

New low NO_x solution for high-speed burners

by **Sabine von Gersum, Martin Wicker**

On the basis of the time-tested BIC series, Elster Kromschöder has developed the new low NO_x solution, menox®. This combines the low-cost, simply structured burner BIC..M with simple control technology allowing to switch between two operating modes: a) traditional flame mode at low furnace temperatures and b) menox® low NO_x mode with flameless combustion at higher furnace temperatures. The new patented solution achieves NO_x values below 150 mg/m³ (reference value of 5 % O₂) at a furnace temperature of 1,200 °C without expensive additional piping.

High-speed burners combined with impulse control create a perfect heating solution for many industrial heat treatment processes. With On/Off control, the burner discharge impulse always maintains full momentum which results in heavy circulation of the furnace. This in turn ensures a high level of temperature uniformity on the material being heated. The NO_x emissions from a heating system with high-speed burners are lower compared to other burner types since the high discharge impulse also results in a reduction in NO_x due to the flue gas being drawn into the flame. However, the fact that emissions regulations are growing ever more stringent has led to the required NO_x limit values not being satisfied by conventional systems in every case and this is particularly true for systems with combustion air preheating systems.

The basic requirement for all industrial burners is that they function perfectly in a wide range of temperatures, beginning with a cold start, i.e. operation with cold air in a cold furnace, to operation with preheated combustion air at high operating temperatures. Low temperatures encourage the formation of CO and the presence of non-combusted fuel components in the flue gas. High furnace chamber temperatures and air preheating to high temperatures result in increased NO_x formation as a result of the high flame temperatures involved. Despite these contradictory effects, the requirement is nevertheless for minimum emissions of both CO and NO_x.

One solution implemented over the last few years is to use the burner in two fundamentally different operating modes [1-4]. One operating mode has been improved to ensure low CO combustion during the heating process while the other

ensures low NO_x combustion at high temperatures. This is achieved by using burners with two separate flow routes for gas or air. The furnace operating temperature determines which route is to be used. The appropriate operating mode is chosen by selecting or disabling the relevant gas or air supply upstream of the burner. For changing the gas supply, for example, one gas valve is closed and another is opened. The solutions which feature a switching of flow routes involve relatively high costs because burner construction is generally complex and dual pipelines as well as control elements are required.

NEW LOW NO_x SOLUTION

The new low NO_x solution menox® combines a low-cost, simply structured burner BIC..M with simple control technology allowing to switch between two operating modes: traditional flame mode at low furnace temperatures and menox® low NO_x mode with flameless combustion at higher furnace temperatures.

A patent has been awarded in Europe for the process which allows low NO_x emissions to be produced considerably below the current limit values [5].

The structural design of the menox® burner BIC..M is similar to the established high-speed burners in the BIC series (**Fig. 1**). Although two operating modes are possible depending on the combustion chamber temperatures, there is only one connection for combustion gas and one for combustion air. Within the burner, too, there is just one flow route for gas and one for air. The ceramic combustion chamber with a reduced outlet diameter features the typical (bottle) form used in high-speed burners. It is installed in the furnace such that the outlet plane is flush with the furnace wall.

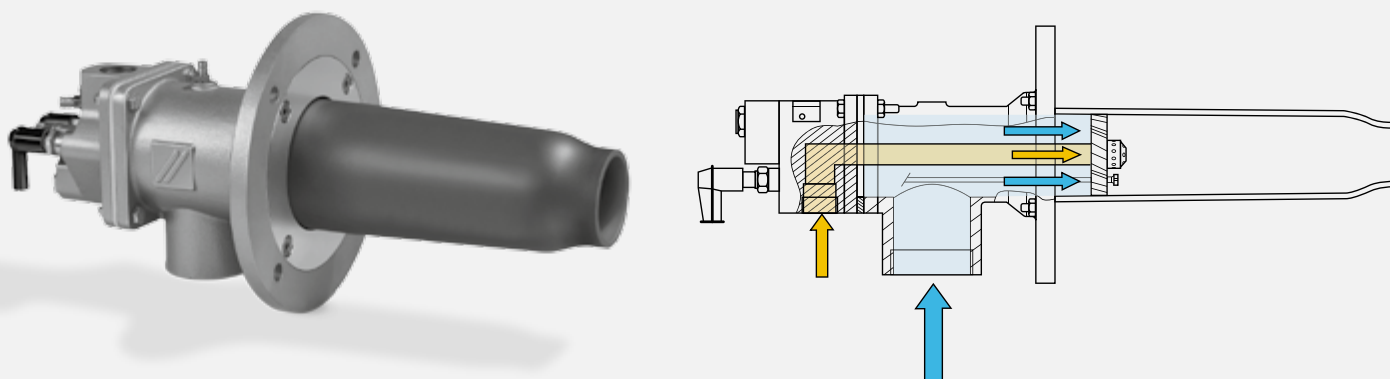


Fig. 1: High-speed burner BIC

FLAME MODE FOR HEATING

In order to heat up the furnace, the burner operates in traditional flame mode as long as the furnace temperature is low. The ignitable gas/air mixture is ignited using an electrical ignition spark and combusts inside and outside of the ceramic combustion chamber (Fig. 2). An ionization electrode monitors the presence of the flame as required by European Standard EN 746-2 for low temperature equipment [6]. The hot flue gas leaves the combustion chamber at a speed of over 120 m/s. The typical blue flame is longitudinal and quite sharply concentrated with a spatially clearly defined contour of the reaction zone (Fig. 3). The high intensity of the combustion reaction at the centre of the flame, identifiable by the red colour in the photograph taken using a UV-sensitive camera, ensures that the combustion produces low levels of CO. At a furnace temperature of just

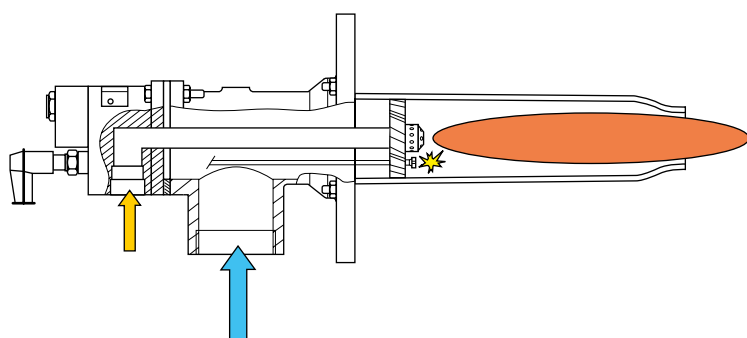


Fig. 2: menox® burner BIC..M in flame mode

450 °C, CO values of as low as around 500 ppm for burner operation with cold combustion air have been measured. As the furnace temperature rises, these values fall rapidly to 50 ppm at 600 °C and they thus lie within the same range as standard high-speed burners of type BIC..HB.

LOW NO_x MODE

With preheated combustion air, switchover to the menox® low NO_x mode takes place when the combustion chamber temperature exceeds 800 °C. The burner is switched off and restarted in the new operating mode. In menox® mode, the gas valve and air control valve are opened without triggering the electrical ignition spark. Although gas and air are supplied via the same connections as in flame mode, the mixture is no longer ignited inside the combustion chamber, but the chemical combustion reaction takes place in the furnace as shown in schematic form in Fig. 4.

In menox® mode, the oxidation reactions take place without a visible flame, which means that only the background radiation of the hot furnace wall can be seen. The picture of the OH radiation in Fig. 5 shows that the reaction zone is considerably larger compared to traditional flame mode. The reaction density is considerably lower and the peak temperatures responsible for high NO_x values are prevented, ensuring that NO_x emissions are drastically reduced.

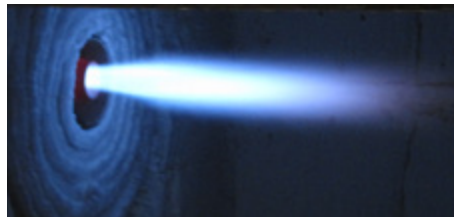
A comparison of the NO_x values for a BIC burner in traditional flame mode and for menox® burners BIC..M is shown in Fig. 6. The blue area shows the considerably reduced NO_x values achieved by menox® while the upper line is based on measurement values from burner model BIC 140MB at 360 kW and the bottom line shows the NO_x measurement values from a BIC 65MB for 35 kW. When the furnace temperature is 1,000 °C, an NO_x value of less than 50 mg/m³ (reference value of 5 % O₂) can be achieved. At a higher furnace temperature of 1,200 °C, an NO_x value of 150 mg can be achieved. The NO_x emissions from smaller burner sizes are even lower, with the NO_x measurement values for a BIC 65MB being recorded at less than 65 mg/m³ (reference value of 5 % O₂) at a furnace temperature of 1,250 °C.

BURNERS BIC..M

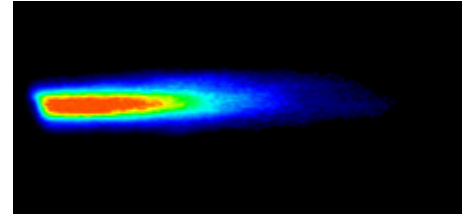
The main novelty about menox[®] is the fact that the combustion air and gas are supplied via the same connections in both operating modes. In menox[®] mode, however, the inflammable mixture of gas and air must be prevented from igniting prematurely in the ceramic combustion chamber each time the burner is switched

on. The combustion reaction can only be transferred to the furnace if the ignition conditions (temperature and concentration limits) are not satisfied inside the ceramic combustion chamber. If the local gas concentration is inside the ignition limits, the temperature must be below the ignition temperature and if the ignition temperature is locally exceeded, there must not be an ignitable mixture in the combustion chamber.

As with all nozzle-mixing burners, the defined local mixing of gas and air in the menox[®] burner BIC..M takes place in the "burner head" mixing unit. The process of mixing the gas and air in the burner head is shown in Fig. 7 for a conventional BIC burner [7]. A new mixing unit (patent pending [8]) has been developed for the menox[®] burner BIC..M. The special geometry of the menox[®] design ensures both reliable ignition and a stable flame while also making sure that the combustion process is transferred to the furnace chamber.



a) Photograph



b) OH radiation

Fig. 3: Flame pattern of the high-speed burner BIC

In addition, the flow velocity at the burner nozzle must be adequately high to prevent flashback into the combustion chamber when operating in menox[®] mode. The burners BIC..M are therefore combined with the tapered ceramic tubes TSC..B tailored to the specific rating for menox[®].

SYSTEM STRUCTURE

The system structure for menox[®] is shown in Fig. 8. The burners is switched on and off in cycles, whereby only an air valve and a gas valve with damping unit are required for this intermittent burner operating mode. The second gas valve is specified for every burner in European Standard EN 746-2.

The control system required for safe burner operation takes the form of a specially designed burner control unit BCU. This coordinates the signals for starting the burner and the fail-safe monitoring of the burner in flame mode. In menox[®] mode, the ignition device and flame control system are disabled using a

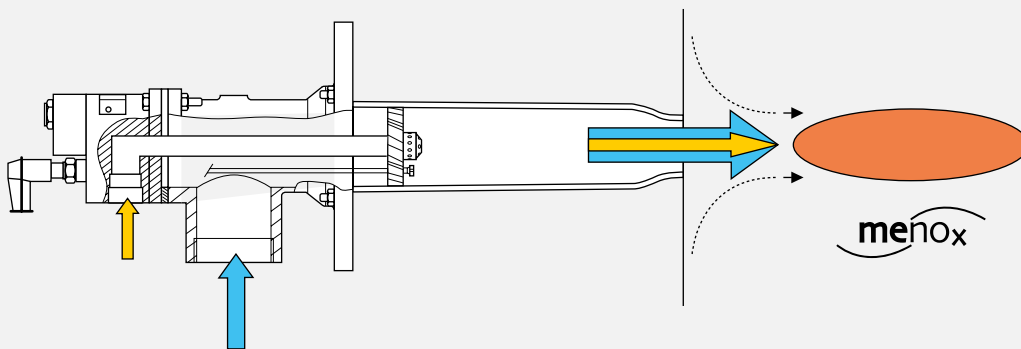


Fig. 4: menox[®] burner BIC..M in low NO_x mode

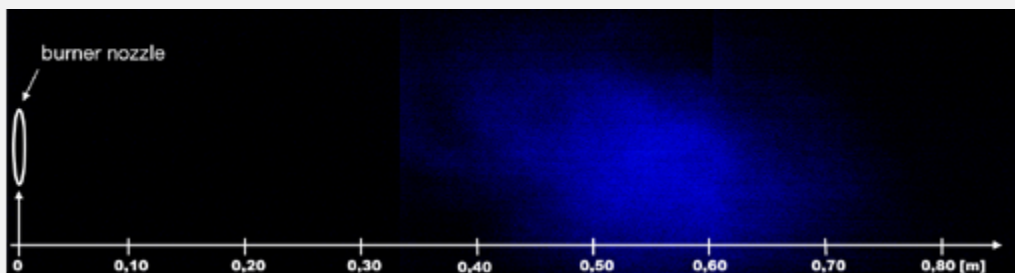


Fig. 5: OH photograph in menox[®] low NO_x mode

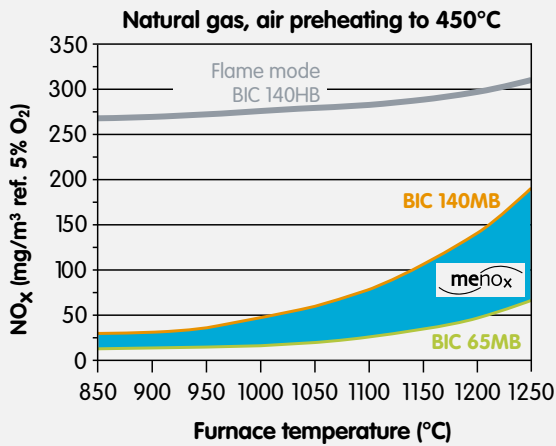


Fig. 6: NO_x emissions for menox®

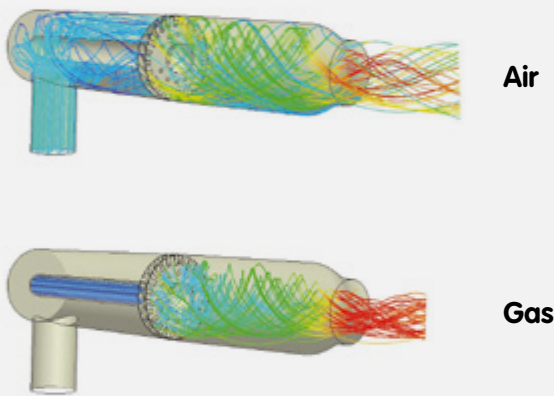


Fig. 7: Flow lines of the "burner head" mixing unit in a conventional BIC burner

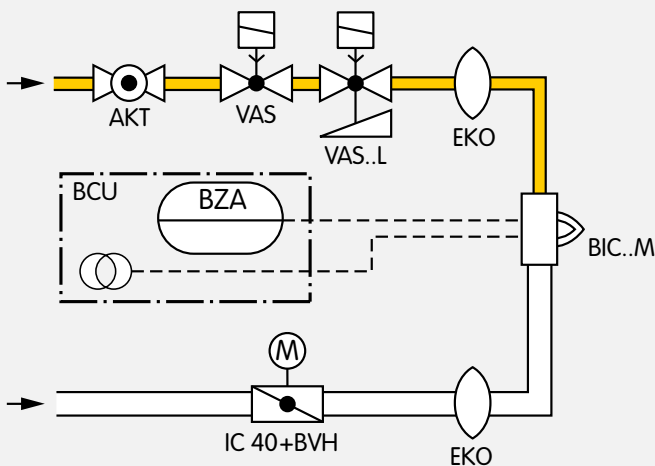


Fig. 8: System structure for menox®

digital signal. The fail-safe evaluation of the furnace temperature by means of a safety temperature monitor is required for this purpose. Alternatively, an Elster Kromschroder control cabinet can provide all the required control and monitoring functions for more complex requirements.

The burners BIC..M and ceramic tubes TSC for menox® are available for six ratings of 35 kW, 75 kW, 110 kW, 180 kW, 260 kW and 360 kW for flame mode using natural gas. In menox® mode, the burner capacity increases by up to 15 %. menox® mode is possible with cold air and with combustion air preheated to a temperature of up to 450 °C. In the event that the combustion air is heated, the customer must provide an air pressure booster for hot air compensation and an air/gas ratio monitoring system.

LITERATURE

- [1] Wüning, J.A.; Wüning, J.G.: Brenner für die flammlose Oxidation auch bei höchster Luftvorwärmung. Gas Wärme International 41 (1992), Volume 10, pp. 438 – 444
- [2] Wüning, J.G.; Milani, A.: Handbuch der Brennertechnik für Industrieöfen, Vulkan-Verlag, Essen, 2007
- [3] TriOx Triple Air Staged Ultra Low NO_x Burner, product brochure, Hauck Manufacturing Company, Lebanon, PA 17042, USA
- [4] E-Jet Ultra Low Hot/Cold Air Burner, product information, Hotwork Combustion Technology Ltd, United Kingdom
- [5] Patent document EP 1893915B1
- [6] EN 746-2:2010, Industrial thermoprocessing equipment – Part 2: Safety requirements for combustion and fuel handling systems
- [7] Giese, A.: Untersuchung der Auswirkungen von Gasbeschaffenheitsänderungen auf industrielle und gewerbliche Anwendungen, DVGW reference G/1/06/10, Intermediate report, Freiberg, 19.06.2012
- [8] Patent document EP 2442026A1

AUTHORS



Dr.-Ing. **Sabine von Gersum**
 Elster GmbH
 Lotte (Büren), Germany
 Tel.: +49 (0)541/ 1214-374
 sabine.gersum@elster.com



Dipl.-Ing. **Martin Wicker**
 Elster GmbH
 Lotte (Büren), Germany
 Tel.: +49 (0)541/ 1214-624
 martin.wicker@elster.com