OTTO JUNKER

Publication

Otto Junker presents an innovative gas-fired billet heater for high-efficiency aluminium billet heating

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Introduction

With the potential inclusion of the German aluminium processing industry in an expanded emissions trading scheme looming as of 2013, the objective of saving energy has become more important than ever. This also and quite particularly applies to the furnace equipment employed in extrusion plants for heating aluminium logs or billets to the hot forming temperature.

Gas-fired heating processes merit special consideration in this context. Given the natural gas / electricity price ratio prevailing in Germany and the specific CO_2 emissions produced with the current German mix of electricity sources, efficiency gains in gas-fired heating processes will improve both the overall economic CO_2 balance and the corporate cost burden.

Billet heaters with direct flame impingement, as established in the market for several decades, have been continuously refined by all renowned suppliers. Still, it is to be assumed that their energy efficiency has its design-inherent limits.

As an alternative to this technology, OTTO JUNKER installed a convection heater at the ALCAN plant in Singen as far back as in the late 1990s. This heating system, an innovative solution at the time, provided significant efficiency gains over conventional billet heaters. On the other hand, it imposed a compromise on flexibility which is why induction-type single-billet heaters were installed downstream of the convection heater.

On the occasion of THERMPROCESS 2011, OTTO JUNKER now presents a combination (patent pending) of the two above-mentioned equipment types which manages to retain the flexibility of the direct flame impingement while providing the efficiency of a convection heated unit.

State of the art in gas-fired billet heating

a) Heaters with direct flame impingement

Gas-fired heaters based on a direct application of the flame to the metal are usually made up of two main assemblies. At the exit end, the aluminium billets are heated in a directly gas-fired section by a multitude of burners of relatively low output (8 to 12 kW) installed in a refractory-lined muffle adapted to the billet geometry.

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Of the total heat input reaching the aluminium billet, convective heating by direct flame impingement accounts for around 30% whereas radiation heating contributes around 70%. Given the reduced emission factor of machined billets, throughput is likely to be lower with this billet type (due to the high radiation portion) than with unscalped aluminium still carrying the casting skin. The temperature control quality of a gas-fired billet heater depends on the number of its control zones.

Upstream of the direct heating section, a so-called preheating chamber is normally arranged at the entry end. In this preheating chamber, the billets are heated by forced convection using the exhaust gas from the gas-fired section before it enters the exhaust stack. Thanks to the high transferable power density which may attain up to 150 kW per sq.m. of billet surface in the section of direct flame exposure, key benefits of this equipment type include its fairly small footprint and the capability to respond quickly to changing cycle times with the final billet temperature kept constant. The temperature loss in the billet head that results from clamping in the hot shear can likewise be recovered quickly.

On the downside, the high power density achieved is owed to temperature differentials (flame-to-billet, muffle-to-billet) which harbour a risk of causing superficial fusion of the billet. Moreover, to minimize losses while ensuring acceptable wall temperatures, the high power densities produced call for an elaborate thermal insulation of the wall. This in turn raises the level of thermal inertia, so that the heater will be of limited flexibility, e.g., when it comes to making quick downward temperature adjustments.

One widespread equipment technology involves the use of combustion air preheating and billet preheating chambers in which the exhaust air is recirculated by centrifugal fans. With a system of this type, efficiencies of 60 to 70% can typically be attained, even in part-load operation. Efficiency gains are achievable by preheating more intensely, e.g., by increasing the length of the preheating chamber or by using the magazine table for log preheating. On the other hand, the costs (investment, space requirements) and benefits (energy savings) must be compared by careful pre-investment analysis.

b) Convection-type billet heaters

Like their gas-fired counterparts with direct flame exposure, these heaters are designed as multi-billet units. They are characterized in that heat is imparted to the billet almost exclusively by forced convection, i.e., hot gas is directed at high velocity onto the billet surface via specially adapted tubular or slot-type nozzles. The hot gas is maintained at the required temperature in heating ducts extending separately from the billet, and it is recirculated by fans. The aluminium billet is not directly exposed to a flame.

Heating is effected by recuperative burners delivering between 100 and 400 kW each. The achievable efficiency varies between 75 and 85 percent. Due to the predominantly convective heat transfer, the throughput reduction associated with scalped billets is less pronounced than with a directly gas-fired billet heater. On the other hand, the power density transferable with this equipment type remains clearly below 100 kW per sq.m. of billet surface area, meaning that the unit needs more floor space than a directly gas-fired billet heater. The temperature control quality likewise depends on the number of control zones with this kind of system; however, it is ensured first and foremost by setting the temperature of the last control zone to the final billet temperature, **Fig. 1-a and 1-b.** The risk of superficial fusion of the metal is thus virtually eliminated, and a particularly high temperature accuracy can be achieved. For design-inherent reasons, the system will obviously not support fast temperature changes, but the mathematical model included in the controller keeps the target temperatures of each control zone continuously adapted to the throughput rate. As the level of fuel efficiency will improve with decreasing process temperatures, thermal energy demand will drop in part-load operation.

Fig. 1-a: Convection furnace of OTTO JUNKER design

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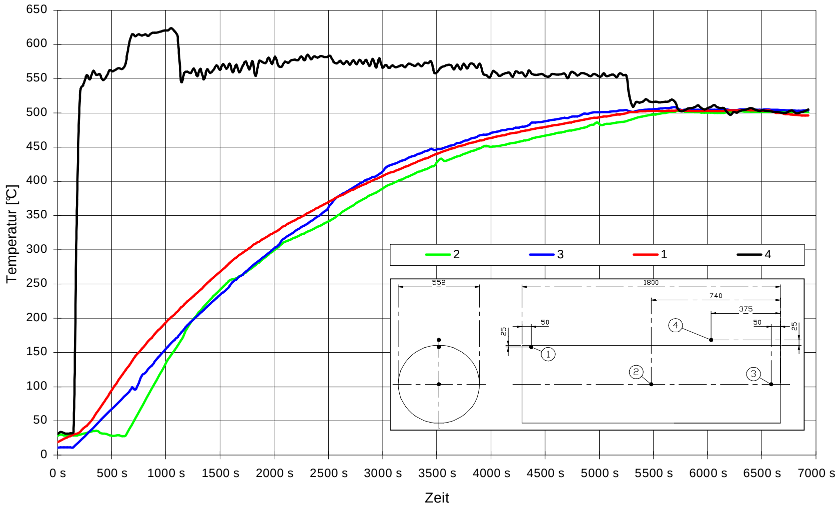

Fig. 1-b: Measured heat-up curve reflecting a temperature accuracy of better than +/- 5K with billets measuring 550 mm in diameter and 1800 mm in length. The energy demand throughout the reference measurement was lower than 180 kWh_{th}/t_{Al} at a throughput of 7310 kg_{Al}/h and a draw temperature of 500℃.

Combined gas-fired billet heating

OTTO JUNKER has now combined the above two state-of-the-art heater types in a special manner. A convection heater with recuperative burners is used to preheat the aluminium logs or billets to just below the extrusion temperature. The convection heater is immediately followed by an "in-line" directly flame-heated section that has been kept as short as possible, having about 1 – 2 times the length of the billet. This latter section serves to achieve rapid temperature changes or to perform selective heating of the billet head. Moreover, this section compensates for the temperature drop resulting from clamping in the hot shear, **Fig. 2**.

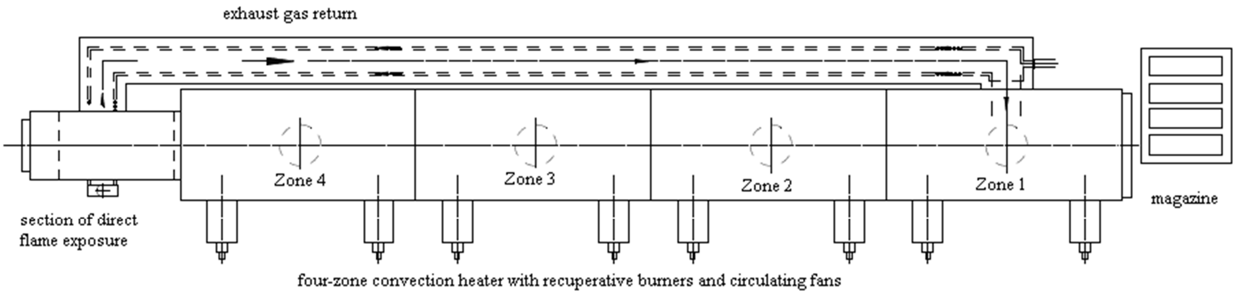

Fig. 2: Schematic drawing of the combination-type gas-fired billet heater ("KombiGAS")

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In order to boost the system's efficiency, the exhaust gas from the directly flame-heated section is returned, preferably, into the first heating zone of the convection heater. On its way to the convection heater the exhaust gas may optionally be used for preheating the combustion air to the directly flame-heated section. In part-load operation at under 75% of nominal throughput, the directly flame-heated section serves merely to compensate for the heat loss caused by withdrawing the logs for shearing or sawing. At the same time, the temperature of the convection heater is steadily reduced, which improves its fuel efficiency and reduces its thermal energy demand by around 10% from the nominal requirement in the most widely used part-load range (i.e., at between 30% and 50% load), **Fig. 3.**

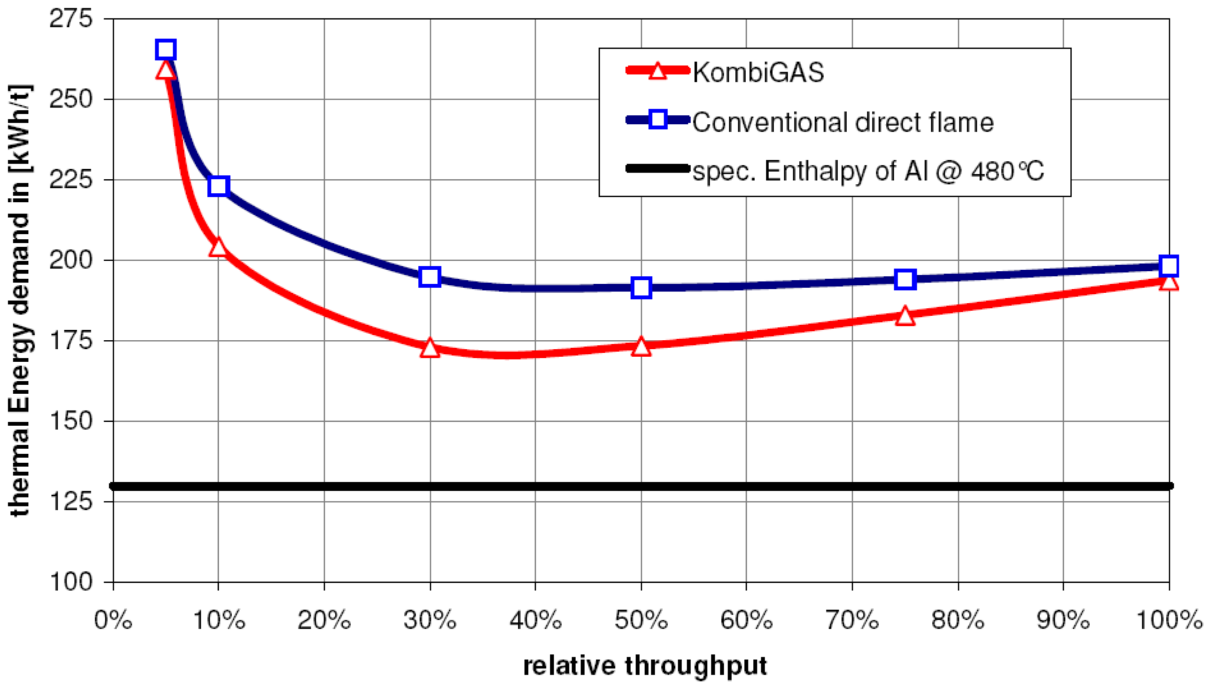

Fig. 3: Comparison of thermal energy demand between a heater with direct flame exposure ("conventional direct flame") and the combination-type gas-fired billet heater ("KombiGAS"), plotted for a system heating 10" aluminium billets to 480℃ and achieving a throughput of 4000 kg/h (100%) under optimum design conditions.

In summary, it can be stated that the combination of the two principles avoids the drawbacks of each while preserving the advantages of both. In particular, its efficiency under part-load conditions will be a major decision-making factor in future replacement or new investment projects.

- particularly high efficiency at virtually all relevant load levels
- reduced footprint compared to an all-convection heater
- ability to accommodate rapid temperature changes
- no negative effects of changes in billet surface state (as cast / scalped)
- low risk of superficial billet fusion
- low thermal load on the interior heater chamber, low wear
- easy access, making the system more maintenance-friendly than a heater using direct flame impingement
- supports any kind of conveyor system (walking beam, live rollers, idle rollers)
- optional combination with hot shears or hot saw

The system thus rounds out OTTO JUNKER's product portfolio by adding another building block holding significant future potential. Needless to say, this latest-generation combination-type heater can also be used in conjunction with a proven single-billet induction heater of OTTO JUNKER design. In this case, the IGBT frequency converter technology developed in our own R&D department and established since 2004 allows temperature gradients in any direction to be established with high accuracy and reproduced with perfect temperature precision. For each system from our range, tailor-made handling solutions designed to provide maximum space and time savings are available, covering the entire workflow from the magazine to the supply of hot billets to the extrusion press. And of course, each system comes with state-of-the-art automation, with software engineering and commissioning being commonly carried out by our own specialists in close cooperation with the customer.