Great energy savings in copper rod breakdown

Giulio Properzi outlines a new wire self-annealing process which cuts the electricity bill in half.

Self-annealed wire exhibited during Wire Düsseldorf 2016

Properzi wrapped a very expensive fountain pen with self-annealed wire without any damage to the pen… it's really annealed!!

A long time ago, when I was a student at the Politecnico of Milan earning my masters degree in mechanical engineering, I was impressed by the energy conservation principle "energy does not get lost, it changes aspect only". One consequence of this basic fact or basic law of our physical world is that theoretically all the energy you use for mechanical deformation is transformed into a higher temperature of that which has been deformed.

This theoretical physics remained in my mind for many years until recently when I had the idea of using our Microrolling® machine in a different and completely new way. A Microrolling® machine is a special rolling mill for small diameters – in other words it is a rod breakdown machine that is used for metals that have some difficulties in the drawing process such as mechanical aluminium alloys, certain copper alloys, niobium, tantalum, stainless steel and so on. It is really a nice application and technologically interesting because of the precise tolerances obtainable when rolling wires of less than 1.8 mm at high speeds.

What made this machine possible was the typical Properzi 3-roll stand configuration, where the spread of the metal under the roll is much more controllable than in the traditional 2-roll system, as well as the extensive and exhaustive studies we have conducted on how to calculate the speeds and the grooves of the rolls in each stand when all stands are powered by a fixed-gear transmission with only one motor.

Application of specialty

There are about 30 such machines in operation on an industrial basis around the world replacing conventional drawing machines to the satisfaction of the end-users. In several cases the Microrolling® machine is rolling in hot condition. As mentioned before, 100% of the applications are for specialty wires of various metals and their alloys. When talking about using the "Micro", our company nickname for the Microrolling® machine, for pure copper the first answer was "copper is so easy to draw that we do not need a machine that is not as simple as a drawing machine", and that ended the discussion.

Only in recent years did I remember the energy conservation principle and completed the following phrase "copper is so easy to draw but needs a lot of energy for heating and annealing so we can use the rolling power to heat and anneal it!". The idea was patented and a dedicated prototype was installed at Anglia Metal U.K., a specialist in fine copper wires, at the beginning of 2016.

Test line operation

The description of the test line is very simple: a standard de-coiling device is placed in front of the Microrolling® mill. The mill has a self-contained emulsion tank, a gear transmission and eight 3-roll rolling stands. It accepts 8 mm rod and provides 2 mm wire at 28 metres per second. The total length of the mill is only 4.0 metres. A large second hand motor, 450 kW DC, was used even though it is twice the size of the expected power demand. Downstream of the mill we left some room for a wire quenching device or something else… just in case. As a take up we installed an available vertical static coiler with its dancer and we began the trials.

The key was to find the appropriate, easily adjustable cooling for the rolling stands that allows the majority of the electric power of the motor to be transformed into heat within the copper under the rolls, thereby enabling an elevated temperature of the exit wire.

We played with the oil percentage in the emulsion and how much emulsion was delivered to each stand. Roundness of the 2 mm wire, as expected, was not a problem.

We were also lucky - during the first week of testing we produced copper wires with up to 50% elongation (on a 250 mm specimen)… much higher than typically required. Then the wire was drawn to the usual final sizes.

Then we took a look at the amp meter when running at 28 m/sec, and with a simple calculation we obtained an electric consumption of around 85 kWh per ton including auxiliary services, which is less than just the drawing power consumption alone. This is because the rolling process itself is a little more efficient than the drawing process, but mainly because of the higher temperature that makes the copper softer, thereby requiring less power for the deformation process. Savings are in the range of 9-12 euros per tonne depending on the electric tariff. The next step for Anglia Metal will be a new rolling sequence for 1.8 mm exit wire that is the usual starting size for their multiwire drawing machines.

Quantifying the saving

The Micro breakdown demands 50% less room, 50% less electric power and is consequently twice as green and therefore friendlier to the environment and to the balance sheet of the end-users. Considering the price of one kWh, which fluctuates from country to country, to be between 0.08 - 0.12 euro and making our calculation easy with 0.10 euro per kWh, one Micro breakdown producing 15,000 tonnes per year (another round figure) can provide savings of 120,000 - 180,000 euros per year on the electricity bill.

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