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INVESTIGATION OF THE ENERGY EXPENDED IN HEATING GLASS RAW MATERIALS TO THE MELTING TEMPERATURE

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The economy of glass-making is strongly correlated with the energy expended per unit of molten glass. With modified DTA equipment it is possible to get information about the energy consumed to heat the raw materials to the melting temperature, including the energy effects in a batch reaction. The influence of different concentrations of batch materials (cullets and slags) on the energy expended was investigated.

The increasing use of waste materials in the gass batch, and the increasing changes in the quality of the raw materials, require that laboratory test methods for the evaluation (before industrial use) of the behaviour of such materials in the glass-melting process should be as simple and quick as possible.

A simple criterion for improved performance is the energy E consumed per day divided by the number of tons produced per day [1]. The energy required to heat the glass batch up to the melting temperature T_m can be written as follows:

$$E = (c * T_m * M) + (\chi * T_m) + (E^* * T_m * \chi)$$

(c is a type of heat capacity, which includes the energy effects in batch reactions, M is the batch mass, χ is the thermal conductivity and E^* is the energy content of the flue gases.) In our further discussion, we shall ignore the last two summands, the energy lost to the environment through the thermal insulation and the energy lost with the flue gases, and we shall concentrate on the first summand. The calorimetric determination of such energy is quite difficult, because the thermodynamic values give information only on the equilibrium state. However, the decomposition of marble or limestone for example, is quite different from glass-making.

The use of traditional calorimeters not only requires considerable time and financial efforts, but also involves low effectiveness for industrial problems.

The aim of our investigations was to test a modified thermal analysis instrument

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for the determination of the energy expended ("summarer Wärmebedarf") to heat a glass batch up to the melting temperature under conditions similar to those in industry.

Experimental

Figure 1 schematically outlines the modified DTA apparatus, which permits the determination of the energy expended to heat a 750 mg glass batch with original consistency from room temperature up to 1400°.

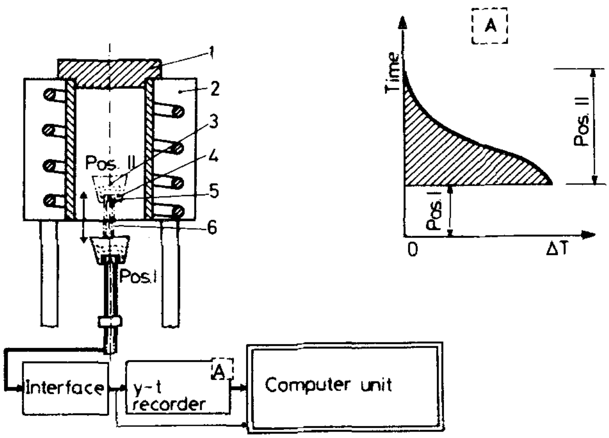

Fig. 1 Scheme of the apparatus for measurement of the energy expended
(A) Typical T *vs.* t curve
1 – Lid,
2 – Furnace,
3 – Crucible,
4 – Specimen,
5 – Thermocouple,
6 – Sample holder,
7 – Interface,
8 – Y–t recorder,
9 – Computer unit

The raw material mixture components were weighed into a corundum crucible. After the sample had been introduced into the hot furnace, the process of thermal equilibration between the sample and the furnace (i.e. the temperature *vs.* time curve of this sample) (Fig. 1, insert A) was monitored. Tests showed that the hatched area under this curve, from the introduction into the furnace up to the thermal equilibration, is roughly proportional to the expended energy. The equipment was calibrated with silica sand and corundum powder.

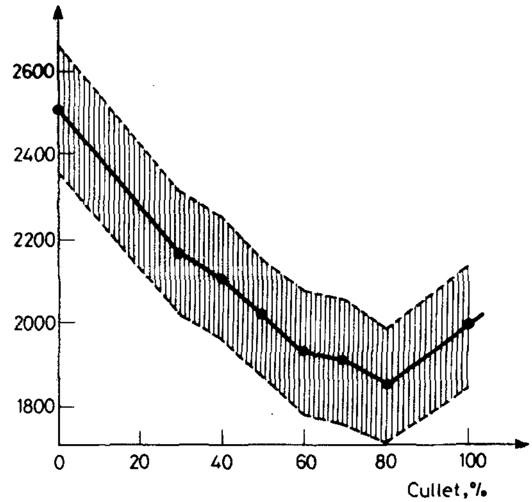

Fig. 2 Variation of the energy expended as a function of the cullet ratio (%)

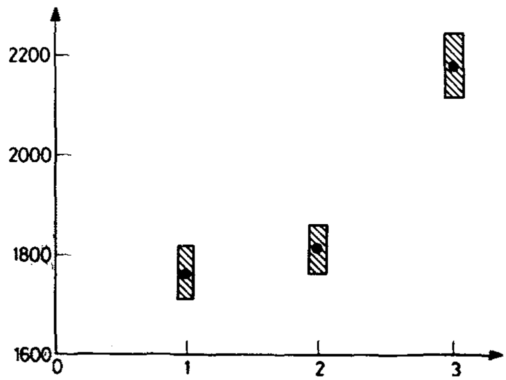

Fig. 3 Energy expended when different batch materials are used
1 – batch mixture with foamed slag (Hüttenbims)
2 – batch mixture slag from the phosphorus furnace (Phosphorofenschlacke)
3 – standard batch mixture

Results

As can be seen in Fig. 2, the energy expended decreases with increase of the cullet ratio in the glass batch. The curve passes through a minimum at a ratio of approximately 70–80%. This is in good agreement with practical experience.

Figure 3 presents results for batch mixture containing different waste materials:

slag from the phosphorus furnace (Phosphorofenschlacke) and foamed blast furnace slag (Hüttenbims). The 10–15% decrease in the energy demand corresponds with the first observations in industry.

A special advantage of the method is the possibility of characterizing the influence of the reaction rate on the energy expended.

A disadvantage at present is the level of the standard deviation, with a mean value of 10–15%.

References

1 A. R. Cooper, Some aspects of the kinetics of the glass melting process — a view toward process improvement. Wiss. Zeit. Friedrich-Schiller Univ. Jena, 23 (2) (1974) 349.

Zusammenfassung — Die zur Schmelze eines bestimmten Glasvolumens notwendige Energie bestimmt in starkem Masse die Ökonomie des technologischen Prozesses. Es wird ein Verfahren beschrieben, wie mit Hilfe eines modifizierten DTA-Geräts der summare Wärmebedarf zur Aufheizung eines Glasrohstoffgemisches bis zur Schmelze bestimmt werden kann. Am Beispiel des Einsatzes von Scherben bzw. Schlacken als Gemengebestandteil wird die Leistungsfähigkeit der Methode demonstriert.

Резюме — Экономия в стеклопроизводстве тесно связана с энергией, расходуемой на единицу расплавленного стекла. С. помощью модифицированной ДТА аппаратуры представляется возможным получить данные об энергии, расходуемой на нагрев исходных материалов до температуры плавления, включая энергетические эффекты в реакционной шихте. Исследовано влияние разных концентраций шихтовых добавок (стеклянных бой и шлаки) на расход энергии.