Compact cold rolling

Modern cold rolling and processing lines produce high quality low carbon finished steel coils with capacities from 200 to 650 ktpy. A whole range of end products is produced, but three basic solutions can be provided to produce all the different final cold rolled and processed coils within the same complex, with one push-pull pickling line, one or two cold reversing mills, and the other process lines.

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While the production of hot rolled coils - or sometimes the cast slab to produce them elsewhere - is increasingly concentrated in countries with iron ore mines and low energy costs, their transformation into cold rolled, galvanised or coated coils is more widespread, particularly in newly industrialised countries, close to the final end-users. Modern cold rolling and processing lines produce high quality low carbon finished steel coils in volume. The compact complexes housing them now have capacities from 200 to 650ktpy. Their output includes annealed & tempered, galvanised, colour coated and tinplate grades. Return on investment for these plants can be very rapid.

Compact cold rolling plants have recently been installed in South Africa, Saudi Arabia, Turkey, Vietnam and Mexico and this trend is continuing with new projects starting in the Middle East, Asia and Eastern Europe.

The success of compact cold rolling complexes rests on four main factors. First, they are easier to operate than full size plants. Second, the hot rolled coils needed to feed them are readily available on the global market, and are easily transported and stocked. Third, compact cold rolling plants have less impact on local communities than full size integrated steelworks, and are designed to be environmentally friendly with technology for waste treatment. Lastly, the widespread use of high-level instrumentation for flatness measurements in the cold mill, or installation of automatic visual inspection systems in the main process lines - plus the application of sensors and automation systems in auxilliary equipment - delivers consistently high quality products.

ELEMENTS OF A COMPACT COLD ROLLING COMPLEX

Three basic solutions can be put together to produce all the different final cold rolled and processed coils within the same complex, with one push pull pickling line, one or two cold reversing mills, and then the other process lines *(see Fig. 1)*. Plant productivity is strongly influenced by the final production mix and by the size and quality of the incoming hot rolled coils. The auxiliary plants, the coil handling equipment and the storage areas have to be sized carefully to avoid production bottlenecks.

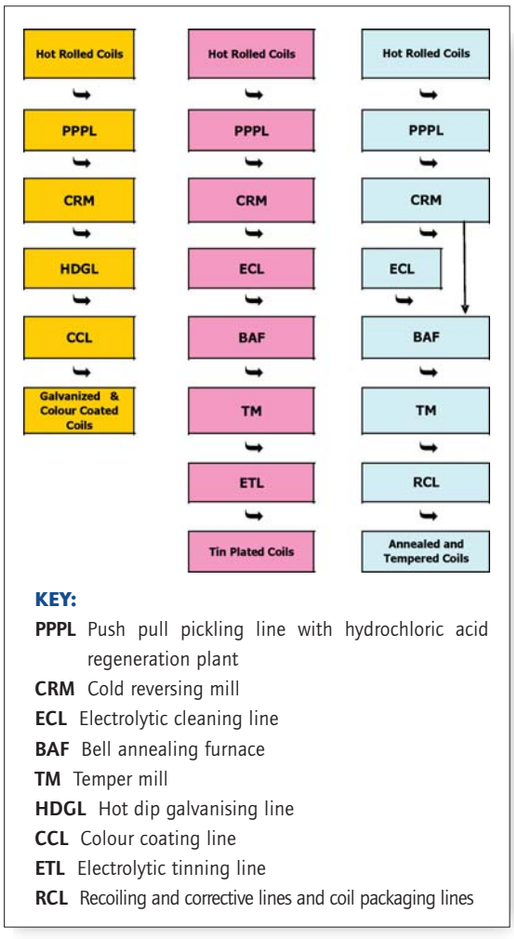

Fig.1 Three basic production arrangements

Push pull pickling Push pull pickling lines mainly process heavy gauge strip, using hydrochloric acid as ▷

Fig.2 Push-pull pickling line in Belgium

the pickling medium in a process that allows the line to run at different speeds *(see Fig. 2)*. One or two pay-off reels and related mechanical equipment form the

Fig.3 Highly automated recoiling line in Ternium (Siderar- Techint group), Argentina

entry section. The pickling process uses three or more tanks filled with hot acid, where iron oxides on the hot rolled strip surface react with the acid to form iron chlorides and water. A final rinsing tank contains pure water to clean acid off the strip. The exit section has a side trimmer with scrap chopper, a bridle, an oiler, a dividing shear and a tension reel. Push pull pickling lines process from 200 to 650ktpy at speeds ranging from 60 to 150m/min.

Tenova recently acquired Key Industrial Solution Industriebau, a company based in Vienna, Austria, which specialises in environmentally friendly hydrochloric acid regeneration plants, using both spray roaster and fluidised bed technology. This plant performs the opposite chemical reaction to the pickling line, transforming iron chlorides and water into hydrochloric acid and iron oxides in a thermal reactor, followed by a series of scrubbers and concentrators.

Cold reversing mill Pickled and oiled strip passes through a cold reversing mill to reduce the thickness by 60-90%. Incoming strip with a thickness from 6 to 1.3mm is reduced to gauges ranging from 2.5 to 0.18mm.

Cold reversing mills have a pay-off reel, two tension reels, and one or two 4-high rolling stands. Recoiling lines can be highly automated *(see Fig 3)*. Two work rolls, with diameters ranging from 400mm to 450mm, and two back-up rolls, with diameters of 1,150-1,300mm, are used. A roll cooling system, level 1 and 2 automation with advanced controls and sensors, X-ray-based thickness gauges, and auxiliary mechanical systems such as a quick roll changing car, coil cars and shear, are important elements in a modern cold reversing mill. To ensure the highest level of flatness, a system that includes an automatic flatness control system to measure the flatness of outgoing strip and control rolling in an automatic closed feedback loop, roll bending, zone cooling of work rolls, and skewing of back-up rolls, must be used. A cold reversing mill with one stand can roll 100-300 ktpy, at speeds varying from 600 to 1,500m/min, with rolling force values between 1,500 and 2,500t.

Electrolytic cleaning Surface quality can be further improved before annealing. This is essential for strip with a thickness less than 0.3mm to avoid coil wraps sticking and other strip surface defects. The cleaning line has a pay-off reel, shear and strip joiner in the entry section, while the process itself includes a pre-wash tank and a pair of brushes using a hot alkaline solution to start oil dissolution. The strip then passes through anodes dipped in an alkaline solution, where an electrolytic process is applied to deep clean the surface of the strip. Finally, the strip passes through brushes and is rinsed with pure water, dried and recoiled on a tension reel.

Tenova's research and development department is currently developing a new system to increase the efficiency of the process by using special steam injectors. Electrolytic cleaning lines process 100-300 ktpy of coil at speeds of 250-650m/min.

Bell annealing furnaces After rolling, strip annealing generates the required elastic-plastic characteristics in the steel. Bell annealing furnaces are traditionally used, each having a base with a fan, above which the coils are piled, burners, and a cooling bell to complete the process. The traditional furnace atmosphere was a mixture of hydrogen and nitrogen, but the development of new sealing devices and advanced controls now allows the use of pure hydrogen. Its use increases heat transfer inside the coils, and makes the process faster and the strip surface cleaner. Compared with the continuous annealing lines used in large cold rolled steel complexes, bell furnaces are simpler and, being modular, can be tailored precisely to the needs of production.

Temper mill Temper (skin pass) mills reduce thickness further, after annealing, in order to give the strip exact mechanical characteristics, eliminate the yield point elongation effect, improve strip flatness, and achieve the desired strip roughness. The strip is stretched typically by 1-5%. For tinplate, the resulting reduction in thickness can reach 40%, achieving a very thin gauge of 0.14-0.18mm. Temper mills have a pay-off reel, a tension reel, and one or two 4-high rolling stands. Work rolls have a diameter of 450-550mm, and two back-up rolls diameters of 900-1,250mm.

Temper mills can be equipped with an entry/exit bridle system to allow low-tension uncoiling/coiling. The system is equipped to minimise strip threading time. Temper mills also include strip detergent, automation and elongation measurement systems. Mechanical auxiliary systems include a quick roll-changing car, the coil cars, the coil preparation station and a pup-coil discharging device. Temper mills also usually provide strip oiling, and coil head and tail conditioning.

For best flatness, temper mills can be equipped with an automatic flatness control system to measure the flatness of outgoing strip and process control via an automatic closed feedback loop. As in cold reversing mills, roll bending and skewing of back-up rolls further enhances flatness.

Hot-dip galvanising Hot-dip galvanising lines typically have an entry section with two pay-off reels, two shears, a welder and a strip accumulator. The process section usually includes a cleaning section, an annealing furnace to heat the strip above the recrystallisation temperature, and then a section to cool the strip to a temperature just above the melting point of zinc - approximately 460°C. The heart of the galvanising process is the molten zinc pot and the zinc wiping equipment.

Fig.4 Electrolytic tinning line in Ternium (Siderar- Techint group), Argentina

The strip is cooled by means of air jets and water sprays, then to improve drawing behaviour, strip flatness, surface condition and paintability, the strip passes through a skin pass mill, a tension leveller and a chemical coater. The exit section has an accumulator, an oiler, a shear and one or two tension reels. For some applications a side trimmer is added.

Chemical roll coaters with an infrared oven are the latest technology for galvanising lines. They uniformly apply a very thin layer of chrome-free chemical as a final treatment to passivate the zinc with anti-fingerprint and paint adhesion properties. The galvanising line alternative to the electrolytic cleaning, bell annealing and temper mill process route, can be built to produce 70 to 400ktpy with a process speed varying from 50 to 200m/min.

Colour coating Fed with galvanised coils or cold rolled and annealed coils, continuous colour coating lines have three sections. The entry section has two pay-off reels, two shears, a strip joiner and a vertical strip accumulator. The process section includes a cleaning section, a passivation treatment, one primer coater with related curing oven, and two finishing ▷

coaters with curing oven. The exit section includes a strip accumulator, a shear, and one or two tension reels. Tenova recently developed a new type of chemical coater and improved the curing oven efficiency, optimising the temperature curve of the strip throughout the heating process. Colour coating lines produce 50-200ktpy, with a process speed of 50-200m/min.

Electrolytic tinning Electrolytic tinning (or chromium) lines receive coils from the temper mill *(see Fig. 4)*. They have an entry section with two pay-off reels, two shears, a welder, a side trimmer and a strip accumulator. The process section includes an electrolytic cleaning section, a tension leveller, an electrolytic pickling section, a plating section, an induction melting furnace with water cooling tank, the chrome-based passivation section, and an electrostatic oiler. The exit section has an instrumentation stand, a flying shear and two tension reels.

The traditional plating process uses soluble anodes of tin immersed in an acid solution with phenolsulphates or methansulphates. Operators usually manually replace the consumed anodes with new ones on a rigid schedule to maintain coating uniformity. Tenova has developed a plating process with an oxygen-based tin dissolution reactor and insoluble anodes to remove that task. Electrolytic tinning lines produce 80-300ktpy, with a process speed varying from 180 to 600m/min.

Recoiling and packaging Recoiling lines are used for strip inspection, trimming, tension levelling, and oiling strip coming from the temper mill. Packaging lines have a series of coil cars to move, lift and rotate coils to allow operators to apply protective packaging. High levels of automation are applied where required.

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