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NEW DEVELOPMENTS FOR HIGH-PERFORMANCE COLD STRIP PROCESSING LINES[1]

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Abstract

Owing to certain developments, for example in the automotive industry, the demands on cold strip products have increased in many respects. Modern Continuous Annealing (CAL) and Hot-dip Galvanizing Lines (HDGL) must be able to process a broad range of materials including multi-phase steels combining high strength with good ductility. Of course while satisfying highest quality demands. The highest degree of cost-efficiency and productivity is also an essential condition. Environmental friendliness is becoming evermore important. SMS Siemag reacts to these challenges with a number of new developments. Furnace technology has undergone continuous improvement to achieve better material properties and to save energy: Through the application of Rebox® DFI systems, the design of a modern cold strip processing line can now be built in a much more compact manner. High cooling rates of up to 120 K/s/mm are achieved with the Ultra Fast Cooling system without extra hydrogen consumption. So high-strength DP and TRIP steel strips can be produced. Cooling rates of more than 1.000 K/s/mm, which are required for martensitic steel grades with yield strengths of more than 1,000 MPa, can be achieved with the water quench system by SMS Siemag. A large number of optimizations made on the air-knife system serve to increase the quality and speed of galvanizing lines and reduce the zinc consumption. An important example of these optimizations is the Demco strip stabilization system.

Key words: Strip processing lines; Continuous annealing lines; Hot-dip galvanizing lines; Furnace technology.

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1 INTRODUCTION

The market for strip processing lines is driven mainly by three major customer requirements:

- economy and flexibility;
- quality and new products;
- environmental restrictions and energy efficiency.

The process stages in cold strip processing lines that influence material quality are surface cleaning, annealing and cooling, coating and post-treatment. SMS Siemag uses tried-and-tested technologies that are constantly being optimized for these process stages. Furthermore, we regularly introduce new developments that increase material quality and plant efficiency, as well as extending the material range. In this paper, you can learn more about the following new developments and optimized methods:

- DFI Rebox® oxyfuel (cleaning, annealing process);
- Ultra fast cooling system (annealing process);
- Water quench system (annealing process);
- Demco® electromagnetic strip stabilization;
- Roll-coater technology.

1.1 DFI Rebox® Oxyfuel

In continuous annealing and hot-dip galvanizing lines, Rebox® Direct Flame Impingement Oxyfuel systems, or “DFI Oxyfuel”, work by burning a gaseous fuel with pure oxygen. The Oxyfuel flames heat the moving strip directly. DFI technology has proved an effective way to increase heat fluxes to 800 kW/m^2 to 1,000 kW/m^2.

One of the key advantages of this technology is that it guarantees an excellent heat transfer, vastly improving furnace productivity. Apart from the higher heat transfer, the DFI Oxyfuel process has even more to offer. Due to the smaller exhaust gas volumes, it reduces fuel consumption. Furthermore, a higher heating capacity can be installed in a decreased furnace volume. That means the preheating zones of annealing furnaces can be shortened. DFI Oxyfuel modules are used at the entry of a vertical or horizontal furnace in a strip processing line. Due to their usage, the preheating section can be removed and some passes of the heating section can be saved. As a result, the furnace length is reduced by several passes depending on the needed heating performance.

Another advantage of this system is that the flames remove residual oil and solid particles such as abraded iron from the strip. Due to this cleaning capability the strip surface no longer needs to be completely contamination free before entering the thermal section and the cleaning section can be simplified too (Figure 1). In this case the cleaning section is acting as a pre-cleaning section ensuring that the degree of contaminations which goes into the furnace is limited. The final cleaning operation is transferred to the DFI system inside the thermal section. The elimination of a part of the cleaning section (electrolytic and one brush cleaning) brings considerable cost savings in maintenance and operation due to energy savings and less wear parts.

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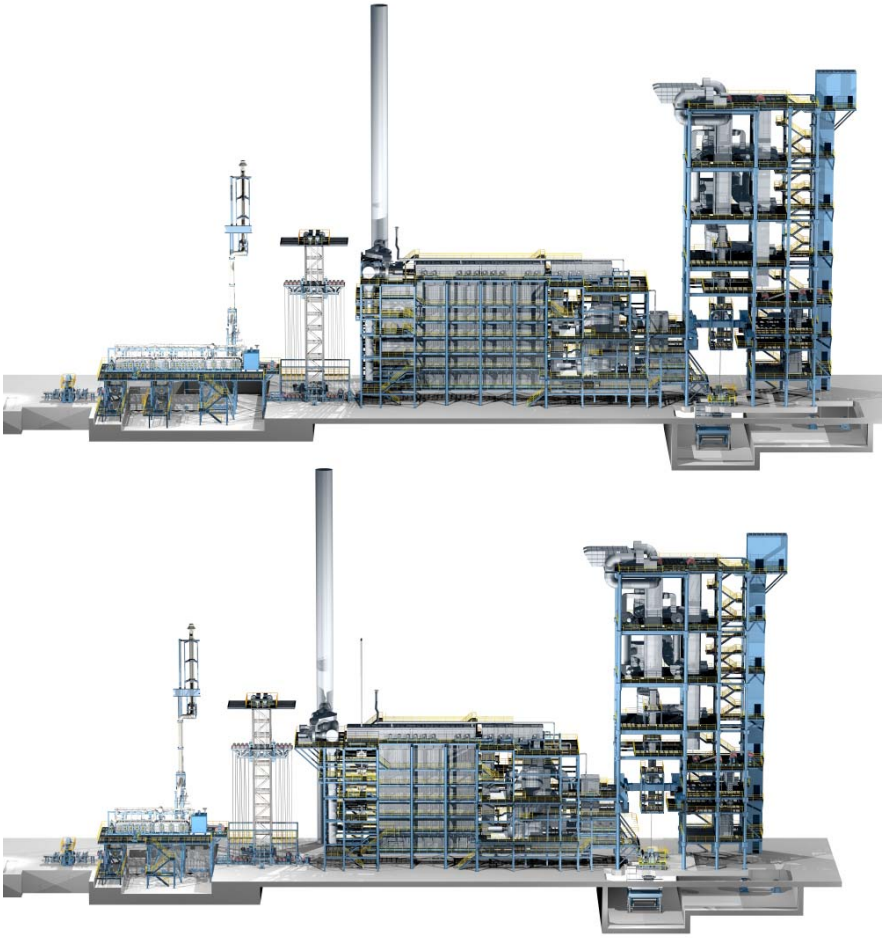

Figure 1. Cleaning and furnace section of a conventional galvanizing line (top) and an improved line with DFI Oxyfuel (bottom).

All this gives DFI Oxyfuel technology the potential to reduce costs in the erection and operation of cold strip processing lines. That's why SMS Siemag is cooperating with the Linde Group to handle the exclusive marketing of this process developed by Linde in new strip processing lines. The process is marketed under the brand name Rebox® DFI. Rebox® is a trademark of the Linde Group.

1.2 Ultra Fast Cooling System

In Continuous Annealing and Hot-dip galvanizing Lines, the re-crystallization annealing of the steel strip is a major process stage. Apart from breaking down the cold hardening structure from the rolling process, the main purpose of the annealing process is creating precisely the right mechanical properties. The decisive factor for the mechanical properties of the final material – especially high-strength steel – is controlled, fast, and even cooling after re-crystallization annealing in the vertical radiant tube furnace under protective gas atmosphere. The automotive industry increasingly demands high-strength steel grades in order to reduce vehicle weight while maintaining or increasing load-carrying capacity. In response to this growing demand, Drever International developed its Ultra Fast Cooling (UFC) system. This system can achieve even strip cooling of up to 120 K/s/mm, with excellent strip shape and very good surface quality.

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The Drever Ultra Fast Cooling system for high-strength steel grades delivers a convection cooling performance of up to 300 kW/m^2. Cooling rates of 100 K/s/mm to 120 K/s/mm mean that strip can be cooled in the rapid-cooling zone within a few seconds from 750°C down to as far as 300°C. This cooling performance is necessary to manufacture high-strength, multiphase, and TRIP steels with yield strengths of up to 1,000 MPa.

The cooling system uses the properties of hydrogen (low density and high heat transfer) to increase cooling capacity. What's special about the patented Ultra Fast Cooling method from Drever is the direct introduction of pure hydrogen into the cooling chamber. That results in a hydrogen content of 20% to 30% inside the chamber, enabling the high cooling performance. Due to the natural diffusion of the gas into the other areas, there is no need for a complicated separation between the cooling and the adjacent zones. That means the process does not use any more hydrogen than conventional furnace operation, with 5% hydrogen in the protective gas (Figure 2).

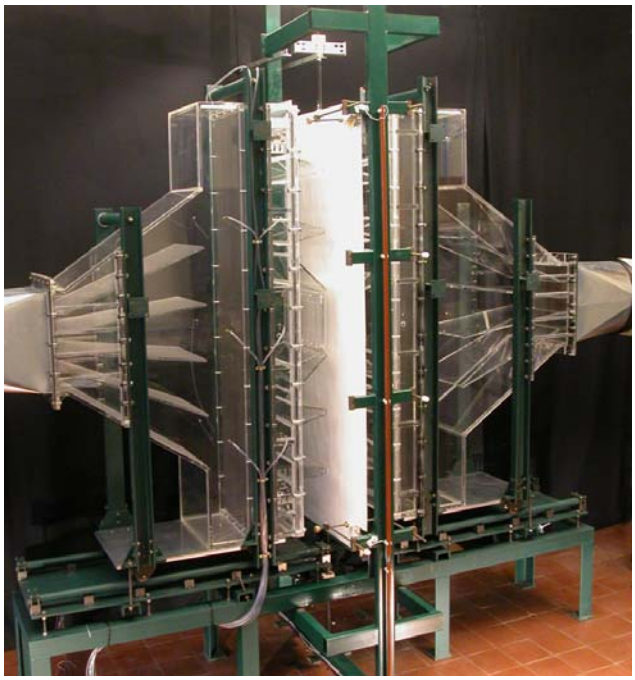

Figure 2. The distance between the strip and the plenum can be altered continuously (test field).

1.3 Water Quench System

The manufacturing of ultra-high-strength steel grades – especially martensitic grades – in continuous annealing lines requires cooling rates of more than 120 K/s/mm. The only way of producing these steels is to integrate a water quench system for rapid cooling after annealing. Water is sprayed onto the strip in a nozzle chamber for very high cooling rates. A special slot-nozzle configuration ensures even cooling over the entire strip width. That prevents flatness deviations, strip distortions, or faults. Anticrimping rolls upstream of the nozzle chamber monitor strip shape.

This configuration makes cooling rates of more than 1,000 K/s/mm possible, a performance that is necessary for the production of martensitic steel grades with yield strengths of more than 1,000 MPa. The system is therefore capable of manufacturing ultra-high-strength steel grades of up to 1,550 MPa.

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In modern Continuous Annealing Line furnaces, we combine the Ultra Fast Cooling and the Water Quench systems to achieve high flexibility. This modular design gives operators two options for fast cooling. After slow cooling, they can choose between the Ultra Fast Cooling system with cooling rates of up to 120 K/mm/s, or the Water Quench system with cooling rates of over 1,000 K/mm/s. After water-cooling, the strip must go through a flash-pickling section to remove surface oxidation.

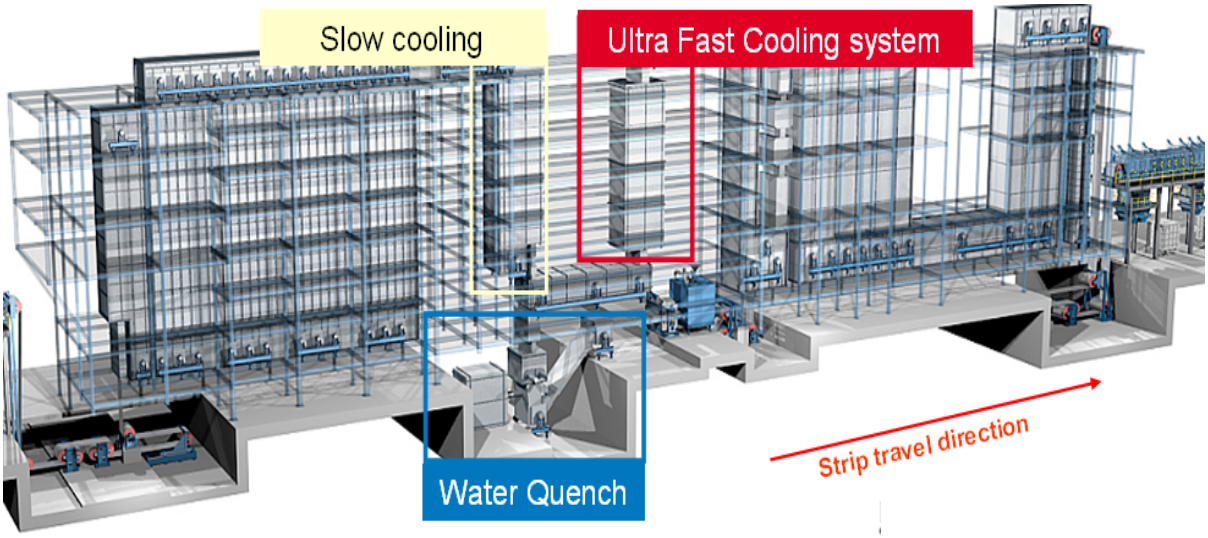

Figure 3. After slow cooling there are two options for further processing.

1.4 Demco® Electromagnetic Strip Stabilization

Conventional strip galvanizing lines use a large quantity of zinc. As the coating process is subject to fluctuations – such as strip movements due to cooling or the bath rolls – excessive zinc must be applied to ensure the minimum coating thickness is achieved at all points. If the strip is stabilized to reduce movements and cross bows, it can be more precisely coated over the length and width. The zinc saved makes this a more cost-effective way of producing high-grade galvanized steel strip. Furthermore, plant speed can be increased as a result of the stable strip running. There are also fewer surface faults caused by contact between the strip and the air knife.

Together with Fontaine Engineering (FOEN) and SMS Elotherm, SMS Siemag has developed the Demco® system for electromagnetic strip stabilization for strip galvanizing lines with FOEN air knives (Demco® – Dynamic Electro Magnetic Coating Optimizer). Using inductive measurement of the strip position, the system controls the magnetic forces in such a way that they immediately equalize unwanted movements or shapes of the strip (Figure 4). The adjustment is contact-free in the area above the FOEN air knives that adjust the zinc coating. Different strip width can be adjusted by moving the intermediate and outer coils. Hereby the optimal operation for strip dimensions is guaranteed. In particular, the movable outer coils correct cross bows in the strip.

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Figure 4. Moveable strip edge magnets to avoid lower overcoating.

Just how high the zinc savings are with the Demco® system depends on the strip width and speed as well as the thickness of the zinc coating. On average, the stabilization saves between 1 g/m² and 2 g/m² of zinc per strip side. If a relatively thick coating of zinc is required, the saving can even exceed 3 g/m². In this way an amortization of the system in possible in 12 months depending on the zinc price and average coating thickness.

1.5 Roll Coater Technology

Usually, galvanized strip is post-treated to protect the zinc coating from white rust. High-quality roll coaters are ideal to passivate, phosphate, or apply an anti-fingerprint coating to the strip. What makes the process stand out is its high efficiency and eco-friendliness. That's because the coating thickness can be set extremely precisely and reliably.

The vertical roll coater coats the strip evenly on both sides. For different coating types, the coaters are equipped with separate circulation systems. The coatings are applied to each side by a roll pair consisting of a pick-up roll and an applicator roll. Here's how the device works: the pick-up roll dives in the solution from the trough which is continually filled from a tank. It then transfers the solution onto the rubber surface of the applicator roll. Finally, the applicator roll is coating the solution evenly onto the strip (Figure 5). Depending on the coating thickness required, the chemical to be applied is diluted with demineralized water to the right concentration. A motor system holds both rolls in an optimal position for even coating. There is also a controlled electric drive unit that ensures the rolls turn in unison. Here, the speed and direction of rotation are adjusted according to the strip speed and desired coat thickness. One big advantage of the SMS roll coater is the hydraulically operated quick retracting mechanism for a rapid opening of the rolls from the strip due to weld passes and line stoppages.

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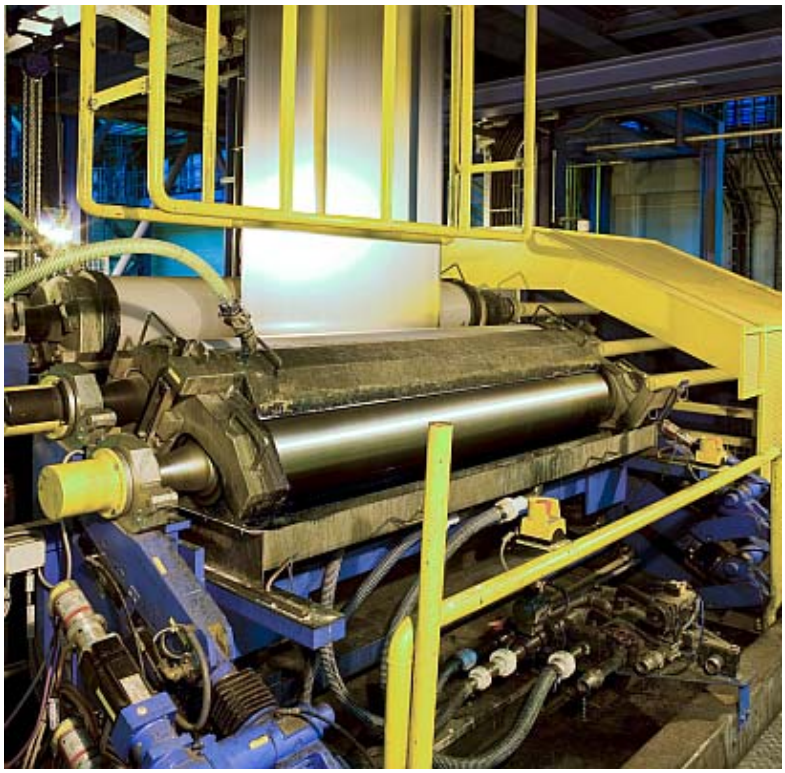

Figure 5. The two pairs of rollers are arranged at different heights.

2 SUMMARY

These new developments and optimized strategies cover all the process stages that contribute to high material quality in Continuous Annealing and Hot-Dip Galvanizing Lines. They ensure plant efficiency and economical use of resources, as well as high material quality over a broad product range. So the cold strip processing lines by SMS Siemag match with the major customer requirements.
Especially the state-of-the-art annealing and cooling technologies make it possible to produce a large spectrum of steel grades that keep pace with developments in the automotive industry, and meet the highest quality requirements. With the Demco® strip stabilization system a vast amount of zinc can be saved while enhancing the surface quality at the same time. The DFI Rebox® system realizes costs savings due to shorter cleaning and annealing sections. The extreme precise and reliable roll coater technology ensures high efficiency and eco-friendliness.