PLASMA MULTIPLIES THE SPEED FOR STAINLESS STEEL AND NICKELY ALLOY ANNEALING

Stainless steel and nickel alloy wires with diameters below 3mm have so far been annealed predominantly in tube/strand annealers. Due to its relatively small speed, the traditional process is normally conducted in a multi-line configuration to ensure sufficient output. In April 2006 Plasmait GmbH, Austria will introduce PlasmaANNEALER that was developed specifically for stainless steel and nickel alloys. The machine demonstrated annealing speeds of 10 to 20 times higher than traditional tube/strand annealers. Plasma annealing of stainless steel and nickel alloys can be performed inline with the drawing machines, whilst ensuring superior surface quality of the finished wire.

The slow speed of traditional tube annealing process means that the manufacturing of premium stainless steel and nickel alloy wires generally involves a multi-line set up. Multi-line process is logistically demanding and involves multiple pay-offs and take-ups. This takes work shop space and locks considerable money in work in progress. Furthermore, drawing is performed separately from annealing, which adds to the complexity of process logistics.

To speed up and simplify the traditional process, Plasmait introduced high-speed PlasmaANNEALER that can operate inline with a drawing machine. For the purpose of this article PlasmaANNEALER was tested with 0.6 mm – 2 mm stainless steel and nickel alloy wires. The materials chosen for the trials had annealing (dwell) times[1] between 2 and 20 seconds.

[1] Annealing or dwell time is the time a material requires to anneal at annealing temperature.

Figure 1. PlasmaANNEALER for high-speed annealing of stainless steel and nickel alloy wires.

For the trials, PlasmaANNEALER was designed to provide the temperature profile to achieve full re-crystallisation – complete annealing for each of the materials. This was achieved with ensuring that the material was held at temperature (dwell time) sufficiently long for each of the materials.

The results of the tests showed that PlasmaANNEALER achieves highly homogeneous crystal structure, constant in cross-section and in the direction along the wire. Grain size was manipulated through the time the material required to cool down i.e. the length of the annealing (dwell) and cooling sections.

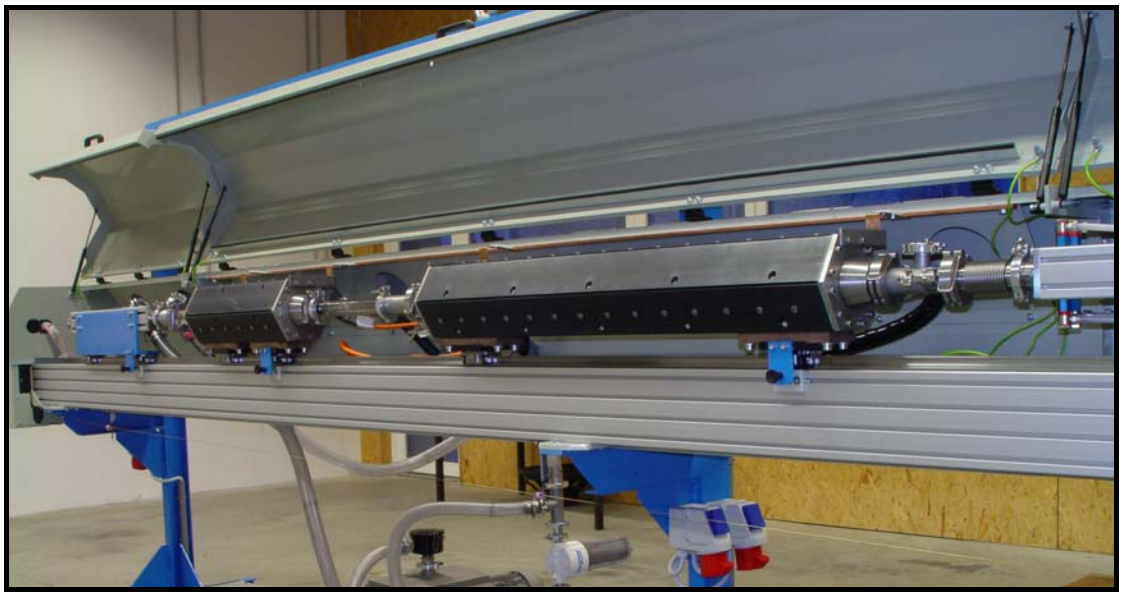

Figure 2. PlasmaANNEALER Heating and Annealing Zones configured for high-speed stainless steel and nickel alloy wires.

Surface quality of the finished wire was ensured through inert atmosphere that protects the surface throughout the process (from heating to cooling section). Pre-cleaning was used to remove drawing soaps from the wire surface prior to plasma annealing. The tests showed that Plasma treatment also provided a degree of surface cleaning, degreasing and deoxidation on the wire surface.

PlasmaANNEALER has proved to be particularly effective for wires that are drawn with oil lubricants. Plasma treatment burned all oil lubricants from the wire surface, resulting in completely clean surface. Furthermore, Plasma treatment removed also other residues that have accumulated in the cracks of the wire surface such as soap residues, dirt. Plasma does not damage the wire surface nor does it make it rougher like it is the case etching (acid cleaning). This makes PlasmaANNEALER particularly suitable for high-end applications with demanding surface requirements such as welding wires and wires used in medical applications.

The cooling section is usually the longest part of PlasmaANNEALER, in particular when gas cooling is used on large diameter wires (larger than 1.5mm). The cooling rate can be increased with a combined gas / water cooling section unless surface quality is compromised with water contact.

Tests on PlasmaANNEALER have so far shown that annealing speeds of up to 3 m per second can be achieved on stainless steel and nickel alloys. As with every annealing method the processing speed is to a large degree dependant on the dwell time of the material. The longer the dwell time for a given material the longer the annealing zone. Nevertheless, annealing zone can be reduced considerably for the process where partial annealing is required (e.g. intermediary annealing).

PlasmaANNEALER demonstrates energy efficiency between 75% and 85% which is considerably better than efficiency of a traditional tube annealer. The usage of processing gas is negligible compared to the gas usage in atmospheric tube annealer.

PlasmaANNEALER Performance Table				
	Diameter	Process speed	Annealing rate	Energy efficiency[2]
Nickel Alloy 1	2 mm	40 m/min	Re-crystallisation	75% - 80%
Nickel Alloy 2	0.7 mm	110 m/min	Re-crystallisation	80% - 85%
Stainless Steel 1	1.5 mm	80 m/min	Re-crystallisation	75% - 80%
Stainless Steel 2	0.4 mm	180 m/min	Re-crystallisation	80% - 85%

We can conclude that PlasmaANNEALER offers three benefits when compared to traditional tube/strand annealer. They are as follows:

- High-speed annealing can be performed in-line with drawing. This reduces the material manipulation and cost of labour, minimises money locked in work in progress and lessens shop floor requirements.

[2] Energy efficiency is calculated as the power induced as heat in the wire material divided by the total power used for operation of PlasmaANNEALER (incl. power required for operation of vacuum pumps).

- Plasma process achieves homogeneous mechanical properties that are superior to a traditional tube/strand annealer.
- PlasmaANNEALER provides superior surface quality thanks to plasma cleaning effect. Plasma can also act as an effective degreaser for applications that use oil based drawing lubricants (e.g. welding and medical wire).

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