Technical Journal „Draht“ (Wire) Sept 4, 2003

Electrolytic Zinc Phosphating of Steel Wire

Overview over the entire Ephos system

Since last February, an electrolytic zinc phosphating system is in operation on the site of a renowned German wire manufacturer. This system creates coatings that have crucial advantages for wire drawing, while at the same time considerably lowering the cost of operation

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Since the system the manufacturer calls Ephos System (of electrolytic phosphating) is the first of its kind, its introduction was preceded by 10 weeks of experiments with a pilot system to demonstrate the announced quality specifications of the plant construction firm STAKU Anlagenbau GmbH.
These specifications are:

- **microcrystalline layer of phosphate that guarantees optimum sliding characteristics and pressure resistance in the drawing die.**
- **avoidance of sludge formation (mud), i.e. no cleaning of baths nor removal of sludge.**
- **adjustability of layer weight via the settings of the current.**
- **less use of chemicals.**
- **clearly shorter overall length of the system compared to conventional methods of construction.**
- **considerable lower energy costs because of the smaller baths surfaces and lower temperature.**
- **fully automated control of the system through fine-tuning of chemical measures according to the ampere-hour used.**

Basis of Operations

First of all, the method is based on the well-known principle of chemical zinc phosphating: hydrogen is discharged on the wire because of the pickling. The result is iron phosphate, zinc phosphate is deposited on the wire. With the electrolytic method, the pickling is obsolete, and so are the discharge of hydrogen and the formation of sludge. Under direct current with a voltage of about 10 volt, the voltage for the disintegration of zinc phosphate is reached. Zinc phosphate or zinc calcium phosphate is deposited on the wire in microcrystalline form because of the electrically induced substance discharge. The amount deposited (g/m^2) is proportional to the current density that is selected (A/dm^2), i.e. it can be controlled via the current. However, the current density can only be increased to the point where the voltage for the disintegration of hydrogen is reached. From that point onward, the current energy that is still supplied is used for hydrogen formation on the wire, which is not only of no importance for the process, but actually damaging with respect to the abrasion strength of the phosphate layer. It is of crucial importance for the stability of the deposit of substance that the phosphate bath is kept constant, especially with a view to the pH value as this value has a direct influence on the deposit value $K=g/_{AS.}$
If an ampere second deposits a certain amount of substance under given circumstances, the bath can easily be controlled via a fine-tuning that depends on the ampere-hours.

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It is possible to add an accelerator to control the pH value, thus adjusting a possible surplus of free hydrogen.

Details about the System

The so-called Ephos system is a 36-strand electrolytic zinc calcium phosphating system for steel wire of 1,3 to 3.0 mm diameter that is then drawn to 0.8 Ø mm while dry and to 0.18 Ø mm by fine (wet) drawn. The system is in line with a patenting system so that the 36 strands will receive different level weight as well as the different diameters and speeds for each forming step. These circumstances necessitate a rather complicated electric control, especially since the current has to adjust itself without manual control when the strands are differently loaded. The voltage (volt) of the 3 separated circuits is set only once and does not need any further regulation. The entire system consists of a H_2SO_4 activator, rinse, phosphating, rinse, lime bath and air strip-off to dry. It works fully automatically, also with respect to the chemicals – fine-tuning. Since all the baths function according to the flood method, it is no problem to add wires in a final process. The entire length of the plant is just 7,300 mm. With bath temperature of only 50 ºC, the operating costs saved are more than 100,000 €, including the lower consumption of chemicals and the avoidance of sludge. Even the investment cost for this system are lower than for the chemical method, since the system is not only smaller, but also manufactured as a single-wall plastic construction.

The heating of the baths is effected via electric immersion bath heaters. The microcrystalline zinc calcium layer, which is only reached by the electrolytic method, effortlessly resulted in an increase of 20% drawn speed in a dry drawing with less abrasion of the drawing die. The fine drawing proved to yield similarly good results when criteria well known to wire-drawing such as rolled wire descaled and pre-drawing are taken into account. Especially in mechanic descaled, the wire surface should not be too rough so that there can be builded a pressure in the lubrication film of the drawing die during fine drawing (comparable to “aquaplaning”), thus keeping the friction force low.

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