Environmentally friendly stainless steel processing lines at ThyssenKrupp

During the last few years the development of stainless steel processing lines has been geared towards minimizing environmental pollution and improving final product quality and line productivity. This article presents stainless steel processing lines recently designed by Techint Technologies for ThyssenKrupp works in Italy and Mexico, i.e. one hot rolled steel and one cold rolled steel annealing and pickling line realized at ThyssenKrupp AST Terni and a bright annealing line for TK Mexinox at San Louis Potosi, Mexico

Figure 1. Uncoiling and entry section (TK AST Terni)

Introduction

A highly sensitive problem in stainless steel processing is to minimize the environmental impact of the plants from the use of highly polluting acids. Severe problems may be caused by the use and handling of hazardous chemical agents common in most stainless steel processing lines.

During 75 years of experience, Techint Technologies have gained a wealth of knowledge in the field of stainless steel processing lines. During the last few years research and development have been oriented towards production technologies for large industrial plants and chemical processes, with a view to minimizing pollution, improving final product quality and line productivity.

At the same time line design must satisfy highest customer requirements, such as major revamping projects performed in just a few weeks, erection of a new line in a confined, existing space or design of a new line using part of the existing equipment. Therefore Techint has developed a "tailor-made" design, based on customers' needs, appreciated by many steel makers worldwide.

Hot strip annealing and pickling line at TK AST Terni works

Following the market trends this project, started up at the beginning of 1998, was geared towards the renewal of the traditional annealing and pickling line for hot rolled stainless steel coils. The main objectives of the project were:

- to increase line production from 150,000 t/year up to 250,000 t/year,
- to reduce operating and maintenance costs,
- to reduce environmental impact,
- to process various kinds of materials within a wide range of thicknesses and widths,
- to improve quality standards,
- to reduce costs for process fluids and effluents treatment.

All these goals could be reached by building a new line or, as decided at Terni works, by modifying and upgrading an existing plant.

The project was performed in two steps during two short line shutdowns, only slightly longer than the usual ones for the scheduled annual maintenance. The main design parameters of the line to produce cold rolled stain-

Stefano Martines, Process & Technology Manager; Pierluigi Curletto, Proposal and Sales Manager, Business Unit Strip Processing Lines, **Techint Technologies**, Genova, Italy

Contact: www.techint-technologies.com
E-mail: pierluigi.curletto@techint.it

less steel (AISI 200, 300, 400 series) are as follows:
- output: 250,000 t/year,
- thickness: 1.2 - 7 mm,
- width: 800 - 1,550 mm,
- process speed: max. 40 m/min.

The uncoiling section was transformed into a double pay-off reel section (figure 1) in order to reduce the time cycle for the head and tail operation and to increase the reliability of the entry section. The pay-off reels were provided with a mandrel having a wide expansion range (580 to 780 mm) capable of loading hot rolled coils with inner diameters of 760 mm and 610 mm.

The entry strip accumulator was improved by introducing a new four-strand horizontal accumulator, provided with steering rolls on board. New drives, bridles and modern steering rolls were provided in order to increase the entry speed from 30 m/min to 65 m/min and to perform closed loop strip tension control in the furnace.

Annealing, shot blasting and pickling section. The catenary-type annealing furnace (figure 2) is characterized by very high heating capacity within a reduced length and by the regenerative flame-less burners limiting emissions and gas consumption by means of internal regenerative systems. The strip cooling section (figure 3) is a 'multimedia' system provided with an innovative first section fed with air and fog by specially designed air-water ramps; the water flow rate is controlled by dedicated software which, considering the strip speed, thickness and temperature, obtains the best strip shape quality and the required strip temperature (< 80 °C).

A specially designed steering roll was installed at the cooling section exit. It centres the strip and elongates the shorter strip edge by means of a tensioning, thermo-flattening effect acting on the strip. The result is improved strip tracking and centring in the entire pickling section as well as in the complete downstream process.

A high-capacity 8-turbine shot blasting machine was installed. Ahead of the first pickling tank, a steam ramp system was installed in order to eliminate residual powders coming from the shot blasting machine, and pre-heat and wet the strip surface. This increases pickling efficiency and reduces acid consumption.

The environmentally friendly pickling section is characterized by low operational costs and minimized post-treatment costs. The innovative tanks were provided with high-turbulence shallow-type pickling and final spray pickling sections, all fed with 'reduced pollution acids'. In this way the use of nitric acid is avoided and consequently nitrates in waste solutions and nitrogen oxides in fumes are completely eliminated. In the sulphuric and hydrofluoric acid bath, the necessary oxidizing ambient is provided by ferric ions. The whole new pickling section was located on a steel structure, above the existing pickling section, and erected and cold commissioned between November 1998 and March 1999, with the line being in operation. The exit steering roll was dismantled and re-assembled in the final position, the pass line was changed, fresh acid, waste piping and the acid analyzer were connected and the new pickling section was commissioned during a scheduled 8-day line stoppage.

Exit section. A new double-strand horizontal looper, to be located on a steel structure over the new exit section, was supplied together with new bridles, steering roll, cut shear, tension reel, coil car and automatic strapping machine.

Electrical and automation system. A completely new system was installed, including AC VVVF drives for strip tracking. The automation and supervision system allows operators to have automatic control of all line processes as well as all automatic sequences in the entry and exit sections. The line layout has been designed to enable the future insertion of a cold rolling mill (type Z-Hi) in the entry section and the insertion of a side trimmer in the exit section.

Cold strip annealing and pickling line at TK AST Terni works

This project, started in March 2001, replaced three existing lines. Completed in January 2003 it represents a con-

Figure 2.
Annealing furnace

Figure 3.
Strip cooling section

tinuation of the renewal of the Terni stainless steel plants. The main design parameters of the line intended to produce cold rolled stainless steel (AISI 200, 300, 400 series) are as follows:
- output: 350,000 t/year,
- thickness: 0.3-3 mm,
- width: 800-1,550 mm,
- process speed: max. 90 m/min.

Figure 4. Uncoiling and entry looping section

The new line has been designed with the following main aims in mind:
- to produce strips to highest quality standards,
- to minimize environmental impact and effluent treatment costs,
- to minimize operating and maintenance costs,
- to process various kinds of materials in a wide range of thicknesses and widths,
- to fit the new line into an existing building.

The line layout is designed to allow the future insertion of a cold rolling mill in the entry section, a cleaning section before the annealing furnace and a skin pass mill and tension leveller in the exit section. All the line sections are characterized by interesting and innovative technical solutions.

The uncoiling section was provided with a double pay-off reel and it is sized to handle 30 t coils with or without metallic sleeve (figure 4). Coil cars with tilting saddle and special sleeve storage skids allow simple sleeve discharging. Up to a thickness of 6.5 mm the coil ends are cut and then, by means of a calender machine bent and wrapped in coils of about 600 mm diameter.

The horizontal 4-strand entry looper enables the accumulation of more than 440 m of strip, allowing the operator to inspect the weld seam and redo welding if necessary. The looper car is provided with two on-board steering rolls of the proportional-integral type.

A special basket roll allows passline adjustment, avoiding additional bending of the strip. The tensiometer No. 1 ensures perfect strip tension control in the looper.

Annealing section. Bridle No. 2 controls the strip tension at the entry of the catenary furnace also using tension feedback from tensiometer No. 2. The furnace was ordered directly by TK AST from another supplier. It is mainly composed of a fume pre-heating section and four heating sections.

The cooling section is composed of four air jet cooler zones and by one final spray water section. At the exit of the cooling section, a steering roll of the double roll proportional-integral type with 'thermo-flattening effect' was installed and follows the same principle as the one installed in the hot annealing and pickling line described above. Tensiometer No. 3 was installed on the second roll to be used as a feedback for the strip tension control at the furnace exit.

Pickling section. The pickling section is shown in figure 5. Bridle No. 3 is located before the pickling tanks. It works as the speed master of the process section. Tensiometer No. 4 is used to control the strip tension at the entry of the pickling section by means of bridle No. 4 located at its end.

The first discaling effect is obtained by two electrolytic shallow tanks, operated with sulphuric acid. In the acid ambient chromium is not present as hexavalent ions (Cr^{6+}), and consequently the Cr^{6+} reduction plants for the waste pickling solution and the waste rinsing water have been eliminated.

The pickling section is composed of a high-agitation shallow tank and by a final spray 'high-flow rate' pickling tank; all these sections are operated with a nitric-free mix of acids avoiding nitrates in the waste water as well as NO_x (nitrogen oxides) in the fumes.

Brush scrubber machines and high pressure water rinsing systems are located at the exit of the electrolytic tank and at the end of the pickling section. The high-pressure water rinsing units enable the line to be operated with very limited use of brushes (in some cases without brushes) resulting in a considerable reduction in operating and maintenance costs.

The final rinsing section is characterized by some outstanding features. It is operated with cold soft water and finally the strip passes through steam-operated ramps capable of mechanically removing water and water salt from the strip surface and at the same time heating the strip, resulting in a remarkable simplification of the final drying process.

Exit looping and delivery section. The exit section of the line at the TK AST Terni works is also visible in figure 5. The exit pickling steering roll is designed to guide the strip having a backward effect in the rinsing and drying equipment. The tensiometer, installed on board, allows 'direct' tension control by bridle No. 4.

The exit looper is similar to the entry looper; here the special design of the basket roll installed on the looper car plays an important role in eliminating plastic deformation of the annealed material.

The exit section, designed to enable the simple installation of a skin pass section, includes a double mirror vertical inspection stand, the cabin of which is connected to the exit pulpit. This is followed by the exit bridle, shear, scrap and sample box.

The tension reel can wind up to 30 t coils and is provided with outboard

Figure 5. Pickling section

Figure 6. Strip being coiled at exit section

Figure 7. The bright annealing line No. 1 of TK AST Terni will be relocated to TK Mexinox for modernization and re-use

bearing support, closed-face mandrel with gripper, belt wrapper and double paper un-winder with automatic paper feeding (from the top) and automatic centring. The exit section is completed by an automatic banding machine and a weighing scale.

The technical solutions adopted and their 'harmonic assembly' within the line layout allowed the production of coils at a very high quality standard from the first coil produced. This excellent performance has been testified by the line operators and the quality inspector who noted that the coils treated in this line (figure 6) were brighter compared with cold strip coils annealed and pickled on traditional lines. Furthermore the frequency of defects has been reduced compared with coils processed in the existing APL lines.

Bright annealing line at ThyssenKrupp Mexinox

In December 2004 ThyssenKrupp Mexinox placed an order with Techint to design and supply a new bright annealing line to be installed in the existing cold rolling mill at San Luis Potosi, Mexico. The main design parameters of the line to produce cold rolled stainless steel (AISI 200, 300, 400 series) are as follows:

- output: 70,000 t/year,
- thickness: 0.3-1.3 mm,
- width: 800-1,350 mm,
- process speed: max. 45 m/min.

The project is characterized by the fact that new and consolidated technology is applied together side by side. Main mechanical items are taken from the shut-down bright annealing line (BAL) No. 1 at ThyssenKrupp AST Terni, Italy, and revamped (figure 7).

The cleaning section is partially taken from the Terni BAL. It will be intensively enhanced by installing a new pre-cleaning section working with a 'Supersonic Steam Box' which pre-heats the oiled strip and removes more than 50 % of the rolling oil. It noticeably reduces the amount of chemical agents and the related polluted effluents.

Other improvement to the cleaning section comes from a new cleaning solution filtering and de-oiling system. This system is mainly composed of rotating drum filters, paper filters, coalescent plate decanter and ultra-filtration membrane operating continuously in order to keep the cleaning solution contamination constant. Ultra-filtration systems are provided to treat the rinsing water.

The new furnace, sized for a maximum capacity of 12 t/h, is of the muffle type, provided with entry sealing chamber, pneumatic dancer roll, heating chamber and cooling section located in the vertical entry strand, double top roll with steering device and exit sealing chamber. The line layout and the steering, deflector and tensiometer rolls have been redesigned in the complete furnace area, retaining as much as possible the existing equipment.

The electrical plant (power centre, drives, and MCC) as well as the automation system (PLC's, Level 1 and Level 2 supervision) are new. This will provide the operators a completely integrated control and supervision environment for all line sections, processes and auxiliary equipment.

Conclusions

Design criteria in projecting and implementing new stainless steel processing lines have changed during the last few years. Plant makers have to pay particular attention to the new needs and are facing new challenges. The projects explained above are examples of the new steel producer needs and how they can be solved.

Techint's capability of managing major and innovative projects, including new high-productivity and high-quality processing lines as well as major revamping and modernization activities, is the result of a long tradition in processing line engineering. Other recent examples include the revamping of high-capacity carbon steel pickling lines as at MMK Magnitogorsk (Russia), ILVA Genova-Cornigliano (Italy), Hellenic Steel Plant in Greece and LISCO Misurata (Libya).

A highly sensitive problem in the stainless steel processing is to minimize the plants' environmental impact caused by the use of highly polluting acids. The new Techint processing lines meet the requirements of high reliability and environmental safety. The processes have widely proven in the Italian plants.

The steel makers will adopt the new environmentally friendly technologies which tackle at their roots serious and dangerous problems that might be caused by the use and handling of hazardous chemical agents common in most stainless steel processing plants. ■