Furnace technology from the rolling mill designer and builder

There is a trend towards plantmakers supplying fully integrated plant and process knowhow, simplifying the supply chain and increasing responsibility, for the resulting products. The establishment, about five years ago, of the Furnace Division, illustrates SMS Siemag’s approach.

Author: Thilo Sagermann
SMS Siemag

In the steel and aluminium industries, it was standard practice for many years for investors to split orders for new rolling mills or strip processing lines into three different packages: mechanical equipment, electrical equipment and thermal treatment, and to award them separately. It was the task of the investor to coordinate the individual packages and to assume responsibility for the interfaces arising from these.

However, customers are becoming increasingly interested in plant makers who are prepared to supply the overall integrated plant, including process knowhow, and who are technologically capable of doing this.

This results in major advantages for both parties: the owners are responsible for fewer interfaces and, by emphasising the process responsibility of the plant makers, owners are able to make the latter accountable not only for the functioning of the plant but also for the resulting product.

This trend commenced when SMS first began to supply the drive engineering and control electronics on the basis of its long experience in mechanical plant engineering, and it led rapidly to the development of process models, for example, for ensuring constant strip dimensions and flatness. Thus, it soon became possible to influence the geometry of a rolled product and to guarantee the geometry.

This market development has provided an opportunity to expand the business and to exploit the benefits offered by assuming overall responsibility.

The influences of the thermal treatment on the properties of the rolled product, however, continued to be an open question. The company regarded this deficit as a challenge to be dealt with on the market. It searched for a solution that would integrate the heat treatment of rolled products into its own portfolio.

NEW DIVISION ‘FURNACE TECHNOLOGY’
The decision to establish this new division was taken about five years ago and was triggered by the acquisition of the Belgium-based company Drever International, a long-established leader in the construction of furnaces for continuous strip processing lines, such as annealing and galvanising lines for carbon and special steels. It continues to be a leader in this field.

The driving force for entering this sector came from the Strip Processing Lines Division, which had always awarded the furnaces portion of orders for integrated plants to sub-suppliers or consortium members, including Drever. Here in particular, it became evident to SMS that the various types of processing lines for steel strip all comprised an essential process step. This critical step, which defines the material properties of the product and requires a great deal of knowhow, takes place in the furnace and during the downstream cooling process.

SMS is convinced that understanding the processes underlying the heat treatment of strip is essential to be able to offer customers added value – and this must go beyond a mere consideration of the interfaces between the processes. Clients are increasingly relying on SMS expertise to achieve specific material properties. In the long term, the only companies that will survive in the marketplace are those which can reproduce the process in its entirety. This applies, for example, to modern steel grades, such as TRIP and dual-phase steels. These materials cannot be produced without using well-targeted heat treatment.

In the succeeding years, the market has provided an ever greater number of new and varied tasks relating to the heat treatment of semi-finished products to be dealt with by the company. At first, besides the continuation of Drever’s successful business, that firm’s general furnace knowhow was used for new developments. This resulted in SMS itself becoming increasingly knowledgeable. Such knowledge was developed mainly in close cooperation with the Strip Processing Lines Division, which was responsible for the mechanical equipment. This process of transition led to the formation of the Furnace Technology division at the beginning of 2011.

SMS Siemag is well-known as a supplier of rolling mills
and strip processing lines for flat products and it was taken for granted that the new business unit would likewise concentrate on the field of heat treatment for flat products as added value and technological challenge are more likely to be found in heat treatment, ie, heating and cooling of the material in a targeted manner.

The new division has positioned itself successfully in the market within a very short time. Thanks to the many new and further developments and to the close cooperation with the Hot and Cold Rolling Mills and Strip Processing Lines Divisions, a large number of orders have been obtained which are important to the future of the division. The division, with headquarters in Düsseldorf, already has around 250 employees worldwide.

Thanks to target-orientated further development, the division has until now been able to draw on its Europe-based resources to implement the following main areas of application for the firm’s own furnace technology for flat products made of carbon and special steel grades and for electrical steel strip, namely:

- Vertical and horizontal furnaces for continuous annealing and galvanising lines
- Floater furnaces for coating and annealing lines
- Heat-treatment facilities for heavy plate, roller hearth furnaces and batch-type furnaces, and
- Roller hearth furnace technology for the latest generation of CSP plants.

**VERTICAL FURNACES FOR CONTINUOUS ANNEALING AND GALVANISING LINES**

Vertical furnaces from the Drever heat treatment range, ie, for the annealing and cooling of steel strip, are an essential constituent of the new Furnace Technology Division and are a factor in its success. An example is shown in Figure 1.

The Drever furnace has been further developed with new technologies, such as measures for enhancing energy efficiency and avoiding nitrogen oxides (NOx) and for strip cooling by increasing the cooling rate. This latter aspect is important not only for efficiency, but also for the fulfilment of ever stricter requirements for the manufacture of high quality steel grades, such as for automotive products. Cooling rates of 100-120K/s per mm strip thickness represent the widely accepted state-of-the-art, but by means of a modified cooling system Drever is aiming at an increase to 150K/s per mm. To this end, highly promising tests are currently underway on gas-jet cooling. To implement this, use is made of especially long cooling boxes which extend on both sides almost as far as the strip running through, and also of special outlets which influence the impact of the gas on the strip. Also of great importance in this context is the increasing of the hydrogen constituent from 15 to 30%, which has been practised by Drever for the past 10 years. Hydrogen is introduced centrally at only three or four places in the cooling chamber rather than via...
each cooling nozzle, and therefore very efficiently, thus minimising hydrogen losses.

Cooling of the strip with water, which could not be done in a targeted manner 20 years ago, has today become a possible alternative thanks to modern process handling and new technology. SMS Siemag has commissioned a continuous annealing line equipped with a water quench for the firm of Protec in the USA. Cooling rates of >1,000K/s should be attained here. The situation is different with special steel strip, where Drever uses an efficient water spray-cooling system.

Historically, annealing and galvanising lines have been built as independent individual plants, however, SMS Siemag offers a solution for applications in which profitability and flexibility are of prime importance. In this solution, the two tasks of annealing and galvanising are unified in a combined line (see Figure 2). A fundamental aspect here is that the basic function of the furnace is comparable for both tasks and thus the furnace, as the most expensive unit in the plant, is required only once. SMS Siemag has now supplied the third plant of this type to Hyundai Hysco of South Korea. The first combined line has been operating since 2006 and a further line since mid-2012 at MMK in Russia. Their chief utilisation is the galvanising of automotive strip. The annealing process is key for the design of the furnace. The heat treatment during annealing and galvanising is performed in a different manner in each case and does not require any alterations to the line when changing over. It has a similar

Fig 2 Comparison between annealing modification in a combined CAL/CGL

Fig 3 Principle structure of a GATV floater furnace
FORMING PROCESSES

structure to that of the hot-dip galvanising line. Even so, following the annealing process in the furnace, the strip can be further processed in two different ways. First, as in the hot-dip galvanising line, the still hot strip can be routed through a zinc pot, coated with liquid zinc and then cooled. The other possibility is to convey the strip into an over-ageing furnace. Here, it is treated for up to 180 seconds at 270-430°C. This causes carbides to dissolve and the danger of ageing is minimised. Annealing is completed by final cooling and water final cooling. The combined line is thus equipped with a furnace which allows the production the same high-quality grades as in a modern continuous annealing line. The conversion of a hot-dip galvanising line into a purely annealing line takes only around 16 hours.

A special status is held by heat treatment facilities for grain-oriented and non-grain-oriented electrical steel strip. Jointly with the Strip Processing Lines Division, the Furnace Technology Division offers a complete range of equipment for the complex manufacturing process for the above. This comprises annealing and coating lines (ACL), annealing and pickling lines (APL), and decarburisation and coating lines (DCL). In these lines the annealing technologies of the Drever furnace are combined with the operation of the floater furnaces after coating.

The SMS Siemag concept is that in future the plant owner will specify the mechanical and metallurgical properties of steel strips to be produced. As the supplier of the integrated plant, the company will then make use of models which illustrate the most suitable process as regards temperature control during rolling and during the subsequent heat treatment. In order to design this process in a reproducible manner, it is monitored and controlled by means of measurements of the mechanical properties attained. A suitable measuring method, which is available from the company group itself, is the ‘Impoc’ system from EMG. The corresponding trials currently being conducted by SMS Siemag on a production facility in Belgium are expected to enable given material properties to be attained precisely.

HEAT TREATMENT OF HEAVY PLATE

SMS is working on the development of metallurgical and flatness models. Here, Drever can draw on its own experience from plants already built. Within the company, an intensive dialogue is taking place between Furnace Technology and the rolling mill construction departments in order to offer the customer a fully integrated process.

With regard to the heat treatment of heavy plate, the corporate objective is to introduce a flexible process that can be easily controlled and reproduced with a view to replacing the current practice of achieving a rapid and high cooling rate for the formation of a purely martensitic microstructure by introducing the largest possible quantities of water over a short stretch of only around 3m in a process that is difficult to control. As is the case with strip processing lines, this flexible process should enable given material properties to be attained precisely. The solution aimed at is inherent in the overall process and comprises rolling, heating and cooling within an integrated procedure.

SMS Siemag is currently executing a demanding order for the heat treatment of special steel for the Swedish works.
enabled an economically and technologically significant alternative to the traditional hot strip production method to assert itself on the market and then become the leader in that market. Even if the investment boom of earlier years has diminished somewhat recently, the demand not only for new plants, but also for modernisation initial facilities, nevertheless continues to be so high that the company is able to invest in the further development of the process.

This is true also for the roller-hearth tunnel furnace, which performs an important role in the temperature control between the casting machine and the rolling mill. These furnaces have until now been supplied by an external firm of furnace builders. In the future, they will be an important product of the firm’s own Furnace Technology Division in cooperation with SMS Elotherm.

The development of our own tunnel furnace makes it possible for the company to incorporate the latest findings with regard to energy efficiency and environmental impact. This subject not only determines the competition for new plants, but is also a crucial driving force in the revamping of existing lines. Thus, the energy consumption per tonne of material produced is today a focal point of attention when deciding on investments. It is a fact that the greatest degree of energy consumption in the entire plant takes place in the furnace. Various criteria need to be considered when it is intended to achieve a reduction here. Energy consumption is not only a question of the furnace design, but it is also very strongly influenced by the process itself. Thus, between the cornerstone aspects of increasing of casting temperature and reduction of the roll-drawing temperature, the use of induction reheating between the furnace segments is a route being followed by the company.

Furnace rolls also have a strong influence on the energy consumption of a furnace. The water-cooled rolls are subject to a 25-30% lower heat loss, and the development of dry furnace rolls currently being pursued raises expectations of up to 90% lower heat losses. Further factors to be considered are the choice of refractory material, the burner design and the structural design of the exhaust gas system.

The future-oriented design of its own furnace in interaction with the casting machine and the rolling mill allows the company to envisage a new CSP concept as an answer to today’s more stringent market requirements, relating to energy consumption. Irrespective of whether electrical power or gas energy is used, the decisive factor is always the kWh consumed per tonne of steel produced.

Thilo Sagermann is Head of Corporate Communications at SMS Siemag AG Düsseldorf, Germany

CONTACT: thilo.sagermann@sms-group.com