Modernisation of pickling lines at the Magnitogorsk Iron & Steel Works

New high-performance effluent-free strip pickling lines provide cost-effectiveness, improved product quality and an environmentally safe process combined with minimum maintenance. The successful design, construction and operation of the Magnetogorsk project represents an important example of the capability of Techint Technologies to manage an important project involving a new high-productivity processing line as well as major revamping and modernisation activities.

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Techint Technologies (Techint SpA) has a long history of processing line projects and in recent years very significant progress has been made in pickling plant technologies. Based on the requirements of the market and the needs of the steel industry new high-performance effluent-free strip pickling lines which provide cost-effectiveness, improved product quality and an environmentally safe process combined with minimum maintenance have been developed. The combination of new pickling technologies and regeneration plants for waste pickle liquor makes it possible to operate pickling plants without producing waste water and pollution.

Recent projects include the Hot Annealing and Pickling Line No.2 for stainless steel at Thyssen-KruppASTs Terni works, the new ILVA No.1 Pickling Line at Genoa-Cornigliano and the Hellenic Steel Pickling Line in Greece.

In 2002, the Strip Processing Lines Business Unit was awarded a contract for the modernisation of two steel coil pickling lines and related equipment by Magnitogorsk Iron & Steel Works (MMK), Russian Federation. Part 1 was completed in July 2003 and part 2 in November 2004, ahead of schedule.

PROJECT DESCRIPTION

The scope of the project included the rebuilding of an existing pickling line into a modern line, the conversion of a second pickling line from sulphuric to hydrochloric acid, the supply of two acid regeneration plants, a new slitting line and the supply of two new entry sections to the existing skin pass mills.

The main features of the modernised No.1 pickling line are the very high capacity (up to 2.2Mt/y of steel strip) the high line speed (800m/min in the entry section, 300m/min in the process section) and the large strip size range (1.2–6mm thickness and 1,050–1,850mm width). The project was particularly challenging due to the high speed and wide size range of the strip and the development of delicate equipment in the line such as the tension leveller. The main characteristics of the plants are:

Fig.1 No.1 pickling line

No.1 pickling line Scope of work included design and supply of the entry section, entry and exit looper sections, process section, acid regeneration plant, electrical automation system and auxiliary plants (see *Figure 1*).

Production capacity	2.2Mt/y (405 t/h)
Material to be processed	Hot rolled strip of unalloyed carbon steel
Strip dimensions	Thickness 1.2–6.0mm
	Width 1,050–1,850mm
Coil dimensions	Entry outside diameter (OD) max 1,950mm
	Entry weight – max 30t
	Exit OD – max 2,200mm
	Exit weight – max 35t
Line performance	800m/min entry
	300 m/min process
	360 m/min exit

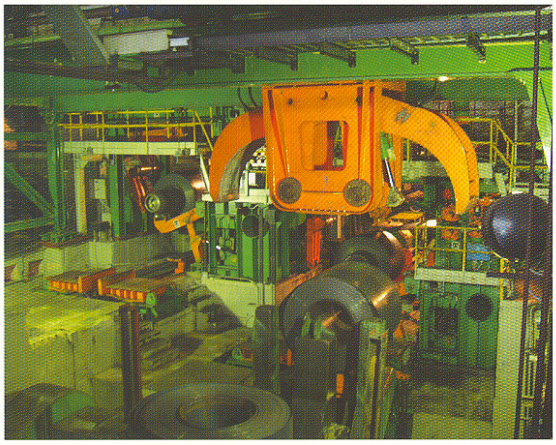

Fig.2 Automatic coil lifting and transportation device

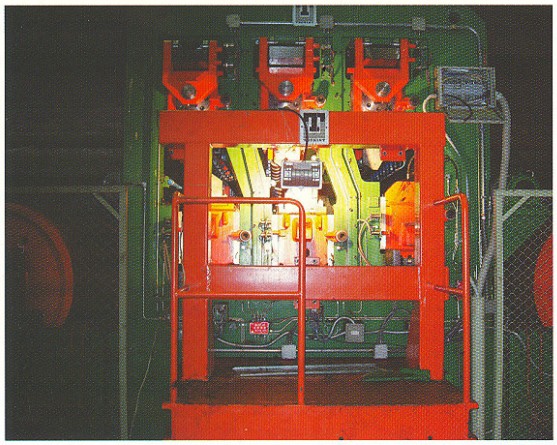

Fig.3 Tension levelling and scale breaking device

No.2 pickling line Scope of work included design and supply of the technological equipment for the process section and a new acid regeneration plant.

Production capacity	1.1Mt/y (max 228t/h)
Material to be processed	Hot rolled low carbon steel
Strip dimensions	Thickness – 1.2–6.0mm
	Width – 1,050–2,350mm
Line performance	Process speed – 220m/min

No.1 and No.2 acid regeneration plants

Main features	Two spray roaster technology plants to regenerate the exhaust acid and the rinsing waste water of both pickling lines

Slitting line Scope of work included design and supply of a complete slitting line including electrical and automation systems

Production capacity	500kt/y
Material to be processed	Hot rolled and pickled low carbon steel
Strip dimensions	Thickness 2.0–2.5mm
	Width – 1,500–1,850mm
Coil dimensions	Entry Coil:
	Internal diameter – 610mm
	External diameter – 1,000–2,200mm
	Weight – Max 35t
	Exit Coil:
	Internal diameter – 520mm
	External diameter – 1,000–2,000mm
	Weight – Max 18t
Line performance	Process speed – 250m/min

NO.1 PICKLING LINE: MAIN PLANT HIGHLIGHTS AND PROCESS DESCRIPTION

Mechanical equipment A very important area of this line is the coil loading section which was specially designed to manage vertical axis coils coming from an existing chain conveyor. The coils, which have no straps, are tilted horizontally through a coil down-ender, then are lifted by a specially designed lifting-rotating saddle operated to rewind the loose external wraps (see *Figure 2*). After this operation a completely automatic coil lifting and transportation device utilising a hydraulically operated coil gripper, performs the following operations:

- Lifting
- Rotation of 180° to get the strip head in the proper direction
- Shifting and loading on special designed coil saddle.

The entry section is provided with a double unwinding pass line to reduce the entry section time cycle and increase production capacity even if coils of reduced size are processed.

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

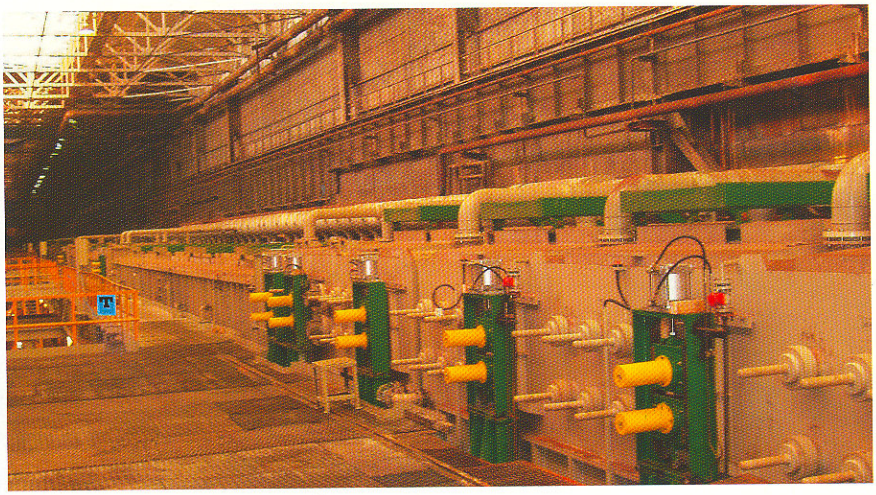

Fig.4 Process section of No.1 pickling line

Tension levelling-scale braking section This is a 'pull-through' flexing unit located in the process section before the pickling tanks which subjects the strip to a bending moment resulting in the top and bottom sides alternately undergoing elongation under tension. By this process it is possible both to break the hot rolling scale on the surface of the strip and to improve the strip flatness (see *Figure 3*).

The flexible housing provides mountings for two sets (four rolls) of work rolls, and one crossbow correcting set. All flexing rolls are backed up 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 rapid opening to allow faster roll cassette replacement. This tension levelling and scale breaking unit, sized to improve the strip shape up to the maximum strip size (6 x 1,850mm), is capable of a maximum exit tension of 650kN.

To apply a such a high strip tension the machine is provided with a entry double roll bridle (BR2) and two exit double roll bridles (BR3 and BR4). BR2 and BR3 are connected through a mechanical 3-differential drive system in order to 'convey' the energy generated in the entry bridle towards the main motor and then to the exit bridle (BR3). One elongation AC motor differential gear box controls the elongation ratio (0–3%) and two AC motor torque-sharing boxes allow strip elastic elongation compensation inside each bridle.

Pickling section The process section was designed specifically for the pickling requirements of the incoming material qualities (see *Figure 4*). Consequently the strip surface is pickled gently, 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 polypropylene (PP) tanks
- Pickling tanks with acid heating and circulation system
- Rinse section of the five-stage cascade spray type, and a high pressure final spray section
- Strip dryer (with edge blowing system)
- Fume treatment system
- Acid analyser to control the Fe^{++} ion concentration.

The pickling takes place in the four-cascade HCl pickling tanks.

The scale layer on the strip is chemically dissolved by the acid at 80°C as follows:

$$FeO + 2HCl \rightarrow FeCl + H_2O \quad (1)$$

$$Fe_2O_3 + HCl \rightarrow 2\,FeCl_2 + 3H_2O \quad (2)$$

$$Fe_3O_4 + xHCl \rightarrow 3FeCl_2 + 4H_2O \quad (3)$$

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 *Figure 5*. This concentration gradient greatly improves pickling efficiency with up to 130g/l of metal in the exhausted solution. To reach this result overflow chambers with squeegee rolls are located between each pickling tank which 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 ▷

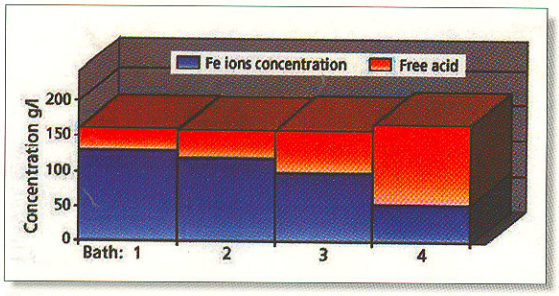

Fig.5 Pickling bath cascade system

system is located thus allowing reduced acid transportation in the rinsing section.

Specific attention was paid in the design to minimise maintenance. The circulating system is designed in such way that for high material throughput all circuits are operating at the same circulation volume; only during slow speed operation (ie, producing thick, or easy pickleable material) are 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) allowing the pickling line to operate to economic and environmental parameters. Acid concentration and pickling temperature can be also adjusted by this model or by the operator in the control room through the supervision system.

To achieve good mixing of fresh acid in the pickle bath and to increase the relative speed between strip and pickle agent, the circulating acid is injected into the pickling bath against the strip run direction. The injection nozzles are distributed throughout the pickle bath at the sidewall to achieve a unique temperature and concentration distribution. Additional spray bars 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. Other advantages of the acid injection from the sidewall are that the main scale layer at the edges of the strip comes quickly in contact with fresh acid and the impulse energy of injected acid is still quite high. Granite blocks protect the sidewall and bottom of the pickle tanks.

The PP tank overflow chambers are designed with a sealing system that allows thermal expansion of the pickling tank, without loss of fumes and liquids. The PP pickling tanks are mainly pre-installed on an integrated drip pan and supporting structure. This minimised the construction and installation activities on site thus the shutdown period was reduced to a minimum. To attain the defined strip catenary in the middle of the pickling tank a specific tension is maintained by means of tensiometers at the entry and exit of the pickling tanks.

For each pickling tank a separate circulation tank is provided so that during plant shut down the total acid content from the pickling tank can be drained into the circulation tanks in less than five minutes. This increases the safety of the whole line. During shutdown the PLC automatically switches the circuit to the so-called 'short circuit' that maintains bath at temperature such that the system can be restarted in approximately 2.5 minutes.

The consumption of fresh acid is kept low by continuous iron concentration determination by means of density measurement in the waste acid. The condensate from the heat exchangers of each cascade is controlled by conductivity measurement. This ensures that no acid breakthrough takes place without an alarm, which locates the leak and hence shortens the repair and maintenance time.

Strip rinsing is performed by means of a 5-cascade spray rinse section. The usage of five cascades economically improves the consumption of condensate for rinsing. The rinse water is collected in a collecting tank where it can be partially used for make-up water in the pickling section, while the balance is sent to the regeneration plant.

CONCLUSIONS

The successful design, construction and operation of the MMK project represents an important example of the capability of Techint Technologies to manage an important project involving a new high productivity processing line as well as major revamping and modernisation activities. All Techint processing lines are designed with high reliability, safety and environmental requirements resulting from years of experience in processing line design, construction and operation. MS

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