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# castube™

## RAUTOMEAD COMBINE WITH SMS TO OFFER NEW COPPER TUBE MANUFACTURING FACTORIES

Rautomead combine with SMS Meer's Schumag and Copper division to offer a new copper tube manufacturing process.

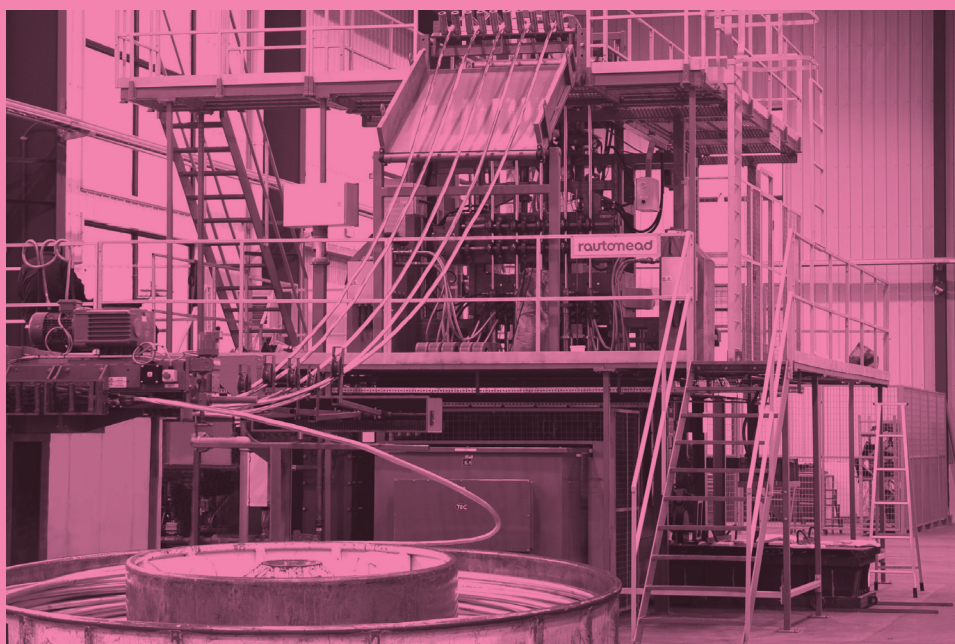
SMS Meer are offering the complete process for the manufacture of copper tubing. Systems are available for production of between 4 to 6,000 to 8 to 12,000 tonnes per year of finished tubes.

The Rautomead castube™ upward vertical casting process produces copper tube shells that are formed into coils. These are subsequently processed on SMS Meer equipment to the finished products through a Schumag preliminary draw machine, annealed, and then drawn further on an MRB spinner block. Finishing equipment is selected according

to specific factory requirements.

SMS Meer, a part of the SMS group, are the only supplier to offer complete turnkey packages of equipment and know how from copper melting to finished tube products.

The copper tube mill concept offers the possibility of new small scale start up tube manufacturing facilities with high production efficiency and minimal investment in equipment and inventory. It will provide the opportunity to install this manufacturing capacity in the vicinity of the consumer or to add additional capacity to existing traditional tube manufacturing plants.



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# RAUTOMEAD DOES WELL FOR DOOWELL IN CHINA

Continuous casting technology specialist, Rautomead Limited, of Dundee, Scotland, secured a highly significant order from Doowell, a major Taiwanese-owned OEM cable assembly manufacturer with a number of large manufacturing plants in China including its main facility in Xiamen employing around 5,000 people. Rautomead has commissioned an RS 3000/6 upwards-vertical continuous casting machine for the production of oxygen-free copper redraw rod.

The Rautomead machine is installed at the Doowell's Changsu City factory, not far from China's economic powerhouse Shanghai, where the company has a licence to carry out melting and casting.

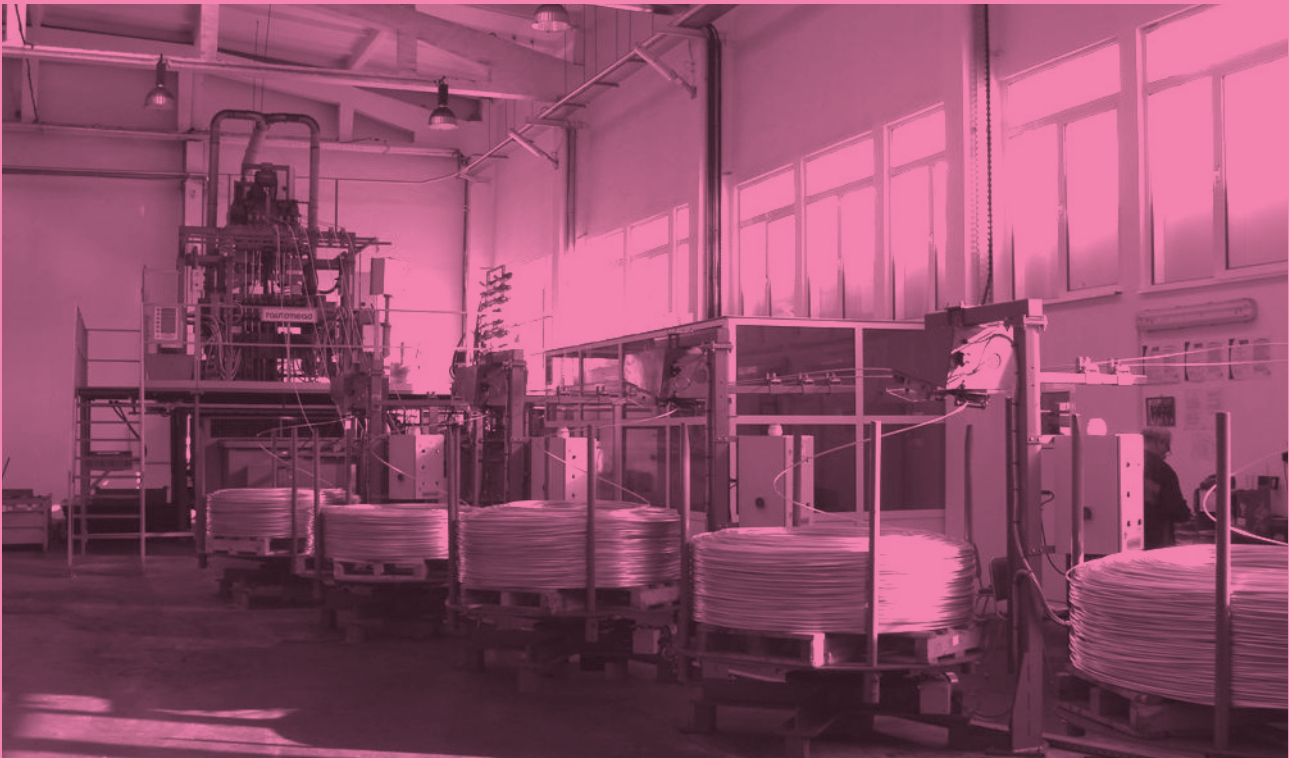
## DOING IT BETTER

With a need to draw the rod to superfine wire of 0.05mm diameter, Doowell sees its investment in a Rautomead oxygen-free copper machine as a way of improving the quality of redraw rod and improving reliability with increased productivity. Technical service support during installation, commissioning and subsequent production

and operation will be provided by Rautomead engineers from UK supported by the Rautomead office in Shanghai. The Rautomead engineering team provided free consultancy service during a visit to Changsu shortly after the contract was finalised. This service is available to all customers to advise them about preparing the factory site and services prior to delivery of the continuous casting equipment. Correct preparation minimises the time required for installation and start up during commissioning.

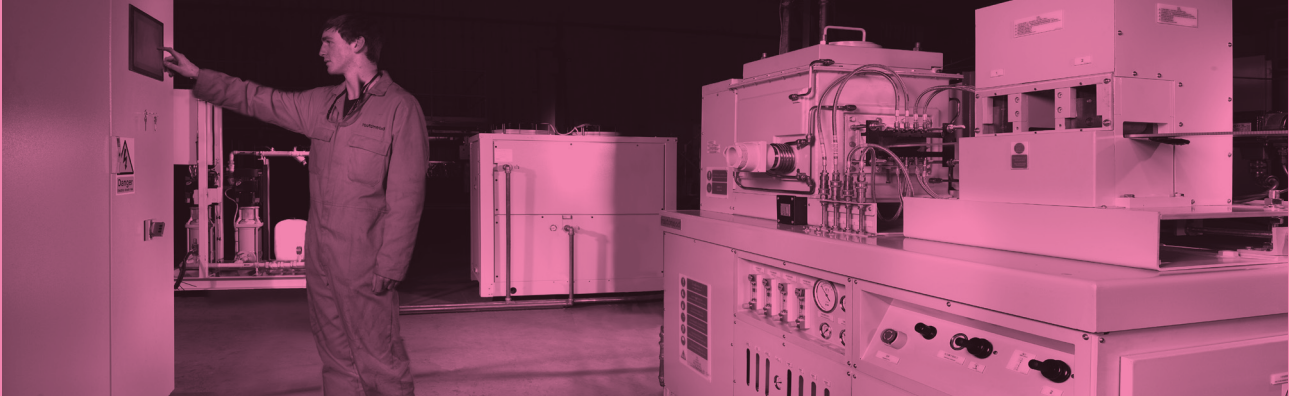
## HOW THE EAST WAS WON

Rautomead have supplied several specialist RS model continuous casting machines to companies in China for the production of CuMg wire rod used in the manufacture of contact wire for the network of high-speed trains currently under construction on the mainland. This machine supplied to Doowell is the first RS machine to be delivered and installed in China for the production of high quality CuOF wirerod. The demands and requirements of rod and wire product quality being sufficient to justify investment in European continuous casting technology.



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# RAUTOMEAD CONTINUOUS CASTING BRINGS CONTINUOUS SUCCESS IN CHINA



Continuous casting technology specialist Rautomead Limited of Dundee, Scotland has delivered two model RMJ/H025 continuous casting machines to Shandong Zhaojin Precious Metals Co. Ltd. of Zhaoyuan City, Shandong Province, China. The two machines will be used to manufacture 120 x 35 mm. strip in fine gold and silver respectively. Rautomead also be supplied two separate closed circuit primary cooling water systems, one for each caster to eliminate the requirement for external cooling water systems. The order represents a significant step in Shandong Zhaojin's ongoing expansion plans. Shandong Zhaojin is one of the largest precious metal refining companies in China.

## CASTING AN EYE EASTWARDS

The contract follows hot on the heels of three other orders from the Far East for RMJ/H025 table-top continuous casting machines to cast fine gold and silver strip. These machines were supplied to the Shanghai and

Shenyang Mints in China, both of which are state-owned through China Banknote Printing & Minting Corporation, and to the Royal Thai Mint in Thailand. Crucially, however, while the Shanghai Mint and Royal Thai Mint orders represented repeat business for Rautomead, with the Shanghai Mint having installed the first of its four Rautomead machines for the processing of gold and gold alloys way back in 1991, the Shenyang Mint is an entirely new customer for the innovative Dundee-based operation. As Rautomead Chairman Sir Michael Nairn explains: 'There is no doubt in my mind that the well-established and respected niche carved out by Rautomead technology elsewhere in the precious metals industry in China was instrumental in bringing this new customer to us. While repeat business is always testament to a job well done, entirely new customers such as Shandong Zhaojin and the Shenyang Mint are particularly satisfying in providing clear evidence of the level of trust the company has achieved in a given market'.

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# NOW RAUTOMEAD CASTS THE BEST YOUNG TALENT

Continuous casting technology specialist Rautomead Limited of Dundee, Scotland has recently proved its aptitude for an entirely different kind of casting in embarking upon a rigorous casting process to identify the best young talent.

Following on from its recent intake of graduates Colin Bell and David Murray (the latter of whom is planning to attend a machine commissioning in Brazil in the next few months as part of his initial training), the company has taken on two extremely promising local apprentices, Finlay Mitchell and Jamie MacPherson, straight from school.

Over the next 4 years the pair will be acquiring a thoroughly rounded view of the Rautomead operation, beginning by spending six months with the company's machine fitters and a further six months with the electricians.

As with the two graduates, in taking on the two apprentices Rautomead was looking out not just for a natural talent and aptitude for the job but also for young people with a natural willingness, and enthusiasm, for engaging immediately and directly with the equipment and getting their hands thoroughly dirty in the process! In fact, so rigorous is the company's selection process in identifying just the right young DNA for the job that Finlay and Jamie are actually the first apprentices Rautomead has taken on in over four years, their predecessor having completed his apprenticeship last summer.

Nor will the two young apprentices be missing out on their academic studies throughout the period of their apprenticeship with tuition being provided one day a week by local Angus College.

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# RAUTOMEAD GRAPHITE CONTINUOUS CASTING TECHNOLOGY: A CONTINUOUS PROCESS OF IMPROVEMENT

## A TECHNOLOGICAL BREAKTHROUGH

Every successful organization has its 'Eureka moment' and it's no different with Rautomead Limited of Dundee, Scotland. Rautomead was founded in 1978 to exploit the technology of continuous casting of non-ferrous metals. But, from the outset, Rautomead was not interested in being a 'me too' manufacturer. So, even though the company's starting point was the patented "Unicast" process, originally developed in the 1950s for the production of semi-finished brass and bronze bars used in the manufacture of fine wire mesh, its introduction of graphite crucibles became the key element in transforming a process that was to score heavily over its competitors who were still employing outmoded methods of induction heating

## MATERIAL GAINS

The materials for the production of which this innovative process was initially developed were leaded brasses for applications in forged and machined brass components for the building, electrical, gas and water industries, soon to be supplemented by leaded and unleaded bronzes.

## SMALL SCALE, BIG ADVANTAGE

A major problem for brass forging and machining companies back then consisted of the fact that scrap and machining swarf, often 30% or more of the input material, would need to be

returned to the large brass extrusion mill for reprocessing before being re-sold at a premium to the secondary producer. Rautomead's solution, having made the continuous casting of brasses and bronzes possible on a relatively small scale, consisted of locating a continuous casting machine on the premises of the secondary producer enabling in-house recycling with its attendant cost savings.

## CASTING FURTHER AFIELD

As word of the company's technological innovations spread beyond these shores, and in response to increasing demand from Malaysia, Australia and New Zealand, Rautomead began designing equipment which could be operated successfully and safely without the manufacturer's intervention and initiating training programmes for operatives with a high standard of technical support.

## STRIKING GOLD (AND SILVER)

The totally enclosed graphite containment system lent itself perfectly to the production of strip and wire rod production in a wide variety of gold and silver alloys using a range of smaller machines which shared the same basic technical features as their larger equivalents.

The unique characteristics of the carbon melt containment process and the resultant high quality of the cast product led the Royal Mint to first appoint Rautomead in 1985 to



continuously cast 22-carat gold strip for the production of bullion coins. And, since then, mints around the world have followed suit making substantial savings in production costs and significant improvements in product yield.

The process has also been widely used in the manufacture of gold and silver jewellery alloys, palladium, gold and silver dental alloys and lead frame alloys for the electronics industry, eventually leading to the development of the RVS and RMJ table-top machines.

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## ATTAINING NEW STANDARDS

In the second half of the 1980s interest was growing in the continuous casting of high melting point alloys which were incompatible with a standard carbon based containment and casting die system. To meet this need, Rautomead developed high alumina ceramic linings for the melt containment and boron nitride composites for casting die linings, while retaining the use of resistance heating and a graphite mother crucible.

## DEVELOPING THE CAPACITY

Also in the late '80s, the larger RX 1100 and RX1400 models were developed to meet the growing need for larger capacity horizontal machines with up to eight strands in production of Si1.5-3.5Cu silicon-bronze as low temperature brazing alloys and also for Mg0.1-0.5Cu trolley wire rod. These machines have also been supplied for making copper and brass extrusion billet in sizes up to 250mm diameter, including hollow billet for tube manufacture.

## ONWARDS AND UPWARDS

In 1991, the decision was taken to adapt the process for the continuous casting of 8mm diameter Cu-OF rod, using a single combined melting and casting furnace.

This involved the reorientation of the process to cast vertically upwards, using a twin chamber graphite crucible. The first such machine was sold in 1994 and, since then, a total of 45 machines have been supplied to 30 customers in 23 countries around the world.

## REDUCING OXYGEN

Once again, the key differentiating feature of the Rautomead upwards vertical process was the use of a graphite containment system and electric resistance heating, compared with channel induction heating with rammed ceramic furnace linings.

With either system, it is necessary to reduce oxygen to less than 10 ppm to achieve an adequate casting die life and economically-viable performance.

Early design studies, however, proved that oxygen could be reduced in a graphite system to close to zero in

a dwell time of around 3 hours with the Rautomead crucible capable of providing a dwell time well in excess of this.

What's more, the Rautomead system is virtually failsafe since it is practically impossible for the operator to make a product that is not oxygen-free. While a much smaller furnace can be used than that required in a single furnace induction-heated system where the only means of oxygen reduction is the metal cover.

## LOW VOLTAGE, HIGH PERFORMANCE

Yet another special feature of the Rautomead furnace design is low voltage electric resistance heating. A mains transformer is supplied as part of the principal equipment which transforms the voltage down to a secondary 36 volts.

Operating at low voltage, the system is remarkably energy efficient, requiring around 320-330 kWh per tonne of copper for melting, holding and casting combined. While the low voltage required also makes it extremely safe for the operator.

## AN AUTOMATIC CHOICE

The control systems used on Rautomead upwards vertical casting machines incorporate a high level of automation, removing the need for a full time operator.

Alarmed parameters are accessible through the main user control console, sensitive parameters can be locked off, over 30 production parameters are constantly monitored, records are stored in the control system and can be downloaded to an external computer,

while remote plant monitoring enables status interrogation by computer or phone.

## A POWERFUL ARGUMENT

Another powerful argument for the Rautomead design is in the way it reacts to mains power failure with a battery-operated emergency hoist being automatically deployed to lift the super-coolers from the molten copper to immediately secure the system.

## BRASSES AND BRONZES

The development of the Rautomead upwards vertical casting process has naturally led to further applications. For example, upwards vertical casting tests immediately showed a significant improvement in the casting speed and physical properties of Zn30 Cu brass, Sn5-8 Cu bronze and Zn25 Ni12-18 Cu nickel silver wire rods.

More recently, the same process has been harnessed for the production of binary brasses, Zn40Cu and Zn35Cu, cast at 8mm instead of 16mm, reducing downstream working time and production costs.

There were obvious advantages in adopting the upwards vertical system for casting Ni-silver, too, enabling the simpler, lower cost vertical tooling to be changed with minimal downtime.

## A HIGH SPEED PROCESS FOR HIGH SPEED TRAINS

Rautomead's horizontal machines have been producing Cu-Mg alloys for trolley wire since 1990. However, the horizontal process is relatively slow and costly. As a result, an extensive series of tests was carried out in 1997 to investigate the upwards

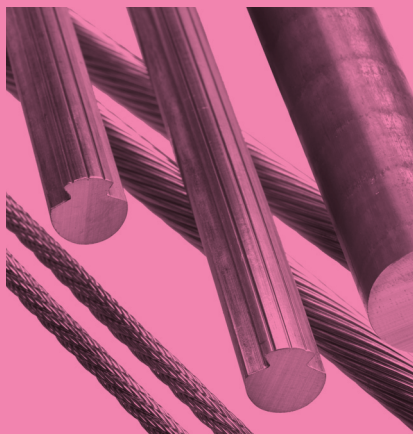


vertical casting of 30mm diameter rod in Cu-Mg alloys. The totally enclosed nature of the Rautomead upwards vertical process and its external resistance heating source were found to produce consistent quality Cu-Mg to tight alloy tolerances.

Cu-Mg is currently the preferred alloy for the profiled contact wire and stranded messenger and dropper wires used in many of the world's high speed rail systems (operating at over 300 kms/hour), offering low resistivity and tensile strength.

### THE QUEST CONTINUES

This pattern of continuous improvement is testament to Rautomead's commitment to the enhancement of the continuous casting process and its tireless quest to extend its application to new materials.



**Development projects currently being undertaken by Rautomead include:**

### SAVING BRASS: AND THE PLANET

Given the ever-growing demand for eco-friendly materials, in 2006-7 Rautomead developed a system to cast Eco brass to near net shapes and high quality cast surfaces in order to avoid further downstream processing and enable the cast product to be used as suitable feed material for CNC machining operations.

Once again, the use of graphite proved the key to the project's success in combining withdrawal pulsing techniques with careful selection of graphite grade for the casting die to achieve a consistent high quality as-cast surface over prolonged periods.

### CRACKING ANOTHER PROBLEM

Since the adoption of 8mm as the common redraw standard for wire and cable making, there has been an increasing demand for higher quality from as-cast Cu-OF processes.

The problem is that conventional quality 8mm Cu-OF rod is suitable for enamelled wire of no more than 1.8mm diameter. In larger enamelled diameter wires, standard (HVCT) current tests have revealed cracks in the magnet wire. In the light of this, Rautomead developed a system to produce rod of the highest quality on a consistent basis on a multi-strand production scale.

This work continues with the objective of optimizing the sequences to achieve consistently high quality.

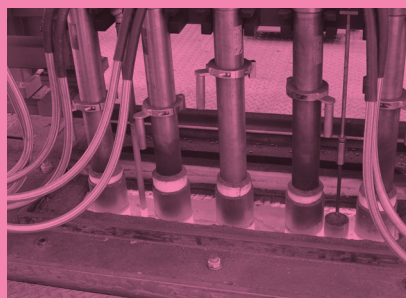
### CuCrZr ROD. BUCKING CONVENTION AGAIN

The conventional method for processing this alloy uses an initial billet cast vertically downwards by a direct chill system. This is then extruded to rod which undergoes further thermal treatments and mechanical reductions to make semi-finished products.

The possibility of reducing processing costs has led to interest in the continuous casting of both Cu-Cr and Cu-Cr-Zr alloys. As a result, Rautomead has undertaken development of a vertical casting system to cast rod between 25 and 30mm diameter at rates from 100 kg/hr/strand to a structural quality which lends itself to cold working from the as-cast state.

The use of graphite has again been the key in exploratory trials to control oxide levels through its naturally reducing environment.

### R&D work continues.



### A REDUCTION IN COST, NOT QUALITY

Rautomead's RS CC model offers a lower cost alternative to its existing range of RS upwards vertical casting machines. But, while the output capacity might be lower than the larger RS models, the RS CC provides the same capabilities for casting high quality Cu-OF and high Cu alloys.

The machine is configurable to cast a range from 8 to 22 mm diameter and is suited for wire and cable applications as well as input feedstock for continuous extrusion operations of Cu-OF and Cu-Ag alloys..



### RE-DRAWING THE BLUEPRINT

Zn products have traditionally been continuously cast in the region of 10 – 22mm diameter while other larger products of non-round sections continue to be produced through extrusion of billets that have been initially static or continuous cast.

However, Rautomead has developed a vertical system to cast re-draw 8mm diameter up to rates 105 kg/hr (5m/min) of suitable qualities for hot-drawing to smaller wire gauges.

While the continuous casting of Zn billet is another Rautomead solution to replace static casting methods in diameters ranging from 55 to 120mm.

The objective is ambitious but achievable: the production of as-cast billet with consistently high surface quality and high integrity internal structure with production quality maintained for long periods.

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# COLLUSION IMPROVES EXTRUSION FOR RAUTOMEAD'S NEW DIVISION

Continuous casting technology specialist Rautomead Limited of Dundee, Scotland has revealed details of an innovative 5 year collaboration with Brunel University.

As part of its 'Advancing Metals Technology' initiative, the company has been working in partnership with the university's 'Brunel Centre for Advanced Solidification Technology' department (BCAST) to develop an entirely new process for extruding aluminium alloys in the semi-solid state that will significantly reduce energy consumption and improve grain structure.

## THE RHEO EXTRUSION PROCESS

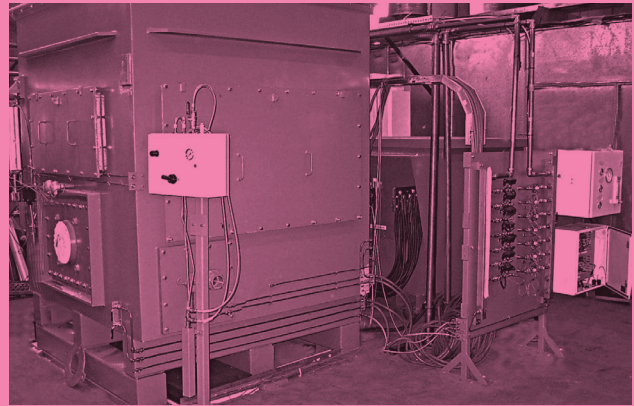
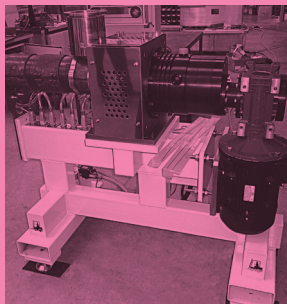
The Rheo Extrusion (RE) process is a patented technology developed at BCAST for the production of high quality, low cost magnesium wrought products. The process innovatively adapts the established high shear dispersive mixing action of the twin-screw extruder to in situ production of SSM slurry with fine, spherical solid particles followed by direct extrusion of the semi-solid slurry into rods, tube or complex extruded profiles.

Harnessing Rautomead's wealth of experience in dealing with molten metals and using special materials and techniques, the BCAST team designed and built from scratch a more "heavy duty" trials machine than previous models, one designed to process a range of aluminium alloys in a more production-scale level. This prototype machine is currently undergoing trials to establish the viability of commercial production. While currently focussed on aluminium alloys, a long term objective for the team is to ultimately use the technology in the higher-temperature environment of copper and copper alloys.

## ADVANCING METALS TECHNOLOGY

'Advancing Metals Technology' is a new and scientifically-based metals research and development division within Rautomead with a specific focus on the scientific exploration and development of non-ferrous metals and processes to drive improvements in metallurgical efficiency in a wide range of global production processes and end-user applications.

In addition to pursuing in-house research projects, the new division's mandate also covers involvement in a wide range of individual projects with universities and research groups in the UK and overseas of which the ongoing collaboration with BCAST is a high profile example. Further collaborations will be sought



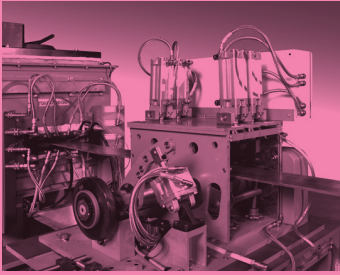
with both existing and prospective customers, with the goal of providing new and innovative processes and products within the non-ferrous metals technology market.

Through harnessing its market-leading expertise in the field of graphite technology and transferring the skills it has developed in continuous casting as the basis for these collaborations, the division's objectives consist of developing imaginative and economical technological solutions with operating systems that will offer the end user significant application improvements in the next generation of Rautomead machines.

Specific objectives consist of innovating technologies which are clean, safe and environmentally-friendly, shorten the manufacturing process, provide economies on the small to medium scale, recycle materials, reduce operating costs and enhance product quality.

## CASTING AROUND FOR THE RIGHT PARTNERS

The selection of BCAST as a suitable partner represents, for Rautomead, the result of a long and exhaustive search for a research partner whose vision and innovative thinking in the field of academic research would prove to be the perfect complement for Rautomead's practical experience and expertise in the commercial world of molten metal technology. But the 'Rheo Extrusion' project merely represents the first collaboration between the university and Rautomead, with a number of other spin-off projects also currently in the pipeline. While the 'Advancing Metals Technology' division's search for further suitable partners, both in academia and industry, continues. As Rautomead Managing Director Brian Frame remarks: 'We have believed for some time that the wide range of skills we have developed over the years provides the potential for applications that go way beyond our core business of continuous casting. And this new initiative, with input from the relevant research partners, is providing us with a unique opportunity to demonstrate just that!'



## INTEREST IN CONTINUOUS CASTING FOR GOLD AND SILVER CONTINUES APACE FOR RAUTOMEAD

Interest in equipment for the production of gold and silver coinage strip from continuous casting technologies

specialist Rautomead Limited of Dundee, Scotland has continued unabated with the company's announcement of three particularly significant orders from the Far East.

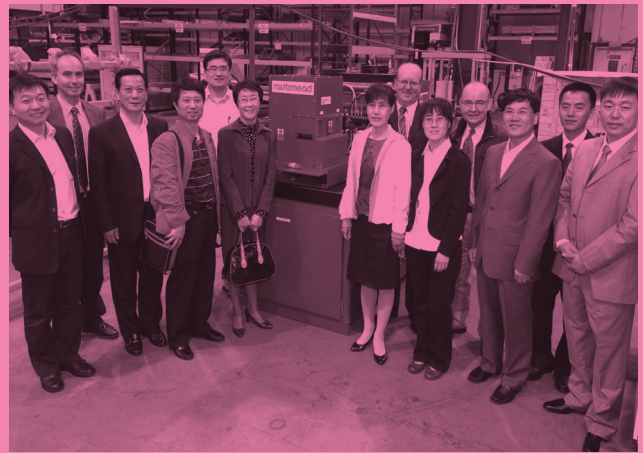
Rautomead supplied RMJ/H 025 table-top continuous casting machines for casting fine gold and silver strip to the Shanghai Mint and Shenyang Mint in China, both of which are state-owned through China Banknote Printing and Minting Corporation. Rautomead also supplied an RMJ/H025 to the Royal Thai Mint in Thailand.

The contracts with the Shanghai Mint and the Royal Thai Mints are significant because they are repeat orders confirming the strength of Rautomead's ongoing relationships and the contract with the Shenyang Mint is significant because the Rautomead machine will replace existing equipment.

### A YEN FOR CONTINUOUS CASTING

The Shanghai Mint installed its first Rautomead continuous casting machine, an RMJ/H025, for processing gold

and gold alloys, way back in 1991 with a second, larger, RMT model casting machine following on in 1994. In 2009/10 the Shanghai Mint opened a new factory facility and, in an expansion of production capacity, installed a second Rautomead RMT continuous casting line incorporating an in-line cut to length saw. The latest new RMJ/H 025 machine was installed during 2011 and is the fourth Rautomead machine supplied to the Shanghai Mint.



## ONGOING TIES WITH THAILAND

The Royal Thai Mint installed its first Rautomead RMJ/H 025 model continuous casting machine with in-line cut to length shear in 1996. During 2010 a second RMJ/H025 machine doubled the installed precious metal continuous casting capacity at the Mint's new factory close to the Don Muang airport in Bangkok. The machine was supplied complete with an automated ingot feed system as well as an automated cut to length shear.

### MAKING A MINT FOR INVESTORS

Global investment in precious metals continues to boom with investors looking for less risky alternatives to stocks and shares. As Rautomead Sales Manager Guy Henderson remarks "We have seen a considerable increase in enquiries for our precious metals casting models from all round the world in recent months. These significant orders from China and Thailand are further confirmation that demand is likely to remain strong".

### THE CRUCIAL CRUCIBLE

The Rautomead casting process is based on the use of a graphite crucible, surrounded by electric resistance heating elements which provide the power to melt and hold the metal charge. Heating is by thermal radiation and heat convection. The interior of the furnace case is filled with nitrogen gas to protect the hot-working graphite

components. Silver in particular has a strong propensity to attract oxygen in the molten state. The totally enclosed nature of the Rautomead process, where the molten metal is in contact only with the pure carbon surfaces of the crucible and casting die, is particularly suitable for casting silver because it eliminates any residual oxygen.



### ROBUST, RELIABLE AND SAFE

Though many features of the Rautomead process have been developed refined and improved over the years, the core graphite technology remains as it was originally designed, over twenty years ago. The machines have proved robust, reliable and safe to operate with many of the early machines still in daily use today.

### CASTING FAR AND WIDE

In all, Rautomead has supplied over 150 continuous casting machines for the processing of gold and silver alloys for coinage strip, jewellery, electronics and dental alloy applications. The special features of these machines, along with over thirty years' experience in graphite furnace technology, have cast Rautomead Limited as the number one choice for mints all over the world.