Rod to Galvanized Wire, Non-stop

Abstract:

This paper will describe a rare process in which carbon steel wire rods proceed rapidly, automatically, and continuously through a galvanizing and drawing process, non-stop. The process is pollution-free, energy-efficient, and requires only one operator, substantially less than the traditional multi-step processes for galvanizing wire. The integration of continuous rod payoff, blast cleaning, induction heating, MHD galvanizing, quenching, wiredrawing, and coiling or spooling, provide an efficient continuous process for galvanized wire manufacture.
Rod to Galvanized Wire, Non-stop, An Update

Presented by Victor Dorsten and Lorenzo Fachinelli, March 2010

This paper describes a modern process in which carbon steel wire rods or wire, 4.0 to 12 mm diameter, proceed rapidly, 1.7 to 5.0 M/sec, automatically and continuously through a galvanizing and drawing process, non-stop. What’s more, the process is pollution-free, energy-efficient and requires only one operator, substantially less than the traditional multi-step processes for galvanizing wire.

The skillful integration of continuous rod pay-off, blast cleaning, induction heating, MHD galvanizing, quenching, wire drawing and coiling or spooling, all managed by touch-screen PC, provide a truly efficient continuous process for galvanized wire manufacture. This paper presents the details of, and principles behind the process elements:

- High speed continuous rod pay-off with regenerative back tension
- Pollution free blast cleaning and rod surface profiling
- Energy efficient steel heating in a protective atmosphere
- MHD (MagnetoHydroDynamic) galvanizing and coating control
- Regulated high speed heat removal from zinc and steel
- In-line wire drawing and process speed control
- High speed continuous coiling or spooling
- Process management by touch screen computer

This paper also presents product capabilities and process benefits.
Rod to galvanized wire, line composition:

The Process begins with a payoff ensemble that reduces tangling and provides a very smooth and continuous payoff operation at high speeds. For low carbon rod a vertical payoff and for high carbon a horizontal payoff are shown below.

![Fig. 1 Payoffs](image)

This unit can host two coils of up to 3000 Kg each. on each stem. The two stems are controlled by a hydraulic unit and they can be lowered in an horizontal position to load the new coils. This operation can be done while the full stem is in the vertical position and the rod is being paid off to the line. Often, at high speed, the rod coil wraps tend to come off the stem two at a time. They have no time to stretch and run smoothly into the downstream process. In this case, the height of the high guide pulley permits the coil to extend before it reaches the upper pulley thereby reducing tangles. Also, before entering the upper pulley a rod tangle detector will stop the line before a bad tangle reaches the upper part.

To further reduce any down time caused by tangling, the Continuous Rod Payoff is followed by an accumulator which provides time to slow down the line. This allows the operator, who hears the alarm, to disengage the tangle before the line stops. To aid threading the accumulator, the upper pulleys are connected to an air cylinder that comes down near the lower pulleys by pushing a button.
The next equipment is the pulling capstan which pulls the rod from the payoff and assures a constant minimum back tension on the rod through the rest of the Process. See Fig. 3. The capstan drive is the regenerative type so that the braking energy needed to achieve rod tension is not wasted but, put back into the electrical system. The synchronization between the pulling capstan and the first block of the drawing machine is very important.

![Fig. 3 Pulling Capstan](image)

Good tension control promotes good rod surface preparation and homogenous coating of the material before going into the inline drawing process. The design of the capstans is such that no slip is generated at the exit of the last groove of the capstan and correct back tension is maintained. Mechanically descaled materials can cause the surface of the capstans to prematurely wear. So, the surface of the grooves are heat treated to avoid such wear.
Blast Cleaning and Surface Profiling

A multi-wheel blast machine is located in-line with the other components of the process where it performs the descaling and surface profiling operation. The rod is fed through guides into the entrance of the blast machine where it passes horizontally and taut, through the blast zone. The rod is exposed to the effects of intense high velocity bombardment by the media working mix. It is here that the descaling work of the blast machine is carried out.

The blast media is one of the key elements for descaling and achieving the desired finish or roughness on the surface of the rod. Properly executed blast cleaning of wire rod not only removes scale and rust from the steel surface, it also creates the profile of peaks and valleys on the rod surface. These peaks and valleys can be mathematically characterized and measured with a hand held device called a profilometer.

See Fig. 4 diagram which illustrates the profilometer Rz parameter.

Fig. 4
Rod diameter and carbon content and desired Process speed dictate the blast machine configuration. For multi-wheel machines the blast wheels are typically arranged radially and sequentially about the rod centerline. Thus, a 3-wheel machine mounts the blast wheels at 120 degrees angle to each other. Often intensifier plates are arranged at the blast wheel. The intensifiers funnel the media from the blast wheel onto the rod thus ensuring that the optimum energy usage is achieved, in some cases further reducing the horsepower requirements. In rod machines the intensifiers are designed to be adjustable where they can be narrowed or widened to suit the diameter of the product passing through the blast machine.

Also, where line speed or rod rust levels dictate, looping sheaves are utilized. The addition of looping sheaves to the blast machine allows passing of the rod through the machine 2, 3, 5 or 7 times to achieve a cleaner product and/or to increase the line speed. Looping sheaves can effectively double or triple the line speed through a blast machine with no increase in horsepower requirements.

**Induction Heating**

The rod now enters an induction heating coil which is fitted with a gas filled liner tube. The tube is filled with a nitrogen/hydrogen atmosphere to prevent oxidation as the rod is heated to annealing or galvanizing temperature. The induction heating system is matched in power and frequency to suit the range of rod diameters and desired process speed. The pictures below show a typical induction heater coil and power supply.

An infrared thermometer is employed to measure rod temperature and report same to the heater control.
In-line Annealing

When requested, the MHD Galvanizing line may include the induction heating capacity to achieve annealing temperature for drawn and cleaned wire. A subsequent TNz cooling system, Fig. 5 reduces the product temperature to that required for galvanizing. Thus no heat energy is wasted in the process.

Fig. 5

MHD Galvanizing

The MHD Galvanizing Machine, including its crucible furnace, magnetic coils and support equipment is shown in Fig. 6. Here the heated rod passes horizontally through an aperture in the side of a crucible containing one ton of molten zinc or zinc-aluminum alloy. The molten metal wets the profiled rod surface and forms a very thin Fe-Zn alloy layer to which the free zinc adheres.

The rod exits the crucible through an aperture on the opposite side. Both inlet and exit apertures are equipped with magnetic coils which seal the molten zinc in the crucible. A typical MHD coil is shown in Fig. 7.

Fig. 6
Additionally, the exit coil controls the coating thickness of the zinc as the rod leaves the crucible. When high power is applied to the exit coil, the magnetic wiping pressure is high and the coating is thin, e.g. 150 gm/sqM. When the power applied is low, the lower wiping pressure allows more zinc to pass with the rod and thicker coating results, e.g. 600 gm/sqM.

Fig. 8 illustrates the typical relation of wiping power to coating weight. Table 1 compares coating weight control for several wiping methods on various sizes of rod and wire. The data shows the MHD process offers superior coating weight control compared to the gas gravel and nitrogen wiping that is commonly associated with classical galvanizing.
The galvanizing machine is compact, measuring only 3 meters length. It is equipped with a semi-automatic zinc ingot feeder and automatic zinc level control. This combination replenishes zinc carried out on the rod and raises or lowers the zinc level when the line is started or stopped. Because the Process requires only one ton of molten metal, it is easy to switch the coating material from zinc to other alloys, such as Galfan, and back to zinc. When the system is idle, only 4 kW is required to maintain zinc temperature in the well-insulated furnace.

**Cooling the Rod**

The coated rod next enters a 33 meter two-stage triple-pass coolant-filled trough where the zinc is cooled to freeze at a controlled rate and then cools the steel to safe handling or drawing temperature. To conserve floor space the trough system is an over / under loop back design. Heat is extracted from the system through heat exchangers so the product contact coolant is in a closed loop, thus non-polluting.
A simple air wipe dries the rod and it then passes a laser micrometer. The Process management computer integrates the real time rod diameter, from the laser, with line speed to report and archive the production in tons per hour. This feature also provides for global measurement of grams zinc consumption per square meter of product.

In-line Wire Drawing

The in-line wire drawing machine has been carefully engineered to accommodate a wide range of galvanized rods from 5.5 to 12 mm and finish diameters from 2.3 to 5.0 mm.

The first die holder is a rotating unit. Being that the rods supplied to the producers tend not to be round, a rotating die on the first reduction is important to create a better and homogenous deformation of the steel and the zinc layer. Lubrication also benefits by creating more uniformity around the wire and giving a better flow of the wire through the die.

The first capstan of the drawing machine works as the pilot of the line to maintain constant speed through the galvanizing portion of the Process. The other blocks can be bypassed accordingly with the drawing practice used.
High Speed Continuous Coiling

Continuous wire packaging is done with a horizontal axis drawing coiler with pattern lay system. The horizontal coiler guarantees a very dense and compact package formation. The machine is equipped with die holders suitable for 55 x 32 mm dies and die cooling is direct by water. The accumulation system is by elevation of a goose neck, pneumatically operated. Capstan water cooling is by “Turbo Cold” pressure system, with water flowing through central shaft. Machine is provided with steel guards that totally enclose the flyer. Synchronization with the rest of the line is by independent dancer arm.

Touch Screen Process Management

All of the Process subsystems, from Payoff to Coiler, are connected by a field bus network to a master touch-screen industrially-hardened computer. Thousands of input/output control points are monitored and managed, real time, and important information is displayed on operator friendly screens. Such software allows easy product set-up and instant system fault diagnosis. What’s more, with wireless communication, useful production data can be instantly communicated to support departments.
**Product Capabilities**

The Process has the flexibility to apply zinc or Galfan. The Process utilizes ceramic materials for all components touched by molten metal. This feature not only increases component life when applying zinc, but permits the application of Galfan. Galfan is the zinc-aluminum alloy that offers superior corrosion protection for wire. When molten however, Galfan is highly corrosive to steel pots and containments. The ceramic components are impervious to molten Galfan.

Table 2 lists the wide variety of products that can be transformed directly from rod to wire using the Process.

<table>
<thead>
<tr>
<th>Rod Dia.</th>
<th>Chemistry</th>
<th>Coating Wt. gm/sqM</th>
<th>Coating</th>
<th>Drawn to Dia. Wire</th>
<th>For Product</th>
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<tbody>
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<td>5.5mm</td>
<td>C1006</td>
<td>210</td>
<td>zinc</td>
<td>2.3mm</td>
<td>Vinyl chain link</td>
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<td></td>
<td>&quot;</td>
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<td>&quot;</td>
<td>3.3</td>
<td>Tite-lock ag. Fence</td>
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<tr>
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<td>412</td>
<td>&quot;</td>
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<td>Comm.chain link</td>
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<td>&quot;</td>
<td>335</td>
<td>&quot;</td>
<td>3.7</td>
<td>Mine mesh WWF</td>
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<td>&quot;</td>
<td>335</td>
<td>&quot;</td>
<td>4.8</td>
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<tr>
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<td>zinc</td>
<td>8</td>
<td>Supermarket trolleys</td>
</tr>
</tbody>
</table>

**Coating Characteristics**

The MHD Process offers advantages of coating quality over classical hot dip galvanizing. Because the molten zinc is in contact with the hot steel for only 0.3 seconds (compared to 10 or more seconds by conventional methods) before it is quenched, the coating's characteristic Fe-Zn alloy layer is much thinner than its traditional counterpart.
Because Fe-Zn alloy is less ductile than free zinc, the thinner Fe-Zn layer improves wire drawability and formability. Also the wire’s corrosion resistance is superior as a result of more free zinc per gram of coating weight. Fig.9 illustrates this performance by salt fog comparison.

**Figure 9**
- A is classical galvanized, 120 hours
- B is MHD galvanized, 120 hours
- C is MHD Galfan, 220 hours

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**Environment Friendly**

The absence of acid, acid rinse water and flux in the Process eliminates the expense of waste treatment and disposal cost of hazardous materials.

**Lower Process Costs**

The Process offers lower operating costs than conventional galvanizing:

- Fewer man-hours are required to operate the Process.
- Material and energy costs to maintain only one ton of zinc, instead of 50 or more, are lower than traditional wire galvanizing.
- Low nitrogen consumption compared to conventional gas wipe methods.
- Zinc dross and oxide losses are typically less than one fourth the losses of conventional systems.
- 3 kW or less will maintain the pot temperature when the system is idle.

**Summary**

The MHD Process offers an innovative approach to the production of galvanized and Galfanized steel wire. The Process creates a wire with superior formability and corrosion resistance and is nonpolluting and energy efficient. Capital and operating costs are lower than traditional hot dip galvanizing.

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