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## Aluminum Casting: Equipment

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*Courtesy of FWS Inc.*

There are three primary operations in the casting process which utilize natural gas fired equipment. In the first process, aluminum ingots and/or clean aluminum scrap are heated to around 650°C where the aluminum melts. In the second step, the molten aluminum is then transferred to a holding furnace where the molten aluminum is [alloyed and degassed](#) if needed, then heated to the casting temperature of approximately 750°C. In the final step, the molten aluminum is then transferred via a ladle or tundish to the preheated die or mold.

### Furnace Types

#### Reverberatory

Reverberatory furnaces heat the aluminum to melting temperatures with direct fired wall-mounted burners. The primary mode of heat transfer is through radiation from the refractory brick walls to the aluminum, but convective heat transfer also provides additional heating from the burner to the aluminum. Reverberatory furnaces are available with capacities ranging from up to 150 tons of molten aluminum. Typical aluminum reverberatory furnaces have melting efficiencies of 15%-39%. Recuperation can also enhance reverberatory furnace efficiencies by 10%-15%, but also adds to maintenance costs.

The advantages provided by reverberatory aluminum melters is the high volume processing rate, and low operating and maintenance costs. The disadvantages of the reverberatory aluminum melters is the high metal oxidation rates, low efficiencies, and large floor space requirements.

#### Ladle Preheaters

Ladles used to carry and pour molten aluminum need to be preheated prior to loading to minimize the thermal shock and damage to the refractory brick. Old practices used inefficient open gas pipes to heat the ladles. This practice has been largely replaced by efficient ladle preheating systems utilizing sealed covers, combustion controls, and even recuperation. Most developments have been large steel mill sized ladles (up to 400 tons), but recent developments have focused in foundry sized ladle (1 to 10 tons)

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### ALUMINUM

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- Rolling

preheating stations which are used to preheat more than one ladle.

### ***Electric Reverberatory***

Electric reverberatory furnaces are used primarily as holding furnaces and are seldomly used as aluminum melters. These furnaces are refractory lined vessels using resistance heating elements mounted in the furnace roof above the hearth. These furnaces are used for smaller melting applications where limitations on emissions, product quality, and yield are of high priority.

Advantages over gas fired reverberatory furnaces include low emissions, low metal oxidation, and reduced furnace cleaning. Disadvantages include high fuel costs, low production rates, higher capital costs, and frequent replacement of heating elements.

### ***Gas Fired Crucible***

Crucible furnaces are small capacity, indirect aluminum melters/holders typically used for small melting applications or exclusively as a holding furnace. The aluminum is placed or poured into a ceramic crucible which is contained in a circular furnace which is fired by a gas burner. The energy is applied indirectly to the metal by heating the crucible.

The advantages of crucible furnaces are their ability to change alloys quickly, low oxidation losses, and their low maintenance costs. Disadvantages include low efficiency (as low as 12%), high emissions, and size limitations.

Energy efficiency can be improved by 50% by adding a ceramic matrix recuperator to the exhaust system to recover waste heat for preheating the combustion air.

Morgan Thermal Ceramics, Ltd. has introduced a regenerative gas crucible furnace that circulates waste heat to provide both high temperature capability and high efficiency.

### ***Thermal Sand Reclamation***

Higher costs of sand, transport, and disposal make sand reclamation economically viable. In thermal reclamation, the binder is removed by heating the sand to about 1500 degrees F using natural gas burners. Several types of furnaces can be used for this purpose: rotary kilns, multiple hearth furnaces, and fluidized bed. Thermally reclaimed sand actually has better properties for casting than new sand: higher thermal stability, minimized weight shrinkage, and better uniformity of grain structure.

### ***Electric Crucible***

Electric crucible furnaces are similar to gas fired-crucible furnaces, but utilize electric resistance-heating elements to heat the crucible and melt the aluminum. Like their gas counterpart, electric crucible furnaces are small and are typically used when alloy flexibility is the most important.

Advantages provided by the electric crucible furnace is the near elimination of emissions and low metal oxidation losses. Disadvantages include increased fuel costs and size limitation.

### ***Induction***

There are two general types of induction furnaces: channel and coreless. Channel furnaces are used almost exclusively as holding furnaces. Channel furnaces operate at 60 Hz where the electromagnetic field heats the metal between two coils and induces a flowing pattern of the molten aluminum which serves to maintain uniform temperatures without mechanical stirring. Coreless furnaces heat the metal via an external primary coil. Coreless furnaces are slightly less efficient than channel furnaces, but their melt capacity per unit floor area is much higher. Coreless furnaces are used mainly for melting of finely shredded scrap where they are most cost competitive with gas-fired furnaces.

Advantages of induction furnaces include high melting efficiency (50%-70%), low emissions, low metal oxidation losses, and high allow uniformity due to increased mixing. Disadvantages are primarily their high capital and operating costs.

### ***Tower***

Tower furnaces are loaded from the top of a vertical tower with aluminum, and burners at the bottom of the tower melt the aluminum. The primary mode of heat transfer in tower furnaces is through convection by direct impingement of the burner on the metal in the lower section of the tower, and by the combustion gases as they travel out the tower past the metal charge. A variation of the tower furnace uses a grate system which lowers the metal through four grates, gradually heating the charge through each grate until on the fourth and final grate, the charge melts and falls into the hearth.

The advantages of the tower furnaces are high efficiency (40%-77%) and low oxidation losses. The disadvantages of tower furnaces are their high capital costs and the furnace size is restricted by height limitations.

### **Glossary**

**Alloyed** - The structural properties of aluminum or other metals can be modified by dissolving and mixing different types of metals together in the molten bath prior to casting. This process is called alloying. Magnesium, manganese, chromium, zinc, and copper are all metals added to aluminum. These aluminum alloys provide advantageous structural properties for various applications.

**Degassed** - Hydrogen gas is dissolved in the molten aluminum during the melting process. If sufficient amounts of hydrogen remain in the molten metal during casting, significant product degradation will occur. Fluxing agents are added to the molten metal prior to casting to remove dissolved hydrogen. This process is called degassing.

