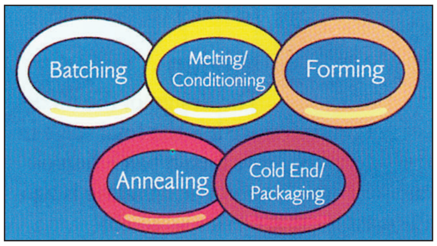
A well designed batch plant can improve profitability

High quality mixed batch is essential for producing quality glass and maximising production yields. Here D D Burgoon of Toledo Engineering Company points out that the glass making process starts at the batch plant and describes the critical features of good batch plant design.*

In Mr Burgoon's article in *Glass International*, September 1999[1], the point was made that the glass manufacturing process is only as good as the weakest element in the process, that is, batching, melting/conditioning, forming, annealing, cold end treatment, or packaging (*fig 1*). Similarly, batch plant performance is only as good as its weakest element, whether it be, materials handling, weighing, mixing or the electronic controls (*fig 2*). This article is written to highlight the essential elements of good batch plant design.



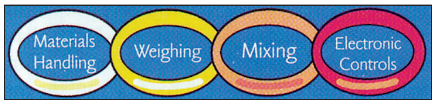
◄ **Fig 1. Basic process steps of a glass manufacturing operation.**

Materials handling

During unloading of the various raw materials, care must be taken to avoid both contamination and segregation. Contamination shows up in the glass as off-chemical composition, or as stone type defects. Segregation will show up as striation (cord or ream).

Contamination can usually be avoided with good operational practices, such as making sure the unloading hopper is clean before use, using a non-residual or non-contaminating bucket elevator boot, and using a distribution system that cannot leak between adjacent silo positions. For critical applications, dedicated unloading facilities are used for each material.

Each raw material is subject to segregation during the silo filling and withdrawal operations. Silos should be kept as full as possible to minimise segregation created by the impact of the material striking the pile during the fill operation. In some applications, diffusers are installed at the silo inlet to minimise segregation during filling. In addition, particle size for all raw materials needs to be in the same range and this is controlled during the procurement phase.

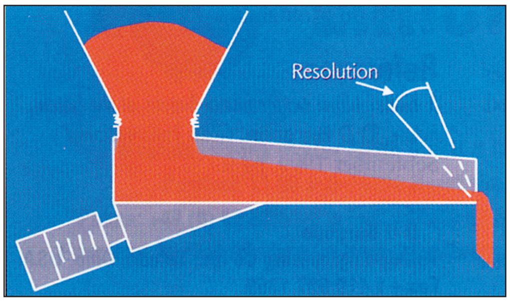


▲ **Fig 2. Basic process steps of a glass batching operation.**

The final control stage in segregation takes place at the silo bottom, where mass flow devices such as bin activators, special flow control inserts and special bin bottom shapes are used to minimise or eliminate funnel flow discharge. Ideal mass flow in a silo would be for all material in the cylindrical section to draw down at the same rate, thereby keeping the surface profile unchanged. Achieving mass flow at discharge helps to compensate for segregation created during the filling operation. Furthermore, mass flow assures a uniform source of material at the weigh feeder inlet, which is essential for accurate, repeatable ingredient weighments.

Batch weighing

Before designing the batch weighing system, the glass technologist establishes the batch composition required to obtain the desired glass characteristics. The technologist also establishes the statistical tolerance limits to which each raw material must be weighed in order to stay within the suitable range of properties. One common property used for statistical process control is glass density. Typical glass density limits for container glass are in the 0.0020 gm/cc range, whereas the limits for float glass are in the 0.0002 gm/cc range. Increasingly, direct glass analysis, such as x-ray defraction, allows direct tracking of the key oxide percentages. With the desired glass characteristics established, the design of the batch weighing system can proceed.



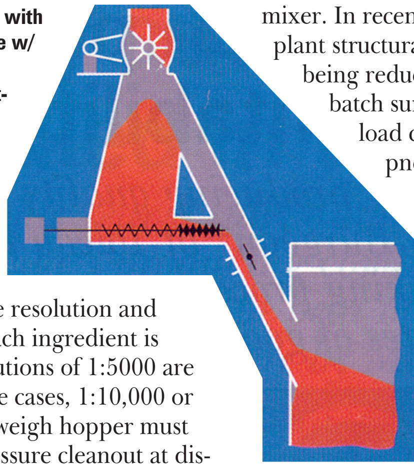
◄ **Fig 3. Vibratory feeder with cut-off resolution shown.**

Feeding devices (not conveying devices) are used to feed raw materials to the scale(s). The feeder type, for example, vibratory, screw or gate is dependent on the raw material characteristics. Free flowing/low permeability materials are usually handled by vibratory feeders (*fig 3*), whereas erratic flowing/high permeability (easily aerated) materials are handled by special screw feeders, with a flush control device (*fig 4*).

All scale feeding devices must be sized for both feed rate and necessary weighment resolution (*fig 3*). The design parameter for necessary resolution (variation in angle of repose at cut-off, plus feeder coast) are usually more than sufficient to satisfy the feeder capacity requirements.

Many years ago, TECO developed the Superfine feeder for handling fine mesh/high permeability materials (*fig 4*). A rotary vane feeder serves as an air-lock to guard against material flushing. The rotary vane feeds a small surge hopper and when full, the material overflows and provides a fast-feed rate for filling the scale. Once near the desired weight, the rotary vane feeder stops and a special screw feeder continues to feed material from the surge hopper, until the batch weight is satisfied. A safety butterfly valve closes to assure that no additional material will flow to the scale. The Superfine feeder can deliver almost any feed rate capacity desired. This feeder type has been used in conjunction with minor ingredient scales, as small in capacity as 20lb. with scale resolution of 0.02lb.

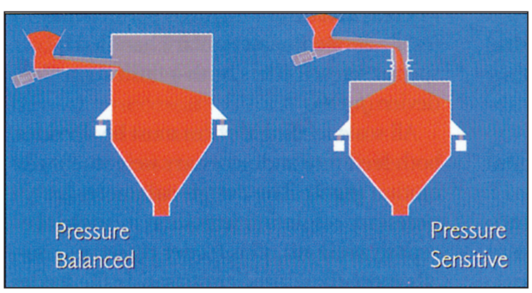
▶ Modern batch plant for the production of 'E' glass (continuous) glassfibre.



▶ Fig 4. Superfine feeder with rotary vane feeder, surge w/ overflow, special screw feeder and butterfly shut-off valve.

The glass composition and statistical limits set by the glass technologist provide the basis for determining scale resolution and accuracy, to which each ingredient is weighed. Scale resolutions of 1:5000 are common and in some cases, 1:10,000 or more are used. The weigh hopper must also be designed to assure cleanout at discharge. The weighing system must be enclosed to contain dust, thus the scale system must be designed to be immune from internal pressure effects, which can be created by the operation of a dust collector, bucket elevator, and/or mixer. Pressure effects on an improperly designed weighing system can create errors that are not immediately apparent, since the scale would be a combination gravimetric plus pressure force detector. One method of obtaining pressure immunity is to have the weigh feeders enter the hopper side (not through the top) (***fig 5***), or by using a feeder ring, which is a pressure counter-balancing scheme.

A check scale is a vital element of any batch processing plant and it is a simple task if a separate batch surge hopper is used between the weigh gallery and the mixer. In recent years, however, batch plant structural height (and cost) are being reduced, by eliminating the batch surge hopper and mounting load cells under the mixer or pneumatic blender/transporter. This requires special know-how to negate erroneous forces created by mixer motion, conduits and piping, which can affect the scale accuracy and repeatability.



▲ Fig 5. Pressure balanced vs pressure sensitive weigh hopper/feeder arrangement.

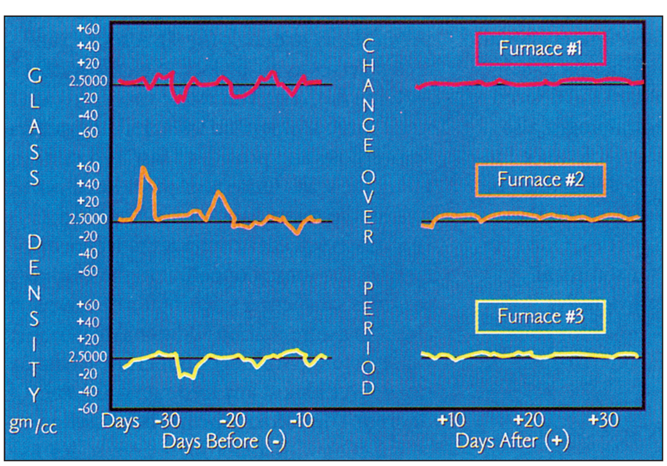
Mixing

The design of the mixing system is critical since it is the final stage in developing necessary mixed batch homogeneity. Today, pneumatic blending is typically used for fine mesh ingredient applications, like E-glassfibre batch, and the turbine-type mixer for the coarse mixes, such as soda-lime batch. Both methods fluidise the batch and introduce a turbulent force to create the mixing action. The mixing time to achieve the desired degree of mixed batch homogeneity is established at start-up.

Cullet is generally introduced into the process after the mixing operation, to reduce wear and maintenance of the mixer, and to avoid cullet/mixed batch segregation. TECO prefers to batch-weigh cullet and blend it with the mixed batch as it is conveyed to the storage bin at the furnace.

Mixed batch, regardless of how it is mixed, is subject to segregation during conveying to storage at the furnace, and subsequent delivery to the furnace charger. Proper design of the conveying system and transfer points will minimise segregation. Most soda-lime batch is wetted with water in the mixer, as a final step to provide cohesion, minimise particle segregation, and dusting.

Typically, mass flow bins are used for batch/cullet storage at the furnace. This is very important for batches that cannot be wetted and must be conveyed dry.



◀ Fig 6. Glass density history 30 days before/after new batch plant.

Electronic controls

The last process element requiring attention at the time of design is the electronic control system. Strain gauge load cells and digital scales are universally used for weight detection. PLCs, with update time in the 25 to 50 millisec range, are commonly used to obtain adequate control resolution for the weighing process. Each ingredient is weighed under the supervision of real-time statistical control, which monitors each weighment and automatically adjusts the ingredient cut-off, in line with the trend of previous batches, thereby minimising process upsets.

The furnace operator is commonly responsible for the batch plant operation. Information and data from the batch plant is transmitted electronically to the furnace control room, as well as to the plant and company-wide information systems.

Results

To test how well a new batch plant (or modernisation) is performing, one can compare glass density variation with a counterpart, that is, the obsolete batch plant or a similar facility within the organisation. TECO recently provided, on a design/build basis, a new batch plant for an existing three-furnace glass container plant. 30 days before switchover to the new batch plant, the glass density data was noted for all three furnaces. After switchover, the density was noted for an additional 30 days. The results of the 'before and after' glass density conditions are shown in ***fig 6***. Obviously, the -30 day is glass density before switchover and +30 day are the results with the new batch plant. An approximate ten-fold improvement in glass density variation was obtained with the new batch plant.

Who said well performing batch plants aren't beneficial? In the above example, the ten-fold improvement in glass density stability increased the pack rate a few percentage points, which had a positive and direct impact on profitability.

References

1 Better plant performance begins at the batch house, D D Burgoon, *Glass International* September 1999, pg 9.

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