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Modern heating system with flat flame burners on rolling mill furnace

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Use of an optimum firing system was aimed primarily at flexible adaptability to requirements such as uniform furnace temperature, economical operation, high-quality combustion and high availability. Both the flat flame burners of Type BIO/ZIO...K and the new actuators IC 40 are convincing components. These products 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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Initial situation

The stringent and constantly increasing technical and economic requirements and an expansion of production capacity necessitate modernising existing, old rolling mill furnaces or replacing them by a state-of-the-art furnace system.

The requirements frequently demanded in this case are as follows:

- Flexible furnace relining with various steels
- Optimum thermal treatment of the steels
- Exact compliance with temperature profiles
- Precise dosing of the oxygen content in the furnace
- Minimising material loss as the result of rework
- Output of products with a constantly high quality
- Enhanced competitiveness overall

Fig. 1: Interior view of a lifting hearth furnace with flat flame burner quarts in the roof

Complying with or achieving values better than the prescribed untreated gas emission values are self-evident requirements even if not simple ones. From an economic point of view, time-optimised passage of the material through the furnace is just as essential as efficient utilisation of the gas fuel.

Maerz-Gautschi (Düsseldorf), Germany, specialising in furnace installations for the steel and metallurgical industries, in very close cooperation with G. Kromschröder AG (Osnabrück), Germany, a competent contact in gas engineering, used state-of-the-art technologies to implement a new lifting hearth furnace (**Fig. 1**) so as to meet the applicable requirements. We shall explain a few technical details below by way of example of a modern rolling mill furnace.

Requirements on the heating system of the lifting hearth furnace

The requirements applicable to the heating system of a modern preheating furnace are many and varied. On the one hand it is necessary to cover a wide control range and on the other hand the atmosphere in the furnace must meet the stringent quality demands of the operation over this broad radius of action. The firing system must adapt to the differing requirements flexibly.

Essential requirements are as followed:

- 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 (**Fig. 2**). Material-specific temperature curves must be complied with accurately, 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.
- Economical operation with preheated combustion air:
  The lifting hearth furnace for stainless steel sheets explained in this article by way of example is operated in continuous mode in the temperature range between 1,050 and 1,250 °C. Use of a recuperator proves to be economically practical with the above-specified temperature range. The firing system and the entire control concept must thus be adapted to the anticipated air preheat temperatures of approx. 450 °C.
  Temperature resistance is an important factor in selection of the valves and fittings. Even adequate insulation of the air piping must be included in considerations.
- High-quality combustion with low free oxygen share:
  Free oxygen “O_2” forms oxide layers on the material surface with the known, negative properties, such as

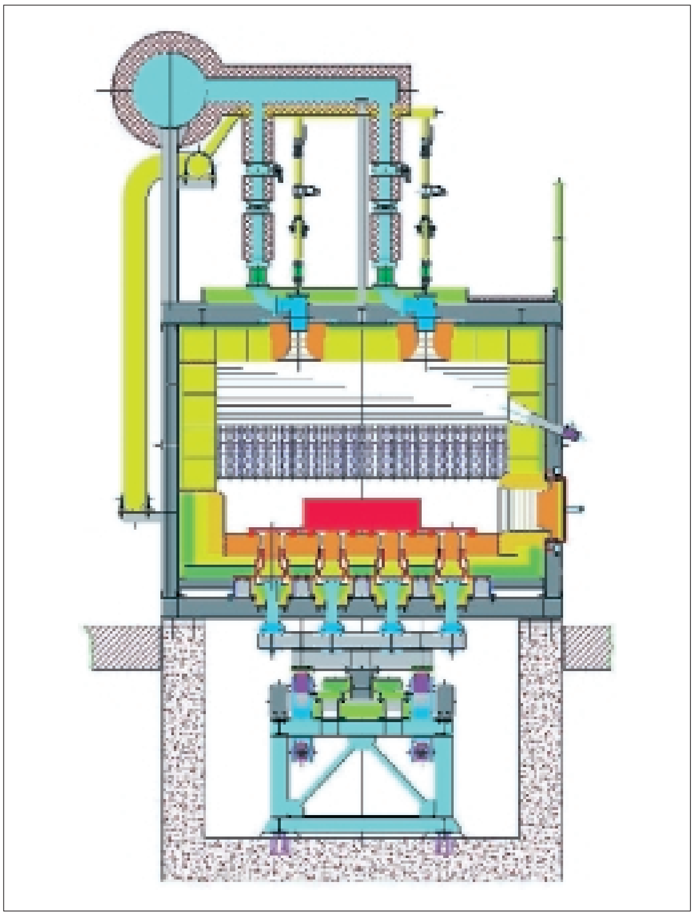

Fig. 2: Cross section through the lifting hearth furnace

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 (proportionally) related to the set gas-air mixture (λ 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.

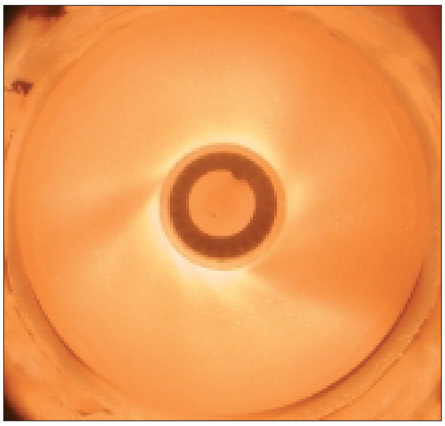

Fig. 3: Front view of ZIO...K flat flame (lab photo Kromschröder)

- Availability
  Precise operation of the furnace installation must be ensured even beyond commissioning. This includes, for instance, ensuring spare part availability for a long period. Maintenance-friendly operation of the firing system is also an important aspect as regards availability. It must be possible to perform routine maintenance quickly and easily without disturbing the operating sequence.

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 the radiation is proportional to the fourth power of the temperature. The combination of a burner with high torsional force and quarl with a large surface area achieves the required maximised radiation surface area. Consequently, a Kromschröder flat flame burner of Type BIO/ZIO...K is installed as a practical burner in this application (**Fig. 3**).

The maximised 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 and prevents excessive production of NO_x. The flame which contacts in the trumpet-shaped quarl produces a negative pressure at the centre of the quarl. The negative pressure 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. The flat flame burner can be supplied in various sizes depending on the required performance profile. The nozzle-mixing burner head is an essential component of the flat flame burner BIO..K (**Fig. 4**). 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 and for ignition. With the main burner switched off, the low fire lance implements a reproducible holding capacity. This 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 is optimally adapted to the application-specific special requirements in Kromschröder's own laboratory.

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

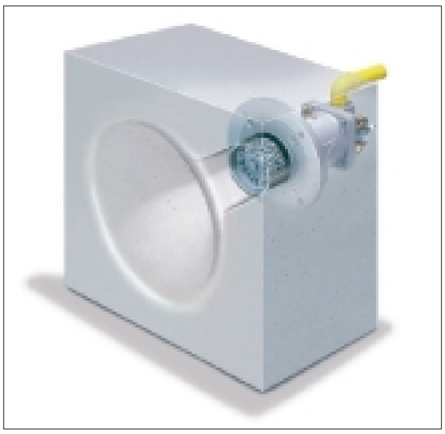

Fig. 4: BIO...K with quarl for flat flame

Fig. 5: Actuator IC 40 with butterfly valve BVH

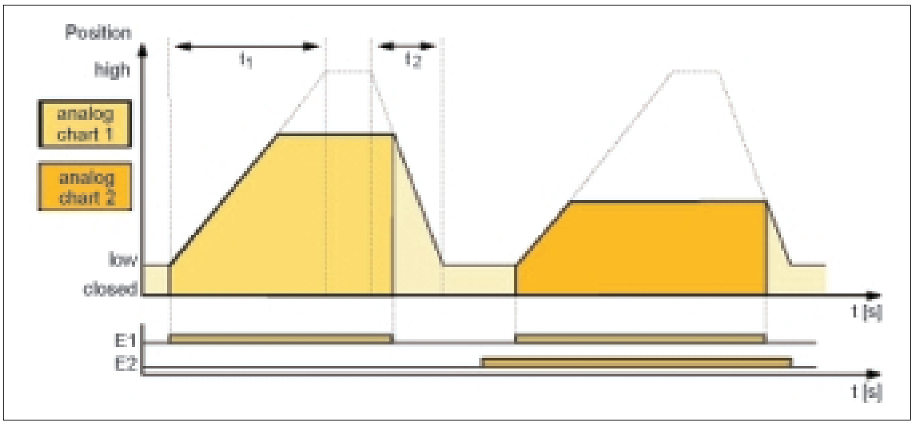

Fig. 6: Capacity and lambda adjustment by analogue and digital signals

Implementation of the hot air side

The zones are operated with hot air in order to substantially increase the efficiency of the furnace. This also allows a major contribution to be made towards reducing pollution and saves energy costs. This represents an ideal field of application for the actuator IC 40 together with the butterfly valve BVH for the hot air side (**Fig. 5**). The patented design of the butterfly valve BVH with the *TWINDISC®* valve disc contour achieves minimal leakage and, thus, compliance with the most stringent requirements in respect of minimum O_2 admission into the furnace, 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 for 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 technological lead offered by the flexible electronic actuators IC 40 (**Fig. 6**). 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 feedforwarded current signal (4...20 mA) pre-sets the setpoint for a corresponding position on these characteristic curves. The position of the actuator is uniquely described only 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. Burner capacity and lambda value can thus be optimally adjusted at any time. Simple reprogramming of the actuator IC 40 allows required modifications to the burner's operating mode to be implemented subsequently. It is possible to select from 16 operating modes at present. This provides tremendous flexibility in conjunction with the option of virtually unlimited combination of the essential parameters.

Implementation of the gas side

The electronic actuator IC 40 can also be used at the gas side, where the actuator is mounted on a certified butterfly valve for gas, the BVG (**Fig. 7**). Two burner capacities can be used with the butterfly valve for gas by selecting two-stage operation of the IC 40, for instance. For precise lambda adjustment, it suffices to perform a reproducible change of the flow rates at the air side. Safe shut-off of the gas side is performed by a safety solenoid valve of Type VG.

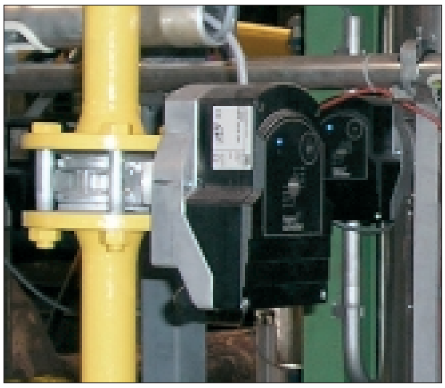

Fig. 7: Actuator IC 40 with butterfly valve for gas BVG (IC40-BVG.tif)

General

The very flexible programming of the actuator IC 40 in respect of functionality and its accuracy mean that a single type of actuator to cover a very wide variety of tasks can be used even on demanding lifting hearth furnaces (**Fig. 8**).

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

Fig. 8: Control system of the roof burners