

TRENDS IN NON-FERROUS METAL WORKING ZAKOPANE, POLAND 4 – 6 OCTOBER 1998

THE MOVE TO QUALITY IN RE-DRAW ROD

Presented by Sir Michael Nairn and Mr Mark Coleman, Rautomead International Ltd, Dundee, Scotland

Rautomead commenced building continuous casting machines of its own proprietary design in 1978. The early machines were integrated melting, holding and horizontal casting furnaces for the production of multiple strands in brass and bronze alloys. The essential elements of the Rautomead design were based on the now out-dated but still high quality performance furnaces sold under the UNICAST banner by United Wire of Edinburgh, Scotland in the 1950s and 1960s. The essential features of this design were electrical resistance heating, solid graphite crucible and a submerged casting die. Heat was transferred to the metal by radiation and convection from a low voltage chain of heating elements through the crucible wall.

Through the 1980s, design of Rautomead machines was refined, particularly in areas of process control and the range of alloy applications. This extended the use of the machines from the original brass and bronze recovery market into production of a wide range of copper based alloys in the forms of rod, strip, and hollow bars. The field of precious metals was an area where high product quality and ease of operation led to several multiple installations by specialist users. Several Rautomead machines are in regular use manufacturing dosed gold re-draw rod for microdrawing as bonding wire for the electronics industry.

In 1991 Rautomead took the decision to adapt this high quality and proven continuous casting system to upwards vertical casting, with the specific objective of processing oxygen-free high conductivity copper re-draw rod at 8 mm.

This adaptation of Rautomead methods to upwards vertical casting gave immediate advantages of higher casting speeds, rapid die change, higher production efficiency as well as inherently safer installations.

Improved process temperature control and the maintenance of a constant head of molten metal at the casting die greatly improved consistency of product quality.

So much for the background. What the user needs to know is how these features influence the performance of the cast copper rod in drawing to fine wire. The key parameters are:

- elongation
- grain structure
- hardness
- impurities both metallic and non metallic
- porosity and voids

For many years, manufacturers of copper rod have graded the output of their plants according to end-use, with only a fraction of the total output being suitable for drawing to fine wire.

Rautomead's objective was not just to offer a casting process capable of producing re-draw rod to match current industry performance, but to capitalise on the inherently sound features of the Rautomead process to achieve an improved quality of copper wire rod capable of being drawn to fine wire on a consistent basis. This included the application of parameters learned in the casting of precious metals to copper processing. The Rautomead system has many features which are conducive towards improvement of the drawing performance compared with traditional rod production processes.

So what are those features ?

1. Graphite Crucible

- Crucible holding capacity selected to provide balance between hourly output, thermal stability and oxygen reduction
- Unwetted by most metals in molten state
- Naturally reducing
- Incorporation of graphite filter
- Plumbed for first-in-first-out metal flow
- Gas bubbling for agitation of melt where required in alloy production, while maintaining stable casting zone
- Metallurgically extremely clean
- Internal metal dump valve to bottom taphole position for simple, quick and complete draining for alloy change-over
- Long life

2. Electric Resistance Heating

- Low, inherently safe secondary working voltage (typically 35 volts)
- Still metal bath
- Low maintenance cost – low skill maintenance personnel
- Simplicity of design
- High efficiency
- Environmentally clean
- Power factor close to unity
- No risk of punctured rammed ceramic furnace linings or of inductor failure

3. Inert Gas Protection

- Prevention of oxidation of high-temperature components, promoting long service life to wear parts
- Low gas consumption
- Low cost
- No fume
- No toxic hazard
- Use of commercially available gas
- Option of nitrogen generator

- 4. Integrated Melting
 - Enclosed process, with no exposed molten metal transfers
 - Avoidance of oxygen or hydrogen pick-up
 - Compact plant arrangement

- 5. Thermal Stability & Advanced Process Control
 - Casting temperature stability within $\pm 5^{\circ}\text{C}$
 - Casting die exit rod temperature $< 80^{\circ}\text{C}$
 - Close monitoring and recording of all key parameters of production including:
 - cooling water inlet temperature
 - cooling water inlet pressure
 - cooling water flow (individual strands)
 - cooling water outlet temperature (individual strands)
 - nitrogen gas flow
 - nitrogen gas pressure
 - metal casting temperature
 - furnace temperature
 - Advanced facilities for statistical control and data analysis
 - Unique cooler design
 - Automatic alarm signalling
 - Close control of casting die immersion depth

Alongside these features, Rautomead has brought to bear its full twenty years of experience of establishing successful continuous casting plants at customers' sites on a world-wide basis. Aspects where special attention is given to user convenience and success include :

- 1. Key Safety Features
 - Low secondary electrical voltage
 - No water-cooled induction coil surrounding furnace
 - Battery operated emergency lifting of casting dies from molten metal
 - Auto-manual over-temperature control
 - UPS to control circuits in event of mains power failure
 - Closed circuit primary cooling water system
 - Inert gas protection to hot-working components

- 2. Floor Mounting
 - No special pits or trenches for installation
 - Standard 150mm reinforced concrete floor only

- 3. Detailed Customer Training
 - In depth training in all aspects of operation and maintenance carried out initially at Rautomead factory, while machine is under test. Continued by commissioning engineer at customer factory. Comprehensive and explicit operations and maintenance manual provided

- 4. Simplicity of Control
 - Rautomead seeks to provide machinery which can be operated and maintained by reasonably competent local labour in almost any country in the world. See list of installations later

- 5. Customer Service
 - It is Rautomead policy to establish and to maintain close working relationships with all its established customers and to provide technical support on a regular basis
 - Key spares available ex-stock

- 6. Technical Developments
 - Rautomead maintains an active Research and Development department and cooperates closely with universities and other scientific bodies in programmes of innovation in this field. The benefits of this work are made available to all customers as they occur.

These approaches to machines design and customer service have led to many successful installations in difficult and demanding geographical and cultural environments around the world.

Rautomead offer several standard upwards vertical models. These are:

For rods 8.0mm to 12.5mm in coils:

<u>model</u>	<u>output</u>	
RS 1050/4/8	2500/3000	tonnes/annum
RS 2200/8/8	3750/4500	tonnes/annum
RS 3000/8/8	5000/6000	tonnes/annum
RS 6000/16/8	10000/12000	tonnes/annum

For rods 8mm to 30 mm in coils:

<u>model</u>	<u>output</u>	
RS 2300/4/30	3750/4500	tonnes/annum

For straight lengths 8.0mm to 50.0mm in bronzes solids and hollows:

<u>model</u>	<u>output</u>	
RSL 500/1/50	400/ 600	tonnes/annum
RSL 750/2/50	800/1200	tonnes/annum

Rautomead's initial upwards casting installations in the Middle East have been in production since end 1995 and have now clearly demonstrated the reliability and economic viability of the process.

Rautomead upwards vertical casting installations are now to be found in:

Iran	3 machines	8mm to 12 mm re-draw rod in OFHC Cu
Belgium	1 machine	8 mm re-draw rod in OFHC Cu
	1 machine	conductor alloys in 12mm to 30 mm range
Germany	1 machine	12mm to 30 mm Brass and Bronze
U.K.	1 machine	10mm to 38 mm Leaded Bronzes
Chile	1 machine	8mm to 12 mm OFHC Cu
Taiwan	1 machine	8 mm OFHC Cu
Malaysia	2 machines	8 mm OFHC Cu
Sudan	1 machine	8 to 12 OFHC Cu
Japan	1 machine	8 to 30 OFHC Copper
USA	2 machines	8 to 30 OFHC Copper

Early installations suffered from various mechanical limitations. These have been overcome as follows:

- Product withdrawal has been redesigned and has now been shown to be dependable
- Rod coiling. Whereas traditional processes deliver hard rolled 8 mm re-draw rod in flat pressed coils, Rautomead cast rod is soft and cannot be pressed. Early installations had a tendency to form dome shaped coils. Following extensive development, the Rautomead process now delivers flat, consistent coils which pay off easily without snagging at the break-down machine.
- Crucible life. Early crucibles in the 8 to 12 mm rod machines suffered from erosion problems, reducing crucible life unacceptably. Development of the protective liner systems and improvements both in the quality of the graphite material and in crucible design now give the life expectancy initially forecast.

So, what of Quality ?

Rautomead re-draw rod has shown consistency of manufacturing quality from customer to customer across many international boundaries.

- **Oxygen** content always below 5 ppm, often below 2 ppm
- **Elongation** never less than 40% often as high as 50%
- **Voids** Rare, often associated with wet cathode
- **Inclusions** Rare, normally associated with poor maintenance at the six monthly maintenance inspections.
- **Chemistry** Minor change to feedstock composition
- **Carbon** Less than 2.5 ppm
- **Surface Oxides** Minimal due to casting exit temperature below 80°C. Expected to be below 15 Å - essential for high quality flat wire production.
- **Re-draw Performance** Consistent quality and re-draw performance throughout the casting campaign, through maintenance of steady production parameters within fine limits at all times.
- **What of the future** Rautomead have already shown that quality rod can be produced, but the market strives to achieve high yields at 20 microns. Such performance, of course, is a function of every stage in the processing of the copper. Rautomead believe that their technology, allied to best practices in materials selection and in wire drawing offers the user the best approach to achieving high quality.
- **Who is it for ?**

Back Integrator:

Rautomead have been very successful in facilitating backwards integration in many alloy fields; with the brass and bronze market re-cycling the in-house scrap; with dental laboratories purchasing grain to cast their own feedstock; with jewellers recycling or producing varying sections. Rautomead firmly believe that this simple approach to re-draw rod production offers the smaller rod user the opportunity to back integrate, hence the RS1050 and RS2200 models.

CCR Producer: The Rautomead process offers a simple small operation for making high quality oxygen-free rod and high copper alloys at low cost compared to resetting a CCR layout. This enables the user to secure orders for total supply to customers. The RS3000 and RS6000 are designed for this user.

Conductor Alloy Manufacturers: Rautomead's simple and flexible machine allows 12 and 30 mm rod to be cast simultaneously and alloys to be charged quickly and efficiently. The integrated approach avoids volatile burn off and homogeneous still casting baths give high quality performance. The RS2300 and RS2500 are designed for these users.

Jobbing Brass and Bronze: Rautomead flexibility permits short casting runs in rounds, hexagons, octagons or strip, to be undertaken interchangeably. Alloys can also be easily changed within alloy groupings. The RSL 750 is designed for this user.

In Conclusion

Overall, the Rautomead approach is to focus on the company's long established graphite-based furnace technology, as being a thoroughly sound basis for the highest quality re-draw rod production. The company offers a range of specialised machines of relatively modest output, but where the emphasis is quite clearly on high and consistent product quality. This philosophy is seen as matching closely the industry trend of increasing emphasis on reliable wire drawing performance down to 0.020mm or 50-52 American wire gauge.