ARL iSpark Series
Optical Emission Spectrometers

Innovative OES
for quality foundry products

Thermo Scientific
Getting The Most From Your Sand?
Cost saving solutions from WES Omega Foundry Machinery

Thermal Reclamation
- Maintenance free burner system
- 24/7 – 3 Year lining warranty
- Integral heat exchanger ensures low gas consumption
- Plants from 0.25 tph to 12 tph
- Suitable for continuous or intermittent operation
- Patented ‘Dead Bed’ design
- Suitable for all organic binder systems
- Over 130 units in operation worldwide
- Suitable for greensand back to core in conjunction with 2-stage mechanical scrubbing

Chromite Recovery
- Systems available from 1 tph to 20 tph
- Cost effective and modular system
- Greater than 98% purity

Secondary Attrition
- Ideal for Alkaline Phenolic and Silicate applications
- Typically 90% reclamation rate at the mixer
- Also suitable for Greensand back to core
More disruptive experiences to come

Buzz words and phrases come and go. One phrase now enjoying high currency is “disruptive technologies”. The speed of the digital world carrying an offer of spectacular technologies and their applications is disrupting the traditional business models of the 20th century. Many of them will not be seen ever again. This disruption is also slowly happening in the metal castings industry.

For the past five years, China has taken central position when talking about the rise in car manufacturers and the attendant supply line of metal castings. At the same time we contrasted this with the demise of the US car market—Detroit becoming a financial basket case. We lamented the export of skills and knowledge to Asia in the pursuit of profits through cheaper labor and construction costs. Now we see how the pursuit of cheaper labor with the mass migration of jobs and a skill bank created a vast disruption of the US car industry.

Emerging at a reasonable speed is the next disruptive phase. The US has started to redesign products and processes enabling less staff, employing robotics and as much automation as possible. This model leads to more cost effective cast products. The added bonus of this transformation is the saving from not paying shipping costs for Asian made products back to the US.

The timing chimes with the increasing wages in China and their subsequent need to increase outsourcing to African countries and other developing nations with lower wages.

The transformation will continue and be reinforced in the manufacturers market for metal castings by embracing the cost effectiveness of light metals. Strong demand from rapidly developing nations has been driving up base metal prices in recent years with an emphasis on magnesium. There is a clear trend in automotive magnesium applications but so far only a handful of upscale carmakers such as Audi, BMW and Cadillac use magnesium parts in their cars. And, the development of magnesium auto parts will basically be non-safety related. But it has been dubbed “green metal of 21st century”.

Reducing weight reduces fuel consumption

Automakers around the world know they must explore the boundaries of fuel economy and commit to meeting an increasing focus on tough new standards. This century demands a focus on green technology and the automotive market is the chief target for fuel emissions. The answer will come from creating light weight cars.

The same focus is extremely strong in the aerospace industry. Very light, very strong new metals and emerging manufacturing processes are set to usher in a new era of aerospace technology. Australia’s Monash University in Melbourne has a metallurgy laboratory so significant in what it is doing that it has attracted some of the biggest companies in the global aerospace industry from the other side of the world.

They are keeping close to the technology that could make this laboratory the genesis of the next generation of aerospace manufacturing. They are also keeping close to a scientist in whose hands their futures may well sit. Professor Xinhu Wu is recognised internationally as a leader in advanced light metals research. The giants of European manufacturers are looking for new materials that are lighter yet stronger, cheaper to manufacture, reliably safe and which will also help them halve aviation’s overall carbon emissions by 2050.

For Professor Wu and her centre it means changing the very nature of metals such as titanium, aluminium and magnesium, modifying their fine-scale structures to give them new and improved characteristics. It requires advanced industrial research underpinned by fundamental science that is exploring new paradigms in metals and their properties.

The total weight of a car body reduced by up to 100 kg means lower manufacturing costs and greater fuel efficiency. And fuel efficiency is one of the most crucial aspects in the automotive industry due to rising fuel costs and increasing regulations worldwide.

As the 21st century continues to gather speed through digital technology disrupting out of date business models, light weight metals will be star performers in the auto and aviation industries. The result will be a reduction in fuel emissions and a big contribution to the reduction in greenhouse gas. And with the new lighter automobiles they will contain enough Light metals technology which will also include the effective use of cast components.

In this edition of Metals magazine you can read more about light metals in the very informative feature by Daniel Allen, Seeing the Light - the challenges and opportunities of advancing light metal technology. There are also two very valuable technical papers, Age hardening study of conventionally cast and semi-solid processed A356 Al Alloy and Microstructure and mechanical properties of Al-alloy--silicon carbide – graphite hybrid particle composites as well as our regular features Back to Basics and Back to the Floor. We continue to take pleasure in bringing you information and knowledge which may provide you with a more informed capability in your work with metal castings.

Barbara Cail
Australia’s first Industry Innovation Precinct opens

Australia’s first Industry Innovation Precinct has been opened by Greg Combet the Minister for Climate Change, Industry and Innovation.

Mr Combet stated that “by bringing together our best research minds and our most innovative businesses, Industry Innovation Precincts will create Australian businesses and industries that can compete on the world stage.”

The Manufacturing Precinct is the first of up to 10 Precincts that will focus on areas of Australian competitive advantage or emerging opportunity. “It will bring together businesses, research institutions, service providers and government agencies to support and create internationally-competitive manufacturing businesses and jobs,” said Mr Combet.

“The Manufacturing Precinct will help Australian manufacturers to improve skills and technologies, to tap into research expertise and to build collaborations.”

Chaired by experienced industry executive, Albert Goller, the Manufacturing Precinct will work closely with Australia’s best manufacturers and researchers who will come together as foundation members.

The Manufacturing Precinct will be headquartered in the New Horizons building at the Clayton Campus of Monash University in Melbourne’s south east. It will be situated alongside 400 staff from Monash and CSIRO, specialising in research into advanced manufacturing, biological engineering and renewable energy.

The Manufacturing Precinct will operate nationally through a network linking manufacturers and researchers. It will also have a presence in Adelaide focusing on defence-related manufacturing.

Businesses and other organisations will also be able to collaborate with the Manufacturing Precinct to apply for funding under the Industry Collaboration Fund, the Industry Collaboration Fund will open later this year.

Mr Combet also announced that applications were now open for the remaining Industry Innovation Precincts. Further information and details about how to apply can be found at www.australian.innovation.gov.au/ip.

In addition, Mr Combet and Science and Research Minister Craig Emerson have announced that more than $23 million has been awarded under the first round of the Federal Government’s Industrial Transformation Research Program (ITRP).

The $256 million ITRP is an integral part of the Government’s Industry Innovation Precincts and will support important industry-research partnerships to improve competitiveness. It will fund projects in Precinct priority research areas; ensuring research is targeted to areas of existing industrial competitive advantage and emerging opportunities.

The second round of the ITRP will address research priority areas in manufacturing and defence manufacturing to match the initial two Industry Innovation Precincts being established.

Mr Combet stated that supporting advanced manufacturing in Australia remains a key Government priority, and that Industry Innovation Precincts are an important industry-led initiative that will accelerate this transformation and ensure highly skilled job opportunities into the future.”

Talking metals in Thailand – from TRIZ to Nano

In late March the Iron and Steel Institute of Thailand (ISIT) hosted the South East Asia Iron & Steel Institute (SEAISI) Travelling Seminar 2013 entitled “Problem solving tools for improvements in steel mill operation”, in Bangkok. During March, in addition to Bangkok, the travelling seminar also visited Shah Alam in Malaysia, Hanoi in Vietnam, Manilla in the Philippines and Cilegon in Indonesia.

The following presentations were given:

• “TPM method to solve problems in the steel mill” by Mr. Wu Kai-Yu, Tung Ho Steel, Taiwan.
• “The use of six sigma improvement tools for optimization of steelmaking processes” by Mr. Michael Davies, Moly-Cop Australasia, Newcastle, Australia.

Thermo Scientiﬁc™ ARL iSpark™ is the most advanced arc/spark OES metals analyzer.

It takes advantage of decades of our expertise in developing high quality OES instruments. It comes with innovative and integrated features which are extremely valuable for any foundry that wants to optimize process and product quality, while reducing operation costs.

The ARL iSpark spectrometer combines the latest CCD technology – the first CCD detector designed for OES – with the PMT optics of the most established OES spectrometer, the ARL 3460. The CCD ensures the high accuracy and precision that are necessary for the foundry to determine reliably major and minor alloying elements, while the PMT detectors offer unrivaled performance in the determination of critical and impurity elements. Thanks to this new optical concept, foundries will find ARL iSpark the most economical analytical solution with uncompromising performance, elemental coverage, versatility and flexibility for future needs.

Furthermore, the instrument has been designed to work with the lowest operation costs. The argon consumption during analysis and stand-by has been minimized and the argon saving ECOModes allow the foundry to make substantial additional savings when the instrument is idle. For short periods, the argon flow is reduced, while it can be completely turned off for periods of time ranging from hours to days or weeks.

With the ARL iSpark, maintenance operations are simplified and time to perform them is reduced, thus increasing instrument and operator availability.

Important contributions come from the Maintenance Management tool and the innovative analytical stand. The first makes these necessary maintenance tasks straightforward and as infrequent as possible, while ensuring highest instrument reliability. The stand can be dismantled and reassembled without tools in a few seconds.

Improved foundry image, products quality and process efficiency

As a high performance OES metals analyzer based on the latest technologies, the ARL iSpark will assist you in optimizing quality, as well as various other aspects, by:

• giving a modern image and analytical credibility of the foundry to its customers, especially from automotive industry
• simplifying product acceptance by foundry customers, with easier accreditation of the instruments to the applied norms
• reducing internal metal scrap with better control of all the elements, resulting in better material and energy efficiency
• using an analytical solution enabling the foundry to help its customers in developing products
• being more competitive than foundries that use limited analytical solutions

The ARL iSpark has all the features allowing these improvements. It is delivered as a turn-key solution, fully calibrated in our factory and thoroughly tested for performance, accuracy and quality before delivery. It has also all the tools necessary to guarantee functionality and performance at the installation and over the years, as the iSpark Synoptics diagnostic tool and automated quality control tool IQ/OQ (Instrument Qualification/Operation Qualification).

For further details, please visit www.thermoscientific.com/ispark

Thermo Fisher Scientific is the world leader in serving science. The company enables its customers to make the world healthier, cleaner and safer by providing analytical instruments, equipment, reagents and consumables, software and services for research, analysis, discovery and diagnostics.

For over 75 years, the ARL OES instruments have set the standard of quality for spectrochemical analysis of metals. Throughout these years, performance, stability, reliability and longevity have been the key attributes of our optical emission spectrometers. Today the OES installed base is larger than 14,000 with instruments used in all the metals markets.
More recycling opportunities for foundry waste

Sashee Moodley from engineeringnews.co.za reports that the foundry industry is one of the greatest recyclers; however, it generates many waste products that end up in landfills when, in fact, they can be used in several applications, says US Department of Agriculture research scientist Robert Dungan. Speaking at the 2015 South African Metal Casting Conference, in March, he noted that there were solutions for waste, such as moulding sand, slag and furnace refractory, produced by the foundry sector.

Dungan noted that foundry sand was the most common waste in the industry and that it could be used in several geotechnical and agricultural applications. Despite the challenges of conducting a business in the global economy because of the global economic downturns, he believes that there are initiatives that can be applied by the energy-intensive foundry industry to improve the bottom line.

The use of foundry waste will benefit the industry, as raw materials and energy are conserved, while disposal costs are lowered. The pollution of water, soil and air resources will be reduced and the competitiveness of foundries will be improved. Waste foundry sand, in particular, has many beneficial uses and can be incorporated into asphalt, concrete, construction fill, pipe bedding and road bases. It also has agricultural and horticultural uses, such as potting and as specialty soils. In direct land applications it improves soil texture and, as topsoil, it is used in landscaping and turf grass.

Foundry sand can be used in manufactured soil and this mixture can be used to successfully grow vegetables that are safe for human consumption, grass and other plants.

When asked about the risks of foundry sand, Dungan said a risk assessment was conducted by the US Environmental Protection Agency in a home-garden scenario, which found that the metal concentrations in foundry sand were similar to the levels found in native soil.

Further, foundry sand has low dieixin, polyyclic aromatic hydrocarbon and phenolic concentrations. The assessment also revealed that most ferrous and aluminium-foundry sand is safe for use in soil-related applications.

The waste sand can also be used in green-building applications. “Rooftop gardens are proven to save heating and cooling energy and costs, remediating stormwater and creating better environments for building occupants. Sandy loam mixed with foundry sand helps create a lightweight blend when combined with Haydite-expanded shale aggregate,” Dungan said.

Further, when used as a road base for embankments, foundry sand is not only an easy-to-handle and uniform material but is also moisture sensitive and susceptible to freeze-thaw weathering. Slag, which is the by-product of smelting ore, was another valuable waste material, noted Dungan. Depending on the type, such as blast-furnace or steel slag, and whether it is pelletised, granulated or air cooled,
slag can be used in asphalt aggregate, concrete masonry, soil cement and glass manufacture, as well as lightweight fill.

Dungan said it was important to market foundry wastes to end-users and recommended that a steering committee be established. “Stakeholders need to be educated about metal casting. Existing regulations and focus efforts should be evaluated and those in industry should host seminars, workshops and demonstration projects. Think of waste as a valuable by-product. Waste is not waste if it is beneficially used,” he concluded.

Source: www.engineeringnews.co.za

Expansion in Thai auto industry continues

Although there are some concerns over the recent strengthening of the Thai Baht the auto industry in Thailand is continuing to invest in expanded production capacity. Mitsubishi is investing around 1 billion Baht to raise annual vehicle production capacity in Thailand from 460,000 to 510,000 by the end of the year. Having first started producing vehicles in Thailand in 1998, the company now has three production plants in Chonburi and, in February 2013, exported its 2 millionth Thai made vehicles. Mitsubishi is also moving some of its research and development to a new expanded Thai centre increasing the productivity by becoming less labour intensive.

According to the Thailand Automotive Institute (TAI) around 8 billion baht of investment is needed to fund a vehicle and component testing centre in Thailand since at present vehicles and parts have to be sent to India, Spain or Taiwan for testing. The Thai Strategic Committee for Reconstruction and Future Development (SCRF) has suggested that the planned centre could be part funded by contributions from car companies in Thailand based on the number of vehicles sold by each company. The TAI is to examine the SCRF plan and other sources of funding for the testing centre which is expected to be the most advanced in ASEAN, the tunnel is designed to perform R&D on air conditioning and engine performance. Denso has over 200 affiliates worldwide, located in 35 countries. In Thailand, Denso has eight companies producing air conditioning systems, power train control systems and engine parts. In developing its Thai operation to be a world-class automotive part production base and to prepare for the upcoming AEC in 2015, Denso plans to expand its Thai testing house to cover engine performance and exhaust emission testing. Denso is also developing OER production in Cambodia and Myanmar.

3D printing boom for small volume manufacturing, prototypes and modeling

As reported by Patrick Pantel on www.sae.org, 3D printing will grow to an $8.4 billion market in 2025—up from $777 million in 2012, according to a recent report by Lux Research.

“3D printing offers design flexibility and rapid implementation, but development needs remain in materials performance and printer throughput,” said Anthony Vicari, a Research Associate at Lux Research and the lead author of the report titled “Building the Future: Assessing 3D Printing’s Opportunities and Challenges.”

“Over the longer term, 3D printing has potential to reshape the manufacturing ecosystem, but it will have the most impact in the near term for products that are made in small volumes, require high customization, and are more cost-tolerant,” he added. Asked by Aerospace Engineering (AE) what constitutes “small volume,” Vicari said it varies by application.

Meanwhile Denso, one of the world’s biggest manufacturer of auto parts with its headquarters in Japan, has invested 200 million baht to build a new climatic wind tunnel test facility in Thailand. Said to be the most advanced in ASEAN, the tunnel is designed to perform R&D on air conditioner and engine performance. Denso has over 200 affiliates worldwide, located in 35 countries. In Thailand, Denso has eight companies producing air conditioning systems, power train control systems and engine parts. In developing its Thai operation to be a world-class automotive part production base and to prepare for the upcoming AEC in 2015, Denso plans to expand its Thai testing house to cover engine performance and exhaust emission testing. Denso is also developing OER production in Cambodia and Myanmar.

Complete No-Bake moulding systems

Core-making machines and robot operated core centers

Shot-blasting, shot-peening and dry-pickling machines

More products for our Customers

Global solutions at your service
“But in many cases, traditional processes are more efficient for runs of hundreds of thousands of units, and metal injection molding may be more efficient for tens of thousands of units. 3D printing, because it does not require molds or custom tools, is often more cost-efficient for runs of one to several hundred or in some cases several thousand units. There are exceptions in extreme cases, such as shapes that simply cannot be made by traditional processes, where 3D printing can be viable even for larger scale production.”

The report notes that “while 3D printing is used largely for prototyping today, small-volume manufacturing will boom from a niche market of just $1 million in 2012 to $10 billion in 2025, led by aerospace engines and automotive components.”

In an e-mail exchange with AE, Vicari noted that there is great growth potential for 3D printing in all aspects of the aerospace industry, but engines represent the main growth area. And the demand will be not only for production parts but also prototypes. Jet engines are promising because they “contain high-performance titanium and nickel alloy parts that are particularly difficult and expensive to machine and assemble,” said Vicari. “Moreover, they often involve machining away the majority of that expensive starting material. In contrast, 3D printing can be used largely for prototyping today, small-volume manufacturing will boom from a niche market of just $1 million in 2012 to $10 billion in 2025, led by aerospace engines and automotive components.”

“Stereolithography, polyjet, digital melting, powder bed inkjet printing, and selective heat sintering. Definitions of additive manufacturing are used to manufacture differently—more cost-effectively, with lower inventories, and lighter-weight components for cost savings. When you think of something, for the most part, it’s a low-volume—production industry. The real value in low volume is now you no longer have to keep an inventory,” he continued. “There are no minimum-order quantity requirements from the supplier, because now you can build it on demand as needed. Let’s say you produce 40 units and now you want to make a slight performance change. Well, now you don’t have the high cost of retooling an injection-molding tool or starting from scratch with a new tool. All you have to do is update your 3D CAD file, upload it to the additive-manufacturing equipment—in our case the Fortus equipment that produced that part—and you’re back in production. We call it ‘production without the line.”’

Stratasys’s Fortus 900mc 3D Production Systems offer the company’s widest range of FDM modeling materials, including high-performance thermoplastics, for parts as large as 914 x 914 x 914 mm. Source: www.stratasys.com

Infrastructure development plans in Thailand

The Thai government plans to invest around two trillion baht over the next 7 years to improve transport systems with the aim of developing Thailand as a regional transportation hub and gateway to neighboring countries. The developments will include several high-speed train routes and mass transit rail lines thereby reducing the present costs of power to increase from the present 3.75 tha per kw-hr to around 5 baht per kw-hr over the next two years. This has raised concerns at the Federation of Thai Industries that some power hungry companies such as foundries could relocate to Indonesia or Vietnam where less natural gas is used for power generation. In response the Energy Ministry has said that Thailand will buy electricity from neighbouring countries, will attempt to reduce environmental opposition to clean coal technology and in particular will continue to support the development and use of biofuels.
Market forces

Today, the light metals – notably aluminium and magnesium, and to a lesser extent titanium – are important for many applications. They are increasingly critical in the automotive and aerospace industries, where the benefits of weight saving include reduced fuel consumption, higher speed and longer range, and improved performance and handleability.

“The recent global financial crisis has seen a renewed emphasis on the need for improved fuel efficiency for both economic and environmental reasons,” says Mark Easton, CEO of the CAST Cooperative Research Centre at the University of Queensland. “It is in this area, known as lightweighting, where light metal alloys can and are making a significant contribution.

The economic, not to mention environmental, imperatives of light metals R & D are clear. In order to reach the target of improving fleet fuel efficiency by 15 percent per annum between 2010 and 2020, the world’s airlines are now in the process of purchasing 12,000 new-generation aircraft at a cost of US$1.3 trillion. Across the globe, and especially in developing countries, the number of automobiles on the road is growing at whirlwind pace. The potential rewards for those foundries that can stay at the forefront of light metals technology are rich indeed.

Car consumption

Automakers throughout the world are now redesigning and retooling to produce smaller, lighter vehicles that will cost less and use less fuel. When the weight of a vehicle is reduced by 10%, fuel consumption drops by 6-8%, which means that the strength-to-weight ratio of steel, plastic and aluminium for every car component is now intensely scrutinized.

Over the last 15 years the quantity of light metals used in automotive manufacturing has continued to increase, and the trend is projected to continue. A recent survey shows that the amount of aluminium used in the average North American vehicle has grown from around 36 kg in 1974 to 128 kg in 2007, and will reach nearly 200 kg by 2012.

“Automakers are now constrained by ever more stringent government regulations,” says Mark Easton. “For example, in the United States, recent changes to the Corporate Average Fuel Economy (CAFE) regulations are driving automakers to seek more aggressive methods for fuel consumption reductions.” With the ongoing development of alternative propulsion systems – such as plug-in hybrids and electric drive vehicles – the trend toward even more lightweight vehicles is set to continue.

With regard to light metal supply, today’s auto industry is extremely demanding. Vendors must provide their product with perfect quality, in complete orders, and on time, every time. Automotive design engineers are no longer constrained by the previously accepted limits of the light metal cold chamber die casting production process. They want die cast products that are larger, thinner, more complex, and stronger, than have ever been commercially produced before.

Vacuum assisted die casting

Today cold chamber die casting remains the most commonly used method for casting aluminium alloys. However, the turbulence of the alloy as it is forced at high pressure into the die cavity, coupled with the complex shape of many casting molds, often causes air and other gases to become trapped in the metal. This results in undesirable porosity and frequent cast rejection.

Vacuum-assisted die casting is a developing technology that can go a long way to eliminating porosity. Before the injection shot occurs, a vacuum is created in both the shot sleeve and mold cavity. The vacuum is maintained until the injection cycle is completed, enabling the alloy to flow smoothly into all recesses. It also allows the fronts of the molten metal to merge freely without forming shuts.

Vacuum technology is continually improving, and today’s best systems are considerably more effective than those of only a few years ago. “Adding a vacuum system to the operating process benefits die casters in several ways,” says Mark Easton. “It reduces rates of rejection and increases the life of the die casting machine. Most importantly, it enables the die caster to produce thinner, stronger, and more complex castings, allowing the foundry to compete in markets it would otherwise be denied.”

Magnesium: the new contender

Largely overlooked until the early 1990s, magnesium and its alloys are now playing an increasingly important role in many industries. In 2008, 121,000 tonnes of magnesium castings were produced in the United States for all markets segments - this figure is projected to reach 166,000 tonnes by 2019.

Within the transportation industry, in particular, the latest casting and processing technologies have significantly raised the importance of magnesium as a metal with a low density and a very high strength-to-weight ratio. As with aluminium, magnesium alloys can effectively reduce vehicle weight which, in turn, reduces greenhouse gas emissions and increases fuel efficiency.
“IF YOU’RE USING LIGHTER WEIGHT PARTS IN VEHICLES, YOU’RE IMPROVING THE POWER-TO-WEIGHT RATIO, AND THE MOST OBVIOUS BENEFITS WILL BE ENHANCED FUEL EFFICIENCY AND REDUCED CO₂ EMISSIONS.”

In recent times the growth of magnesium HPDC has mirrored the growth of the automotive industry, where the demands of assembly line manufacture has driven demand for a quick, reliable way to make components. With the growth of JIT manufacturing, the automotive industry continues to be the dominant user of HPDC parts. In addition to the automotive market, there is still a strong market for sand cast military and aerospace components, as well as growing markets for power tools, sporting goods and other commercial castings. A thriving casting prototype market also exists to produce sand cast prototype components that will ultimately be made by HPDC.

Looking to the future, the growth potential for magnesium is unprecedented in view of the accelerating demand for lightweighting of transportation and portable devices. However, the metal must become cost and environmentally competitive with other lightweight materials, particularly aluminium. Future growth will also require environmental competitiveness; magnesium producers need to utilize process technology that provides a much more attractive life cycle assessment than is currently achieved.

HPDC alternatives

While magnesium castings are traditionally produced either by HPDC or precision sand casting, each of these processes has its disadvantages. These include constraints on casting design geometries and unacceptable levels of porosity. While precision sand casting can produce a wide range of part shapes with high levels of soundness, the process is expensive and generally limited to high value, limited production run components such as those used in the aerospace industry.

With the increased emphasis on vehicle weight reduction, finding alternative casting processes has recently been a high priority for magnesium alloy researchers. Many R&D performers and design engineers are now examining the production of near-net shape components through the lost foam casting process.

Some of the advantages of using a lost foam casting process for both aluminium and magnesium alloys are closer dimensional tolerance, higher casting yield, and the elimination of sand cores and binders,” explains Mark Easton. “The ability to create a single component that replaces multiple fabricated components means that the lost foam process has the potential to reduce manufacturing costs significantly.

“If you’re using lighter weight parts in vehicles, you’re improving the power-to-weight ratio, and the most obvious benefits will be enhanced fuel efficiency and reduced CO₂ emissions.”

While the lost foam process is capable of making castings with extremely complicated shapes at high soundness levels and low manufacturing cost, it also produces many complex design challenges as a result of the low heat content of magnesium alloys.

During conventional lost foam casting, the comparatively low heat content of the magnesium melt often means that patterns do not fully decompose. Mold filling is also obstructed because the magnesium melt, with a low specific weight, is held back by the pressure of gases occupying the empty spaces.

The low pressure lost foam casting process for magnesium alloys is an innovative technology which takes advantage of the benefits of both gravity lost foam casting and low-pressure casting. As a result of the applied pressure the molten metal rises up an ascension pipe to fill from below the binderless silica sand mold, the cavity of which is filled by a foam pattern. The pattern is vaporized by the casting heat and the molten metal takes up the place of the foam pattern. Throughout the casting process the mold is subjected to low pressure which removes casting gases and also stabilizes the mold.

The low-pressure lost foam casting process gives casters far more control over the casting process. Being able to vary the pressure means the gating system can be minimized without compromising casting quality, and lower metal temperatures means significant energy savings are possible. In contrast with other casting processes, the low-pressure lost foam technique also enables slag-free casting and prevents undesirable oxidation and gaseous emissions.

As new materials are developed, ongoing research will lead to a better understanding of the applicability of the lost foam process in magnesium casting, with the associated potential for lessening environmental impacts. To date lost foam casting has generally become accepted in the United States, and is also gaining traction within the Chinese casting industry.

T-MAG

Lost foam casting is not the only area of magnesium casting innovation. Established in 2007 with the goal of developing a new magnesium alloy casting system, the T-MAG project is a venture between three South Australian entities and the CSIRO, Australia’s national science agency. Steve Groat, Managing Director of T-Mag Casting Technology says “The T-Mag casting process offers foundries exciting opportunities to produce high quality magnesium alloy castings for the automotive and associated industries”.

The T-MAG process involves a specially developed casting machine, which can provide melting and casting operations in a single compact unit. The unit holds a furnace with an enclosed retort of molten magnesium alloy under a cover gas atmosphere, connected to a die via a steel transfer pipe.

With the machine resting in the horizontal position, the molten magnesium alloy in the transfer tube lies just below the die. When casting, the machine rotates about a horizontal axis at a controlled speed, allowing molten magnesium to fill the die from the bottom. This process ensures a smoother flow of material into the die and greater casting integrity than traditional high-pressure methods. As the system is fully enclosed, cover gas consumption is also minimized.

T-MAG has the potential to extend the capability and reduce the cost of permanent mold casting for a wide range of high-performance magnesium components. The fact that the process can incorporate sand cores, for complex hollow features inside castings, is a major competitive advantage, and castings can also be heat treated and welded, unlike many castings produced through HPDC. “With a trend towards environmentally friendly products the T-Mag casting process offers manufacturers a cost effective and greener solution for casting magnesium alloys”, says Steve Groat.

Going green

The growth of magnesium die casting has lead to an increase in the quantity of magnesium scrap, typically due to end-of-life vehicles and manufacturing by-products. Effectively recycling such scrap means regaining the original chemical composition and purity of the original alloys, while environmental considerations dictate the minimization the life cycle costs, energy consumption, and greenhouse gas emission.

Magnesium in its molten state reverts and forms oxides when exposed to air. This rapid oxidative burning must be controlled in order to facilitate safe and efficient magnesium production, die casting, and recycling activities.

An intense white flame characterizes burning magnesium.
with temperatures that can exceed 1300°C. For several decades the magnesium casting industry has traditionally used sulphur hexafluoride (SF₆) to inhibit melt surface oxidation. While SF₆ is an effective cover gas due to its ability to supply fluorine to the melt surface, SF₆ is also an extremely powerful greenhouse gas, with a 100-year global warming potential (GWP) estimated at 23,900 times that of carbon dioxide (CO₂).

While recent research has shown that for hot chamber die-casting 10 percent of the SF₆ delivered to the melt is typically “consumed,” the gas’s extreme GWP means researchers are now seeking substitutes. These include sulphuryl fluoride (SO₂F₂), baron trifluoride (BF₃), HFC-134a, hydrofluoroethers, and a fluorinated ketone (Novel 612). Compared to the lowest estimated emission factor for SF₆, both HFC-134a and Novel 612 have been found to reduce cover gas-related GHG emissions by more than 95 percent.

Energy saving innovation

The fact that metal casting is such an energy intensive process means there are opportunities for many light metal foundries to slash energy use by adopting new casting techniques. Recently developed by the United Kingdom’s Birmingham University and a local company called N-Tec, the CRIMSON (Constrained Rapid Induction Melting Single Shot) process is an innovative method of casting aluminium that could save light metal foundries up to one third of their energy costs, while significantly improving casting quality. The innovative CRIMSON process ensures that the exact amount of aluminium needed for a particular casting is melted rapidly in a crucible using induction heating. It is then squeezed upwards into a cast using a device like a toothpaste pump dispenser. The fully liquid metal is pushed up with a piston controlled by hydraulic motors, linked back to computers that accurately control filling of the casting.

“The process uses the pressure of molten metal acting on the walls of the crucible to force the molten metal through the nozzle,” explains Binxu Zeng, a researcher based at Cranfield University in the UK. “The molten metal is transferred to the casting directly after melting, which means at least a 30% energy saving over traditional processes. In addition, anti-gravity filling means less metal is required to make the actual casting.”

“We calculate that if the traditional aluminium foundries participating in our research employed CRIMSON, their estimated energy savings would be in the order of 43 GJ per tonne for producing the A354 aluminium alloy,” continues Zeng. “This would reduce their production costs by about US$400 per tonne.”

HIP replacement

With more design opportunities arising every year for aluminium casting, commercial demand for engineered cast components continues to increase. However, a major limitation of aluminium castings is the potential presence of porosity, which occurs when the melt solidifies and contracts. Internal shrinkage porosity is a common life-limiting factor – this can be true for very small amounts of porosity in high-quality castings, and for more prevalent internal voids in lower quality castings.

Hot isostatic pressing (HIP) is a form of heat treatment that uses high pressure to improve material properties. This pressure is applied by an inert gas, usually argon. HIP removes internal porosity, utilizing plastic yielding, creep and diffusional effects. Defects of considerable dimension may be removed by the process, as well as the more typical scattered shrinkage and hydrogen gas porosity.

The improvements to micro-structural homogeneity and material properties that HIP can achieve mean that cast aluminium can now be used in more demanding, severe stress applications, such as automotive engines, structural aerospace parts, turbopump components and other critical industrial components.

“Use of HIP extends the range of possible aluminium casting applications, with numerous advantages in comparison with wrought material,” says Mark Easton. “Recent advances in larger and faster cycling equipment have significantly lowered the per-unit costs for HIPped aluminium processing.”

Despite recent advances, however, HIP treatment of cast aluminium remains a costly and often inefficient process (the process cycle can last from 6 to 24 hours). Price limitations still make HIP treatment unfeasible for large volume production runs, such as those connected with the automotive industry.

To overcome the limitations of HIP, a new process has recently been developed, called liquid-phase hot isostatic pressing (LHIP). This process is a modification of the traditional HIP technique, which allows the use of a molten salt or low-melting-point alloy and conventional hydraulic presses for the treatment. Treatment time is typically reduced to three to five minutes, which has reduced cost and made LHIP suitable for the production of quality aluminium castings for car parts.

Light metals & lasers

Direct metal laser sintering (DMLS) is an emerging technology for the rapid, additive manufacturing of metal parts. Among other applications, it is well suited to production of high-strength, low-weight components at low manufacturing volumes. As such, it has exciting potential for light metal usage in the aerospace industry.

Laser sintering prototypes and fixtures already achieve significant cost and time savings. More excitingly, the process offers the potential for design-driven manufacturing – the creation of a component based solely on its ultimate function, without the compromises imposed by process limitations.

Since DMLS is an additive technology, it dramatically reduces material waste when compared to traditional processes. Investment casting of titanium, for example, is difficult and often has a high scrap rate. Currently, many titanium aerospace components are machined from solid stock, which means at least a 30% energy saving over traditional HIPped processes.

The expanded use of laser-sintered titanium parts will follow the same route as composites are travelling now, and as aluminium did before. Today, aerospace companies are evaluating manufacturing applications for DMLS through proprietary projects and small-scale studies. As engineers become familiar with the technology, they start to fully implement design-driven manufacturing to push the boundaries of innovation further. DMLS also has the potential for use in the manufacture of aluminium-based parts.

Future focus

Looking forward, aluminium, magnesium and titanium can all play significant roles enabling energy savings across a wide range of applications. With their high strength-to-weight ratios, these metals can enable lighter, fuel efficient vehicles and airplanes with no reduction in performance or safety.

The higher cost of light metals relative to steel and stainless steel is currently a barrier to adoption in many applications. In order to achieve the large energy reductions that are possible with their use, the primary processing of such metals must be radically rethought in order to reach parity with heavier metals on cost, energy consumption, and greenhouse gas emissions. The future of light metals and light metal alloys casting process is changing the very nature of the metal itself – modifying the nano-structural composition of the material to endow it with new and improved characteristics. New processing techniques such as laser additive manufacturing and net-shape HIPping will continue to be at the forefront of light metal production, redefining the casting process and introducing new economies of scale.

In light of a rapidly evolving technological environment, light metal foundries can only be successful in the face of future competition if they have highly skilled staff. As workforces are reduced, competition for personnel will be fierce, but even more so between light metal foundries and alternative production processes. Training and education remain key, and the complexity of the casting process and alloys being handled must not be underestimated.

Today, thanks to pioneering research and development, new pathways for light metal processing are being conceived, realized and implemented on an industrial scale. As the need for increased fuel efficiency, lower greenhouse gas emissions and metals that can withstand extreme conditions intensifies, the drivers for such development will only become more pressing.
Profiling world’s leading foundry suppliers

SUCCESSFULLY REACH ... CONNECT ... ENGAGE READERS ATTENTION

Include your relevant solutions and detailed information for response

Annual September Edition
BOOK EARLY TO AVOID DISAPPOINTMENT
See Booking form page 29

Speak with Adam about your profile
Tel: +61 2 9420 2080
Email: adam@rala.com.au
Age hardening study of conventionally cast and semi-solid processed A356 Al Alloy

By Amporn Wengnoong, Kissana P. Torratin Chaiaungyey, John Pearce

Introduction

Cast Al – Si6G – 0.1% Mg alloy (A356) is commonly used for automotive parts such as cylinder heads and engine blocks and for structural components in the aerospace and general engineering industries due to its excellent casting characteristics, corrosion resistance and high strength-to-weight ratio in the heat-treated condition [1,2]. However, in comparison to wrought alloys, cast alloys tend to have lower reliability due to the presence of discontinuities such as fine porosity, oxides and other inclusions that can occur during the casting process [3]. Casting process developments and better control of heat treatments have been used to improve the reliability and properties of cast aluminum alloys. However the present conventional casting processes such die casting, permanent mold and sand casting that are usually employed for producing aluminum alloys parts have some disadvantages. For example, without use of vacuum high pressure die-casting tends to give entrapped gas bubbles limiting subsequent heat treatment and properties, while permanent mold casting is limited to relatively uncomplicated designs. Other than the Cosworth process and its variants, sand casting cannot meet the demands of dimensional accuracy and surface roughness for aluminum alloy precision components [3].

All of the conventional casting processes give relatively coarse dendritic structures hence there is considerable interest in the use of semi-solid casting processes which can provide finer and more uniform microstructures with improved properties. There are two common techniques in semi-solid casting: thixo casting and rheocasting. Thixo casting utilizes a pre-cast billet with non-dendritic structure which is reheated to the semi-solid temperature range, and then the semi-solid material is forced into a die. The main two disadvantages are that special billets that must be used and scrap cannot be directly re-used. Rheocasting involves forming in the semi-solid state direct from a cooling melt without the need for pre-stack solid with a globular structure. This is a major advantage over thixo casting because less expensive feedstock, in the form of conventional ingot of typical die casting alloys is used allowing direct recycling [4-6]. One method of rheocasting is the sloped cooling plate method in which molten metal is poured via an inclined plate or tube. During processing the partially solidified primary phase becomes rounded such that the semi-solid state consists of near spheroidal solid particles dispersed in lower melting point liquid. The resultant primary microstructure has a finer, less dendrite form than that produced in conventional castings leading to improved mechanical properties [7-8]. A356 alloy is a hypoeutectic Al-Si alloy with two main solidification stages: the formation of primary aluminium rich (Al) dendrites followed by Al-Si eutectic. However, the presence of additional alloying or impurity elements such as Mg and Fe leads to other intermetallic phases such as Mg2Si and AlFeSi. Strengthening of this alloy depends on precipitation from supersaturated solid solution during suitable aging treatments. Research has continued to determine how variations to T5 and T6 age hardening treatments, and semi-solid processing might be used to improve mechanical properties [9,10,11,12]. However, the effect of age hardening of A356 prepared by the sloped cooling plate method has received little attention. The aim of the present work, therefore, was to compare the effect of age hardening on microstructure and hardness of A356 aluminum alloy produced by permanent mold casting and semi-solid processing.

Experimental details

Commercial A356 alloy foundry ingot was melted in a graphite clay mould to provide cylindrical bars 15 cm long by 2.50 cm in diameter. The melt was conventionally cast in a metal mould to provide cylindrical bars 15 cm long by 2.50 cm in diameter. The semi-solid processed sample was produced by pouring some of the remaining liquid metal over a semi-circular cooling plate, made from copper, 10 cm in diameter and 25 cm in length, inclined at 90°, into a metal mould as for the conventional casting. Each bar was sectioned transversely to give cylindrical specimens with an approximate thickness of 150 cm. The specimens were then heat-treated to T6 condition via solution treatment for 2, 4, 6, 8 hours at 540°C in an air furnace followed by quenching into hot water at 82°C and then artificial ageing at 145, 160, 180°C for 6-54 hours followed by hot water quenching. The shortest solution treatment time that gave maximum hardness was selected for the aging studies. The chemical composition of the cast alloy is given in Table 1. The casting and heat treatment conditions are listed in Table 2.

Specimens for examination by optical microscopy (OM) and scanning electron microscopy (SEM) were ground on silicon carbide papers to 1000 grit, and then progressively polished with 1 and 0.5 μm Al2O3. The etchant used was 5 ml of HF in 100 ml distilled water. The area fraction of eutectic structure present was determined from optical micrographs using Image J software. The mean values quoted are based on ten different areas. Macro-hardness testing was performed on un-etched specimens with a Rockwell hardness tester using the B scale (HRB) with steel ball, 100 kgf load and 15 seconds indentering time. The mean values are based on ten different areas on each specimen.

Results and discussion

The as-cast microstructure in the conventionally cast alloy (sample C1) consisted of primary Al dendrites with interdendritic eutectic Si and intermetallic phases. In the semi-solid cast alloy (sample S1), the primary α-Al was non-dendritic and had a globular form. The conventional and semi-solid cast microstructures can be compared in Figure 1(a) and (b). The eutectic structure in both cases had a flake-like morphology with sharp edges, but it was considerably finer in sample S1 compared to sample C1 as shown in the SEM views of deep etched microstructures in Figure 1(c) and (d). As illustrated in Figure 2(a-c) with respect to the semi-solid cast material the microstructures after solution treatment are similar to those of the as-cast condition, except that some spheroidisation of the eutectic Si has occurred and some intermetallic phases have been taken into solution. The area fraction of eutectic constituents was decreased from the as-cast condition as shown in Figure 3, the decrease being greater at higher aging temperatures at longer time. The SEM view in Figure 2(b) of a deep etched specimen reveals the rounded edges of the residual eutectic Si phase. SEM-EDS analysis confirmed that the phases present in A356 alloy are α-Al-rich phase containing Si, eutectic Si-rich phase and intermetallics comprising mainly of plate-like Al2FeSi3. Figure 4(a-c) shows the levels of macro-hardness in conventional and semi-solid castings in the as-cast condition and after solution treatment at 540°C for 6 hours plus aging at 145, 160, 180°C for 6-54 hours. The mean macro-hardness of the conventionally and semi-solid cast alloy in the as-cast condition was 11 and 12 HRB, respectively. The peak macro-hardness of conventionally and semi-solid cast alloy was increased up to 43 HRB and 47 HRB, respectively after T6 solution treatment plus aging at 650°C for 30 hours. At higher aging temperature the peak macro-hardness was achieved after a shorter aging time. At low ageing temperature or shorter times, the hardness was lower due to...
Spheroidisation of the eutectic Si after solution treatment.

In the as-cast A356 alloy, the dendritic form of primary Al produced by incomplete precipitation. While at higher ageing temperature or longer times, the hardness was reduced from the peak level most probably due to precipitate coarsening and loss in coherency effects. Fine scale microstructural aspects of precipitation stages and growth in both conventional and semi-solid cast A356 and A319 are being studied by high resolution TEM work [10,11].

Conclusions
1. In the as-cast A356 alloy, the dendritic form of primary Al produced by conventional casting is changed to near spheroid by semi-solid casting.
2. T6 age hardening decreased the area fraction of eutectic structure and produced some rounding of the angular shape of the eutectic Si.
3. The macro-hardness in the as-cast condition is not different for conventionally cast and semi-solid cast A356.
4. After T6 heat treatment, the macro-hardness in semi-solid casting alloy was slightly higher than that of the conventionally casting alloy. Peak aging for both cast routes was obtained at the aging temperature 160°C for 30 hour.

References
Microstructure and mechanical properties of Al alloy – silicon carbide – graphite hybrid particle composites

Panajk Sadana, Lakhvir Singh and P. C. Maiti
Assistant Professor, Mechanical Engg., DAV Institute of Engineering and Technology, Jalandhar, India
Professor, Mechanical Engg., Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, India, Metall Casting and Materials Engineer

Introduction
Aluminium alloys reinforced with ceramic particles such as SiC, Al2O3, Si3N4, TiB2, B4C and graphite have been studied extensively in the past few decades due to their improved hardness, yield and tensile strength at room temperature and elevated temperature, elastic modulus and wear resistance compared to monolithic alloys [1-3]. Hence these materials are being considered for various automotive and aerospace applications. The ceramic particles can be classified into two groups, namely, hard particles and solid lubricants. The hard ceramic particles are SiC, Al2O3, Si3N4, TiB2, B4C, whereas graphite is soft and a well known solid lubricant. It has been reported that addition of hard ceramic particles such as SiC to Al alloys improve hardness, tensile strength, elastic modulus and wear resistance [1-3], whereas incorporation of graphite particles into Al alloys improve wear resistance and seizure resistance and reduce co-efficient of friction [4,5].

Concept of the present work is to study the microstructure and mechanical properties of Al alloy matrix SiC and graphite particle reinforced hybrid composites. Size of the graphite particles has been varied to study its effect on the properties of the hybrid composites.

Experiments
To prepare the Al alloy matrix SiC and graphite hybrid composites, the following materials were used:
1. Al alloy: LM6 alloy having nominal composition Al-12% Si
2. SiC: SiC particles of 50 – 100 µm size
3. Graphite: Three different size of graphite particles, 106-150 µm, 212-300 µm and 300-425 µm.

Alloy of about 1 kg was melted in a crucible and the molten metal was stirred with a graphite impeller revolving at 800 rpm. 2wt% Mg was added to the molten metal before addition of the ceramic particles to improve the wettability of the particles by the liquid metal. The required amount of ceramic particles were preheated at around 300°C and added into the vortex formed in the liquid metal slowly. After complete addition of the particles, the composite melt was stirred further for about 2 minutes to distribute the particles uniformly in the liquid metal. Subsequently the composite melt was poured into preheated cast iron moulds of 25 mm internal diameter. The compositions of the composites thus produced are shown in Table-1. Generally the fluidity of liquid Al is adversely affected by the incorporation of ceramic particles in it. However in the present study, the alloy used was a eutectic alloy that has excellent fluidity. Hence in spite of incorporation of SiC and graphite particles into the Al alloy, the fluidity of the liquid composites was sufficient at the temperature of pouring and the composites melts could be cast successfully into metal moulds.

The microstructures of the base Al alloy and the composites are shown in Figure 1. The micrograph of the base alloy shows the eutectic dendritic structure containing α-Al and Si phases. In the composites, the SiC and graphite particles are observed with clustering of SiC particles at some locations. Since the solidification of the eutectic alloy is instantaneous compared to off-eutectic alloys, the clustering of the SiC particles is attributed to the gravity segregation to some extent just after pouring of the liquid composites and before its solidification.

Mechanical properties of the composites
To study the effect of ceramic particles on the mechanical properties of the composites, tensile and hardness tests were carried out. Tensile tests were carried out in a Universal tensile testing machine with specimens of 12.5 mm gauge dia. and 75 mm gauge length at a crosshead speed of 2.0 mm/min.

Density of the polished specimens was measured by water displacement method. Hardness of the polished specimens was measured in a Brinnell hardness testing machine at 500 kg load with 10 mm dia. steel ball as indenter. Tensile tests were carried out in a Universal tensile testing machine with a cross-head speed of 2.0 mm/min.

Table 1. Details of compositions of the composites

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Matrix</th>
<th>SiC (wt%)</th>
<th>Size of graphite particles (µm)</th>
<th>Graphite (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LM6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>LM6</td>
<td>10</td>
<td>106-150</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>LM6</td>
<td>10</td>
<td>212-300</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>LM6</td>
<td>10</td>
<td>300-425</td>
<td>4</td>
</tr>
</tbody>
</table>

Results and discussion
Specimens of suitable sizes for optical microscopy and measurement of density, hardness and tensile strength were taken from the cast composite samples. Samples for optical microscopy were polished in emery papers and cloth in a conventional manner and etched with Keller’s reagent. The polished and etched specimens were observed under an optical microscope at 100x. Density of the Al alloy and the composites were measured by water displacement method. Hardness of the polished specimens was measured in a Brinnell hardness testing machine at 500 kg load with 10 mm dia. steel ball as indenter. Tensile tests were carried out in a Universal tensile testing machine with specimens of 12.5 mm gauge dia. and 75 mm gauge length at a crosshead speed of 2.0 mm/min.
The density of the Al alloy and the composites are presented in Table 2. Minor increase in density is observed in Al alloy – SiC composite in comparison to the base alloy. On the other hand, addition of graphite particles has reduced the density of the composites to some extent. The theoretical density of Al is 2.7 g/cc and that of SiC and graphite are 3.2 g/cc and 2.4 g/cc respectively at room temperature. Hence the increase in density of Al-SiC composite and reduction of density of graphite added composites is observed. It has been reported that due to agitation of liquid Al alloy during its processing by vortex method induces air into it and reduction of density is possible due to the presence of resultant porosity in the matrix of the composites. Therefore the density of the composites could be slightly higher than the measured values when free from voids. Coarser graphite particles result in higher density probably due to lesser porosity in the composites associated with incorporation of air in liquid Al along with ceramic particles. The hardness of the composite containing 10 wt% SiC particles has improved significantly compared to the base Al alloy. The hardness of SiC particles is much higher than that of Al alloys. Hence the improvement of the hardness of the composite containing SiC particles is observed. With the addition of graphite particles, the hardness of the composites has reduced to extent where the graphite particles are much softer than Al alloys. At the same level of 1 wt% of graphite particles with increasing size, the hardness increase slightly, probably due to increase in average inter-particle distance and less porosity in the matrix, when the particles are coarser.

The tensile strength of the base alloy is 127 MPa (Table 2) and it has reduced to 118 MPa in case of Al alloy with 10 wt% SiC particles. Generally the tensile strength of Al matrix composites with SiC particle reinforcement is higher than the same of the base alloy when the composite is free from porosity. The strength of the composites increases due to load transfer from the matrix to particles of higher strength and higher dislocation density around SiC particles resulted from lower co-efficient of thermal expansion of the ceramic particles than that of the matrix. The type of particle-matrix interface also dictates the tensile strength of the composites, as poor bonding between the particles and the matrix affects load transfer from matrix to particles. On the other hand, in presence of porosity, the strength of the composites decreases. Hence the net strength of the composites depends upon the type of the reinforcement particles and its vol% and the porosity% in the matrix of the composite. In the present work, the composites have been prepared by vortex method which incorporates air into the molten Al alloy along with the particles. Hence the presence of porosity is attributed to the lower tensile strength of the composite with 10 wt% SiC particles. The addition of graphite particles into the composite with 10 wt% SiC reduces further, as the graphite particles are softer than the Al matrix.

**Conclusion**

1. 10 wt% SiC and 4 wt% graphite particles of different sizes could be incorporated into Al alloy matrix successfully by vortex method.
2. The particles are distributed in the Al alloy matrix uniformly, although clustering of SiC particles were observed at some locations.
3. The density of the composite with SiC only is slightly higher than that of the Al alloy due to higher density of SiC than Al alloy. Graphite particles reduce the density of the composites. Coarse graphite particles result in higher density than finer particles.
4. The hardness of Al matrix composite with SiC particles has considerably higher hardness. Addition of graphite particles reduces the hardness of the composites with SiC particles. The size of graphite particles has negligible effect on the hardness of the composites.
5. The tensile strength of the composites is lower than that of the Al alloy. Addition of graphite particles further reduces the tensile strength of the composites in comparison to that of the composite with SiC only.
6. Coarser graphite particles result in higher density and hardness of the composites.

**References**

Aluminium China 2013
When: 2-4 July 2013
Where: Shanghai New Int’l Expo Centre, Shanghai – China
Summary: ALUMINIUM CHINA 2013 is Asia’s leading aluminium industry platform, annually held in Shanghai. By presenting new customized matchmaking programs and product related tours for international visitors from different industry sectors as well as a world class conference program, ALUMINIUM China 2013 sets new standards in terms of sourcing and networking opportunities in Asia. Over 450 international exhibitors from 30 countries representing the entire aluminium production chain – from Aluminium raw materials, semi-finished and finished products to production and processing machinery – will meet with 5,000 qualified professionals and buyer delegates from China, all the key Asian markets and other global emerging markets.
E: alu@reedexpo.com.cn
W: www.aluminiumchina.com

ITPS - International Therm Process Summit 2013
When: 9-10 July 2013
Where: Düsseldorf Congress Centre, Düsseldorf – Germany
Summary: This B2B-forum for executives and top management offers a complementary platform for information interchange as well as for meetings between industry specialists. Executives from plant manufacturers and customers’ sectors have an opportunity to discuss relevant strategic topics. In addition to the high-level information supplied, the ITPS will also have a working function. Contacts between highly ranked representatives of the participating companies are established and maintained.
E: cecof@vdm.org
W: www.itps-online.com/

Casting Technology New Zealand Inc. 2013 Foundry Conference
When: 16-18 August 2013
Where: Monaco Resort (The Grand Mercure), Nelson – New Zealand
Summary: Casting Technology’s Annual Conference, promises to provide a unique forum to share the latest international and national technological developments driving competitive advantage in the foundry industry, as well as a wonderful opportunity to network and socialise with foundry experts. The event will provide a platform to compare with others, and to seek solutions to the challenges confronted by the industry. This year we have been successful in securing Bob Puhakka (www. castdifferently.com) as keynote speaker. Discussion will focus on modern methodologies and practices and will be taken further with ‘hands on’ computer modelling of some of our conference attendees more difficult challenges. Bob Puhakka is a world renowned foundry engineering professional specialising in metal casting technology and processing metallurgy. He will be joined with an interesting mix of other national and international speakers. The social events will include a Banquet dinner set amongst the Classic Cars at the WOW Museum (World of Wearable Art & Classic Cars Museum). For those that like to get out and about, we have a site tour organised. The conference will be a rewarding, fulfilling and value adding experience for all who attend. For more information on submitting a paper to the

6th Philippine Die & Mold Machineries and Equipment Exhibition – PDMEX 2013
When: 26-28 August 2013
Where: Venue World Trade Center Metro Manila, Philippines
Summary: VISITORS’ PROFILE: Aerospace Manufacturer, Automotive Manufacturer, Builder Construction Company, Product Design, Die & Mold Manufacturer, Electronics & Electrical Manufacturer, Electroplating, Furniture Manufacturer, Foundry, Machinery & Equipment Manufacturer, Machining Services, Metal Parts & Component Manufacturer, OEM and Sub Contractor Manufacturer, Lubricants, Metalcasting - Plastics and Packaging Manufacturers, Semiconductor & Precision Engineer, Storage and Material Handling, Associations & Government Agency, Distributors / Agents, Education and Training Institutions and other related industries.
E: adoro@hotmail.com
W: www.pdmexmacle.brinkernet/index.html

ALUMINIUM India 2013
When: 12-14 September 2013
Where: Bombay Exhibition Centre, Mumbai – India
Summary: India’s leading B2B trade event for the aluminium eco-system and its application industries, ALUMINIUM India brings together producers, processors, technology suppliers and consumers along the entire value chain - i.e. from raw materials through to semi-finished and finished products. We look forward to welcoming you mark your on the aluminium landscape of the future.
E: Vidula.Kagal@reedexpo.co.uk
W: www.aluminium-india.com/

3rd Annual International Conference on Materials Science, Metal and Manufacturing
When: 9-10 September 2013
Where: Chatrium Hotel Riverside, Bangkok - Thailand
Summary: Materials science has been pushed to the forefront of research and development not only in universities but in industries as well. With the planet’s resources being mined each day in order to supply the growing demands of industrialization, one major task of materials science is to revolutionize the manufacturing industry with the best materials for manufacturing that are sustainable for the long term. Materials science is also paving the way for new theoretical and empirical research in areas of physics, engineering and chemistry. This conference will provide the venue to discuss these recent developments.
E: info@m3-conference.org
W: www.m3-conference.org

13th Global Foundry Sourcning Conference
When: 12 September 2013
Where: Shanghai New Int’l Expo Centre, Shanghai – China
Summary: The semi-annual Global Foundry Sourcing Conference is sponsored by the China Foundry Suppliers Union (CFSU) and organized by Suppliers China Co., Ltd. (SC), and co-sponsored by the National Technical Committee 54 on
Foundry of Standardization Administration of China. Its purpose is to establish a communication and trading platform for global casting producers and Chinese casting customers. It also provides opportunities for the buyers to make special purchasing presentations, and for the suppliers to hold product promotion seminars.
E: info@fcsb.com
W: www.en.fcsb.com/FSCPReview/info.jsp?id=38

Aluminium India 2013
When: 12-14 September 2013
Where: Bombay Exhibition Centre, Mumbai – India
Summary: India’s leading B2B trade event for the aluminium eco-system and its application industries, ALUMINIUM India brings together producers, processors, technology suppliers and consumers along the entire value chain - i.e. from raw materials through to semi-finished and finished products.
W: www.aluminium-india.com

China Diecasting 2013
When: 16-18 September 2013
Where: Guangdong Modern International Exhibition Center, Dongguan - China
Summary: Sponsored by Chinese Mechanical Engineering Society, organized by Foundry Institution of Chinese Mechanical Engineering Society (FICMES) and co-organized by NürnbergMesse China, 2013 Asia-Pacific Die-Casting Industry Exhibition (CHINA DIECASTING 2013) will be held during 16th -18th September, 2013, at Guangdong Modern International Exhibition Centre. With the development of more than a decade, CHINA DIECASTING 2013 has become the most influential and popular exhibition in China’s die casting industry. It is an exclusive event to the die casting industry and its suppliers. This exhibition will bring you the unprecedented business opportunities and offer you the professional communication platform.
E: nate.he@m-china.com.cn
W: www.diecastexpo.cn

10th China International Foundry Industry Expo 2013
When: 16-18 October 2013
Where: Beijing Exhibition Center, Beijing – China
Summary: The 10th China (Beijing) International Casting Industry Expo 2013 is the next major event for the foundry industry. The aim of the event is to promote sustainable development of China’s foundry industry and growth of industry. With the deepening of global economic integration and the growth of technology, foundry equipment and raw and auxiliary materials are becoming the largest growth market driving global attention. CIFE seeks the opportunity and follows the trends of the markets. Based on domestic market, CIFE takes global perspective and has made great contribution to the prosperity of the foundry industry. Further, it will also display products for pressure casting, cast steel, centrifugal casting, cast iron, lost foam casting, nonferrous alloy casting precision casting, low-pressure casting and more.
E: hwexpo.lucy@hotmail.com
W: www.bcife.com.cn
Solving porosity problems in graphitic iron castings can seem a complex problem as almost every process parameter will affect how an iron solidifies and the volume changes that occur on freezing.

In order to consistently produce porosity free iron castings it is necessary to have a basic understanding of the unique solidification mechanisms and volume changes that occur. Porosity defects in graphitic cast irons are invariably caused by a failure to adequately control pressure on the liquid within the mould cavity. Positive pressure must act on the liquid throughout the solidification process. Initially, atmospheric pressure must be allowed to act on the liquid within the risers in order for feed metal to flow to the casting to compensate for the volume reduction caused by the temperature drop from the pouring temperature.

Secondly, pressure associated with the eutectic expansion phase must be converted to internal liquid pressure. Expansion must be controlled within manageable levels and remain on the liquid until solidification is complete. Manageable expansion is primarily determined by the rigidity of the mould material, or more particularly, the ability of the mould material to withstand the pressure of expansion without dilating.

Risers used on graphitic iron castings will often reflect these volume changes and as such can be a valuable diagnostic tool for solving porosity problems. Figure 1 shows a selection of risers from grey iron castings. The initial shrinkage as the liquid cools from the pouring temperature can be seen as the “piping” from the upper surface whilst the exuded metal at the bottom of the pipe is evidence of the expansion phase.

### Solidification mechanisms

**Grey irons**

The majority of commercial flake graphite (grey) cast irons are of hypo-eutectic composition (CEV less than 4.25). In such alloys, solidification begins at the liquidus temperature with the nucleation and growth of primary austenite dendrites at the mould wall. Austenite growth causes the remaining liquid to be enriched with carbon until it reaches eutectic composition at which point the eutectic of austenite and graphite begins to solidify with both the austenite and graphite growing in direct contact with the liquid. Freezing progresses by the growth of eutectic cells of austenite and graphite at the expense of the liquid until the solidification process is complete.

The precipitation of the graphite phase in direct contact with liquid has a strong “self-feeding” affect. Indeed, when the cooling rate is low such as with heavy section castings, there may be a net volume gain during solidification which potentially negates the need to add risers to compensate for shrinkage. In the case of smaller castings which have a higher cooling rate, solidification will generally result in shrinkage which needs to be fed with appropriately positioned risers. In these cases it is necessary for risers to show piping as evidence of atmospheric pressure acting on the liquid. It is also often desirable that there is some indication of metal exuding into the riser pipe.

Figure 2 shows such a riser from a small grey iron casting.

**Ductile irons**

Ductile irons are generally of hypereutectic composition (CEV value greater than 4.25). In these alloys, graphite precipitation commences in the liquid, that is, at a temperature above the liquidus. The remaining liquid is subsequently depleted in carbon until it reaches eutectic composition. At this point, austenite cells begin to solidify around the graphite nodules so that only one phase, austenite, is in direct contact with the liquid and the graphite spheroids continue to grow by diffusion of carbon from the liquid through the solid austenite shells.

As the eutectic graphite is growing within a shell of solid austenite, and not in direct contact with liquid as is the case with grey irons, the self-feeding affect is not as significant and generally ductile irons will require more feeding than grey irons.

Again the risers need to show pipe as an indication that atmospheric pressure is acting on the liquid. Ductile iron risers will not show the exuded metal at the bottom of the pipe as the graphite is not growing in direct contact with liquid. Evidence of expansion as a result of eutectic graphite growth can, however, be seen as the “eruptions” on the pipe surface. Figure 3 shows these features.

Consideration of the differences in solidification mechanisms between flake graphite and ductile irons helps to explain the different feeding requirements of the two alloys. For instance, it is generally acknowledged that ductile iron castings are more prone to shrinkage porosity defects than flake graphite iron castings. This is despite the fact that ductile irons are generally of higher CEV than those of flake graphite irons. With flake graphite irons, the solid austenite shell that generally forms on the mould wall, particularly when cooling rate is relatively high, is more capable of withstanding the pressure of eutectic expansion and transmitting that pressure back to the liquid. When eutectic expansion occurs in ductile irons, the skin is more easily deformed which can result in dilation of the mould wall and loss of pressure on the liquid. Also, as graphite flakes grow in direct contact with the liquid, they have a more powerful effect in forcing feed metal along inter-dendritic channels.

Figure 1. Selection of risers from grey iron castings

Figure 2. Riser from grey iron casting showing pipe and exuded metal

Figure 3. Riser from ductile iron casting showing pipe and surface “eruptions”
Having come to an understanding regarding the elementary principles involved in the inner life of metals, the author coined “Romancing the Metal of the Virtual Bronze Foundry” (December 2012 MCT Issue) and the article entitled “Raw Materials for the Virtual Bronze Foundry” (March 2013 MCT Issue), we are now able to appreciate the chemical and physical tests generally required by the customer, after which we will be in a better position to deal with the various foundry precautions concerning individual alloys that are commonly purchased and used in the foundry.

For chemical analysis

In chemical analysis, the method of taking the sample, or the form and method of casting the test bar in the case of physical testing are of basic importance. If the sample or test bar does not truly represent the average condition of the metal tested, then the results are useless.

Turning to the matter of chemical analysis and supposing that a shipment of ingot bronze of the composition copper 85%, tin 5%, lead 5%, zinc 5% is to be tested. A number of ingots should be taken at random, and suitably sampled by drilling. (A detailed description of the sampling method for good results will be discussed in my next article in MCT.)

To put the process of chemical analysis in simple terms: A small weighed quantity of the sample is digested in acid which leaves the tin behind as a white paste that is filtered off. Another acid is added to the clear solution which precipitates the lead, which is also filtered off. The copper is then precipitated from the filtrate by the gas sulphurated hydrogen and so removed and later estimated. Any iron impurity is then removed by the addition of ammonia solution and filtered off, and finally the zinc in the remaining solution is determined.

An alternate method is to submit the solution, after the tin has been removed, to an electric current which deposits the copper on a suitable platinum cylinder and lead (as an oxide) on another platinum cylinder. This is known as the electrolytic method. Spectrographic methods are also available, especially where one is dealing with very small amounts.

If it is desired to analyze the metal in a casting, suitable drillings are taken and a procedure similar to the analysis of ingot is adopted. Sufficient samples should be retained by the foundry so that the customer or seller can have a portion for their own tests and still enough be left for an umpire’s test, if necessary.

For physical testing

Turning to physical testing, the so-called keel-block gives the best all-around test bar. The mold material is prepared as follows:

- Sand: Silica sand that is washed and graded having an AFS Fineness Number between 60 and 80, with less than 1% clay and 98.5% or more silica, and not more than 3% of water as purchased is used.
- Corn flour binder: 0.2%
- Western bentonite, ground, foundry grade: 3.0%
- Dextrose: 1.5%
- TOTAL: 100%

Mix dry in a sand muller for one minute and then add water to give 3% moisture in the final product. Mix for five minutes more and use for the mold. Bake the mold between 400 and 450°F (205 and 232°C).

This keel block is shown in Figure 1, which gives three closely agreeing bars in all bronze bars that are cast. These include tin bronze, leaded tin bronze, aluminum bronze, manganese bronze, silicon bronze, phosphor bronze, and leaded phosphor bronze. It is not suitable for the light metals such as aluminium and magnesium alloys. The amount of metal involved is some 45 lbs. (20.5 kgs.), including the gate and sprue. This may be claimed that other shaped bars are more sensitive to the weaknesses introduced by occluded gases; but this is not quite true. If the metal is poured too hot or too cold, or gassed, or oxidized, the fracture of the keel bar will indicate it and the other tests will support the findings of the fracture.

Consider the foregoing, the keel block is still the best one to use both for the foundry and the customer. It could be claimed that other shaped bars are more sensitive to the weaknesses introduced by occluded gases; but this is not quite true. If the metal is poured too hot or too cold, or gassed, or oxidized, the fracture of the keel bar will indicate it and the other tests will support the findings of the fracture.

For testing melt quality

There is a “melt quality test” which, while not providing regular test bars as does the keel block, is possibly even more suitable for evaluating “melt quality” only. This is described as a V-test block that can be used for ascertaining the “melt quality” of molten metal in regard to gassing.

The essential features are a mold to provide a wedge of metal of about 4-inches high, 3-inch wide at the point, 2½-inches wide at the top (d) and 3 inches long. The same has an integral part a rectangular riser 3-inches wide (d) by 3-inches long by 3-inches high – this riser being a continuation of the broad base of the wedge, as shown in Figure 2. The wedge itself is in the drag of the green-sand mold while the riser is surrounded by a gypsum insulating layer 1/8-inch thick, itself surrounded by the green-sand mold. The casting is poured through the riser, and when filled, the surface of the molten metal is covered with gypsum insulating powder. Under these circumstances it is believed (and tests have been made which confirm this belief) that the wedge is perfectly fed. This being the case, no porosity due to the shrinkage areas should be present. Furthermore, as the molten metal does not traverse the green-sand mold prior to entering the casting area, it should not pick up any gas during its transfer from the melting unit to the casting cavity. Consequently, any porosity developing in the wedge may be assumed to be due to gas acquired by the metal before or during the melting operation.

By slicing up the wedge, as shown in the lower part of the figure, specimens can be obtained for the fracture, density, radiograph, and macro-etch tests. Tests have been conducted which showed, by all these tests, that the metal could be...
to approximately 2200°F (1204°C), the flux thickened with dry
added after the copper was molten. The melt was then heated
ounce of this flux was used for each pound of melt. The tin was
of silica sand, 3 parts of borax, and 2 parts of cupric oxide. One
copper under a pre-fused flux consisting of 5 parts by weight
The alloy was made from virgin metal by first melting the
metal were used for deoxidation.
sharp sand and then removed, and the zinc then plunged into
Tin quality test (in lieu of green sand) of a composition consisting of
dry synthetic sand molds were used for the mold in the melt
The time for casting, fracture, and inspection is less than 5
The greater measure of standardization would prevail if
dry synthetic sand molds were used for the mold in the melt
quality test (in lieu of green sand) of a composition consisting of
the alloy used for the laboratory tests was copper 88%, tin
10%, zinc 2%, and the casting temperature was 2075°F (1135°C).
The alloy was made from virgin metal by first melting the
copper under a pre-fused flux consisting of 5 parts by weight
sleeves in a suitable mold. The pre-formed sleeves were baked
order to achieve temperature reductions, dust suppression, humidity control,
the specimen for “Melt quality tests” with the mold and the specimen shown
obtained of a density of 8.82 (8.92 is taken as 100% of the
possible density), which by calculation gives only 0.56% of
the voids.
The gypsum sleeves were made by mixing a slurry of 16 parts
by weight of water with 10 parts of plaster of Paris, forming the
sleeves in a suitable mold. The pre-formed sleeves were baked
for 8 hours at 45°F (23°C).
The alloy used for the laboratory tests was copper 88%, tin
10%, zinc 2%, and the casting temperature was 2075°F (1035°C).
The alloy was made from virgin metal by first melting the
copper under a pre-fused flux consisting of 5 parts by weight
of silica sand, 3 parts of borax, and 2 parts of cupric oxide. One
ounce of this flux was used for each pound of melt. The tin was
added after the copper was molten. The melt was then heated
to approximately 2200°F (1204°C), the flux thickened with dry
sharp sand and then removed, and the zinc then plunged into the
mold. Three ounces of 15% phosphor-copper per 100 lbs. of
metal were used for deoxidation.
About test bars
Returning to the question of test bars, there used to be a very
widespread misunderstanding as to the role of the test bar
played, and even now there are those who fail to appreciate
the limitations of its use in the bronze foundry. It was this lack of
appreciation of the real duty of the test bar that lead to the
insistence of having the test bar made as an integral part of
the casting. This serves no useful purpose and in many instances
defeats the very objective desired. The trouble came about by
thinking that the test bar was to be a measure of the physical
properties of the casting.
The fact is that by making the test bars as an integral part of
the casting, many factors contribute to a not so representative
test bars. To wit:
• The host casting may be so complicated that it would be
difficult to locate and attach the test bar.
• A host casting that has different section thicknesses likewise
makes the test bar not so reliable due to differences in metal
temperature as it passes and reaches the various sections.
• Being attached to the casting, the test bar may draw on the
casting to the latter’s detriment.
What, then, is the role of the test bar? One thing, and only
one thing, namely, to assure the customer that the quality of
the metal entering the mold is satisfactory. It then follows
that the test bar should be so cast that all the conditions favor
optimum physical characteristics. This means pouring the
test bar, the “keel block” in this case, at a fixed temperature for
each alloy. Other conditions regarding the casting of the test bar
must also be made as constant as possible.

Figure 2. Making the specimen for “Melt quality tests” with the mold and the specimen shown.

References
(a) Harold J. Brand, Cast Bronze

References
(a) Harold J. Brand, Cast Bronze

References
(a) Harold J. Brand, Cast Bronze
Whatever your foundry requirements are, talk to us. Reduce waste or perhaps improve process control. As a reliable and trusted supplier, Foseco can help you to improve mechanical properties, increase casting integrity, lower fume emissions, and develop innovative solutions to suit your metallurgical needs.

Our locally based teams of foundry specialists are on hand to help you with innovative solutions to suit your metallurgical needs.

The world is full of great double acts. Our technology and your foundry, for engineers who produce great technology that serves us every day.

Foseco has been associated with the global metallurgical industry for more than 70 years, and is an innovative and progressive organisation. Foseco supply a wide range of products to the metal casting industry including:

- Refractory Coatings
  - Isomol and Holcote
- Mould and Core Binders
  - Fenotec, Furitec, Plotitec and Ecolettec
- Insulating Exothermic Sleeves
  - Kalmin and Kalminex
- Filtration for Iron and Steel
  - Silex, Sedex, and Sivex
- Ferrous and Non ferrous treatment products
  - Inocum Carbone, Modulant and Coveral,
    - Furnaces and Ladle refractories
    - Crucibles, stoppers and nozzles.

Coveral, Furotec, Politec and ecolotec are trade marks of the Vesuvius Group, registered in certain countries, used under licence.

Hayes Metals Pty Ltd
No 7, Stuart Street Padstow NSW 2211 Australia
Phone: +61 2 9914 5500 Fax: +61 2 9914 5547

Hayes Metals
For Australia’s and New Zealand’s largest range of Alloy Ingots for Foundries and the Die Casting Industry
- Copper Alloy Ingots & 15% Phosphor Copper Shot
- Primary Grade Aluminium Foundry Alloy Ingots
- Secondary Aluminium Foundry & Diecasting Alloys
- White Metal Alloys & specialty Solder Alloy Ingots
- Zinc Aluminium Alloy Ingots
Technical Support by way of full in-house Analysis Laboratory

Pacific Rim Foundry Services
Large Selection of equipment, competitive pricing
We also do Foundry Equipment Asset Evaluations and Liquidations
www.pacrim.com.au

AMETEK, Inc. SPECTRO Analytical Instruments (Asia-Pacific) Ltd.
No. 9 Sheung Yuet Road, Kowloon Bay, Kowloon, Hong Kong
Phone: +852 2797 2850 Fax: +852 2797 2851 Email: asiapacific@metallurgy.com

MAGMA Engineering Asia Pacific
25 International Business Park #03-7679 German Centre
Singapore 609916 info@magma.com.sg www.magma.com.sg

Synchro ERP
Cast Metal Specific Software

A member of the AMETEK Materials Analysis Division, SPECTRO is one of the worldwide leading suppliers of analytical instruments, employing optical emission and X-ray fluorescence spectrometry technology, used for the elemental analysis of materials in industry, research and academia.

Synchro ERP can tell you.
WeS Omega Foundry Machinery Pty ltd

Based in the UK.

August 1st 2012 has formed a joint venture with Warill engineering Sales (Aust) Pty ltd, (WeS) as of

Contact: Les Craig / Bob Dorsett / Peter Dimopoulos
16 Lanyon St, Dandenong, Victoria Australia 3175

Thermo Fisher Scientific is the world leader in serving science. The company enables its customers to make the world healthier, cleaner and safer by providing analytical instruments, equipment, reagents and consumables, software and services for research, analysis, discovery and diagnostics.

Featured Thermo Scientific products for metals analysis include:

Thermo Scientific™ ARL iSpark™ Series Optical Emission Spectrometers for outstanding analytical performance on a wide range of elements with dual CCD/PMT optics

Thermo Scientific™ ARL iSpark™ Series Optical Emission Spectrometers

Innovative Metals Analyzers for Foundries

See page 7

Thermo Fisher Scientific

Chemin de Verney 2
CH-1024 Ecublens, Switzerland
Tel. +41 (0)21 694 71 11
Fax +41 (0)21 694 71 12
info.spectrometry@thermofisher.com
www.thermoscientific.com/elemental

Thermo Scientific™ ARL iSpark Series Optical Emission Spectrometers

Innovative Metals Analyzers for Foundries

See page 7

New Thermo Scientific ARL iSpark Series Optical Emission Spectrometers

Thermo Scientific ARL iSpark Series Optical Emission Spectrometers for outstanding analytical performance on a wide range of elements with dual CCD/PMT optics

Optical Emission Metal Analyzers offering rapid and complete elemental analysis of solid metallic samples from trace up to major elements

X-Ray Material Analyzers enabling elemental and phase analysis of a wide variety of materials through X-ray fluorescence and X-ray diffraction systems

MCT is the only magazine that is totally dedicated to the foundry and metal casting industries throughout the Asia Pacific Region.

AN ABSOLUTE MUST READ!

MCT is the only magazine that is totally dedicated to the foundry and metal casting industries throughout the Asia Pacific Region.

Australia – AUD$104.65 (includes GST, postage & handling)
Overseas – AUD$132.40 (includes postage & handling)

Name: .................................................................................................................................................................................................
Address: ................................................................................................................................................................................................
State: ................................................................................................................................................................................................
Postcode: ........................................................................................................................................................................
Country: ........................................................................................................................................................................
Telephone: .......................................................................................................................................................................
Mobile: ........................................................................................................................................................................
Fax: ..................................................................................................................................................................................
Email: ..............................................................................................................................................................................
Website: ...........................................................................................................................................................................

Please let us know your industry and interests:

Industry

- Automotive components
- Coating
- Die casting
- Education and research
- Equipment and suppliers
- Ferrous
- Furnaces and refractories
- Heat treatment
- Industry groups
- Investment castings
- Light alloys
- Non-ferrous
- OH&S
- Pattern making
- Software
- Tools
- Other (please specify):

Payment Details (please tick):

- Subscription to METALS magazine to be sent within Australia – AUD$104.65 (includes GST, P+H)
- Subscription to METALS magazine to be sent overseas – AUD$132.40 (Includes P+H)
- Back issues $15 each except Annual Who’s Who at $25.00 each (plus postage P+H).

Method of payment: ○ Cheque attached ○ Mastercard ○ Visa

Card number: ........................................ | ........................................ | ........................................ | ........................................

CCV #: ........................................

Name: ................................................................................................................................................................................................
Expiry Date: .....................................................................................................................................................................

Signature: ........................................................................................................................................................................

*CCV: We ask for this information for your security, as it verifies for us that a credit card is in the physical possession of the person attempting to use it. Your card security code for your MasterCard or Visa card is a three-digit number on the back of your credit card, immediately following your main card number.
Just add Foseco

Responding to the increasing challenges you face, Foseco simplifies your operations, providing innovative solutions that deliver real world results.

For over eight decades we’ve sustained an unrivalled reputation for game-changing ideas, adding new value to almost everything you do. And, by consistently ensuring premium quality results, we’re now the partner of choice for foundries worldwide.

So, release your true potential: just add Foseco.

+ Partnership
+ Global Technology - Locally Delivered
+ Creative, Innovative Solutions
+ Expert Advice
+ Reliability
+ Knowledge Leadership

Phone +(61) 2 9914 5500
Fax +(61) 2 9914 5547
www.foseco.com.au