The economic significance of batch calculation

As in many other branches of industry, raw material costs have a decisive share in the manufacturing costs of glass production. This applies especially to mass produced products such as bottles or float glass. Henning Katte* of Ilis, Germany explains the economic potentials that exist when using modern batch calculation programmes such as Ilis' BatchMaker Suite.

The objective of batch calculation in glass production is compliance with a defined chemical glass composition, which determines the properties of the final product but also has an influence on melting properties and processability. Thus batch calculation also has a substantial influence on the energy costs involved in glass manufacture.

Batch calculation

Fig 1 shows the basic batch calculation process. A pre-condition is knowledge of the chemical composition of the raw materials used and the types of cullet. The raw material analyses are either maintained directly in BatchMaker or imported from a separate laboratory information management system (LIMS). The data originates from the relevant raw materials supplier and/or are based on own analyses.

The desired chemical composition of glass (nominal analysis) as well as the statement of the main carriers for each component (for example glass sand for SiO_2, soda for Na_2O, limestone for CaO, feldspar for Al_2O_3) are the essential components of the glass recipe. The batch recipe containing the weights of the individual raw materials and the theoretical glass composition inversely calculated from these (known as the synthesis) is calculated automatically from the glass recipe and the raw material analyses. The synthesis should correspond to the desired glass composition.

In calculation it must be taken into account that, for example, SiO_2 is included not only by the assigned main carrier but also originates from carrier raw materials of other oxides such as feldspar. Furthermore, not all raw materials can be calculated automatically since certain prerequisites must be fulfilled that cannot be derived from the glass composition, for example fixed glass percentages for cullet or fixed additions of reducing, refining or colouring agents.

The calculated weights are then communicated to the batch house. The batch recipe contains the associated batch and glass properties as well as the raw material costs and the glass price (€/tonne of glass).

Fig 2 shows a typical glass recipe for container flint glass including a statement of the desired glass composition and allocation of the carrier raw materials. ***Fig 3*** shows the batch recipe calculated from these. It is notable that raw materials such as Calumite or recycled cullet bring many different components into the glass, which would make manual batch calculation very time-consuming and susceptible to error.

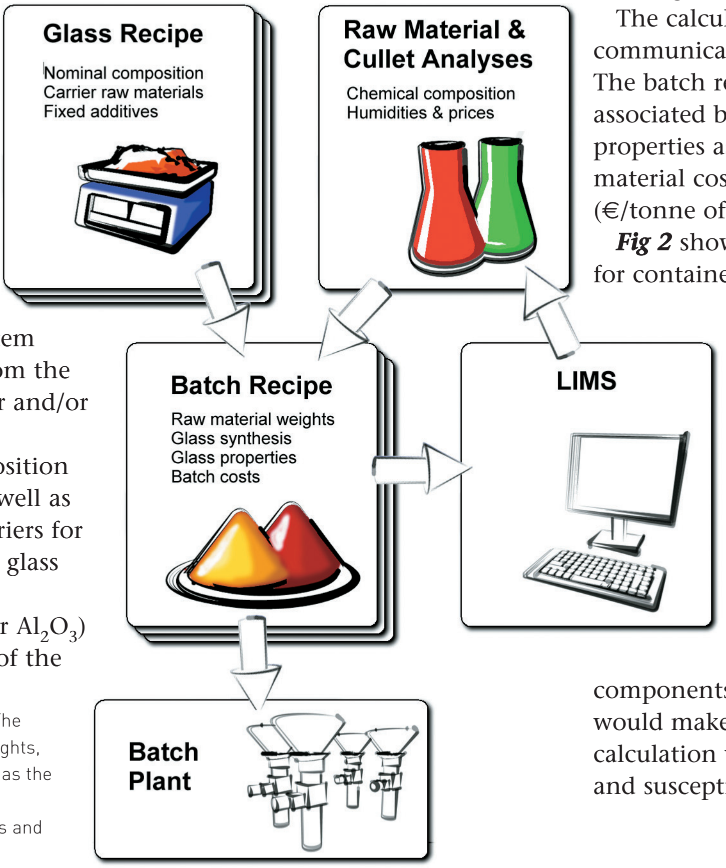

Fig 1. Typical batch calculation process. The batch recipe, containing raw material weights, the theoretical glass composition as well as the glass properties resulting from this, is calculated from the raw material analyses and the glass recipe.

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Three specific examples follow, for which saving potentials exist when using modern batch calculation programmes such as BatchMaker.

Example 1

Let the current chemical composition of a container glass be 72% SiO_2, 14% Na_2O, 10% CaO, 1.5% Al_2O_3 and 2.5% MgO (all data in mass-%). With assumed raw material costs of €30/t glass sand, €200/t soda, €15/t limestone, €20/t feldspar and €30/t dolomite, raw materials costs amount to approximately €22,000/day at an average daily production of 300 tonnes glass (see **Table 1**).

By reducing the sodium oxide share by 1% (in exchange for CaO and SiO_2), the raw material costs can be reduced to approximately €21,000/day in this scenario. The savings potential therefore is approximately €350,000/year. Since the glass is now 'shorter' and therefore reaches its strength faster, an increase in cutting rate of 2-3% can also be expected.

Table 1. Saving potential by changing the glass chemistry for a container glass tank with a daily production of 300 tonnes glass.

	Before change	After change
SiO_2	72%	72.5% (+0.5%)
Na_2O	14%	13% (-1%)
CaO	10%	10.5% (+0.5%)
Al_2O_3	1.5%	1.5%
MgO	2.5%	2.5%
Thermal expansion	9.32 10^{-6}/K	9.01 10^{-6}/K
Density	2.504 g/cm^3	2.504 g/cm^3
Rel. machine speed	110.2%	113.3% (+3%)
Batch costs (per day)	€21,938.60	€20,986.62 (€-951.98)
Batch costs (per year)	€8,007,589	€7,660,116 (€-347,473)

Example 2

To avoid unwanted green colouration, the iron percentage in flint glass should not be greater than 0.15%. For this purpose glass sand with a relatively low iron content is used, which is €5/t more expensive than the normal quality. The actual iron percentage in the produced glass lies in this example at approximately 0.1%, therefore is clearly below the limit.

By definition of a nominal value of 0.15% for Fe_2O_3 and stating the standard sand as 'carrier raw material' for iron, BatchMaker can calculate automatically how much of the low-iron sand can be replaced by the normal quality without the limit being exceeded. For a production amount of 300tpd and 40% cullet the savings potential is approximately €500/day or €180,000/year.

Example 3

When fixed weights are used even small changes in the raw material chemistry inevitably lead to smaller or larger fluctuations in glass composition. This is not desirable, especially for components that are brought into the glass by expensive synthetic raw materials such as soda. The fluctuation range can be minimised by regular recalculation of the weights on the basis of the current raw material and glass analyses. Assuming a soda price of €200/t and a daily tonnage of 300 tonnes the raw material costs of glass can be reduced by approximately €100/day or €36,500/year by reducing the size of the Na_2O fluctuation range for instance from 0.2% to 0.1%.

Prediction of properties

Great economic importance is attached to the prediction of glass properties, since the number of trial melts and thus the expense of time and costs can be reduced drastically by further developments of glasses.

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Fig 2. Glass recipe for a typical bottle flint glass in BatchMaker.

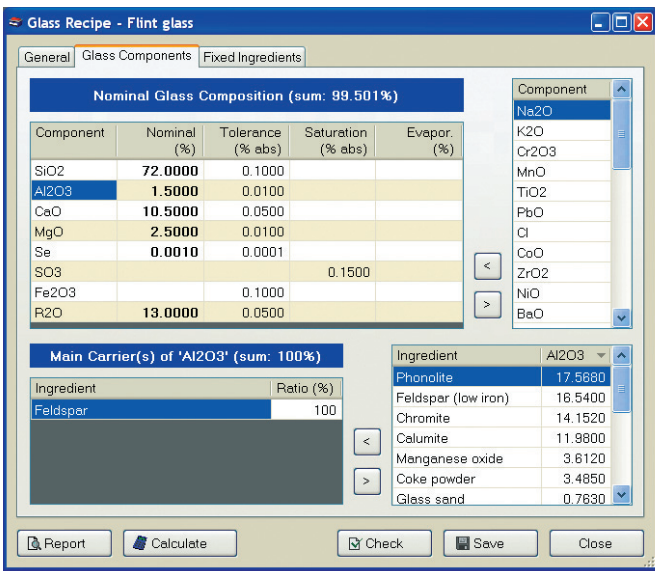
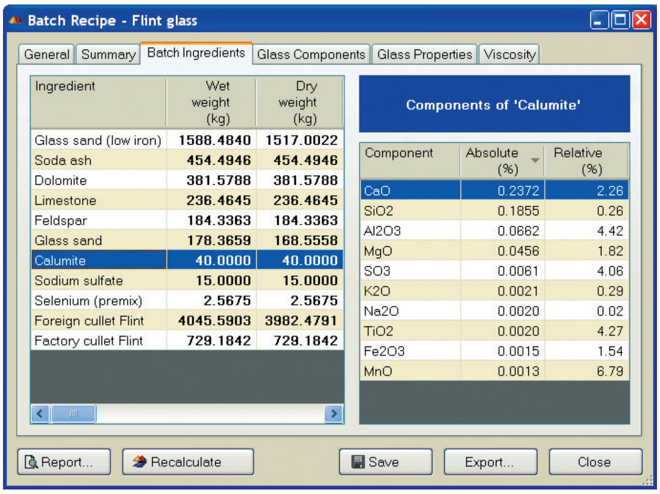


Fig 3. Batch recipe for the glass recipe from Fig 2. The right side of the window shows which components the raw material marked on the left brings into the glass and at which percentages.



In addition, many glass properties, such as viscosity, can only be determined chemically with great measuring effort. The measuring equipment required for this is not available in many glass plants. Also, authorising an external laboratory means a time delay, which in the case of a fault can cause a loss of several days' production.

However, even during normal production it is important for maximising the yield and avoiding complaints to know whether changes in glass chemistry, whether intentional or not, have an effect on the processing ability and the product properties promised to the customer. The calculation of the relevant glass properties on the basis of the current glass analysis is therefore an important building block in the sense of process stability.

For a long time there has been a large number of simple mathematical models for calculating glass properties from chemical composition. It is important in this connection that each model is valid only for certain glasses.

Unfortunately, the application limits are not clearly defined for many literature models and an error consideration is often not possible.

Therefore, modern calculation models that are based on the statistical analysis of hundreds of single analyses are used in Ilis' BatchMaker. ***Fig 4*** shows, as an example, the temperature-dependent viscosity curve as well as important viscosity fixed points for three different glasses. The confidence interval is stated in each case after the calculated temperature. The red background in the 'lead glass' column means that the associated glass composition lies outside the application limits. ■

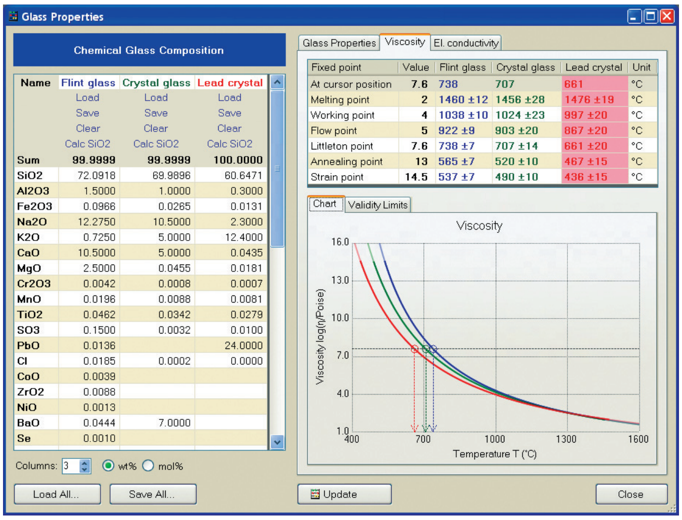


Fig 4. Calculated viscosity curve for three different glass compositions. Apart from the calculated temperature values, the confidence intervals are stated in the table.

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