Reduce Power Consumption

Without Sacrificing Production

To minimize exposure to high power rates, induction melters should optimize operating and maintenance practices, and evaluate equipment and generator systems.

BY MARK T. ECKERT

Most U.S. metalcasters are accustomed to cheap, reliable and plentiful electrical power. Consequently, we often are not prepared technically or psychologically to deal with the high electrical power costs that have become the norm.

But you can minimize your foundry's exposure to today's high rates by reducing your electricity consumption, and do it without sacrificing profitable production.

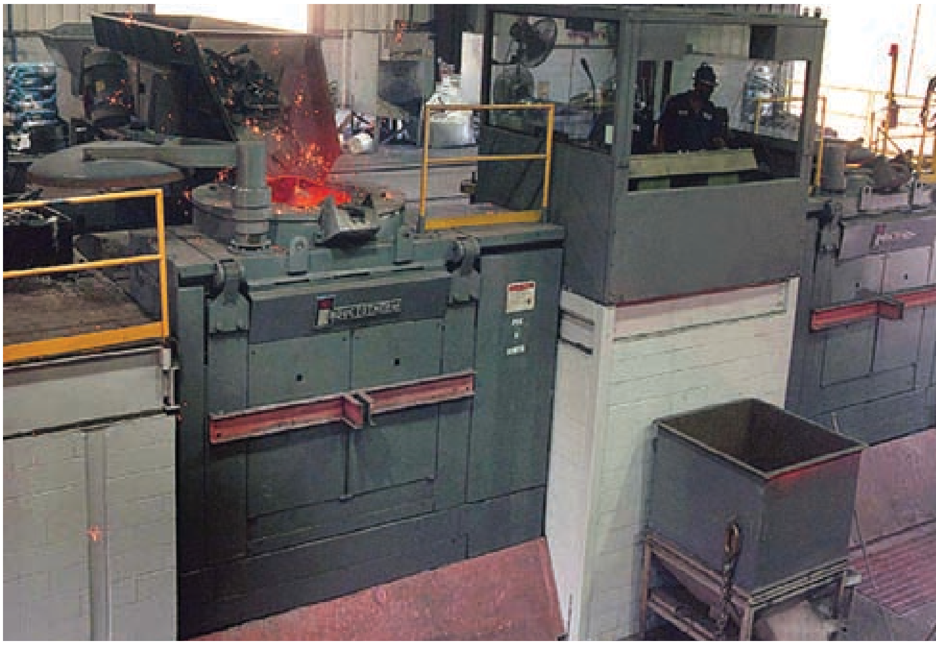
There are four major areas for energy cost reductions: operating procedures, maintenance procedures, capital equipment , and generators.

Changes to operating procedures

For many foundries, the largest energy savings can be realized by replacing their current melting equipment with equipment that is more productive and energy efficient. But whether or not you are ready to make that investment, you should investigate operational changes that also may produce significant cuts in your power use. Many of these can be made at little or no cost.

Maximize equipment utilization — The way you use your equipment can greatly cut power use. High melting equipment utilization generally means that holding times are short. Low melting equipment utilization typically results from long holding times. Long holding times require greater energy consumption, while short holding times cut energy consumption.

A good example is the New England investment casting facility that pays all of its foundry workers on an incentive basis.



Various systems can be applied or adapted to expedite furnace charging.

Melters get paid for metal over the spout: it doesn't matter whether it goes into a ladle or into a catch basin, they get paid the same. Pourers get paid on how much metal goes into molds, so if the metal comes out of the furnace and goes into the catch basin, they don't get paid for it.

Accordingly, when a furnace is ready to be poured, the melter blows a horn and starts tilting the furnace. Hopefully, the pourers are in a position to catch the metal. This has a tremendous impact on the utilization of the melting equipment. There is very little, if any, wasted time here. Utilization of the equipment is extremely high and, therefore, energy consumed per ton of metal poured is an absolute minimum.

Increase charging speed — What else affects utilization? First there is charging. If done by hand, charging can be a long, tedious and dangerous process. In most cases, manual charging cannot keep pace with full power melting and power has to be throttled back. Charging by magnetic crane can result in similar pacing problems. Long charging times mean low equipment utilization.

Ideally, charging should be done rapidly and metal should be put into the furnace as fast as the furnace is able to melt it under full power. Except in smaller furnaces, this requires automated charging systems.

If furnace charging is a bottleneck, a faster automated charging system can reduce energy consumption. There is a wide variety of systems available, one or more of which are adaptable to virtually any melting facility. There are vibrating conveyors that pivot, traverse, and/or index to the furnace, depending on melt deck configuration.

Charge buckets can be used in facilities with ample overhead clearances. Belt conveyors can move scrap to conveyors if the charge storage area is at a different elevation from the melt deck. These systems can be combined in just about any way to meet the needs of your melt shop. As a rule of thumb, the charge carrier should hold one full furnace charge. When circumstances make this impractical, it should hold at least half of a charge.

Overfilling overheats furnace components and allows heat to escape, wasting electrical power in two ways. It also jeapordizes safety, and is not recommended.

Avoid overfilling — Overfilling the furnace, that is, having cold charge materials laying above the upper melt line level recommended by the furnace manufacturer, also will cause wasted energy. The problem is twofold. First, this will cause overheating of furnace components in the top part of the furnace leading to energy loss. In addition, with the furnace overfilled, the lid cannot be closed. Ideally, the furnace lid should be left closed as much as possible, to retain heat in the furnace. Overfilling furnaces is more of a problem in furnaces with short freeboard area, particularly if the furnaces are being charged with buckets.

The bath should never be allowed to go molten when there are cold charge materials still to be added to the furnace. This increases the risk of wet or damp charge materials causing eruptions from the furnace when moisture comes in contact with the molten metal.

Rather, cold charge materials should always be added on top of unmolten materials, so that the heat from the top of the bath will help dry any residual moisture before it contacts molten metal.

Use clean scrap — Dirty charge materials waste a tremendous amount of energy and increase electrical consumption. Sand has two times the heat content of iron, so that every pound of sand in the charge equals two pounds of iron not melted. Another way to look at this is that for every pound of sand that goes into the furnace, two times the amount of energy is needed to bring that sand up to the same temperature as a pound of metal in the furnace.

If your current melting practice generates a lot of slag, you should look at the cost of cleaner scrap and compare it to the cost of the energy wasted by the dirty scrap. Also, slag takes time to remove, decreasing utilization.

Remove slag more quickly — It is also important to reduce the time needed to remove slag during the melt cycle. For furnaces of 5-6 tons and larger, back-slagging mechanisms allow slag to be removed more easily, more effectively, and more quickly. For very large furnaces, mechanical slag grippers can be effective tools for fast slag removal.

Streamline temperature measurement and sampling — Temperature checks also can be time consuming and costly, particularly if your operator frequently undershoots or overshoots target temperatures and must make adjustments and take additional readings. Computerized melt control systems can greatly increase the likelihood of hitting desired temperature levels.

While furnace sampling is a relatively minor operation, make sure you've done everything you can to optimize it and have it take as little time as possible.

A large aluminum-alloy melter in South Africa had 16 furnaces, but just one button mold, on a single melt deck. Melt operators would take samples from their furnaces and walk 30 or 40 feet to get to the mold. Naturally, if anybody else was using it they would stand back with the samples rapidly losing temperature. This lowered furnace utilization significantly and, therefore, increased electricity consumption.

Operators at a stainless steel foundry in New England thought they needed more melting capacity. The melt shop was not able to fulfill all of the foundry's molten metal needs over the course of a shift with its existing equipment. However, totaling the kilowatts of installed induction melt systems showed that there should have been more than sufficient melting power available for the foundry's molten metal needs. It was apparent that the problem was equipment utilization, not capacity. Further evaluation of the operation showed that the laboratory was taking 30-35 minutes to return the analysis of the metal samples to the melt deck. With the purchase of a new spectrometer, the foundry's "melt problems" disappeared.

The lesson here is to take a look at your entire alloy sampling and checking procedures to make sure that the minimum amount of time is being spent on them.

Optimize pouring — While your furnace is pouring, it is not being used for melting. In fact, if tapping takes too long, the metal may require reheating, a waste of electrical power. Look at your tapping practice to see if it is being completed as quickly as possible. Determine if larger ladles could reduce the number of taps.

A large Midwestern jobbing foundry

increased its melt furnace utilization by 30% simply by increasing the width of the trough in the transfer launders from the melters to its holding furnaces. This not only allowed them to decrease pouring time and, thereby, holding time and also pouring temperature which cut energy consumption and increased refractory life.

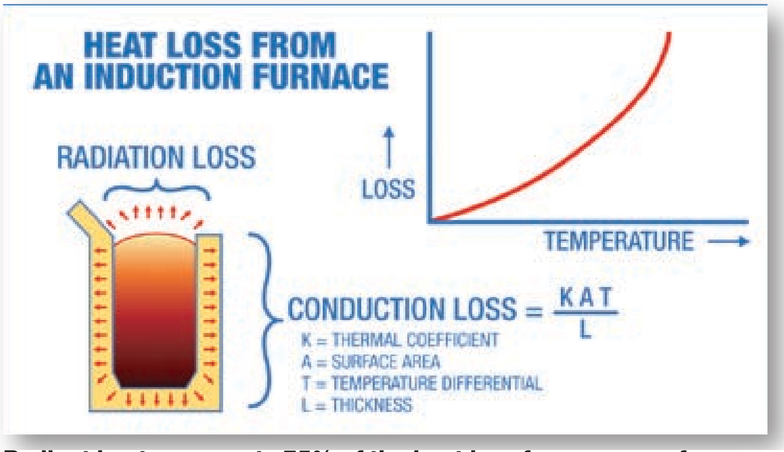
Another way to reduce energy consumption in the furnace is to pour at the coolest temperature that is practical and avoid temperature overshooting. For example, if metal that could have been poured at 2,750°F is allowed to rise less than 10% to 3,000°F, heat losses are boosted by 33%, using significantly more energy.

Schedule and control power use — A recent survey of melting practices showed that many systems are well under-utilized, not due to poor melt deck practices but due to simple lack of demand for metal. If this is the situation in your melt shop, you can cut your electrical costs significantly by reducing the peak output power of the melt power supply, saving money on demand charges. Check with your melting equipment supplier because this may create a problem for some types of equipment.

Alternatively, you should melt fewer days per week and more hours per day, if practical. This alternative will save on energy charges because you will be spending less time holding molten metal in the furnace at temperature. It also will increase your refractory life. Refractory life is not only a matter of metal temperature and throughput, it also is affected by the number of hot/cold cycles it goes through. The fewer of these cycles it sees, the longer the refractory will last and the more throughput per lining you will achieve.

Many foundries realize significant savings in both energy and demand charges by melting off-peak. Most of these operations will melt and pour simultaneously, but others actually have changed their equipment in order to allow them to do the melting off-peak, storing it for pouring during the regular day shift.

One New England malleable iron foundry added a fourth 8,000-lb furnace to its melt deck, giving it a total of 32,000 lb of metal ready to pour when the day shift started (on-peak). As each furnace was emptied, its holding power was added to the fourth furnace. This allowed the foundry to do a little additional melting in that furnace. By the time the first three furnaces were emptied, a significant amount of melt power was available for the fourth furnace while maintaining an even, low-demand charge.



Radiant heat represents 75% of the heat loss from an open furnace.

Save power with maintenance

Close attention to normal maintenance procedures can produce surprising energy savings at minimal additional cost.

Keep a lid on it — About 75% of the heat loss in an induction furnace when the lid is open is in the form of radiated losses into the air from the surface of the molten bath. The other 25% is lost via conduction through the refractory walls and floor.

The best way to reduce heat lost through radiation is by keeping the lid on. This means closing the furnace lid as quickly as possible after adding charge materials and after taking temperatures or adding alloying materials. Of course, if your lid doesn't fit properly due to warping or improper installation or a worn top cap and/or lid refractories, it will not be as effective. Regular maintenance to ensure correct lid fit, therefore, will save the energy that would otherwise be needed to replace radiant heat losses. Also keep in mind that radiated heat losses rise exponentially with metal temperature. As noted, a 10% increase in molten-metal temperature results in a 33% increase in radiated heat losses. You should look for ways to lower peak metal temperature and/or minimize temperature overshoots. Not only will these save energy, but they will increase refractory life and reduce alloy burn off.

If you thought your small furnace didn't need a lid, that was probably before you faced today's power costs. Inexpensive, manually operated, precast lids are readily available for retrofit for most furnaces.

Keeping refractory thickness as specified — Many metalcasters mistakenly believe that making the refractory linings in their induction furnaces thicker will extend lining life and save energy due to the higher insulating value of the additional lining. However, thicker refractory means that the metal will be further away from the coil. This results in a lower coil-power factor and lower coil efficiency that produces higher current in the furnace coil and much greater electrical losses.

Further, since there are more electrical losses in the coil, there is less energy available to melt metal, so every melt will take somewhat longer than it would with a standard refractory thickness. This results in more conducted and radiated heat losses, increasing the amount of energy consumed even further. The best refractory design is the one the furnace manufacturer provided on the cross-section drawing of the equipment.

As refractories heat and cool, they will expand and contract. Over time it is normal for the diameter of the furnace coil to grow slightly due to the pressure being exerted on it by the refractories. This results in a thicker lining and a lower efficiency, as outlined above. It also means you will be using more refractory every reline.

The solution to this condition is to have coils rebuilt and resized periodically to make sure that the diameter remains as intended by the manufacturer. You can slow the process of the coil growing in diameter by regularly tightening the shunts in the furnace. This will help prevent the pressure of the expanding refractory from distorting the furnace coil. (This cannot be done on all furnaces; check with your furnace's manufacturer.)

Configure your leads — A furnace's water-cooled leads can produce unnecessary electrical losses if they are not properly maintained or configured. If they are old and have gone through many cycles of furnace tilting, there may be broken cables inside the leads that cannot be seen but cause higher resistance in the lead and higher electrical losses.

Lead length is also important. Each foot of length in the flexible water-cooled leads adds another increment of electrical losses. Minimize voltage drop and power loss by making sure that the furnace leads are no longer than they absolutely must be.

Leads should be tied together and polarized. Leads that are allowed to split apart from each other will have higher electrical losses than those that are bundled together properly. Furnaces with four lead systems should be bundled with lead polarities opposite to each other, creating a "diamond" type configuration.

Properly managing the furnace lid is critical to energy savings.

Eliminate hot spots — Many foundries will do periodic infrared scans of all of their equipment. Any hot spots on the power supply, interconnecting bus bar, water-cooled leads, or furnace assembly are created by purchased energy that is not getting into the metal. Another benefit of a

Know How Your Electric Utility Generates Your Bill

Commercial electric power bills can contain seven or more cost elements:

Base Charge — This is the fixed monthly charge the electric company imposes for maintaining your account.

Demand Charge — This charge is based on your highest level of power use during a month. It may be based on peak kVA use or peak kW use. If your demand charge is based on kVA, check your power factor to see if power-factor correction would help. Power companies explain that demand charges are used to pay for capital equipment; e.g., generating plants and transmission lines they need to meet customers' power demands.

Energy Charge — This is the most straightforward item on your bill. It is the amount you pay for the power you actually use. It is based on kilowatt-hours (kWh) consumed. This is a charge for the utility's cost of generating the power.

Special Adjustments — This category includes fuel-cost adjustments, tax assessments, and other extra charges. Fuel adjustment is the most common charge and can be quite substantial. These charges are assessed based on your energy (kWH) consumption. In California, one adjustment is based on the average daily high temperature during the month.

Power Factor Penalties — In some cases, you are charged a penalty if your line power factor drops below a specified level. Typically, this level is 80% but may be as high as 95% in some areas.

Ratchet — This allows the power company to assess charges even if you shut down your foundry for the month. Most power companies will charge 80% of the highest monthly demand charge during the preceding 11 months as a minimum billing, whether or not you operated during the month.

Time-of-Day Rate Differentials — Power companies offer lower rates for power consumed during "off peak" periods. These are the times of the day or night when overall power demands are lowest. In addition, there are some intermediate "shoulder" periods when the kilowatt-hours are charged somewhere between the high "on peak" rate and the lower "off peak" rate. Power companies offer these rate discounts to help even out their loads throughout the day. Sometimes, these discounts are seasonally based as well.

Interruptible Rates — In many cases, rate discounts are available if you become an interruptible power user. That is, you will allow the power company to cut or reduce your power service for a specified period when the power company needs to reduce its overall load.

Another type of interruptible rate sometimes offered will provide kilowatt-hours at a discount during regular operations. However, during periods that the supplier is short of energy, you will be offered the option of shutting down or purchasing the electricity at a substantial premium.

periodic infrared scan of the equipment is that it will reduce equipment downtime by identifying components likely to fail due to heat build up before a failure occurs.

Control fume collection flow — Another area of potential energy savings is in the fume collection system. The amount of flow through the fume hood should be no more than what is necessary to remove the fumes effectively. Excessive air flow will simply draw more heat off the top of the furnace, increasing energy losses.

New equipment

Having maximized the power savings achievable by optimizing your operations and maintenance, the next step should be to find energy-saving opportunities relating to your melt shop's capital equipment.

Review the assumptions you made when your melting equipment was first acquired. Pay particular attention to changes that have taken place since the equipment was installed. Have the number of shifts changed? Are you melting the same metals and alloys? Has your production level changed? Are your casting sizes as anticipated? Are you using the same size ladles? Are your charge materials the same? Has your electricity rate structure changed? Once you have this information, take a close look at your melting equipment as it is operating today.

First, evaluate your induction power supplies. The electrical efficiency of these units has improved significantly over the years. Many induction units built before the advent of solid-state systems were about 80% efficient, compared to electrical efficiencies up to 97% today on large systems.

But, that's only part of the story. Look at how all elements in your melting system work together. Single-furnace induction melting systems built in the 1950s and 1960s required about 5,000 connected kilowatts and 750 kWh/t to produce 6 to 7 tons of metal per hour.

Two-furnace systems from that period needed about 4,000 connected kilowatts and 800 kWh/t to produce the same amount of metal. The higher level of energy consumption for two-furnace systems resulted from doubled heat losses from the use of two furnaces rather than one.

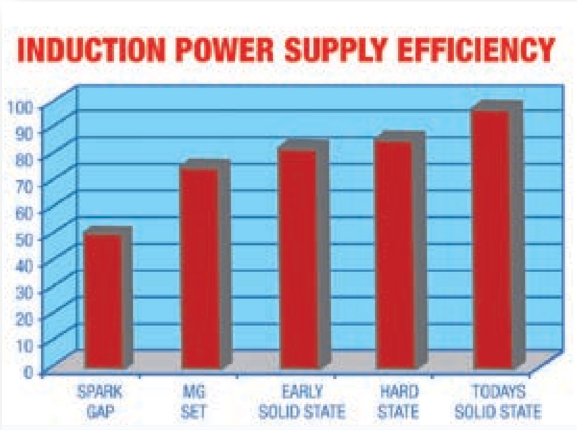
Induction melting systems built in the 1960s and 1970s and running two furnaces also needed about 4,000 connected kilowatts to produce 6 to 7 tons of metal per hour. These systems, however, consumed just 650 kWh/t due to higher operating frequencies that allowed smaller furnaces with lower heat losses to be used.

With the widespread adoption of batch melting, two-furnace induction systems built in the 1970s or 1980s required just 3,500 connected kilowatts and consumed 550 kWh/t to produce 6 to 7 tons of metal per hour.

Since the 1990s, high power-density induction systems with multiple power outputs and multiple furnaces have achieved efficiencies allowing production levels of 6 to 7 tons/hr with only 3,000 connected kilowatts and a power consumption of just 500 kWh/t.

To summarize, today's induction melting systems need 25% fewer connected kilowatts than systems built in the 1950s and 1960s, saving a tremendous amount in demand charges while using 38% less power to produce the same amount of metal. Perhaps more significantly, they require almost 15% fewer connected kilowatts and 10% less power than systems built a little more than a decade ago.

Looking at a typical two-shift/five-day operation producing 6 to 7 tons/hr, today's most power efficient systems might be expected to save about $80,000/year in electricity costs compared with induction systems built just a decade ago. This is based on a current mid-range demand charge of $5 per kilowatt and power use rate of $.04/kWh. Of course, you must do the calculations to determine your own potential savings, using your current equipment and electrical rates in comparison with the electrical use data for new melting equipment.



The electrical efficiency of induction-power supply systems has increased notably since the earliest models.

Generators

Foundries should evaluate the purchase of generators as part of any overall energy-optimization effort. Naturally, there are issues with permits, space, and noise that have to be addressed.

One cautionary note. Not all types of melt equipment can be powered by generators. Check with the manufacturer.

In summary, the keys to minimizing your electricity costs are:

- Understanding your complete electricity rate structure and how it is (or might) affect your operation.
- Understanding how your equipment operates within that electricity rate structure.
- Optimize the operation of your existing equipment given that rate structure.
- Maintain your equipment properly to maximize its efficiency.
- Consider upgrading to new, more energy efficient melt shop systems.

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