Oxy-fuel melter with batch and cullet preheater[1]

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1. Introduction

In this paper the concept of an oxy-fuel-fired furnace with external heat recovery will be described. In addition, it will be reported about the operating results and experience after a running time of 18 months.

2. New furnace concept

In January/February 1997, furnace no. 2 was under repair at Glashütte Gerresheim GmbH of Düsseldorf, a plant of the German concern Gerresheimer Glas AG. Up to this time, this furnace was a regeneratively heated, cross-fired furnace, where mainly amber glass was melted (table 1). At a melting area of 117 m^2, the pull was 380 t of glass/d, corresponding to a specific pull of about 3.5 t of glass/(m^2 d). The specific energy consumption of the furnace, using oil, gas and electrical boosting, was about 5028 kJ/kg of glass (= 1200 kcal/kg of glass), with a cullet ratio of 65 %. More than 11 000 t of glass/m^2 were melted over the life of the furnace. The NO_x emission[1] was about 2200 mg/m^3.

The new furnace no. 2 was designed to accomplish the following criteria: The pull should be 400 t/d of flint glass. NO_x emission and also the specific energy consumption should be low. Because of increasing customer specification, the quality of glass should be improved, primarily in respect of seed and blister levels. The new furnace should give a better opportunity of putting into solution small ceramic and porcelain particles as contained in recycled cullet.

These criteria were taken into consideration to evaluate different types of furnaces. The first option was the regenerative cross-fired furnace, with primary NO_x reduction. The second option was the LoNOx melter, which is existing technology in Budenheim, another plant of Gerresheimer Glas. The third option was the oxy-fuel melter with batch and cullet preheater.

The evaluation showed that the oxy-fuel melter with batch and cullet preheater was the best alternative for Glashütte Gerresheim.

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[1] Presented in German at: 72nd Annual Meeting of the German Society of Glass Technology (DGG) in Münster (Germany) on 26 May 1998.

[2] Here and in the following the concentration of waste is given at standard conditions.

Table 1. Furnace data of the old furnace no. 2

type of the old furnace no. 2:	regeneratively heated cross-fired furnace
glass colour:	amber glass
melting area:	117 m^2
furnace pull:	380 t of glass/d
specific pull:	3.5 t of glass/(m^2 d)
fuel:	oil, gas and electrical boosting
specific energy consumption:	5028 kJ/kg of glass (= 1200 kcal/kg of glass)
cullet:	65 %
specific pull of the furnace campaign:	11 000 t of glass/m^2
NO_x emission:	2200 mg/m^3

Table 2. Furnace data of the oxy-fuel melter

type of the new furnace no. 2:	oxy-fuel melter with batch and cullet preheater
glass colour:	flint glass
furnace pull:	400 t of glass/d
melting area:	150 m^2
specific pull:	2.7 t of glass/(m^2 d)
cullet:	65 %
specific energy consumption:	3143 kJ/kg of glass (= 750 kcal/kg of glass)
NO_x emission:	equal or less than 500 mg/m^3

3. Description of the oxy-fuel melter with batch and cullet preheater

This type of melter consists of the following main components: the furnace, the oxygen plant, the combustion system and the waste gas system, and in addition, the batch and cullet preheater (figure 1).

The furnace was planned and built in cooperation with the Nikolaus Sorg GmbH & Co. KG of Lohr (Germany). Glashütte Gerresheim have carried out other projects with this company also in the past. As mentioned above, the average pull of this furnace was expected to be 400 t of glass/d (table 2) corresponding to a melting area of 150 m^2, and a specific pull of about 2.7 t of glass/(m^2 d). The specific energy consumption, with 65 % cullet addition, was expected to be about 3143 kJ/kg of glass (= 750 kcal/kg of glass). The NO_x emission should be equal or less than 500 mg/m^3. The

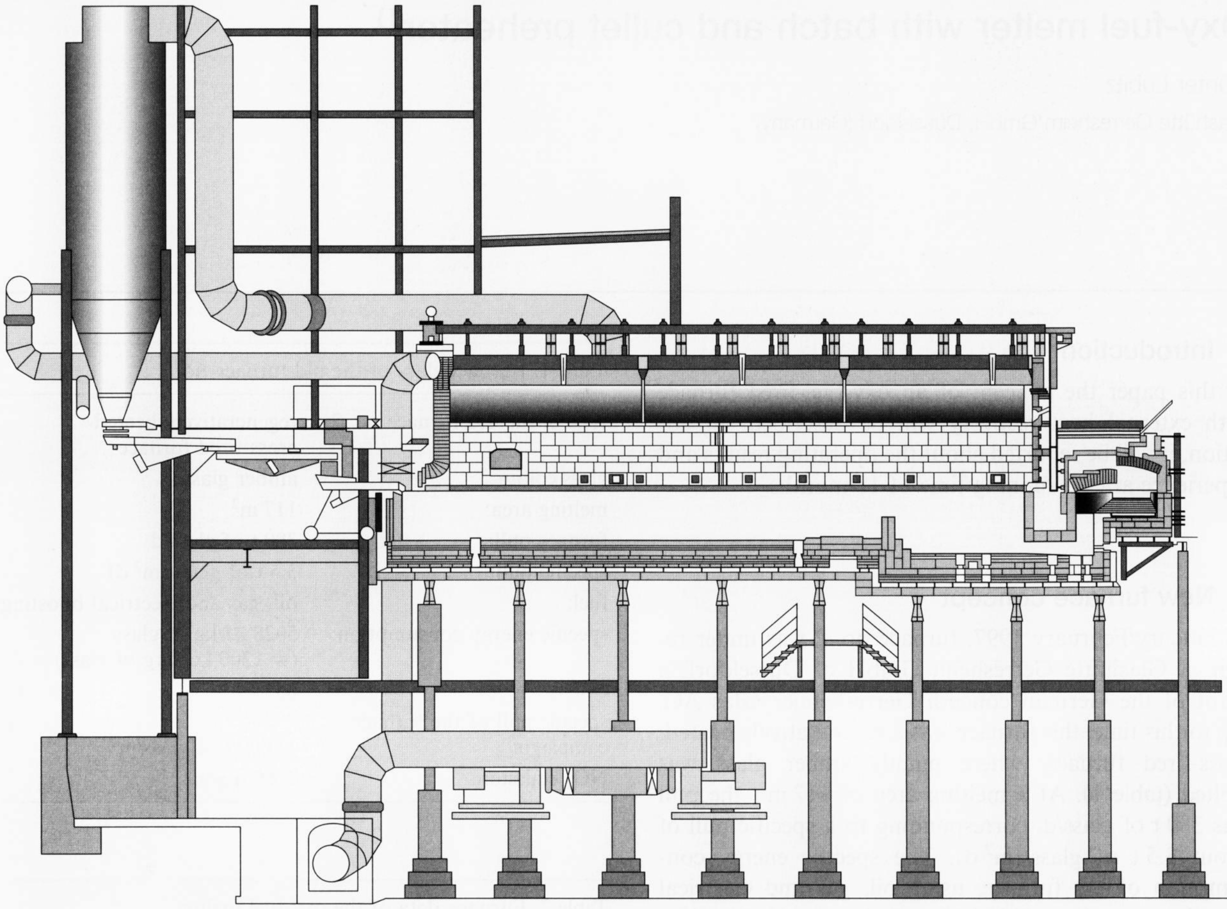

Figure 1. Oxy-fuel melter with batch and cullet preheater.

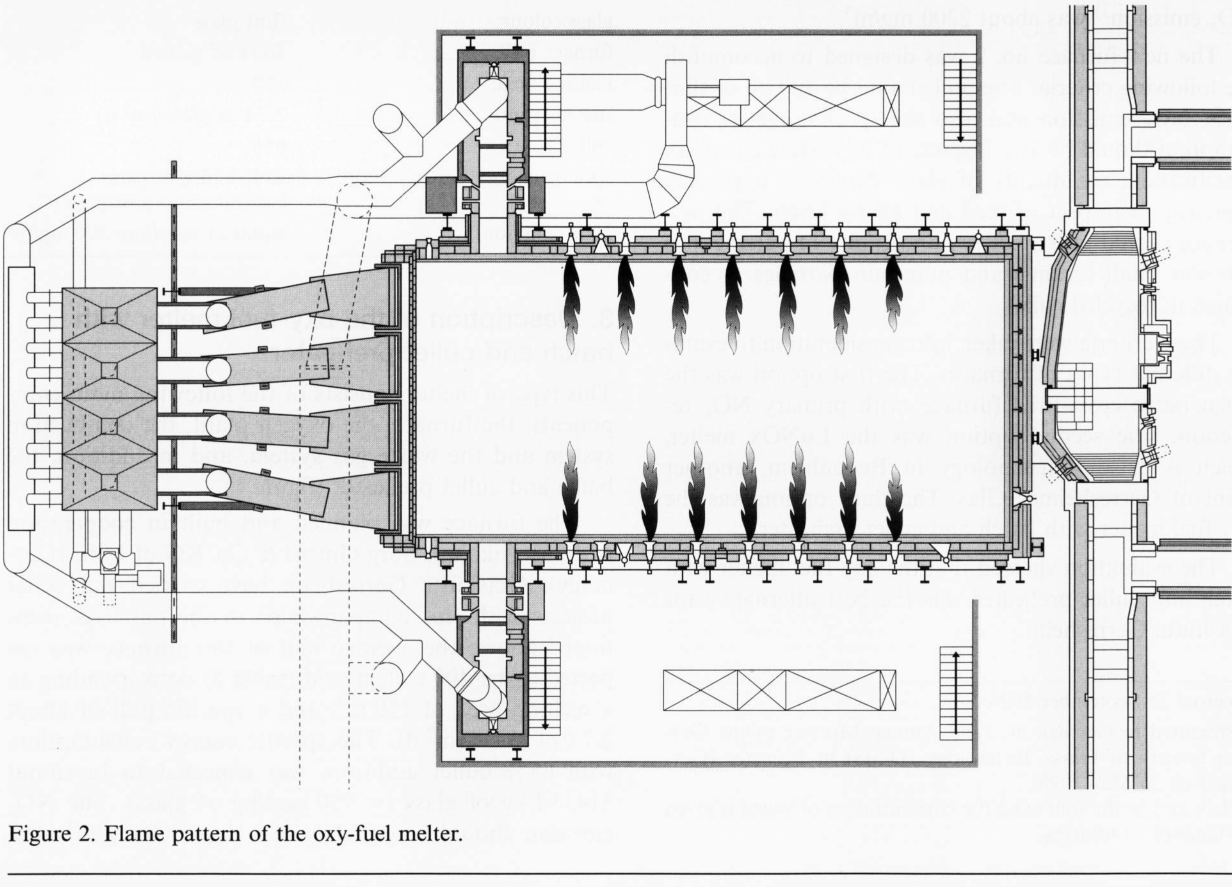

Figure 2. Flame pattern of the oxy-fuel melter.

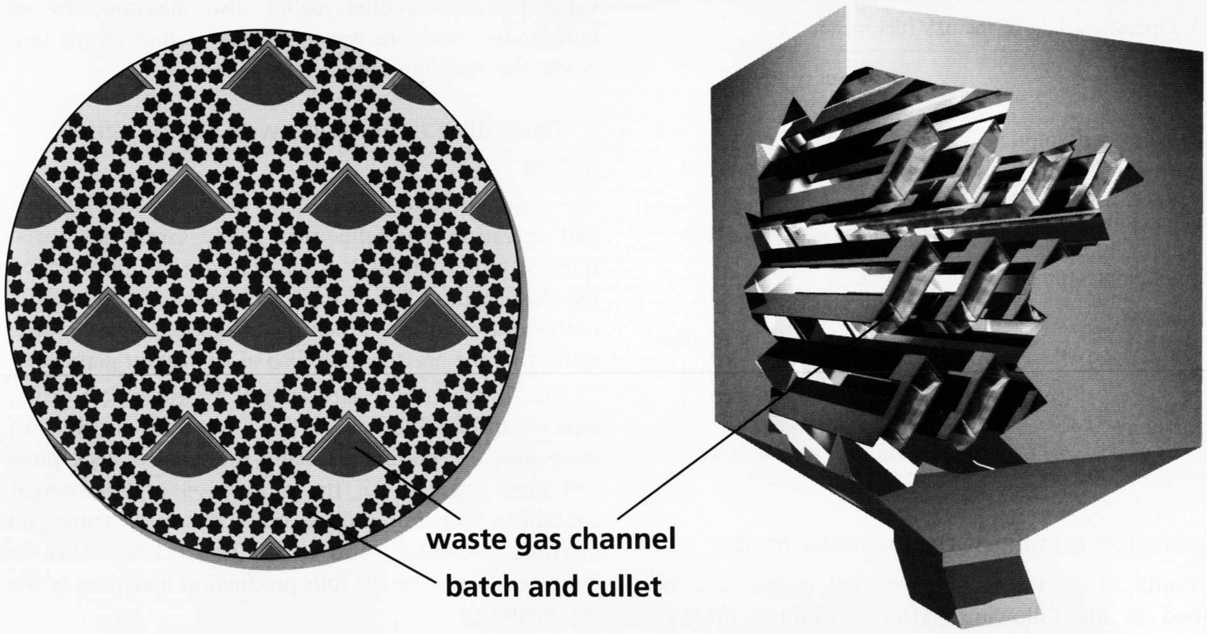

Figure 3. Batch and cullet preheater.

oxy-fuel melter should be heated with a mixture of oil, gas and oxygen without any electrical boosting.

The following construction specifications for the new furnace were defined:

- length/width relation = 2.3:1;
- glass depth of the melting area = 1.39 m;
- glass depth of the refining area = 1.8 m;
- height of the dam = 0.6 m.

The refining zone of the furnace is deeper than the melting zone, which causes a better homogenization of the glass. A bubbling row is installed in front of the dam. The refractory of the oxy-fuel melter corresponds to that of a conventional furnace. The crown is constructed in silica.

Actual downtime for construction was scheduled to be 60 days glass to glass.

Oxygen for the heating of the furnace is produced by a CVSA (compact vacuum swing adsorption) plant located at Glashütte Gerresheim. The plant was developed by Air Liquide of Düsseldorf (Germany) and is also operated by this same company. It is constructed for an oxygen supply of up to 107 t/d with 90% purity of the oxygen.

A backup system, which consists of several containers of liquid oxygen and a vaporizer, can supply the furnace with sufficient oxygen in case of a breakdown of the CVSA plant.

The CVSA plant works with the well-known selective adsorption technology which decomposes air to its single components and separates the by-products in adsorption material. The so-called regeneration of the adsorption material results cyclically from pressure variations in the vacuum area.

The 14 burners of the furnace, each of which may supply oil, gas and oxygen, are products of Maxon International N.V., Vilvoorde (Belgium). They are located offset on both sides of the furnace and operate with an oil-gas-oxygen mixture. The oil is atomized by the gas. The flames cover almost the whole glass surface (figure 2).

The waste gas leaves the furnace through two waste gas channels, after the combustion process. The waste gas channels are located in the back end of the furnace and the waste gas temperature is about 1400 °C. With a special quench air system these waste gases are cooled down to 560 °C, and then conveyed to the batch and cullet preheater.

The recovery of waste heat was an important point for the oxy-fuel melter project. Different options have been taken into account, such as production of steam and electricity or batch and cullet preheating. The main consideration was to use the waste heat directly for the melting process. Therefore, it was decided to install a batch and cullet preheater.

Several systems with indirect and direct preheating are offered by suppliers. After examination of all alternatives, a preheater of Interprojekt GmbH of Essen (Germany) was installed. This company had previously installed several units in cooperation with Nienburger Glass GmbH of Nienburg (Germany) which developed this preheater (figure 3).

The preheater operates as follows: the waste gas with a temperature of 560 °C is passed through the preheater cross-counter current in channels which are open on the underside.

Steam, resulting from drying and heating, is channeled off from the system, together with the waste gas at the time when waste gas and batch and cullet make contact. The different positions of the channels and the slowly downwards floating batch and cullet result in a good heat exchange.

Table 3. Operation data of the oxy-fuel melter

starting date:	25 February 1997
furnace pull:	350 to 420 t of glass/d
specific energy consumption with batch and cullet preheating:	3017 kJ/kg of glass (= 720 kcal/kg of glass)
specific energy consumption without batch and cullet preheating:	3436 kJ/kg of glass (= 820 kcal/kg of glass)
preheating temperature:	300 °C
cullet:	55 to 70 %
seed count:	20 seeds per 100 g of glass
stone count:	25 % less compared to a conventional furnace
NO_x emission:	0.25 kg/t of glass (limit 0.7 kg/t of glass)

4. Operation results of the oxy-fuel melter

The results of operating the oxy-fuel melter will be described in the following. After a running time of 18 months, the results were almost satisfactory (table 3).

The pull of the furnace over those 18 months was between 350 and 420 t of glass/d. The average specific energy consumption, including batch and cullet preheating (preheating temperature = 300 °C, cullet addition = 55 to 70 %), was about 3017 kJ/kg of glass (= 720 kcal/kg of glass), which is only 70 % of a conventional furnace. Without batch and cullet preheating the energy consumption is about 3436 kJ/kg of glass (= 820 kcal/kg of glass). For the oxygen production further 231 kJ/kg of glass (= 55 kcal/kg of glass) are required. This amount is not included in the 3017 kJ/kg of glass (= 720 kcal/kg of glass) as given above.

The workability of glass melted in an oxy-fuel furnace is excellent; and the glass quality, regarding inclusions and seeds, is, compared to a conventional furnace, better. At the Glashütte Gerresheim laboratory, each day the seeds and stones are counted. In addition, all stones are identified and the glass composition is analyzed, using a Philips X-ray fluorescence device. The seed count is on average 20 seeds per 100 g of glass, and the stone count is about 25 % less compared to a regeneratively heated furnace.

For the old furnace no. 2, the limit for the emissions of NO_x had been set to 2500 mg/m^3. For the oxy-fuel melter, an NO_x limit of 0.7 kg/t of glass, corresponding to an equivalent of 500 mg/m^3, was established by the state officials. The actual value for NO_x emissions for this furnace is only 0.25 kg/t of glass as measured by an independent institute.

Direct batch and cullet preheating can cause dioxin emissions. The permitted value is 0.10 ng/m^3. The actual value for the oxy-fuel melter also measured by an independent institute, was 0.04 ng/m^3, which clearly falls below the emission limit.

5. Operating experience with the oxy-fuel melter

The production start caused no problems. During normal operation the melter runs stably. Great pull variations of more than 20 t of glass/d have no influence on the glass quality. The furnace is continuosly heated from both sides with no reversal of firing, which results in a stable furnace pressure and also in a constant glass level.

On furnace no. 2, jars as well as water, soft drink, liqueur, and cooking oil bottles are produced. Many of these jobs are performed using the narrow neck press and blow process. For the production of light-weight containers with this process on a 10-section triple-gob machine, a constant gob weight is necessary. This requirement is met by the four production machines of the oxy melter.

Different fuels with variable fuel ratios can be used for the heating of the furnace. The furnace was started with pure gas-oxygen heating. Later on, there was a change to oil-oxygen heating. The oil-oxygen flames showed, compared to the gas-oxygen ones, a more compact flame pattern. Moreover, the energy consumption was reduced by about 3 %, after the change. The third step was the change to oil-gas-oxygen heating with 40 % oil and 60 % gas. The flames are very luminous. With this combination of gas and oil, the energy saving originally found when using oil and oxygen only continued.

At the beginning, quenching, i.e. injection of cooling air into the waste gas channel under a 90° angle, resulted in a higher furnace pressure and in pollution in the dog house area. The pollution, primarily consisting of batch dust, was so heavy that the furnace was for a short time operated without the batch and cullet preheater. After modification of the quench air system, and the installation of a vacuum system above the dog house to collect batch dust, furnace pressure and pollution could be drastically reduced.

6. Summary

In conclusion, it can be said that the oxy-fuel melter with batch and cullet preheater meets the expectations. Glass quality, specific energy consumption and emission levels are more than satisfactory. The new melting technology gives the possibility of meeting also higher future standards, regarding NO_x emission and heat recovery. Thus, Glashütte Gerresheim is equipped with a powerful, flexible and innovated melting process for the future.

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