BATCH MIXING SECRETS

David Gruenig
West Barnet, Vermont

My first glassmaking experiences involved melting Keystone cullet. That cullet was a mixture of clear (almost) glasses of differing expansions and some yard dirt scooped up by the backhoe-loader. The results were far from professional and I soon learned to separate chunks that looked like tableware from chunks that looked like auto headlight covers (different expansions). After separating, the glass was washed prior to loading into the furnace. Results were better, but still far from professional. Therefore, it was time to design a better formula for hand-working, and mix some batch.

The required glass chemistry, which anyone can learn, has been explained in The Independent Glassblower [Issues 4, 5, 9, 10, 13, 16, 17, 18, 20, 21, 22, 24, 25, 28, 29].

Mixing the batch ingredients was a difficult process to learn because no one knew or would tell the “secrets” of batch mixing. Many almost-successful batches made it obvious that changing the glass chemistry (finding that magic, secret formula) was not the important factor in melting a good glass. At first I thought it was, but now I know that any reasonable batch formula will make a perfectly clear glass. It is important to realize that you can change glass batch chemistry at will, and get a perfect melt with each new formula.

What is the secret to getting such good melts? It took a lot of trial and error to discover this very simple answer: All the batch particles should be the same size and they must be evenly distributed. When that is the case, careful melting technique will give perfect glass. (See Crucible Charging Technique, Issue #23). If the batch meets the above requirements, but the results are less than perfect, then there are parameters other than the batch that are responsible. Some parameters are contamination through handling, contamination by corroding furnace refractories or burner refractories, and poor thermal history.

It is mandatory to start with properly mixed batch. Properly mixed batch must have:

1. Equal Sized Particles
2. Equal Distribution of All Components

EQUAL SIZED PARTICLES
Batch ingredients come in many particle sizes. It is not feasible to literally have equal sized particles. It is feasible to prevent gross variations in particle size. There is no definition for “gross variations” but it is very easy to tell if particle agglomerates are too large. When they are too large you get bad melts. Bad melts have undissolved lumps and seeds (small bubbles that reduce brilliance and clarity). Do not confuse this with pelletized batch which is deliberately agglomerated. This explanation of particle size suggests avoiding partial agglomeration.

Particle sizes can be changed by selection of raw material and also by mixing technique. For example, soda ash is available as a heavy or light material. The only difference is particle size. Heavy soda has free flowing sand-like particles while light soda has smaller particles resulting in a light, fluffy powder. Sand is available as a very fine sand or as a flour. Lime hydrate is a fine, sticky, flour and dolomite lime has larger, free flowing particles. The variation in these particle sizes is NOT critical if you have even distribution. The mixing behavior of these different particle sizes IS critical if they should cause your final mix to have increased Particle Size Variations. The increased size variations are a result of the process of agglomeration, or sticking together of small particles to make larger particles.
The ideal situation is to have all particles the same size and perfectly mixed. Since this is not practical to achieve, we simply have to insure that the particles are in a size range that will melt perfectly and insure that they are evenly distributed. **We must avoid partial agglomeration in order to maintain the size range.**

Increased Particle Size Variations are nothing more than a result of the physical behavior of the raw ingredients in the mixer.

**SUMMARY:** It is permissible to combine fine (almost granular) powders with very fine flours IF you achieve equal distribution of components AND prevent increased particle size variations. *The distribution process is responsible for controlling these variations.*

**EQUAL DISTRIBUTION OF ALL COMPONENTS**

Equal distribution of particles is a function of:

1. Type of mixer used
2. How the mixer is loaded and operated
3. Moisture
4. Raw Material Particle Size

The type of mixer is a long story, we will have many discussions about mixing devices. Any mixer will work fine if you learn how to load it and how to control it. I achieve excellent results with a horizontal, rotating cylinder. This is not a flat cylinder because it is a steel cement mixer with the blades removed. Steel contaminates batch with iron (it colors the glass green) so I cleaned the barrel with acid and then gave it a galvanized zinc coating. Automotive stores sell a galvanizing zinc compound in spray cans. Since mixing is best with a small load, I help the mix with a shovel after adding the last of the sand (because 100 pounds of batch fills the mixer too much for good mixing on its’ own). The shovel is also zinc plated. It should be obvious that plastic, or some other non-ferrous tools and cylinders would be a better choice if available.

**MOISTURE:** Low humidity makes batch mixing easy. High humidity makes batch mixing very difficult. If the humidity is high, following the procedure outlined here will allow you to make perfect batch, if you work at it. You must be very alert to prevent agglomeration and segregation. Hygroscopic ingredients (soda ash) will have the wrong weight (they pick up water from the air). Read SODA by Kent Fiske in issue #25.

**How To Load The Mixer:**

The sequence and particle sizes are important. If you put all the ingredients for a 100 pound batch into the mixer, then turn it on, it will take a long time to mix evenly. Increased mixing time leads to creation of larger particles as the fine powders begin to stick together (agglomerate). It is possible that like will stick to like, and cause not only large particles, but also segregation (separation) instead of mixing. A partially agglomerated batch mix (and possibly segregated) will give a poor melt, with cords (stringy appearance) and lumps. It will also have an erratic time and temperature profile because you might be tempted to change these factors in order to make a bad batch dissolve. This can cause erratic expansion coefficients because of variations in the amount of soda vaporized. When your batch has this kind of behavior you can conclude that it is a partially agglomerated mix containing powders, grains, and larger particles, very poorly distributed. Avoid this with the following procedure:

**SCREEN YOUR BATCH TWICE**

Screen your raw materials prior to weighing, just before mixing. After mixing is completed, there will be some agglomerates that you may not see. Screen the mixed batch before melting. Screening breaks up small soft particles. If the final mix passes through a window screen it should melt perfectly.

Let us continue with **MIXER LOADING TECHNIQUE:**

The smallest ingredients must
be completely mixed with a small amount of free-flowing sand or soda ash before adding the lime, and the bulk of the soda and sand. First screen and weigh Sand, Soda and Lime and place each in its own container. Next, all of the smaller ingredients must be perfectly mixed (distributed) in a non-sticky matrix. A good choice is fine sand or heavy soda. Choose one of these and put 10 or more pounds into the mixer. Since these are pre-screened and pre-weighed there is no need to weigh the 10 pounds. Using your eye, add your choice to the mixer so that there is a good amount but small enough to get perfect mixing while the cylinder rotates. While the mixer is rotating, weigh and add the smaller ingredients, starting with the smallest, and working up to the next largest in order. For example, start the mixer with 10-15 pounds of sand, weigh and add a pinch of cobalt for decolorizing, weigh and add .18# of antimony, weigh and add .53# of barium, etc. Allow each addition to mix well. Usually, by the time you screen and weigh each small item, the previous items are well mixed (distributed) in the diluent (sand or soda).

This is because you have a large rotating cylinder, with the optimum (small) amount of grain-like (non-sticky) material to which you are adding smaller amounts of material. Mixing is fast and excellent at this stage. If it looks like more sand will help, add a little more. You have pre-screened, pre-weighed the sand, and you can add the best "mixing amount" by eye, until you finally put it all in.

At this point you have weighed and added everything except the three largest ingredients: lime, soda, and sand. Also, the cylinder now contains a grainy, non-sticky, perfect mix of all the smaller ingredients. It is time to add more sand to increase the size of this perfect mix. Let this mix, then add all the lime. When this is well mixed (maybe 5 minutes) add all the soda. When it is well mixed add the remainder of the sand and finish mixing. It will not take long because most things are already well distributed. If you use something the size of a cement mixer, 100 pounds is too much for good mixing.

During this final stage, I assist mixing with a shovel, and it has produced good results. The final mixing might take around 15 minutes. If you allow it to mix for a long time, it may go bad due to agglomeration and segregation.

If you think your lime hydrate is a bit sticky, it might help to add all or over half the soda before adding the lime. This might give the lime a reasonable non-sticky diluent to mix with and prevent it from rolling into little balls before it mixes. During each stage, observe the mixture and decide if more diluent (sand or soda) will help. This is visual and it will vary with types of raw ingredient available at the time. Watch carefully if it is humid.

When I was starting to learn about mixing, I made some large, solid, glass spheres and put them in the mixer to help distribute and break up lumps. At the time I thought it was helping, but I get better (excellent) results with the process outlined above and I no longer use the balls. Since the cement mixer blades are designed for wet cement, not for dry glass batch, I obtained better results without the blades (plug the bolt holes with round head bolts).

**SUMMARY:** Small amounts of material do not mix properly with large amounts of material. Small amounts of material must be mixed with the appropriate amount of diluent. When perfectly mixed, this mass can be mixed with a larger amount of diluent. The physical nature of the diluent can enhance or detract from proper mixing, and must be selected for best mixing qualities. Screen ingredients twice, once before weighing and mixing, and again after mixing.

**CHANGING BATCH COMPONENTS**

I was getting great clear glass with fine sand. My next big load of fine sand gave a faint
tinge of green due to increased iron in that load of sand. This can be decolorized, but decolorizing decreases brilliance. The best low iron sand available then was a fine flour. Also, the only soda available then was a fluffy, light soda. The dolomite had too much iron, so the best choice was a lime hydrate which gave excellent melts, but it was a light, sticky flour. All these fine flour ingredients can be mixed as described above, although they tend to mix slower and therefore have a tendency to agglomerate. To make the mixing process faster and easier I used 10 pounds of the fine sand (grainy, not powder) to start things out, and finished the balance of the sand with the low iron flour sand. The 10 pounds of fine sand did not have enough iron to color the glass, and it simplified and improved the mixing process. Later dense soda became available and that provided the option of using soda for the primary grainy non-sticky diluent.

ANALYSIS OF BAD BATCHES

It is very frustrating to go through all that work and end up with a poor melt. It is no longer my misfortune to have bad melts because of proper mixing, double screening, and proper melting. "No longer" is a relative term because bad melts can happen. If you often have bad melts, it is time to follow the batch mixing and screening procedure as described. Then proceed with the following topics. These are the Main Causes Of Bad Melts:

1. Poor Mixing and failure to Double Screen
2. Contamination
   A. Furnace Refractories
      (Replace)(Cords,Lumps,Seeds)
   B. Burner Parts getting in glass
      (Replace) (Cords, Lumps, Seeds)
   C. Bad Batch Ingredient
      **Change Your
      Lime** (Cords, Seeds)
   D. Screening Failure
      (Hole in Screen)(Cords, Lumps, Seeds)
   E. Finished Batch stored too long(Lumps, Rescreen, Discard)
3. Poor Thermal History
   A. Burner Not Hot (Cords, Seeds, Not Dissolved)
   B. Loading Crucible: Too much at a time.
   C. Too Hot-Overcooked: Lower expansion, cords, seeds

This looks like a long list, but if you mix and screen as described, almost every failure will be due to lime, which you must change. Second to that, almost every failure will be due to poor charging and melting technique. These two problems are easy to correct. It is reasonable to expect almost every melt to have No Problems with cords, seeds, lumps, green color or dullness. I have found that some dolomites make small seeds. The seeds do not occur with other dolomites, or other calcium sources. If someone can please tell me why, it would be very interesting. But you will still be better off to change your lime.

TYPES OF MIXERS

CEMENT MIXER: Help it with a shovel. No blades. Plastic? I have produced excellent batch for 20 years with the same cement mixer. It is the same mixer that also built Dads' cement house foundation in the forties. I might use it to build a new house foundation in the nineties. Meanwhile, it makes incredible batch.

OLD STUDIO GLASS TRICK:

ANOTHER OLD STUDIO GLASS TRICK: This is the familiar ball mill without the balls. Use a 50 gallon drum, horizontal, rotate it. (Rotate it on rollers like a ball mill (best) or put a horizontal shaft through it (inconvenient to work with).
YET ANOTHER OLD STUDIO GLASS TRICK: Another 50 gallon drum: Operate vertical with a shaft through the middle. This is a tumbler. The first one, ever, was called a butter churn. If you get tired of making batch, you can make butter.

ROLL OUT THE BARREL—you’ll have a barrel of fun: Roll a 50 gallon drum up the hill, then roll it down the hill. When it rolls downhill, try to miss your house.

DO THE BUCKET HOP: Half fill a bucket, snap on the lid, turn it end over end....a lot.

DO THE SCOOPY DO: Build a big wooden “mortar” box, use a hoe and/or a shovel scoop. Plastic tools?

THE FUN WAY: Spend a zillion dollars on vibrating sieves and commercial powder mixers. Do not expect to pay for this by mixing, melting and blowing batch. Be a politician or rob a bank. Then you can pay for it.

Which mixer is best? Only research will tell. This is the “space age” and people are starting to realize that most mixers do not mix very well, which explains all kinds of anomalous results. Glassblowers have known this for years, because NO MIX=NO GLASS. They may disagree about which mixer is best, because operator skill is a large factor. Mixers can separate ingredients, mix ingredients, or do both simultaneously. It is your responsibility to make the apparatus mix properly by using observation, skill, and tips and tricks of the trade.

***REMEMBER*** Breathing SILICA DUST is a good way to die fast. Be like the Pres—You can Mix it Up—but Don’t Inhale!

GRUENIG’S AUTOMATIC SIEVE:

Once upon a time people in Vermont could go to the dump. The dump was a place where you could leave lots of stuff you no longer want. On the way out you could fill up your truck with a bunch of stuff that someone else did not want. When you were tired of that stuff, you could take it all back to the dump and get a new load of stuff. In this manner I found a incomprehensible item and turned it into good use. It was an oscillating seat or stool, presumably for people with bad backs, which I have, but I did not sit on it. I built a 4 posted stand to hold a sheet of plywood suspended horizontally by springs. There is a large round hole in the plywood. Insert a large sieve into the hole. Make the round sieve with sheet metal and a 1/4" mesh galvanized metal screen. Place window screen on top of the mesh support. Clamp the oscillating mechanism to the frame and to the suspended plywood. Place a bucket under the sieve and dump a bucket of sand in the top, plug it in, and watch it go. Help it with shoulder length rubber gloves and a rubber or plastic spatula of some kind. DO NOT INHALE while doing this, just have fun. Do not screen any glass batch until you first invent and complete a ventilated/dust removal work area for weighing, sifting and mixing.

I also wear a full head-face helmet with a forced, filtered air supply. The helmet is powered by a belt worn battery pack with a blower and a super-fine HEPA filter. Air helmets blow filtered air over your face and this works. “Gas masks” and respirators are a poor choice for this kind of work. I heard that some people tie a handkerchief over their nose and mouth, and I would ask them how it works, but everyone who did that has died already and there is no one to ask. I would not mix batch without an air helmet, shoulder length rubber gloves, and other protective clothing. Air helmets are very expensive, so I cancelled my $3000 medical insurance for one year and bought a helmet instead, now I am ahead of the game. It was only major medical and it did not cover ordinary medical bills, or dental, or eye care, so it was a good trade. Get a helmet, get a life. Better yet, start an insurance company, get rich. Check your Industrial Safety Equipment suppliers
for information and prices for air helmets. The batch making work area is forcefully ventilated. The great sucking sound that you hear, is dust whooshing out of the batch area.

Wishing you all perfect batches,

David Gruenig

BATCH MIXING SECRETS

Art Allison  Pottsboro, Texas

Editors’ Note: Art Allison sent a newspaper clipping from the Dallas Morning News, March 20, 1995. It is a report by Tom Siegfried, science reporter, titled “Mysteries of mixing powders make science mighty exciting”. I do not have permission to quote the article so I will merely give my impression of the general theme of the report. If you wish, look it up yourself in the newspaper.

The article indicates that scientists do not understand solid mixing processes. Therefore mixers cannot be designed according to scientific theory. The article indicates that mixers do not work as well as intended. It goes on to describe using magnetic resonance imaging to “see” the movement of poppy seeds in a cylinder. This research is just beginning.

Some simple experiments and results were described. One mixer tested did not mix at all when half full. It mixed a little when more than half full. It mixed better when less than half full. My personal conclusion from this report is: A mixer may mix powders and it may not mix powders. How it is used (speed, rotate, shake, fullness, etc.) may affect results. We know almost nothing about mixing and researchers are just beginning to realize that.

Now, back to Art Allison:

Please see the enclosed article. I consider this information to be a milestone in mixing technique. After my blade-type mortar mixer gave up the ghost via rust (green glass—yuk!) and motor failure, and, since I discovered how much time and money and work was saved by buying Spruce Pine Batch (pre-mixed and ready to use), I have taken to mixing the occasional experimental batch in a 55 gallon drum with a lid and seal-ring.

I roll the barrel up the hill and back down, occasionally turning it end for end. This is repeated. I also (up until today) put in triangular pieces of 2x6 (wood) to “help” the mix. I mix about 100 pounds at a time, which makes the barrel about 1/4 full.

I have always felt, and thought I observed, that I was getting a better mix this way, better than a blade-type mortar mixer or a concrete mixer.

In the mortar mixer, I always wondered if I was having a layer of unmixed material around the periphery (next to the shell of the mixer).

I used concrete mixers before using the mortar mixer. I covered the opening with “Naugahyde”, a plastic over stretchy fiber. The plastic side was placed facing the batch and it was held in place with a bungee cord made into a big rubber band. The mixer was operated in its lower, or horizontal position. I left the blades in the mixer, although after reading the enclosed article, I would remove them.

A problem with operating the drum horizontally is stress on the power supply end of the drum, where the drum meets the pully shaft. I destroyed 2 drums in 2 years with this method. The bottom of the drum is “pig metal” and it fatigues rapidly. It develops cracks where the shaft and pig-metal are welded. I am sure that better quality drums are available, but I never found them. According to the new information available, the best mixing is done in a cylinder about 1/4 full. That means: no blades, no chunks of wood, no glass balls. Just roll the barrel up and down the hill.

Seriously, if I did not find it so convenient to buy ready made batch, and with the enclosed information in hand, I would probably build a slow speed drum turning roller device for
a 55 gallon drum. One might load the batch, and let it turn, turn, turn at a slow speed.
As for me, I will continue to purchase my batch ready-made, and continue to roll my experimental batches up and down the hill.
Art Allison

Topics discussed in THE INDEPENDENT GLASSBLOWER are not intended as guaranteed safe or as directions for amateurs to follow. Any discussions are intended for professionals with full knowledge of hazards of materials and proper safety precautions. We cannot assume responsibility for damage resulting from improper use of experimental methods as described herein.

BOOK REVIEW

Contemporary LAMPWORKING by Bandhu Scott Dunham is a practical guide to shaping glass in the flame and it is also a valuable technical reference text.

The glassforming exercises and techniques are particularly well suited to the contemporary studio artist because they inspire and open doors to creativity. The techniques will allow you to make anything you can imagine, they do not lock a person into swan or unicorn mode. Therefore, this is a true teaching manual. It is not a repeat of earlier how-to books.

The technical information in Contemporary LAMPWORKING is up to date, accurate, and clearly explained. Bandhu Scott Dunham brings his past experience in chemistry and science to the glass art studio, and gives this experience to the beginner and to the advanced artist in clear, easy to understand language. This is a well indexed reference book.

Everything important about glass is included. In addition to basics, there are facts, tips and tricks concerning equipment, setting up a studio, tool making, color, expansion/compatibility, annealing, eye protection, health and safety hazard, suppliers and much more.

This is a hardcover 272 page book, with over 60 excellent photographs plus more than 280 step by step illustrations. If you could have only one book, it would be wise to consider this one. If you have many books, this will be your best one. If you are teaching glass, this book should be required reading for the class because it not only teaches what people must learn, it also replaces some former misconceptions with accurate information.

For more information, contact Bandhu at Salusa Glassworks, P.O.Box 2354, Prescott, AZ, 86302. Phone/Fax: 1-800-515-7281/1-520-445-5445.

You can order this book from Bandhu for $32.95. At this date, in the US, postage is $3.00 for book rate and $5.00 for priority. Outside the U.S., $5.00 surface, and $22.00 for air mail.

Thank you, Bandhu, for giving so much to people who need to know these things.

David Gruenig