Diecasting News

Support for Australian diecasters

The production of large volumes of complex metal shapes relies on diecasting. The process is commonly used to manufacture automotive components such as manifolds, because it is fast, accurate and can produce versatile shapes with intricate detail.

The diecasting process has been around for more than 150 years but continues to evolve with refinements to both the process and the alloys used, leading to more applications for diecast products. One research centre focussed on refining aspects of diecasting is Australia's CAST Cooperative Research Centre. CAST conducts industry-driven research in metals technology and is dedicated to supporting the Australian diecasting industry.

Australia's diecasting industry currently turns over approximately AUD$280m per annum, much of this output being related to the automotive sector. The automotive industry is a very competitive market currently under threat in Australia from imports and the global financial crisis. To ensure the sustainability of diecasting in Australia, the industry needs to continually improve to maintain international competitiveness.

CAST is one of the world's leading light metal research institutes and a member of the Global Light Metals Alliance, which includes members from Canada, the USA, Germany, South Africa and Austria. It is supported under the Australian government's CRC Program, and represents a collaboration of businesses and researchers. The following is an overview of the latest developments in diecasting research at CAST.

Diecasting research at CAST

Cycle time reduction

CAST develops and deploys technologies for casting and tooling with the aim of reducing the manufacturing costs of light metal castings, its 'diecasting costs' research programme is dedicated specifically to this task. The programme has a strong focus on cycle time, that is, the time it takes to cast each part. The primary control on productivity in diecasting plants is cycle time, this, in turn, affects the thermal balance of the casting process.

To run faster cycle times with existing diecasting machines requires more than just speeding up the discrete events that make up a casting cycle. Since casting involves filling steel dies with molten metal, the cycle time is dependent on the rate at which heat is removed from the molten metal. Speeding up the process increases the amount of heat to be removed and can lead to an increase in the number of defective parts produced. CAST is developing technologies to decrease cycle time (hence increasing the number of parts manufactured) while maintaining or improving product quality.

Diecast components manufactured at Nissan Casting (Australia) Pty Ltd, one of CAST's industry partners

A typical high-pressure diecasting machine located at the facilities of one of CAST's industry partners

Extending die life

Another way to reduce costs is by improving the resistance of dies to heat. Dies are very expensive to manufacture so extending their life can result in significant cost savings as well as improving the efficiency of casting operations. CAST has developed a simple, low cost way for diecasters to repair their equipment, called 'CASTrepair' which enables effective repair of cracked cooling lines in dies, hence increasing the lifespan of these expensive pieces of infrastructure.

The dies used in high-pressure diecasting range in price from AUD$100k to AUD$750k depending on the size and complexity of the metal component being produced. The average lifespan of a die typically varies from 100,000 to 500,000 shots and, depending on an individual company's productivity rate, this means that dies may only last one year before they must be repaired or replaced.

New dies usually require more than six weeks to manufacture and their costs can contribute up to 15% of a casting's final selling price. Unfortunately, during operation, dies containing water lines may develop cracks that extend into the die cavity which cause coolant to leak into the die cavity resulting in a dramatic decline in casting quality and productivity.

Before the invention of CASTrepair, attempts would be made to repair cracks by sleeving the hole, which, while preventing water leaks, substantially reduces the cooling capacity of associated water lines. This reduction

in cooling performance is matched by a decrease in production rate, thus requiring more time to allow the die to cool between shots. The decrease in cooling efficiency also impacts on the quality of the cast component. The ineffectiveness of this repair method commonly requires the die to be replaced, costing both time and money.

CAST's research team used alloy design principles to create a metal that would provide special mechanical sealing as it cooled, filling the gap around the brass or copper seal and hence creating a good thermal connection between the tube and the die, creating a cooling line with almost the equivalent thermal properties of the original (uncracked) version.

The metal (CASTrepair) can be quickly applied to cooling lines on the shop floor, restoring production with a minimum of disruption and cost. In the first instance, CASTrepair was designed to be a stop-gap measure, to keep a die in production until it could be replaced by a new die. However, it has surpassed original expectations and, in many cases, will keep a die operational until taken out of service.

Due to the high capital cost of dies, many small to medium-sized enterprises only have one die for each component they manufacture so there is a high potential for lost time if that die should fail. CASTrepair overcomes these issues by providing a quick and reliable solution to cracked water lines that can extend die life well beyond the time that a replacement would normally be expected.

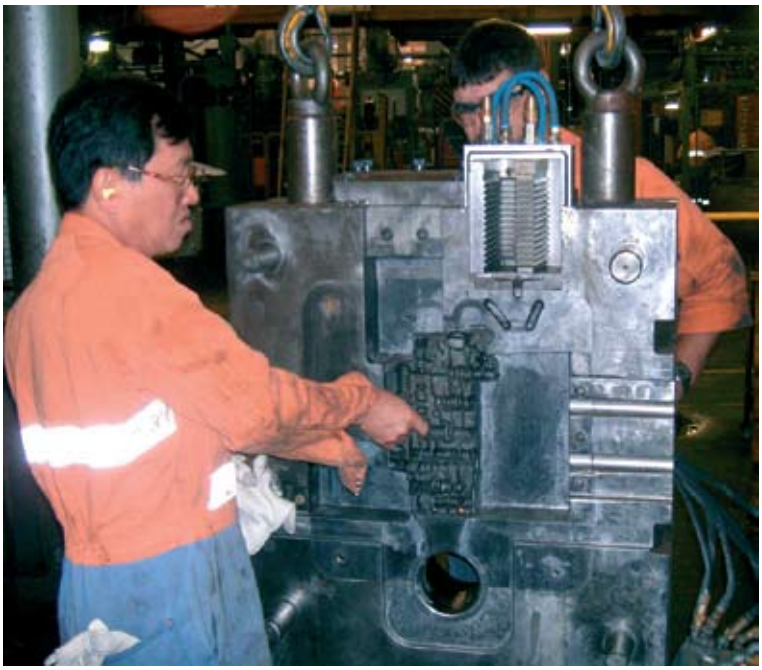
Reducing scrap

A standout achievement for CAST's research programme has been the success of CASTvac at industry partner Nissan Casting (Australia) Pty Ltd. CASTvac is a new robust low-maintenance vacuum valve for high-pressure diecasting. It is more reliable than mechanical vacuum valves and more effective than chill vents.

It provides chill faces that are nearly perpendicular to the die parting plane, an increased chill surface area without increasing the die projected area, modular wedge-shaped inserts, and a controlled uniform venting gap. With this technology, Nissan engineers were able to adopt casting parameters that improved quality and significantly reduced scrap losses. CASTvac has been robust under production conditions with the ability to perform without stoppages, now exceeding 150,000 castings on one manufactured component.

Future challenges

Rising fuel costs and a stronger Australian dollar continue to threaten the viability of Australian manufacturers, particularly in the diecasting sector. For this reason, the success of CAST's cost-reduction research will have a significant impact and future research work will concentrate on developing solutions that will deliver benefits within a short timeframe.



CASTvac in operation at Nissan Casting (Australia)

CASTrepair successfully applied to a leaking sprue bush due to cracks. The two sleeve inserts shown are cast in with CASTrepair alloy

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Modular high-pressure diecasting concept for high performance aluminium cylinder blocks

To meet future demands on CO_2 emissions and fuel consumption, lightweight design is one of the challenges of the automotive industry, say Dr Stephan Beer and Dr Eduard Koehler from KS Aluminium-Technologie GmbH.

The cylinder block is the heaviest single component in a vehicle and provides a variety of solutions to achieve a significant mass reduction. KS Aluminium-Technologie GmbH is introducing several concept modules to satisfy the demand for downsized lightweight, high performance engines.

It will hardly be viable to achieve the 2012 EU fleet target for CO_2 emissions without comprehensive lightweight design and downsizing of the engines. The first-mentioned approach generates new impulses for using aluminium as a substitute for grey cast iron in cylinder blocks, with a focus on solutions favouring low component weight in particular.

Downsizing means the trend to reduce the swept volume and, at least for premium-car engines, also to reduce the number of cylinders. This implies a distinct boost in specific power output in order to compensate the loss of performance and consequently also leads to higher ignition pressures.

This development will prompt a 'skyrocketing' further increase in mechanical and thermal component stress, which will primarily affect the cylinder block as the central component. In future these changing general conditions will determine the selection of the component concept.

At the International Automobile Exhibition 2005 (IAA), KS Aluminium-Technologie GmbH presented an innovative cylinder block concept based on high-pressure diecasting incorporating the implementation of various technologies (fig. 1). This concept was specifically geared to meet future demands.

By means of prototypes, the technical feasibility of the concept was demonstrated in principle. This basic idea has meanwhile been developed to a highly flexible, mass-production compatible 'modular high-pressure casting concept' for aluminium cylinder blocks.

Engines downsized on the basis of the new concept excel by high specific power output and benefit particularly from the development approach of the initial concept for implementing the cost-effective production of a light-weight but nonetheless rigid, highly stress-resistant and absolutely function-optimised cylinder block for diesel and petrol application with ignition pressures up to 200 bar.

The smaller the cylinder block, the higher the cost pressure that prevails, even for downsizing, despite ever growing demands. Thanks to its extremely high productivity, high-pressure diecasting is the method of choice to achieve the most favourable production costs.

Casting technologies for lightweight aluminium cylinder blocks

With the 'modular high-pressure die casting concept' individual concept modules compensate the process-specific disadvantages of conventional high-pressure diecasting. These modules may be applied selectively without being interdependent, resulting in high flexibility of the concept. By suitable module combinations, a high-pressure diecast aluminium cylinder block can be produced that is nothing short of high-grade, low-pressure die or sand castings and which offers a decisive cost benefit in mass production.

High-pressure diecasting allows the realisation of extremely thin walls, the nominal average wall thickness being 3.2mm. Hence it meets especially favourable pre-requisites for lightweight design.

In combination with its near net shape benefits compared to low-pressure diecasting (when disregarding the light-weight benefit of technologies that do without liners) which does not require a core or only applies a water-jacketed sand core, the component weight can be reduced once over by between 8 and 15% if the specific application permits.

Although in comparison to sand casting, high-pressure casting generally constrains the design freedom appreciably, similarly low component weights can be achieved provided that the component design is tuned to

Fig 1. Innovative cylinder block concept

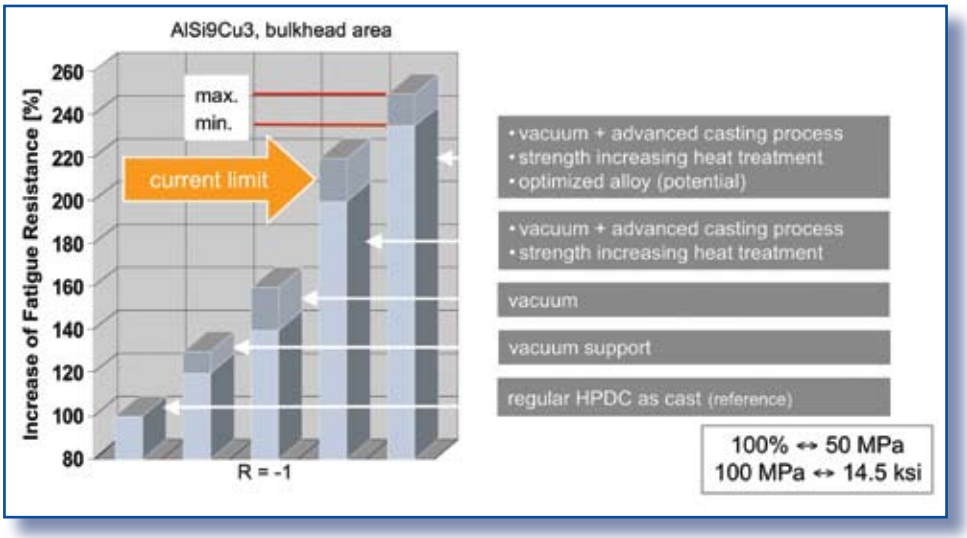

Fig 2: Increase of strengths through process optimisation

the casting method applied.

The concept modules of the 'modular high-pressure casting concept' for aluminium cylinder blocks are in detail:

Module 1: High strength through high-pressure diecasting which permits unrestricted heat treatment

Process-specific porosity (gas inclusions under high pressure) and the re-feeding problems involved only enable a relatively low strength level to be achieved with conventional high-pressure diecasting, especially in the thick-walled bearing bulkhead area (fig. 2).

In addition, the former problem prevents strength-promoting heat treatment as it may lead to component destruction through blister formation during solution annealing. A multitude of process optimisation steps, ranging from optimised die filling through to the application of vacuum in the high-pressure die, allows production of unrestrictedly heat-treatable castings, even in high-pressure casting machines.

Also, with a view to the dynamic characteristics, the attainable strength values are up to the standards of low-pressure die and sand castings (where in the latter case elaborate local mould chilling is required!).

Fig 4. High-pressure diecasting cylinder block (top) and coated water jacket sand core (bottom)

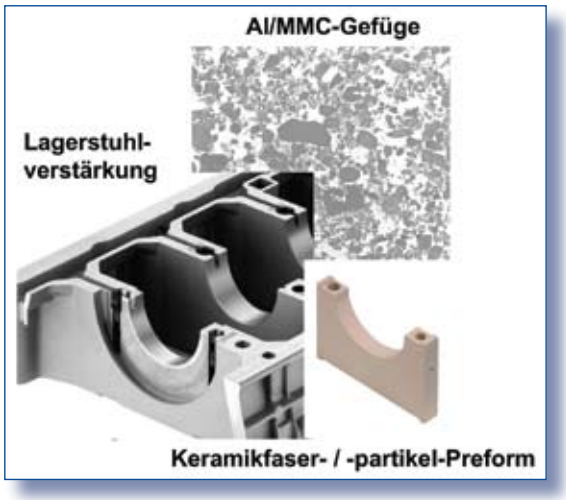

Fig 5. MMC microstructure (top), MMC application in bedplate (bottom left), MMC preform (bottom right)

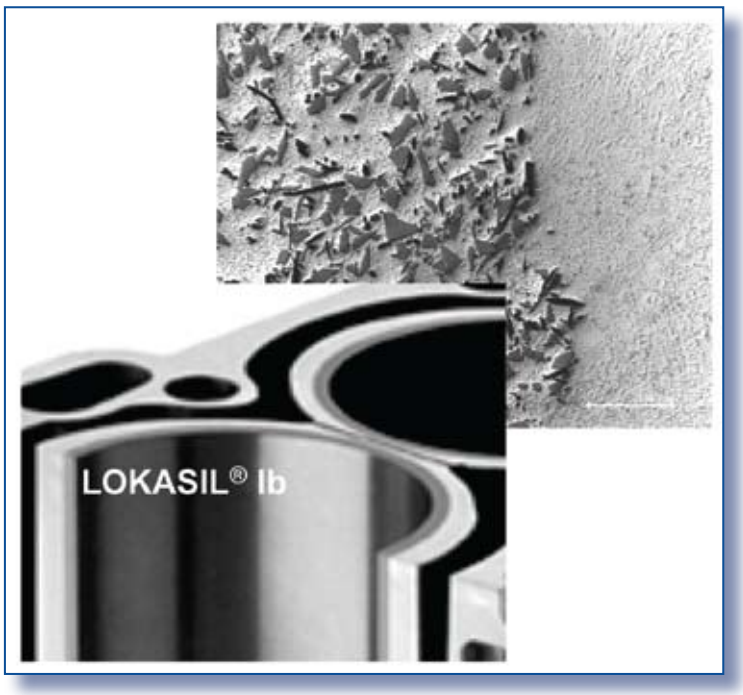

Fig 3. LOKASIL microstructure (top) and application (bottom)

Module 2: LOKASIL® or coated cylinder bore surfaces as a substitute for heavy grey cast liners

High-pressure diecasting features the general advantage of producing, during the casting process, local aluminium matrix composites (MMC) with adapted material properties by infiltrating highly porous pre-forms made from application-specific particles and/or fibres under high pressure. As a result, LOKASIL cylinder bore surfaces optimally fit in with the 'modular high-pressure diecasting concept' (fig. 3).

These surfaces are able to replace the usually cast-in massive grey cast liners and additionally contribute to weight reduction. With the LOKASIL Ib variant, for some time a further low-cost pre-form, based on silicon particles and specific ceramic fibres, has been available that is absolutely competitive with grey cast liners.

LOKASIL contributes to the achievement of a very compact component design with minimum bore distances of 4.5mm; it reduces cylinder distortion and causes thermal relief.

A further positive feature is that the cylinder bore surfaces are suitable for coating thanks to the excellent quality of the material in combination with the already mentioned optimised casting technology (cf. concept module 1).

On the other hand, the presented modular concept supports all current liner solutions.

Module 3: High component rigidity through closed-deck design with sand core suitable for high-pressure diecasting

Open-deck design is required as a standard in conventional high-pressure diecasting to allow steel moulding. However, this design is a constraint to the rigidity of a component, especially in the top cylinder area. For small high-performance engines, especially diesel engines, the closed-deck option may therefore be a mandatory necessity.

That is why for many years KS Aluminium-Technologie GmbH has made endeavours to develop suitable technologies for producing lost sand cores for water jackets that can be used for closed-deck designs in a reliable high-pressure diecasting process (fig. 4).

Based on a warm-box core with specific coating, it has now become possible to offer the closed-deck option as high-pressure diecasting at acceptable cost for specific mass-production applications.

Module 4: MMC bearing bulkhead reinforcement

The MMC bearing bulkhead reinforcement option was already presented in detail in connection with the Prototype 2005. In this case, too, the material's characteristics were specifically tailored to the application.

The main focus is on light-weight design in combination with

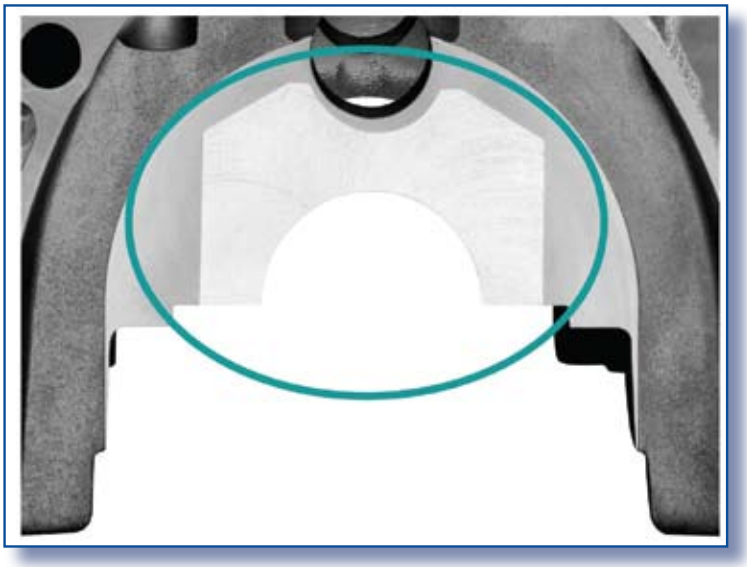

Fig 6. MMC application in engine block main bearing

References, trademarks and contacts

Illustrations are from KS Aluminium-Technologie GmbH, Neckarsulm, Germany, and LOKASIL® is a registered trade name of KS Aluminium-Technologie GmbH, Germany.

Dr Stephan Beer studied foundry engineering at the RWTH in Aachen, Germany and received his PhD at the Max-Planck-Institute in Düsseldorf, Germany, where he specialised in light metals. His professional career started 1995 at Kolbenschmidt in the piston division. From 2000 until 2002 he worked for Hydro Aluminium, becoming director of the process development department of KS Aluminium-Technologie GmbH in 2003

the compensation of the temperature-related clearance fluctuations in the crankshaft main bearing which are inevitable in the case of aluminium (minimisation of bearing clearance losses/dissipation loss of oil pump and noise stimulation).

The composite material which is applied locally, is able to replace heavy cast-in parts, mostly made of nodular cast iron, in the main bearing area of bedplates (bottom parts in the case of bipartite design of the engine block) with the beneficial effect of saving weight (fig. 5).

The gap-less integration with the adjacent aluminium has the additional advantage of preventing leaks in the lubricant oil supply line to the main bearings (fig. 6).

Conclusions

With the 'modular high-pressure diecasting concept', KS Aluminium-Technologie GmbH offers a proper solution to the demand for downsizing, especially for current and future high-performance engines. Subject to suitable design of the components, the concept can also be applied to diesel engines for passenger cars.

High-pressure diecasting as a highly productive casting method combined with an array of independently applicable technologies accounts for the great flexibility and economics of the concept.

In contrast to casting methods implying product quantity restriction, the Casting Concept is generally appropriate for unrestricted mass production of high-grade aluminium engine blocks. The local application of aluminium matrix composites in the cylinder bore and main bearing areas (in the case of bipartite design) is suitable for achieving additional light-weight construction potential, apart from the functional benefit.

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German die maker defies the crisis

The decision to expand its portfolio to include production and machining of prototypes was the right choice at the right time, say Schaufler Tooling

Like many others the German die maker says it was taken by surprise by the worldwide economic crisis. Companies with links to the automotive industry were hit particularly hard, the recession striking with such a magnitude that it was difficult to predict and prepare for.

Schaufler will therefore be increasingly tested for its capabilities, technological, personnel and organisational drive to get through this difficult time.

The crisis has arrived at Schaufler Tooling, despite the fact that the 130-employee company ranks in the top ten for diecasting dies used in the light-metal diecasting industry.

"We have to absorb the impact in the maintenance and service area in particular," said Siegfried Heinrich, president of Schaufler Tooling, "as in times like these customers can pull that work in-house to keep their own employees working." At the same time he says, "Schaufler Tooling made the decision two years ago to expand the portfolio of services and that is going to help us through this time."

Expansion of the process chain

The company's range involves manufacturing diecasting dies for high-volume production, from engineering to sampling and casting of small production volumes in the in-house diecasting center. This has now been expanded to incorporate the capability of providing complete prototypes.

Schaufler Tooling delivers the initial complete milled aluminium prototypes, typically at first sand-cast at partner foundries. For the sand casting prototypes, the company takes over the complete machining and project management starting at CAD and going through each stage to customer delivery. Subsequently it builds the prototype dies for larger volume prototype parts, which are in turn produced in its in-house diecasting facility.

In the in-house Die Casting Center Laichingen, a joint venture between Schaufler Tooling and Bühler Druckguss AG in Uzwil, Switzerland, operates a diecasting cell with a real-time controlled Bühler Evolution 420 D machine.

Over the years, Schaufler Tooling has expanded its prototype and machining knowledge and, according to Siegfried Heinrich, "we have emphasised this business segment through added investments."

Examples of projects include:

- A prototype instrument panel, the scope comprising building of a prototype die, the casting of two times 50 parts and complete machining of all parts.
- Two prototype dies for structural automotive parts, which was accomplished within a very short time frame.

Investing in the future

For the machining of prototypes, the company has invested in an additional 5-axis milling centre to support the short lead-time for producing the prototypes. In addition, a new gun-drilling machine has been added to support the manufacturing of large dies needed to produce body and structural parts for the automotive sector.

"We are seeing an increased trend that the debate and demand for greener cars is not going to be limited to luxury cars", says Siegfried Heinrich. "We are therefore now in the position to also offer customers new and innovative parts in stages from prototypes to production-ready dies."

The management of Schaufler Tooling says it is confident that the company will not only survive the crisis, but also emerge stronger than before.

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Optimising diecasting die production

Improved cooling within temperature-sensitive areas of diecasting dies can be achieved using the LaserCUSING process.

Close co-operation between an automotive manufacturer and the process developer, Concept Laser GmbH, has resulted in die cores being produced with cooling channels close to the surface contours which improve the quality of castings.

Using new process management techniques, LaserCUSING® has succeeded in overcoming the traditional shortcomings of laser sintering technology.

Components with minimal distortion and virtually 100% density can be generated using modern laser systems, specially developed light exposure strategies and standard metal powders. By using original materials, intensively cooled die inserts can be produced with material characteristics identical to that of the source material, permitting the use of these components under manufacturing conditions.

Concept Laser GmbH in Lichtenfels, Germany, was offered new opportunities to test its laser technology and make it accessible to the diecasting sector through a development programme with an automotive manufacturer. The target material - a hot-working steel - for the manufacture of the die cores for aluminium pressure diecasting was clearly defined.

Concept Laser carried out the verification of both the development process and material qualification throughout this period of co-operation with the automotive manufacturer. The new material, CL 60 DG, is a hot-working steel (similar to 1.2709) suitable for the series production of cooled die cores. It has a high basic toughness, tensile strength of up to 1800N/mm^2 and hardness of up to 54HRC.

Fig 2. Test core after 55,964 shots. The core is in very good condition, without any visible heat cracks although the bore shows initial heat cracks

Fig 3. Test core after 71,282 shots. The core is in very good condition, there are no visible heat cracks although the bore shows increased heat cracks

Fig 1. Test core after 104 shots: the core has the same characteristics as a normal core, no cracks or irregularities being visible

From test series to pilot project

Initial trials were carried out to test this material, to determine the strain on the specimen resulting from pressure diecasting and to draw conclusions on the design of the component. Test cores were evaluated as soon as the initial trials were successfully completed. The cores were generated on a Concept laser M3 linear laser melting system. The process is fully automatic, so no operators are required. Subsequently the cores were finished and fitted into a gearbox.

The tests were designed to yield information regarding the durability and hot cracking behaviour of the test cores. The tests carried out to date have been extremely convincing as, after more than 100,000 castings, the test core is still in a very good condition. The test piece does not show any hot cracks, the borehole in the die, produced using conventional methods, in which the test core is set however, shows major hot cracks (figs. 1-3).

With the tests proving successful, it was decided to initiate a pilot project with the aim of developing the new technology to a production level. The development partners wanted to test the tempering close to the forming surface contours of a cylinder crankcase in the area of the knock sensor0 (figs. 4a and 4b).

The tool making department decided which serial tool was to be fitted with a die insert produced by LaserCUSING and in which area it would be used. The decision was made to place the insert in the contour within the area of the knock sensor boss in the sliding attachment of the four-cylinder crankcase.

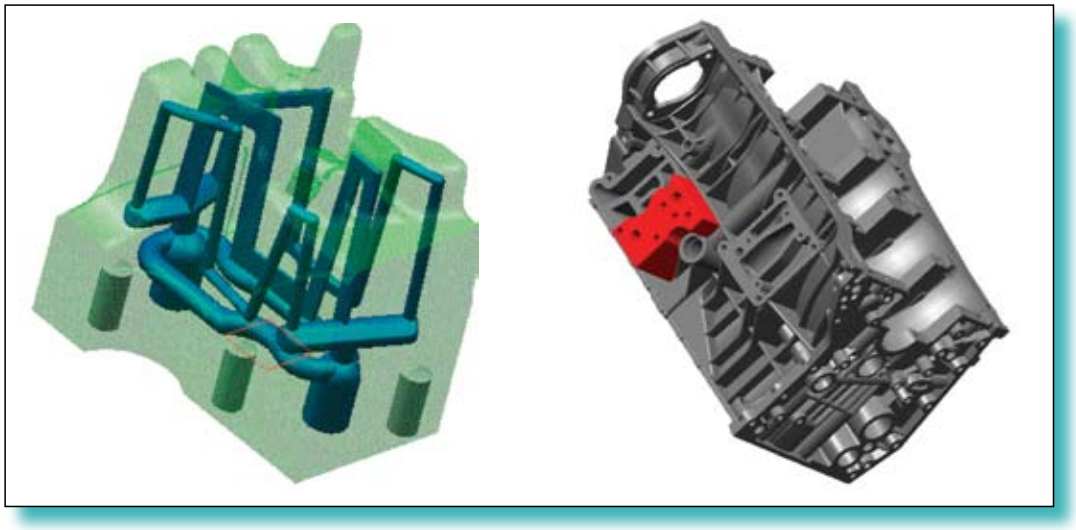
The insert was to be replaceable within the shortest possible time without having to unclamp the die from the machine to avoid major production shutdowns. To prove the insert's capability, all trials were carried out under serial and production conditions. The purpose of these trials was to gain insight on how to optimise the temperature control in the insert and the resulting casting quality. Moreover, the aim was to test the behaviour of the insert, e.g. lifetime and crack formation.

The focus was mainly on:

- Insert lifetime and number of shots.
- Thermo-graphic images of the individual inserts taken by an infrared camera (oil temperature control or water cooling.
- Casting quality in the area of the knock sensor (oil temperature control or water cooling).

Extensive tests have shown the quality benefits obtained from the new die insert. The reduced time needed to spray parting agent minimises the cycle time, because the temperature difference, ΔT, of the die core is reduced. The lower temperature difference means less thermal stress, which in turn reduces the susceptibility to hot cracking by thermal shock. Using less parting agent improves cleanliness and lowers the costs of spraying.

In addition, the subsequent disposal costs are reduced, which is also an ecological benefit. Moreover, temperature stability after spraying differs greatly without temperature control close to the shaping surface contours. Analyses have shown that it is not possible to control the heat balance solely by spraying, but that temperature control close to the contour can sometimes completely replace spraying.



Figs 4a and 4b. Mounting situation of the LaserCUSING insert on the cylinder crankcase project. (Photos: Concept Laser)

Confirmed technology capable of series production

At the request of the foundry, the insert was connected to an independent temperature control cycle, so not connected to the slide. O-rings are not required and the possibility of leaks is eliminated. The remarkable benefit of a contour close, or conformal, cooling system is the fact that the contour shape is freely definable, that is there are no limitations whatsoever with regard to manufacturing specifications. For instance, channels and ejectors can be 'bypassed' rather conveniently.

Conventional machines are only capable of producing straight bores. Contour-close, conformal cooling keeps the temperature differences within the die to a minimum, which reduces tool wear and increases the lifetime of the die. The cooling process of the liquid aluminium, approximately 700°C, is also accelerated, which in turn results in reduced shrinkage porosity or blowholes in the casting.

The automotive manufacturer in question confirmed that the LaserCUSING process is a technology ready for series production. Working as an interface between prototypes and series production, the system provides the following cost and quality benefits:

- Increased die productivity by cooling channels close to the forming surface contours.
- Reduced casting distortion through efficient cooling.
- Improved product quality by reduced micro-shrinkage.
- Pre-machined contour of the die inserts.
- Short production time and fully automated manufacture of inserts.
- Programming reduced to a minimum.
- Suitability for serial application.
- Patented hybrid design for the economical production of larger die inserts.

The development co-operation with the automotive manufacturer, which lasted for a number of years, proved that the LaserCUSING process is suitable for the serial production of pressure diecastings. To provide the basis for continued technological leadership, the automotive manufacturer plans the strategic use of this technology and its application to other fields of production. For some time now they have incorporated intensively cooled inserts produced by LaserCUSING into new dies.

LaserCUSING technology

The term LaserCUSING is a combination of the words 'concept' and 'fusing' and is based on the fusing of one component, metallic powders with the help of a laser. This generative process makes it possible to build up components layer by layer from practically all kinds of weldable materials (stainless steel, hot working steel, QT steel, light metals), to completely melt the metal powder layer by layer. The typical thickness of the powder layers is between 20 and 50µm. The process is currently gaining a foothold in traditional tool making and mould making.

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Brazilian-German instructor team gets close to diecasting

The Wilhelm-Maybach School in Stuttgart Bad-Cannstatt, Germany, is an industrial occupational and technical establishment specialising in the fields of metal, vehicle and foundry technology. It offers many different types of courses for both career starters and professionals in search of further education, from vocational preparatory sessions right through to master classes.

For more than 15 years the Stuttgart school has had a friendly association with the Brazilian Centro de Educacao Profissional SENAI Lindolfo Collor. This initiative was created as a result of the desire of German companies to hire skilled, Brazilian-trained employees for their production plants. Located in Sao Leopoldo in Brazil's Rio Grande do Sul region, the Centro de Educacao offers young people two-year training programmes to prepare them for careers in metal working.

Jairo Valmir da Silva, head of the Brazilian partner school, and his colleague Cleumar Ferreira travelled to Bad-Cannstatt for a three-week exchange of information and experience to get a picture of German teaching methods and find new project ideas that the Centro de Educacao could use.

The German team, under OSD Hans Prommersberger, organised an informative programme of visits to well-known Swabian companies, including the Schorndorf-Weiler-based manufacturer of hot- and cold-chamber diecasting machines, Oskar Frech GmbH & Co KG. As a market leader in this field, Frech also operates in Brazil through its own subsidiary. In 2007, Frech expanded and strengthened its position with the acquisition of the diecasting division of Müller Weingarten AG.

Frech's diecasting specialists and teaching staff from the Wilhelm-Maybach School have been in close contact for many years and exchange information on new developments in the industry. The two Brazilian teachers, together with three German colleagues, were warmly greeted at Frech's head office in Schorndorf-Weiler by Dr Norbert Erhard, ceo of Oskar Frech. After a short introduction about the latest developments in diecasting, Martin Schlotterbeck, training director at Frech, explained the latest innovations in hot-chamber machines that significantly contribute to processing stability and to the reduction of cycle times in the diecasting process.

The teachers were also able to form an impression of cold-chamber diecasting machines in Frech's new plant in Plüderhausen, where the company builds machines with locking forces of up to 52,000kN. For these series, mounting plates of 48 tons, assemblies of up to 66 tons and machine columns of up to 9,000mm in length must be warehoused, transported and assembled.

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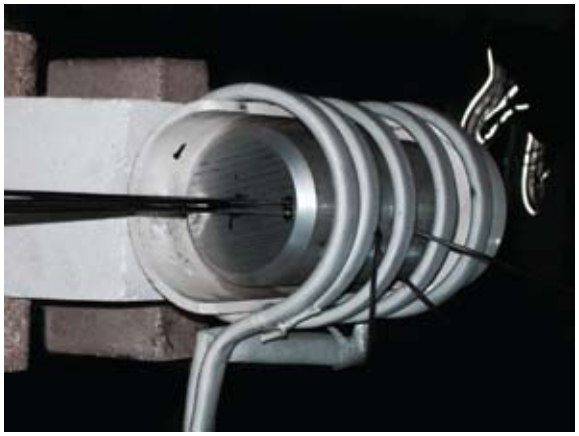
Helping take thixocasting from laboratory to shop floor

The 'Metadistretti Project' has encouraged Italpresse, Gauss, a university and two foundries to exploit thixotropic alloys.

A research and development project, promoted by the Lombardy region in northern Italy, allowed the Italian pressure-diecasting equipment specialist, Italpresse (www.italpresse.it), its sister company Gauss, the Engineering University of Brescia and local foundries Fon Stam Press and Posalux, to test thixotropic alloys – the so-called semi-solid or SSM grades.

A diecasting cell comprising a 1350 ton unit, an induction furnace, pouring robot, thermo-regulating devices and die sprayer, diecast a Comefco chair base, the aim being to monitor advantages and differences between traditional and thixocasting alloys. It also looked at the possibilities of making the process more industrial, profitable and increasing the use of an alloy that has extraordinary metallurgical features, but remained at that time largely unknown.

The result of these trials was that thixotropic alloys remained rather unexploitable and uneconomic as a modern industrial process. However, this initial project became the incentive to develop new solutions, both from a mechanical-hydraulic and electronic point of view, which are now available over the Italpresse equipment range.



Billet pre-heating detail

Initial work pays dividends

Working with Alcan-Pechiney in the mid-1980s, Italpresse claims to have been the first company active in relevant research involving the innovative thixotropic alloy. It assembled a vertical diecasting machine incorporating a special vertical shot end. In 1987, the company built its 750-ton IPECH machine whose main feature was the vertical toggle-closing end. Using this unit installed in the Voreppe, France, laboratory foundry, Pechiney engineers carried out the first tests with thixotropic alloys, producing thixo billets of various diameters.

In early 1995, Reynolds Wheels, part of the Hayes-Lemmerz group, collaborated with Italpresse to develop production of 17-inch aluminium car wheels via the thixo process. Italpresse was responsible for the diecasting machine, the pick-and-place robot and the die sprayer; Reynolds for the die and billet pre-heating furnace; Pechiney for alloy production.

It was in 2003 that Italpresse reached a milestone in thixocasting when the Japanese company Homark, a leader in low-pressure aluminium wheel production, ordered an automatic diecasting cell for the production of thixo wheels. This experience led to the 'Metadistretti Project', so-called because it involves experiences from different industrial disciplines to enhance co-operation amongst various industrial districts and areas.

Homark wanted to pursue the thixo alloy in conventional diecasting due to the high quantities involved and the possibility of reduced cycle times using low-pressure techniques.

The Reynolds and Homark projects had great technical value since their respective closing forces of 2,150 tons and 2,500 tons were progressively adjusted to the required casting needs. Previous tests had shown that billet dimensions needed a longer shot stroke to enable them to be loaded in the shot sleeve. Even if having a spherical structure, the material showed a higher viscosity compared with the liquid conventional alloy, thus the shot dynamic phases must exceed the standard value. The same goes for the final compression where the specific pressures reach values similar to squeeze casting, from 1,300 to 1,500kg/cm^2.

The fully-integrated diecasting cell

The new TX machine

The thixocasting experience gained over many years by Italpresse resulted in the launch of its TX machine. Basically similar to a traditional unit, the main difference is at the shot end where a longer stroke allows the robot to remove the semi-solid billet and a higher shot force is required due to the alloy's elevated viscosity in the semi-solid state.

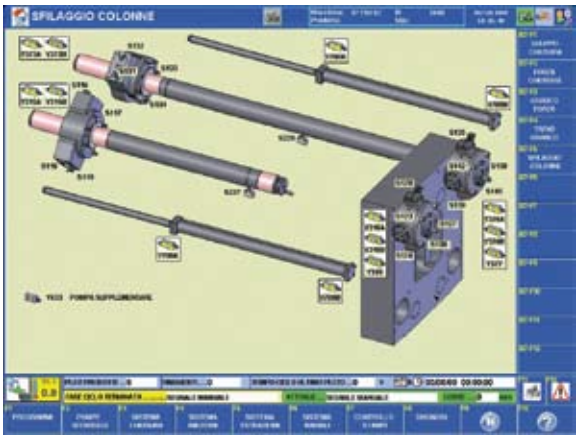
Control for the shot speed phase (die filling) and pressure (final compression) are in real-time to guarantee the correct shot parameter repeatability and a high flexibility in speed curve programming and pressure increase.

Real-time control advantages include:

- Ease of selection as shot speed and pressure are shown as absolute values.
- Repeatability at each machine cycle.

Cast wheels 'hot off the press'

Plant for thixo experiments



A screen from the electronic control display

Cast wheels require high integrity . . .

. . . coupled with aesthetic excellence

- Repeatability over time as real-time control corrects for the effects of wear.
- Sophisticated hydraulic fluid filtering.
- High performance hydraulic fluid thermo-regulation.
- Top end hydraulic components.

When designing the new electronic system, attention was taken to provide an operative system equipped with embedded, multitask and real time that needs limited resources and can function on a flash card and on a low power and fan-less processor, thus offering high reliability in a hard working environment.

There is one PC for the real-time part and video and a long hardware working life comes from ETX technology and C++ and JAVA languages.

The system also incorporates a user-friendly graphic interface and keyboard layout whilst all actual communication technologies are readily accessible.

Gauss, the sister company of Italpresse, took care of the engineering side and harmonisation of the diecasting cell. The machine was integrated with a robot for billet loading and casting extraction; die thermo-regulation devices, a critical phase in semi-solid casting; a die reciprocator; a pre-heating furnace etc.

Results and conclusions

Returning to the 'Metadistretti Project', the University of Engineering of Brescia, assisted by Inn.Tec-CSMT, has supervised the modifications of the existing die with Fon Stam Press plus all the diecasting tests with both the traditional alloy at Posalux foundry and the thixotropic alloy at the Italpresse works.

The result of these and other tests were presented at the 29th Foundry Congress held in Italy in 2008. The final report is available at the Department of Industrial and Mechanical Engineering of the Engineering University of Brescia.

Faster casting

Ultra-modern technology helps Nemak meet increasing demands for production of engine blocks and other aluminium parts in Poland.

Text by Margo Cygielska, photos by Manuel de la Cruz. This article was first published in ABB Robotic's 'Foundry' magazine (www.abb.com/robotics).

The tiny IRB 2400 is busy passing liners to the IRB 6650s, which towers over the new Ford Sigma station in the high-pressure diecasting foundry at Nemak Poland in Bielsko-Biala, in south-west Poland. This is one of four new stations installed over the last three years and using ABB's latest-generation robots for diecasting car engine parts from aluminium.

"By February 2009 we will have one more station working for the same client," says Jacek Kwiatkowski, automatics department manager, "as the estimated production volume in 2010 should be 600,000 engine blocks."

With another big project on his hands, 10 different castings for Hyundai car manufacturer, Mr Kwiatkowski is busy supervising the existing stations and co-ordinating upcoming ones. He is the person responsible for new project development, working closely with Nemak's engineers and the station's manufacturer on the layout, the technical solutions and the final installation.

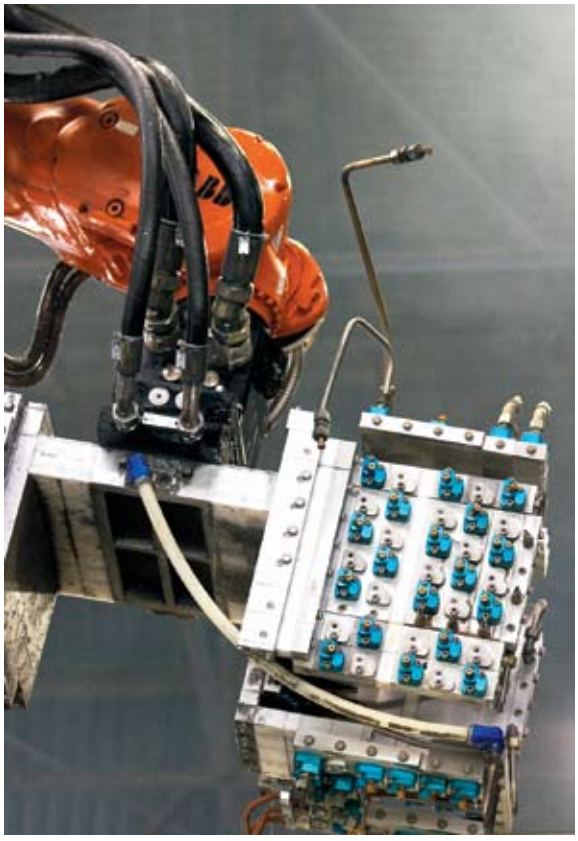
"Such a station usually consists of diecasting machine and robot as a peripheral installation with different applications, depending on the needs," Mr Kwiatkowski explains. "The dies for high-pressure diecasting, which are extremely complicated devices, are mainly constructed at the foundry's tool shop following the client's instructions. It takes a few months from signing a contract to having the station up and running."

Automotive history

The foundry's history goes back to the 19th century, between 1970 and 1991 casting parts for the Fiat 126 and Fiat Cinquecento. In 1992 it became part of Teksid Italy and went through extensive modernisation. Two years ago the plant became one of the 16 units owned by the Nemak Group worldwide.

It covers over 122,976m^2 and comprises a high-pressure diecasting foundry, gravity foundry and tool shop. The main production stays the same, car engine aluminium parts. The three biggest clients in 2008 were Fiat (31%), Ford (27%) and Toyota (11%).

"The production volume has been growing slowly since 2002, but it has risen sharply over the last two years thanks to big contracts with Ford and Hyundai. The production value for Toyota is also expected to go up," says Mr Kwiatkowski. "We are going through big organisational changes as well as making large technical investments in new machines and automation. The Nemak Group has a corporate contract with ABB, so we are buying their robots for the new stations as well for the old ones that need replacements."



The casting station has increased production by 25%

Mr Kwiatkowski explains that dealing directly with ABB Poland's sales department is very helpful and thanks to the corporate contract the two companies have, the price is very competitive.

"We have had a few of the older models like the IRB 6400 on the casting stations since 1999 and we are very happy with its performance," he adds.

The Nemak Poland foundry operates 50 robots. "With such a fast production growth we will be purchasing more robots," says Mr Kwiatkowski. "One of them will be an IRB 6640 for the Hyundai programme. Its application will be pulling out the castings from the press. Automation of the stations is one of our team's top priorities. There are no production lines in the foundry so we still need employees working the stations, but with the robots it's a much safer workplace and 20 to 25% more efficient. Every robot reduces the production cycle by 20 to 25%."

He also explains that the ABB interface is user friendly and the steering panel is small, compact and easier for programming as well as unproblematic for maintenance.

"In addition to the ABB robots in the foundry, we also use an ABB RobotStudio offline program for computer simulations of production stations. ABB Poland organised a workshop for six Nemak employees this year based on specific problems and solutions that came from our close business relationship."

As the foundry suffered serious underemployment under the previous management, the ongoing automation of the stations is not reducing staffing levels. "To the contrary," Mr Kwiatkowski says, "we need to hire more engineers and technicians to be able to meet our clients' expectations."

Engine blocks cast at Nemak are made with a 25% faster cycle time using robots

Jacek Kwiatkowski, automation department manager

Currently, Nemak Poland has 809 employees, who work on three shifts turning out a production valued at €121 million in 2008, which is expected to rise to €169 million in 2011.

Mr Kwiatkowski points to the IRB 6650s with a spraying head application. "This is one of the most advanced stations in the world," he says. "We were able to assemble it together with the Italpresse team, which manufactures casting presses, in nine weeks." He is proud of this ultra-modern technology on the grounds of a foundry that goes way back in time.

With new contracts and more engine parts to be cast for the car manufacturers spreading across central Europe, Nemak Poland's future looks bright, and quite orange.

Nemak Poland at a glance

- Founded: 19th century – beginning of industrial activity, various owners, since spring 2007 part of the Nemak Group
- Location: Bielsko – Biala, Poland
- Number of employees: 809 total, 510 in the high-pressure foundry and gravity foundry
- Production details: Aluminium castings for car manufacturers – engine blocks, transmissions, cylinder heads. Biggest clients in 2008 are Ford, Fiat and Toyota
- Total sales in 2008: €121 million; forecast for 2009 €140 million.

Better with robots

Benefits for Nemak Poland of casting stations automation with the ABB's IRB 6650S, IRB 6600, IRB 2400 and IRB 6640 include:

- Reduction of production cycle by 20-25%
- Increased casting station efficiency by 20-25%
- Safer working environment and less physical stress
- Higher automation, easier maintenance and better work flow.

Metal Prices

Ferro-alloy and other metals

Ferro Silicon
(per 1,000kilos) 75% loose in bulk (Mt) £720.00; 75% drums on pallets (Mt) £770.00; 75% bulk bags on pallets (Mt) £740.00.
Tennant Metallurgical Group Ltd

Ferro Silicon Briquettes
Gross 1.2kg, containing 1kg available Si, 85p per briquette (462 briquettes per pallet).
A&S

Ferro Molybdenum
Carbon free £15.50 to £16.50 per kg Mo contained.
William Rowland

Ferro Vanadium
50/80% or 70/80%, £24.50 to £26.00 per kgV.
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Ferro Titanium
67/72% content, £3.30 to £4.20 per kgTi.
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Ferro Niobium
70%, £31.00 to £33.00 per kg Nb contained.
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Ferro Tungsten
£21.00 to £22.50 per kgW.
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Ferro Phosphorus
£490.00 to £550.00 per tonne
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Electrolytic Manganese
99.9% minimum, £2,600.00 to £3,000.00 per tonne.
99.7% minimum, £1,830.00 to £1,950.00 per tonne.
William Rowland

Metallic Chromium
99% minimum Cr, £5,800.00 to £6,400.00 per tonne.
99.5% minimum Cr, £6,500.00 to £6,900.00 per tonne,
William Rowland

Ferro Manganese
(standard) 78%, £880.00 to £970.00 per tonne
William Rowland

Ferro Manganese Briquettes
Gross 1.80kg containing 1kg available Mn, £1.05 per briquette (960 briquettes per pallet).
A&S

Pig Iron
Basic, £275.00 to £295.00. Hæmatite, £290.00 to £310.00. Nodular, £290.00 to £310.00
Hempel Metals

Non-ferrous metals

Aluminium Alloys
LM2 £1,005.00;
LM4 £1,055.00;
LM6 £1,197.50;
LM24 £985.00
LM25 £1,197.50;
LM27 £1,020.00

Copper
Cash, Grade A, US$4,500.00. Three Months: US$4,525.00

Lead Refined Pig
Cash: US$1,450.00 to US$1,451.00 Three Months: US$1,440.00 to US$1,441.00 Settlement: US$1,451.00
Calders

Zinc
Cash: US$1,425.00 Three Months: US$1,475.00

Tin
Cash: US$13,895.00 Three Months: US$13,615.00

Other metals

Magnesium Ingots
(10 tonne lots delivered) £2,800.00 to £3,100.00 per tonne
William Rowland

Antimony
99.65% min £3,280.00 per tonne
AMC

Nickel
US$12,450.00 Three Months: US$12,545.00

Foundry Trade Journal accepts no responsibility for the accuracy of the prices quoted here, which are published on an advisory basis only. In the current volatile state of the market it is advised to check prices on a regular basis and to note that these 'guideline' prices were quoted to us on 13 May 2009.