Dutch goals for glass recycling

Dutch Goals for Glass Recycling*

The Dutch glass industry has set itself a target to reduce CO_2 emissions by 100,000 tonnes through increased rates of glass recycling. The organisation of cullet collection and separation, in line with future demands, are discussed, in addition to the implementation of new technologies to handle such high cullet quantities.

The collection of waste glass and its recycling in the glass manufacturing process has several major advantages:

- Savings in raw materials use, for example sand, soda, lime etc.
- Energy savings; for each percent of cullet, a decrease in energy consumption for the glass melting process of about 0.25% has been measured.
- A reduction in the total weight of household waste.
- Reduced risk of injury to refuse collectors.

About 25% of glass containers in the Netherlands are non-returnable and 75% are returnable (eg beer bottles and most soft drink bottles). The non-returnable bottles are especially important in relation to household waste. In 1990, about 280,000 tonnes of waste glass were collected in Dutch banks. In the same year, though, 420,000 tonnes of non-returnable glass came on to the market in the Netherlands. The collection ratio, therefore, based on the amount of non-returnable glass, was 66%.

The development of the collection ratio over the last 10 years and in the future is shown in *fig 1*. *Fig 2* shows the collection ratio for non-returnable glass containers in 1990 for several European countries; the Netherlands and Switzerland lead the list and have the oldest tradition in waste glass recycling.

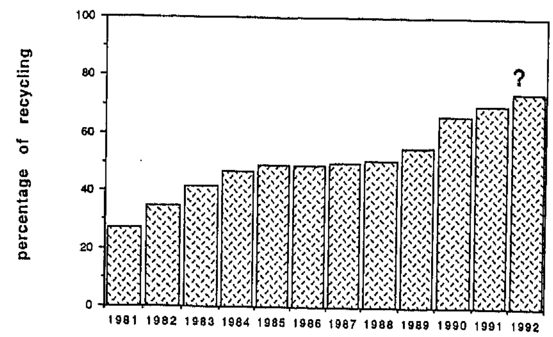

Fig 1. Collection ratio of non-returnable glass in the Netherlands.

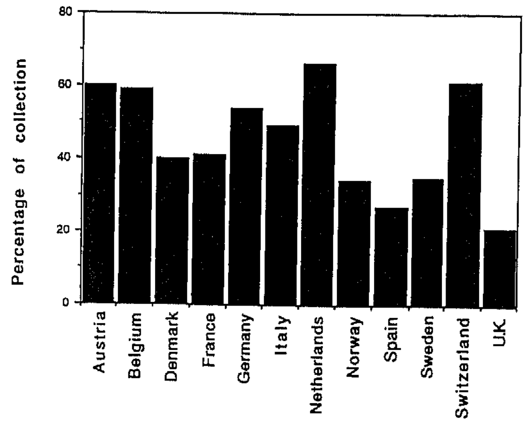

Fig 2. Collection ratio of non-returnable glass in Europe, 1990.

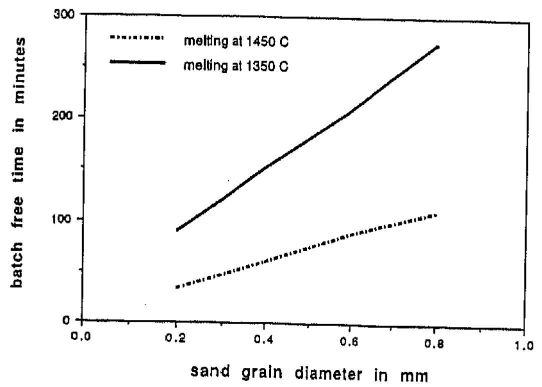

Fig 3. Dissolution of sand grains in a soda lime glass melt.

Colour separation

Several limitations are evident when using waste glass as a raw material for container production. About 40% of mixed cullet can be used for amber glass and up to 80% for green glass. For flint, however, no mixed cullet can be used. Therefore, it is important to separate the different colours in order to increase cullet usage for the production of amber, flint and green container glass.

In addition to separating the different colours, ceramic, ferrous and non-ferrous materials must be removed from the cullet to produce a high quality glass. Foaming in the furnace may occur if cullet with large quantities of organic materials is used in combination with moisture. Foam reduces the heat transfer from the flame to the melt. Organic substances can also cause problems with refining and/or the incidence of cords in the product.

As stated earlier, in the near future separation of glass by colour will be necessary if all collected cullet is to be remelted to produce high quality glass. Green glass can be produced using up to 80% mixed cullet but higher ratios may cause instabilities in the refining process and the colour of the final product. It follows that to use 100% green cullet, waste glass must be accurately separated by colour.

Remelting 100% cullet may have several advantages from a theoretical point of view. Firstly, no or low amounts of sodium sulphate are needed as a refining agent because there are no carbonates to cause the release of CO_2 gas. Normally, carbon dioxide has to be removed from the melt by a sulphate fining process. Using only green cullet, which has a much lower sulphur content (because of a lower sulphate solubility than flint or amber glass), the sulphur input in the furnace via raw materials will be moderate. In gas-fired furnaces, especially, SO_2 emissions may then be as low as 300-500mg/m^3.

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* *Based on a paper by Dr Ir R Beerkens of the TNO-Institute of Applied Physics, Eindhoven, Netherlands (and co-authors Ir Enneking, Vereenigde Glasfabrieken and Drs Faber, also of the TNO-Institute) presented at the EC-Thermie Seminar in Wiesbaden, Germany, February 4-6, 1992.*

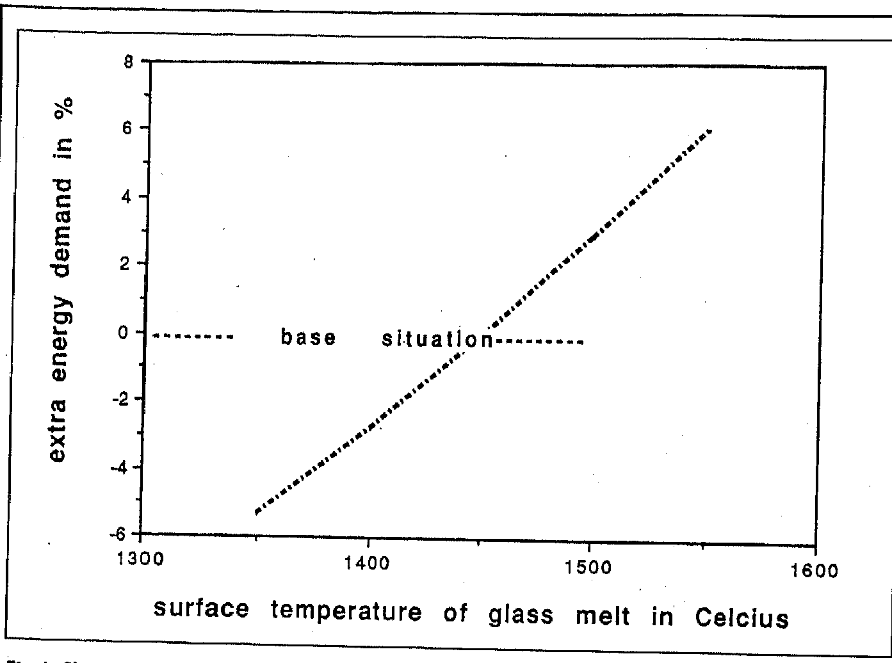

Fig 4. Change in energy requirement, depending on glass melt surface temperature.

Lower melting temperatures

Normally, when sand is introduced by raw material batch, it has to be dissolved completely to obtain a 'batch free' melt. This is only possible with melting temperatures up to 1500°C. It is feasible, however, to decrease this maximum temperature when using 100% cullet. From kinetic observations of the melting process[1], it is clear that even small amounts of coarse sand may need relatively long dissolution times in glass melts (see *fig 3*).

Lower melting and refining temperatures for remelting pure cullet can save considerable amounts of energy. *Fig 4* shows the energy savings as a function of melting temperature for an industrial furnace. Using 100% cullet batches means that no endothermic chemical reactions have to take place; as a result, energy savings of 0.25% cullet[2] are possible.

Volatilisation from the glass melt will decrease as the surface temperature drops. Lower vaporisation rates of NaCl, NaOH, NaF or heavy metal compounds are among the main objectives for the future, namely reducing atmospheric pollutants.

Results of model calculations with a relatively simple vaporisation model are shown in *fig 5*; vaporised sodium reacts in the cooling flue gases with sulphur oxides to form sodium sulphate condensates, which will be emitted as dust into the environment.

Full scale trials

A full scale experiment using 100% green cullet in a 250 tonnes/day furnace is planned for this year, to validate these theoretical advantages. A preliminary laboratory study has been carried out to establish the optimum conditions and specifications for cullet.

Using cullet which contains relatively large sized rather than small sized fractions resulted in a melt with much fewer bubbles and seeds. Sodium sulphate additions seem to be efficient for refining and oxidation only, for remelting small cullet pieces of less than 10mm.

Small quantities of ceramic (porcelain), larger than 1mm, dissolve completely only at temperatures above 1450°C and after more than four hours at that temperature. Organic substances, especially in the fine fractions, may cause amber cords in flint glass melted from white cullet, with pieces smaller than 10mm. The addition of sodium sulphate prevents this amber cord formation. Moisture and organic materials in fine cullet increase the possibility of foam formation, as can be seen in industrial glass furnaces.

Non-ferrous metals, like aluminium and lead, have to be separated almost completely to prevent reduction processes (silicon formation), lead corrosion of the tank bottom and lead vaporisation from the melt.

The full scale experiments mentioned above are to be initiated during 1992; energy consumption, gaseous and dust emissions and glass quality will be measured during a period of several weeks, using 100% cullet. Attempts will be made to lower the furnace temperature during these tests without decreasing glass quality.

Cullet preheating

Field tests with cullet preheating have been carried out on a pilot system, installed at a container glass furnace. The objective was to study the efficiency of heat transfer from waste gases to cullet, the potential reduction in emissions by direct waste gas/cullet contact and the possible reduction of organic matter in recycled cullet, by preheating with waste gases.

In the pilot system, about 4% of total waste gas from a large glass tank is led through an isolated vessel containing 0.5 tonnes of cullet. The required draught for pulling the waste gases through the cullet bed, with a flow of about 500^3m/h, is provided by an 11kW fan situated at the exit end of the vessel. Different batches of 100% cullet have been heated in this pilot system including internal cullet and collected green and white cullet. During each test, waste gas temperature and composition, both before and after the pilot preheater, were measured as a function of time.

Before and after each test, samples from the batch were taken and melted, to study the influence of the cullet preheat treatment on glass quality. A typical example of temperature evolution before, during and after pilot preheat is presented in *fig 6*. This shows that the cullet temperature increases exponentially but only after its total mass has reached the temperature for saturation of the water partial pressure in the waste gases (circa 55°C).

From the exponential heating curves of different batches, an average heat transfer co-efficient (h) in the range 5-10J/m^{2}Ks has been derived. For convective heat transfer by gases, h usually lies in the range 1-100J/M^{2}Ks[3]. The potential saving on melt energy by preheating 100% cullet to 350°C is, therefore, approximately 11%.

Reduced pollutants

Flue gas analyses, both before and after the cullet preheater when using green glass cullet, during the first 30 minutes of the heating cycle, show that the reduction in fluoride concentration is more than 40% and for chlorides about 35%. In other experiments, fluoride reductions of up to 80% and chloride reductions of up to 65% have been recorded.

The SO_2 content is reduced by about 75%. However, total SO_X (SO_2 + SO_3) concentrations, before and after the cullet preheater, are approximately equal. It appears that after the cullet has reached its final temperature of 350°C-400°C, gaseous emissions undergo absorption in the preheater and are reduced in most cases.

Total dust content of the gases behind the preheater is increased, probably as a result of glass particulates and organic dust being carried along from the cullet. However, analyses of dust samples showed that the net quantity of Na_2SO_4

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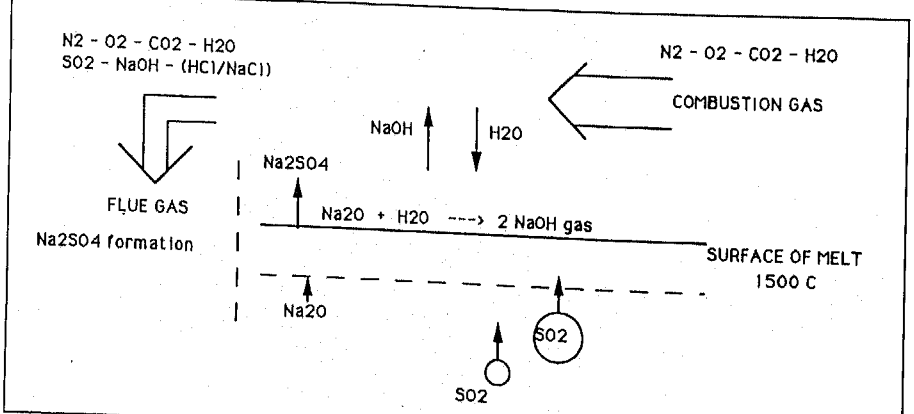
Fig 5. Volatilisation of sodium and sulphur compounds from glass melt.



after the cullet preheater is reduced by about 25%.

From the melting experiments, it is concluded that glass quality is not influenced by flue gas treatment. No enrichment or reduction of cords or seeds have been observed.

A full scale cullet preheater, feeding a glass tank with high (90%-100%) percentages of cullet should have a typical capacity of 10 tonnes/h. Applying the test results from the pilot system, a full scale cullet preheater should have the following features:

- For an optimum heat transfer, the preheater should operate in counterflow, with the contact area between waste gases and cullet as large as possible.
- In view of the absorption of gaseous components and Na_2SO_4 dust, the flue gases should come into direct contact with (cold) cullet.
- To prevent desorption of condensed waste gas components, the dwell time of cullet in the hot region of the preheater should not exceed 30 minutes.
- To prevent organic dust and glass particulates in the cullet from being carried along with the gases, gas velocities in the preheater should be kept as low as possible.

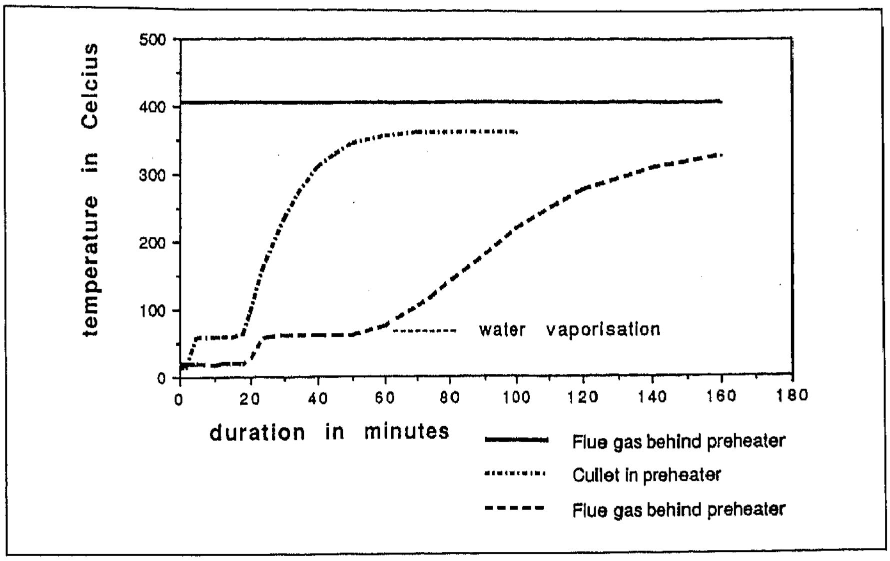


Fig 6. Flue gas and cullet temperatures during preheating in pilot system.

Year 2000 goals

Over the next few years, an intensive effort will be made by the Dutch container glass industry to reach the following goals:

- An increase in cullet recycling from 66% of non-returnable containers to more than 80%, including separation by colour.
- A decrease in specific energy consumption of at least 20% by the year 2000, compared with the situation in 1990.
- Lowering emissions of sulphur oxides, dust, chlorides, fluorides and nitrogen oxides by introducing fewer sulphur chloride, fluoride and heavy metals into the furnace and by reducing the melting temperature. Additionally, recent developments in LoNox combustion techniques are scheduled to be implemented.

The actions necessary to reach these targets involve an increased effort to separate the different colours from mixed cullet, remelting up to 100% of this cullet without the addition of other raw materials, the installation of cullet preheaters and improvements to combustion systems. The Dutch agency for Energy and Environment, NOVEM, supports these developments financially and this programme fits into the Dutch environmental policy plans for the next decade. ■

References

1. Beerkens R, 'Kinetik der Quarzsandauflosung in Gemengeteppich und in Glasschmelzen' 63. Glastechnische Tagung der DGG, Kurzreferate 1989 Stuttgart, pp 65-70.
2. Lubisch G, Trier W, 'Energiebedraf bei der Herstellung von Behalterglas in Abhangigkeit von Scherbenanteil', Glastechn Ber 52(6), pp 141-142 (1979).
3. R B Byrd, W E Stewart and E N Lightfood, 'Transport Phenomena', John Wiley & Sons (1960).