RESURRECTING COPPER SCRAP FOR PRODUCING HIGH QUALITY FRHC COPPER ROD, INGOTS AND OTHER PRODUCTS

Typical copper scrap yard

One of the best evergreen achievements that we wish to present is the technology to resurrect copper scrap, with a controlled quantity of impurities, into new copper products.

The term ‘copper scrap’ is a general indication that encompasses all types of scrap from bright and clean copper scrapped in the drawing shop (which is very near to cathode purity) to old scrap, coming from demolition, which is very polluted with a minimum copper content around 93%.

Naturally it is possible to mix many kinds of copper scrap according to what is available on the market and what is recirculated from the drawing shop.
What Continuus-Properzi suggests for producing FRHC (Fire Refined High Conductivity) copper depends on the kind of scrap but also on the available quantity of scrap.

There are three types of Continuus-Properzi processes for the production of FRHC copper, each with their relevant hardware:

No. 1 Batch Process with maximum refining	No. 2 Continuous Process with limited refining	No. 3 Batch Process with limited refining
Copper scrap mix ≥93% 40-250 tons per batch	Copper scrap ≥97% 25,000-100,000 tpy	Copper scrap mix ≥96% 40-100 tons per batch

Evidently the economic feasibility of the project depends on quality, quantity and mainly on the price of the scrap, the worst scrap being the cheapest and most convenient.

For many years the worldwide industry has referred to copper rod produced by Properzi equipment and technology starting from copper scrap as FRHC rod using our No. 1 Process. In addition to rod, the FRHC copper has been successfully used for casting ingots, billets and slabs. The vast majority of the plants installed in the last 20 years are of the No. 1 Process type.

Whatever is the final application, the heart of the plant is one or more tiltable reverberatory refining furnaces having a nominal capacity ranging from the smallest 40 ton up to 250 ton or larger. The input material is 100% copper scrap having a copper content higher than 93-94%, provided that harmful impurities such as Nickel, Tellurium and/or Silver do not exceed certain values as detailed in the technical documents.

Table A displays the various combinations of refining furnaces, CCR (Continuous Casting & Rolling) rod lines and the expected yearly output.

TABLE A

Furnace Capacity [t]	CCR Hourly Output [tph]	Expected Yearly Output [tpy]
40	7	12,000
60	10	18,000
80	12.5	24,000
100	16.5	30,000
150	25	45,000
200	30	60,000
250	40	75,000

Note: the above yearly output is based on 300 batches per year

Just to make a few comments on Table A, we can say that the production of FRHC rod using the reverberatory refining furnaces is a batch cycle including the following steps:

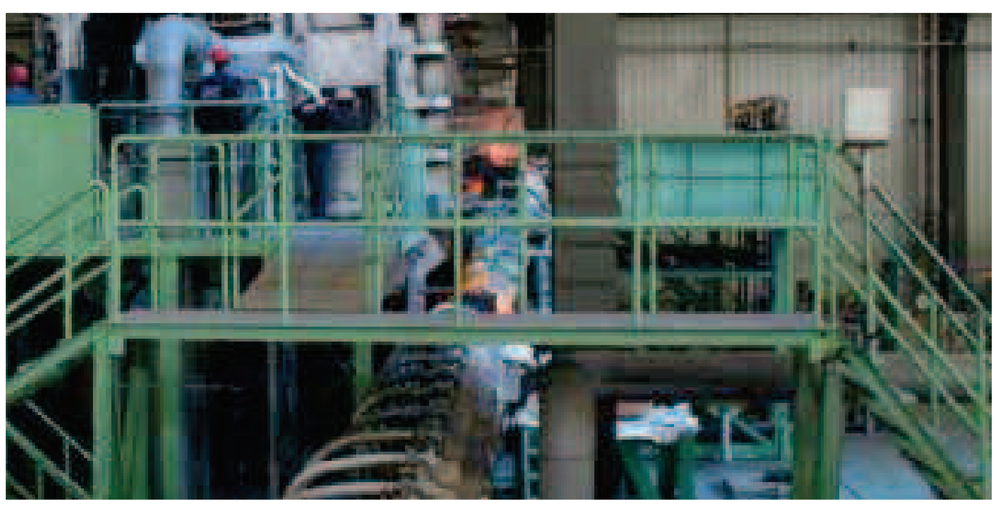
- **>>** Charging of the furnace and melting
- **>>** Refining cycle in 2 to 4 steps

After 16 hours, or 20 hours in the worst cases, the furnace is ready to provide the liquid metal to the CCR line. As we can see from Table A, such CCR lines are dimensioned in order to have the capability of emptying the furnaces in a time period ranging from 6 to 7 hours.

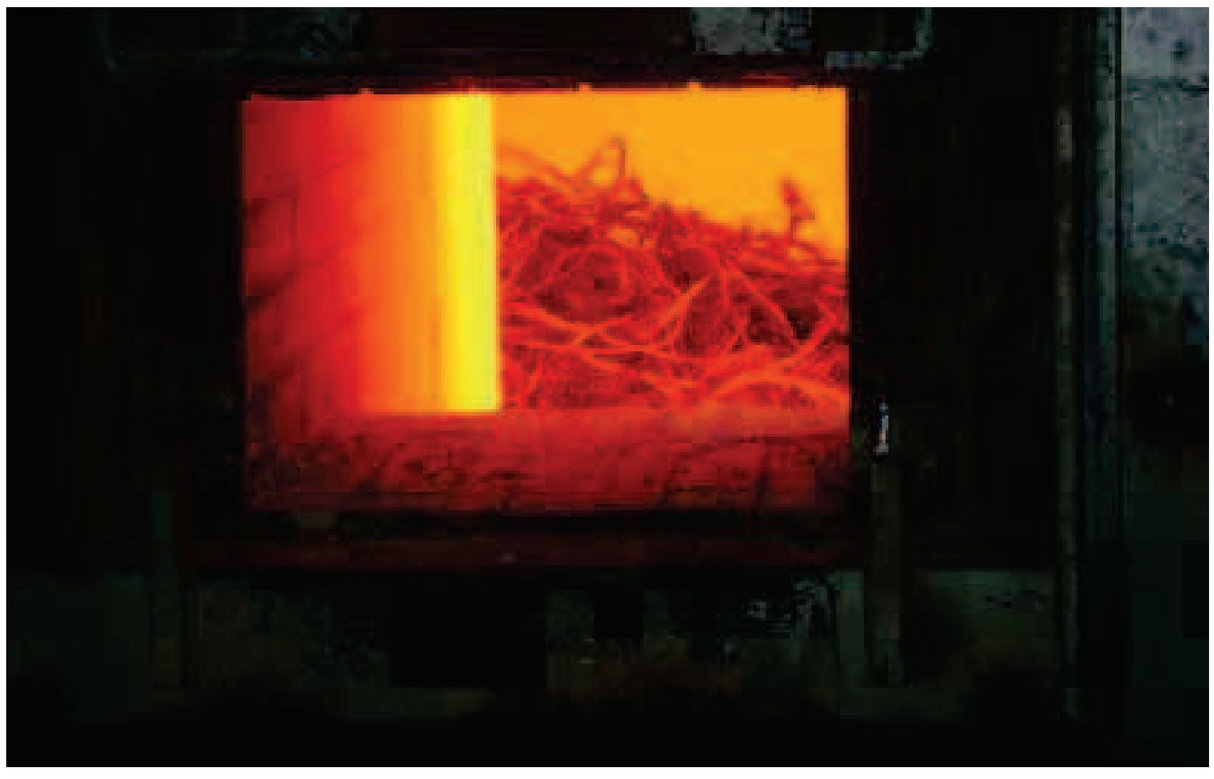
Over the years great work has been done by Properzi and by the Users of such technology so that the FRHC rod of today is an economic commodity which can comply with ASTM-B49 and EN1976 standards. It can be processed in high-speed multiwire drawing machines down to 0.3 mm (0.25 mm and smaller for experienced producers) and used in many engineering applications other than fine wire, as has been stated in several papers given on this subject.

The number of wire breaks per ton, until reaching this diameter, will be comparable in all respects to the best copper rod available on the market by making minor adjustments during the annealing process.

When it is possible to buy high quality copper scrap with copper content ≥ 96-97%, such scrap can be processed by using a continuous system of furnaces, including one modified shaft furnace with two refining/holding furnaces.



View of Refining Furnace and Launder



Copper scrap inside the Refining Furnace through inspection door

View of the Rolling Train – By courtesy of SDI-La Farga (USA)

Table B below displays the typical chemical composition and characteristics of FRHC rod.

TABLE B

Parameter	Reference	Value
Chemical composition	Cu+Ag %	>99.90
Oxygen	ppm	150 ÷ 250
Elongation	A_{100} %	45 ÷ 51
	A_{200} %	38 ÷ 43
Tensile strength	Kg/mm²	22.8 ÷ 23.5
Conductivity	IACS %	100.5 ÷ 101.3
Twist test to failure	No	43 ÷ 50
Best drawability	mm	0.25
POPS test – surface oxides	Ångstrom	100 – 200
Re-crystallization temperature	°C	7250 ÷ 280

For more than twenty years Continuus-Properzi has delivered and put into operation several dozen refining furnaces and copper rod lines in many countries around the world including Italy, USA, Korea, Iran, Mexico, Brazil, China, India, Ukraine, Russia, Cuba and others. The smallest plant supplied and currently in operation has a capacity of 10,000 tpy whereas the largest plant, commissioned in the USA at the SDI-La Farga facility, has a capacity of 75,000 tpy and is equipped with a revolutionary refining furnace, patented by Giulio Properzi, which loads the scrap from the top.
As previously mentioned, the level and the kind of impurities in the scrap make a big difference. The level and the kind of impurities in the scrap make a big difference. When it is possible to buy high quality copper scrap with a copper content ≥ 96-97%, such scrap can be processed by using a continuous system of furnaces, including one modified shaft furnace with two refining/holding furnaces.

The loose or baled scrap is charged at the top of the shaft furnace by a front loader using a dedicated ramp. At the bottom of the shaft furnace the melted copper is collected in a basin where it is treated and slagged.
Two launders bring the melt to a couple of holding/refining furnaces which alternate with one another. Refining is generally limited to oxidation and reduction.
This furnace set called CSMR (Continuous Scrap Melting and Refining), corresponding to our No. 2 Process, can feed Properzi rod lines ranging in size from 5 up to 20 tph.
There are cases where the CCR rod line has a combination of furnaces: one CSMR furnace set working about 16-18 hours per day and one reverberatory refining furnace for very low grade scrap (≥ 94%) feeding the caster for the rest of the day. Another combination is one refining furnace to produce FRHC rod and a standard shaft and holding system for cathodes to produce ETP rod.

In the above cases refined copper goes directly from furnace to the caster to produce FRHC products (rod, billet, slab) but one more system to recycle scrap is available and in use. This is the No. 3 Process commonly known as “off-line” process and is intended to produce ETP products.
In the larger rod systems using consistent amounts of cathodes it is possible to mix a small percentage of FRHC ingots with cathodes and get ETP quality.

Usually the “off-line” system recycles internal good purity scrap with some scrap from the market so the required refining is much less intensive than in the No. 1 Process; therefore the tilting furnace is simpler and the caster is a standard open top mould chain.

In summary, regarding the reclamation of copper scrap, Properzi is willing and able to offer and support the following:

- Complete plants for producing FRHC rod equipped with one or two reverberatory furnaces with daily output ranging from 40 to 250 tons.
- “Continuous System” or “Cosmelt” System for clean scrap with output of FRHC rod ranging from 5 to 20 tph.
- Combined plants for the production of ETP and FRHC where the CCR Line is fed for approximately 16-17 hours with liquid metal coming from a vertical furnace using ETP cathodes and for the remaining time up to 24 hours the CCR Line is fed with FRHC metal. This system gives the maximum flexibility of using both raw materials (cathodes and scrap) either on a daily basis or on a campaign basis according to the availability of scrap and cathodes.
- Last but not least, the “off-line” system for the production of ingots or plates to be blended in with the cathodes charge of existing ETP rod facilities.

Properzi is also available to supply such plants on EPC (Engineering, Procurement, Construction) basis so that the buyer is only minimally involved with the installation of the plant.

By G.P. & C.M.B.