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CONTINUOUS CASTING OF PRECIOUS METALS FOR COINAGE STRIP

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INTRODUCTION

Rautomead International Ltd. design, manufacture and supply continuous casting equipment for the non ferrous and precious metals industries world wide.

Rautomead offer a wide range of continuous casting equipment which can be divided into four separate categories:

- Upward vertical continuous casting for wire rod
- Upward vertical continuous casting for straight lengths & hollows
- Horizontal continuous casting for billets, rods, strips & hollows
- Downwards vertical continuous casting of rods strips and hollows

The continuous casting process, converting ingot, process scraps, virgin metal (or a combination of these) by melting and casting to produce a "semi finished" section is one of the initial manufacturing processes in the production of many non ferrous metal products.

End products manufactured by customers utilising Rautomead continuous casting technology are diverse and incorporate many industrial sectors

- copper wire for wire, cable, telephone and computer wires
- copper alloy wires : in robotic arms and automotive wiring overhead catenary cable for electric trains and trolleys
- bronze bars and hollows for machine bearings
- copper tube for domestic and industrial plumbing
- brass bars for forged and machined components, e.g.: sink wastes, water meters, cable glands, valves, electrical connection blocks
- electronic contact materials and solder preforms
- dental alloys
- jewellery products, silver cutlery, picture frames, gold chains
- gold and silver coins and medals



Rautomead have supplied more than 180 machines to customers in over 30 different countries. Of these, 15 machines are being used specifically for the continuous casting of precious metal strip for subsequent processing to coins and medals.

Most of these customers are using either one of the RMT or RMJ model horizontal continuous casting machines. The selection is governed by the required production capacity and the preferred "as cast" section size.

ADVANTAGES OF CONTINUOUS CASTING

There are many advantages of continuous casting over conventionally produced materials.

Technically, the ability to continuously cast a "semi finished" product close to near net shape minimises the number of subsequent downstream operations required to produce the finished product. The quality of the semi finished product and its continuous production can significantly improve the production yield.

Commercially, the improved yield and reduced number of operations lowers the cost of production. Also the ability to continuous cast semi finished products "in house" can provide independence from outside suppliers, avoidance of extended delivery lead-times and close control of metal product quality.

When considering the specific production of precious metal medallions and coins where a fine grained, uniform, metal structure is requirement, the thickness of the "as cast" strip is determined by the reduction process deemed necessary to achieve the required metallurgical structure in the coinage strip.

The emphasis must always be on product quality. Coins and medallions, especially proof quality ones, demand a top quality coinage strip free from defects with a fine grain size capable of accommodating detailed designs on coining.

Continuously cast strips, inherently have a relatively large grain size. If there is insufficient reduction and recrystallisation of these grains during the processing of the strip "orange peel" type defects will be apparent either at blanking or coining.

QUALITY CONTROL

By controlling various parameters during the continuous casting operation (withdrawal cycle, primary and secondary die tooling, agitation of the molten metal just prior to solidification) the size of the as-cast grains can be minimised.

Typically, a short "on/off" withdrawal cycle coupled with rapid cooling is required.

The Rautomead continuous casting machines offer the facility to control and monitor all of

the key production parameters to allow repeatability of conditions from one cast to the next and traceability for quality audit purposes.

PROCESSING OF CAST STRIP

1) ORANGE PEEL

Normally it is necessary to provide at least a 50% reduction in area from "as cast" followed by an annealing cycle to achieve the required change in grain size. However, this may not be adequate for top quality coinage strip. It is often preferred to have at least two stages of mechanical reduction, (50% each) each followed by a low temperature anneal to guarantee the elimination of potential orange peel defects.

2) TIGER BANDING

Silver copper alloy coinage strip has an additional problem associated with inverse segregation. In continuous cast material this manifests itself as "tiger banding", stripes on the surface of the as cast strip, formed at the pulse marks during casting which are still faintly visible on the finished rolled strip.

The surface of cast copper silver alloys is "copper rich" and must either be mechanically removed by machining or gradually assimilated into the matrix of the alloy during several stages of rolling and annealing.

A significant advantage of continuous cast silver copper alloy strip (when compared with static cast ingots) is that it is not essential to remove the as cast surface by milling. A significant yield advantage. However, when planning the rolling and annealing reduction schedule, care must be taken to incorporate sufficient cycles to assimilate the copper rich phase to eliminate the "tiger bands".

Some manufacturers include a minimal surface treatment (rubbing with abrasive paper) before commencing the reduction sequence, others prefer to maintain a surface milling procedure.

The actual production sequence for coinage strip varies from one customer to the next according to their respective individual preferences and internal quality targets.

As a general rule, to eliminate the problems of tiger banding and orange peel defects associated with copper silver alloy coins it is necessary to start with a continuous cast strip of at least 5 or 6 times thicker than the finished coin thickness. In fine silver and gold, inverse segregation is not an issue, but to eliminate orange peel defects, the as cast strip should be at least 4 times the thickness of the finished coin.

RAUTOMEAD DESIGN FEATURES

Most Rautomead continuous casting equipment incorporate the same fundamental design features: graphite containment and casting crucible, graphite electric resistance heating elements with nitrogen gas bubbling and protection of high temperature components.

Graphite is selected as a crucible material for its favourable properties:

- high thermal conductivity
- excellent machining characteristics
- non wettable for the majority of non ferrous alloys
- provision of a reducing environment to contain liquid metal
- long operating life

Graphite resistance heating is preferred for:

- accurate and stable furnace melt temperature control
- ease of operation and maintenance
- safe operation (low volts)

Limited mixing and stirring of the melt is provided with nitrogen gas bubbling through the liquid. Accurate alloy composition can be maintained within tight tolerances by careful control of feedstock to the furnace. In coin manufacture, where 50% of feedstock to the casting machine can be alloyed blanked sheets, the balance can be made up with other alloyed material or virgin metals.

ELIMINATION OF COMMON DEFECTS

The use of the graphite system employed by Rautomead contributes to the elimination of three other problems which can be associated with the production of silver coins. Scoring, black spotting and blistering.

1) SCORING

Scoring marks visible on the coin field are caused by impurities/inclusions in the metal. Often the presence of insoluble impurities comes from the gradual degradation of the crucible material (silica, zirconia, alumina etc) . This is not an issue with graphite crucibles.

2) BLACK SPOTS & BLISTERING

The main advantage of the graphite crucible (coupled with nitrogen gas) is the provision of a reducing environment for the liquid metal. The Rautomead furnace is

operated with a closed top lid, a graphite cover on top of the melt and a nitrogen gas environment. All these features combine to minimise the absorption of oxygen in to the liquid metal and then to remove any that is there.

The as cast material from the Rautomead machines is virtually oxygen free.

Black spots are usually copper oxides. With oxygen free material, provided the cooling is controlled to prevent formation of copper oxide on the surface of the continuous cast strip, rejects associated with black spots can be minimised.

Blistering may be caused by expansion of entrapped oxygen during annealing. With static cast material rejects due to blistering alone can be over 30%. By producing oxygen free material from the Rautomead machine, rejects from blistering can be eliminated.

TRAINING & COMMISSIONING

All machines manufactured by Rautomead are installed and operated at the Rautomead factory in Dundee for thorough testing prior to shipment. Customers' engineers are invited to visit Dundee at this time to participate in the pre shipment testing and to gain some instruction and training in the operation and maintenance of the equipment.

Many of Rautomead's customers have no prior experience of melting and casting metal.

SUMMARY

Rautomead offer:

- Equipment with proven design, as used by many precious metal blank and coin suppliers
- Incorporating inherent design characteristics which contribute to the production of top quality coinage strip
- Training of customers engineers in the operation of continuous casting equipment under supervision in Dundee
- Installation and commissioning of equipment at each customers factory