RAW MATERIALS AND ENERGY SAVING

by Alan Reynolds*

Adjustments to batch compositions may assist glass melting, promote faster refining and help to save energy in several ways. Various aspects of the raw materials scene are considered here, an important conclusion being that ecology cullet is coming into its own.

Both chemical and physical properties, ie principally their reactivity and particle size, are important in determining the energy requirements of glassmaking raw materials. Materials that are very reactive, ie powerful fluxes, melt more easily and thus require less energy, as also do finer particle-sized materials. The way in which the raw materials are treated and fed into the furnace, however, can also markedly affect their melting energy requirements. The more intimately mixed the materials are, the easier they melt.

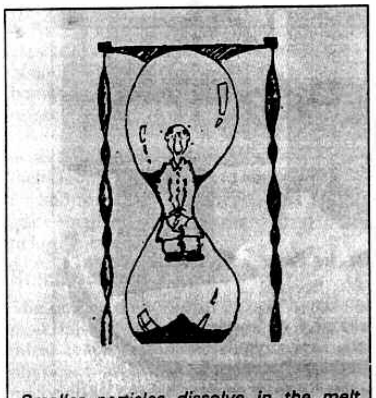
Raw materials may save energy not only by being easier to melt but also by helping to promote faster refining of the glass. They may also save energy by virtue of the fact that they undergo less chemical changes than conventional materials or that a larger fraction of the total is converted into glass.

Accepting that the glass composition used for a particular application is the optimum, the energy saving aspects of raw materials are defined by what energy gains can be made from melting that composition, or one with similar properties, from alternative raw materials.

Most, if not all, of the topics discussed below have been tried by various glassworks at some time or another. But equally, few have been universally adopted. Although many of the materials mentioned have shown measurable gains in melting efficiency, the overall cost of making the glass has often not been reduced and may even have actually increased.

The reasons for this arise from the way in which the total amount of energy required to convert a raw material from its original state into a glass is made up. Energy is expended first, in processing the material dug out of the ground, in order to produce a consistent product with various impurities removed. In some cases also, more energy may be expended in changing the physical form of the as-dug material, eg by crushing and grinding, or by converting the chemical form to one more easily handled.

Second, energy is expended in transporting the raw material from its source to the glassmaking furnace. Finally, energy is expended in incorporating the raw material into the required glass, ie by the chemical combination of the raw materials and the elimination of moisture, air and carbon dioxide, etc. Whether the energy saving in the furnace that is produced by using a particular raw material or form of raw material is worthwhile, depends on how, how much and where the energy is expended.



Smaller particles dissolve in the melt more easily than larger ones!

Fluxes

Typical additives of raw materials that are used to contribute to energy saving in soda-lime-silica glasses, by virtue of their powerful fluxing properties, are sodium borate, lithium carbonate or lithium in the form of spodumene or petalite and fluorides, generally in the form of calcium fluoride or sodium and potassium silicofluorides.

Small amounts, ie less than 1%, of these materials can make quite significant reductions in melting energy requirements but at a cost. Sodium borate, being a highly refined chemical, has had a high energy input before being added to the furnace and this costs more than the melting energy saved. The same is also true of lithium carbonate.

Petalite and spodumene are much more attractive forms of lithia, in that they have had less processing and contribute other glassmaking elements such as silica and alumina. However, in most cases, the other elements can be sourced much more cheaply and the transport costs can cancel out most if not all savings in melting energy.

Fluoride chemicals, such as sodium and potassium silicofluorides, also suffer from high processing costs as does fluorspar, although to a lesser extent. As well as this, fluorine emissions are very unwelcome and the use of fluorine-containing chemicals in glass is now restricted, principally to opal glasses melted in cold top electric furnaces.

Soda and lime

Energy savings may also arise from the chemical form of fluxes, principally if they are incorporated as oxides or hydroxides rather than in the more usual form, as carbonates. For instance, caustic soda (NaOH) may be used instead of soda ash (Na_2CO_3) for at least part of the sodium requirement of the glass.

Calcined lime (CaO) or hydrated lime ($Ca(OH)_2$) may be used instead of limestone; and magnesia or calcined dolomite may also be used instead of magnesite or dolomite. In all these cases, energy is saved by less gas going up the chimney and carrying away heat. Also more efficient use is made of the raw materials, in that a greater percentage of the feed material is incorporated in the glass.

It is known that batches incorporating burnt lime melt more easily than equivalent batches containing the lime as limestone. Purely from an energy point of view, however, the efficiency of burning lime is not quite as good as that for converting limestone into glass. The cost of the conversion from carbonate to oxide is thus more when effected outside the glass furnace than within it.

Where energy saving by using burnt lime instead of limestone may be advantageous, is when the lime(stone) has to be transported a long way to the glassworks. The saving from carrying only 56 tonnes of material (CaO) instead of 100 tonnes of material ($CaCO_2$) may overcome the extra cost of driving off the extra 44 tonnes (CO_2) in the lime burning process.

In the case of substituting caustic soda for sodium carbonate, the situation is different. Although the problems of handling burnt lime as against limestone have been ignored, these problems are probably less severe than those posed by using caustic soda instead of sodium carbonate. All glass plants are designed to handle solid, principally, fine, granular materials. Caustic soda, however, is best handled as a 50% solution in water, which imposes extra capital and the handling costs of another separate system. The energy savings obtained from using caustic soda in place of soda ash thus have to pay for these extra costs, as well as for the material itself.

There are other factors in favour of caustic soda, such as the reduction of particle emissions and their use as a binder in pelletising or briquetting. Despite these advantages and significant melting energy gains, the price differential per unit of Na_2O in favour of caustic has never been enough for a long enough time for the substitution to be widely adopted.

Refining

Examples of materials that save energy by improving refining are sulphides, in the form of, say, iron sulphide or calcium and sodium sulphides contained in iron blast furnace slag, ie Calumite. Carbon as coke or coal may also perhaps be considered under this heading when it is not added primarily to produce a colour, as in iron sulphide amber glass. All of these materials

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are used widely in both flat and container glass compositions and show significant furnace energy savings when they are employed.

Particle size

Energy saving arising from the physical form of raw materials arises principally from their particle size. Smaller particles dissolve in the melt more easily than larger ones. This is most marked with the most refractory materials, eg silica, alumina if added in the form of calcined or hydrated oxide and such materials as iron chromite which is the most widely used green colourant in container glasses.

If sand is considered, for example, the expectation would be the saving of significant amounts of melting energy by using finer sands and this has been confirmed. If a suitable deposit of fine sand is available, all well and good. The hard work of grain size reduction has already been effected by nature. If it becomes necessary to grind the sands to make them finer, usually the extra cost of the energy supplied to make the sand finer and thus easier melting can exceed the cost of the melting energy saved in the glass furnace.

If the larger particles are sieved out, there is a cost for the energy to do this. It is also necessary to consider whether the larger particles rejected can be sold and at what price. Again, very often the extra cost incurred by the sand processor is greater than the cost saving of the melting energy saved by the glassmaker. This, of course, is not always true, as markets do exist for some of the coarser sand fractions.

The gains to the glassmaker, however, by the removal of a small number of excessively large grains by the sand producer, generally exceed the extra costs incurred. That this is an effective way of reducing energy costs by reducing raw material particle size is probably reflected by the trend in UK sand specifications to tighten up more on the elimination of a small number of coarse particles. Where the sands available are not predominantly fine, energy savings produced by eliminating these small numbers of coarse particles are proving more effective than trying to reduce significantly the average particle size by grinding or by large-scale sieving.

As well as particle size effects, one would expect surface area also to affect the ease of melting of particles, with the effects again being more specially marked with the more refractory raw materials. Several studies have shown that sand with a more angular aspect and containing crevices and peaks, melts more easily than sand with more regular and rounded grain shape. This effect is quite small, however, in comparison to particle size effects.

Batch preparation

The potential energy saving effects of raw materials are not just confined to their chemical reactivity and/or particle size. The physical form in which the mixture of raw materials is charged can also have a marked effect on the ease of melting. Faster melting is obtained from better mixed batch, due to the intimacy of the reacting grains and the fact that less stirring and mixing is required from the furnace to obtain a glass of the necessary homogeneity.

Batches containing free moisture, ie moist batch maintained above about 37°C to prevent the formation of hydrates of sodium carbonate, have been shown to melt much more easily than dry batches for these reasons.

Pelletising and briquetting are also effective in promoting faster melting due to more intimate contact of the individual batch grains. The advantages to be gained from this technique have been shown many times over a number of years. Despite this, however, the extra costs of the briquetting or pelletising process have always outweighed the melting energy savings. Where pelletising has been successful, it has been because it has proved the most efficient answer to other problems, for instance environmental ones with lead-containing batches, rather than for energy saving alone.

Preheated raw materials also reduce the amount of energy required to convert them into glass in the furnace but this is perhaps not properly considered a property of the raw materials per se. Similarly, oxygen boost is more sensibly considered as part of the fuel and heating aspect, rather than as an energy saving raw material.

Melt aids

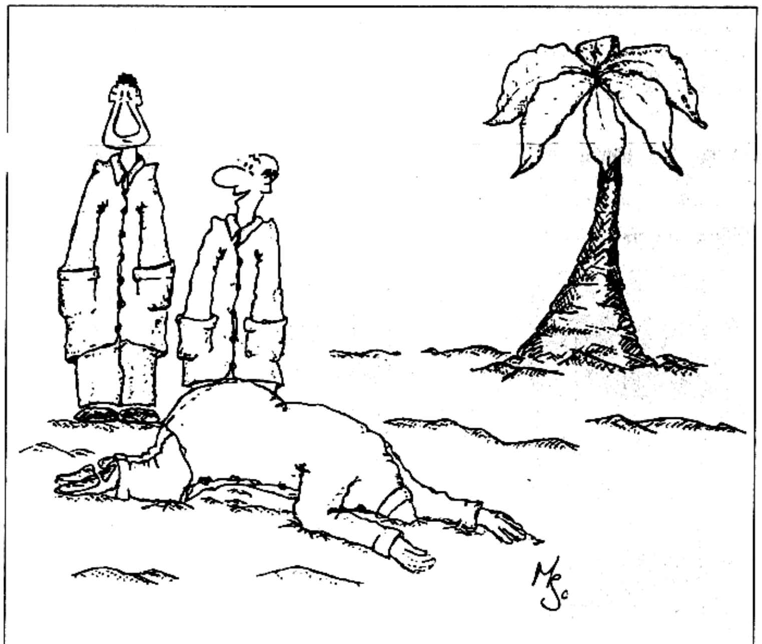
Probably the most successful areas of energy savings arising from raw materials have been in the use of materials where most of the work has already been done, eg Calumite and most especially, cullet. These materials may be described as 'melt aids'.

Despite several potential shortcomings, Calumite slag has been widely adapted in the glass industry and continues to show energy savings in many glassworks all over the world. Calumite may be considered as a melt aid as well as a refining agent, in that it is primarily a glass made from raw materials such as limestone and/or dolomite, silica and aluminosilicates. The chemical work required to convert these materials into a glassy form has already been done in the iron making process, leaving a lower energy requirement to incorporate the resulting slag into the main body of the glass being made.

Cullet is also a prime example of a melt aid, in that the chemical work has already been done in the first melting to transform the original raw materials into glass. Recycled glass or ecology cullet, while perhaps differing slightly in composition from the process cullet, is also very easily incorporated into the melt with minimal energy requirements.

Cullet, especially that now recycled from the customer (the ecology cullet) is now coming into its own. The energy savings from using a certain percentage of cullet are well known and reproducible in all furnaces. The environmental pressures are now driving the economics of cullet use in favour of the glassmaker, despite obvious problems from contamination by other materials and by colour.

The costs of processing and transporting the raw material to the glassworks are minimised by the public's involvement in bottle bank schemes. The costs of presenting ecology cullet in a suitable form at the glassworks are thus more than offset by the savings in energy in the melting process. Therefore, recycled glass is probably set to be the raw material contributing most to energy savings for some time to come. □



Now there's a novel way of measuring the moisture content!