Melting Aluminum: Does Higher Energy Efficiency Equal Lower Operating Cost? (Not Necessarily)

Robert J. Nealon, President
Thermtronix® Corporation
Adelanto, California

One would think that higher operating efficiencies for any type of machinery would automatically convert to lower operating cost and improved productivity. Unfortunately, life in the die casting industry is not that simple.

Die casting managers across the country and around the world are facing rapidly escalating energy costs, almost on a daily basis, with no short term relief in sight. Their focus, by necessity, is increasingly aimed at improving the efficiency of larger energy consuming equipment and processes within their plants. At the very top of the list for most aluminum die casters is the melting furnace. Whether electric or gas, it is often the single largest user of energy in the facility. Melting aluminum is an energy intensive process, more so than with most other commonly cast alloys. In fact, it takes approximately the same amount of energy to raise one pound of aluminum to 1300°F as it does to raise one pound of iron to 2700°F. Therefore, very careful attention must be focused on the melting equipment, the operation of this equipment and the maintenance on it.

In the selection of new melting equipment the die caster must look carefully, not only at the efficiency of the new furnace but at the cost of the energy associated with its specific application. Let's take a real world example:

Two 1200 lb. crucible style aluminum melting furnaces

Furnace #1 – 100 kW Electric Resistance Furnace – 83 percent efficient.

Furnace #2 – 1.5 MBtu Gas Fired Furnace – 28 percent efficient.

Note: Before we go any further, are you surprised by the above efficiency ratings? Don't be.

An energy efficiency of 83 percent for an electric resistance furnace is outstanding. It represents a properly designed, well insulated, high quality electric resistance furnace. In fact, it is the most energy efficient, practical form of aluminum melting in common practice today. Equally high in its energy efficiency rating, within its own class of equipment, and surprising to the casual observer is the 28 percent efficiency rating for the gas fired crucible furnace.

You would assume that in a strict cost of energy comparison, the electric furnace in the above example would be a hands down winner. Perhaps not, if we look a little closer.

Let's examine two 500 ton machines at the same die cast facility running the same part. This part requires a 4.8 lb. shot and has a cycle time of 75 shots per hour. The job runs an average of 14 hours per day, 22 days per month. The only difference between the two machines is that one is operating with the above referenced electric furnace and the other with the gas fired furnace. Given the stated parameters, each furnace is being used to melt 5,040 lb. of 380 aluminum alloy per day. The electric utility rate is $0.075 per kilowatt hour with a demand charge of $6.30 per kilowatt. The gas utility rate is $0.70 per Therm. For purposes of simplification, we will assume there are no time-of-day or seasonal adjustments. Unfortunately, this is a rare occurrence in today's energy markets.

Figure 1: *Energy efficient solid state electric resistance furnaces in a die casting facility with robotic pouring.*

100 KW ELECTRIC
RESISTANCE FURNACE 83% EFFICIENT

1. Demand charge @ $6.30/KW x 100 KW x 12 Month/Year . . . . $ 7,560
2. Melting cost @0.175 kWh/pound x 5,040 lb./day x 22 day/month x 12 month/year x $0.075/kwhr . . . . $ 17,464

3. Holding cost @ 10 kWh/hour x 10 hour/day x 5 day/week + 48 hour/weekend x 52 week/year x $0.075/kWh . . . . $ 3,822

TOTAL ANNUAL
ELECTRIC ENERGY COST $28,846

1.5 MBTU GAS
FIRED FURNACE 28 % EFFICIENT

1. Demand or standby charge . . . . $ 0

2. Melting charge @ 1,800 Btu/pound x 5,040 lb./day x 22 day/month x 12 month/year / 100,000 (100,000 Btus = 1 therm) x $0.70/therm . . . . $ 16,765

3. Holding cost @ 1 therm/hour x 10 hour/day x 5 day/week + 48 hour/weekend (optional) x 52 week/year x $0.70/therm . . . . $ 3,567

TOTAL ANNUAL
GAS ENERGY COST . . . . $ 20,332

As you can see from the above example, which is not atypical, the gas furnace that is 28 percent efficient has an operating cost, again for energy only, that is approximately 30 percent less than the 83 percent high efficiency electric furnace. A word of caution is warranted here before you rush out to trade-in your electric furnaces for gas fired units. This article deals only with energy efficiency and its associated cost. Many other factors must be considered. One example, melt loss from oxidation which is always higher with a gas fired furnace than with an electric furnace, could easily change the balance of the total cost of operation in the above comparison. Other factors such as quality of melt, environmental and working conditions, speed of processing, volume requirements, hours of operation, etc., may have a very substantial impact on overall operating cost.

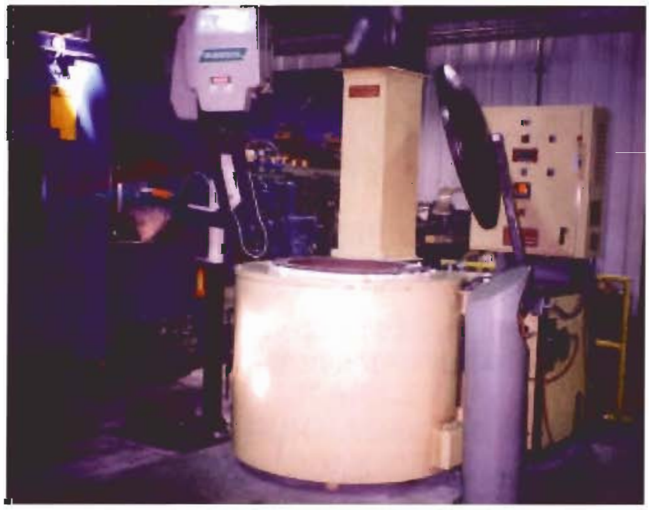

Figure 2: Energy efficient, robot ready gas fired furnaces are available with features such as fully automatic UL Listed Controls, insulated pneumatic furnace lids, flue stacks to reduce noise and raise heat and fumes above the operators head.

It is not uncommon for this author to be on a plant tour of an aluminum foundry or die casting facility with a perspective customer and to have him comment on one of his older gas or fuel fired furnaces. Typical will be, "I know that old furnace is probably only 50 percent efficient." At this point I will generally interrupt to state that if his furnace was anywhere near 50 percent efficient I would not have anything to offer him.

Figure 3: Typical of an older gas fired furnace of 5-to 10 percent energy efficient variety still in use in many plants today.

I'll go on to explain that we make what we feel is one of the most energy efficient gas fired crucible furnaces on the worldwide market today. It is only 28 percent efficient and I should not use the word "only" in front of 28 percent when referring to the energy efficiency of a gas fired crucible style aluminum melting furnace. An energy efficiency of 28 percent is very good for a gas fired crucible style furnace.

Before we proceed further, and certainly before an aluminum die casting manager can reach an intelligent decision regarding the selection of the most cost effective energy source and style of furnace for their particular application, it is helpful to have a common denominator when evaluating energy cost whether it be electricity, natural gas or propane.

In most of Europe, energy bills (gas and electric), are generally stated in kWh (kilowatt hours). In North America, a direct comparison is not quite so simple. Electric utility bills are normally stated in kWh (kilowatt hours) consumed during a one

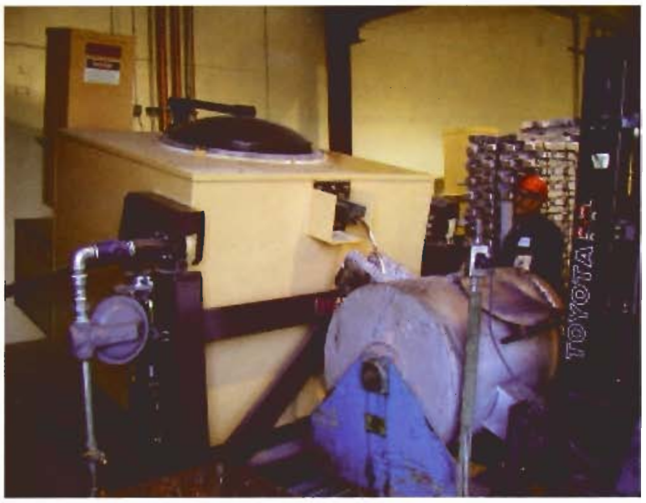

Figure 4: Solid state gas fired bulk melt furnace eliminates the need for costly holding of large volumes of aluminum in a conventional reverberatory furnace.

month period. A "demand charge" is commonly added to the monthly bill based on the maximum or "peak" kW (kilowatt) level reached during any 15 minute period for the same month.

This demand charge can be a very substantial part of the total electric bill. In many cases, it can be the single largest item on the bill. For this reason, when preparing a cost study, the demand charge should never be overlooked or "factored in" by simply adjusting the kWh charge. During a slow month, (even though electric furnaces may be idled) the electric bill, depending on rate structure, could be 80 percent of the previous bill when all furnaces were operating at full production.

Natural gas utility bills, although generally less complicated, also require close examination. Natural gas is often priced per CF (cubic foot), per CCF (100 cubic feet), per MCF (1,000 cubic feet) or per Therm (100,000 Btu), with the Therm being a measurement of heat content based on the Btu (British Thermal Unit).

Propane, LPG and other bottled gases are generally sold by the gallon or liter. One U.S. gallon of propane equals approximately 91,600 Btu.

With the matrix of utility rates within North America that a die casting manager must work with, the single most useful common denominator is the Btu. Using a schedule like the one below will allow one to evaluate the true cost of various energy sources.

Electricity, 100 kWh (Kilowatt Hour)
341,200 Btu

Natural Gas, CF (Cubic Foot) . . . . . 1,000 Btu

Natural Gas, CCF (100 Cubic Feet) . 100,000 Btu

Natural Gas, MCF (1,000 Cubic Feet)
1,000,000 Btu

Propane, U.S. Gallon . . . . 91,600 Btu

No.2 Fuel Oil, U.S. Gallon . . . . 139,000 Btu

Using a theoretical operating efficiency of 100 percent it takes approximately 500 Btu to raise one pound of aluminum from 68°F to a pouring temperature of 1250°F. In far too many cases documented, often with the assistance of local utility companies, older furnaces have been shown to consume 7,000, 10,000, even 14,000 and more Btu per pound of aluminum melted. These figures result in shockingly low energy efficiency figures from 6.5 percent to less than 3.5 percent. Perhaps this explains the old cliché often heard in aluminum melt shops "that everything is getting hot except the metal."

If the energy efficiency numbers stated above seem difficult to believe and you are operating older suspect furnaces, you may want to get out your calculator, current production numbers and your most recent energy bill. A few minutes of simple math may move you to connect an individual gas meter to one of the suspect furnaces for closer scrutiny. You may want to invest in a phone call to your local utility company. Many utility companies are able to provide assistance and some will even loan the necessary gas metering device. If you find your furnace is on the wrong side of the above energy curves you need to consider contacting several reputable furnace manufacturers. An investment in energy efficient, modern melting furnaces could result in a substantial improvement to the bottom line in today's spiraling energy market.

Figure 5: Energy efficient Non-Crucible furnace melting and holding aluminum at the die cast machine

Thermtronix® Corporation
17129 Muskrat Avenue / PO Box 100
Adelanto, CA 92301-0100

Tel: 760-246-4500
Fax: 760-246-4550
E-mail: RNealon@thermtronix.com
Web: www.thermtronix.com