ONLINE GLASS ENGINEERING

FOR OPTIMISING GLASS MELTING PROCESSES

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1 INTRODUCTION

Glass manufacturers are constantly under pressure to enhance production, improve quality, meet increasingly strict emission regulations and reduce costs and investments.

Glass Melting is a key element within the glass production process from batch preparation to product packaging and the main goal is to cost optimize glass melting processes.

In the last 40 years there have been various trends to achieve this cost optimization and the main drivers can be highlighted as follows:

- Higher melting efficiencies
- Longer durability of the melting furnaces
- Better fuel utilization or fuel reduction
- Glass quality improvements
- Emissions reduction (NOx, SOx and particulates)

Today there is not a clear trend but a complex mixture including all of those drivers. Depending on the boundary conditions i.e. fuel and electricity prices, emissions regulations, company (legal form and history etc.) the emphasis on a drivers importance vary considerably.

1.1 Heat & Mass balances

With the experience on a large variety of furnaces it is possible to forecast possible variations mainly focusing on the fuel consumption, such as:

- Electricity vs. Fuel as well as fuel changes
- Batch and/or glass changes
- Heat recovery modifications
- Production increase (with additional electricity or oxygen)
- Conversion from air fuel to oxy fuel combustion (or vice versa)
- Recuperator or regenerator repairs

All these forecasts are based on heat and mass balances according to the most common enunciation of the first law of thermodynamics, that the increase in the internal energy of a thermodynamic system is equal to the amount of heat energy added to the system minus the work done by the system on the surroundings.

The overall heat and mass balance of any glass melting furnace can be described as

$$\dot{Q}_{INPUT} = \dot{Q}_{OUTPUT}$$
$$\dot{Q}_{INPUT} = \dot{Q}_{energy} + \dot{Q}_{combustion\ \mathrm{air}/oxygen} + \dot{Q}_{batch}$$
$$\dot{Q}_{OUTPUT} = \dot{Q}_{glass} + \dot{Q}_{flue\ \mathrm{gas}} + \dot{Q}_{losses}$$

with

$$\dot{Q}_{energy} = \dot{Q}_{fossile\ \mathrm{energy}} + \dot{Q}_{electricity}$$
$$\dot{Q}_{batch} = \dot{Q}_{cullets} + \dot{Q}_{raw\ materials}$$
$$\dot{Q}_{glass} = \dot{Q}_{endothermic\ reaction} + \dot{Q}_{useful\ heat} + \dot{Q}_{melting\ losses}$$
$$\dot{Q}_{flue\ gas} = \dot{Q}_{flue\ gas,\ combustion} + \dot{Q}_{false\ air}$$
$$\dot{Q}_{losses} = \dot{Q}_{wall\ losses} + \dot{Q}_{radiation\ losses} + \dot{Q}_{cooling\ water\ losses} + \dot{Q}_{cooling\ air\ losses}$$

The accuracy of the forecast is much depending on the base case and the type of variation or forecast respectively, where the base case can be an existing furnace with given data or even a new furnace design with only assumptions.

Based on an existing furnace, knowing all input variables, a forecast is very accurate. The fundamental idea behind is that with the given parameters the overall losses, as described above, can be calculated very quickly without evaluating the furnace refractory conditions etc. in detail.

Within a specific forecast these losses will not change significantly. Even when the given parameters are not 100% correct, the forecast or trend respectively will be very accurate anyhow.

Linde and Ogis have jointly developed a program, Online Glass Engineering (OGE) which is available through www.glassglobal.com portal site.

As technology leader in the glass industry, Linde Gas is a defining force for glass melting, polishing and surface treatment innovations. OGIS GmbH, operator of glassglobal.com, the biggest glass portal worldwide with over 1.2 million page impressions a month, has exceptional reach and experience in the glass industry. Together, they are a winning combination that can work to your benefit.

With Online Glass Engineering, glass factories are provided with a perfect program to execute various kinds of calculation any time, whenever needed or required to check profitability or potential of optimization.

This program (Chart 1 gives an abstract of different result pages) provide detailed information and calculations about production data on the basis of furnace specifications such as melting temperature etc. the complete raw material data with output of furnace efficiency and optimization potential

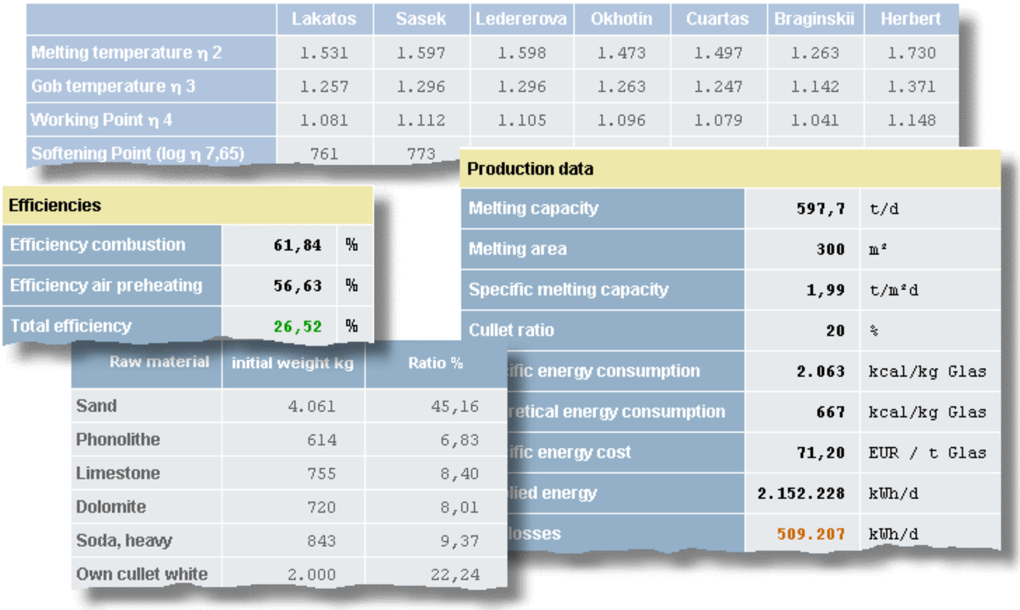

Chart 1: Online Glass Engineering (OGE)

The input variables of OGE are shown in chart 2 (not mentioning the heat recovery devices as well as media prices i.e. for natural gas, oxygen or electricity):

Variables - Analysis	**Typ. unit**
Air/oxygen analysis (main combustion)	…
False air analysis	…
Fuel (gaseous, liquid, solid, mixtures), main c.: Analysis or lower caloric value	… or kcal/Nm³ or /kg
Fuel (gaseous, liquid), add. burner: Analysis or lower caloric value	… or kcal/Nm³ or /kg
Batch: Composition or type of glass	…
Glass: Analysis or type of glass	…
Melting losses: Analysis or blanket	… or %

Variables - Temperatures	**Typ. unit**
Temp. combustion air/oxygen	°C
Temp. add. combustion air/oxygen	°C
Temp. flue gas	°C
Glass temp. (throat)	°C
Batch temp.	°C
Cullet temp.	°C
Fuel (gaseous, liquid, solid) temp.	°C
Temp. water electrode inlet	°C
Temp. water electrode outlet	°C
Temp. ambient air	°C
Humidity ambient air	°C

Other variables	**Typ. unit**
Melting area	m²
Furnace length	m
Melting capacity	t/d
Cullet ratio	%G
Oxygen content in the flue gas (after the furnace)	%
Lambda, main combustion	…
Lambda, add. burner	…
Fuel consumption, main combustion	Nm³ or kg/d
Fuel consumption, add. burner	Nm³ or kg/d
Electricity	kW
Water amount in the cullet	%
Water amount in the batch	%
Melting enthalpy	kcal/kgG
No. of electrodes	No.
Water flow per electrode	l/h
Barometric level	mbar
Altitude	m

Chart 2: Input variables

The following table shows some results from those OGE calculations:

2 All Oxy Fuel

One of the most popular oxygen applications, all oxy-fuel-fired melting eliminates the need for a combustion air or heat-recovery device. This process is one of the most efficient ways of reducing nitrogen oxides (NOx) and particulate emissions from glass furnaces.

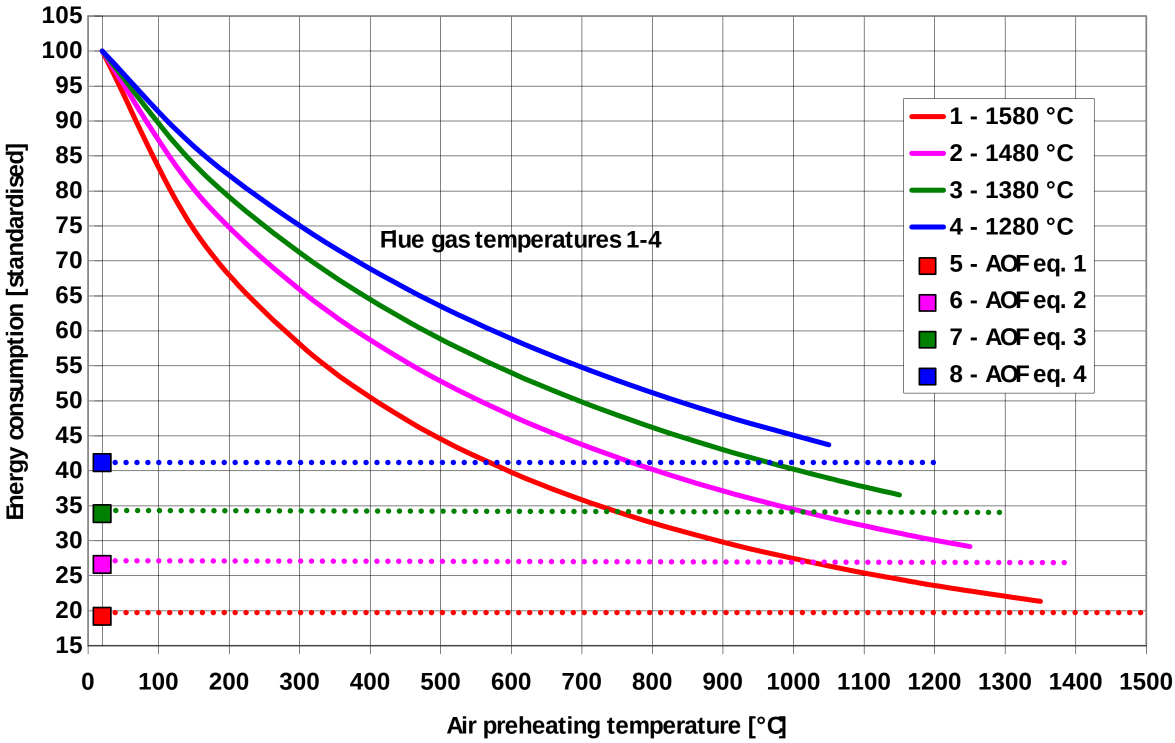

Chart 3: Energy consumption of air fuel and oxy fuel installations as a function of the flue gas and air preheating temperatures

Chart 3 shows the energy consumption of different air fuel and oxy fuel installations as a function of the flue gas and air preheating temperatures i.e. a furnace with a flue gas temperature of 1480 °C and an air preheating temperature of 1000 °C saves 65% (100-35) of the energy compared to a furnace with no air preheating. When this furnace would be converted to AOF we can count with another 9% (35-26) compared to the furnace with no air preheating or 26% compared to the case of air preheating of 1000 °C.

3 Cullet ratio

It is well known that increasing the cullet ratio reduces the amount of energy required significantly. Assuming a furnace for 300 t/d of typical container glass, per 10% of cullet, the energy consumption can be reduced by about 4-5%.

4 Cullet preheating

One way to reduce the energy consumption is to introduce cullet and/or batch preheating. Assuming the same furnace as above with a typical cullet ratio of 60%, per 100 °C, the energy consumption can be reduced by about 2,4%.

Water content in the batch

Water in the cullet is typically introduced to the batch to prevent from carry over with typical volumes of 2-3%. Per 1% of water less in the batch, the energy consumption can be reduced by about 1,5%.

5 False air

False air is not wanted, but always involved. False air has a very important influence on the energy consumption. 1% less oxygen content in the flue gas results in 6,0% of energy savings.

With Online Glass Engineering, glass factories are provided with a perfect program to execute various kinds of calculations any time, whenever needed or required to check profitability, potential of optimization or amortization of planned investments.

The variations are unlimited and allow the glass producer to determine the optimum solution tailored to his specific furnace (melting process).

6 Your advantages

The Online Glass Engineering Program is an all-in-one solution. This means huge transparency for glass producers as all modules are mutually compatible. It is also available at any time and from any place. Highly favorable conditions make it the most economic way for glass producers to reduce costs and optimize processes. An experienced support team of glass engineers is also permanently available.

"Online Glass Engineering " gives you transparent insights that translate into an immediate advantage. To give you an idea of how your business can profit from more transparency, you have the option of a free trial for three weeks. Register now for your free trial at www.glassglobal.com/engineering or ask our team for personal support.

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