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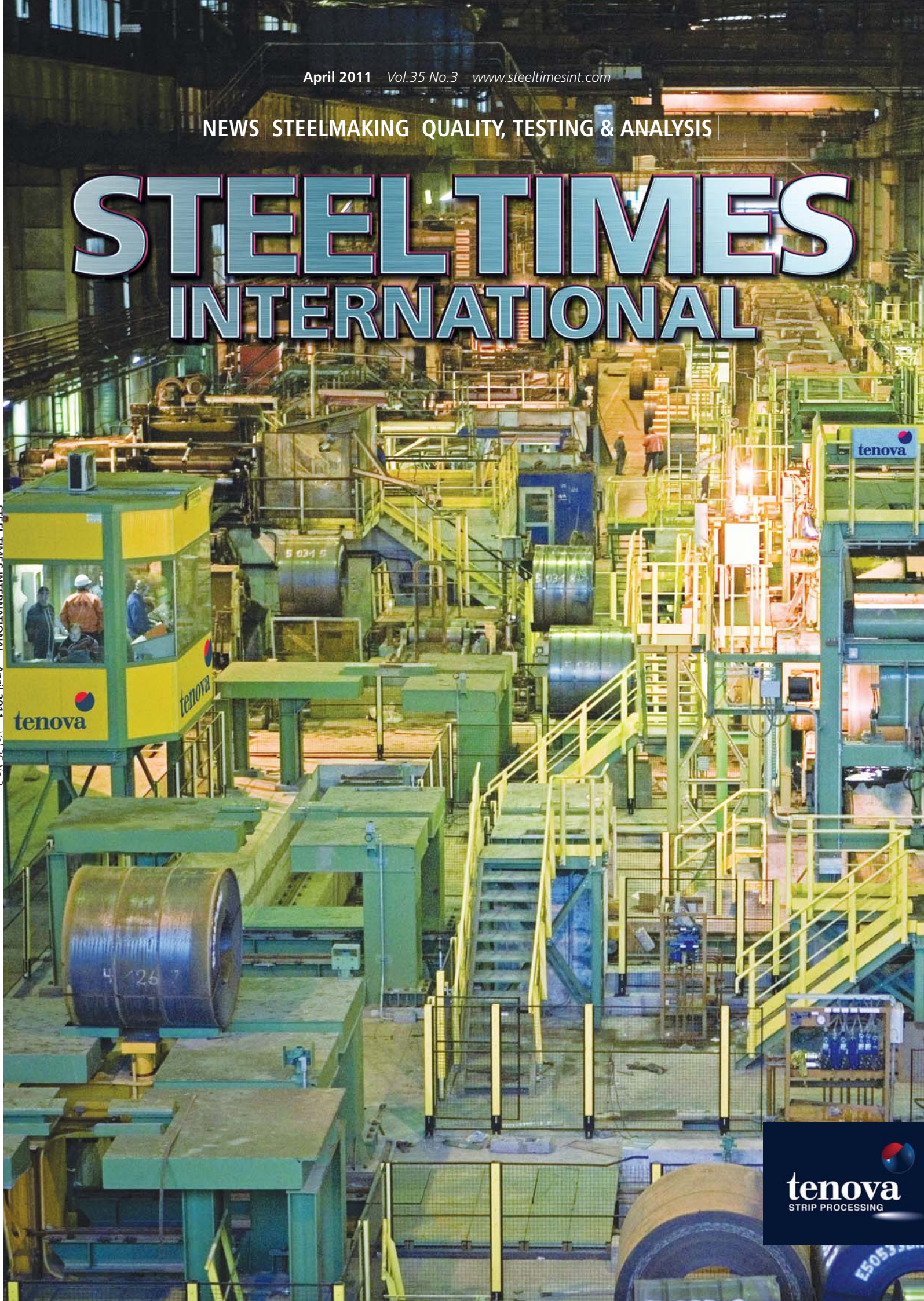

Latest technologies in pickling of stainless, silicon and low carbon steel strip

By combining the expertise of four group companies, Tenova has references and know-how in pickling and annealing lines suitable for; stainless steel, silicon steel and carbon steel both in large continuous pickling lines and smaller push pull pickling lines. Tenova's technology assures reduced environmental impact through an innovative acid regeneration plant with zero effluent discharge.

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Fig 1 Pull-out roller stands in the continuous annealing furnace enables exchange of a roller without interrupting production

IN the past 10 years Tenova (part of the Techint group) consolidated its steel pickling technologies by merging the mechanical expertise of the former American Aetna Standard with the experience of the Italian Italimpianti company and the acid regeneration technology of Austria's Key Technologies (formerly KCS). This has enabled the pickling processes applied to steel strip products to be optimised.

Furthermore, thanks to the co-operation with furnace maker Tenova LOI Italimpianti, Tenova is able to supply all the most modern technologies applied in Annealing & Pickling Lines for Stainless and Silicon Electrical steels.

Stainless Steels

An Annealing and Pickling Line (APL) for hot and cold rolled stainless steel strip was commissioned in Italy in 2010, for ThyssenKrupp-AST in Terni. The line was relocated from Torino and underwent a complete upgrade, starting from the furnace and all its electrical and mechanic equipment and a new and innovative 'multi-media' cooling section added. In addition, the pickling section was revamped, including recirculation, acid management equipment and automation.

The main parameters of the line are now:

- Hot rolled stainless steel (AISI 200,300,400) & Titanium
- Cold rolled stainless steel (AISI 200, 300, 400 series)
- Thickness H Roll 2.0 - 7.0mm
- Thickness C Roll 1.3 - 5.0mm
- Width 600 - 1550mm
- Productivity (max) 50t/h (Hot coils)

The project was conceived and developed with the aims of:

- Increasing the line productivity;
- Improving the strip quality;
- Minimising the environmental impact;
- Minimising the civil works.

Strip tracking

To improve strip handling in the line a new 4-strand type looper car was installed with two steering rolls on board as well as new steering rolls in the line, some with motor driven rolls. The strand separator arms of the looper are actuated by a cam mechanism according to the Tenova's 'no-scratch design' suitable to support cold rolled material.

Thermal equipment

A new preheating chamber was installed to pre-heat the strip prior to entering the open flame burner furnace. This section is particularly useful to pre-heat cold rolled strip and remove residual rolling oil thus avoiding the need for a chemical cleaning section. For energy efficiency, heat is recovered from the exhausted fumes of the furnace.

New roller stands of the 'up-and-down' type have been installed in the furnace to enable rapid roller change while the line is still running (**Fig 1**).

A new innovative 'multi-media' cooling section consisting of an air plus light water mist section, a water mist section and a final sprayed water section has been added. The first section was designed to allow a uniform temperature across the width of the strip to avoid the production of strip flatness defects (**Fig 2**).

Pickling Section

The pickling section is composed of a shallow tank in which sulphuric acid is used for de-scaling and a single spray pickling tank followed by a shallow tank with submerging rolls. These latter two are fed with a 'reduced polluting' mixture of acids which contain no nitric acid so eliminating nitrates in the waste waters and NOx in the exhaust fumes.

All the recirculation tanks, heat exchangers and instrumentation are designed to improve the operation and safety conditions. New storage and buffer tanks have been installed to manage and store the acids.

New brushing units have been supplied as well the final brushing, rinsing and drying sections.

The first tank was modified to install two exit steering-wringer rolls to improve strip tracking in the pickling section.

A new double stage acid fume exhaust system was supplied to comply with the strict local environmental regulations.

The line's electrical and automation system has also been completely renovated using new digital drives supplied by Tenova's automation division.

Tenova Key Technologies has also developed a new technology for mixed acid recovery that can be used for stainless steel pickling lines where Nitric and Hydrofluoridic acids are used.

Silicon Steels

At Wuhan Steel in China, two modern and high productivity Annealing and Pickling Lines (APL) were supplied to treat the highest quality Grain Oriented (GO) and Non Grain Oriented (NGO) Silicon Steel grades in 2009.

The main parameters of the lines are:

- H R & CR Si Steel (GO & NGO) (Si up to 3.5%)
- Thickness 1.3-3.0mm HR
- Thickness 1.45-1.55mm CR
- Width 800-1300mm
- Productivity (max) 60t/h (HRC)
- Process speed 30-50m/min

Furnace & Cooling Section

The furnace and cooling section was supplied by Tenova LOI Italimpianti and consists of:

- A direct-fired Non-Oxidising Furnace (NOF) operating under a reducing atmosphere with an excess of fuel gas. This requires various safety measures and a post-combustion system to ensure that the flue gas does not contain any combustible and toxic components.
- The later sections are for heating, soaking and/or slow cooling under a nitrogen atmosphere. This requires safe and reliable atmosphere separation at the exit of the direct fired furnace.
- The cooling section has to perform a wide range of cooling rates, mainly dependent on the steel grade – non-grain orientated (NGO), grain orientated (GO) or high grade GO.

For quality reasons, a strip temperature control mode instead of the commonly used furnace temperature control is incorporated in the automation control system. Since the heat transfer in the furnace is mainly determined by radiation, there is an auto-adaptive algorithm, to 'learn' online the strip emissivity which is needed for both pyrometric strip temperature

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measurement and for heat transfer calculations using a thermodynamic model.

Pickling Section

The pickling section uses hydrochloric acid and is composed of: a pre-rinse; three turbulent pickling tanks; a four stage rinsing section and a dryer. A turbulent shallow tank used for the HCl pickling (**Fig 3**).

The Tenova Mathematical Model controls the acid concentration of the solution using an algorithm that calculates the amount of iron in solution and controls the make up flow rates with the following input data:

– line automation (strip width, speed etc);
– measurements by field instruments.

The algorithm accuracy is 5-10% for the set value of the acid concentration (g/l) within 24 hours. The system can prevent over-pickling (eg due to slow down of the line) by changing the number of feeding pumps in operation to control the pickling solution turbulence.

Silicon is removed from the waste acid by an effective state of the art removal system developed by Tenova Key Technologies.

Carbon Steels

For large tonnage throughputs, continuous pickling lines are required while for smaller tonnages, such as used by Service Centres, 'Push-Pull' lines are more suitable.

Continuous Pickling Line

The scope of a project for MMK in Russia required two high capacity continuous pickling lines for low carbon steel, for a total production of more than 3Mt/y. The first plant required the dismantling of an existing obsolete pickling line and replacing it with a modern pickling line in the same location with minimum modification to civil works and maximum re-use of the existing heavy steel structure. The second pickling line required the conversion of the pickling media from sulphuric acid to hydrochloric acid and the design of new pickling recirculating equipment and a new rinsing section.

The main parameters of line 1 are:

– Material	H R Low C steel
– Thickness (mm)	1.2-6.0
– Width (mm)	1050-1850
– Productivity (max)	2.2Mt/y (405t/h)
– Line speeds (m/min)	800 entry; 300 process; 360 exit

Main parameters of line 2 are:

– Material	H R Low C Steel
– Thickness (mm)	1.2 – 6.0
– Width (mm)	1050 – 2350
– Productivity (max)	1.1Mt/y (228t/h)
– Line speed (m/min)	220 process

Regeneration Plant

Two new spray roaster Acid Regeneration Plants of capacities 11 000l/h and 7500l/h were supplied to regenerate the exhausted acid and the rinsing waste water of both pickling lines.

Mechanical equipment

At the Entry Section, a high capacity coil loading section able to handle up to 20 coils per hour was tailor designed to automatically handle coils with the axis vertical and without straps, as they arrive on an existing chain conveyor. These are then automatically loaded to the Pay-off Reels in double uncoiling pass configuration.

New entry and exit looper cars were provided, respectively six-strand and four-strand type. The looper cars incorporate a strip cam-lever mechanism with no-scratch separator arms; steering units were installed between each loop strand, at the exit of the pickling and rinsing sections.

Tension leveller-scale breaker

The tension leveller is designed to break the hot rolling scale on the surface of the strip so increasing the pickling capacity by 12% and is sized to improve the strip shape, thanks to the available maximum strip tension of 650kN and the entry and exit roll bridles driven by a motor through a mechanical differential drive system.

Process Section

The pickling section is composed of a pre-rinse section followed by four 33 metre long turbulent flow shallow tanks, five cascade spray type rinse tanks with high pressure final spray bars, a strip dryer with edge blowing, a fume treatment system, and acid analyser controlling the ferrous ion (Fe^{++}) concentration.

The pickling recirculating tank arrangement allows high concentration gradients which greatly improve the pickling efficiency and permits effective pickling with up to 130g/l of metal in the spent solution. Between each pickling tank are installed overflow chambers with squeegee rolls to minimise acid transport from one tank to the next.

The circulating acid is injected into the bath in a direction counter to the direction of travel of the strip in order to achieve good mixing of fresh acid added to the pickle tank and to increase the relative speed between the strip and pickling solution.

Injection nozzles are distributed along both sidewalls of the tanks and additional spray bars are located at the entry and exit ends of all the pickling tanks allowing direct chemical interaction between the scale on the strip surface and achieve immediate transfer of heat from the hot acid and the strip.

As a result of injecting the acid from the tank sidewall the thicker scale present at the edges of the strip is in contact with fresh acid from the very start and while the impulse from the jets is highest.

The consumption of fresh acid is kept at a low level by continuous and reliable determination of the iron concentration in the spent pickling solution by measuring its density.

Rinsing of the strip is achieved by means of a 5-cascade spray rinse section minimising consumption of make-up water .

Push Pull Pickling with Zero Waste

A push Pull Pickling Line with Acid Regeneration Plant (ARP) 'Zero Waste Technology' for small plants has been designed for a Compact Cold Mill Complex in Romania and also for a mill in Uganda. Zero effluent operation saves pickling process costs and reduces water consumption.

The Tenova concept for zero effluent is the answer to the increasing demand for environmental friendly plants including energy saving operation and use of water in the plant. This permits producers to operate without any acid effluents, an additional major advantage in regions where water is scarce.

In particular, Tenova has developed complete compact packages to provide optimised, tailored and an all-comprehensive solution for pickling lines using dedicated acid regeneration units.

The increasing market demand for small size and low cost pickling lines, usually in Service Centres, requires a new approach and a new concept for this kind of application.

The lowering of the cost of consumables is increasingly important and the restricted availability for effluent treatment combined with strict emission limits becomes a challenge that small producers can meet by a combination of pickling and acid regeneration.

Fig 2 Air jet headers with water headers in between during installation in the cooling section of the furnace

Fig 3 Turbulent shallow tank for pickling with HCl

In a conventional design, the excess water is sent to a plant for neutralization. The consequences are on the one hand a cost penalty and on the other loss of the resultant chlorides.

The Zero effluent concept achieves near total recovery (99.9%) of the metal from the spent solution as oxide and regenerates the acid using a pyrohydrolysis principle in which the metal salts in the spent pickling solution are converted to their oxides using steam and oxygen at high temperatures. Hydrochloric acid is also recovered in its free and bonded state.

The oxide by product is a high-quality iron oxide powder suitable for sale to the ferrite and pigment industries or the ARP can be operated to produce oxide in granulated form for reused in steelmaking (**Figs 4 & 5**).

This concept has been applied by Tenova in numerous projects assuring the following benefits:

- Investment saving:
  - No need for a waste water treatment plant for acidic effluents;
  - Only one combined scrubber system for the ARP and Pickling Line.
- Operation costs:
  - Efficient use of water, combined Rinse & Off-gas scrubber system;
  - No neutralisation costs chemicals/sludge disposal, etc;
  - loss of HCl practically zero.
- Environment:
  - Respect of strict emission values (imposed in European Union).

Zero Effluent Concept

Tenova's Zero Effluent concept consists of an effective process tank pickling system (suitable for capacities up to 300kt/y) and a rinse system, using part of the rinse water from the tank fumes scrubber.

This scrubber has a dual function and it is engineered to clean:

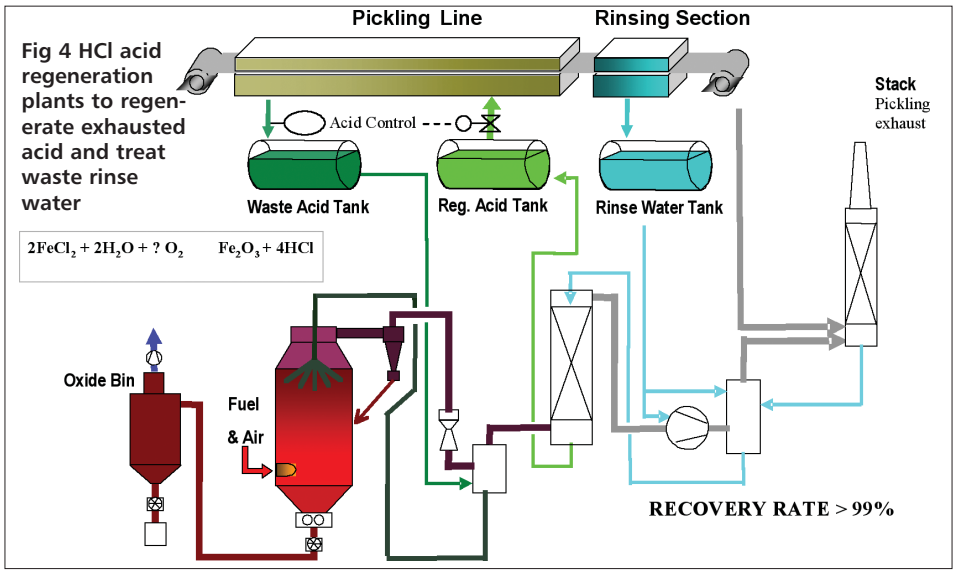

Fig 4 HCl acid regeneration plants to regenerate exhausted acid and treat waste rinse water

Fig 5 Acid regeration plant with zero emission discharge

- the off-gas coming from the Acid Regeneration Plant; and
- the fumes collected by the Pickling Tank suction ducting.

The design assures the respect of strict emission values without the use of alkaline chemicals. The acidic water from the rinse section and the scrubber can be fully used in the Acid Regeneration Plant in the absorption step.

With such a compact plant, it is possible to achieve the highest environmental standards and product quality with minimum investment, energy and consumption values. ■

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