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Rolling technology: Seamless steel tube production at Tianjin

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Steel mill waste recycling at ThyssenKrupp Duisburg works

Modernization of pickling lines at MMK Magnitogorsk

In July 2004 Techint successfully started up the refurbished pickling line No.2 at MMK. To convert this line from sulphuric to hydrochloric acid completely new acid and rinsing recirculating systems were provided. The high-capacity No.1 pickling line had been set into operation at the beginning of November 2004, well in advance of the originally scheduled date. The No. 1 line is anticipated to reach its nominal capacity during the next few months. Main features of the line include its very high speed, its strip dimension range (1.2-6 mm thickness; 1,050-1,850mm width) and its high-turbulence, high-efficiency polypropylene pickling tanks.

Figure 1. Pickling line No.1 was modernized to reach a nominal capacity of up to 2,200,000 t/year

Introduction

In autumn 2002, the Strip Processing Lines Business Unit of Techint Technologies (Techint SpA) was awarded a contract for the modernisation of two pickling lines and related equipment for steel coils by Magnitogorsk Iron & Steel Works (MMK), Russian Federation. The order was covered by an innovative Citigroup/SACE financing scheme which was the winner of the "Deal of the Year 2003" prize awarded by the Trade Finance magazine. In fact, 85% of the value was financed under a buyer's credit scheme, backed by SACE, the Italian export credit agency. Apart from contributing to the success of Techint's strategic transaction, this represents a remarkable step towards a new approach to the enhancement of the creditworthiness of foreign companies.

The first part of the project was successfully started up in July 2004 on the occasion of a twofold celebration, namely of the 75th anniversary of the foundation of the town of Magnitogorsk and of the Russian Metallurgy Day. Pickling line No.1, which was the last step of the project, was put into operation at the beginning of November 2004, much ahead of the original schedule. The scope of the project included:

- the rebuilding of an existing pickling line into a modern state-of-the-art line,
- the conversion of a second pickling line from sulphuric to hydrochloric acid,
- the supply of two acid regeneration plants,
- a new slitting line, along with
- the supply of two new entry sections for the existing skin-pass mills.

The modernized pickling line No.1 **(figure 1)** stands out for its very high capacity (up to 2,200,000 t/year of steel strip), its high line speed (800 m/min in the entry section, 300 m/min in the process section) and the wide strip size range (1.2 to 6 mm thickness, 1,050 to 1,850 mm width). The project was not only challenging due to the high processing speed and wide size range of the steel strip, but also due to the more delicate equipment in the line, such as the tension leveller, which had to be specially developed by the Techint engineering department.

Pickling plant technology has seen very important achievements and progress in recent years. Based on the requirements of the market and the needs of the steel industry, Techint Technologies has developed new high-performance effluent-free strip pickling lines. These technological evolutions meet the requirements of cost-effectiveness, improved product quality and environmentally safe processing, combined with minimized maintenance requirements. The combination of new pickling technology

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	Pickling line No. 1	Pickling line No. 2	Slitting line
Nominal capacity:	2,200,000 t/year (max. 405 t/h)	1,100,000 t/year (max. 228 t/h)	500,000 t/year
Material to be processed:	Hot rolled unalloyed carbon steel	Hot rolled low alloyed carbon steel	Hot rolled, pickled low carbon steel
Strip thickness	1.2 – 6.0 mm	1.2 – 6.0 mm	2.0 – 2.5 mm
Strip width	1,050 – 1,850 mm	1,050 – 2,350 mm	1,500 – 1,850 mm
Coil dimensions			
Entry OD max.	1,950 mm	(n.d.)	2,200 mm
Entry weight max.	30 t	20 t	35 t
Exit OD max.	2,200 mm	(n.d.)	2,000 mm
Exit weight max.	35 t	35 t	18 t
Line performance			
Process speed:	300 m/min	220 m/min	250 m/min
Entry speed:	800 m/min	(n.d.)	(n.d.)
Exit speed:	360 m/min	(n.d.)	(n.d.)

Table 1. **Main characteristics of the plants**

and regeneration plants for waste pickling liquor enables the operation of pickling plants without producing any waste water or pollutants. The main characteristics of the plants for steel strips are summarized in **table 1**.

Scope of supply

For pickling line No. 1 the scope of work included the design and supply of the entry section, entry looper section, process section, exit looper section, electrical and automation systems and auxiliary plants.

For pickling line No. 2 the technological equipment for the process section and a new acid regeneration plant were designed and supplied. The No. 2 acid regeneration plant features spray roaster technology to regenerate the exhaust acid and the rinsing waste water of both pickling lines.

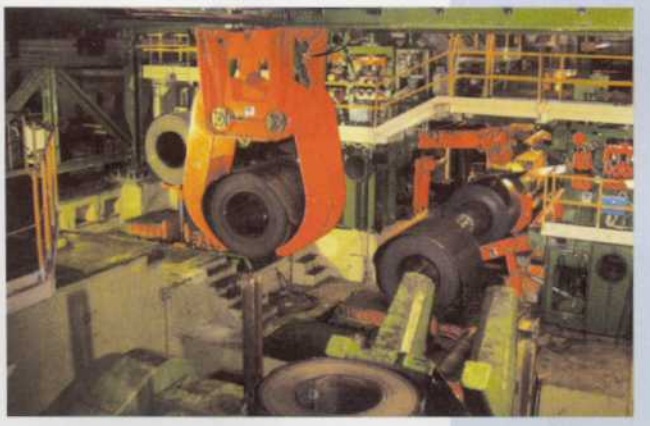

Figure 2. **Automatic coil lifting and transportation device**

Figure 3. **Tension levelling and scale breaking device**

For the completely newly designed slitting line the scope of work also included the electrical and automation systems.

Highlights and process description of pickling line No. 1

Mechanical equipment. A very important and special feature of this line is the coil loading section. It was specially designed in order to handle vertical axis coils coming from an existing chain conveyor. Coils that are conveyed without straps are tilted into the horizontal axis by a coil downender and then lifted by a specially designed lifting and rotating saddle which rewinds the loose external wraps. After this operation a coil lifting and transportation device equipped with a special hydraulically operated coil gripper **(figure 2)** fully automatically performs the following operations:

- lifting,
- rotation through 180° to turn the strip head into the right direction,
- shifting and loading on the specially designed coil saddle.

The entry section is provided with a double unwinding pass line in order to reduce the cycle time in the entry section, thus enabling high production capacity even if smaller coils are processed.

The entry and exit looper cars, which are of the six-strand and four-strand type, respectively, are provided with movable-type grooved winches, which improve the accuracy of winding and the rope life, and with strip separator arms moved by means of a reduced-acceleration cam-lever mechanism. Steering units are installed for each strand of the loopers and at the exit of the pickling and rinsing sections

Tension levelling and scale breaking section. This "pull-through" flexing unit located in the process section before the pickling tanks subjects the strip to an alternate bending moment resulting in the top side and then the bottom side undergoing elongation under tension **(figure 3)**. Through this it is possible both to break the hot rolling scale on the surface of the strip and improve strip flatness.

The flex housing provides mountings for two sets (four rolls) of work rolls and one crossbow correcting set. All flexing rolls are backed by a series of small face rolls nested over the entire face of the flexing rolls.

The top beam assemblies, including the work and back-up rolls, are supported by hydraulic cylinders which raise the beam assembly for "quick opening" to allow quick replacement of the roll cassettes.

This tension levelling and scale breaking unit, sized for the maximum strip size (6 x 1,850 mm), is capable of applying a maximum exit tension of 650 kN. For such a high strip tension the machine is provided with an entry double roll bridle (BR 2) and two exit double roll bridles (BR3 and BR4). BR 2 and BR3 are connected through a mechanical 3-differential drive system in order to convey the energy generated in the entry bridle toward the main motor and then to the exit bridle (BR3).

One elongation AC motor differential gear box controls the elongation ratio (from 0 to 3%) and two AC motor torque sharing boxes allow elastic elongation compensation of the strip inside each bridle and proper torque sharing.

Pickling section. The process section **(figure 4)** was designed considering the pickling requirements of the incoming material qualities. Consequently the strip surface is pickled in a smooth way, over-pickling is suppressed and the consumption of chemicals and energy as well as the production of emissions are controlled efficiently.

The pickling process includes the following equipment:

- pre-rinse section,
- pickling section with four modern shallow tanks made of polypropylen (PP),
- pickling tanks with acid heating and circulation systems,
- rinse section of the 5-stage cascade spray type and high pressure final spray section,
- strip dryer (with edge blowing system),
- fume treatment system,
- acid analyser to control the concentration of ferrous ions.

Pickling takes place in the four-cascade pickling tanks at a processing temperature of 80 °C. The scale layer (ferric and ferrous oxides FeO, Fe_2O_3, Fe_3O_4) on the strip is chemically dissolved by the acid (HCl) to form ferrous chlorides (FeCl, $FeCl_2$ in solution) and water.

Figure 4. Process section of pickling line No. 1

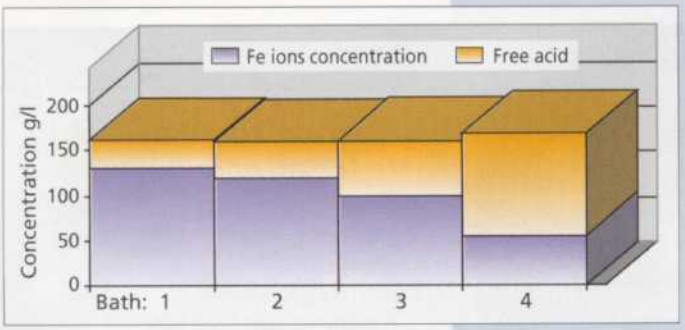

Figure 5. Diagram of the pickling bath cascade system

In the pickling bath the cascade system results in a stepwise concentration of the dissolved scale and free acid between the pickling cascades as shown in the block diagram in **figure 5**. This concentration gradient greatly improves pickling efficiency and permits sufficient pickling results with up to 130 g/l of metal in the exhausted solution.

To reach this result overflow chambers with squeegee rolls are located after each pickling tank. The squeegee rolls suppress carryover of acid by the strip to the downstream circulating tank. After the last pickling tank a double squeegee roll with integrated strip guiding system is arranged enabling reduced transportation of acid into the rinsing section.

Also acid circulation and bath agitation play important roles. They have been improved and simplified in terms of operation and maintenance.

The circulating system has been designed in such way that with a view to a high material throughput all circuits operate at the same circulation rate. Only during low speed operation (i.e. producing thick material or material easy to pickle) one or more circuits are switched off.

The pickling requirement analysis is done automatically by the process PLC taking into consideration coil qualities and size (information coming from the Level 2 system) in order to operate the pickling line economically and in an environmentally conscious manner.

Acid concentration or the pickling temperature can also be adjusted by this model, or by the operator in the control room through the supervision system.

To reach high mixing of fresh acid in the pickle bath and to increase the relative speed between the strip and the pickle agent, the circulating acid is injected into the pickling bath opposite to the strip run direction. The injection nozzles are distributed all over the pickle bath at the sidewall to achieve a uniform temperature and concentration distribution. Additional spray headers are located at the entrance of the pickling tank allowing direct chemical interaction of the strip surface with the scale and immediate heat transfer into the strip.

Another advantage of acid injection from the sidewall is that first the main scale layer at the edges of the strip comes into contact with fresh acid, the impact of the injected acid still being quite high.

Granite blocks protect the sidewall and the whole bottom of the pickle tanks. The PP-tank/overflow chambers feature a specially designed sealing system enabling the thermal expansion of the pickling tank without drainage of fumes and liquids.

The PP-pickling tanks are generally pre-installed on an integrated drip pan and a supporting structure. In such a way construction and installation activities on site and the shutdown period can be reduced to a minimum.

To reach a defined strip catenary in the middle of the pickling tank, a specific tension is set by means of tensiometers at the entry and at the exit of the pickling tanks.

For each pickling tank a separate circulation tank is provided. During plant shutdown the total acid content in the pickling tank is drained into the circulation tanks, the return pipes are sized large enough to keep the drainage time as short as possible (below 5 minutes). This increases the safety of the whole line.

During a shutdown, the PLC automatically switches the circuit to the so-called "short circuit" which keeps the bath at temperature. By this installation the restart of the system back to operation conditions is kept as short as possible (approx. 2.5 minutes).

The consumption of fresh acid is kept low through the permanent and reliable determination of the iron concentration by means of density measurements in the waste acid. The condensate from the heat exchangers of each cascade is controlled by conductivity measurements. This ensures that no acid breakthrough takes place without an alarm in the system, enabling the locating of the leakage and reduced repair and maintenance work.

The rinsing of the strip is performed by means of a 5-cascade spray rinse section. The use of five cascades improves the economy of condensate consumption for rinsing. The rinsing water is collected in a collecting tank. Part of the rinsing water is used for make-up water in the pickling section, the balance is sent to the regeneration plant.

Conclusion

The **MMK** project represents a new important example of Techint Technologies' capabilities in handling major projects, including new high productivity processing lines as well as comprehensive revamping and modernization activities.

This is the result of a long history of project experience in processing lines as well as major revamping projects handled during the last few years like, for example, the hot annealing and pickling line No. 2 for stainless steel at the Terni works of ThyssenKrupp AST, the new Ilva pickling line No. 1 at Genoa-Cornigliano (both in Italy) or the Hellenic Steel pickling line in Greece. The vast experience in managing complex revamping projects helps to keep shutdowns to a minimum and retain as much existing civil work and structures as possible. Any interventions are studied beforehand and consistently planned based on the customer's requirements. The design observes the requirements of reliability, safety and the environment. ■