

# TECHNICAL ACHIEVEMENTS IN WIRE-ROD PRODUCTION: TECHNOLOGIES AND PROCESSES OF THE H<sup>3</sup> SYSTEM<sup>1</sup>

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## Abstract

Since the beginning of the 2000s the technologies and methods used to produce wire rod have undergone significant changes. At the same time, machine builders have been racing to provide the market, and specifically their customers, with innovative, reliable solutions backed by continuous research and development and new, advanced engineering materials and solutions processed by more evolved automation systems. These new concepts have led our customers to invest (or to optimize their investments) because they believe that the market will continue to grow once this current economic crisis is over: they sense the urgency to find innovative solutions, together with the mill equipment suppliers, in order to increase the quality of their products with considerable energy savings and enhanced performance. Danieli, as a world leader in the construction and installation of large steelmaking plants, has made great strides in helping and supporting its customers, and/or prospective customers, to reach the standards set by world markets. This article aims to focus primarily on the methods, machines and the processes used in the production of high-quality wire rod.

**Key words:** Wire rod mill; H<sup>3</sup> system.

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# 1 FROM REHEATING FURNACE TO COIL FINISHING SYSTEMS ... GREAT CARE APPLIED TO EVERY PHASE OF THE WIRE ROD PROCESS: IMPROVEMENTS AND OPERATING RESULTS

## 1.1 Reheating Furnace

Since the start of the recession there has been an increasing level of discussion about energy savings and innovative, technologically advanced materials, with the single goal of limiting or eliminating the operating costs of steelmaking plants, in addition, obviously, to the protection of the environment. Danieli, through its Danieli Centro Combustion division, has consistently improved its product, making it a winner in terms of production, quality and consumption. As a result, our customers are able to be even more competitive, gaining unexpected niche markets that were not previously anticipated. One of the many examples of this research and development was the design and construction of a billet reheating furnace in the two-strand wire rod mill installed at Ferriere Nord in 2005. The furnace had been conceived to charge cold or warm billets. It was then expanded to include hot charging, which means billets can be handled and charged into the reheating furnace at a starting temperature of 800°C. From its initial phase, the furnace designed by Danieli Centro Combustion together with Ferriere Nord was intended to reheat billets from ambient temperature to 1,200°C, with a production rate of 150 tph. Thanks to continuous improvements made since its startup in January 2006, the furnace has exceeded a steady 200 tph in hot charge mode, actually increasing capacity and production at the same time.



**Figure 1.** Ferriere Nord RHF.

This result is also due to a high level of automation, resulting in a significant drop in gas consumption and, consequently, scale content. Various software programs used in both design and management made it possible to reach excellent recorded values of 30 Nm<sup>3</sup>/t of gas consumption in cold charge mode, and 0.6% scale produced at 160 tph; to simulate the furnace profile; and to optimize the various reheating curves of the charging temperature, the required discharging temperature, and the types of materials charged in terms of section and quality, and by means of FEA and FVA analysis, the critical construction points of the furnace and all its components. What's more, the furnace's particular design and construction entails low temperature dispersion, which keeps its operating efficiency high.

## 1.2 Rolling Units – From SHS Stands to the New SHS<sup>Plus</sup> Stands: the Evolution of the Species

The rolling units are absolutely the best selling items in both traditional “open” rolling mills and in modern continuous mills. To date, Danieli has manufactured and installed more than 8,100 cartridge stands, which were originally developed, designed and patented by Morgårdshammar in 1948. The new SHS<sup>Plus</sup> rolling stands follow the SHS “Star Housingless Stands,” which were modified considerably with both structural and functional changes, resulting increased safety and operating rates. The stand was designed with a higher safety factor and protected on all sides to contain any material outflow (cobblestones, water splashes, etc.). This solution secured operator safety in the rolling area, minimizing the accident risks to zero.



Figure 2. SHS<sup>Plus</sup> in operation at ABS – Italy.

The cartridge design was optimized and most of the external tubes for media connection (water/air/oil). This means that the assembly time for hoses is more than 50% shorter. Substantial changes were made to the spindle design. The new stands are the sturdiest ever built, providing customers with 20-30% more operating advantages than the SHS stands, in terms of type and manufacturer.

## 1.3 Rolling Units –ESS/ESC, Energy-Saving Stands and Energy-Saving Compact

The ESS/ESC units are a sound alternative to cartridge stands. Facts show that to date Danieli has built and installed more than 1,000 since 1972. The ESS/ESC stands provide significant advantages in terms of installation, investment costs and operating costs. Installing ESS/ESC in a plant results in the following savings:

- 20% in structures for buildings
- 40% in length (referring to rolling mill length)
- 30% in civil works and foundations
- 25% in construction and start-up time
- 10% in electric power consumption

ESS/ESC stands are available in nine sizes, featuring rolling ring diameters from 250 to 920 mm, in horizontal and vertical arrangements. (For smaller ESS/ESC sizes, a Convertible H/V configuration is also available).

## 1.4 WRB Pre-finishing Block

The latest generation WRB Wire Rod Block is equipped with cutting-edge finishing-rolling technology for producing high-quality wire rod and small-size bars at ultra-high speed and low operating costs. Since 1975, more than 250 high-speed blocks for bars and wire rod have been installed and successfully commissioned by Danieli, 167 of which have been “Delta” type blocks. In recent years the Danieli workshops have been working over capacity, making more than one finishing block per month for the most varied markets. This means that our experience at fine-tuning over the years has enabled us to establish this type of machine and its performance in terms of reliability and duration, thus confirming our leadership in the field of high-speed wire rod mills. Some impressive examples are the speed record of 126.6 m/min. reached at Nucor Steel Arizona with a 5.5-mm round, the installation of new bearings on the modules to ensure speed, and high work loads and stresses, with a 50% longer lifetime.



**Figure 3.** 4-stand and 2-stand PFB Blocks in operation at Ferriere Nord Italy and Angang Anshan I&S P.R. Of China.

Ferriere Nord: another example of efficiency and reliability. Installation of the first Danieli wire rod blocks in the second half of the 1970s, in operation until the beginning of 2003. These stands were replaced with two of Danieli’s high-speed Delta-type blocks, as they had become obsolete because of the new speed and rolling conditions. This occurred after 30 years of valuable service. The same thing happened to the rod mill at Ori Martin, whose block was replaced due to new operating requirements. These are examples of reliable machines used by customers all over the world in the harshest operating conditions. The DWB finishing blocks are assembled and started up on the site according to the “plug-and-roll” concept. We have recently implemented the multiple-drive concept on the finishing block, in synergy with Danieli Automation, and developed a new ring-changing robot for fast changes under 1 minute for each pass of the block.

## 1.5 2012: A “youngster” joins the WRL family....The CSB High-Speed Compact Sizing Block

The CSB Compact Sizing Block developed by Danieli was created to improve the properties of the final product (tight dimensional tolerances, finished product quality) and up the current speed of 110 m/s to the industrial running speed of 130 m/s. This means highly repeatable dimensional and geometrical tolerances, thanks to a roll pass designed specifically for the finishing/sizing block with independent

drives/motors for an ideal overspeed setting for each section, as well as less out-of-tolerance turns due to:

- Smaller center distance between prefinishing and sizing blocks
- No need for guides between prefinishing and sizing blocks (possible cause of cobbles at high speed)
- Tension optimization thanks to sizing block independent drives
- Possibility of variable reductions on the finishing pass
- Possibility of reducing the number of leader passes
- Possibility of using rings of various diameters
- Possibility of controlling tension on the rolled stock tail
- Possibility of intensifying cooling between the prefinishing and sizing blocks

The automation and control systems developed by Danieli Automation played an important part in this project. All the devices controlling the cross-section of the rolled stock, installed at the entry/exit of the prefinishing block on both lines, ensure that the cross-section of the rolled stock is kept constant. The gap is closed frequently and micrometrically on the entire cross-section of the rolling mill thanks to the high level of automation. This allows the operators of the Ferriere Nord wire rod mill to roll in a consistent, stable and precise manner without encountering major changes in cross-section, tension or speed. This type of operation lengthens the life of all the guides, reduces the number of rolling accidents and above all enhances the quality of all the rolled stock in each plant area, thus ensuring a finished product with a high level of quality. The wire rod mill is run in strict compliance with reheating, rolling and heat treatment schedules for each section and type of material and finds its ideal application in existing mill modernisations.



**Figure 4.** The CSB in operation at Ferriere Nord – Italy.

In the wake of these new developments, the CSB has gone straight to the heart of the wire rod market, with positive feedback flooding into the extensive Chinese market, and culminating in the order recently awarded to Danieli by the Yuxi Xianfu Iron & Steel Group based in Yuxi, Yunnan Province – P.R. of China, for a new machine to be installed in the existing wire rod mill.

### **1.6 The Core of the high-speed wire rod process: TMB-Twin Module Block® and Multiple drive technology**

Based on our experience in manufacturing and installing wire rod finishing blocks, about 10 years ago we decided to present and launch the Twin Module Block, and then less than one year ago the evolution with the ultimate technology in wire rod sizing solutions with multiple drive configuration, to achieve ultra-high finishing

speeds for a wire rod range extended to smaller sizes with higher plant efficiency, better material yield, stricter product tolerances, and lower production costs. Why did we design the TMB? What did we do to make it so innovative?



**Figure 5.** The Twin Module Block in operation at Zhangdian I&S – P.R. Of China.

First, we designed the mill to give our customers the possibility of producing steels with tight dimensional tolerances and making fast, efficient production changes, with limited investment costs. The TMB is the ideal solution for quality wire rod production and is possible to increase both Quality and mill Efficiency applying the Low Temperature Rolling down to 750°C. This, together with the achievement of excellent size tolerance ( $\pm 0.1$  mm with 50% Ovality) and the single pass family concept. All the production changes are concentrated in the TMB thanks to quick changing device granting production changes in less than 4 minutes.

For the electrical point of view we do the following actions:

- Having a motor that is able to control each pass;
- Optimizing speed between oval/round and optimizing interstand tension for each profile (less ring wear);
- Splitting up the ring family to save on the number of rings in circulation and their re-machining;
- Absolute improvement in reaching tolerances;
- The electrical advantages, including low-voltage motors similar in size to those of the rolling mill, without special medium-voltage transformers. Consequently, there is a considerable reduction in capital spares.
- Installing air-cooled motors that are easy to find, even in non-European markets
- Easy-to-install motors and drives requiring no specific know-how/training, thus saving on maintenance/service. Therefore, the cost per kW is considerably less (-15%), but there is more installed power (+20%)

### **1.7 HSS High-speed Shear and LLH-Loop Laying Head**

The latest generation shear is designed for head and tail trimming of 5.0-mm to 27-mm-dia wire rod, at speeds of up to 120 mps (design speed 130 mps) for both plain and deformed water-quenched/self-tempered wire rod. The latest generation Danieli high-speed shear features a series of advanced design characteristics that make it superior to any similar machine available today. Its particular features and associated benefits are:

- Unbeatable unit compactness (only 2700 mm of overall dimensions)

- “Single-pair blade-holder / single-drive” design, enabling cropping and chopping operations to be carried out by the same pair of blade holders.
- Advanced blade locking/centering system with faster blade changing (only 12 minutes of actual recorded time to replace the entire blade set)
- Latest-generation “short-stroke” electrically-actuated diverter. The new diverter design was one of the key elements in developing the second generation HSS shear as it enabled:
  - Reduction of deviation angle amplitude (reducing friction and minimizing wear on diverter and conveyors).
  - Shorter deviation cycle, enhancing operation synchronism and efficiency well beyond the design speed.
  - Significant reduction in blade width.
- Narrower blade-holder, only 90 mm, less than half of other shears, resulting in:
  - better operating efficiency;
  - less friction on guiding elements with lower wear rate;
  - reduced noise levels at the highest speeds.

Research and development focused on all areas of the high-speed wire rod line, particularly the loop layer. This new design has created a machine that is unprecedented in terms of reliability, noise level and coil formation. The use of sophisticated programs for solid 3D and finite element modelling has enabled the development, construction and successful startup of the latest edition by Danieli: an oil-film loop layer that is capable of working uninterruptedly at extremely high rolling speeds (over 140 m/s), guaranteeing perfect coil formation and limiting vibrations, with values declared by customers of less than 1 mm/s!! It can also accommodate the latest generation rotors and loop-laying tubes that, thanks to the new geometry, reduce tube consumption by more than 15%, with a significant reduction in the changing time of both tube and rotor.



**Figure 6.** The HSS-High Speed Shear in operation at Ferriere Nord – Italy.

## 1.8 Loop Laying Head

Today, the latest developments in loop laying technology ensure a superior coil pattern and an optimised laying pipe wear rate with absolute operating stability and vibration-free operation at production speeds of up to 140 mps.

The traditional laying head concept has radically changed with the application of the following innovations.

## 1.9 The Patented “Oil-film Bearing” Laying Head

The latest generation laying head features a unique “oil-film bearing” patented design for rotor support (instead of traditional roller bearings) that provides absolute stability during operation, lower wear, and extended life of the laying pipe, as well as minimized maintenance.

A very sturdy advanced design ensures an optimal response even in highly unbalanced conditions, and vibration-free operation at full speed.

The number of balancing operations is therefore drastically reduced.



**Figure 7.** The latest generation LLH in operation at Angang Anshan I&S – P.R. Of China.

This innovative technology is available with all new Danieli laying heads, and can easily be applied to upgrades of existing units. The rotors are optimized and designed for very high speeds (170 m/s design speed and 150 m/s in constant operation) with very few vibrations (less than 2 mm/s at a speed of 120 m/s). This proves that thanks to the use of calculations and three-dimensional checking of the machines in the design phase, the loop laying heads can reach unparalleled performances and first-rate finished product quality, with very low consumption in the loop laying pipes and less need for spares (i.e. oil film bearings .... no need for anti-friction bearings). Through research and development, Danieli has created a pipeless loop layer that offers numerous advantages for operators, which can be summed up as follows:

The newly designed pipeless rotor does away with 60 worn pipes...meaning reduced maintenance and downtimes. It ensures repetitive loop formation with steady, regular laying on the Controlled Cooling Conveyor and reduced noise level (86 dBA vs. 110 dBA) compared to the traditional LLH. Further benefits are diminished unbalance vibrations due to axial-symmetrical wearing and predictable and controllable wearing results, with no cobbles due to unexpected pipe wear.

## 1.10 The DSC System, from the water lines to the wire rod cooling conveyor: EDC and UFG, the new technologies for producing quality wire rod

## 1.11 WCL – Water Cooling Lines - Different and possible installations on DSC system

Latest design of fixed, shiftable, remote-controlled or rotating water cooling line (RotoCooler patented) with a pre-mounted set of cooling elements. This enables fast, accurate changing procedures (less than 2 minutes) according to the product being rolled, to reduce operating downtimes and improve plant efficiency.



> Benefits:

Perfect and guaranteed alignment

Time saving on setup changes= 55-58 minutes.

> Traditional = 60 minutes, RotoCooler patented = 2 minutes.

Today, in-line heat treatments are already widely used on many wire rod, bar, spooler and bar-in-coil mills. The last few years have seen intensive research and development aimed at perfecting treatments to reduce total transformation costs (meltshop + rolling mill + downstream equipment).



**Figure 8.** The latest generation Water Cooling Boxes.

By making minor additions or changes, a series of machines and innovative in-line treatments can be integrated into the layout of Ferriere Nord, as described below:

“Cold skin” rolling (also referred to as UFG = Ultra Fine-Grained Treatment) used in the production of steels for reinforced concrete. This treatment involves cooling in the optimum range for low-temperature rolling and then rolling, leaving a minimum equalization space between cooling and final deformation. It is already widely used in plate production, and is being optimized for long products as well. It consists of intensive cooling of the wire rod surface before the last rolling passes. The surface of the material is rolled at a particularly low temperature while the core is still hot.

This treatment allows you to obtain a very fine surface microstructure and enhanced final mechanical properties. The microstructure in the core is similar to that of a steel rolled at high temperature.

This process enables you to significantly reduce transformation costs in the meltshop, and to optimize the chemical composition of materials by improving their mechanical properties.

Cold skin rolling requires that a new generation fast finishing (sizing) block be inserted into the layout as well as some additional waterboxes.

The addition of a new rolling block will also provide substantially improved dimensional tolerances. The tolerances that can be reached without difficulty are in line with those of the best specialty steel plants ( $\pm 0.1$  mm with 70% ovality for all products).

EDC (Easy Drawing Continuous ) cooling can be used as an alternative to fan cooling to achieve on-line patenting of high carbon steel.

The treatment is simple and uses boiling water without any additives.

The main benefits of the EDC process are well-known and summarized here below:



**Figure 9A and 9B.** EDC system in operation at Angang Anshan I&S – P.R. of China

- Optimized microstructure for the whole range of high-carbon steel
- Higher mechanical properties. An increase of 30 – 70 MPa on UTS can be achieved (Depending on grade and size )
- Better uniformity of mechanical properties
- Lower amount of scale on the final products
- Better scale quality
- Better cold drawability

In order to achieve good process flexibility and cover the entire range of possible heat treatments, the first part of the cooling conveyor is installed on a shifting trolley. The working mode (EDC process or “conventional” cooling with hoods and fans ) can be selected simply by shifting the carriage.

### **1.12 Coil Finishing Systems: Various customized configurations and solutions with new coil compactors**

Sund Birsta, part of the Danieli Group, has years of experience in the field of automatic binding equipment and this was its calling card when it started to focus on the entire wire rod finishing area approximately 45 years ago. It has resulted in many generations of binding machines - and then compactors - when coil weight exceeded 1000kg.

The range of equipment, starting in the reforming area where developments in the reforming tub and distributor have been a success, has provided many customers around the world with stable production, high availability, and perfectly shaped coils in the new mills, as well as in the old revamped mills.

The modularized SUNDCO coil transportation system, either in vertical mode with pallets carrying the coils or in horizontal mode with C-hooks, has proven to be maintenance-free for 15 years. It is considered to be state-of-the-art all over the world. The modularized SUNDCO coil transportation system is manufactured in Sweden where only premium components and top, modern manufacturing methods are used. For example, robot laser cutting technology is used for the wheel set steel frame, resulting in the most cost efficient manufacturing.

The key machine in the coil finishing system is the compactor for pressing and binding.



**Figure 10.** SUNDCO V-H system in operation at AscoMetal – France.

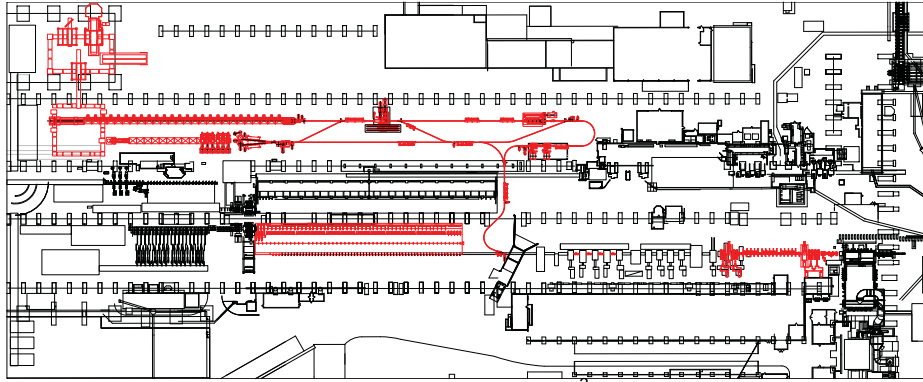
The very latest, fourth generation horizontal compactor — type PCH Alfa — was presented in late 2009 and has been sold in substantial numbers worldwide, delivered and put into operation in a number of mills in China, the Middle East and Europe with very good results. Superior cycle time, availability, advanced HMI for control and maintenance are key improvements over the top model of the previous generation. But what stands out most is that energy consumption is 50% less compared to previous generations, while continuing to perform with higher press force and shorter cycle time. This is achieved by a new advanced power-controlled hydraulic unit system, which also reduces installed power. Other new compactors, specially designed to handle coils processed in post-treatment lines, are also part of the company's new, successful developments.

Recent sales of compactors, reforming and coil finishing systems in China, to customers such as Changzhi I&S and Xinjiang Yili I&S, are added to a long reference list. This venture into China started in 1986 when the first compactor was sold to Jiuquan I&S. Sund Birsta has recently received more than 200 compactor orders from China.

### **1.13 Latest WRL technologies applied on worldwide projects: Nucor Darlington and some European and Chinese Customer's trusted Danieli Long Products equipment for the modernization of their wire rod mills. Benefits and advantages**

For the Danieli Group, the Year 2012 marked a year of intense activity in the wire rod mill market. After several successful installations in the P.R. Of China, the NUCOR Group awarded an order to the Italian group for its H<sup>3</sup> wire rod line (the 1st with WRS Wire Rod Sizing technology) and bar-in-coil line for engineering and special steels.

With a production capacity that exceeds 26 million tons, Nucor is the largest producer of steel in the U.S.A. But more than a steelmaker, it is the world's foremost steel recycler and one of the largest recyclers of any kind. In order to stay one step ahead of its competition and enter new market niches, in February 2012 the Nucor Corporation awarded Danieli an order for the upgrading of rolling mill #2, with the installation of the H<sup>3</sup> wire rod line, where H<sup>3</sup> stands for High Efficiency, High Speed and High Quality, designed and dimensioned for the production of engineering and CHQ steel long products. Danieli will also be undertaking a major revamp of rolling mill #1. The new state-of-the-art plant will be installed in Darlington, South Carolina and equipped with all of Danieli's latest technologies and "high-tech" equipment available in rolling, on-line processing and heat treatment of wire rod and bar-in-coils including LTR-Low Temperature rolling process.



**Figure 11.** The Nucor Darlington H<sup>3</sup> Wire Rod Line.

The project basically includes:

- Two PFB 2-stand independently-driven Wire Rod Blocks
- One 8-stand Wire Rod Block acting as pre-finishing mill,
- One 4-stand Wire Rod Sizing high-speed finishing block.
- Latest generation-high-tech Oil Film Bearing loop laying head
- A Danieli Structure Control System including water cooling line and Controlled Cooling Conveyor,
- One Rotary Reforming Tube and Easy-down systems for perfect coil formation. A future provision for the Quenching and Tempering process for Wire Rod is provided.
- An ultra-modern Bar-in-Coil line, designed for 2.5-t coil handling:
  - Controlled cooling line for bars
  - Two Garret coilers
  - One walking-beam coil conveyor fitted with hoods and fans for slow/natural and fast cooling treatment. The two lines will be served by the latest ultramodern V-H SundBirsta coil handling equipment for wire rod in order to meet the new requirements.
- 6-SHS Roughing stands in H and V configuration able to handle the new starting billets, 6 loopers on the finishing mills and a new cooling bed connected to the existing cutting-to-length facilities already supplied by the Danieli Group in 2002.

The production range starting with sq. 7" (178 mm) and sq. 8-1/8" (207 mm) 8.2 and 10.7 m conticast billets, includes 7/32" to 1" dia wire rod (5.5 to 25 mm dia), rebars DR6 to DR12 (6 to 12 mm), 3/4" to 2" dia bar-in-coil rounds (19 to 51 mm) and hexagons 5/8" to 2" (16 to 51 mm) weighing up 2,700 kg and round bars 1-5/8" to 4 1/2" (41.1 to 114.3 mm) in CHQ grades, low, medium and high carbon grades, spring steel, bearing steel, micro-alloyed grades and free-cutting grades at the maximum speed of 115 m/s on the wire rod line and 13.5 m/s on bar-in-coil line. Electrical and automation equipment will be supplied by Danieli Automation including the latest generation HiProfile, Section Gauges and HiTest laser units.

The table below summarizes the advantages provided by the new H<sup>3</sup> line.

**Table 1.** Nucor Darlington areas and highlights

<b>Item</b>	<b>Area</b>	<b>Highlights - Benefits</b>
1.	Roughing Stands and loopers RM#1	Better product feeding, speed increase, better surface quality, multi-bypass layout solution to increase plant yield and mill utilization factor
2.	Two (2) 2-stand M <sup>2</sup> Multiple drive Pre-Finishing Blocks	"One-size-fits-all" concept: one mandrel for all the PFB/WRB/WRS stands (except the sizing block)!!!,
3.	8-stand Wire Rod block	Automatic disengageable Dan-Joints to disconnect unused stands during rolling operation – Less energy consumption
4.	4-stand Wire Rod Sizing Block	<ul style="list-style-type: none"> <li>- Excellent size tolerances (<math>\pm 0.1</math> mm with 50% ovality)</li> <li>- Single-pass family in the upstream mill resulting in higher efficiency</li> </ul>
5.	LLH <sup>Plus</sup> -Loop Laying Head with 2-rotor pipes	<ul style="list-style-type: none"> <li>- Very low vibration (less than 1.0 mm/s at 120 m/s)</li> <li>- Low pipe wear thanks to optimized pipe shape and material (5-6 times more than the conventional laying heads)</li> <li>- Optimum control of the last ring formed</li> <li>- Large rings up to 27 mm</li> </ul>
6.	DSC with new Controlled Cooling Conveyor for Wire Rod	<ul style="list-style-type: none"> <li>- Shiftable water boxes resulting in reduced changing times down to 5 minutes, Low Temperature Rolling process for all the products, multi-bypass layout solution to increase plant yield and mill utilization factor. Optimized configuration of the roller conveyor and related parts with 3D fluiddynamic design and simulation in order to guarantee a superior positioning of the fans and improved cooling for every steel grade processed</li> </ul>
7.	RRT and EDS	<ul style="list-style-type: none"> <li>- Deposit of eccentric wire rod loops and gradual coil lowering during formation.</li> <li>- Regular &amp; homogeneous coil formation</li> <li>- High coil compactness (Lower height before and after compacting)</li> <li>- Smooth &amp; cobble free un-coiling for end users.</li> </ul>
8.	Bar-in-Coil System	<ul style="list-style-type: none"> <li>- Scratch-free conveying system with rollers along the line</li> <li>- Perfectly-shaped, low-height coil</li> <li>- On-line heat treatment along the walking beam conveyor using centrifugal fans and/or hoods</li> </ul>
9.	Sund-Birsta Coil Handling	State-of-the-art coil finishing facilities, solutions for every customer's request including handling, transportation, trimming, sampling, compacting, tying/strapping, weighing and collecting for wire rod and for Garret coiling lines.
10.	Q3 Danieli Automation System	<p>Quality: Excellence in Quality and Product Quality certification</p> <p>Quantity: High productivity</p> <p>Quickness: Faster Reaction to Situations</p>

## 2 AUTOMATION AND PROCESS CONTROL

DANIELI Automation provides a consistent solution for the control high speed wire mill from the process control to basic automation systems integrated with a set of special sensors specially designed for quality control and production monitoring.

In the design, all automation units and instrumentation are integrated each other through a local area network to meet plant production and process requirements. The architecture of the automation system is based on client-server structure, with a single process control system database assuring consistency of the data used to calculate the equipment set-up and to manage the production. Material tracking, automatic labelling, consumption accounting, quality monitoring and equipment life tracking are some of the most significant additional functions provided by the process control systems. The large amount of data acquired from instrumentation and basic automation can be analysed with a dedicated business intelligence tool QIntelligence. Operator workstations, based on personal computer hardware, support the operator's decisions displaying the necessary information about process and equipment status. The equipment control automation system is based on distributed architecture of PLC units, where the single unit is dedicated to control single machines or groups of them, simplifying handling and maintenance, making troubleshooting easier.

### 2.1 Special Sensors and Instrumentation

In the following a brief description of the set of sensors developed by DANIELI Automation for long product rolling mills is reported.

#### 2.1.1 MD2000

It is a magnetic presence sensors that uses the disturbances caused by the metal material being rolled on the magnetic field induced to determine the bar presence. Installed inside the water boxes used for the material thermal treatment this sensor allows precise material detection and tracking of both hot and quenched bar even in presence of water and steam.



**Figure 12.** HiSection in operation at Ferriere Nord.

The HiSECTION is a modern system for the on-line measurement of cross section of hot rolled bars. A magnetic contact-less sensor forms the core of the system; sturdy and compact, it is designed to be maintenance and wear free. The working principle of the sensor is based on detection of the eddy currents, generated on the surface of

the rolled stock by a variable electromagnetic field. The HiSECTION system can be exploited with the following main applications:

- > Weight/meter and section measuring
- > Section control.

> Optimization to the minimum tolerance

Typically installed downstream each section of mill (intermediate, pre-finishing) the HiSECTION system allows achieving some immediate benefits:

- > Reduction of cobbles.
- > Reduction of wear of roller guides.
- > Reduction of breakdowns of roller guides.

> Precise gap adjustment for wear compensation and easier set-up of a new production

- > Instant warning in case of out of tolerance events.



Figure 13. HiPROFLIELite in operation at Ferriere Nord.

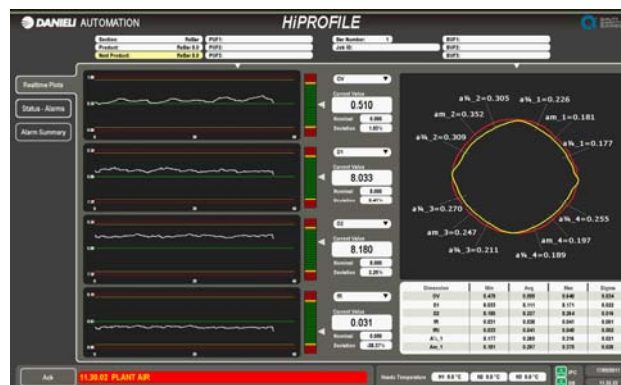


Figure 14. HiPROFLIELite OWS in operation at Ferriere Nord

A HiPROFILE LITE sensor is installed at finishing block exit. The sensor is equipped with one or two rotating measurement heads. Targeting rod and bar rolling mills, HiPROFILE LITE provides non-contact on-line profile hape inspection and dimension measurement for either hot or cold rolled products. Thanks to the HiPROFILE LITE, integrated with automation system, it is possible to:

> achieve fast 100% inspection of shape and dimensions, reading and monitoring of the complete bar profile

The HiPROFILE LITE is especially designed for round and hexagonal profile and as really innovative and hard task is able to measure the rebar profile showing rib height and groove.

### 2.1.2 Additional instrumentation

**HiTEST:** In-line Round Bar Surface Inspection System. It is a no-contact inspection system dedicated to on-line detection of surface defects in rolled round bars.

**HiLINE:** Roller Guide Calibration and Alignment System. It is a calibration system designed to aid the operator during:

- setup of the roller guide in the workshop
- alignment of the roller guide mounting bases with the rolling ring pair groove in the fast finishing blocks.

### 2.1.3 Control Packages

A set of proper functions and high speed controls have been implemented and largely applied in the DANIELI wire rod lines:

- DSC & QTR: water boxes control system to achieve and maintain the desired temperature of the quenched stock. It provides:
  - Quick set-up based on shape, size and grade of the stock
  - Closed loop control based on actual temperature readings
  - Controlled cooling of the whole bar
  - Compensation of differences between head and tail
  - Monitoring of coolers broken or clogged

The set-up of the Water Treatment needed for a new product can be automatically calculated thanks to the DANIELI LONG PRODUCT PREDICTOR (DLPP) engineering tool. Thanks to DLLP integration with process control system (L2) and basic automation the calculated set-up can be directly sent to the DSC & QTR water boxes control system. This allows a fast and consistent start-up of the production of a new steel grade.

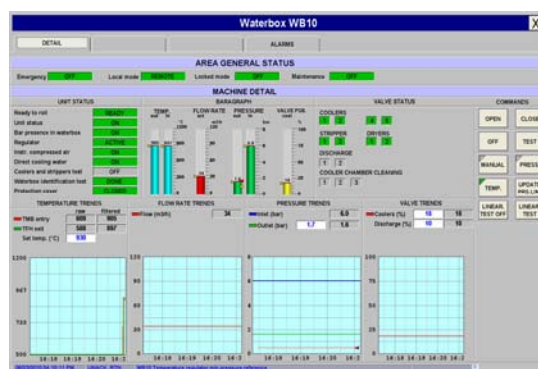


Figure 15. DLPP in operation.

- Impact Drop Compensation for twin module block and multi-drive blocks. An High-Speed auto-adaptive speed drop compensation of the drives at biting of the material in each stand (or group of stands) is provided. It allows reducing relative speed variations of between the motors of a multi-drive block down to 0.5% or even less of the nominal speed. The right tension in the material is maintained along the front end transient. Therefore the section of the material is kept constant along the whole stock length.
- High speed controls are also provided for high speed shear rotor-diverter synchronization that allowing reliable head and tail cut up to 120m/s. Furthermore the synchronization between the laying head and High speed shear rotor during at head cut allows a 100% reliable and precise positioning



of the first loop of the wire on the cooling conveyor. This avoids the risk of cobble on the cooling conveyor.

### 3 CONCLUSIONS

Danieli's research and development, which is done in close collaboration with the final users, motivates these users to support continued innovation of rolling machines and processes because in this period of global recession they need to optimize production costs and find new markets, and their products increasingly have to be of certifiably high quality in order to be successful. The facts show how much care and attention Danieli places on the production of steelmaking machines, whether they are manufactured in our Buttrio workshops, among the most important in Europe, or elsewhere in the world. The customer feels that he is being listened to and is reassured, with Danieli providing the solution to any problem arising on a daily basis in the world of steel. This is a clear example of the continuous evolution and improvement that mark yet another advance toward the best quality wire rod with better productivity and higher efficiency in the global steel market.



**Figure 16.** 3D rendering overview of the LLH in the H<sup>3</sup> showroom at Danieli headquarter

All of this helps us to look to the future with caution but with a certain growing optimism. We are in the process of building an HCube showroom in Italy (expected completion date is summer 2013), to give our customers the benefit of our “Danieli H<sup>3</sup> vision”, enabling them to quickly respond to changing market demands and to become front runners with Danieli as a strong, reliable partner.