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Economic and Ecological Lead Furnace Improvements

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Abstract: Due to higher energy costs and an economic driven force to substantially increasing melting rate by lowering the specific production costs Oxyfuel burner is the only issue in the lead industry because of the higher combustion efficiency, low investment costs and therefore a small return on investment. The diluted or flameless combustion by an internal off gas recirculation solves the problem with the high flame temperature by overheating the melt and the refractory material in small areas of the furnace. More homogeneity of the melt and refractory temperature, a higher convective term of the heat transfer and a high amount of radiation is the way to an economically and ecologically lead production.

This paper describes the well established Messer Group GmbH. Oxipyr®-burner technology and a revamping of a lead short drum furnace from heavy oil-air burners to the Oxipyr®-Flex flame methane oxygen burner system.

Introduction

In 2005, Messer Group established a technology competence centre for metallurgy in Gumpoldskirchen (Austria), with the aim to develop oxygen burners which satisfy today's and upcoming standards of legislation as well as customer requirements. With the assistance of the Development Sponsorship Fund (FFF) of Austria, cooperation with the University of Leoben was agreed on. With the long term experience of the Gas-Wärme-Institut "GWI" in Essen (Germany) and the University of Leoben, different new burners have been developed.

Oxygen in the combustion process

The efficiency of industrial combustion processes can be increased in two ways (Figure 1), either by preheating the fuel and combustion air or by adding oxygen. Due to the high N_2 amount at air combustion, only low flame temperatures can be reached. This results in high heat loss in the exhaust gas, caused by the low combustion efficiency.

Oxygen can be introduced into the combustion chamber using different techniques:

- Oxygen fuel burners
- Direct oxygen injection into the fuel air flame
- Underlaying of the fuel air flame
- Enrichment of the combustion air

In Figure 2, the theoretical flame temperature for the stoichiometrical combustion of natural gas is plotted against oxygen enrichment. Therefore, it can be concluded that even low enrichment values produce higher flame temperatures and result in higher combustion efficiency.

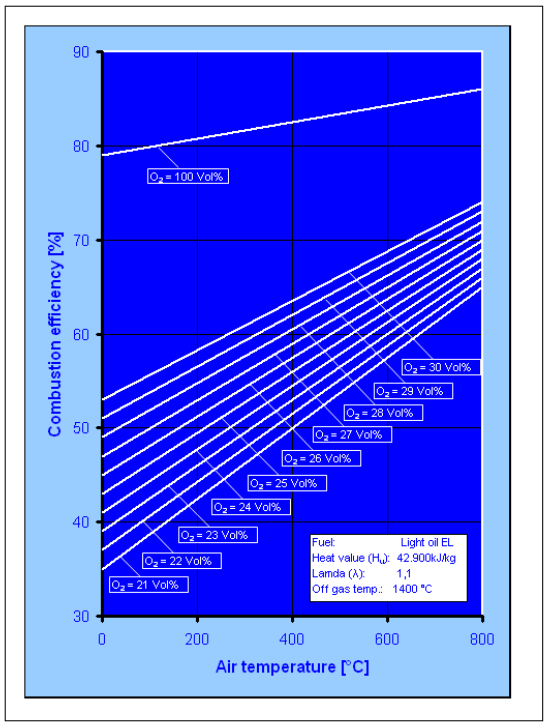

Figure 1: Influence of the combustion air temperature and the oxygen concentration on the combustion efficiency [1]

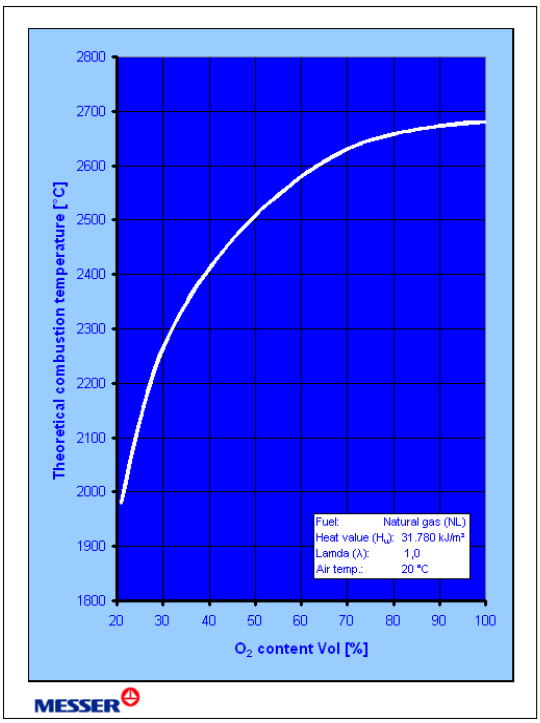

Figure 2: Theoretical flame temperature for the stoichiometrical combustion of natural gas as function of the oxygen content [1]

The enrichment with oxygen and the usage of pure oxygen is also mentioned in different BAT (best available techniques) bulletins. The most common reasons for the usage of oxygen are:

- Better flexibility due to higher melting rates and shorter tap-to-tap times
- Reduction of the specific energy consumption
- Lower amount of exhaust gas
- Lower environmental impact of the emissions
- Reduced material loss because of lower momentum

- Lower investment costs because of smaller filtering units
- No air preheating necessary
- Integrated post-combustion possible

Flameless leads to „cold combustion“ with oxygen
Flameless combustion with the correct scientific term volume combustion is a process in which the flame is diluted with exhaust gas in order to cool and lengthen the flame. As a result of this procedure, the flame becomes nearly invisible. The original intention lies in a substantial reduction of NO_x values and a more homogeneous distribution of heat (a diluted flame still holds the same heat quantity). Although no nitrogen is introduced during oxyfuel combustion, the high flame temperature aids the formation of NO_x, which originates from nitrogen in the fuel or the leak air. This is different from the combustion of air fuel mixtures, where air consists of 79 % nitrogen. With the flameless process, the NO_x emissions are lowered below the legal government and TA-Luft limit values.

The mode of operation of a diluted or mild combustion can be seen in Figure 3. With a recirculation of the exhaust gas, a dilution of the flame is achieved, which leads to a reduction of the temperatures at the mouth of the burner as well as a reduction of the NO_x values. This effect is reached with both air and oxygen burners. The temperatures of the oxygen burners are at the same level as the conventional air burners.

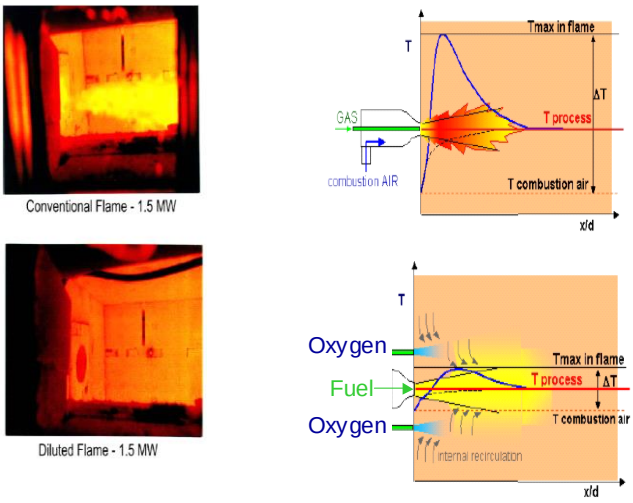

Figure 3: Diluted combustion – a possibility to reduce NO_x [3]

Flameless leads to a homogenization of the temperature inside the furnace
The distribution of the temperature inside the furnace can be seen. For the flameless Oxy-fuel combustion, the temperature is lower and more evenly distributed due to the strong internal recirculation of the furnace atmosphere in front of the burner mouth.

Lower investment costs of rebuilding and newly built plants
With the oxygen optimized design of furnaces, a reduction of up to 30 % of the investment costs can be achieved. The reason for this is the reduction of steel construction and

refractory material because of the smaller furnaces which result from increased production and lower exhaust volume flow. Air burners based on regeneration and recuperation are up to 2/3 more expensive and are more cost intensive to maintain because of their design than oxygen burners.

The Oxipyr®-Flex – the all-rounder among oxygen burners

The problems at burners are controllability and flexibility. If the power level is changed, the flame length and geometry are changed as well. For hearth-type furnaces for scrap metal melting, it is a necessity to have a flexible and adjustable flame, because the distance to the material increases during the melting period, but the power level of the burner should not decrease so that the melting time is not extended (Figure *4*4). For a constant temperature of the metal on the far side, a long soft flame with a high radiation ratio should be adjusted. Here, diluted combustion leads to advantages due to the good homogenization characteristics. If high dust concentrations are present, a partial diluted combustion is possible in order to reach the allowed low pollutant emission levels. The Oxipyr®-Flex allows tailor-made but also flexible working in metallurgy.

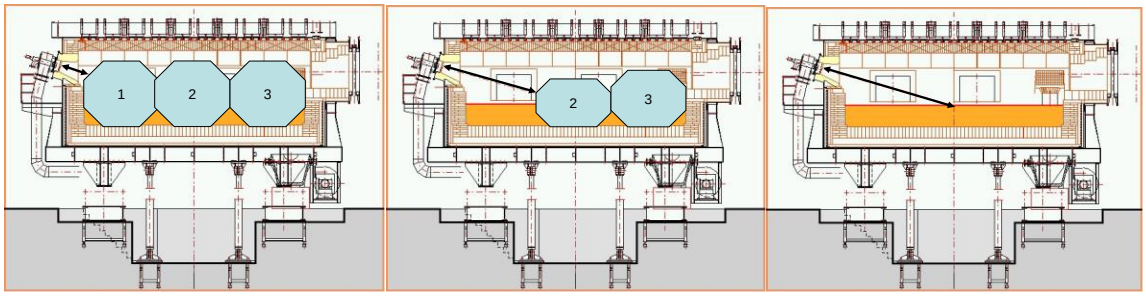

Figure 4: Development of the changing of distance between scrap metal and the burner mouth in a hearth-type furnace[5].

Preliminary investigations

In the technology center of the Messer Group, the investigations in the burner chamber took place with a trial burner of a nominal power of 300 kW. Special attendance was given to a flameless combustion. Due to the longitudinal adjustment of the burner head, a variation of the flame length such as in Figure 8 can be achieved. At a burner power level of 900 kW, a variation of the flame length from 1 up to 3 m was measured. The flame in the furnace is between 20 to 30 % longer than at the free test stand.

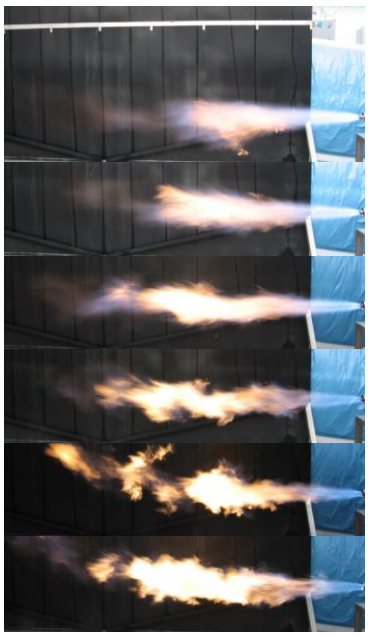

Figure 5: Flexible Flame of a 900 kW Oxipyr®-Flex burner from 1 m to 3 m and from a hard to a soft flame at the free test stand

Design of the Oxipyr®-Flex

A longitudinal adjustable burner head leads to a change in cross-section between the wall and burner head. The existing natural gas supply enables the exact adjustment of the flame parameters for every furnace type. A control range of at least 1:20 in flameless mode of operation was the targeted value, which was reached successfully. The fuel gas velocities can be kept low for high dust concentrations and high for dust free feed. The ceramic burner block or outer metal tube is available in metal or ceramic design in order to allow a maximum of flexibility of the furnace system. An example for the field of application in the recycling industry is shown in Figure 9 by means of a 900 kW Oxipyr®-Flex burner. The length and the mounting of the burner can be shaped according to the needs of the customer, if necessary also water cooled.

Figure 6: Design of a 900 kW Oxipyr®-Flex for short drum furnace for lead recycling

Furnace improvements

Since the last three years, Messer revamped 9 different short rotary drum furnaces for lead over Europe. The size of the furnaces was between 3 and 30 tons per cycle. Some furnaces uses desulphurization before melting, some no pretreatment. The flexible burner system Oxipyr®-Flex allows to customized every cycle in every furnace. An interesting figure is also the plastic separators load of the charge. The e energy, which is bonded inside the plastic should used to melt the grids and paste and not to be burned in the post combustion. With the lancing mode of the high impulse burners and the sucking of the offgas to the burner allows to save energy in form of natural gas or oil. Specific consumptions of 57 m³ natural gas (98% Methane) per ton of bullion for desulfurized paste and 70 m³ natural gas (98% Methane) per ton of bullion for non desulfurized paste were reached. We have also experience with silicate and soda slag.

Different burner positions leads to different efficiencies
The most important issue is the position of the burner. The Figure 7 and Figure 8 shows different burner positions at short rotary drum furnaces. With the flexible flame is every position more efficient than with normal Oxyfuel burners.

Figure 7: Burner opposite the offgas system

Figure 8: Burner under offgas system

Also the position inside the furnace of the flame is very important. The Messer Lead technology achieves with small changes in the angle to the charge and out of the center of the furnace approx. 5 percent higher efficiency (Figure 9).

Figure 9: Customized Burner angle to charge and out of furnace center

Conclusion

In this paper, the state of the art of burner technologies has been displayed. The usage of oxygen in the combustion process leads to many benefits, especially concerning the reduction of energy costs. Every furnace is different, and without the experience and knowledge of the process, the furnace and the knowledge of the burner technology no economic solution can be achieved.

The Oxipyr®-Flex combines the controllability of many Oxipyr®-P burners, including the flameless combustion, has a significant influence on the economics of melting processes in the light and non-ferrous metal industry. The increased flexibility is gained because of the possibility to operate at different power levels. This shortens melting times while reducing melting loss and refractory wear.

The Messer Group has experienced technical staff and will cooperate with you in an effort to optimize every furnace type.

References:

[1] Potesser, M., et.al: Burner Development of the Messer Group for the Nonferrous Metallurgical Industry. BHM, 153. Jg. (2008), Heft 3, S 121 – 125
[2] Holleis, B., Spoljaric, D., Adendorff, M.: Einsatz von technischen Gasen in Giessereien Sauerstoff bei Schmelzprozessen, Giesserei-Rundschau 52 (2005), 76 - 82
[3] Milani et. al.: Flameless Technologies: Industrial Applications and R & D projects in Italy 5th Int. Symposium in High Temperature Air Combustion and Gasification, Tokyo, 2002
[4] Schuster, F.: Verbrennungslehre, Oldenbourgverlag, (1970)
[5] www.maerz-gautschi.com, (retrieved on the 2.3.2007)
[6] Spoljaric D.; Wieck D.: EP1402078 - Method for melting down aluminum, 2004-03-31