

Abs qwr 4.0 quality from the start: new rolling mill concept and free furnace enhanced operational performance, sustainability and product quality

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Today, success in the wire rod market can be achieved only by combining high plant productivity, efficiency, superior-quality finished products and plant flexibility. These requirements, in addition to Danieli's latest research efforts and industrial setup activities, point the way to environmental sustainability, true green-steel production and the adoption of a circular economy model, as seen in the tangible results achieved by the ABS QWR 4.0 project, which rolled the first billet on November 27th, 2020, and now is considered a word leader and benchmark between the wire rod suppliers.

KEYWORDS: QUALITY WIRE ROD MILL, DIGITALIZATION, GREEN STEEL

INTRODUCTION

With a 190-million-euro investment, the plant in Cagnacco (Udine, Italy) produces 500,000 tpy of special steel and automotive application wire rod, from 5.0 to 25 mm dia., at a finishing speed of 430 km/h. Actually, the final product is equally shared between the Italian and European markets.

The high plant productivity and flexibility are guaranteed not only by the up-to-130-tph capacity, but also by both the 170–230-mm round blooms and the 150–180-mm square billets, to be used as starting material, which come only from ABS (IT) or Sisak (HR) facilities.

LAYOUT

The whole layout was developed following the principle by which the entire rolling mill production area is intended more as a mechanical workshop, like those used for numerical control machines, rather than a conventional rolling mill. The building structure is a clear expression of this concept: a low roof height with a short-span shed, with the individual machines used only when needed, optimizing spaces, process flexibility and equipment readiness. The workshop area is located behind the shutter doors, and all installed equipment can

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be automatically moved there to be prepared or changed due to wear.

This integrated approach embraces the design of long-life, easily refurbished equipment, with resources and energy consumption optimization in favor of renewable sources. The 10,000 tons of Ecogravel® (EAF slag recovery) used for paving is a virtuous example of environmental care but also a profitable investment.

To maximize the product size change, Danieli custom-designed three routes for specific dimensions and steel grades—ABS has more than 1,000 steel grades in its portfolio—which play a fundamental role in the changing sequences.

Three specific rolling lines are installed to optimize both the process and machine utilization and availability. The straight roll pass line is adopted for 5.0-to-11.5-mm final diameters; the second one allows bypassing the semi-multi-drive Fast Finishing Block eight passes, and is adopted for 12.0–23.0-mm final dimensions. The third line is used for final sizes ranging from 23.5 to 25 mm and also permits bypassing the six-pass multi-drive Pre-Finishing

Block, guiding the feeder material into the sizing Twin Module Block, operated by a multi-drive system.

Respecting the “any size, any grade, at any time” motto, this concept optimizes process flexibility in terms of steel grades to be produced, rolling strategies to be applied, and quick size changes, including for small-scale orders. This plant makes 35 automatic changes on rolling stands, blocks, water boxes, high-speed shears, HiProfile devices, loop laying head and Hi-Profile guide channels. Everything that is required to change a section is fully automatic and automated.

It is required only eight minutes to change the entire mill—and, generally, no more than 15 minutes in particular circumstances—to which should be add three minutes between one billet’s end and a new section’s beginning.

To further confirm the flexibility of the plant, it is possible to adopt different routes to cool down the material also on roller conveyor (air cooling, slow cooling under the hoods, fast cooling with fans or by the EDC), and there is the possibility to collect the material in two different positions, using the hot or cold pit.

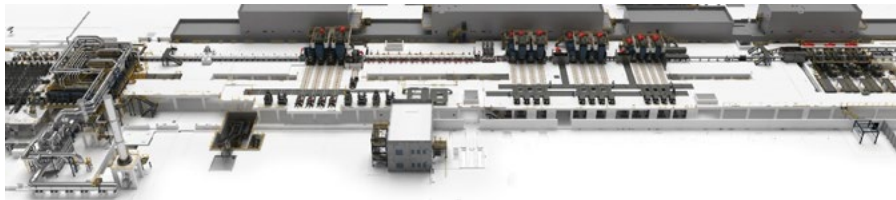


Fig.1 - General Layout from re-heating furnace to Pre-Finishing-Block.



Fig.2 - General Layout from Pre-Finishing-Block to Cooling Conveyor.

EQUIPMENT

Re-Heating Furnace

Danieli Centro Combustion installed the first walking-beam furnace designed to minimize oxidation phenomena through the combination of a highly accurate combustion control in sub-stoichiometric conditions and a tightly sealed furnace chamber.

Preface to this technological advancement, scale formation is affected by long residence times of steel at high temperatures in combination with oxygen presence. For this reason, the patent-pending furnace chamber has been separated into several “micro-chambers” using walls, noses and diaphragms in order to control individual volumes with a different air-gas ratio. By controlling

such parameters, it is possible to actively intervene on oxidation kinetics to inhibit scale formation.

Enhanced combustion control was developed through higher pressure-drop flow transmitters for gas, and flow straighteners for air. Furthermore, the reducing atmosphere generated in the hottest zones is compensated with post-combustion air injected into the furnace by nozzles arranged on the roof and side walls. A laser spectrometer continuously detects oxygen percentage in the recuperative zone before the waste gases leave the furnace, and this parameter is inserted in a safety control loop that acts on post-combustion air in order to have the desired oxygen at fumes exit. Then, the oxygen presence in the furnace is reduced thanks to new mechanical and customized solutions to guarantee the chamber tightness.

Rolling Mill Equipment

All SHS 4.0 housingless stands are fully electrified to comply with the "green mill" concept. Replacing hydraulic controls with electrical ones ensures multiple advantages, from eliminating oil and oil leaks to cutting off the central hydraulic unit's electrical consumption, as well as savings in civil works and erection time.

The 3-MW Danieli Automation induction heating technology is installed between the free roughing stands and the continuous mill: it represents a most environmentally friendly solution for reheating steel and reducing scale formation. Its environmental advantages include reduced consumption when efficiently transferring energy to the material, no gas emissions, while required electrical energy can come from renewable sources by green energy production systems.

The already-discussed complete automation includes the high-speed shear, which avoids manual operation of head and tail trimming and, therefore the need for a dedicated workforce. It can trim rolled material with high accuracy and repeatability at 430 Km/h speeds and beyond, synchronizing the laying head to ensure proper coil laying on the cooling conveyor. One additional benefit from this equipment is that it increases the safety of operators in the area.

The Easy Drawing Continuous system—EDC for short—can be applied as an alternative to traditional cooling

fans to achieve in-line-patenting of high-carbon grades using boiling water. For maximum flexibility, the system has been designed to shift sideways from in- to off-line position in order to treat suitable steel grades and dimensions through a process water tank. Compared to other methods, the EDC process provides a sorbitic microstructure, in terms of uniformity and controlling grain growth and scale formation, enhancing cold drawability.

On-Line Sensors

The most recent iteration of automatic, motorized smart guides is installed in both the stands and the wire rod blocks and will receive real-time feedback from each billet, adjusting the guide force acting on the bars as well as rollers position, and monitoring bearing status.

Several pyrometers and thermal imaging cameras are placed along the entire line: these tools continuously monitor and record material temperature, and fine-adjustments to the reheating furnace, on-line induction heating and all in-line water box treatment status are made possible thanks to sophisticated automation systems.

In addition, Hi-Section (eddy-current mass flow meters), and Hi-Profile (laser-based measurement instrumentation) solutions continuously control material dimension, offering live feedback to automatically regulate workflow, ensuring bar optimization in terms of size tolerance, cobble reduction and rolling guide wear. Furthermore, special cameras installed between the stands check material tension, for a looper-less mill layout.

Thanks to the equipment reliability and process toughness on September 17th, 2021, has been set a rolling mill speed record, of 132.4 m/s, equal to 476.6 Km/h rolling 5.5-mm-dia wire rod. Until now, this record remains unbeaten for other special steel producers.

PRODUCT TRACEABILITY

Danieli believes maintenance is paramount to ensure high plant availability and reliability. That is why all key equipment includes an ID tag with a barcode to identify device information, such as storage operations and remaining tons/hours before refurbishment. Many devices, such as cartridges, cylinders and guides are equipped with radio-frequency identification tags. A

workshop management system supervises equipment preparation and organization, checking and providing continuous grooves and guides status updates. An advanced, integrated laboratory located next to the coils finishing facilities is used for instant feedback on the rolled products' final mechanical and metallurgical properties; additionally, it allows final product certification before shipping, with real-time product traceability, closing the circle on a fundamental requisite for a modern plant,

tracking the product from melting to customer delivery. Finally, coils are stored in a fully automated warehouse designed to safeguard the products' surface quality, while ensuring a high degree of process flexibility with short lead-times on orders. It can hold more than 11,000 tons of wire rod coils. After being automatically tagged and stored, the material can be organized in relation to incoming orders and production requirements.



Fig.3 - Fully automated warehouse.

A new-generation pulpit with 3Q technologies is fundamental to support advanced technologies such as artificial intelligence, augmented and mixed reality, empowering the operators' perception and helping them to both identify and predict anomalous process behaviors. An additional advantage of this pulpit is that all mill

function and process parameters are supervised by two operators only—one for the mill process itself and the other for on-line heat treatments—who monitor the main plant KPIs and process parameters.



Fig.4 - Overview of the latest-generation, highly automated pulpit.

PROCESS SOLUTION

The development of all these concepts is guided by the new QWR process solution and production approach: this is the one and only wire rod mill in the world today where mill management is remotely controlled, based on the zero-man-on-the-floor approach during production and size changes. All mill activities are performed

automatically thanks to the strong automation control, so that there are no operators on the field.

Benefits from this method are manifold: it preserves operators' safety, significantly improving working conditions; only fourteen highly qualified operators are required per shift, compared to a traditionally operated rolling mill with a similar product portfolio, thanks to the

strong emphasis on automation control. Indeed, advanced automation plays a fundamental role throughout the plant, especially with the "first coil in quality" concept (i.e. without trial losses), which is achieved thanks to on-line sensors and measuring instruments working in a closed-loop control managing metallurgical, dimensional, and quality aspects. The process efficiency is directly related to the ability of managing the process: that is why the rolling line is controlled via an innovative monitoring system with more than 2,000 data acquisition sensors, and over 15,000 continuously recorded parameters. Sensors provide continuous real-time process and plant data, whether directly measuring physical values or applying process models. Digitalization helps the operators to avoid mistakes, increasing workplace safety and, as an added benefit, product quality.

Thermo-Mechanical Rolling

The in-line heat treatments need mentioning, thanks to their ability to control steel by applying Thermo-Mechanical Rolling, ensuring appropriate final wire rod metallurgical and mechanical properties to improve steel strength, toughness and ductility. That is why grain refinement may be considered the most-effective way to deal with these demands without increasing alloying elements, thanks to the several controlled cooling stages along the mill and roller conveyor.

The thermomechanical rolling process is characterized by deformation in the non-recrystallization region of austenite, usually in the range from 750 °C to 850 °C, where it may be carried up to a specific area of reduction to obtain the desired grain refinement and microstructure modification.

For the medium-carbon, micro-alloyed steels for cold forming, the reduced prior-austenite grain size (PAGS) achieved by means of thermomechanically controlled processes avoids hardness hot spots that would have required annealing treatments before cold forming. Also, improvements in cold drawability can be achieved by controlling the scale layer, which is thinner and uniformly distributed.

The mechanical strength of high-carbon steel is related to interlamellar pearlite spacing and can be enhanced

through control of continuous cooling on roller conveyor. Thanks to this, variation in the mechanical properties along the coil and ring can be reduced. Benefits can be achieved also for the bearing grades where deformation at a non-recrystallization region of austenite may permit enhanced carbide distribution and dimension.

QUALITY FROM THE START

Flexibility in configuration, speed in set-up changes, no-trial billets, and first coil produced in full quality (both for dimensions and metallurgical characteristics) cannot be achieved by neither overwhelming operators nor stressing equipment.

The QWR approach is to have the operator supervising and controlling all changes and mill preparation activities with limited-to-null manual intervention, enhancing equipment robotization, extensively using on-line instruments and sensors for quality and product checkup in a closed-loop control, and multi-route layout for different steel grades and product dimensions. The automatic setup for heat treatments is an example of this, where the process control system automatically loads the proper setup table from the database and sends it to the equipment control, without manual intervention.

The equipment has been changed from traditional maintenance management and condition-monitoring systems to real-time support and diagnostics.

The process has been developed so that models and monitoring are widely deployed to manage all parameters along the mill and, consequently, optimize final product quality and mill performance. Additionally, predictability is now possible, to understand a phenomenon before it manifests. The implementation of the "Danieli Intelligent Plant" philosophy is a revolution for plant management and post-processing analysis.

CONCLUSION

ABS QWR 4.0 is the latest wire rod mill reference for Danieli and features the most advanced technical solutions. This is a concrete example of the proactive approach which has always made our activities and values stand out. ABS and Danieli put words into action, showing that we walk the talk as undisputed leaders in the rolling mill field. This means investing to ensure our customers stay ahead

of the field in the future, too: ABS Quality Wire rod 4.0 terms of technological innovation, digitalization, safety is today the realization of the rolling mill of the future in and a green steel approach.

ABS QWR 4.0 qualità sin dall'inizio: nuovo concetto di laminatorio e forno senza scaglia per migliorare le prestazioni, la sostenibilità e la qualità del prodotto

ABS QWR 4.0 ha laminato la prima billetta il 27 novembre 2020. Lo stabilimento situato a Cagnacco (Udine) produce 500.000 t/a di vergella per acciai speciali e applicazioni automotive, da 5,0 a 25 mm dia. a velocità di finitura massime di 430 km/h. Il riscaldamento ad induzione della Danieli Automation rappresenta una soluzione per il riscaldamento dell'acciaio riducendo la formazione di scaglia. Inoltre, l'energia proviene da fonti rinnovabili e ciò rappresenta una soluzione che rispetta l'ambiente. Un pulpito di nuova generazione con tecnologie 3Q è fondamentale per supportare tecnologie avanzate come l'intelligenza artificiale e la realtà aumentata, potenziando la percezione degli operatori e aiutandoli ad identificare e prevedere comportamenti anomali del processo. Lo sviluppo di tutti questi concetti è guidato dal nuovo approccio al processo e alla produzione del QWR: questo è oggi l'unico laminatoio per vergella al mondo in cui la gestione del laminatoio è controllata a distanza, basata sull'approccio zero-man-on-the-floor durante la produzione e cambi di prodotto/acciaio.

Inoltre, la prevedibilità è ora possibile, per comprendere un fenomeno prima che si manifesti. L'implementazione della filosofia "Danieli intelligent plant" è una rivoluzione per la gestione degli impianti e l'analisi a valle del processo. Danieli Centro Combustion ha avviato con successo il primo forno a trave mobile "senza scaglia", progettato per minimizzare i fenomeni di ossidazione attraverso la combinazione di un controllo della combustione estremamente accurato in condizioni sub stechiometriche e una perfetta tenuta della camera del forno, riducendo quindi l'Opex. La formazione di scaglia è influenzata dal lungo tempo di permanenza dell'acciaio alle alte temperature, combinato alla presenza di ossigeno. Per questo motivo la camera del forno è stata suddivisa in più "microcamere" da pareti, nasi e diaframma in modo da poter controllare singoli volumi con diverso rapporto aria-gas. Controllando tale parametro è stato possibile lavorare attivamente sulla cinetica di ossidazione inibendo la formazione di scaglia. Tutte le suddette soluzioni hanno permesso anche di ottenere ottimi risultati in termini di consumo specifico. La presenza di ossigeno nel forno viene poi ridotta lavorando in condizioni di assoluta sicurezza, grazie a nuove soluzioni meccaniche atte a garantire la tenuta della camera e personalizzate per questo progetto, come la macchina di kick-off a tenuta d'acqua, la porta di scarico con barriera all'azoto, il tetto chiuso coibentato con fibra ceramica, e tutte le visiere di ispezione a perfetta tenuta. ABS Quality Wirerod 4.0 è la realizzazione del laminatoio del futuro per innovazione tecnologica, digitalizzazione, sicurezza e approccio green steel.

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