Glass Melting in the Studio

Many studio glass-makers believe that melting good glass involves nothing more than shoveling the batch (raw materials) into the furnace, turning up the heat and going to the pub while the glass melts out!
If you don't mind lumpy glass and high fuel bills, this approach is fine. However, to achieve good quality glass while using minimal fuel, it is necessary to develop a loading and melting schedule tailored to the equipment in use.

There are two separate steps to batch melting, these are outlined below.

Loading the materials

The first step is to unload the furnace. (Loading on to a half full furnace can cause problems, see 'Cords' below) Ladle the glass into water and crush into cullet. Discard the glass from the very bottom of the furnace.

- Heat the furnace to loading temperature, and let it sit there for a few hours (known as a 'soak') to ensure the temperature has risen throughout the entire furnace. This is particularly important in tank furnaces, where the linings can easily weigh 2-3 times the glass they contain.
- Load on batch to around 50-70mm depth. For best results, mix the batch with around 30% cullet. Alternatively, load alternate shovels of batch and cullet. It is possible to load batch only, but the next step will take longer.
- **Wait until the batch is melted before loading again.** This is perhaps the most important stage of the process. Test the melt by making a small gather and allow this to run off the iron into a thread. If there are any opaque lumps, wait. (Bubbles are ok, fining is a separate process) When the batch is lump free, load on another 50-70mm, and repeat until furnace is full.

There is no need to make tests with every melt. Note the number of shovels required to fill by 50-70mm, the time required to melt this out, and repeat. Typical time between loads might be around 1 ½ hrs (longer for tank furnaces), but is dependent on the ability of the furnace to recover heat.

Fining the glass

Once all the materials are loaded, the temperature is raised to remove the bubbles from the melt.

- Raise the temperature to the fining point, and thread test to see when all the larger bubbles are gone. It is not necessary for all the fine seed to go, if the glass is correctly formulated, these will re-dissolve as the glass cools to working temperature (known as 'squeezing' the glass). Typical fining time might be around 1hr for every 40mm of glass depth (longer for tank furnaces)
- Cool to working temperature within suggested cooling rate of the furnace. (See 'Stones' below)

Developing Melting Schedules

The 'Schedules' are the specific times and temperatures applied to the process of melting. Every furnace and batch type has different requirements. Tank furnaces, for example, will generally require higher temperatures and longer schedules than free standing pots.
The ability of a furnace to recover heat has a great bearing on the time it will take to melt batch. Furnaces with high mass liners or low rated burners (e.g. atmospheric venturis) will require special attention as they will recover their heat more slowly.

Correct points can only be found by experimentation. To develop a melting schedule for your particular furnace/ batch combination, I would suggest the following process.

Determining Loading Schedule

- Minimum loading temperature would generally be 100-150 degC above the highest devit point for the glass being melted. To find a suitable loading point for your situation, maybe start at around 1220 degC. If each charge melts out readily (no 'snot' or lumps in the glass) then lower the loading point temperature in successive melts by 20 degC until you get problems, then return to the previous temperature.
- **It is critical to successful melting that sufficient time is allowed between loads for all batch materials to dissolve before loading on again.**
- The batch materials are most corrosive when first melted, keeping the loading temperature as low as possible can greatly extend the life of your furnace. However, care is required, as going too low will encourage devit.

Determining Fining Schedule

- Higher temperatures require more fuel and can lead to 'bleeding' from hot-face materials, so we should find the minimum temperature where the glass will fine out within an acceptable time. Maybe start around 1340 degC, and reduce this temperature till the seed takes an unacceptable time to disappear, then return to previous temperature.

Always remember that melting and fining operations are functions of time as well as temperature, these functions being inversely proportional; e.g. more time/less temperature, or less time/more temperature. If we take more time, we can use less fuel.
It has been my experience that a good loading schedule can save as much fuel as, say, a heat recuperator, with far less cost and complexity, whilst also minimizing furnace wear.

Good melting procedure takes time and attention. There is no way around this.

Problems and Solutions

Many issues can arise when melting glass, most of which can be dealt with in the studio. The following are some of the more common problems, how to recognize them, and how to deal with them.

Devitrification (Devit)

If you have 'Icebergs' or 'Snot' floating on your glass, you probably have Devit! It is perhaps the least understood but most common problem, and is almost always caused by careless melting. The most common cause is loading fresh batch on top of half melted material.

Glass 'devitrifies' when it comes out of its vitreous or liquefied state, to form solid crystals. As in most crystal formation, precipitation is aided by the presence of a nucleation agent, usually partially melted batch particles.
'Devit' presents itself as small, translucent coagulations within the body of the melt, which may congeal into 'icebergs' which float to the surface of the molten glass. In extreme cases, it may cover the entire surface of the glass. Devit will also grow on the walls of the tank or crucible when the furnace is held at low temperatures for a period of time, from where it drags off as the glass is used.

***All soda-lime glasses will devitrify if given an opportunity*.**

Devit occurs when the glass is held for an extended time at low temperatures. Generally, fastest growth will occur between 700-950 degC, but occurrence is a product of time as well as temperature. Given sufficient time, most soda glasses will develop devit anywhere below about 1050 degC.
While glass furnaces are generally held above 1100 degC, cool zones will develop during loading, and this is where most problems occur. As cold batch materials are loaded on, the glass under the fresh batch will cool into the devit temperature zone. Devit formation will

depend on how quickly the glass recovers temperature. *Fresh batch loaded on to half-melted material is particularly likely to cause problems.* If you are getting devit after loading, you need to load more slowly, or at a higher temperature.

Devit will also form if the furnace temperature is kept too low. Many glass-blowers will turn the furnace down to save fuel, and get devit as a result, so be careful with this.

Devit will melt out, so there is usually no need to discard the material. To do this, ladle out the glass to form cullet, crush this and mix with at least 50% batch and reload, melting a little hotter than usual. A successful re-melt can be an indication that devit is the source of the problem.

Stones
Stones are hard, opaque lumps in the melt. Often confused with devit, stones are usually bits of furnace that have dropped in from above the glass. Often the result of rapid cooling after melting, (e.g. leaving the door open) which can cause the refractories to spall or 'ping off' into the melt. They can also come from worn out linings, or from softer material behind the linings as cracks open up.
Furnace stones will not melt out. Usually they will sink slowly to the bottom of the melt. For this reason, the bottom layer of glass should be discarded when emptying out.

Cords
Cords are transparent hard lines in the surface of the blown form (sometimes known as self decorating glass!). These are usually caused by the ceramic binders in the above tank refractories melting into the glass, or by decay of the glass contact material.
Sometimes a result of getting the furnace too hot while attempting to solve other problems, but usually an indication of a poor quality or worn out furnace.
Solution: build a new furnace!

Short glass
This is glass which has a short working life and/or cracks easily while working.
Commonly caused by the glass being left in the furnace for too long, or being recycled too often. The more volatile fluxes which keep the glass workable evaporate off over time, altering the quality of the material.
Solution, start again with fresh material.

A great many problems can arise when melting glass from raw materials. It is always easy to blame the batch supplier or furnace builder for your rotten glass. In the old days, the weather often got the blame, or even the slaves for not stoking up the furnace quickly enough! Before you are tempted to get the whip out, be sure you have your own act in order. Most problems arise, and are only solved, in the studio.

Richard Morrell