A Summary of Almost 50 Years of Glass Furnace Preheating

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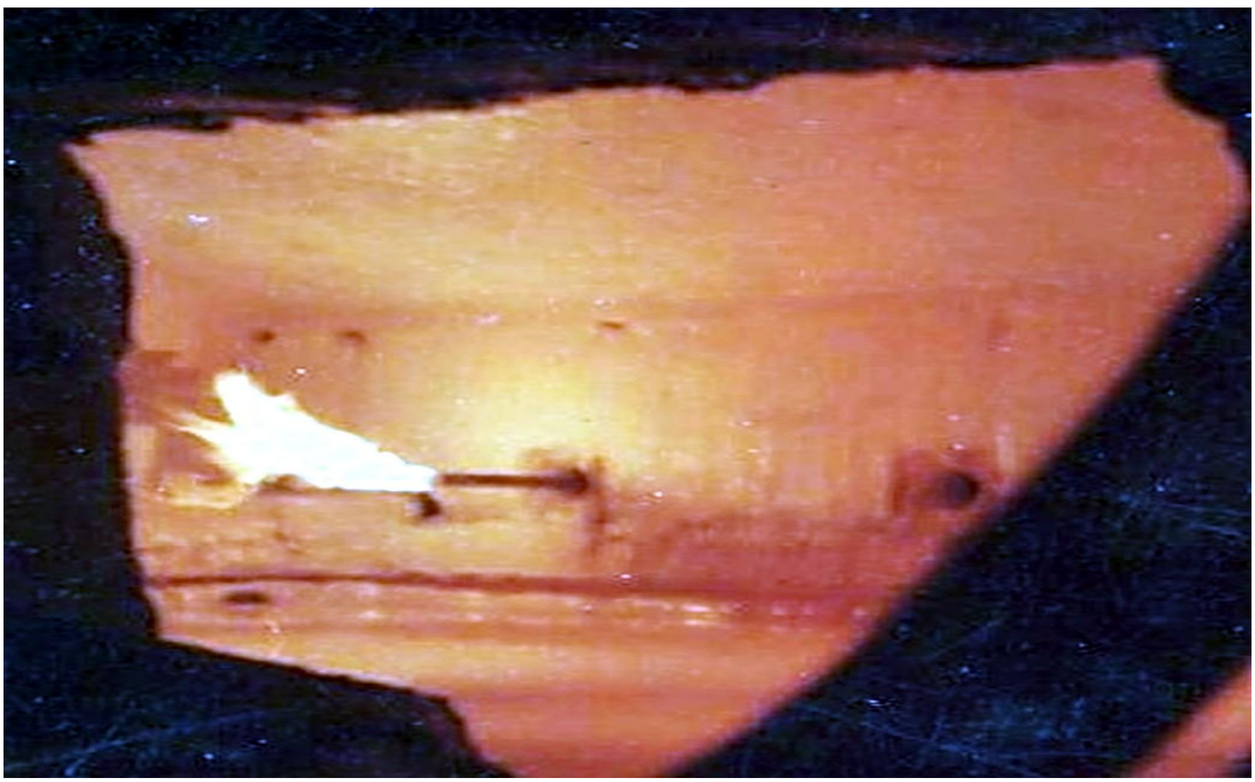
This paper will cover the almost 50 years of preheating glass melting furnaces with the Hotwork technology that was invented in 1962 by Mr. Trevor Ward of Dewsbury England, UK, and to which we refer to as pressurized hot air heating. We were awarded the license to use this technology in North and South America in October 1965. I joined the company in January 1966 and was trained by Mr.Ward and others as how to build and operate the equipment.

The technology is centered around a unique burner that Mr.Ward developed that could fire with a flame as tiny as that on a home cook top range but with tens-of-thousands of cubic feet of air pressure passing by it. This provided the opportunity to pressurize the furnace by using air as the medium. This enhances temperature uniformity while at the same time allowing safety devices like automatic ignition, flame failure detection and fuel shut off devices which are difficult to apply to torches or piles of wood and coal that were used previously.

PIPE BURNER HEATING



This is a photo of a gas pipe or stick burner as they were called that was provided by Mr. Phil Ross on one of the last glass furnace heatups that he did before the introduction of our technology. Many of these pipe burners were used on even small furnaces in an attempt to eliminate hot spots near and above the burner flame.

Mr. Ron Walton told me that on his last large plate glass furnace heatup , and I quote "We used 80 stick burners , two 1" black iron pipes stuck through the tuck space from each side of the furnace, all 4 feet apart the entire 160 foot length of melter and working end. We pulled them back 4" per day for the 30 days of heatup, except the ones in the port area which we removed when we went on port gas" end of quote.

And, even with this much effort, there was no guarantee that the refractory was not damaged on the newly rebuilt furnace!

Explosions also occurred due to the lack of ultra violet monitoring of the flames and sometimes crowns would collapse due to the severe temperature non-uniformity from side to side.

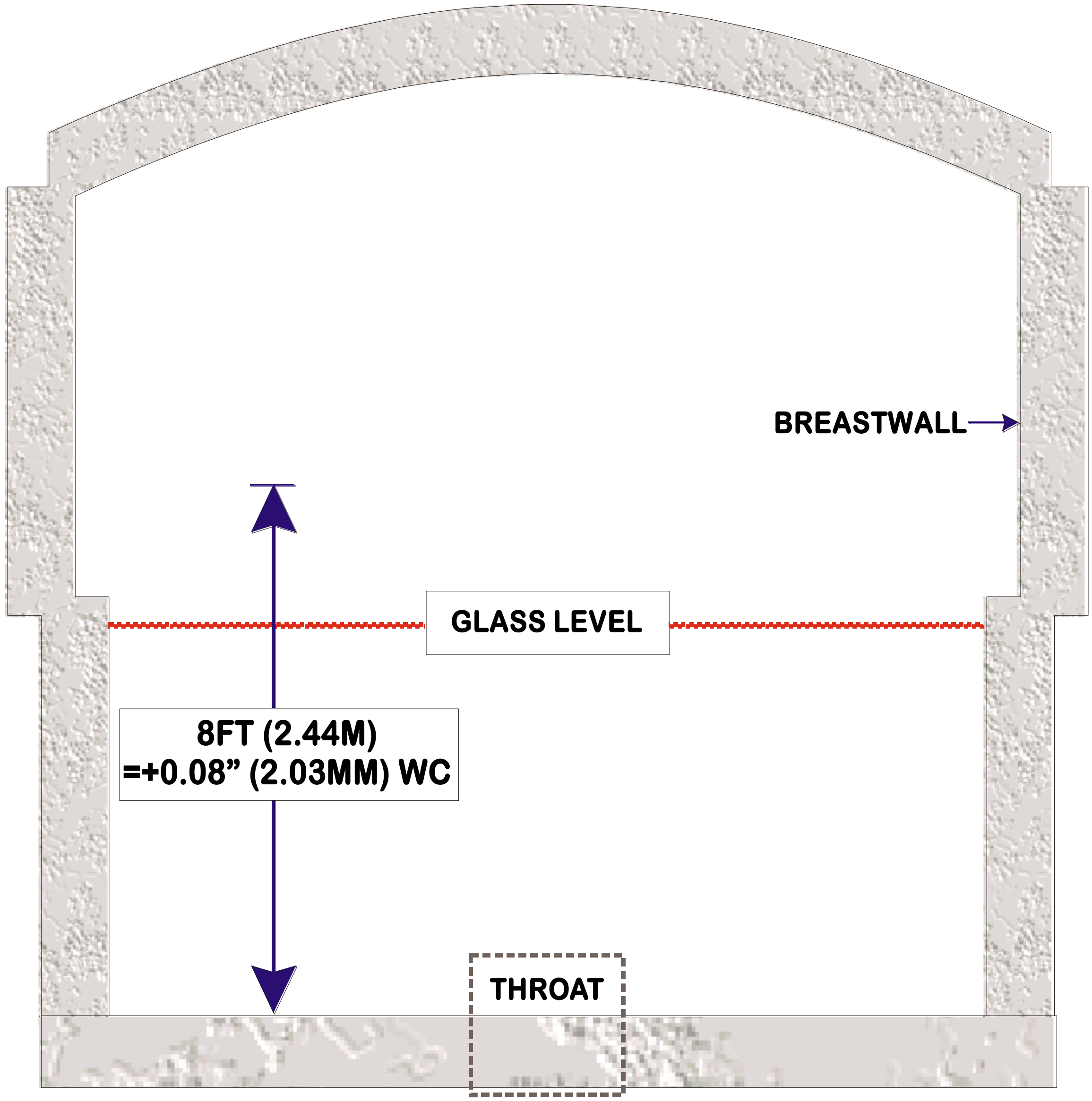
TYPICAL BURNER SETUP

This is a photo of a standard set of heatup equipment and the number of burners used is dependent on the size and complexity of the furnace. This shows the burner, combustion air fan, and fuel train with all of the safety gear inside.

Because the torches, or piles of burning wood or coal did not have a combustion air supply they relied on a negative pressure in the furnace so that cold air could be drawn in, which increased the internal temperature non-uniformity.

By using the pressurized hot air method, the furnaces were heated more uniformly and furnace downtime was significantly reduced. This method uses what some refer to as excess air high velocity burners to provide a forced convection type of heating. We don't like to use the word "excess" as it denotes "wasteful' or "too much".   These burners do use more air and therefore more oxygen than is required for the initial combustion process, but the additional air is used as the medium for the forced convection process. This provides the scrubbing action of dry, warm air across the surface of the refractories.

IMPORTANCE OF A POSITIVE INTERNAL FURNACE PRESSURE



FURNACE PRESSURE - RULE OF THUMB

Internal furnace pressure is one of the most crucial items in obtaining a thorough heatup of the refractories. The furnace pressure must be high enough to drive the heat to the bottom, through the throat and out the forehearths. The pressure must also be constant.

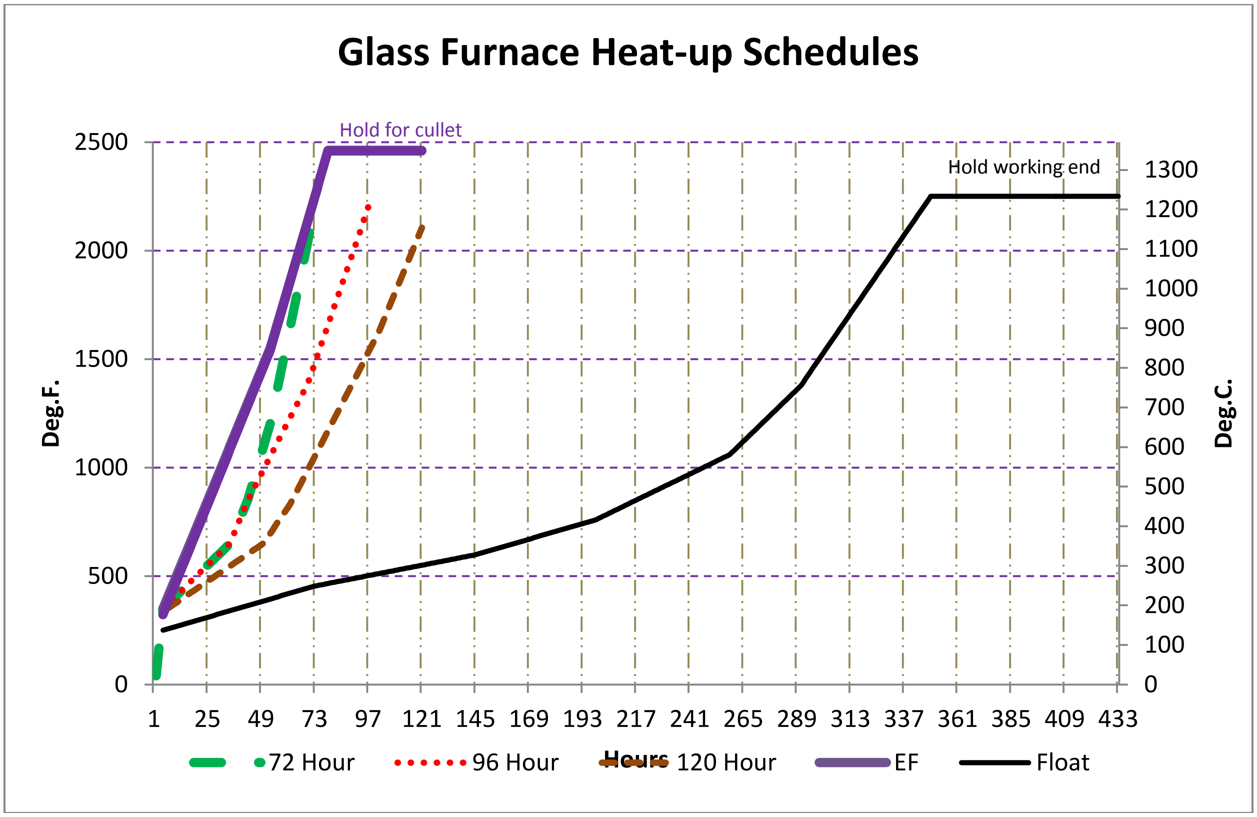
Our rule of thumb is to have +0.01 inch of water column for every foot of height from the throat to the furnace pressure tap.

If the tap is 8 feet above the throat, then the furnace pressure should be at +0.08 inch W.C or higher to ensure that the heat is driven to the bottom.

If pressures below this guideline are attained, it should be noted that most of the heat source for the furnace bottom and throat will be via radiation from the crown. In certain instances this may not be acceptable. If tamped or rammed refractories are present then steam explosions can occur when the heat source is via radiation vs. convective heat. Convection provides more uniform temperatures across the entire refractory surface and starts the drying process much earlier than radiant heat. As the furnaces have grown in size over the years, the pressure taps may have been raised which negates targets used in the past.

When we started in 1965 the owner of Hotwork was my cousin Bob Burger who had worked for a glass bottle manufacturer after graduating from ceramic engineering college. He then went to work for a large refractory manufacturer, so he knew the importance of a proper heatup of the refractory after the furnace rebuild.

Downtime was always a problem for manufacturers and with the help of furnace engineers and large glass manufacturers, Bob developed some very fast heatup curves which we still use to this day. These faster curves would never have been successful using previous heatup methods.



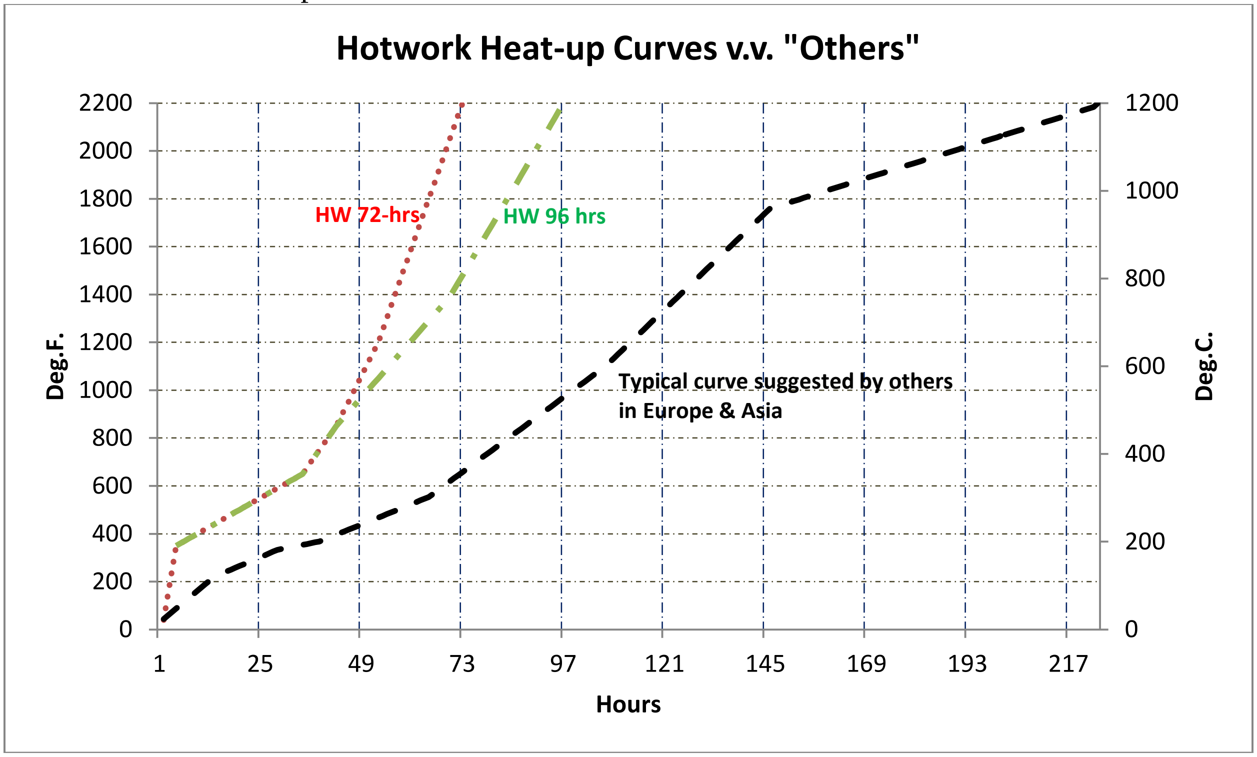
This shows the 72 and 96 hour schedules used successfully on thousands of glass furnaces. I should note that with these fast schedules it is imperative that the personnel doing the rod work and the tools, wrenches, etc. be excellent.

As the bottle, fiberglass, tableware, and TV furnaces got bigger we slowed the schedules to 120 hours. Electric melting with zero silica brick had different schedules based on AZS and later dense chrome refractories. When fused cast “M” Refractories came on the scene we followed those manufacturer’s schedules.

Float glass furnace schedules are typically longer mostly due to the physical size and since the owner wants normally just one person supervising all refractory movement and steel adjustments because there are hundreds of jack bolts, pressure plates and cross and longitudinal rods to attend to.

In 1984 Mr. Ward's company went out of business and many of the licensees started doing their own thing.

After Hotwork-USA purchased the remnant of the original English company and one of their operations in Asia/Pacific, we saw that the balance of the world was approaching heatups entirely differently. The schedules were normally much longer and the approach to heating the front ends was not acceptable to us.



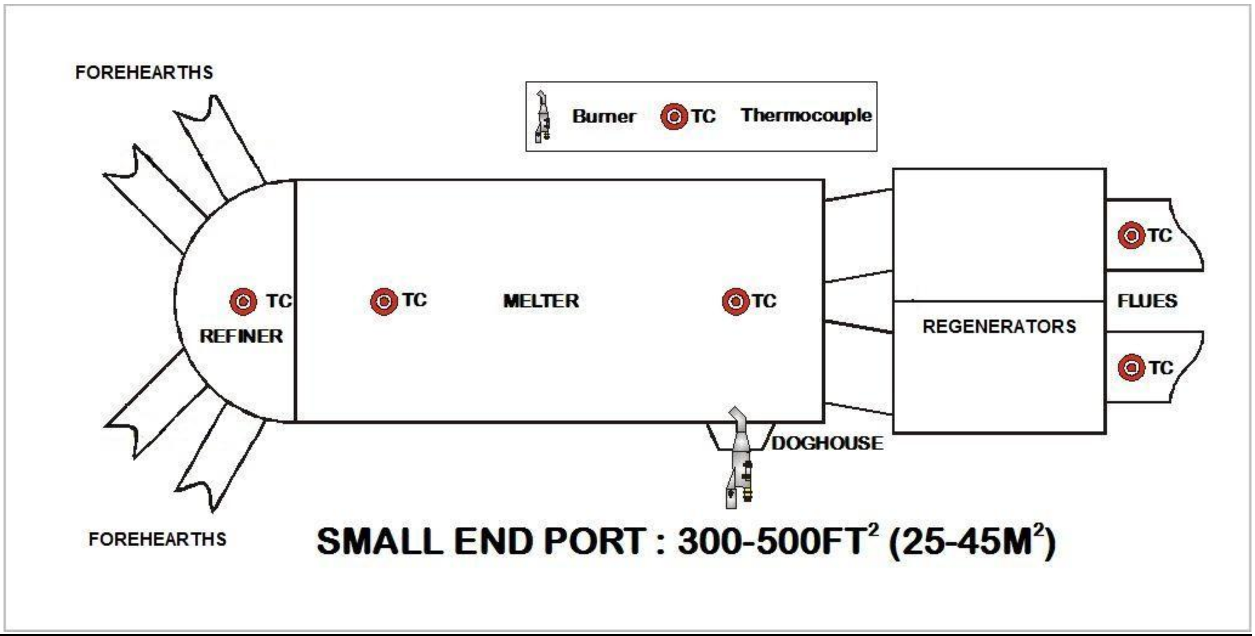
This slide compares the popular 96 hour schedule that we have used to a European schedule that is much longer. The surprising thing is that the designs of the furnaces and the refractories used are very similar and they are sometimes owned by the same global glass manufacturer.

In the early days, the type of fuel sometimes affected the heatup rate. Eventually the English Hotwork improved their oil firing burners to be more stable and capable of following an aggressive schedule. Even after that problem was addressed and even now that natural gas or LPG is available worldwide, I'm still not sure why the schedules are so long. It's not that the furnaces will run longer because of a slower heatup as most of our clients are getting 12 to 15 years of operation under normal circumstances. It's normally the type of glass made or operating problems that shuts them down sooner.

Actually I believe it's cultural in that Americans seem to be more aggressive by nature.

We sometimes find even longer schedules in Asia even though the same heatup equipment and personnel are being used. It's certainly something that needs to be addressed by the industry as even the schedules submitted by the major refractory suppliers are slow compared to what we have been doing for 46 years this month!

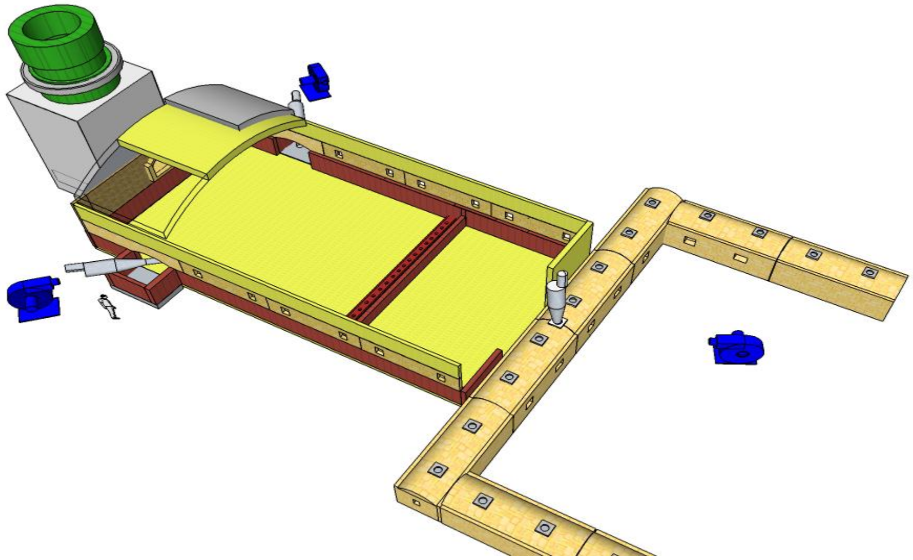
EVOLUTION OF HEATUP BURNER LOCATIONS



This slide shows what was typical in the USA in the 1960's - either a small side port or end port and normally only one opening large enough for our burner.

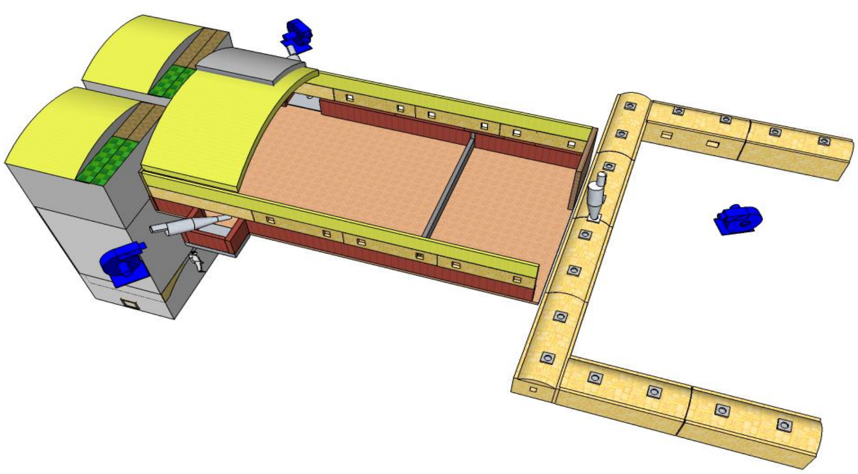
There was no client combustion air fan and the combustion air was drawn in by a natural draft stack. It was difficult to obtain internal pressures above +0.05" WC. But since the furnace was so small, the heatup was still better than the stick burner method.

Unit Melter With Recuperator



As the front ends become larger and more complicated the clients needed a heat source for those. Here you can see a “T” shaped nozzle in a distributor near the throat. These require a large opening for maximum pressure and temperature uniformity. We also started to use more burners in the melter and by the early 1970’s most furnaces had combustion air fans that we used to supplement the air we were pumping in.

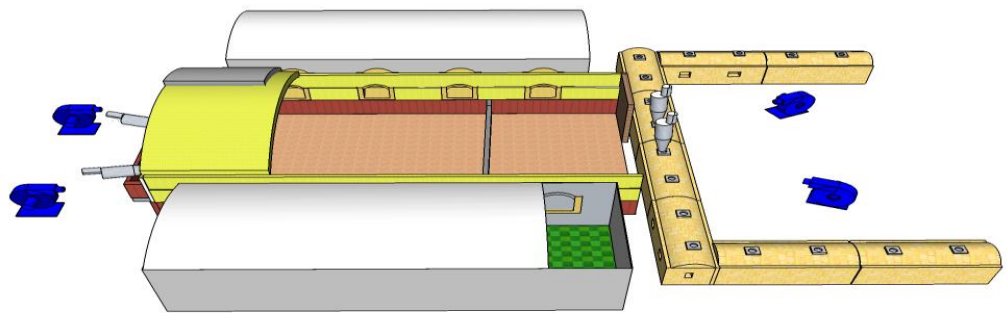
End Fired Regenerative Furnace



This shows a similar setup on an end port.

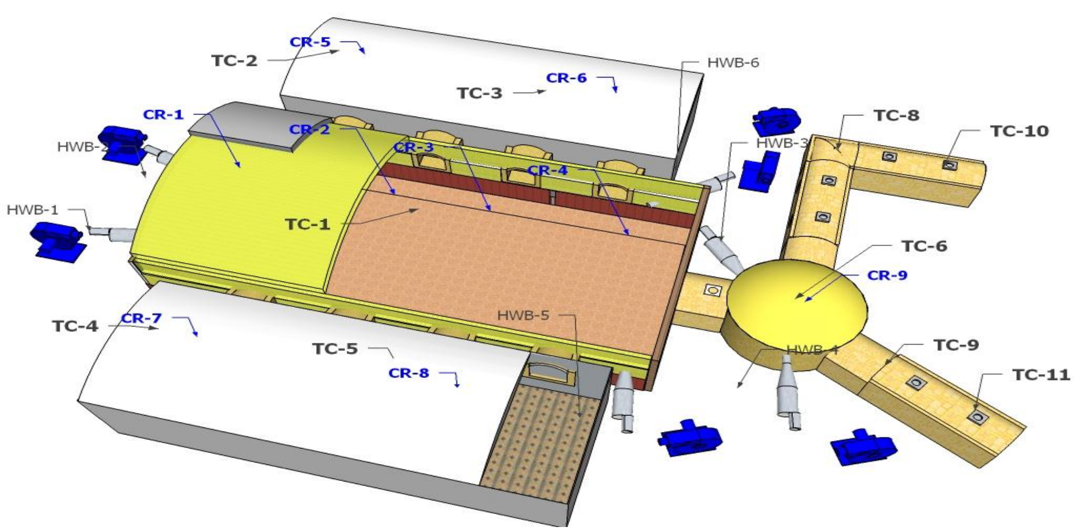
The doghouses were getting larger to accommodate the higher pull rates so we started asking for burner openings in breastwalls, endwalls, and backwalls as the burner in the doghouse created a lower temperature area and we want it to get a good heatup too.

Cross Fired Regenerative Furnace



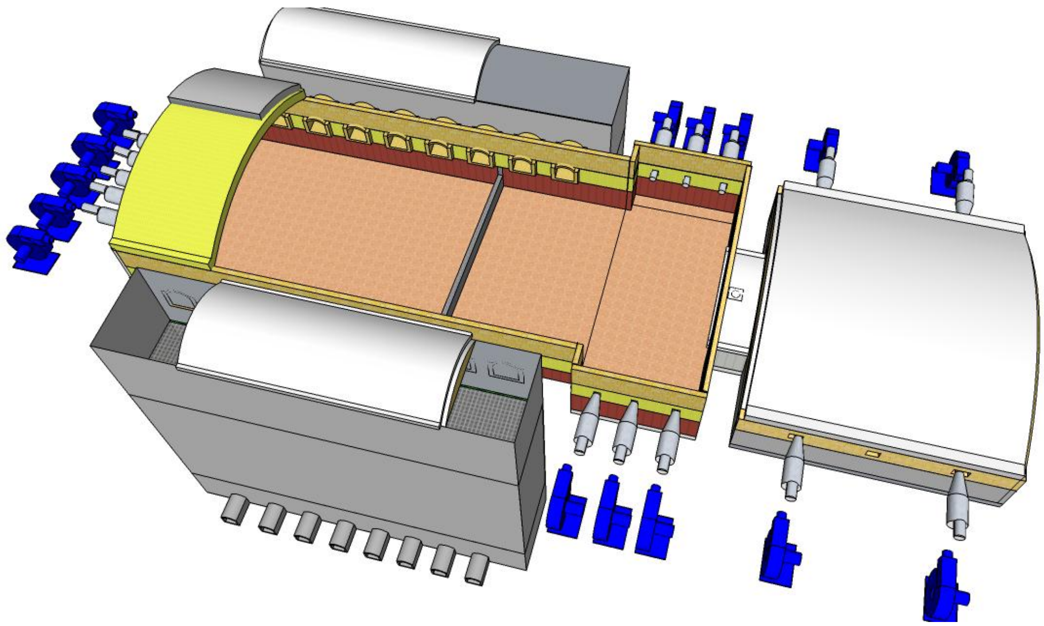
Some clients started using atmospheric baffles in distributors and forehearths so we had to use two 90° outlet nozzles firing left and right so as to not damage the baffles.

Large TV Furnace w/ Round Refiner



By the 1980’s the furnaces were getting much larger but it normally allowed more positions for more heatup burners, which enhanced the temperature uniformity. The checker packs almost doubled to make the furnaces more fuel efficient so we needed more fire power for this.

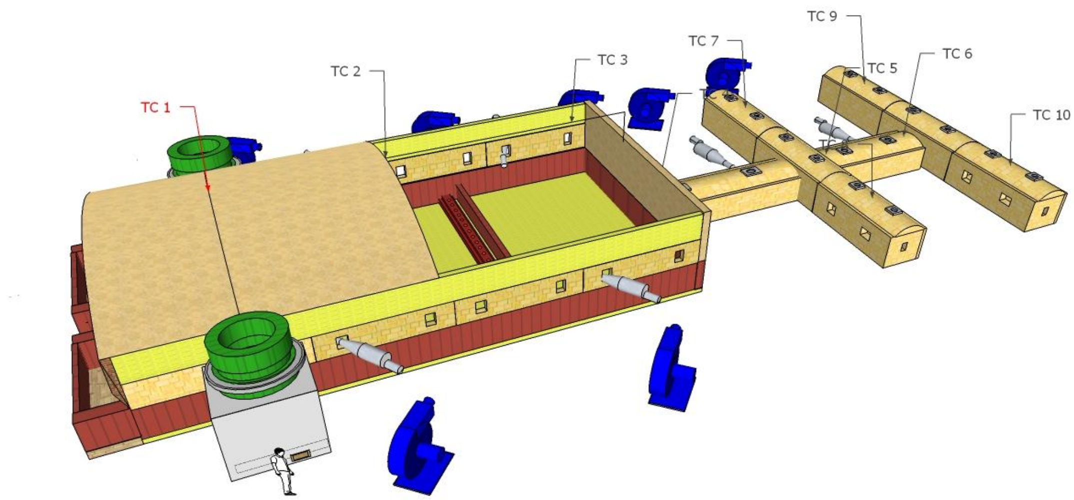
Float Furnace



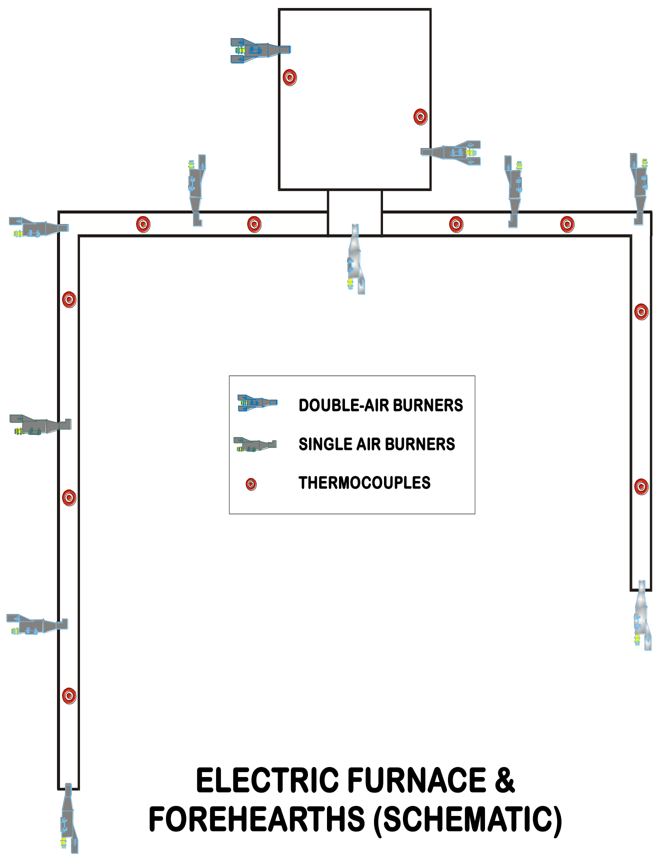
When we first started doing large plate, sheet, and float glass furnaces we used ten burners as that's what experience with smaller furnaces showed us that we needed. Many people said we must use 15 to 25 burners as less burners would shorten the campaign life, but our clients were getting 12 to 17 years furnace life which is about what we later found throughout the World.

We normally use about 15 to 18 burner sets now and it does provide a better temperature uniformity but the furnaces don't run any longer. Our clients are now approaching 20+ years, but that is normally due to hot repair maintenance that developed over the years.

Oxy/Gas Furnace w/ “H” Forehearths

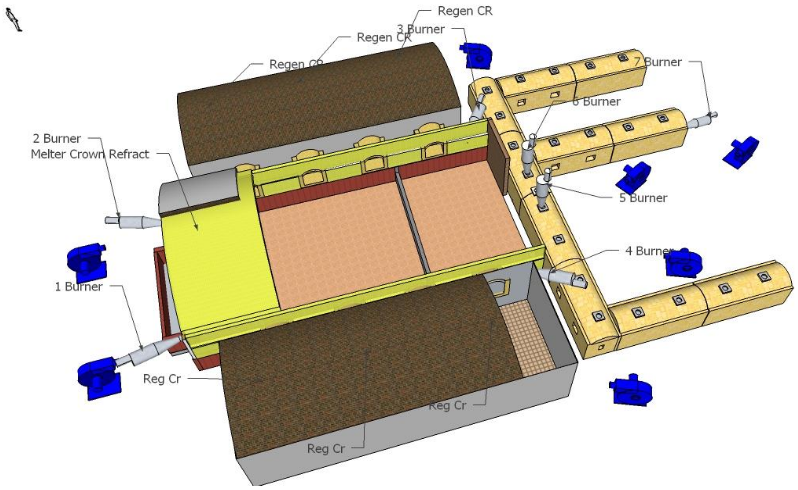


When oxy/gas furnaces came into play, this allowed an even better heatup burner positioning. We recommend a circular rotation for maximum temperature uniformity. You can see the front end burners and both are firing “downstream”.



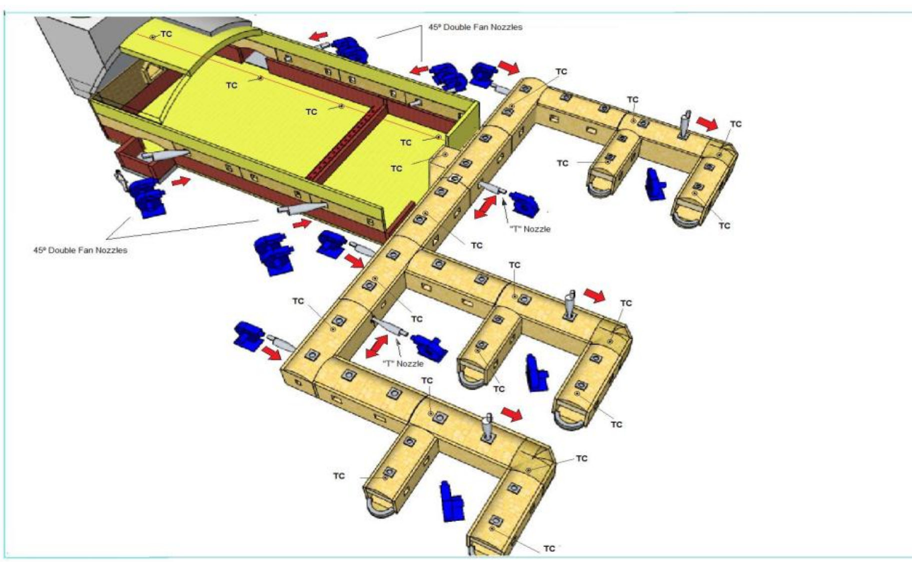
By the 1990's we started to see extremely long and narrow distributors and forehearths. We found that the best rule of thumb is to have a heatup burner every 30' and all waste gas flowing in the same direction either upstream or downstream.

Large Side Port w/ Three Forehearths



Here's a large system where adding the third forehearth required additional fire power.

Large Oxy Gas Furnace w/Complicated Front End

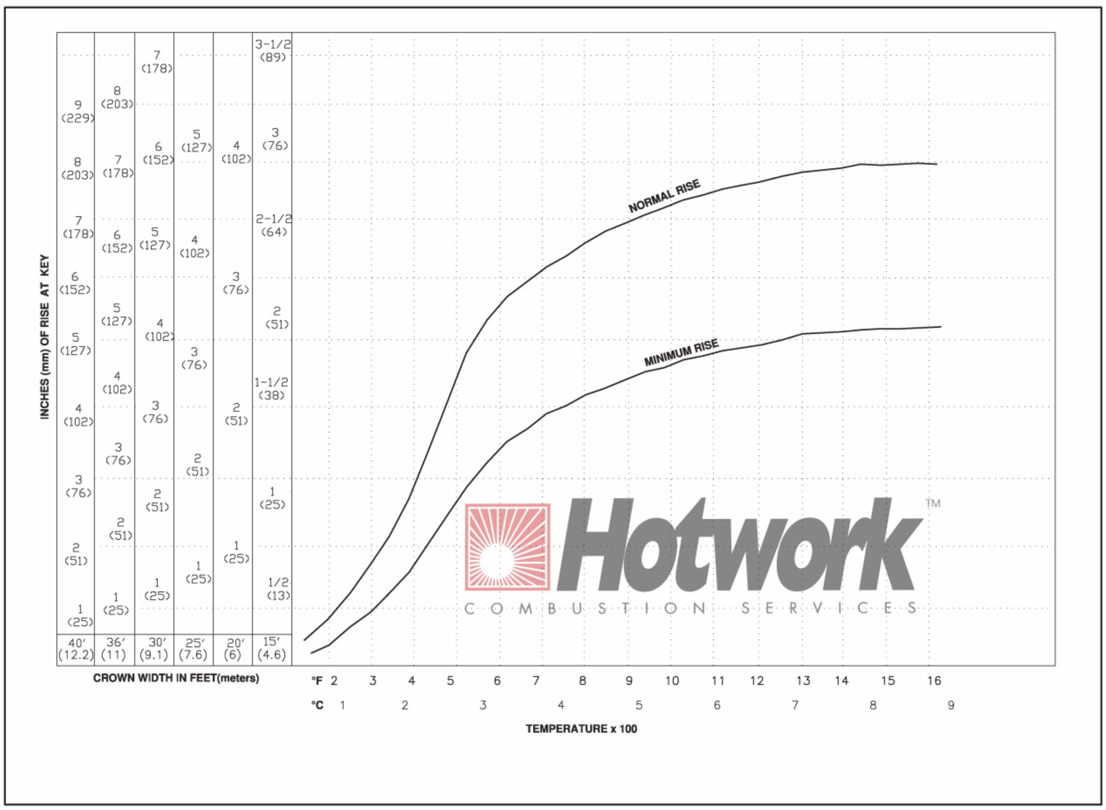


Nowadays the front ends are extremely large and it's important that in the early design stages that properly sized and strategically located openings for heatup burners are planned.

Other considerations must be taken into account as oil cannot be used on the “T” and 90 degree outlet nozzle. These deflector type nozzles can only operate to the 1800°F range without deteriorating. If temperatures above this level are required for all electric front ends or for boosting the temperature at the throat, the “T”’s and 90’s must be removed, and a straight nozzle installed.

This drawing also shows the circular motion in the melter.

<u>SILICA CROWN GROWTH</u>



This last slide is a guideline that we formulated from information gathered over the years showing expected silica crown growth. The vertical axis on the left lists inches of rise at the key line for crowns of various widths, 40 feet wide down to 15 feet wide. The horizontal axis lists the temperature up to 1600° F. The lower curve represents the minimum rise that we would like to obtain on a heatup. The normal rise is shown in the upper curve. For example, if you have a silica crown that is 30 feet wide, then you should expect about 3 inches of rise at 500°F. and about 5.5 inches of rise at the end of the heatup.

<u>CONCLUSION</u>

Since 1962 thousands of glass melting furnaces have been preheated using the pressurized hot air method. This method has allowed manufacturers to build very large and complex furnaces containing a wide variety of refractory material.

The application of preheating equipment has changed over the years, but the original technology has not and has been accepted throughout the world. It is regarded as the state of the art method for preheating glass furnaces.
We are proud of our involvement in helping to introduce this technology to the glass industry and look forward to serving the industry for another fifty years.