselves much more closely under the Honeywell umbrella, a decision that we believe will enhance our image in the marketplace and augment still further our partnerships with customers.

I hope that you enjoy reading this latest edition of Booster. Thank you for your continuing support.

Rob Gillette
President & CEO
Honeywell Transportation Systems



The VNT™ D

Ground breaking technology spans the globe

Third generation – the innovation continues

It's the turbocharging technology that changed the face of engine boosting – and helped to transform the driving habits of an entire continent.

Honeywell's variable geometry turbine (VGT turbochargers have revolutionized the design o diesel engines – and in particular the Garrett® Variable Nozzle Turbine turbo, or VNT™ has led the way for more than a dec ade. In the last 15 years, more than 13 million VNT™ turbos have been installed in passenger cars across the world, most notably in Europe where diesel engines account for 43% o the marketplace.

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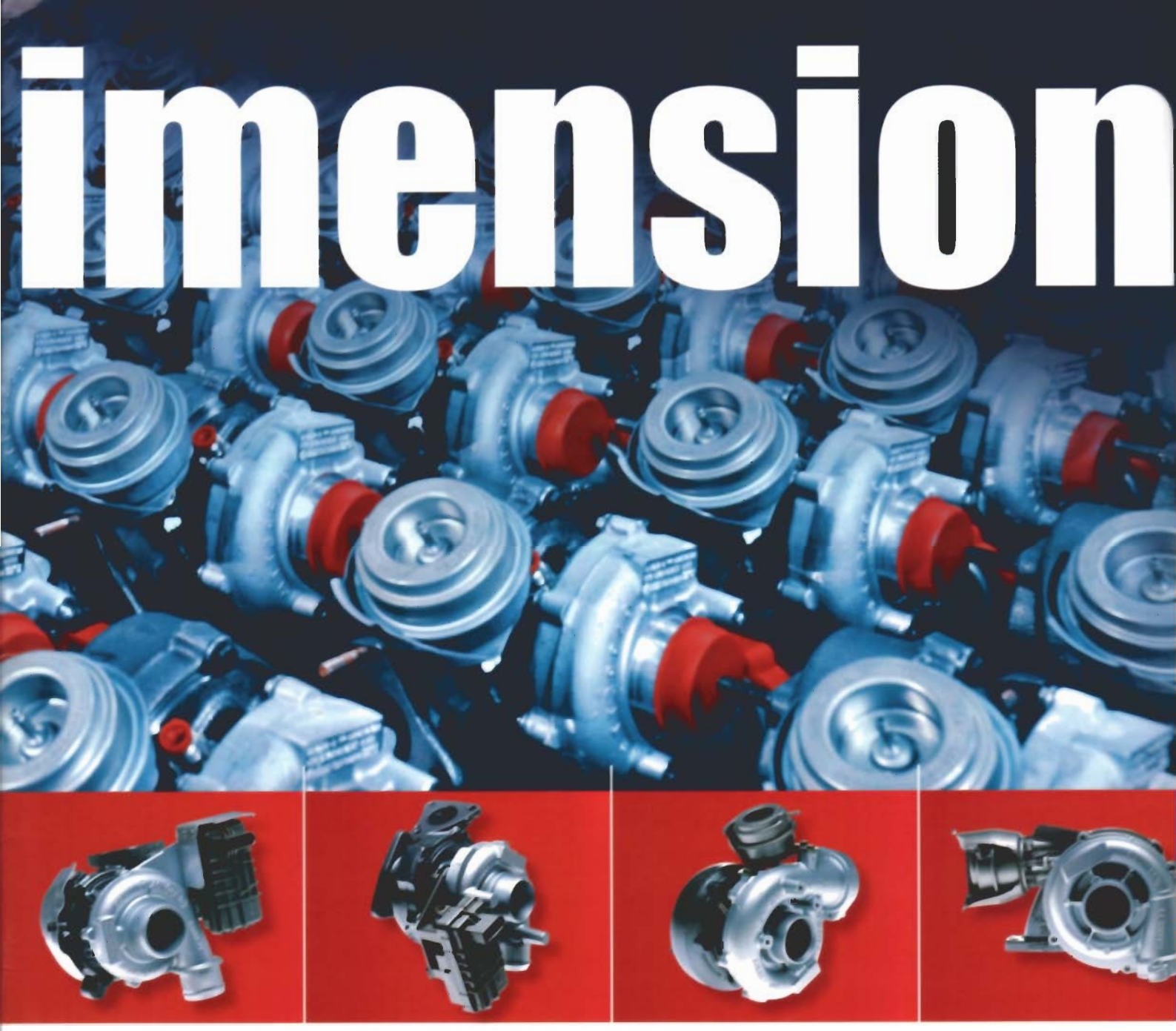


All this has stemmed from the first Garrett® VNT™ turbocharger produced in 1989 – interestingly for a Nissan commercial diesel application. The first passenger car application followed in 1990, when FIAT put the VNT™ turbocharger in the Croma, matching it to a 1.9 liter, direct injection diesel engine.

A world first

Next in line was the Renault Espace 2.1 liter diesel - but it was in 1995 that VNT™ really started to come of age, when the VNT™ developed for the Volkswagen-Audi 1.9 liter direct injection diesel engine was unveiled at the Frankfurt Motor Show.

The launch represented the beginning of mass production of VNT™, a technology that was unique because it involved a turbine housing that had the ability to change its internal configuration to adapt to variations in the engine's air boost requirements.

The Volkswagen Group was interested in using engine boosting technology, alongside an electronic injection system, to increase the power output of its base 66kW diesel engine, but couldn't achieve the desired results with wastegate technology. Honeywell and Volkswagen Group worked closely together to apply VGT technology – and succeeded in uprating the power output to 81kW while lifting the torque to 230Nm at 1500 Rpm.

VNT™ technology was clearly delivering major gains in torque and power by improving engine back pressure – and the major automotive manufacturers immediately recognized the huge potential.

Growth takes off

Soon, VNT™ was on a major growth curve that would see volumes climb dramatically from the 200,000 units produced in 1996. The company invested in advanced manufacturing facilities and automated assembly lines dedicated to customers to keep pace with the rapid increase in demand for the new technology.

The remarkable take-up of variable geometry turbocharging was augmented with the incremental gains developed through the second generation VNT™, launched in 1998, which significantly enhanced the controllability required by the newer electronic injection systems. Within a year, VNT™ broke through the one million unit barrier – and growth has

How VNT™ works

A Garrett® VNT™ turbocharger works by adjusting the gas throat section at the inlet of the turbine wheel in order to optimize turbine power with the required flow velocity.

At low engine speeds and small gas flow, the turbocharger reduces the throat section, increasing turbine power and boost pressure. At full engine speed and high gas flow, the VNT™ turbocharger increases the throat section, avoiding turbocharger overspeed and maintaining the boost pressure required by the engine.

The throat section modulation can be controlled directly by the compressor pressure through the use of a pressure actuator, or by the engine management system using a vacuum actuator. To modify the throat section, VNT™ Multivane™ models use a mobile multivane system composed of a number of vanes which rotate relative to the turbine wheel axis.

been accelerating ever since, with 3.9 million units produced in 2003 at world-class manufacturing centers in Italy, Romania, France, Japan, Korea, Brazil and Mexico.

Comments Denis Jeckel, Honeywell Worldwide Product Line Director: "Put quite simply, our customers like the competitive advantages that VNT™ technologies give them through higher power, higher torque, lower fuel consumption and better emissions control – but they also like the evolutionary nature of the VNT™. This approach has ensured that VNT™ turbochargers complement the pace of change in engine development."

The latest generation

Now the VNT™ story is about to take another turn, with the launch of the third generation. The latest generation VNT™ is groundbreaking in the way it attaches the variable geometry mechanism onto the bearing housing through an elastic shroud. This new platform has delivered many innovations – a new vane shape, a new generation turbine wheel and better controllability. The result is a unit that is delivering up to 10% turbine efficiency gains and 130% of VNT™ 2nd generation boost at 90% of back pressure.

Says Denis: "There is already considerable interest in this latest generation – the first application will be in the BMW 1 series in September, but many more programs are in the pipeline."

And the story of VNT™ doesn't stop there. Denis Jeckel points to growing interest in the technology in Asia, to the popularity of Advanced Variable Nozzle Turbine (AVNT™) in the US and to the development of VGT technology adapted to gasoline applications.

"Auto manufacturers face considerable challenges in the years ahead, most notably in meeting ever more stringent emissions standards. VNT™ technology has proven its worth over the last 15 years – and will become even more relevant going forward."

Focus On Fiat

Interview with Carlo Ugaglia, Fiat-GM Powertrain Global Product Manager for diesel and gasoline engines from 1.9 to 2.4 liter, who explains how the partnership with Honeywell is developing and looks at the role that VNT™ technology has played in the company's success.

How has the partnership with Honeywell contributed to the success of the company's engine platform?

The partnership between Fiat Auto and Garrett® started in the mid-1980s with turbo technology being applied to the legendary Lancia Delta Integrale – the winner of consecutive world rally championships. This was followed by the Fiat Coupe 2.0 L 5 cylinder application - in my view the best production turbo gasoline engine ever made.

As far as diesel is concerned, in the late 1980s we were proud to utilize Garrett® VNT™ technology in the first DI production engine, and when we launched the world's first production common rail in 1997 we included a second generation VNT™ as part of a state-of-the-art diesel engine platform.

Today, our partnership with Honeywell includes the application of VNT™ turbo technology to the first engines sold as Fiat-GM Powertrain (the 1.9 L "convergence" engines).

What benefits resulted from the application of VNT™ technology to common rail engines?

Variable geometry turbocharging enhances common rail injection technology by optimizing exhaust gas energy while accommodating the thermo-mechanical stresses on the engine.

What added value was created by the application of VNT™ with integrated manifold in the later Fiat GM Powertrain model?

We are producing engines (and gearboxes) for a large numbers of different applications. The use of the integrated manifold coupled to VNT™ technology give us design and development freedom and enables us to satisfy customers' needs with a (relatively) limited number of components.

How is your company developing its turbo diesel offering around the world?

We believe there is potential for significant increase in demand for boosted diesel engines in many regions around the world, based on the production of advanced technology engines that meet the fuel and emissions requirements of each locality. For example, the conditions are now more favorable for diesel use in countries like the US and parts of Asia.

Looking ahead, what do you expect future engine boosting technologies to deliver?

Increasingly stringent emissions regulations will focus attention still more on engine boosting technologies, as OEMs seek engine downsizing solutions that marry the demand for performance with environmental concerns. For our part, we see wastegate technology as being applicable to 100hp engines, VNT™ from 100hp to 180hp and innovative turbo solutions over 180hp.

What are the qualities that will determine the nature of the Fiat/Alfa Romeo partnership with Honeywell in the future?

Fiat GM Powertrain, as a supplier of Fiat/Alfa Romeo, believes that quality and product reliability are the more important factors when looking for our partners; moreover we increasingly seek collaboration from the earliest project stages. We ask our partners not just to adhere to our product development procedures but also to respond quickly to our demands for new products and for performance data as we drive forward our plans to maintain our technical leadership.

VNT™ Facts and Figures

- Between 1991 and 2003 13.2 million VNT™ turbochargers have been produced
- Of the 7.9 million Garrett® turbochargers produced in 2003, 3.9 million were VNT™

Dave Cote
Honeywell Chairman
and CEO

To

■ Honeywell CEO celebrates successful Romanian transformation
■ Romania to manufacture 10% of worldwide turbocharger output

The transformation is complete. Just 12 months after the decision was taken to convert Honeywell's Bucharest component plant into a major manufacturing and assembly center, the first turbos were being shipped to customers. It is a remarkable achievement by any standards - and one singled out for recognition by Dave Cote, Honeywell Chairman and CEO, during a high level visit to Romania.

Mr. Cote saw the results of the Bucharest investment as part of a visit that included a series of meetings with government officials and the media, during which he cited the turbocharger manufacturing center as an example of the success of Honeywell's investment strategy in Eastern Europe.

The story of the transformation of the facility is one founded on a motivated workforce, Europe-wide cooperation and investment in world class systems and processes. Already, the plant is exceeding performance targets and recording extremely high customer quality ratings.

o Marks

Aligned for success

By the end of the year, Bucharest will have manufactured 800,000 turbocharger units. This is testament to the effectiveness of a logistical exercise involving the physical reconfiguration of the plant, the recruitment and training of new and existing staff and the alignment of business critical processes to Honeywell's global standards.

During his meetings in Romania, Mr. Cote said that the Bucharest facility demonstrated the success of the corporation's strategy in investing in Eastern Europe and highlighted the determination of the turbo business to serve its customers as effectively as possible.

He commented: "The new facility in Romania is producing 10% of Honeywell's total turbocharger output and has exceeded our initial production and quality objectives, thanks to the impressive commitment and teamwork of our people. This is an important development for Honeywell and our customers, and demonstrates our active support for the strategic requirements of those automotive manufacturers who have themselves invested heavily in Eastern Europe."

Increasing momentum

The project required meticulous planning and involved:

- The complete reconfiguration of the plant to accommodate two passenger car turbo modules and one commercial diesel module
- The recruitment and integration of 40 salaried staff over a six month period
- Extensive training for all the 434 people at the site
- The fastest-ever Honeywell SAP implementation (4.5 months)

"This was a real team effort, not just for the people on the ground but for our European operation as a whole," said Bucharest Plant Manager Gheorghe Dudau.

"We received excellent support from Atessa (Italy), Thaon-les-Vosges (France) and Skelmersdale (UK) as we implemented new quality, production and manufacturing engineering systems. Now we must increase the momentum, particularly as we ramp up production towards our output target of 4,000 turbos per day by the end of the year."

Americ

In Harmony

an Tune

With Our Customers

An interview with Jeff Donnell

Honeywell's turbocharging business in the Americas is looking forward to another year of sustained growth, building on the 1,200,000 turbo units delivered annually to customers from its Mexicali (Mexico) and Sao Paulo (Brazil) manufacturing centers.

As Jeff Donnell, Honeywell Turbo Technologies' Vice President and General Manager, Americas, explains, the automotive sector is facing some real challenges in the run up to new emissions regulations in 2007 – and Honeywell is shaping up to deliver the support needed by its customers.

What are the immediate priorities for Honeywell's turbocharging business in the Americas and for its customers?
At the top of everyone's agenda just now is developing the engine platforms and technologies that will meet the 2007 emissions standards. Whereas in Europe fuel tax is a significant driver for engine downsizing, in the US the issues are really about meeting the requirements of ever-more stringent emissions standards, particularly around NO_x emissions and particulate matter. This is moving our customers towards more advanced turbocharger technology, such as variable geometry.

In the heavy-duty sector, the emissions regulations have really hit home and will clearly continue to do so into 2007 and beyond. Our main priority is to ensure that the new product introduced in recent times is delivered with world class quality. We are also working with a number of customers to develop turbos for more diesel applications in the light truck/SUV segment – a trend that started in the mid to late 90s with the acceptance of diesel in smaller vehicle applications.

How do Honeywell's turbocharging technologies meet the needs of customers?
Customers look to us to deliver performance, fuel efficiency and emissions control.

Our boosting solutions for heavy-duty on-highway vehicles are founded on our patented double-axle VNT™ technology, with some customers adopting a wastegate series arrangement. In medium and light trucks and the SUV segment, Garrett® AVNT™ will remain the key building block through to 2010. Depending on the air requirements for 2007 and

Innovation and Concepts Group

Honeywell established its Innovation and Concepts Group at Torrance, California, in May last year.

The group currently includes seven of Honeywell's top design, engineering and aerodynamics specialists, and is led by its Director, Steve Arnold, who was responsible for the development and introduction of the Garrett® AVNT™ product range. Says Steve: "It's really about trying to understand the challenges facing our customers, particularly during the next six years when we will see a 90% reduction in emissions.

"The engines of that time will be very much different from the engines of today. We need to understand what technologies are going to be required – some will be improvements to engines themselves, some will be after-treatment but the air system will also be an integral part of meeting these requirements. We aim to take all these issues into account and then come up with innovative new products aligned to our customers' objectives – and then get them into production."

And the advantages are clear – one recent project saw the period from product concept to testing reduced from one year to just four months.

American Tune

In Harmony With Our Customers

beyond, there could possibly be reasons to have a series arrangement for light truck/SUV but that would likely include an AVNT™ as one of the two turbos.

We have established an Innovation and Concepts Group specifically to look at emissions solutions for 2007 and beyond, both in the heavy duty and light truck/SUV segments. These next generation solutions will be informed very much by what we have learned through Garrett® AVNT™ technologies and applications.

How far has diesel gained credence as an alternative to gasoline in the US?

At this point many of our customers are working on diesel applications for passenger cars for 2007 and beyond. The big question facing many OEMs is whether the solution is going to be US-engineered and developed or whether this will come from Europe. There is no doubt that diesel engines will meet the 2007 requirements - but the main issue is at what cost premium relative to gasoline engines?

This year will see the introduction of some interesting diesel powered vehicles and it's going to be fascinating to see how the US public responds.

I think the proof is in putting the pedal to the floor – when people feel the performance it dispels their misconceptions.

What about gasoline boosting?

There are some interesting changes underway in the gasoline segment. We are in discussions with a number of customers about downsizing naturally-aspirated gasoline engines, taking say a V6 and downsizing to a boosted in line 4 engine. We don't see enormous demand for downsizing in the immediate future, but we do see exciting opportunities for niche, performance applications. People want vehicles that are fun to drive.

What is Honeywell focusing on this year to meet the needs of customers?

It goes without saying that we are already working on programs for 2007 through our customer teams. But above and beyond maximizing these relationships, my main focus for the business is three-fold – quality; supplier development; and the robustness of our new product introduction process. In 2002 we completed the consolidation of manufacturing in Mexicali and, having gone through a period of significant change, we are now ideally placed to deliver high quality with the benefits of a lower cost location. Our customers are demanding ever increasing quality standards. Creating a quality mindset through the organization from initial product development to final product delivery will require significant focus from myself, my team and the entire Americas organization.

2003 Cliff Garrett Award

Steve Arnold was the recipient of the 2003 SAE Cliff Garrett Engineering Award, an accolade established in 1984 to honor Cliff Garrett as an aerospace pioneer. Steve was recognized for his contribution to turbomachinery and, in recognition of the Award, presented the 19th Cliff Garrett lecture at the SAE World Congress in Detroit, Michigan in March.

"Receiving this award is a tremendous honor," says Steve. "It feels great to be associated with an industry icon whose innovative spirit remains a strong inspiration for Honeywell engineers working on the latest Garrett® turbo technologies."

Pulling Power

- **New models shift perception in US**
- **Boosted diesel engines win plaudits**

This year sees the introduction of some innovative diesel powered passenger cars into the US market. With the focus on future emissions regulations and performance on the road, could 2004 be the year when consumers press the accelerator on the dieselization program?

There's a new impetus to the passenger car dieselization program in the US. This Spring saw the introduction of three high profile diesel passenger car launches – and the positive reviews suggest that 2004 could be the year that the take up of diesel among performance-seeking US drivers goes up a gear.

Honeywell's turbocharging technology, notably the Garrett VNT™ range, is playing a key role in helping auto manufacturers deliver passenger cars that meet the aspirations of US consumers.

When Mercedes-Benz recently introduced its E320 CDI to the US market, the response was overwhelmingly positive. One journalist wrote "Torque, or pulling power, is what 'feels' sporty in stop-and-go driving, and 500Nm is stratospheric, particularly since it peaks quickly at 1800 rpm. This is what makes the CDI so fun to drive. It leaps from stops like a rifle shot." Another noted that, "We expect the diesel to outperform its gas counterpart by nearly a second to 60 mph, while returning 35-plus mpg (EPA combined)."

In another important development, Volkswagen unveiled its Passat TDI at the New York Auto Show, featuring a four-valve 2.0 liter engine capable of delivering 134 hp and an impressive 335Nm of torque. The automotive industry will also be looking closely at the reaction to the new Jeep Liberty CRD (common rail diesel) as an important indicator for diesel acceptance in the US

Jeff Donnell, Honeywell Turbo Technologies' Vice President and General Manager, Americas, comments: "SUV and pickup owners are already used to the lower-revving, high torque characteristics from the large-displacement pushrod gas engines in their vehicles. The new generation diesels will feel much the same, except that the low-end torque will feel more responsive and they'll stop for fuel a lot less frequently. Everyone who drives them absolutely loves them.

"Light trucks, which include pickups, SUVs and minivans, now make up more than 50 percent of new consumer vehicles in the U.S. Because light trucks are typically heavier and carry or tow heavier loads over long distances, they are ideally suited for broad diesel adaptation."

Super Cooling

Innovation creates marine industry 'first'

Partnership leverages success for Mercury

A four year development program between Mercury Marine and Honeywell has created what is being described as 'the most sophisticated marine propulsion unit in history.'

Mercury's Verado Engine is the result of Mercury's $100 million investment and signals a step change in outboard engine technology, featuring a 'new generation' marine charge-air cooler and integrated oil cooling system.

The platform is a fourstoke 2.6 liter inline, 6 cylinder, 4 valves per cylinder, DOHC engine that utilizes a unique supercharged induction system with charge-air cooling and oil cooling to develop 200 - 275 hp combined with remarkable torque and acceleration results.

Supercharged technology

Honeywell thermal engineers implemented new technologies to support the world's first production supercharged outboard engine with new cooler

Performance

technology. The use of plastics and die cast aluminum components, combined with robust coating technology, provided a lightweight, compact unit with exceptional corrosion resistance. The Honeywell project team also designed an integrated oil management system comprising cooling filtration and thermostatic control.

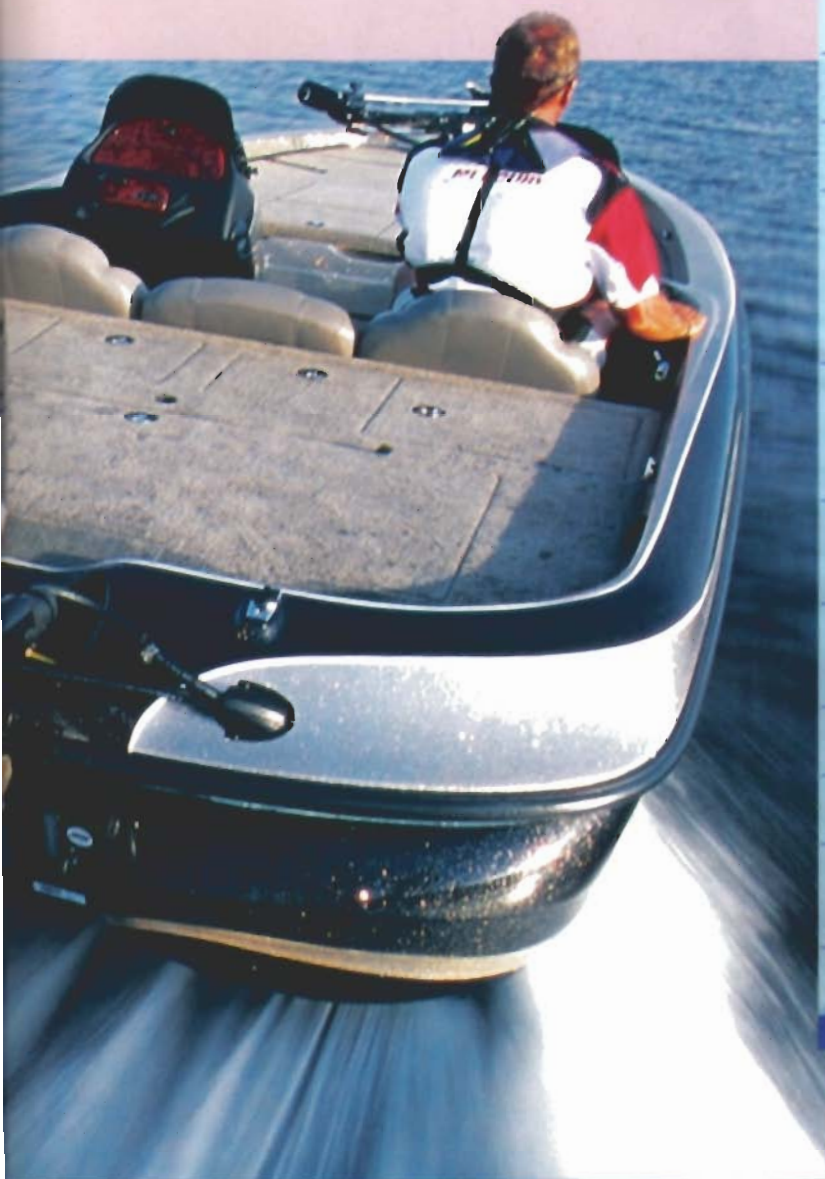
"This was true partnership in action," said Stuart Halley, Engineering Manager, Engine/ Propulsion Integration at Mercury. "Together, we developed a high efficiency bespoke marine charge-air cooler with minimum packaging constraints, so enabling us to achieve our performance targets as well as our reliability, durability and corrosion resistance requirements."

New processes

Six Sigma and lean methodologies played key roles in achieving improvements in value through new heat transfer surfaces, new jointing and sealing techniques and improved manufacturing methods, supported by rigorous testing in the Birmingham, UK and Torrance, US facilities.

Honeywell also gained maximum benefit from a new project supply chain and introduced new manufacturing processes, augmented by investment in the latest automated assembly machinery. The company has created a dedicated manufacturing cell with a new fin press, automated roller expansion of tube to tubeplate joint and a new one piece flow washing plant to achieve the tighter customer cleanliness specification driven by the supercharger.

In summary, it's a story of success founded on technological excellence and the spirit of collaboration.



Specification 275

Propshaft Rated Horsepower	275 hp (205 kW)
Max RPM at Full Throttle	5800 – 6400
Cylinders/Engine Configuration	Straight-6, 24-valve, direct-acting, double overhead cam (DOHC)
Displacement	2.6 Liters (L)
Bore/Stroke	3.23" x 3.23" (82mm x 82mm)
Induction System	SmartCraft DTS electronic throttle, supercharged with charge-air cooling and electronic boost pressure control
Fuel System	Computer-controlled sequential multiport Electronic Fuel Injection (EFI)
Fuel Requirements	Unleaded regular 92-octane minimum (R+M/2)
Ignition System	SmartCraft PCM 03 digital inductive
Starting	Electric (turn-key)
Exhaust System	Through prop
Cooling System	Water-cooled with thermostat & pressure control
Lubrication System	Integrated dry sump

Market Torque

Asian manufacturers push technology envelope
Diesel penetration set to grow

AVL Diesel Cell

Asia is set to play an increasingly important role in the future of Honeywell's turbocharging business. The company continues to invest in China, Korea and Japan, working with a range of OEM customers to meet the challenges emerging from major economic development and ever-more stringent emissions control.

Over the last three years Honeywell has recorded significant growth in Asia. Chris Cowland, Technical Director of specialist powertrain engineering company AVL, provides an insight into what is currently driving the Asia marketplace.

In the past ten years, how have Asian powertrains evolved in comparison with their European and North American counterparts?

Obviously Japanese powertrains are sold all over the world extremely successfully. They tend to be engineered to suit multiple markets using the same basic concept. The engines tend to be very high-tech and more in keeping with European-type engines than those produced in North America. Many engines feature VVT/VVA (Variable Valve Timing; Variable Valve Actuation) systems to improve fuel consumption, emissions control and driveability.

For China, the internal market is potentially so huge that the general trend appears to offer powertrains for the home market rather than for export. Many European and US companies have begun joint ventures with Chinese companies and it remains to be seen how these will further expand.

What is the role of turbocharging in Asian powertrain design?

Interestingly there are two main camps with respect to turbo-

charging on gasoline engines – one group of manufacturers has mainly avoided turbocharged engines and concentrated on naturally aspirated engines while another group has gone the turbocharged route.

How do Japan, Korea and China, the major automotive markets today in Asia, differ from each other as far as powertrain is concerned?

In general, Asia is somewhat split between Japan and the rest of Asia. Japan has its own emissions regulations whereas many of the other countries tend to follow Europe. As stated before, Japan has a large home market but also a huge export market whereas China has more of a domestic focus.

What are the current issues most affecting powertrain engineering in Asia?

The vastly differing cost structures of say Japan and China offer some interesting opportunities. Engineering vehicles and powertrains in China could be an extremely attractive proposition. In addition, many of the North American OEMs are currently looking into the possibility of offshore engineering to reduce costs.

How would you explain the lower rate of diesel penetration in Asia compared to Europe?

Many of the Asian manufacturers have not really concentrated on diesel passenger car engines either for the domestic or export market. Generally there was a lack of technology relating to HSDI (High Speed Direct Injection) – this however is changing with many manufacturers working on HSDI diesels particularly for export to Europe. Some of these engines are really pushing the technology envelope and when they are introduced in the next few years will challenge the best that the traditional European heavyweights have to offer.

What about the trends in gasoline? Do you see increased boosting in the gasoline segment and why?

Downsized, turbocharged, gasoline engines are one logical route forward to improve fuel consumption. Other options could be advanced direct injection systems or fully flexible variable valve actuation. Unfortunately those concepts for powertrains do not necessarily have the lowest production cost and hence the application needs to be carefully determined. Here the trade-off between the potential of fuel consumption reduction and the cost for implementation and production will be the determining factor.

Looking into your crystal ball, what will be the trends affecting turbocharging applications in Asia over the next five to ten years?

Direct Injection coupled with turbocharging offers some interesting potential for the highest performance gasoline vehicles. The inherent charge cooling effect of DI makes extremely high bmeps feasible without detonation problems. AVL has been running prototype gasoline engines at over 30 bar bmep for a couple of years now and the future for this approach seems promising. These levels of torque allow the gasoline to match the traditional advantage the HSDI diesel has held with respect to driveability. This is however, not a cost effective solution for mainstream powertrains at this point.

AVL

AVL is the world's largest privately owned and independent company for the development of powertrain systems with internal combustion engines, employing 2,850 people world-wide.

AVL's activities stretch from advanced R&D to the development of the complete engine.

The company is also an industry leader in developing test bed equipment and advanced simulation technologies.

Manufacturing A Better En

Minimizing waste through innovation and ingenuity
Reuse and recycle is the Waterford way

It's hard to imagine a better example of sustainable manufacturing. Picture the scene. A passenger car exhibiting all the attributes of a turbocharged diesel engine – performance, fuel efficiency and low emissions – sweeps through the Irish countryside across miles of smooth roads …the surface of which contains the manufacturing by-product of the same turbocharger.

Too fanciful? Well try this. The same car drives past a building site in Belgium where the cement being poured contains the process waste from the Garrett® turbocharger under the hood. The first scenario is in the development stage …but the second is already a reality – thanks to the determination and vision of both Lorraine Casey, Health, Safety and Environment Manager of the Honeywell foundry in Waterford, Ireland and the waste minimization team.

Environmental dividends

The foundry is succeeding in recycling or reusing 80% of the waste resulting from its activities – from aluminum runner bars and swarf to cardboard and fluorescent tubes.

But it was the waste from the compressor wheel production that created the greatest challenge, particularly the gypsum 'slurry' that results from the water-intensive process.

Says Lorraine: "In the past, this was shipped to landfill sites, but as part of our commitment to environmental best practice we decided to see if there was a better way ahead." The first challenge was to find a way of making the waste easier to handle, by converting the slurry into a solid form. A year of intense activity, in partnership with an environmental consultancy, eventually paid dividends, with the water being removed by spreading the slurry on a porous belt.

vironment

"In between times, we had found an end user for the recovered material - and today the waste is transported in bulk straight to a factory in Belgium where it is used in cement."

Global commitment

Waterford is a remarkable success story. Since 1999, the facility has slashed the volume of non-hazardous waste by half to its current level of 6,396 tons. It has taken an incredible amount of effort and no little ingenuity to achieve this position, but plans are now being drawn up that will lead to 90% of all the Waterford waste being recycled.

Anthony Wareham, Honeywell's Worldwide Director of Health, Safety and Environment Remediation, says the Waterford facility is at the forefront of a global commitment to the environment that goes way beyond the achievement of the ISO14001 environmental management standard.

"There are, of course, sound economic reasons for this activity – not least the cost of waste disposal – but this is also about being a good corporate citizen and respecting the environment within which we operate," says Anthony.

Next on the program is trying to recycle the vermiculite material used in the turbine wheel production. This is a much harder compound and the latest investigations center around using the material in road construction. "Now that would be the ultimate sustainable success story for our business," says Anthony.

Pole P

■ Technology and innovation drive racing partnerships
■ OEM teams head for the checkered flag

It's go, go, go for 2004. All the planning, prototyping and testing is coming to fruition as the motor racing season accelerates off the start line.

For the Honeywell motorsports team and its many OEM race partners, it means revving up for another year of high velocity action – and the signs are good.

Already, Garrett® turbochargers are boosting OEM partner race machines to the top of the podium in the FIA World Rally Championship and there's confidence of further success for the CART Champ Cars season and the American Le Mans and The 24 Hours of Le Mans (France) events. And the expectation is well founded – last year OEM teams with Garrett® turbochargers swept the constructors' championships in every series.

Trust and technology

"In short, it's leading edge technology that leads the way in motor racing," says Doug Milliken, Honeywell Turbo Motorsports Manager. "Our track record is one of true partnership with our OEM customer race teams - we have a dedicated team of engineers and manufacturing specialists working to develop the boosting systems that will give the teams the edge."

Technological expertise and innovation are 'given' attributes in partnerships clearly underpinned by trust in an environment where minute improvements in performance can make the difference between winning and losing.

That performance clearly varies according to the racing environment – response and durability for the punishment of World Rally, fuel efficiency and endurance for the Le Mans 24 Hour event and power and compactness for the CART Championship.

Optimum performance

The motorsports group develops products specially optimized for each racing team and each race series, founded on ball bearing technology for better boost response and utilizing materials that make the turbos extremely light-weight – about one third of a mainstream application.

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"The focus is always on optimum performance on the track," says Doug, "and this means constantly refining our work in a number of areas – for example reducing backpressure on the engine exhaust, improving boost response and reducing the turbo weight and size. From time to time, developments will also spill into wider usage – for example Audi's FSI fuel injection system introduced at Le Mans is being rolled out into its passenger cars and, equally, we have found applications for our ball bearing technology and other innovations in the commercial market place. But this is really about supporting our OEM customers – and creating true 'win-win' outcomes for us all."

Ho Pin Tung Heads For The Top

Look out for the Dutch-born Chinese racing driver Ho-Pin Tung this season. Ho-Pin Tung, who will carry Honeywell colors, is being tipped as a star of the future after winning the 2003 Formula BMW Asia title and is hoping for similar success in the German F3 Championship with the Dutch based VAR Racing Team.

Ho-Pin Tung was born in The Netherlands, but lives in Shanghai. Last year he raced for the Meritus Team in the Formula BMW Asia series, in which he claimed no less than 12 pole-positions and 10 race wins! He won the title and was offered a test with the BMW-Williams Formula 1 team.

"I had high expectations of Formula 1, and it was like a dream come true getting my first miles in such a machine! It is unbelievable what modern technology does: The high speed corners give you high G-forces all over your body and that is a fantastic feeling… This experience makes my desire even stronger to become the first ever Chinese F1 driver."