How Do I Choose the Right Aluminum Furnace?

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This paper intends to present the pros and cons of various types of furnaces to help you decide which best suits your needs. It will include the latest technology for stack melters, gas and electric reverbs and immersion element furnaces that hold metal next to the die casting machine. Discussions on ROI and actual energy savings, metal melt loss and maintenance will be covered.

"How do I choose the right furnace?" is asked many times through out the year and answers vary depending upon which salesperson you are talking to. So let's cut through all the salesmanship and get to some facts.

The first question any salesperson should ask is, "What are your goals for this project?" Is it highest quality metal, low up-front costs, energy cost, metal melt loss, safety? Prioritize these items and then look at what best fits your goals. Also, items furnace manufactures need to know are... what alloy are you using, what temperature do you want to cast your parts and are you modifying the alloy in any way? Do you want to melt chips or recover inserts from your parts? Once we have this information and your plant layout, we can better recommend what type of furnace best fits your plant and goals.

So, let's start with the highest quality metal. No doubt and proven time and time again the electric radiant reverb is the furnace that produces the highest quality metal without any ancillary equipment. With the addition of one extra item, a bonded particle filter, you will have inclusion free metal also.

Electric Reverberatory Melting Furnaces

As far as efficiency lets look at the overall numbers.

Electric Radiant Roof Electric Reverb .23-.25KW/# 750 BTU/LB
Equivalent to 66.7%

With Molten Metal Circulation .21-.23KW/# 687 BTU/LB
Equivalent to 72.8%

Highly efficient electric radiant roof furnaces provide the highest quality metal on the market today - no gassing of the metal with products of combustion. Since Schaefer designed and built the first electric reverb in 1974 the electric radiant roof reverb has become many die casters and foundries first choice for low cost production of clean high-quality aluminum. Approximately 85% of the electric reverbs in the country have the Schaefer nameplate.

The electric power of the radiant roof furnace is controlled by a reliable solid-state power control unit. The temperature controller is a 1.4% accuracy single loop microprocessor with full proportioning features. This allows for very close temperature control avoiding the widely fluctuating "on-off" system. The control panel is completely automatic and comes with a set of high-low alarm functions to assure you of proper casting temperatures. If the furnace should overheat to a preset alarm level the panel will shut down. We also feature a very important "alarm-type" control thermocouple in these furnaces that will sound an alarm in the event of a thermocouple protection tube leak.

1. The melting furnaces are offered in a wide range of holding capacities from 4,000 pounds to 30,000 pounds. These metal capacities allow for maximum draw-down prior to recharging. The melt capacities range from 400#/hr. through 2500#/hr.
2. The furnace is capable of melting back down if a metal freezes up condition occurs due to extended power failure. The timeframe of the re-melt is dependent on metal temperature and holding capacity. Keep in mind it is not a good furnace practice to allow the metal to freeze inside the furnace unless you drain it down past the submerged arches.
3. The furnace dip and charge wells are designed to meet each customer's particular needs. The most common dip well sizes range from 12" x 12" up to a 30" x 30" well. Exposed well surface losses will run at 6500-7400 btu's per square foot per hour depending on your metal temperature, so careful consideration should always be made sizing dip wells. Most customers prefer an "in-line" configuration with the charge well on one end and the hot metal dip-out well on the other end.

Silicon carbide resistance elements transfer radiant heat to the workload to melt with only .23-.25 kwh/#. Metal melt loss is less than 1% when charged evenly. If we take that fact alone, you can get a relatively short payback on this melter. From a furnace efficiency standpoint, they are about 67% efficient. Gas fired furnaces are at best 37% efficient unless you put heat exchangers or regenerative burners on them.

600#/hr. x 20 hours melting per day x 340 days/year melting = 4,080,000# of aluminum melted per year in this furnace. In a typical competitors gas fired furnace you will lose about 4% in metal melt loss. However, for the purposes of this research we will use 3%. 3% of 4,080,000# is 122,400# of metal melt loss. You can achieve less than 1%, but we will use 1% (for comparison) you will lose 40,800#

to metal melt loss. By using the electric reverb, you will save over 81,600# @ $ 1.10/# = $89,760.00 saved per year.

Depending upon your costs for electricity vs natural gas your energy costs will be $66,924.00 (using .065 cents per kw) to operate electric and $18,630.00 to melt with gas (using $3.00/ 1000 cubic feet), so you spend an additional $48,294.00 annually to melt with electricity*.

So, add up the savings minus the extra costs and the difference is still lends itself to electric melting.

Savings in metal melt loss	$89,760.00
Minus difference cost to melt with electricity	$48,294.00
Total saved in one year	**$41,466.00/year in metal purchased**

To hold metal only with while in production you should use 30-38 (avg. 35) btu's/#/hr. for a gas fired melter* and 005968 KW/pound/hr. in the electric** @ 1250˚F. Your 600 #/hr. furnace holds about 5,200# if gas fired and 6,000# if electric. These numbers are built into the melting numbers since you do not melt the entire 60 minutes of an hour.

As a matter of fact, that plus less scrap, because you have much cleaner metal to start with, will pay for the entire new furnace in less than 3 years.

We recently changed out two companies - one gas and one electric fired crucible - with electric melters and their very high scrap rate went to almost zero!

The numbers we publish are conservative and with proper charging practices and cleaning procedures you can easily hit these numbers.

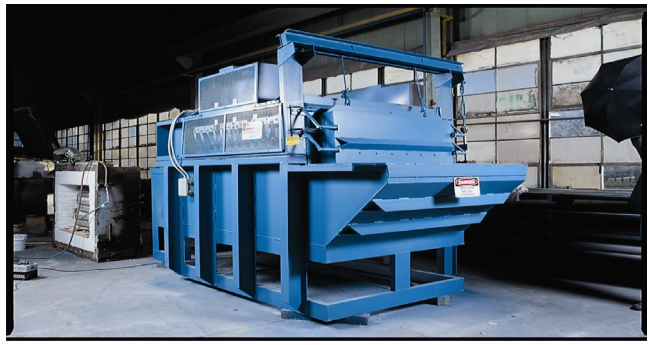
Four more points for electric reverbs, on the positive side:

1. No need to obtain a permit for the flue, and less heat in your building.
2. No additional make up air for the building required.
3. Quiet operation. You won't even know it is running.
4. Very high-quality metal.
5. Your emissions to replace a gas furnace goes from 148.41#/Hr.CO_2 to zero, 118.14#/Hr. of H_2O to zero and 708.294#/Hr. of NOx to zero.

On the negative side:

1. Electric reverbs do not have a very good recovery rate. So, if you get behind the electric will take time to recover.
2. You must evenly charge the electric ¼ of its hourly rated capacity every 15 minutes.
3. Electric furnaces must be cleaned regularly.
4. They usually hold about 9-10 times what they melt. So, they are slightly larger than gas reverbs.

You want to provide the best furnace for your plant and community look at the electric melters and holders to get your emissions down, your purchased fossil fuel way down and your number of EPA permits lowered, thus resulting in you possibly getting off the EPA radar. In addition to that, having a cooler plant and the cleanest metal in the business, because you cannot make a good part with bad metal.



Gas Fired Central Melters

One of the most common question we get asked is which is better central melting or machine side melting and holding? The answer always comes in the form of questions. The answers to these questions will undoubtably solve the puzzle.

1. Are you running more than one alloy or do you plan to? If the answer is yes then machine side melter holder is the way to go.
2. Are you running high volumes of two different alloys? If yes then you look at central melting and transferring to holding furnaces.
3. Do you need to degas and filter you metal if using one alloy? That is usually better accomplished in the central melter and then feed your holders through a molten metal launder so you don't pick up any more hydrogen or inclusions from the three turbulent transfers if you are tapping into a transfer ladle and pouring into holders.
4. Do you have enough space between machine to put in a melter holder? You generally need at least 16-foot centers and nothing in the way of the melter position so the dip well can be placed as close to the shot sleeve as possible.

Understand there are significant cost differences. Central melters and transfer ladles or launders can be much more up-front cost than individual melter holders at the machine. You need to way the benefits of central melting vs machine side melting to better understand your true ROI.

Things to consider are:

1. One stack permit to run the central melter vs many to run gas fired machine side melter/holders.
2. Scrap can be returned in hoppers to the central melter. You need to convey scrap back to the melter/holders by the machine one at a time with a conveyor to get the most efficiency out of the furnace.
3. You have to plan to clean every cell furnace every day vs one central melter every day.
4. You will have to hire other people to run the fork lifts handling molten metal and scrap unless you use a launder system then the transporting of molten aluminum goes away.
5. Maintenance and cleaning of the launder and or ladles.
6. Energy usage. Well-designed central melters with a pre-heat hearth and circulation can melt at 1250BTU's/hr. The in-cell gas fired melter will melt at 1500BTU's/# because these typically cannot support preheat hearths or circulation due to space constraints.

7. Central melters can melt chips with the addition of chip melting ancillary equipment in the charge well. It is possible to recover up to 96% of your aluminum chips using this method.
8. You can also look at dry hearth melters to recover your cast iron inserts from your aluminum parts. You simply load a basket with the parts, place them on the dry hearth and the furnace melts away the aluminum and you have recovered your inserts. Typically, on dry hearth melters there are two chambers: the dry hearth chamber, separated by a divider wall, and the holding chamber where the molten aluminum ends up. This dry hearth type melter has two separate combustion systems (melt zone and hold zone). Because it is not reliant on the stored BTU's in the aluminum to melt, the dry hearth melter typically holds only 3-4 times what you are melting per hour.

Crucible Melter/Holders

Let me start by saying that if you are comfortable using crucible furnaces, you really don't know how much they cost you a year. With worker comfort issues, maintenance, crucible bowl costs, downtime, reline costs when they leak (and they will leak eventually) and workers comp or safety costs associated with these units, they can cost more than the dollars you save in space, metal inventory (3-1 hold to melt ratio) and lower upfront costs.

Crucibles have their place, don't get me wrong. If you change alloys a lot, shut furnaces down often for extended periods of time and have extremely limited space, then you really have no choice but to go to another crucible furnace.

There are some ways to eliminate some of the headaches involved in crucible melting and holding at the machine. Play particular attention to the design approach in making crucibles. There are a lot of companies out there offering quick change elements. The reason is you have to change them often. Elements should last at least two years. Some companies use only one burner on large units and they should be using two.

Here is some basic advice on crucible operations. Never allow a bowl to be drawn down more than 4 inches. After that the temperature differential at the top of the bowl and the middle is so great that the top expands and cracks prematurely. In addition, do not allow ingots to be dropped into the bowl. This can cause the cracks to occur in the bottom of the unit. With a little pre-planning and care you should be getting a year or more of life out of your crucible bowls.

We have always taken basic melt rates very conservatively in order to assure good crucible life and metal quality. Through years of experience of foundry men pushing melt-to-hold rates on crucibles at 2 to 1 range have resulted in drastically reduced life. Also, many times chilling or sludging results, causing alloy desegregation, inclusions and metal chemistry problems. Due to these facts, we have gauged our melt rate on the conservative side. We have a minimum 3-1 hold to melt ratio and a lot of times go to 4-1 to insure a more even temperature. If a customer wants to melt beyond rated capacity then make sure the furnace has the input power to perform the task.

Evenly charging the furnace with ingot or small scrap (while it is still hot) will increase the efficiency of a crucible furnace. The rule of thumb is put in whatever you take out every 15 minutes. Unless you are casting very large sand castings or permanent mold casting that require most of the liquid metal in the bowl do not batch charge a crucible! It will greatly reduce the life of the silicon carbide bowls.

Follow these few guidelines to minimize down time usually associated with crucible furnaces.

Tower or Stack Melters as an Option

The stack melter either as a central melter or a melter holder by the machine (mini melter) can be the way to go and does solve a lot of small issues that machine side melter/holders have. I think by now everyone knows how these operate but just in case you don't, it is a simple process. Everything, scrap and ingots, gets loaded into a hopper and the hopper travels up to the top of the stack and dumps its load down the shaft to a hearth. The high to medium velocity burners point directly on the hearth to melt what reaches the hearth and the products of combustion from those burners and sometimes the holding chamber burner go up that stack to preheat the load. So, lets look at these facts!

1. Stack melters will melt between 900-1100BTU's/# melted.
2. Some furnace companies claim a 1% metal melt loss but, depending on what you melt, it can be as high as 7-9% for lightweight scrap.
3. They are very safe to operate. If you quench your parts then dry hearth melters or stack melters might be the safest method of melting your scrap.
4. You will need extra height in your building as these stacks can be quite tall particularly on central melters.
5. Because you are firing burners right at the aluminum with flame impingement you will produce dirtier metal in stack melters than in reverb furnaces with flat flame burners or electric melters.
6. A lot of major automotive companies using stack melters clean the metal up in our filtration/degassing furnaces before making parts with that metal.
7. Stack melters with the lifting mechanisms to load typically take up more room than the gas or electric reverbs.

Electric and Gas Holders

Choosing a holding furnace is just as important as choosing the right melter. Each type has their own unique benefits.

1. Energy usage in the gas fired furnace is extremely low. As an example, a 2,000-pound capacity holder at 1300˚F will use approximately 27.5 btu's/lb. (55 cubic feet of gas per hour) to hold with the well covers on. For an electric low energy holder under the same condition it is about 3KW/hr.
2. Furnace cleaning is drastically reduced and, relative to the molten metal process is easy to clean. This operation normally will take less than 15 minutes reducing furnace labor costs. Optional air operated furnace roof and covers are available that make cleaning even easier.
3. The furnace has been designed to give many years of low maintenance service. All controls are laid out for ease of troubleshooting.

Gas holders that utilize a flat flame burner will be less detrimental to your metal. Remember aluminum hates flame impingement. When products of combustion scrub the bath of aluminum your hydrogen pick up increases substantially.

Electric holders have no products of combustion, as long as you deliver metal to them in a timely fashion and at temperature, they hold metal temperature very well. One note, make sure the holder has enough power connected to have a passing gear. It doesn't cost that much more to connect 15-20% more than you will ever need to hold just in case you need it to make up temperature or you have a power outage and need to catch back up to operating temperature quickly.

Electric Immersion Holding Furnaces

The latest in electric furnaces are the immersion element furnaces. They originated in Japan over 25 years ago but became popular in the U.S. only about 18 years ago. There have been numerous improvements to the original design. By using a dense castable hot face and a micro porous silica back up super insulated lining, you can get excellent energy numbers from these furnaces. Casing temperatures with 1250˚ metal temperatures are as low as 108˚F.

The new electric immersion element holding furnace utilizes electric elements inside sialon tubes in the middle of the aluminum bath. This produces no thermal head temperatures which means less metal loss, less oxide growth, less dross, excellent bath temperature uniformity and a casing temperature of less than 108˚F. What more could you ask a holding furnace to do? How about holding aluminum at temperature (1250˚F) for less than 15 BTU's/# (if you convert the electric usage to BTU's) with well covers on and less than 20BTU's/# in production? This is compared to 25-40 BTU's/# in a conventional radiant roof gas or electric holding furnace.

They average 2 years life on the elements and over 5 years life on the tubes. You can change the elements on the fly and can stay hot with one element till the other one gets changed. The 2,000# units have 25KW connected, 4400# units have 35 and the 9,000# units have 90 KW connected. Schaefer also makes vertical immersion element holders. These you can change both the elements and the tubes without draining the furnace. The only issue is you need to hold more metal in depth to accommodate the hot zone of the elements.

All of Schaefer's immersion element furnaces have additional power connected in case you need a passing gear. Since these units have full proportional controls you only use what you need to maintain temperature saving you more energy vs the on off designs.

Dosing Furnaces

Dosing furnaces have become an expensive option vs ladling into the die casting machine. Generally speaking the dosing furnace has to be up high in the air to allow the metal to dose down into the shot sleeve. Generally speaking the speed of the metal going into the shot sleeve is faster than ladling which according to some recent research may create young oxides in the metal right there at the machine. If using a dosing furnace, pressurize with nitrogen instead of air. Aluminum oxide loves free air and by pressurizing with O_2 you are crating a smorgasbord for oxide to grow.

Here are the pros and cons of dosing furnaces:

- Dosing holders are good for small parts.
- Hold temperature + or – 15˚F.
- Fairly accurate on small parts.
- Less dross (with nitrogen purge)
- Less oxide growth (with nitrogen purge)

The cons:

- The dosing pumps may have more maintenance than with an auto ladle.
- Some difficulty in hitting shot weight on larger parts if not kept full.
- Harder to clean.
- Uses 35-40 BTU's/# (equivilent) to hold.
- Should not use O_2 to purge.
- Filler tube high maintenance. Safety concerns with pouring molten metal that high in the air.
- Difficult to clean.
- More turbulence than a ladle pour.

Conclusion

In conclusion, there is a lot to think about when deciding on which or whose furnace to buy. Decide your priorities then develop a specification that each furnace company must bid to. This will give you independent ideas on how to accomplish your goals. Do your research and pick a company that has a long history in the industry after all do you want to trust your production to a company with 9 employees and only 5-6 years in the business? Remember this important fact.

"It's unwise to pay too much. But it's worse to pay too little. When you pay too much, you lose a little money, that is all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do.

The common law of business balance prohibits paying a little getting a lot. It can't be done. If you deal with the lowest bidder, it is well to add something 'for the risk' you run. And if you do that, you will have enough to pay for something better. There is hardly anything in the world that someone can't make a little worse and sell a little cheaper and people who consider price alone are this man's lawful prey."

- John Ruskin, 1819-1900

** Gas fired melters work at 1.5 cubic feet/# of metal melted. With pre-heating and recirculation, you can achieve 1250 BTU/s/# (or 1.25 cubic feet/#).*

*** Gas pricing based on $3.00/1,000 cubic feet: electricity based on $ .065 per KWH.*