Direct and indirect heating with BICR recuperative burners

In order to optimise combustion processes in directly or indirectly heated furnace installations, it is necessary to meet various requirements, such as lightweight design of the burner, low maintenance effort, fast and flexible installation and short delivery times. The BICR recuperative burner from Kromschröder meets these requirements and offers the installation operator diverse advantages, such as reduction in energy costs, reduction in emission values and increase in productivity and efficiency at the same time. The modular design of the recuperative burner allows operation both for indirect radiant tube heating and for direct furnace heating.

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Introduction

When it comes to converting or renovating a furnace installation, the important basic principles of capital expenditure budgeting must be taken into account: for one thing, economy must be guaranteed, while it is also important for emission volumes to be reduced. At the same time, the ever more stringent requirements applied in terms of economy and environmental friendliness must not be allowed to cloud the issue as far as the project payout time is concerned. There are often many possible ways in which the profitability of a process can be optimised. It is practically impossible to identify all of the existing possibilities, as the potential for cost savings covers a wide variety of aspects, from initial provision of the actual furnace through to flue-gas channelling at the end of the process. One important starting point for process optimisation is the selection of the appropriate firing unit with suitably matched control technology. Burners with an integrated air preheating system are suitable for this purpose, as they save energy, reduce emissions and increase profitability at the same time.

Requirements

The following list presented the main requirements for the firing unit:

Economy
- Rapid, flexible assembly
- Reduced energy costs
- Low maintenance costs
- Long service life
- Short project payout time
- Low-cost control

Long-term aspects
- Availability of spare parts
- Availability of customer service

Miscellaneous
- Short delivery times
- Simple structure

Recuperative burner

Industrial gas burners with an integrated air preheating system impose significant stresses on the construction materials used. The hot flue gases from the high-speed burner are channelled back through the burner, imposing a considerable stress on the recuperative material in use. On the other hand, a heating system must be easy to install and must provide low-maintenance operation over the long term. These requirements apply both for new systems as well as the modernisation of existing systems. This gives rise to a conflict between the requirements for burner construction and the wishes of the system operator. This is where the BICR burner provides a ‘bridge’ with its ‘simple’ but efficient construction.

Modular burner construction

The BICR recuperative burner is based on the modular system inherited from the BIC standard series. This represents the application of a reliable existing concept making it possible to exclude the sources of faults associated with a completely new development, as far as possible. The individual modules of the BICR burner have been in use for some years now as elements of standard burners in an extremely wide variety of fields of application. The BICR burner is thus a complement to an existing product with the additional benefit of integrated air pre-heating. The modular construction allows the use of the BICR burner, providing both indirect radiant tube heating and direct furnace heating. The heart of the burner is represented by the ceramic smooth-tube recuperator, manufactured from a single piece and also including the combustion chamber. This combination allows the number of burner components to be reduced, with the associated positive effect on the maintenance costs for the burner. The flexible construction of the ceramic-tube model makes it possible to produce the heat exchanger in a variety of lengths. This, in turn, allows the burner dimensions to be tailored exactly for the specific installation location. With its smooth surface finish, the ceramic smooth-tube recuperator is not susceptible to fouling. Unlike the ribbed recuperator, it offers practically no scope for deposits of dirt particles to build up. This means that the necessary cleaning intervals are extended, and this, in turn, reduces ongoing operating costs. Moreover, the design of the recuperator unit features reduced weight subject to the proviso of reducing the overall weight of the firing unit. This measure and the modular design mean that the burner can be installed by only one person. The burner flue gases produced during firing are channelled out of the process through the exhaust-gas housing (EGH). However, it is not absolutely essential to use an exhaust-gas housing. When modernising existing systems, in particular, it is often possible to continue to use the old housing currently in place. The customer also has the option of using his own solution for exhaust-gas channelling and thus achieving an optimum cost-benefit ratio (**Fig. 1 and 2**).

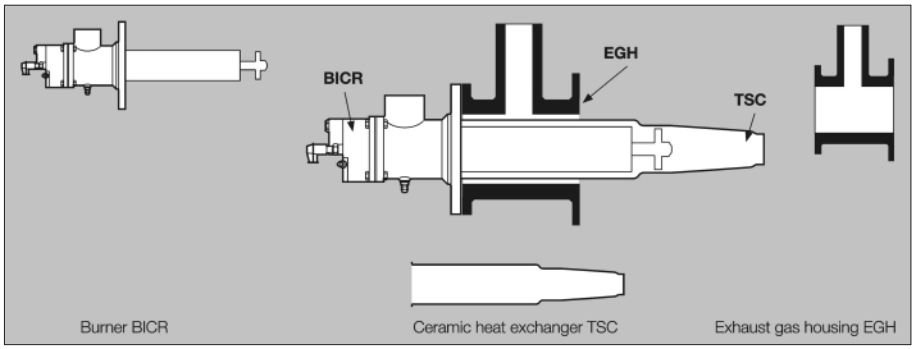

Fig. 1: Modular burner construction

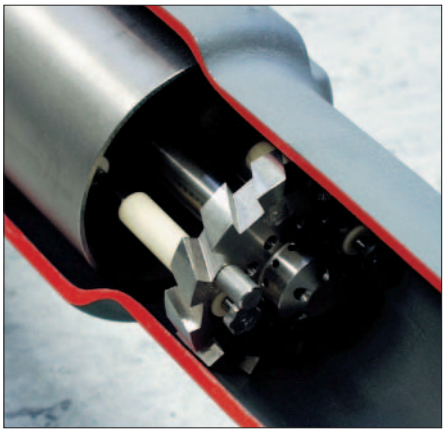

Fig. 3: Burner head in the SiC-tube

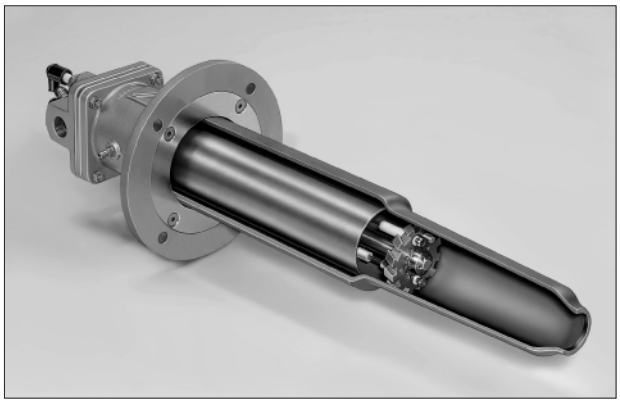

Fig. 2:
Section of a burner with no EGH exhaust-gas housing

Combustion

The BICR burner features a nozzle-mixing burner head which mixes the combustion gas with the combustion air both on the basis of the counter-current principle and in parallel flow. Owing to the special arrangement of the gas and air bores, this burner head is matched to use in heating installations with pre-heated combustion air. The burner is directly ignited and ionisation-controlled by means of two low-maintenance electrode sticks from series production. The major part of the combustion reaction occurs in the ceramic combustion chamber. The minor part is visible in the form of the flame behind the ceramic tube outlet. The burner is operated only in "ON/OFF" mode in order to achieve a uniform temperature profile over the entire radiant tube length. Extensive laboratory tests have confirmed the assumption that continuous control of the burner has a negative impact on uniformity of temperature on the radiant tube. In addition, the high flame outlet velocity at rated burner capacity is the basis of NO_x reduction by recirculation of the flue gas streams at the outlet of the ceramic combustion chamber. Consequently, a high value of approx. 120 m/s is selected for the flame outlet velocity and the combustion chamber outlet diameter is matched to this (**Fig. 3**). The NO_x values for the burner are in the region of 180 mg/m^3 at a furnace temperature of 950 °C (reference value of 5 % O_2).

Control

Indirect heating

For a BICR recuperative burner of modular construction, a control system of similarly modular construction is a logical conclusion (**Fig. 4**). To provide an adequate supply to the burner, a gas control valve is provided at the both the gas and air sides, involving minimal

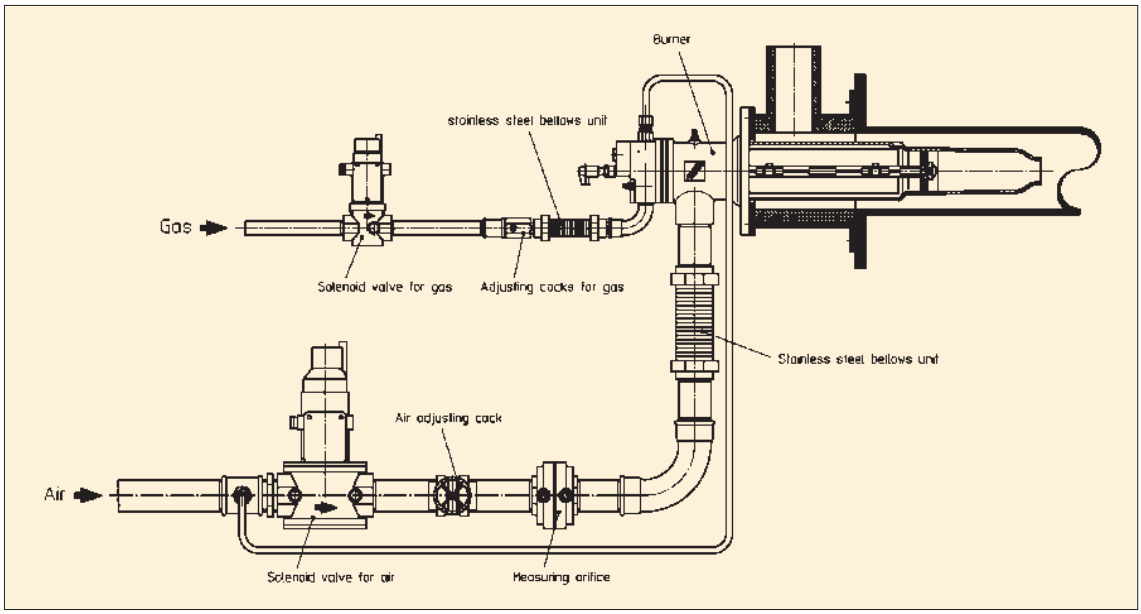

Fig. 4:
Control of a BICR burner in the radiant tube

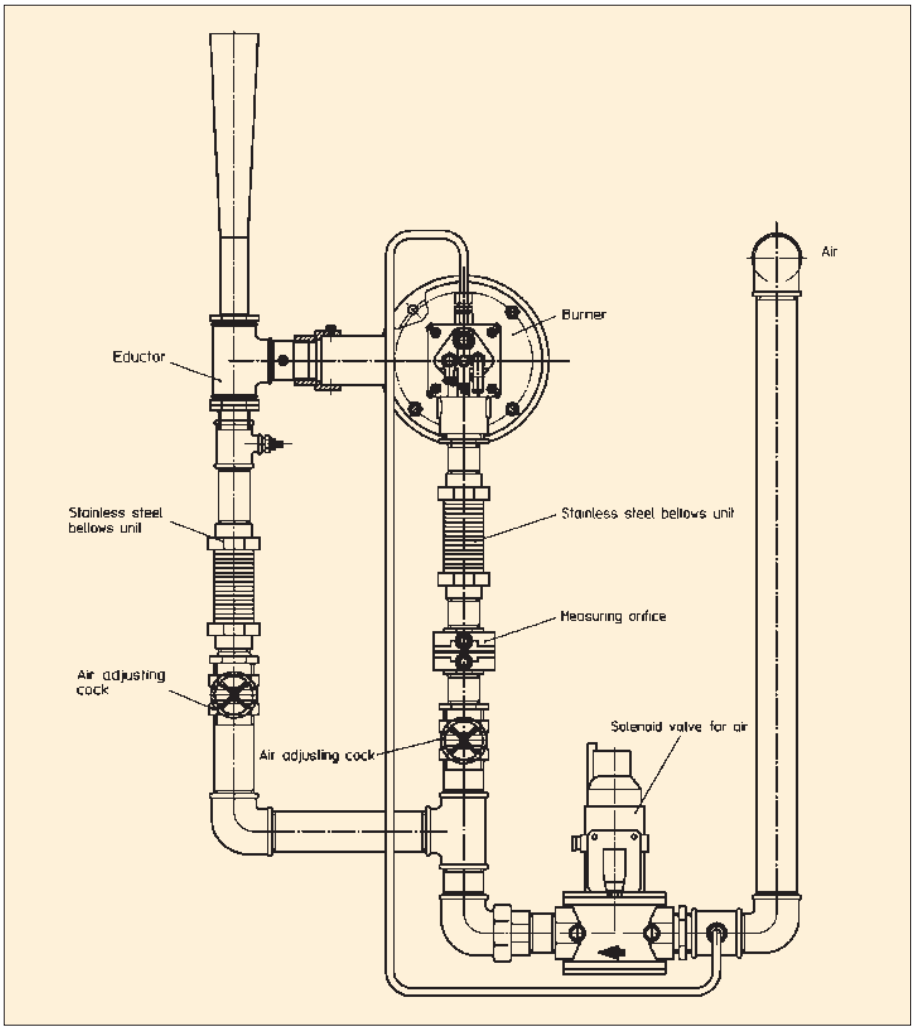

Fig. 5: Air supply for a BICR burner with eductor

installation costs. Both the gas and the air control valves are damped in their opening movement. The orifice plate integrated into the burner's gas connection flange makes it a simple matter to calculate the volume of the gas flow by means of differential pressure measurement. At the air side, it is possible to install an appropriate orifice assembly (FLS) for the flow rate in the air line upstream from the burner.

Direct heating

Direct heating necessitates an eductor at the flue gas end of the burner. The eductor ensures recycling of the flue gas via the burner from the furnace chamber since there is no forced recycling present as is the case with indirect radiant tube heating. The eductor is connected to a separately routed air supply line (**Fig. 5**). The air flow supplied to the eductor corresponds approximately to 1.5 times the quantity of the combustion air volume of the BICR burner.

Operating costs

Fuel

Depending on construction type, the use of recuperative burners leads to a reduction in the amount of fuel used, and therefore to savings in operating costs. The reduction in fuel consumption is due to the integrated recuperator within the burner. As they flow back in, hot process gases transfer their heat by the heat exchanger principle, via the recuperator to the incoming cold combustion air. The energy saving from the preheated combustion air is a considerable component of the economical aspects of a firing unit of this kind.

Electrical current

A considerable proportion of the ongoing operating costs for a furnace are accounted for by the high level of power consumed by the combustion air fans. In particular, when recuperative burners are being operated within the direct furnace heating system, this function is based on a high level of supply pressure at the eductor. On the basis of experience, the pressure ratio lies in the range 2:1 (eductor: burner). Consequently, a large part of the fan power and electricity costs must be made available for a secondary process.

Owing to the low pressure loss through the ceramic smooth-tube recuperator, there is a relatively low air supply pressure at the eductor on the BICR burner. The ratio between combustion air supply pressure and air supply pressure at the eductor consequently has a very economical impact. Despite the relatively low air supply pressure at the eductor (approx. 40-45 mbar), it is ensured that the entire flue gas volume of the burner is recycled from the furnace via the burner (**Fig. 6**). Additional flue gas ducting from the furnace is not required.

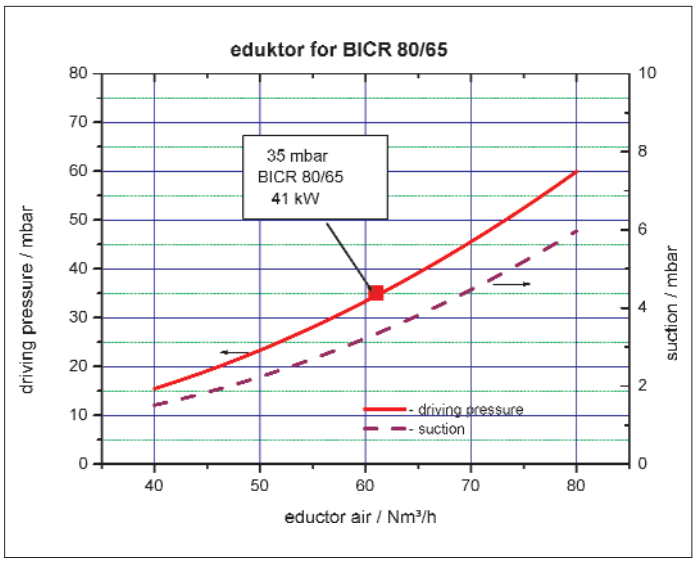

Fig. 6: Pressure profile at the BICR eductor

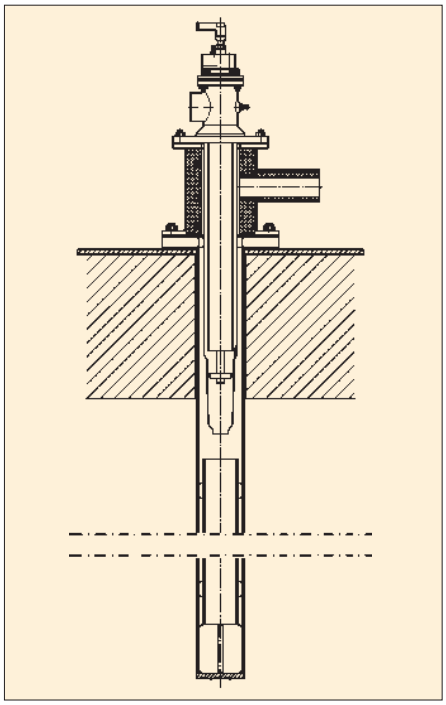

Fig. 7: BICR burner (21 kW capacity) installed in a previously electrically heated radiant tube.

Fig. 9:
Burner flames

Applications

Exchange of electrical radiant tube heating systems

Owing to the greatly increased electrical power prices in certain regions of the world, furnace operators in these regions are forced to consider alternatives for furnace heating with electrical power. Exchanging electrically heated radiant tubes by gas-operated units is thus one possible approach to solving the problem. However, continued use of the existing radiant tubes is a fixed element of any considerations in relation to exchange for the furnace operator. The slimline, lightweight design of the BICR smooth-tube recuperator offers the option of exchanging gas burners by electrically operated radiant tube heating elements in such cases with continued usage of the existing radiant tubes (**Fig. 7**). Ribbed recuperators are frequently used in such installation situations since the size of the recuperator is too large for the relatively small radiant tube diameters.

Direct heating

The simple structure of the control system can be identified from this example of a BICR application in the direct heating system for an annealing hood for steel wire. In addition, the burner flames can be seen during operation. The rapid commissioning of the hood represents a peripheral commercial benefit for the operator.

Basic data

Fig. 8 and 9 are showing the control and flames of the BICR burner on the annealing bell by the furnace constructor SUMON Industrial Furnace Co., Ltd., Taipeh, China End customer: GEM-YEAR Industrial Enterprise, JiaShan, China.

- Bell-type annealing furnace for steel wire
- Loading capacity: 6 metric tons of wound steel wire
- Max. temperature: 850 °C
- Working temperature: 700 – 760 °C
- Temperature accuracy achieved: 760 °C +- 1 °C
- Burner type: BICR 80/65 (41 kW)
- Type of gas: LPG
- Number of burners: 8 burners in two zones
- Control: ON-OFF
- Temperature control with Kromschröder MPT 700 impulse system

Radiant tube heating

The construction of the burner is adapted for use in combination with metal radiant tubes. Attention is concentrated on the jacket tube or P-tube heating system, as these are the most commonly found radiant tube construction forms.

Conclusion

The modular-design BICR recuperative burner is equally suitable for directly heated furnace installations and for indirect radiant tube heating. When considering the efficiency of a recuperative burner, it is important to consider not only the fuel saving. Many aspects, from commissioning through to connection rating of the fan, must be included in this consideration in order to obtain an objective overview. The BICR combines lightweight design with low maintenance requirement and, at the same time, offers installation operators low emission values, high productivity and efficiency.

Fig. 8:
Burner control