Laminação
Rolling
49º Seminário de Laminação - Processos e Produtos Laminados e Revestidos
49th Rolling Seminar - Processes, Rolled and Coated Products
ISSN 1983-4764

ANOTHER STEP FORWARD TO THE BEST QUALITY WIRE ROD, WITH BETTER PRODUCTIVITY AND HIGHER EFFICIENCY[1]

Fabrizio Mulinaris [2]
Nicola Redolfi [3]
Andrea Taurino [4]

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: High productivity; High utilization factor; On-line structure control; Production cost optimization; Wire rod.

[1] *Technical contribution to the 49th Rolling Seminar – Processes, Rolled and Coated Products, October, 22nd-25th, 2012, Vila Velha, ES, Brazil.*

[2] *Executive Vice President Bar & Wire Rod Mills, Danieli & C. Officine Meccaniche S.p.A., Email: f.mulinaris@danieli.it, Phone: +39 0432 195 8701*

[3] *Executive Product Manager Bar & Wire Rod Mills, Danieli & C. Officine Meccaniche S.p.A., Email: n.redolfi@danieli.it, Phone: +39 0432 195 8568*

[4] *Marketing Manager Long Products Division, Danieli & C. Officine Meccaniche S.p.A., Email: a.taurino@danieli.it, Phone: +39 0432 195 8379*

ISSN 1983-4764

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 products, 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.

Figure 1. WB Furnace in Operation – Ferriere Nord – Osoppo (UD) – Italy.

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. This result is also due to a high level of automation, resulting in a significant drop in gas consumption and, consequently, scale content.

ISSN 1983-4764

Various software programs used in both design and management made it possible to reach excellent recorded values of 30 Nm3/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^{Plus} 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 8,000 cartridge stands, which were originally developed, designed and patented by Morgårdshammar in 1948. The new SHSPlus 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 (cobbles, water splashes, etc.). This solution secured operator safety in the rolling area, reducing the accident risk to zero. The cartridge design was optimized and most of the external tubes for media connection were eliminated (water/air/oil). This means that the assembly time for hoses is over 50% shorter. Substantial changes were made to the spindle design so each machine size has only one type of spindle, common to horizontal, vertical and convertible machines. This reduced significantly the need for operating spares, by over 60%. 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.

Figure 2. New SHSPlus cartridge rolling stands.

ISSN 1983-4764

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 machine cost
- 10% in electric power consumption
- 40% in spare parts costs

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).

Figure 3. ESS/ESC Rolling Units.

1.4 DWB Pre-finishing Block

The latest generation DWB Delta-type twist-free 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 240 high-speed blocks for bars and wire rod have been installed and successfully commissioned by Danieli, 157 of which have been “Delta”

ISSN 1983-4764

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-tuneing 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.
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.

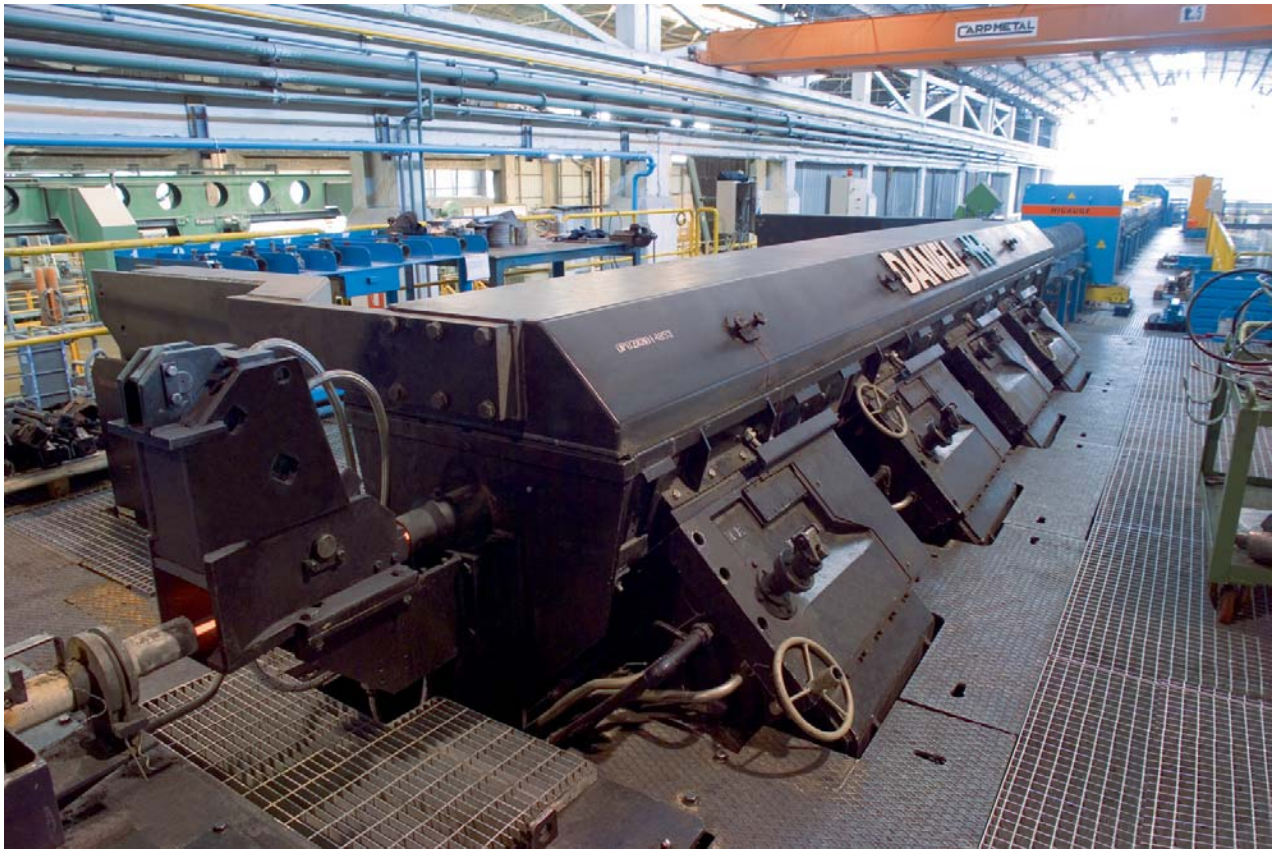

Figure 4. DWB Pre-finishing Block.

ISSN 1983-4764

Figure 5. TMB Finishing Block.

1.5 The Core of the High-speed Wire Rod Process: TMB Finishing Block

- Based on experience in manufacturing and installing wire rod finishing blocks, about 10 years ago we decided to present and launch the Twin Module Block, the ultimate technological advance to achieving 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? First, we designed the mill to give our customers the possibility of producing steels with tight dimensional tolerances and fast, efficient production changes, with limited investment costs. This is innovative because the machine's design is based on:
- 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 obtainable tolerances, or at least facilitating their obtention;
- 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 motors with air cooling that are easy to find, even in non-European markets

ISSN 1983-4764

- The same drives installed on the rolling mill require no specific knowledge, thus saving on maintenance/service. Therefore, the cost per kW is considerably less (-15%), but there is more installed power (+20%)

1.6 HSS High-speed Shear and Loop Layer

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).
  - Shortened 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 was 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 start-up 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 significant reduction in its changing time and that of the rotor.

ISSN 1983-4764

Figure 6. HSS High-Speed Shear.

Figure 7. Loop Layers.

ISSN 1983-4764

1.7 The DSC System, from the Water Lines to the Wire Rod Cooling Conveyor: EDC and UFG, the New Technologies for Producing Quality Wire Rod

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).
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.
The temperature trend during rolling is shown in Fig. 8:

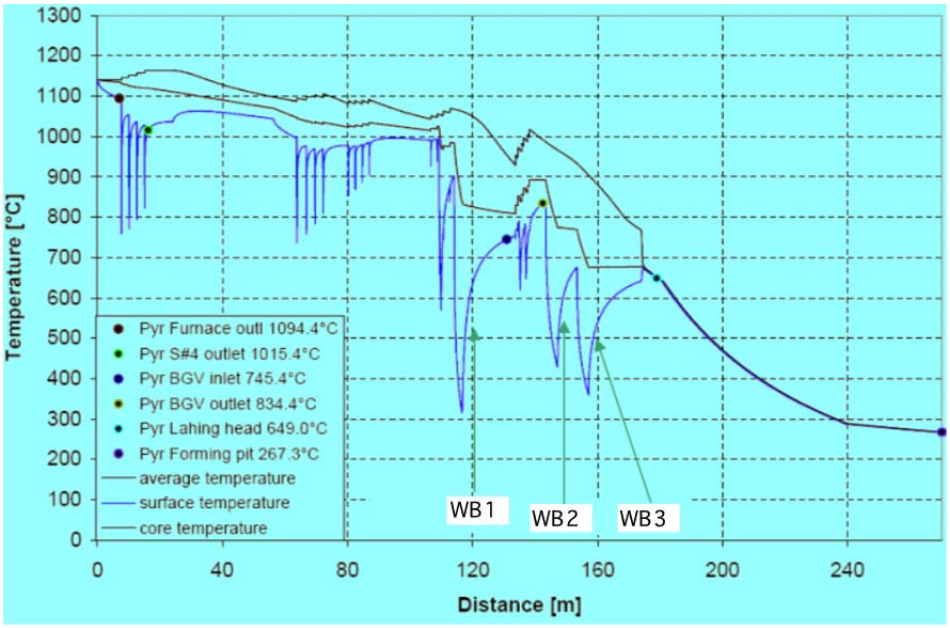

Figure 8. Cold Skin Rolling.

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.

ISSN 1983-4764

Fig. 9 and 10 shows the huge difference obtainable between core and skin using this treatment.

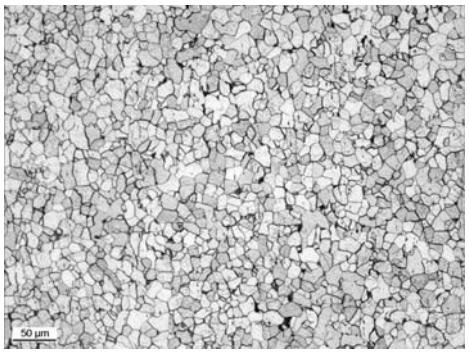

Figure 9. Surface and Core - Microstructure Bar Center (ASTM 10).

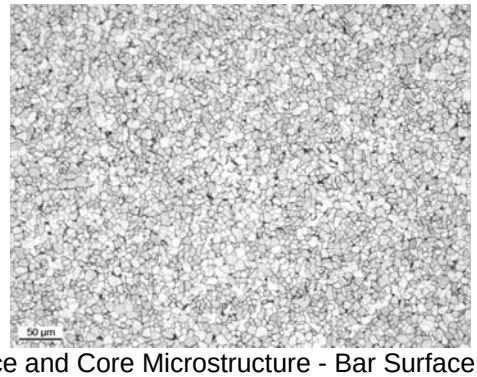

Figure 10. Surface and Core Microstructure - Bar Surface (ASTM 12)

This process enables you to reduce transformation costs in the meltshop significantly, 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 also will provide substantially improved dimensional tolerances. The tolerances that can be reached without difficulty are in line with those of the best specialty steel plants (± 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:

- 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.**

ISSN 1983-4764

Figure 11. EDC (Easy Drawing Continuous) cooling.

1.8 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, later 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, have 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 key machine in the coil finishing system is the compactor for pressing and binding.

The very latest, fourth generation horizontal compactor — type PCH Alfa — was presented last year, and already has been sold in substantial numbers worldwide, delivered and put into operation in a number of mills in China and Europe with very good results. Superior cycle time, availability, high press force, advanced HMI for control and maintenance, optimized energy consumption are key improvements over the top model of the previous generation. Other new compactors, specially designed to handle coils processed in after treatment lines, are also part of the company's new, successful developments.

ISSN 1983-4764

Figure 12. The latest compactor generation PCH Alfa.

Recent sales of compactors, reforming and coil finishing systems in China, to customers such as Qingdao I&S and Shanxi Zhong Yang 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. Danieli has recently received more than 150 compactor orders from China.

1.9 Automation Systems: DLPP (Danieli Long Product Predictor) for Wire Rod Lines – a Silent, Efficient Friend for Control and Automation of Wire Rod Lines

This is a software program designed for off-line prediction of final mechanical properties of hot rolled long products, especially bar and wire rod.
Can be used in:

- New plants
- Upgrading and development of existing rolling mills

What it processes:
Recrystallization, grain size of deformed austenite and conditions of precipitation hardening.
Diagram of austenite decomposition in the secondary structure, interaction with temperature curves resulting from final cooling technology; calculation of hardness, tensile strength and yield stress of the rolled product.

2 CONCLUSIONS

Danieli's research and development, which is done in close collaboration with the final users, motivates the latter 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 the care and attention that Danieli places on the production of steelmaking machines, whether they are manufactured in our Buttrio workshops, among the most important in Europe, or elsewhere 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 another advance toward the best quality wire rod with better productivity and higher efficiency in the global steel market.