A much greener copper wire production

The Self-Annealing Microrolling (SAM) process was born of a need to improve energy efficiency, writes Eng. Michele Moretti of Properzi.

The energy used for the mechanical deformation in a metal working process is transformed into a higher temperature of the material which is being deformed. This also applies to traditional copper rod breakdown machines which use dies to reduce the diameter, but in this case the process requires that the copper must be cooled before entering the next die to avoid wire breaks. This leads to hard wire and to the subsequent need for annealing, which consumes a great amount of electrical energy. The question is if there is a more efficient way to work, to avoid the dissipation of energy by cooling down the copper and then reheating it in the annealer.

3-roll mill

Properzi's idea was to use a Microrolling® mill, a typical Properzi 3-roll mill for small diameters, with the capability to process hot materials, thereby allowing the energy of the rolling process to be transformed into heat, increasing the wire temperature step by step to a level that lets the copper be deformed in a less severe hardening condition, almost as if it were hot-worked, and letting it reach a temperature in which a partial recrystallisation process can begin. At the end of the rolling process, it is only necessary to maintain the wire at the recrystallisation temperature for a short time in an inert atmosphere and then cool the wire to facilitate coiling.

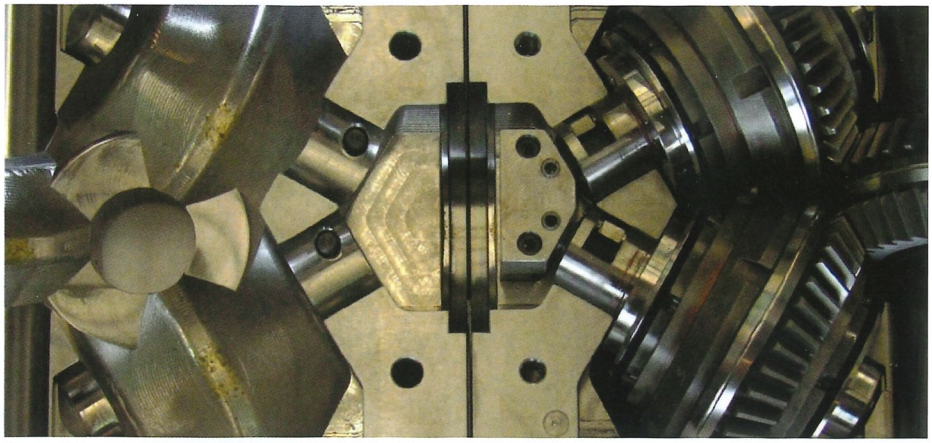
This process heats the copper and gives it time to recrystallise, thereby providing the desired characteristics of an annealed copper wire with elongation A% > 25%, while avoiding the energy intensive resistance annealing process. From there, the "Self-Annealing Microrolling", or "SAM", process was born.

To reach this result, a new Microrolling® line has been developed. This new line provides the appropriate, easily adjustable, amount of cooling for the rolling stands so that the majority of the motor's electric power is transformed into heat within the copper wire that is being deformed under the rolls, thereby enabling an elevated temperature of the exit wire and, at the same time, guaranteeing the reliability of the line. Concurrently, an inert gas insulated pulley box, with very low consumption of nitrogen and without electrical power, has been designed and developed to guarantee the correct recrystallisation time for the wire before it is cooled through a compact and highly efficient cooling unit.

The SAM process can be seen as a small, compact rolling plant with a total length of about 25 m. It consists of a rod pay off, a Microrolling® Mill with its auxiliaries, an inert atmosphere (N2) pulley box, a high-pressure cooling system, and a wire coiler.

Proving the process

A rigorous testing campaign was carried out with different materials and different outlet diameters, to study and develop the process to achieve the best wire quality in terms of elongation, dimensions, and shape.



Empty semi-shell and complete semi-shell. Photo: Properzi

We can say that, after several tests processing ETP-Cu rod from different producers and in different quality grades, the wire has a minimum elongation of 27%, with shape and dimension tolerances which make it ideal for subsequent processing in multiwire drawing applications. The most interesting result is the electrical energy savings that are possible with the SAM process. Comparing the total energy consumption per ton of produced wire, we have the following results:

- For 2.6 mm ETP-Cu wire, at a production rate of 5.1 tons per hour with exit speed of 27 m/s, the energy consumption is 70 kWh/Mt with SAM versus 110 kWh/Mt with a traditional rod breakdown drawing machine. This equates to 35% less energy consumption.
- For 1.8 mm ETP-Cu wire, at production rate of 2.4 tons per hour with exit speed of 27 m/s, the energy consumption is 120 kWh/Mt with SAM versus 220 kWh/Mt with a traditional rod breakdown drawing machine. This equates to 45% less energy consumption.

In addition, FRHC-Cu rod has been successfully tested to obtain a very good 1.8 mm wire at a production rate of 1.8 tons per hour, with energy consumption of 150 kWh/Mt. In this case, as expected, FRHC requires more deformation power that translates into an increased wire temperature at the end of the rolling process. More deformation power is also required in rod breakdown drawing machines with FRHC-Cu rod due to microstructural impurities but, unlike the SAM process, this increased power is also dissipated by the cooling system and therefore even more electrical power is required in the annealer. For this kind of Cu rod, the energy savings in the SAM process are even greater.

A green decision

The SAM process has been tested and confirmed to be a good choice and a great alternative to the traditional rod breakdown drawing process for Cu wire that has to be further processed in intermediate or multi-wire drawing machines to obtain wires below 0.25 mm. The SAM process can guarantee a constant and high elongation value for both 'subprime quality' ETP and FRHC copper rod.

SAM at Properzi headquarters. Photo: Properzi

Passage of the rod in the Properzi Microrolling® Mill. Photo: Properzi

Copper wire obtained with Properzi SAM. Photo: Properzi

Today there is a global push throughout industry to increase efforts towards a greener planet as everyone strives to save even a small percentage of their energy consumption. The Properzi Self Annealing Microrolling Machine is a revolutionary, greener option that decreases the required energy consumption to produce annealed redraw wire by 40 to 45%.

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