7.4 Installing Radiant Panels in Crucible Furnaces

Crucible furnaces are an inexpensive melting method generally employed for melting small amounts of nonferrous metals, such as aluminum. The advantages of these furnaces are that they have low space requirements, avoid direct impingement of the flame on the metal, and limit heat loss by the refractory walls. They commonly are used as holding furnaces in die casting shops or for melting small amounts of metals in jobbing shops. They are simple to tap and charge, easy to clean, and enable the facility to rotate the number of alloys they can melt.[41] This was the case at Aluminum Casting Facility-2, which cast over 30 different alloys utilizing 42 natural gas-fired crucible furnaces to perform all of their melting (page 82).

A major drawback to these furnaces is that they are quite inefficient. The typical efficiency of a crucible furnace is low (i.e., 7 to 19%), with over 60% of the heat loss due to inefficient radiation.[42] Furthermore, these furnaces have a low melt rate and their available combustion space limits heat transfer.

One method for improving the efficiency of these furnaces is to install radiant panel linings, which combine a dense, high-alumina radiant panel with low thermal-mass insulation back-up materials. The design of these liners incorporates a series of raised nodules that create a high surface area to promote radiant energy transfer to the outer surface of the crucible. Backing up these radiant panels with a low thermal-conductivity refractory and insulating material reduces the heat loss through the sides of the furnace and increases the furnace's efficiency. These radiant liners require neither mixing nor drying which is required with traditional refractory liners that must be mixed with a cement like material. A benchmarking study by Case Western Reserve University found that these liners, in conjunction with an improved gas burner, increased efficiency in a natural-gas-fired crucible furnace from 8% to 16%. Engineers estimate that the panels themselves account for 50% of the improvement, and the remaining 50% is attributable to the improved burner. These panels cost approximately $4,000 per crucible. The assessment team recommends that foundries and die casters that employ crucible furnaces perform a cost/benefit analysis to consider installing radiant panels.

7.5 Shifting to Stack Melters

A stack melter is a modified reverberatory furnace that preheats the metal charge with waste heat gases. The efficiency of this enhanced furnace is significantly better than that of a typical reverberatory furnace because of its superior sealing and use of the waste heat to preheat the charge.

The charge is stacked above the hearth where flue gases heat and dry it prior to its entering the melting chamber. Preheating the charge minimizes the risk of an explosion occurring because it evaporates moisture that may build up on the charge. Preheating also reduces the cooling effect of charging cold metal into the molten bath of metal, thus reducing the energy used to maintain the molten bath.[43]

Stack melters offer higher efficiency and lower metal loss when compared with traditional reverberatory furnaces. A traditional reverberatory furnace has a thermal efficiency of 20-25%

with melt loss of 3-5%, where as a stack melter has a thermal efficiency of 40 to 50% with a melt loss of approximately 1%.[44] Actual plant data determined by a Metal Casting R&D project showed a reverberatory efficiency of 25% vs. 44% for a stack melter, with both furnaces installed at the same die casting operation. However, in the past, metal casters avoided stack melters because they required more labor and materials to maintain the refractory in the metal charging chamber. This is because charges enter the furnace from the top and the refractory lining at the bottom of the charging door suffers from repeated impact and excessive wear from the dropping charges. The cost of labor and materials for maintaining the refractory would typically offset some of the financial savings achieved by reduced energy consumption.[45] In addition, stack melters have been limited in the percentage of returns and ingot. They are unable to take advantage of lower cost, lower charge materials such as T-sows or RSI sows due to the stacking requirments of the charge.

However, in light of steeply rising natural gas costs and improvements in the stack melter design, metal casters should reexamine the cost effectiveness of these furnaces. Researchers at Case Western Reserve University that have benchmarked stack melters have documented their high efficiency and have noted their improved operability and design. Facility managers should perform a detailed cost analysis and determine whether these offer economic benefit for their operation.

7.6 Implementing an Energy Management Program

Foundry and die casting managers are always seeking ways to reduce costs without compromising the quality of the castings they produce. A good way of achieving this goal is to implement an energy management program to help improve their facility’s bottom line in the face of rising energy costs. The plan should focus on low-cost, low-risk opportunities such as improving the efficiency of compressed air systems, lighting, and equipment belts. Another important element of the plan is the need to understand the rate schedule the facility has with the local utility and consider whether they can adjust their operating schedule to take advantage of non-peak load billing periods.

7.7 Eliminating Leaks in Compressed Air Systems

As previously mentioned, minimizing compressed air use and optimizing compressed air systems is an easy way to save energy. A single 1/16 inch diameter air leak in a compressed air system at 100 psi loses air at 6.5 cubic feet per minute. At a $.06/kWh rate, based on 24 hours/day operation, this can result in a cost of $633/year.[46] The assessment team noted numerous leaks at a number of the facilities visited during this project. These leaks caused the compressed air system to consume more energy to maintain adequate pressure. Implementing a tag and repair program can easily remedy this situation. Such a program can be designed to have employees use color tags to identify leak locations, and then, after-hours or during the weekend when the equipment is not operating, a team can repair each leak. In addition, after-hours or weekend periods offer an additional optimal time to perform leak detection since the peripheral noise associated with production is then absent. Furthermore, the repair team can note the weekend horsepower that is required to maintain pressure in the line. This will provide input as to the number of air leaks and the equipment that is using non-essential air.