Overcoming Barriers to Energy Efficient Process Improvements in the Foundry Industry

Nels Andersen, Franklin Energy Services

ABSTRACT

Many barriers to implementing energy efficient process technologies continue to exist. High first cost and uncertainty of savings are typically ascribed as the greatest barriers. This paper will illustrate how Wisconsin's Focus on Energy program, specifically through the efforts of the Industrial Program, creates symbiotic relationships through their trade ally networks to deliver sustaining energy savings to customers. We examine an example industry, aluminum foundries, which have significant potential for improvements with melting technology. We describe the current market and potential for savings, the technologies typically employed, and why stack melters are a good energy efficient alternative. This leads into a discussion of how the Focus on Energy program promotes savings and technologies through trade allies and how this relationship benefits both entities.

Overview of the Foundry Industry

As of 2004, there were about 2,480 metal casting facilities in the United States. This industry employs approximately 161,000 people. Six states comprise over 60% of shipments (Table 1). Most metal casters are small businesses. Eighty percent of metal casters employ less than 100 people, 14% of the casters employ 100-250 people, and only 6% have more than 250 employees (Eppich and Naranjo, 2007).

Table 1 – Metal Casting Shipping, State Leaders

State	Industry Share
Alabama	14.3%
Ohio	12.8%
Indiana	11.1%
Wisconsin	11.1%
Illinois	7.3%
Michigan	7.2%

Source: Eppich and Naranjo, 2007

Gas-fired processes comprise 60% of the energy use for the foundry industry. Melting alone accounts for 55% of the total energy use in the industry. Melting process energy consumption is a significant concern for foundries, but technologies with low energy efficiencies continue to be used (BCS, 2005; Eppich and Naranjo, 2007). Implementing best practice melting technologies in aluminum foundries is estimated to save 63% over the existing industry average. If aluminum melting best practices were incorporated by all foundries, energy use and CO_2 emissions would be reduced by 21.6 % and 21.9%, per annum (Schifo and Radia, 2004).

As the metal casting industry is dominated by small businesses, there is hesitancy to implement capital intensive projects. It is difficult for small business owners to assume the high first costs associated with changes to their melting equipment. Also, there is a reluctance to change established processing methods for fear of negative effects. Finally, small metal casters have seen significant erosion of their profit margins. These reasons all make it more difficult for typical foundries to invest in capital intensive technologies (BCS, 2005).

As a whole, foundries spend capital on incremental and retrofit opportunities. This is done as these types of expenditures require smaller outlays of capital. They also look at the bottom line contribution of improvements and do not factor energy efficiency into their justifications. Limited financial resources tend to be used on molding and finishing technologies rather than melting systems (BCS, 2005).

Current non-ferrous melting technologies include reverberatory furnaces (90%), crucible and induction furnaces (5%), and stack melters (5%) (Schifo and Radia, 2004). This paper will address only the furnace types that use natural gas as a potential fuel source, so induction furnaces will not be covered.

Crucible Furnaces

This is a furnace where metal is melted in crucibles. For small batch melting of non-ferrous metals, crucible furnaces are the least expensive alternative. As they are easy to tap and charge with different alloys, they are most popular in jobbing and die casting foundries. The flame does not directly contact the aluminum. Energy efficiency is low, typically 7-19%. Most of the heat loss is due to radiation. Thus, heat loss is limited by the quality of the refractory walls. Crucible furnaces typically are short-lived, and control of temperature is problematic (BCS, 2005).

Reverberatory Furnaces

A reverberatory furnace is a melter that has a roof designed to redirect the flame and heat toward the hearth on which the metal charge rests. Reverberatory furnaces can be either dry hearth or wet hearth. In a wet hearth configuration, the charge enters directly into a molten aluminum bath whereas in a dry hearth the charge is preheated and begins to melt on a sloped entry between the charging door and the molten metal bath. Advantages to the dry hearth configuration include 1) some of the heat is recovered in preheating the charge, and 2) the preheating portion of the cycle removes any contamination or water residue, thus preventing splashing or explosions. Sows or ingots are directly deposited in a wet hearth reverberatory furnace. This configuration is beneficial for melting scrap that has large surface to volume ratios where oxidation might occur unless melting occurs quickly (BCS, 2005).

Reverberatory furnaces have the advantage of large molten metal supply. However, this comes at a cost of low energy efficiency, high oxidation rate, and a large floor space requirement. Typical energy efficiency of reverberatory furnaces is 20-25%, with most of the heat lost through the exhausting of hot flue gases. Due to the large surface to volume ratio of the large molten metal bath, much of the aluminum is in contact with the furnace gases resulting in formation of dross (slag). Melt loss rates from dross formation range from 3-5% (BCS, 2005).

Stack Melters

A stack melter is a specialized type of reverberatory furnace where the metal charge is preheated in the flue gases. They are also known as a tower or shaft melter. Efficiency is improved by improved sealing and the recovery of the flue gases for charge pre-heating. The charge travels down a vertical stack into the melt zone. While in the stack, the hot flue gases pass by the charge prior to being exhausted from the furnace. In the melt zone (basically, a dry hearth) the metal is heated by gas-fired burners and, once molten, flows into a holding zone. High melt rates are capable and the smaller holding capacity (relative to a reverberatory melter) reduces energy losses. Because of the design, stack melter efficiencies range from 40-50% (BCS, 2005, Schifo and Radia, 2004).

In addition to the efficiency improvements, stack melters have other advantages over reverberatory and crucible furnaces. First, preheating vaporizes moisture, thus reducing explosion risk. Secondly, preheating reduces the cooling effect resulting from charging cold metal into the molten bath. This reduces the amount of energy needed to maintain the aluminum in a molten state (BCS, 2005). Finally, as the charge is exposed to low-oxygen content exhaust gases during pre-heating and it is liquefied prior to entry into the molten bath, oxidation is significantly reduced, minimizing slag formation (Schifo and Radia, 2004). Dross, or melt loss, is approximately 1% (Eppich and Naranjo, 2007).

Focus on Energy

Focus on Energy is a state-wide energy conservation program in Wisconsin. It is a public benefits fund program where all investor owned utility, and many municipal and cooperative utility, ratepayers contribute. The program is overseen by the Public Service Commission and administered by a non-profit corporation (Wisconsin Energy Conservation Corporation). Services are rendered through market sectors, i.e. Industrial, Commercial, Schools & Government, and Agriculture.

The Industrial Program's mission is to promote energy efficiency in all manufacturing facilities in the Focus territory. It is program managed by SAIC and field activities are conducted by SAIC and Franklin Energy Services. Some of the offerings available through the Industrial Program include project implementation grants, feasibility study grants, third-party review of technologies, and facilitation of energy teams. Most of the companies participating in the program have an energy advisor that acts as their energy expert and primary conduit to all of the program services.

Much of the Focus on Energy program's success comes through their active trade ally networks. Trade allies are defined as energy efficiency product and service providers. Much of the Focus program's success results from leveraging their offerings through the trade ally network. Thus, trade allies that participate in the program and increase their sales through the financial and technological offerings of the Focus program tend to be vocal promoters of the program.

Trade allies benefit from being in the program primarily through the financial incentives available to their customers and unbiased review of technologies. The Focus on Energy financial incentives help reduce the first cost of energy efficiency measures which improves the return on investment for the customer to the point where they will implement a project that otherwise would not get approved. Allies may enlist the program to provide veracity to the energy saving estimates they provide customers during the sales process. Many customers are skeptical of vendor saving estimates. Many times their uncertainty is alleviated once a Focus energy advisor has reviewed and blessed the calculations and explained how the technology works.

Modern Equipment Corporation makes equipment for the foundry industry and has been an active trade ally in the Focus program for many years. They have used their relationship as a trade ally to implement a number of stack melters in Wisconsin foundries that, absent a program such as Focus on Energy, would not have been installed.

Since 2005, seven stack melters have been installed with assistance from the Focus program at four customer sites. All of the stack melters were products manufactured by Modern Equipment, which is not surprising as there are only a few manufacturers of this type of melter and Modern Equipment is the only one located in Wisconsin.

All of the customers that installed a stack melter through the Focus program cited financial reasons as their largest barrier to implementing the technology. Specifically, lack of or competition for capital is the reason for requesting financial assistance. Simple return hurdle rates for the companies range from 18 months to 2 years, and in most cases the incentive reduces the first cost of the equipment enough so that the project is approved. Most of the projects are very capital intensive, with final costs from $75,000 - $550,000. Incentives approved for these projects were cash grants, payable upon implementation of the equipment. Grant amounts were calculated on an estimated therm savings supplied by the trade ally and reviewed by the Focus on Energy energy advisor working with the particular customer. Incentives ranged from a low of $5,800 for the smallest capacity stack melter to a high of $127,900. The incentives offset the project costs by 7.7%-30% (Focus on Energy, 2009).

The second most prevalent concern of customers was the uncertainty of savings. Process equipment improvements not only have to contend with the skepticism with savings and other types of efficiency improvements but also from the mindset of “don’t mess with the process”. That is, any change in the process equipment needs to prove that it will not deleteriously affect the quality of the product. As Focus on Energy is an energy conservation program, it only examines the former question and leaves the product quality concerns to the ally to address.

In the case of stack melters, the first application that was submitted included test data from Modern Equipment that was reviewed by the Industrial Program energy advisor. This test data was in two forms – data that Modern Equipment had collected from previous installations and data from an independent test (Groteke and Fieber, 1999; Focus on Energy, 2009). Both sets of data were in agreement, appeared to be conservative, and used proper test collection methods (direct measurement of fuel and charge). After review and approval of the grant, this initial customer installed the stack melters.

As a condition of the first grant approval of a technology new to the Focus on Energy program, the customer agreed to let the program perform measurement and verification of the installation. Using the IPMVP Measurement & Verification Option B (direct measurement) it was found that the savings were actually double the savings estimate in the original application. This is due to very conservative assumptions regarding the production rates in the application. After the installation of the stack melter the customer was so pleased by the performance of the unit that they increased the production capacity, effectively doubling the actual savings. The energy use per pound, claimed to be 1,000 Btu/lb in the application, was found to be 962 Btu/lb from the M&V data. Another benefit was that the customer’s dross (metal loss) reduced by over 50%, going from 4.9% to 2.1%. Combining the energy savings and the reduction in dross, the customer projects to save over 99,000 therms and almost $120,000 annually (based on delivered fuel and aluminum costs at that time of $0.85/therm and $0.90/lb, respectively) (Atkinson and McLeer, 2007).

Based on production rates at the time of grant application approvals, all seven projects are estimated to save a combined 730,000 therms annually. From the inception of the Focus on Energy program, there have been 458 gas saving projects of all types (process and other) completed for the Industrial Program. Thus the stack melter projects comprise 1.5% of the projects completed and delivered 3% of the total Industrial Program gas savings of over 24M therms (Focus on Energy, 2009).

The Focus program also allows the incentives to be paid directly to the trade ally. As a service to their customers, Modern Equipment takes advantage of this provision. They reflect the credit of the cash incentive on the final invoice to the customer, assuring the customer that they are getting the full benefit. By paying the ally's discounted pricing, the customer benefits from the time value of money, i.e. they are not waiting the 4-6 weeks after final installation of the project to receive the incentive check. Also, the financial benefit of the incentive is reflected directly to the internal budget line item for the project rather than having the check go to the accounts payable department and be deposited into the customer's general account.

Modern Equipment also provides their potential customers with a performance guarantee. If the projected energy savings for the melter is not realized they will remove it and the customer owes nothing. The M&V result provided by Focus gives them peace of mind and the customer in providing this guarantee.

As part of the promotion of new energy efficiency technologies, the Industrial Program encourages trade allies to provide the energy advisors with information. This allows the energy advisors to understand what is new in the market and how it can benefit the customers they serve. Upon completion of the first stack melter project, and issuance of the M&V report, Modern Equipment presented at an Industrial Program quarterly meeting. This allowed them to interact with all of the energy advisors, promote the energy saving and technological advantages of stack melters, and answer questions. Similar presentations have been given by many trade allies, primarily those with truly new or process related technologies. They are not sales pitches but an explanation of the technology and how it saves energy and what markets benefit the most from it.

Many trade allies use their initial successfully implemented projects with the Focus on Energy program to promote their technology to new customers. For example Modern Equipment uses their projects successfully implemented through Focus on Energy as third-party documentation in the sales cycle with new customers.

Not all of the benefits are unidirectional. Trade allies gain from all of the above noted benefits of participating in the Focus program and the program benefits from the association of successful allies. Knowledge transfer of the new technologies to the energy advisors, as noted above, is one of the benefits. Having more knowledgeable energy advisors interacting with customers has an obvious benefit for the program. There are also spillover effects for Focus. For many of the customers that installed stack melters, their first contact with Focus on Energy was because Modern Equipment involved the program. After the successful implementation of the melter project some of the customers are investigating or have implemented additional energy savings measures. This allows the energy advisor to provide greater benefit to the customer than otherwise possible. In one specific case, the energy advisor documented that the successful implementation of the stack melter project directly led to consideration of additional projects and got the advisor more involved with customer. Previously, the customer was only marginally interested in the offerings of the program. In the case of the customer that installed the first stack melter, they have since installed an additional two stack melters (Focus on Energy, 2009).

Conclusions

Based on industry and market data, implementing stack melters can significantly reduce energy consumption in aluminum foundries. However, first cost of installation and uncertainty of savings remain as significant barriers to this technology.

Using the example of stack foundry melters, a specialized energy efficient process technology, this paper shows how the partnership between energy conservation programs and trade allies results in mutually beneficial outcomes for both partners. Specifically, the relationship delivers:

- Financial incentives that reduce return on investment barriers;
- Flexibility in payment of the incentives provides additional customer benefits;
- Unbiased third-party verification of savings;
- Case study type documentation that can be used to promote projects with customers;
- Education of conservation program employees so that they can knowledgeably communicate the effectiveness of the technology.

References

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