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MAXIMISING YOUR PROFITS WITH ADVANCED COLD FINISHING EQUIPMENT[1]

Developments in SBQ finishing

Stefano Casco[2]
Kristiaan van Teutem[3]

Abstract

The paper covers the design aspects, development and implementation of state of the art Cold Finishing Plants in order to maximise profits for in-line processing of SBQ bars for final use in the automotive, power generation, and other similar specialised engineering sectors that are rapidly growing in Brazil.

Key words: Cold finishing; Quality; Added value; SBQ.

MAXIMIZANDO SEUS GANHOS ATRAVÉS DE EQUIPAMENTO AVANÇADO PARA ACABAMENTO A FRIO

Desenvolvimentos no acabamento de "SBQ"

Resumo

Este trabalho engloba os aspectos de projeto, desenvolvimento e implementação de Instalações de Acabamento a Frio visando a maximização dos ganhos no processo de barras "SBQ" para aplicação nos setores automotivo, geração de energia e em outras áreas de engenharia especializada que vem obtendo um rápido crescimento no Brasil.

Palavras-chave: Acabamento a frio; Qualidade; Valor agregado; SBQ.

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2 *Sales Manager, Danieli do Brasil S.A., Email: s.casco@danieli.it, Phone: +55 11 3508 5900*

3 *Executive Vice President, Danieli Centro Maskin, Email: k.vanteutem@danieli.it, Phone: +39 0432 195 7295*

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1 IN-LINE COLD FINISHING LINES FOR SBQ BARS – KEY CONCEPTS

The modern design of a plant for the production of carbon steel SBQ bright bar must fulfill the following criteria: high capacity rates, high production flexibility, be market oriented and therefore able to process small lots in sequence mode, have a precise product tracking to guarantee product segregation and bars anti-mixing, minimize product handling, minimize manpower, guarantee process repeatability and a high quality of the final product.
The complete manufacturing route from immediately downstream of the rolling mill consists of the following processes each of which adds increasingly significant value (therefore profit margin) to the steel due to the increasingly high dimensional tolerances, surface finish and quality guranteed:

- Hot rolled bar inspection and conditioning,
- Bar to bar and coil to bar drawing,
- Peeling,
- Centreless Grinding.

2 PROCESS DESCRIPTION AND KEY EQUIPMENT COMPONENTS

2.1 Pre Processing of Black Bars

2.1.1 Black BAR LOADING AND PRE-STRAIGHTENING

Black bars are usually processed on a separate black bar processing line due to the fact that the straightening process is much faster than the peeling process. Bars are straightened, cut to length and NDT tested for internal and external defects for optimum processing on the downstream peeling line.
At the line entry side a bundle charging chain transfer with bundle receiving and transferring pockets is installed and designed to house 3 untied bundles weighing up to 5 M. tons (11.000 lbs) each (See fig 1).

Figure 1. Bar loading transfer for 3 bundles.

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From the bundle receiving pockets bars are transferred to a bar unscrambling station (See fig 2) where they are spread out on layers and where a set of hydraulically lifting levers gently moves them to obtain an even layer to better feed a chain transfer located in front of the 2-rolls black bars straightening machine.
From the feeding chain transfer bars are loaded to a bar lining up roller table for aligning the bars with the bar pre-spinning unit located at straightening machine entry side. The bar pre-spinning unit is a pinch roll mounting skewed rollers designed to feed in a positive way bars into the rolls of the straightener and to put them in rotation for limiting the front end bar bulging effect, to better control bar end damaging and to increment the life of the straightening machine rolls.

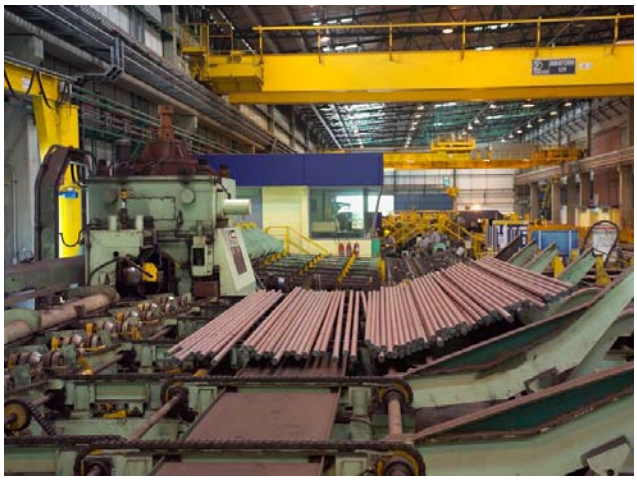

Figure 2. Bars unscrambling station.

Hot rolled bars can be straighened both by two roll straightening technology or 10 roll straightening technology. The choice of technology will depend on the incoming bar straighteness, surface condition, presence of hooked ends.
The 10 roll straightening machine has 10 vertically mounted skewed rolls and is designed to straighten bars diameters from 15 mm up to 100 mm in this example (See. fig. 3).
The machine straightens bars at up to 120 m/min, and since no guide blades are used (that can wear) the machine has an extremely high production efficiency
For the above diameter range only 1 set of straightening rolls are used for most engineering steel grades.

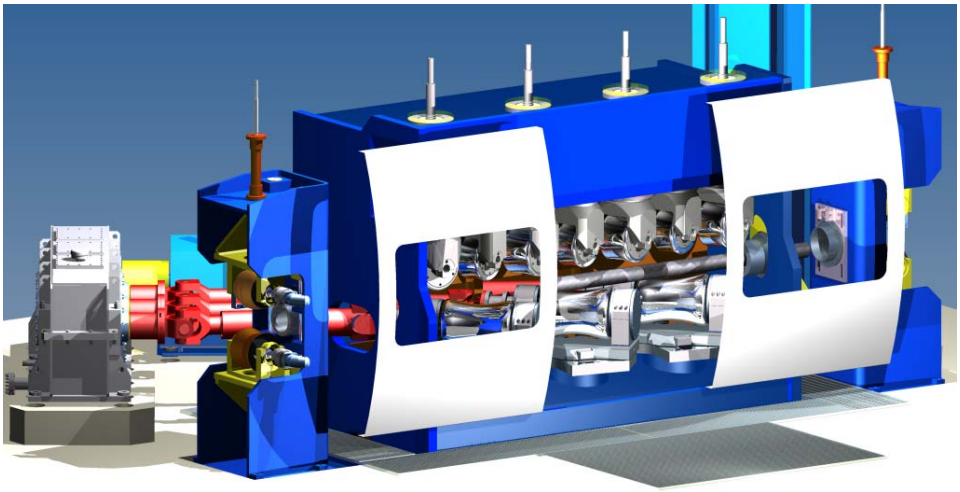

Figure 3. Ten roll, high speed black bar straightening machine.

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The machine has a sturdy design that houses 3 large diameter bottom rolls and 7 smaller diameter top rolls. All 7 top rolls are electrically adjustable in angle and vertical position, while the 3 bottom rolls are electrically adjustable in angle.
The unit is provided with recipes (programs) for the automatic setting of: straightening roll angle and gap, straightening roll working speed, etc., as well as for the settings up the speeds of the pre-spinning unit, the exit pinch roll, the entry-exit guiding time cycle, etc., for minimizing the line setup time during production changes and also to prevent potential human setup errors.
At the straightening machine exit side there is a bar pulling pinch roll designed to pull the bar from the straightening rolls and deliver it to the straightening machine exit table for the downstream operations.
The complete straightening assembly including feeding and exit tables, pre-spinning unit, exit pinch roll and so forth, are designed for a minimum bar-to-bar gap of approx. 2-3 seconds.

2.1.2 Bar Chamfering station

After the straightening station bars are collected in a transferring table and conveyed to a Bar Chamfering station (See. fig. 4) whose purpose is to eliminate all burrs on the hot rolled bars that could damage the delicate NDT equipment downstream.
After being cut to finished lengths bars are conveyed to the bars chamfering station for chamfering bars at both ends.
Bars are moved towards the chamfering heads located at both sides of the bar ends using roller tables and are transferred from one table to the next with a high speed walking beam assembly which includes an eccentric system, driven with an AC motor controlled by inverter.
Bars are neatly chamfered at both ends and then delivered with a roller table to the automatic NDT bar control station.

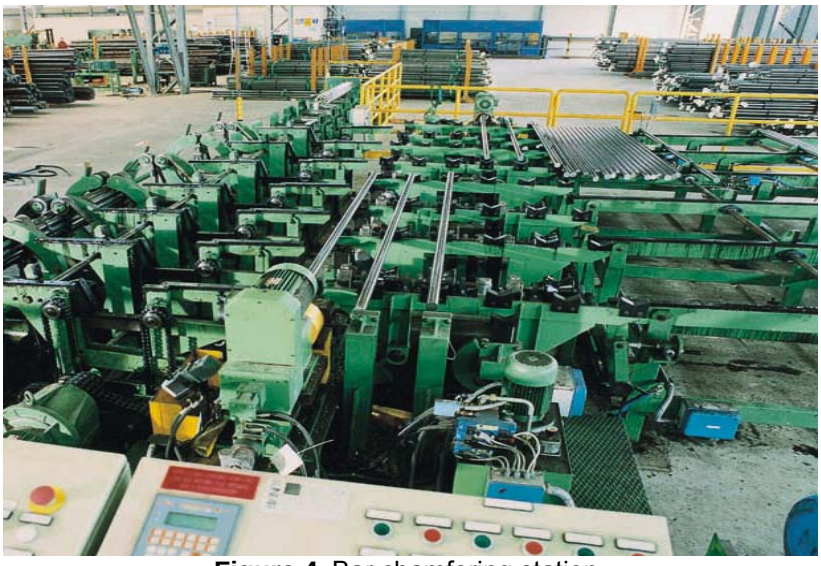

Figure 4. Bar chamfering station.

2.1.3 NDT (Non Destructive Testing) Bar Inspection Station

The NDT bar inspection station (See. fig. 5) is designed to control grade, surface an internal defects. It includes at entry side a bar washing cabin followed by an air drying station. The bar then is conveyed to a Foerster Circoflux for surface defect inspection and after to the UT station for the inspection of internal defects. It also

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includes a bar marking station for defect identification and bar segregation. Defective bars are diverted to a set of bars receiving pockets and latter removed using the overhead crane. Good bars proceed to the hexagon bundle formation station.

Figure 5. Ultrasound and flux leakage non destructive testing station.

2.1.4 Hexagon bundle formation, tying and weighing station

Finished bright bars are then sent to the automatic bundling, tying, weighing, tagging and bundles holding chain transfer.

They are transferred to the hexagon bundling station with a bars feeding roller conveyor and loaded on a set of bars transferring chains. In this location a bar marking station where either a needles type or laser type marking unit can be supplied and which is designed to mark the front ends of the bars in process.

The bars transferring chains are designed to load a set of the bars transferring and hex bundle formation levers. When bars reach the required number, the bundle formation levers are lifted and transferred forward for depositing the layer of bars into the bars bundling cradles (See fig. 6 and Fig. 7).

Subsequently further layers of bars are transferred to the bundling cradles for bundle formation.

Figure 6. Bar feeding table.

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Figure 7. Hexagon bundling station.

When the bundle is completed the bundling cradle lowers to the bundle transferring level where a set of side transferring cradle takes the bundle and transfers it in line with the bundles tying station. In the meantime bundles forming cradles are lifted back to home position to receive new sets of bars and proceed with the preparation of the next hexagon bundle.
The side transferring cradles are completed with one set of bottom driven rollers and two sets of side idle rollers for neatly transferring bundles to the automatic strapping machine station.
After the tying station bundles are conveyed to the bundles weighing, manual tagging station and finally are transferred over a chain transfer table for temporary storage and latter be removed with the bay overhead crane.

2.2 Peeling and Reeling

Once the hot rolled bars have been pre-straightened and also tested for internal defects, they are passed to a separate area for peeling to remove the surface of the bars by a cutting action , with depth of cut 0.5-5 mm on the radius according to the incoming material state. The cutting dept clearly is sleceted in order to guarantee 100% surface defect free bars after processing and dimensional tolerances of IT8.
Herein we include a description of a modern peeling line designed to produce SBQ bright bars of carbon and low alloy carbon steel grades for the engineering and automotive steel industry.
A line of this nature which is composed of several working areas with multiple functions placed in-line, guarantees a full production process from pre-straightened black bar to finished bright bar while it eliminates any intermediate manual handling. It allows producing a high quality product, assures product segregation and anti-mixing due of human error and requires minimum manpower.

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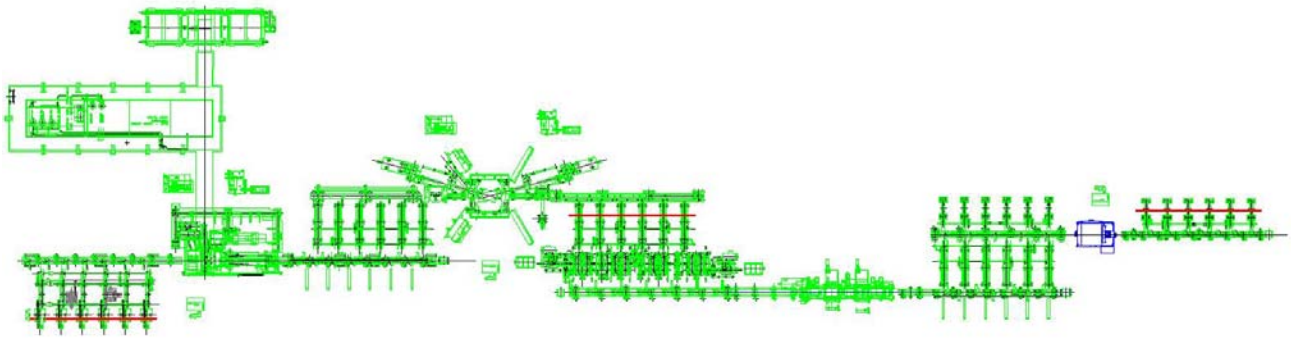

Figure 8. Peeling Plant layout to produce SBQ bright bars from pre-straightened black bars.

Strategically located operator's pulpits and control desks allow operation of a plant of this nature with 5 people including bar loading and unloading operations.
However an integrated system so conceived can efficiently operate only if it is composed of well engineered and efficient bar receiving, transferring and process equipment, which shall work in a continuous mode with high reliability and requiring little maintenance to guarantee high production rates and a constant quality product.
Bars are evenly loaded on a bar receiving and transfer table, automatically sorted and transferred on a roller conveyor feeding a high precision centerless turning-peeling machine. The entry roller conveyor is automatically height adjustable in order to remain on the peeling center line when the bar diameter is changed. It is also designed to feed continuously bars into the peeling machine feeding rollers with tail-to-head bar contact in order to guarantee a continuous bar peeling process which better controls potential head and tail vibration and preserves toll life.
The peeling machine – Danieli model CTMPL 100 (See. fig. 9)– is composed of the following main components and features:

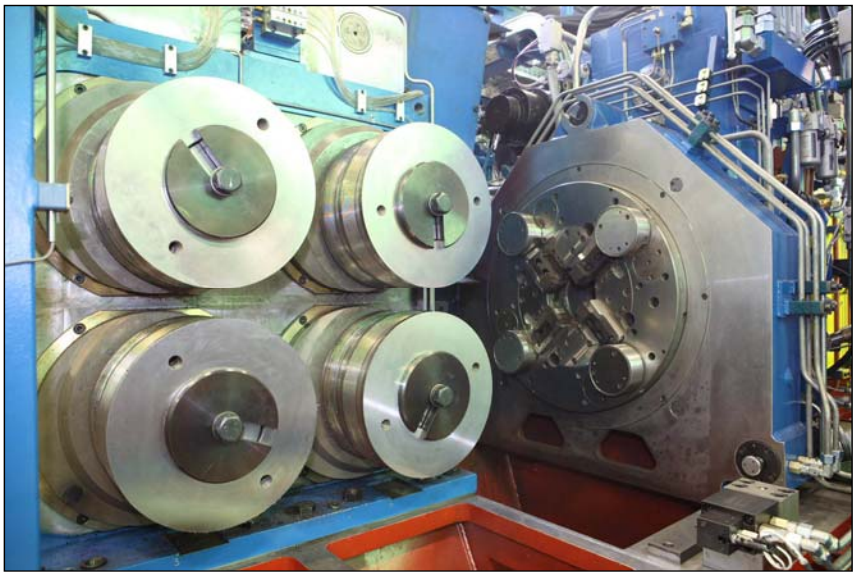

Figure 9. Bar Peeling machine model CTMPL 100.

Double Infeed pinch roll composed by four auto-centering rolls with the possibility to regulate the clamping pressure on the bar. Rolls shape and dimensions are designed in order to have only one set of rolls to cover the complete working range of the machine thus reducing the machine set up down time.
Bar entry guide composed of four radial rolls placed at 90°. Guiding rollers are automatically regulated in order to maintain the bar in the exact peeling centerline.

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Guiding rolls are spring preloaded and controlled by a hydraulic cylinder complete with linear position encoder. A single guiding set covers the full bar size range.
Cutting Head with Turning spindle & drive unit composed of a sturdy structure laser aligned, keyed-in and bolted on the machine base. It is capable to absorb vibrations to guarantee excellent bar surface quality and longer tool life.
The turning head tool positioning is directly connected with a combined radial and a differential group (See. fig. 10) that continuously adjusts the cutting tools with micro regulations following the bar diameter readings by the laser measuring system mounted at turning spindle exit side. One turning head covers the full production range while diameter changes ranging within the reach of the tool holders mounted on the machine are set up directly from the pulpit through the PLC by means the recipe system.
The unit incorporates a 2 speed gear transmission box with heavy duty; case hardened and tempered gears.
The easy access on the machine allows a quick tool changing system which is performed in less than 5 minutes.
Coolant conveying chutes and all parts subject to chips abrasion are lined with hardox and wear-proof, special hardened steel material, easily replaceable.

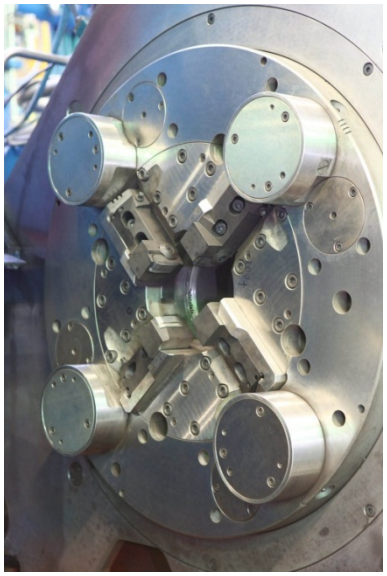

Figure 10. Peeling machine radial group with four cutting tools.

Bar exit guide composed of optimized material guiding system with three (3) sets of 3 radial guides installed at cutte head exit side. Each set is equipped with 3 hydraulically controlled and balanced rollers (or pads), capable of applying a controlled pressure on the material to avoid marks even for soft materials.
The first set of guiding rollers is positioned very close to the cutting tools to guarantee an excellent bar supporting action, to efficiently absorb process vibrations also for the smallest bar diameter and to provide a high finish of the complete bar surface including front and tail ends.
The exit guiding system incorporates a high performance coolant spraying system supplying coolant at high pressure (16 bar or 230 PSI) close to the tools, in order to spray away chips and to create a fluid barrier to prevent chips from entering into the exit guide. It also provides an efficient tools cooling and produces a thermal shock on the cut chips therefore they break easier and thus chips flushing becomes more efficient while any tendency of bar clogging is eliminated.

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Bar Pullout Assembly composed of welded structure traveling on high precision ball bearing linear guides and driven by means of a heavy duty low friction ball bearing screw system allows a precision displacement in total synchronization with the Bar Infeed unit. Such requirement is of maximum priority when turning high precision bars having close tolerance (h7-h8) and a high finish surface. It includes two auto-centering bar clamping jaws made of special bronze or specialty steel material to prevent bar marking, closing precisely on the machine centerline. It also includes two rollers mounted on the bottom one at entry and the other at exit side which are height adjustable to effectively support the bars in process.
Laser Unit mounted at the exit side of the peeling machine to provide a continuous bar diameter reading for the automatic, close loop tools adjustment. This feature guarantees a timely and continuous adjustment of the cutting tools which is done also while the bar is being peeled in order to process bars within the set tolerance range.
Protection enclosure (See. fig. 11) that surrounds the entire machine to both protect the machine from entry of airborn dust/dirt and also for the operator's safety during peeling. The highly ergonimic design ensures rapid access for both operational and maintenance purposes:

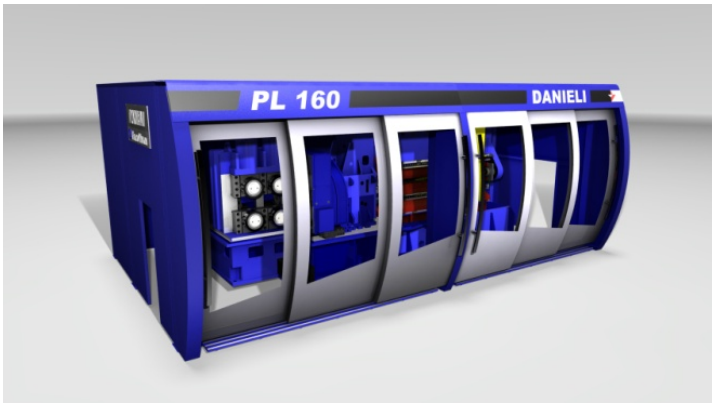

Figure 11. Peeling machine enclosure.

2.3 Bright Bar Straightening and Burnishing (Polishing)

From the peeling line bars are transferred on a bar transferring table and conveyed to the bright bars straightening-burnishing machine to ensure a bar straighteness of ≤0.5 mm/m.
The straightening-burnishing machine - Danieli Model RL 100 - has also two vertically mounted skewed rolls and it is designed to straighten bars in diameters up to 110 mm with a straightening force of approx. 132 tons. Polishing oil (not emulsion) is used to ensure an improvement in the surface roughness of the bars in addition to being straghtened to ≤ 0.5 mm/m.
Straightening rolls are driven by two 130 kW (approx. 180 HP) AC motors.
The 2-roll straightening plant includes a bar pre-spinning unit at entry side and the bar pinch roll at machine exit side, the same as for the black straightener (See fig 12).

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Figure 12. Two Roll Straightener.

At the machine entry side the bar is guided with a rotating guide mounted on largely dimensioned antifriction bearings and made in bronze material to prevent bar scratches.
The side guides mounted on the mid body are made of special bronze material to guarantee a good bar guiding and avoid scratches.
The straightening machine bar feeding and exit channels are also lined with anti-scratch material to preserve the bar surface.
The entry and exit bar transferring tables are lined with anti-scratch material to guarantee a good bar surface.
The process lubrication media is oil which is sprayed on the top and bottom straightening rolls. The oil lubricant is fully collected and conveyed to the oil receiving tank, filtered, cooled and then pumped back to the straightening-burnishing machine for being recycled.
The unit is also provided with recipes (programs) for the automatic set up of the machine and of the service equipment installed at entry and delivery sides.
The complete straightening-burnishing machine assembly including feeding and exit tables, pre-spinning unit, exit pinch roll and so forth, are designed for a minimum bar-to-bar gap of 1 to 2 seconds.

2.4 Electrical and Automation System

The electrical and automation system is supplied by Danieli Automation. The concept applied in the design of the electrical and automation system is to minimize maintenance of the electrical hardware and machine components and, given the variety of products and high production rates needed, to be user-friendly and highly dependable. These requirements are achieved by using AC motors throughout the line while the drives, hardware and PLC's selected are of prime quality.
The highly sophisticated user-friendly material tracking as well as the entire automation system which incorporates highly redundant characteristics from the engineering stage through the hardware production stages, allows to use minimum production personnel who is strategically placed for plant supervisory purposes.
It also guarantees high productivity, close monitoring and a quality reporting at all times (see Fig. 13 and Fig. 14).
The fully integrated automation system supplied incorporates the following characteristics:

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- High flexibility to cover the wide range of products,
- Consistency in the various phases of material tracking and processing,
- Centralized data storage,
- Early and consistent quality control,
- Quality-oriented and comprehensive production reporting.

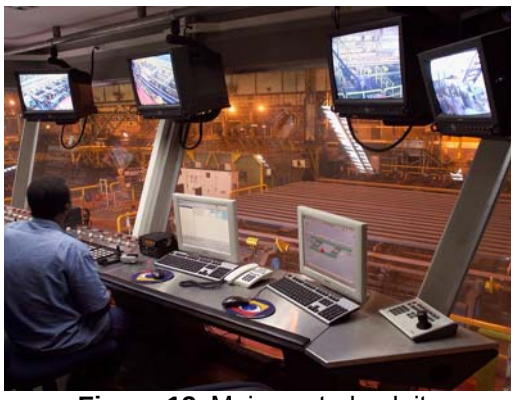

Figure 13. Main control pulpit.

Figure 14. Electrical cabin.

The supplied automation is generally tailor made to conform to the client's server architecture and is based on highly specialized automation units where the server is dedicated to database management while single "client units" strategically located in the plant allow the operators to directly make use of the various production management functions
The complete line uses the Danieli Recipe (Program) System where the operator can memorize the settings of the all plant, for each material grade and bar diameter processed which can be automatically recalled and reutilized when the same size, the same grade or both is produced again. This system allows the operator to set up the main parameters of the equipment and handling tables of the complete Cell in less than 15 minutes.

3 PLANT PERFORMANCE

The design and construction of the equipment making up a plant of this nature shall fulfill the principle earlier described in terms of a straightforward layout, equipment sizing, quality handling to allow high speed production cycles and high production capabilities, hardware redundancy to guarantee limited maintenance and lower downtime.

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It must also include a comprehensive automation system, an effective bar tracking system, complete production reporting at the operator's disposal in strategically located areas and quality control functions which ensure high production levels and constant plant performances.
In order to guarantee high productivities on a consistent basis and a short plant operation learning curve, the Danieli supply includes a high level of training for client's personnel for both operational and maintenance people. The training supplied normally includes: theoretical class training, practical training in our facilities during equipment assembling and in-house testing, and finally hands-on training at plant site during plant start up and the beginning of plant production phases.

4 CONCLUSIONS

The State-of-the-Art Danieli Centro Maskin plants for SBQ bar processing are conceived and realized with the utilization of the most modern solutions with the application of the highest quality standards for both mechanical and electrical equipments. These plants are also controlled by a comprehensive automation which together with the supply of a high quality training for client's operation and maintenance personnel, allows faster plant production and a shorter learning curve.
A faster plant utilization is however subject to a very close relationship and interfacing between vendor's technical personnel and client's personnel in order to have a clear idea on the production practices and actual production methods normally used by the client in his existing plants and requires a close analysis about what can be incorporated in the new plant and in the automation architecture together with a standardization of production charts, maintenance procedures, reporting methods, etc., to tailor make the plant procedures which generally results in a shorter plant learning curve and higher production rates.
The teaming-up approach between supplier and client's personnel has by our experience, produced the best results in project development and project implementation and, together with the use of standard working practices and reporting methods already applied by the client but implemented according to the most modern requirements for top quality and product certification, allows a faster plant handover as well as an accelerated plant utilization.
Unlike the small $ added value margins in hot steel processing, cold finishing operations can add up to 250 $/ton if not more value, a very significant value that allows investment in modern equipment, provided of course that a majority of the productivity of the plant is utlised to satisfy product sales. Therefore although initial equipment costs are high, the payback is attractive which is why an increasing number of steel processors are currently investing in the best European cold finishing technologies.