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A new concept for desoaping – galvanizing lines

This article presents a new concept for cleaning wiredrawing soap residue from wires (Desoaping) in preparation for hot-dip galvanizing. This recent development by the company Sirio Wire will be explained through the results of their work at the company Swedwire, a Swedish producer of galvanized steel rope. In particular, this article will focus on the benefits that have been realized in terms of energy savings and improvement in working conditions. Sirio Wire srl are specialists in the design and manufacture of chemical treatment systems for wires.

A classic desoaping - galvanizing line consists of :
- Desoaping by molten lead bath (or in very few case an open fired furnace or a fluidized bed)
- Water-quenching bath
- Pickling bath (typically HCl)
- Rinsing (multiple steps in some cases)
- Fluxing
- Drying
- Hot-dip galvanizing in molten zinc bath

The first step in the lead bath is customarily, but incorrectly, called “desoaping”. Because the lead is normally at a working temperature of approximately 450°C, it is not removing the soaps from the wires but simply burning them in place. The HCl pickling that follows actually removes the burned soaps and the oxide present on the wire. Finally, the rinsing steps dilute the residual acid present on the wire and the flux bath prepares the wire for the hot dip galvanizing process.

This process presents several concerns for wire manufacturers, specifically:
- Lead bath operation is regulated due to health and environmental concerns
- High energy consumption to keep the lead bath molten
- HCl acid bath presents maintenance and operational concerns in controlling corrosive and hazardous fumes. Furthermore, neutralizing the rinse waters is expensive.

Chemical desoaping has been an interesting alternative to the lead bath for a number of years. Two types of technologies can be proposed for this scope: ultrasonic cleaning or electrolytic cleaning.

The best results of desoaping of the dry drawings lubricants are obtained with electrolytic cleaning in alkaline solution or ultrasonic cleaning in phosphoric acid based solution. Both technologies can adequately replace the lead bath and improve the cleanliness and performance of the product.

Let’s briefly review the two technologies:

Ultrasonic cleaning is the use of high frequency sound waves to provide a mechanical ‘scrubbing’ of the wire surface. The mechanical action is due to a process called cavitation where micro-size bubbles form, grow and implode due to alternating positive and negative pressure waves. Just prior to the bubble implosion, there is a tremendous amount of energy stored inside the bubble itself. When the implosion event occurs near a hard surface, the bubble becomes a jet, which travels at a speed of approximately 400km/h towards the hard surface. Because of the inherent small size of the jet, ultrasonic cleaning has the ability to reach into small crevices removing entrapped soils very effectively.

The **basic components** of an ultrasonic cleaning system include some ultrasonic transducers, an electrical generator, and a tank containing the cleaning solution. The ultrasonic generator creates the high frequency electrical impulses required to drive the transducers. The higher the frequency, the smaller the bubbles created during the cavitation will be. The transducers consist of PZT elements (Pb-Zr-Ti), which convert the electrical energy into mechanical vibrations by piezoelectric action. The transducers are located inside a watertight stainless steel box submerged in the cleaning bath just below the wire field. A watertight cable connects the transducer assembly to the generator.

The working **temperature of the bath** has a profound effect on ultrasonic cleaning effectiveness. In general, higher temperatures will result in higher cavitation intensity and therefore better cleaning. However, if the solution temperature nears the boiling point, the liquid will boil in the negative pressure areas of the sound waves, thus reducing or eliminating the cavitation effect. A working temperature around 60°C (140°F) offers an excellent compromise.

In the **electrolytic process**, the wire is passing through an electrolyte in a processing zone divided in different chambers. Electrodes are located in each chamber and adjacent electrodes are connected to opposite poles of a direct current supply source. Electrical current is constantly passing between the electrodes in the adjacent chambers through the electrolyte and the wire while the wire is travelling through the chambers in the processing zone. In this way, the wire is alternately polarized negatively and positively as it travel trough the processing zones. The migration of ions of the electrolyte as a result of the polarization will cause chemical reactions to take place quickly at the surface of the wire resulting in formation of hydrogen or oxygen bubbles. Because the bubbles are formed at the actual surface of the wire, beneath the layers of soap and dirt, they will tend to mechanically lift the material away from the wire.

As previously mentioned, replacing the lead bath by an ultrasonic or electrolytic cleaning bath has already been applied successfully in different plants. For the new concept in our particular case study, we had a second goal: the complete removal of the HCl pickling bath.

At Swedwire, the wires are coming from dry drawing machines located in the same building as the galvanizing line. Therefore, the wires are free from oxide (rust) at the entrance of the line. If the wire is free of oxide coming to the line and we are no longer creating oxide on the wire in the lead bath or furnace, there is no longer a need for the HCl pickling bath. After desoaping the wires in a low acid bath, such as the phosphoric acid used in the ultrasonic cleaning system, no additional surface activation is required for proper galvanizing.

We can in fact replace the lead bath, the quenching bath and the HCl pickling bath by only one bath: the ultrasonic cleaning bath of a phosphoric acid based solution. The advantages in terms of ecology and energy savings are substantial, as we will describe herein.

After the cleaning operation, it is necessary to thoroughly rinse the wire in order to remove any chemical residue. To achieve a superior rinsing effect along with efficient use of rinsing water, we incorporated a final rinsing section with 5 counter-flowing rinsing baths. Sirio Wire has developed a special system working with water under pressure allowing the optimum rinsing effect. Furthermore, all Sirio Wire equipment is provided with special mechanical drop traps and very effective air wiping devices to minimize the liquid drag out between baths. As we had liberated lots of space on the factory floor by removing the lead bath and HCl pickling, the extended length of the rinsing section presented no problems.

Because of the special design for efficient water use, fresh water is added in the last rinsing step only. Overflow from each rinse tank flows into the previous tank. And, since the ultrasonic cleaning bath operating at 60°C requires significant makeup water due to evaporation, this water is taken from the first rinse tank. This system allows the complete cleaning operation to function with zero rinse water effluent. The neutralization/treatment plant that was required to treat the HCl pickling rinse water is no longer required. This offers substantial savings in terms of operation cost. .

Case study : Swedwire AB – Varberg - Sweden

Swedwire is a company producing galvanized steel products since 1917 near the harbour in the medieval city of Varberg, at the heart of Sweden's west coast. Their main specialty is the production of galvanized steel rope used for road barriers.

Swedwire had a galvanizing line constituted of an electrically heated lead bath, one quenching bath, one HCl pickling, rinsing and fluxing bath working with 25 wires in the diameter range 1,5mm – 4,5mm. (0.059" – 0.177") The operating speed of the line was limited by the length of the HCl pickling bath. The first step was to install and operate a single-wire pilot plant for 6 months to prove the feasibility of the project. During the summer of 2008, the complete desoaping/pickling line was replaced by one ultrasonic cleaning line with 5 rinsing steps.

A calculation of the **return on investment** for the line has been made considering the following:

In the old line:

	Approximate Annual Consumption
Lead	10 Tons
HCl Acid	100 Tons
Energy	700 MWh
Water	3.000 m^3 (790,000 gallons)
NaOH	minor amt.-scrubber

In the new line:

	Approximate Annual Consumption
Phosphoric Acid	12 Tons
Energy	250 MWh
Water	600 m^3 (160,000 gallons)

The actual pay back for any particular line will of course depend on the local costs of energy and consumables. In all practical cases this is a very agreeable Return On Investment calculation. Coupled with the lower total operating cost, in this particular case, the total production capacity of the line has been improved by ~50%. The final result is a huge potential reduction in costs per Ton produced. In addition to the monetary savings, the improvement in working conditions for the line operators has been incalculable.

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When ecology concerns and energy savings are the focus of every wire producer, this case study shows us that innovation is the key to success.

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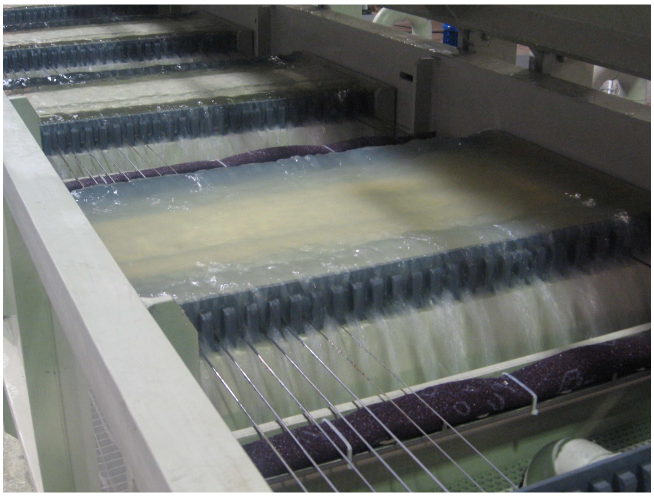
View of the old line

View of the new line

View of the ultrasonic section



View of the rinsing section