Quality and flexibility enhancement of a lifting hearth reheat furnace

Increasing technical, production and economic requirements necessitated replacing an old lifting hearth furnace with a modern facility. Processing of a very diverse range of steels requires flexibility, coupled with accurate and precise compliance with temperature profiles and furnace oxygen content. Flat flame burners and new electronic actuators are key components.

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Böhler-Bleche manufactures approximately 20,000 tonnes per annum of steel sheets at its various sites in Austria. The range of steel grades is very extensive, including:

- High-speed steels
- Tool steels
- Hot work steels
- Plastic mould steels
- Heat-treatment steels
- Stainless steels
- Heat-resistant steels
- Corrosion-resistant steels
- High-temperature creep-resisting steels
- Non-magnetic steels

The hot- or cold-rolled sheets and plates are available in thicknesses ranging from 0.8 to 100mm and in sizes up to 6,600mm x 2,000mm. The individual sheets or plates may weigh up to two tonnes. Individual cutting to size, surface treatments and edge machining can be performed.

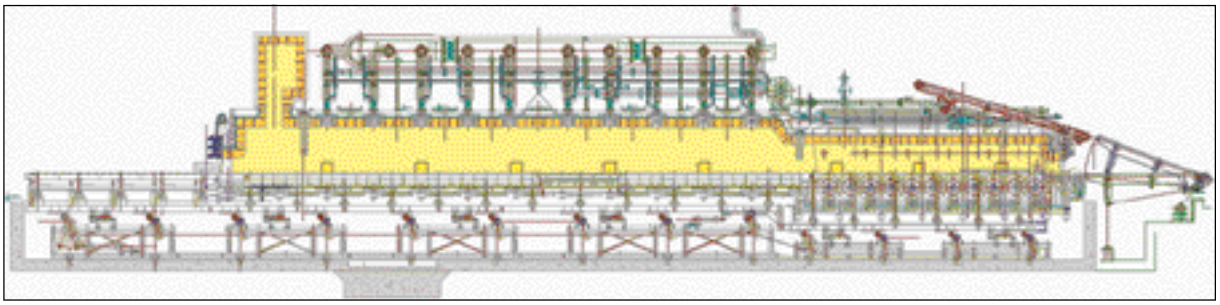
Reasons for new furnace installation

The stringent and constantly increasing technical and economic requirements, and an expansion of production capacity, necessitated replacing an existing, old lifting hearth furnace with a modern facility. Manufacturing and processing of the widely diversified range of steels flexibly, competitively and at constantly high quality, require furnace installations in which the sheets can be subjected to optimum thermal treatment both before and after rolling. This involves accurate and precise compliance with temperature profiles and the oxygen content in the furnace atmosphere, which are specific to the plate being treated. Compliance with the pre-set heating parameters is absolutely essential in order to give the material its properties and minimise material loss resulting from finishing and subsequent processing. Economically, optimising the time taken for material passing through the furnace is just as essential as efficient utilisation of the gas fuel. Compliance with environmental requirements is, of course, mandatory.

Kromschröder AG, specialist in gas engineering, has cooperated with Maerz-Gautschi (Düsseldorf), which specialise in furnace installations for the steel and metallurgical industries, to implement the new lifting hearth furnace at Böhler-Bleche so as to meet the applicable requirements. *Figures 1* and 2 show a longitudinal schematic and photo of the furnace charging side.

Requirements of the heating system

The requirements applicable to the heating system of a modern preheating furnace are many and varied. It



● **Figure 1** ***Longitudinal section through the lifting hearth furnace***

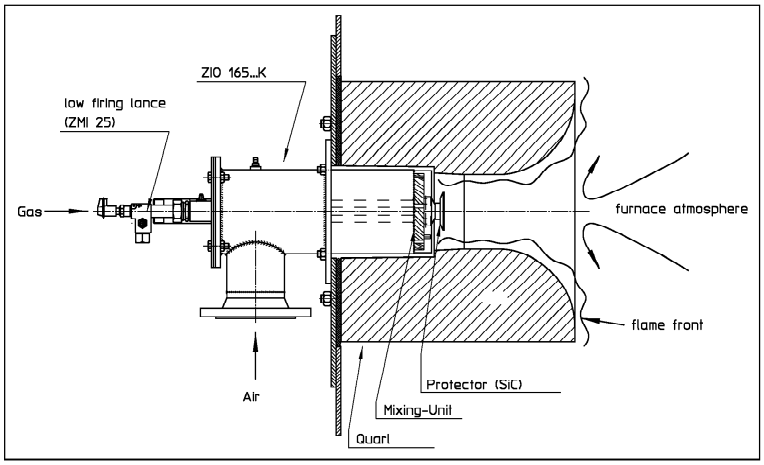
● Figure 2 *Lifting hearth furnace sheet charge line*

is necessary to cover both a broad temperature control range and a specific furnace atmosphere to meet the stringent quality demands of the operation over this broad range. The firing system must, therefore, be extremely adaptable and flexible. The essential requirements are described below:

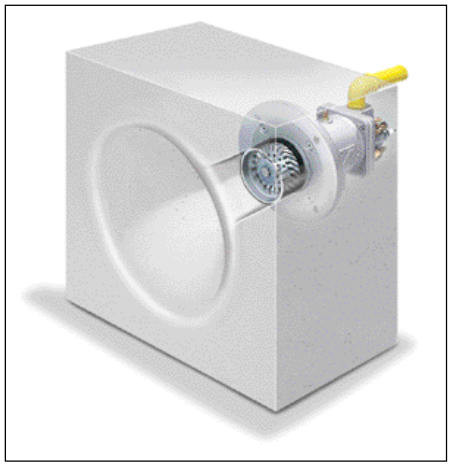
- **Uniform temperature profile over the entire furnace width or furnace zone** Uniform heating of the product over the entire cross-section is an important criterion for the anticipated quality of the rolled product. Material-specific temperature curves must be accurately complied with, even in the case of differing geometrical dimensions and varying material qualities. Thermal material overstressing is avoided by material-adapted temperature curves. In addition, the variable drive speed of the lifting hearth is used to influence material heating.
- **Economic operation with preheated combustion air** The heating furnace for stainless steel sheets is operated in continuous mode in the temperature range 1,050–1,250°C. As use of a recuperator proves to be economically practical within this temperature range, the firing system and the entire control concept must be adapted to the anticipated air preheat temperatures of approximately 450°C. Temperature resistance is an important factor in selection of the valves and fittings and even adequate insulation of the air piping must be included in considerations
- **High-quality combustion with low free oxygen** Free oxygen, (O_2) forms oxide layers on the material surface with the known, negative effects such as impaired surface quality and material loss. The formation of scale thus has a negative influence on the economic efficiency of the overall furnace installation. Scale formation is directly proportional to the set gas:air mixture (lambda value) on the burner. Precise burner mixture setting over the entire control range, and even at the variable air preheat temperatures, is thus an essential basic requirement. Installing a furnace pressure control system is one important contributory factor towards achieving a low O_2 value
- **Availability** Precise operation of the furnace installation must be ensured. This includes, for instance, ensuring long term spare part availability and maintenance-friendly operation of the firing system. It must be possible to perform routine maintenance quickly and easily without disturbing the operating sequence

Project implementation

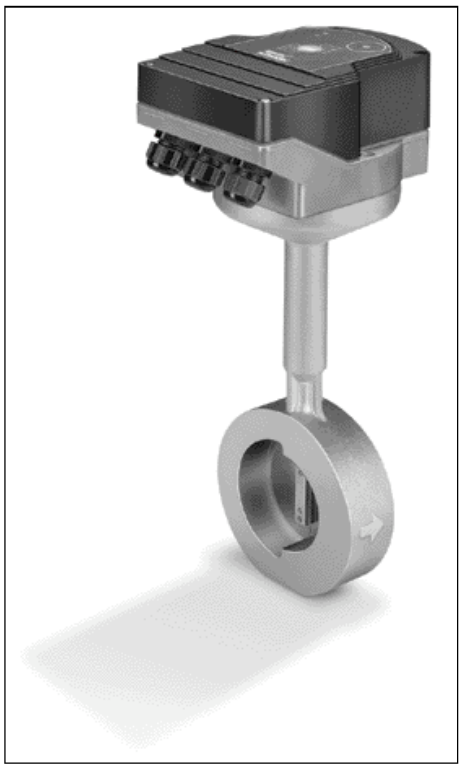
Selection and specification of the burners The share of heat transmission by radiation predominates at furnace temperatures in the range above 1,000°C, the intensity of radiation being proportional to the fourth power of the temperature. The combination of a burner with high torsional force and a quarl with a large surface area achieves the required maximised radiation surface area. Consequently, a flat flame burner of type BIO/ZIO...K is installed as a



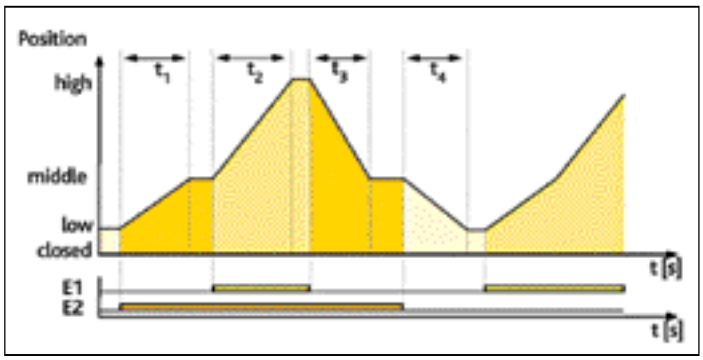
● Figure 3 *Z I O...K with quarl for flat flame*



● Figure 4 *Z I O...K 3-D view*



● **Figure 5** ***IC 40 actuator with BVH butterfly valve***



● **Figure 6** ***Control example: IC 40 actuator – two-stage operation***

practical burner in this application (see *Figures 3* & *4*).

The large flame surface area allows large quantities of energy to be emitted quickly. This keeps the flame temperatures low even with high air preheat and furnace temperatures. The flame, which contacts in the trumpet-shaped quarl, produces a negative pressure at the centre of the quarl, which is compensated for by inflowing furnace atmosphere which, in turn, is discharged to the outside via the flame. The furnace atmosphere also ensures cooling of the flame.

Two sizes of burner BIO...K are used, owing to the required performance profile:

■ **Preheating zone and heating zone 1**
ZIO 165..K with a maximum capacity of 570kW/low fire 120kW
Integrated low fire lance 3.5kW

■ **Heating zone 2**
BIO 140..K with maximum capacity of 300 kW/low fire 90kW
Integrated low fire lance 1.5kW

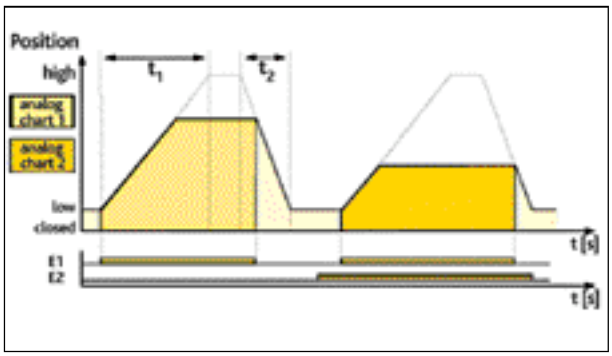
The nozzle mixing burner head is an essential component of the BIO..K burner. The special, time-tested geometry of the mixing unit ensures precise, stoichiometric combustion in the burner's required capacity range. Both burner types feature a low fire lance for step-by-step expansion of the control range.

With the main burner switched off, the low fire lance implements a reproducible holding capacity which ensures a low O_2 furnace atmosphere even in holding mode. A mixing head protector made of SiC ceramic material protects the mixing unit against thermal overload as the result of penetrating furnace atmosphere – particularly in holding mode. The geometry of the quarl was optimally adapted for the application in Kromschröder's own laboratory.

Separate ionisation control of the burner and of the low fire lance using the burner control unit, BCU 480, ensures maximum safety and system availability. In addition, the Profibus interface of the BCU 480 allows easy and comprehensive integration in the plant automation system.

Regulation of the cold air side The burners of the furnace, which is split into four zones, are operated both with hot air (zones 1 to 3) and with cold air (zone 4). This results in differing requirements applicable to the regulation system and, also to the control elements of the various zones and zone groups. Zone 4 operates in 'OFF – LOW – HIGH mode'. Switch over between low and high fire is performed at the air side by an IC 40 actuator that is mounted on a butterfly valve (BVH; *Figure 5*). Changes to the valve disc lead to changes in the air stream that represent a reference variable for the gas side. An air impulse tap in the piping downstream of the butterfly valve routes the air pressure to the air/gas ratio control (GIK) installed in the gas circuit. The GIK adapts its gas outlet pressure to the air pressure of the impulse line. This so-called 'pneumatic link' ensures that gas and air pressures always increase or decrease in the same direction. The flow rates and, thus, the burner capacity, also change as a function of the gas and air pressures.

Two burner capacity points are possible owing to two setting points of the BVH, which are approached by feed forwarding digital control signals to the IC 40 actuator. The burner capacity points are absolutely reproducible thanks to the very precise positioning of the combination of the IC 40 and BVH. The OFF position is achieved by closing the



● **Figure 7** ***Capacity and lambda adjustment by analogue and digital signals***

butterfly valve at the air side and deactivating the solenoid valve for gas. *Figure 6* shows a control example.

Regulation of the hot air side Zones 1–3 are operated with hot air up to 450°C in order to substantially increase the efficiency of the furnace. This also allows a major contribution to be made towards reducing pollution and saving energy.

Here the IC 40 actuator is also used together with the BVH. The patented mechanical construction of the BVH with TWINDISC (a specially designed hot air butterfly valve) means minimum leakage quantities even at hot air temperatures of 450°C. Capacity and lambda adjustment are performed with the control elements. The various air densities in the case of cold and hot air are compensated by varying the speed of the fan. It has been possible to implement simple and simultaneous adjustment of the capacity and lambda values by the technically advanced and flexible IC 40 electronic actuators. It is possible to switch between a low fire characteristic and high fire characteristic of the actuator with a digital signal applied to the actuator.

A feed forward current signal (4–20mA) pre-sets the setpoint for a corresponding position on these characteristic curves. The position of the actuator is uniquely described by a combination of current value and a digital value. The current signal controls the lambda value and the digital signal controls the capacity value (*Figure 7*).

Regulation of the gas side A pneumatic link with air/gas ratio control GIK is implemented only in zone 4. Zones 1–3 operate with the IC 40 mounted on a certified butterfly valve for gas. Two burner capacities are used here with the butterfly valve for gas, thanks to selected two-stage operation of the IC 40. Lambda adjustment is performed only by varying the flow rates of the air side. Safe shut-off of the gas side is performed by a Type VG safety solenoid valve. *Figure 8* shows the heating system of the ceiling burners.

● **Figure 8** ***Heating system of the ceiling burners***

General

The very flexible programming of the IC 40 actuator in respect of functionality and accuracy means that a single type of actuator to cover a very wide variety of tasks could be used on this demanding lifting hearth furnace.

In addition, the option of saving settings and copying them to other devices has greatly shortened commissioning time. New approaches were taken in the documentation of settings on the actuators thanks to saving all setting parameters. In respect of future maintenance or servicing call-outs, the history memories integrated in the IC 40 also facilitate fast diagnosis and thus enhance the system availability.

Summary

Use of an optimum firing system was aimed primarily at flexible adaptability to requirements such as uniform furnace temperature, economic operation, high quality combustion and high availability. Maerz-Gautschi and Kromschröder AG implemented the project jointly. Both the flat flame burners of Type BIO/ZIO...K and the new actuators IC 40, meet the optimum preconditions for enhancing quality, flexibility and performance of a lifting hearth furnace. In addition, use of the burner control unit BCU 480 with Profibus ensures maximum safety, reliability and system availability for the furnace constructor together with a higher level of convenience.

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