



Reduce Furnace Energy Consumption Using Calumite

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Introduction

Calumite is an environmentally beneficial alumina source used in all types of soda-lime-silica glass making. Its unique melting and refining properties enable glass makers to reduce furnace energy consumption, reduce NO_x and CO₂ emissions and improve final glass quality.

In this paper examples are shown of energy savings that have been seen on introducing Calumite to the batch of different container glass furnaces, including reduction of total energy and specific reduction in the use of electric boost.

What is Calumite?

Calumite is a granular material that is 99% glassy in nature. It has traditionally been viewed as an alumina source, but it is a valuable source of all the major glassmaking oxides, as shown in table 1.

	Scunthorpe (%)	Ostrava (%)
CaO	40.0	37.2
SiO ₂	36.0	37.8
Al ₂ O ₃	13.0	9.0
MgO	8.5	12.7
Na ₂ O	0.30	0.30
K ₂ O	0.30	0.75
TiO ₂	0.60	0.95
MnO	0.50	0.75
Fe ₂ O ₃	0.23	0.22
C	0.02	0.10
S ²⁻	0.70	0.85
SO ₃	0.02	0.08
Redox	-0.0650	-0.0766

Table 1: Chemical composition of Calumite from Scunthorpe and Ostrava

Calumite is produced from granulated blast furnace slag, a co-product of the iron-making industry. Its use in the batch partially replaces sand, limestone, dolomite and alumina sources, such as feldspar or nepheline syenite, thereby reducing the quarrying of virgin raw material. Due to the amount of carbon dioxide that is released on decomposition of the carbonates, 1 tonne of Calumite used in the batch saves almost 1.4 tonne of virgin raw material from being mined.

Calumite is a weak reducing agent due to the presence of a small amount of carbon and sulphur as sulphide, S²⁻. The amount of Calumite in the batch is usually expressed as a percentage of the dry sand weight. The level of Calumite usage



depends on factors such as glass colour, glass composition and local raw materials. In flint container glass Calumite is typically 6-7% of the dry sand weight, in green container glass it is 10-13%, while in amber glass, up to 18% of the dry sand weight is used. In float glass, Calumite is typically between 4 and 8% of the dry sand weight.

Energy Reduction

The glassy nature of Calumite combined with its chemical composition reduces the total energy required for melting. The following examples show energy savings that have been achieved using Calumite. For illustration, the data is split into three periods – prior to Calumite usage, during Calumite implementation and running at optimum Calumite use. The average values during these periods are calculated and shown on the graphs. The energy savings quoted are based on these average values.

Figure 1 shows the reduction in total energy consumption on addition of 14% Calumite to an amber container furnace. In this example, the glass maker needed to reduce energy consumption due to a problem with the furnace structure during the campaign. Calumite proved to be successful, reducing the energy consumption by 4%.

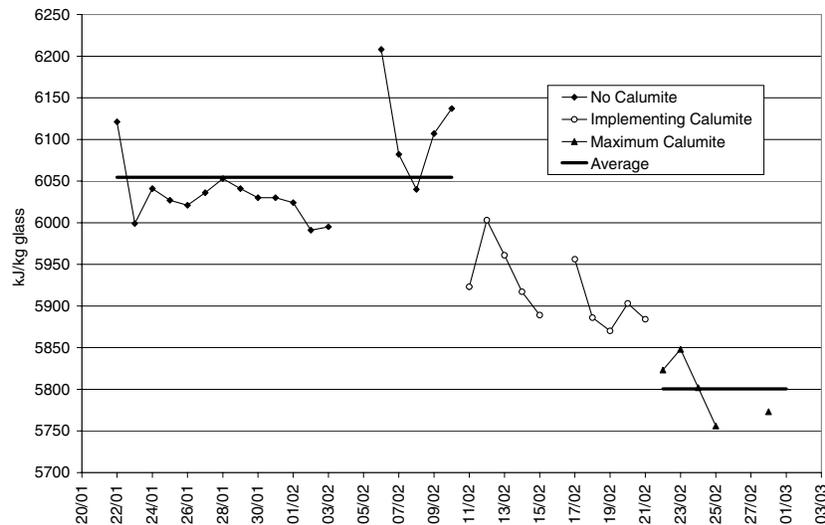


Figure 1 : Showing the 4% energy reduction on addition of Calumite to an amber container furnace

The second example is from a Calumite trial in which 13% Calumite was added to a green container furnace. In this trial, the addition of Calumite had a major impact on the melting behaviour of the batch. The batch logs became more active, with more bubbling visible within the batch. The batch line moved back, which allowed the crown temperature and consequently the fuel oil set point to be reduced.

The total energy consumption was reduced by 3% during the trial period, as illustrated in figure 2. This was made up of a modest reduction in fuel oil consumption, but a significant reduction of over 25% in the electrical consumption through the use of electric boost, illustrated in figure 3. This was possible due to the



significant increase in furnace bottom temperatures that was observed, due to the faster melting with Calumite. The benefit of a fixed period trial such as this, is that the effects are seen in reverse on removing the Calumite, with the energy consumption returning to the original level, verifying that the positive effects are due to Calumite.

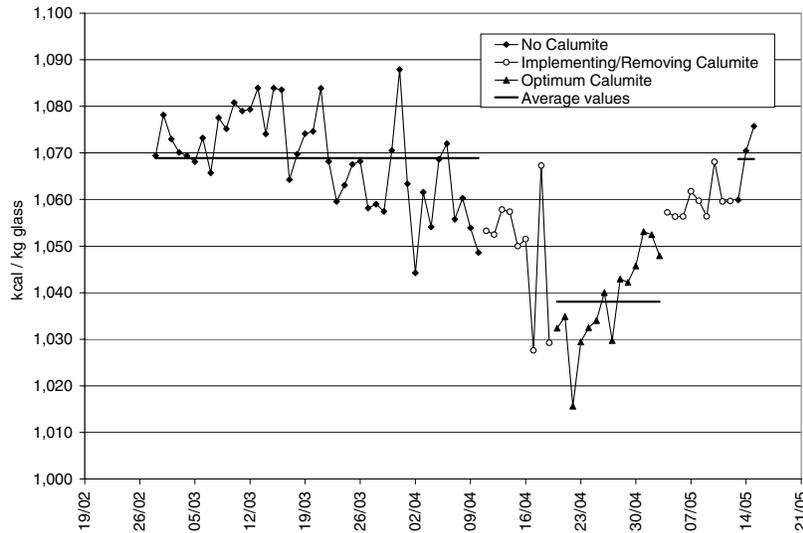


Figure 2 : Reduction in total energy consumption during a trial of 13% Calumite in a green container furnace.

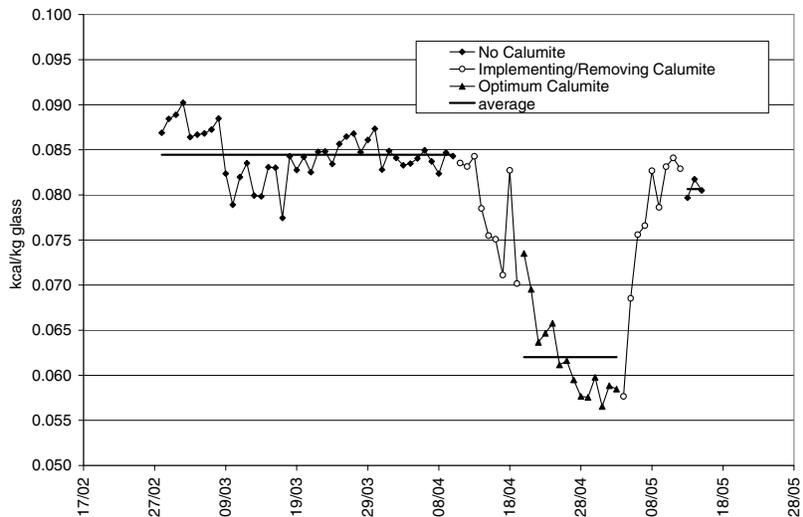


Figure 3 : Reduction in electrical energy consumption during the Calumite trial in a green container furnace.

The overall reduction in energy consumption led to a 5% reduction in the average energy cost per tonne of glass, through the use of Calumite.



Improved Glass Quality

The risk of such a reduction in energy consumption is a deterioration in the quality of the glass produced. However in this case, although already low, the seed count reduced by an average of 66% across all three of the furnace's production lines. This improvement in glass quality is shown in figure 4.

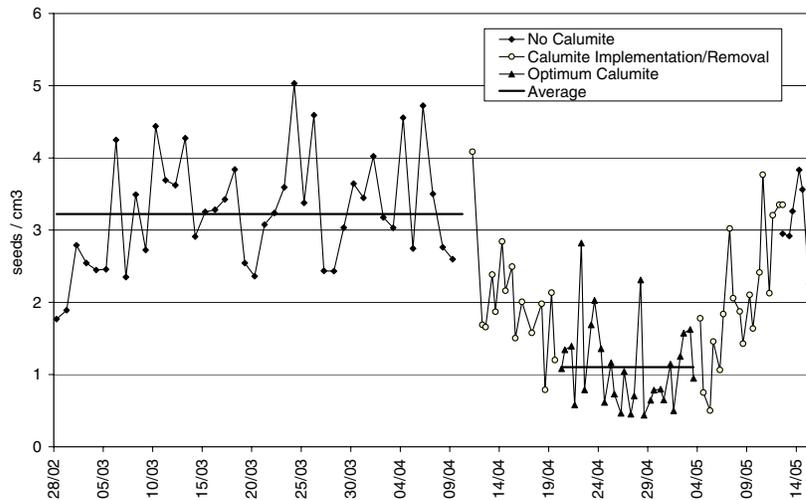


Figure 4 : Effect of Calumite on the average seed count across three production lines of a green container furnace.

A significant improvement in glass quality such as this is often one of the most dramatic benefits seen on implementing Calumite, due to the virtual elimination of seeds and blisters caused by excessive residual sulphate. Figure 5 shows the effect of Calumite addition on the seed count in a number of different flint container glass furnaces, presented as a relative reduction from the original values.

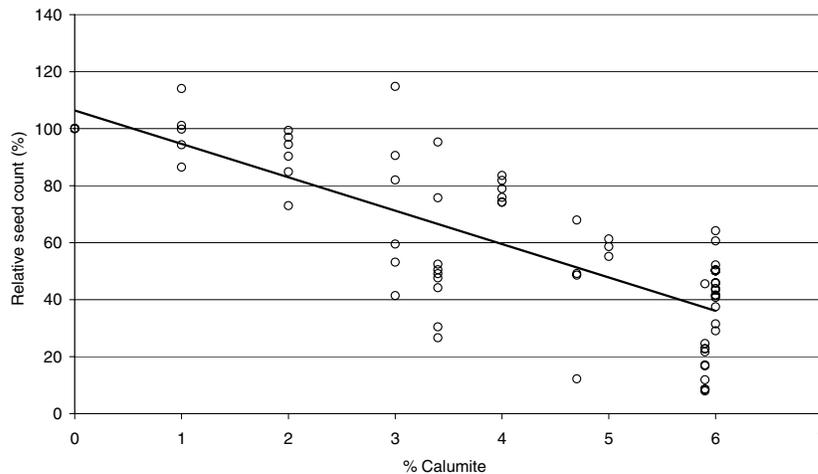


Figure 5 : The effect of Calumite level on the relative reduction in seed count for a number of different flint container furnaces.



In some cases, when the improvement in glass quality is not commercially beneficial, it is possible to reduce the energy consumption or furnace temperatures whilst monitoring glass quality, to return to the previous quality levels but at reduced energy consumption.

In addition to the striking reduction in seed count, the use of Calumite can lead to a significant reduction in the number of un-melted silica defects, as shown in figure 6, where silica defects were virtually eliminated once 4% Calumite was used in a clear float batch.

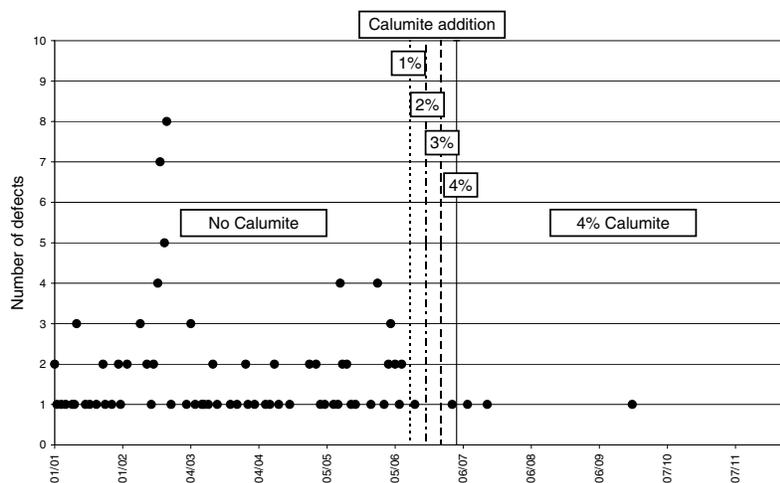


Figure 6 : Showing the virtual elimination of silica defects on introduction of Calumite to a clear float furnace.

Discussion

There are a number of ways in which Calumite is believed to influence the melting process, to achieve the energy savings illustrated. The glass melting process is in effect a series of reactions rather than a true melting process. In the glass tank a large number of these reactions occur simultaneously, depending on the small local variations in composition, temperature and atmosphere that will inevitably occur within the furnace.

As the batch is heated, liquid phases start to form at around 750-800°C.^[1] These liquid phases coat the raw material grains, increasing the contact between batch ingredients and enhancing the reactions within the melt. Due to its chemical composition and glassy nature, Calumite forms early melt phases in the batch, thereby accelerating the melting process.

The use of Calumite provides between 15 and 40% of the CaO in the new glass from batch. The remainder is typically provided by limestone and dolomite, which decompose, between 800-900°C, via an endothermic reaction releasing CO₂. Using Calumite the CaO is available to take part in the batch reactions at lower temperatures, improving the homogenisation of the batch and also reducing the endothermic effect associated with the decomposition of the carbonates.



In addition, the Calumite reduces the surface tension of the melt phases, improving the wetting of the sand grains and therefore enhancing the sand grain dissolution, as illustrated in the example of figure 6 above.

The striking reduction in seed count on use of Calumite is due to the presence of sulphide, S^{2-} , from Calumite which reacts with the sodium sulphate in the batch. Sodium sulphate is added to the batch as its thermal decomposition produces a stirring action that accelerates the dissolution of un-melted particles and allows bubbles to rise rapidly through the melt. However the low solubility of sodium sulphate in the final glass melt composition can result in foam or bubble formation from the decomposition of any excess sodium sulphate.

In the presence of sulphide, the decomposition of sodium sulphate occurs at a lower temperature of around 900°C . The beneficial effects are therefore experienced earlier in the batch melting process. In addition, the sulphate – sulphide reaction ensures nearly all the sulphur in the batch is released as SO_2 , reducing the possibility of foaming or reboil as a result of excess sulphate.^[2]

Summary

Examples have been shown where the use of Calumite in the glass batch reduced total energy consumption by 4% in an amber container furnace and 3% in a green container furnace. In addition, a number of examples were shown where use of Calumite had improved the glass quality, with respect to seed count, but also un-melted silica defects.

The use of Calumite is believed to increase the melting rate of the batch, primarily due to the formation of early melt phases in the batch. The improved refining is due to the presence of sulphide sulphur in the batch which reacts with sodium sulphate, virtually eliminating the formation of seed and blister caused by excess residual sulphate.

References

- [1] Beerkens, R.G.C., "Modular Melting Part 1. Industrial Glassmelting Process Analysis" American Ceramic Society Bulletin 83 [4] 28-32 (2004)
- [2] Simpson, W. "Calumite Slag as a Glassmaking Raw Material for the Increase of Furnace Productivity" Glass Technology 17 [1] 35-40 (1976)