



TENNESSEE METAL CASTING INDUSTRY



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Identify the Numbers

Tennessee is the 10th largest producer of metals and metal castingsⁱ in the United States. In 2002, Tennessee's primary metals industry generated \$4.4 billion, employed 13,495 people across 120 establishments; 53 of which are foundries. The metal casting establishments are small to medium sized businesses with less than 100 employees.

The industrial trend within the US over the past decade has seen increases in three markets, 1) the automotive and light truck market sector as the automotive industry seeks lighter, more fuel efficient designs; 2) military applications as the defense industry shifts to faster, more mobile forces; and 3) municipal castings (pipes, valves, meters, street signs and lights, etc).

Additionally there has been a shift in material usage. Castings which previously were done in iron have are now being casted with lighter, non-ferrous metals; primarily aluminum. Tennessee metal casters are matching this US industrial trend as nearly 84% of all castings are iron or aluminum.ⁱⁱ

Whereas aluminum and iron castings are 84 percent of the production, they are 82 percent of the energy used. This would seem that production matches energy consumption. This is not the case. In Tennessee iron comprises 65 percent and aluminum makes up 19 percent of industry casting shipments. However, the energy consumption is not along a 65-19 split. Iron castings consume 48 percent of the market's energy. By contrast aluminum castings consume 34 percent of the energy consumed by the entire casting sector. Therefore, considering the current market shift from iron to aluminum, the energy consumption within this industry is expected to increase.ⁱⁱ

Why is this market sector a good fit for CHP?

CHP reduces the need for purchased fuels by creating electricity with recycled waste heat. Metal casting and foundries, which consume 70% of the energy within this sector through the melting processes,ⁱⁱⁱ provide an opportunity to use purchased fuels for CHP, as well as the thermal energy stored in the process waste streams to generate electricity. Since this "waste" energy is available onsite, there is no additional fuel cost incurred for equipment operation. This waste energy could then be used to generate steam for driving a steam turbine, or to drive an Organic Rankine Cycle (ORC) turbogenerator.

The Department of Energy (DOE) has identified four areas where metal casters can employ CHP methods to reduce energy costs. Those areas include heat generation, heat transfer, waste heat recovery, and heat containment. By following these practices, metal casters can reduce their energy costs by 10-30 percent.^{iv}

What is the market potential for this sector?

In 2002 the metal casting industry categorized under NAICS 3315 consumed 165 trillion Btu,^v and foundries accounted for 92 trillion Btu. In 2002 there were 2512 metal casting establishments in the US. Hence, the average facility consumed 65.7 billion Btu. Therefore Tennessee's consumption, which has 120 establishments in 2002, averaged roughly 7.9 trillion Btu.

Most foundries consume hundreds of kWh/ton during the melting process, which often is 35-100 percent in excess of the theoretical energy requirements. Energy losses during melting are multiplied by yield losses during casting and finishing, which EERE estimates can be as high as 40 percent. Total energy losses (including melting and casting operations), can be 3.0 to 6.0 times the theoretical energy requirement. Energy savings are estimated to be approximately 10 to 30 percent of the total operating cost in the metal casting industryⁱⁱⁱ.

What are the potential benefits and uses?

Heat management can bring additional savings to the metal casting industry, especially within a foundry.

Heat generation is optimal with complete combustion. Improved efficiency therefore comes from a controlled air-fuel mixture. Too much air increases exhaust and wastes heat. Too little air will result in incomplete combustion which will waste fuel and emit too many pollutants. Oxygen content should be less than 2 percent in flue gases. Proper air-fuel ratios will result in 5-25 percent in energy reductions in the furnace and can save up to \$170,000 a year^{iv}.

Heat transfer, while more of an industry best practice and not a CHP methodology, is included as it provides energy savings and energy recycling, the latter of which is a CHP practice. Maximizing the heat transferred to the metal charge will result in energy savings up to 25 percent as well. Proper loading of aluminum coils in annealing furnaces, utilizing high-velocity burners, implementation of recirculating fans will distribute the heat evenly along the surface areas of the furnace. Uniform heat distribution increases productivity as melt time is decreased. Additionally, the temperature of the heel is steady and less energy will be required for the next melt and hold cycle. Overall, productivity is increased, quality is increased (i.e. less bubbles), reduced heat demand, and thereby less energy consumed.

Recovering waste heat is essential to CHP. Waste heat is recovered from the furnace exhaust gases and recycled back into the system. This recovered heat is often used to preheat

combustion air, preheat the charge metal, generate steam, heat water via a boiler, or supply heat (and potentially cooling) to other onsite facilities or processes. In the metal casting industry, recuperators are used in flue gases that are relatively clean, such as those found in the exhaust from heat treating furnaces. In stack melters, regenerators serve the same purpose in areas which contain contaminants. Recovering this waste heat to preheat the combustion air and the charge by an additional 800⁰F can potentially save 9 MM Btu/hr of consumed fuel; which could save the company \$350,000 per year^{iv}.

Additional Interest

This market assessment was completed for the \$4.4 billion metal casting industry in Tennessee. The Tennessee metal casting industry is a large, energy intensive, multi-billion dollar market that accounts for more than 120 establishments and over 13 thousand employees.

While CHP may provide a cost saving, energy efficient methodologies for metal casters, there are two reasons why CHP utilization must be evaluated on a case-by-case basis. First is the cost of fuels. Without an infrastructure to support alternative fuels, such as methane based gases, electricity is more economically advantageous on a Btu basis. Secondly, the industry operates on a batch or semi-batch process. As the costs of electricity rises and as the practices within the industry develops more continuous operations, CHP utilization will become increasingly more beneficial to the economic health of this market sector.

For those metal casters who are considering CHP implementation, the next step would be to conduct an engineering and economic analysis which will determine if a project using CHP technologies would be profitable to install. While initial costs associated with establishing CHP are viewed as relatively high, rising fuel costs may cast a more appealing light on such proposals and subsequently create a large market for CHP applications.

For interested parties, CHP technologies offer a potential opportunity for increased economic efficiency within the agricultural process. As such, there are numerous government, trade, and support organizations for the implementation of CHP equipment.

The Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) offers *Quick Plant Energy Profiler (Quick PEP)* software on its website to help determine how energy is currently being used and where opportunity exists to save cost and energy. The Department of Energy also sponsors *Industrial Assessment Centers (IACs)* which provide no-cost energy assessments for small and medium sized facilities.

ⁱ US Census Bureau. NAICS 331 Primary Metal Manufacturing. 19 June 2008. 11 Aug. 2009 <<http://www.census.gov/econ/census02/data/industry/E331.HTM>>.

ⁱⁱ Vondra, Dr Fred. Professor at Tennessee Technological University. Personal interview. Nov. 2008.

ⁱⁱⁱ Strahs, Glenn. DOE Industrial Technologies Program 2008 Corporate Peer Review. 28 Oct. 2008. 15 Aug. 2009 <http://www1.eere.energy.gov/industry/about/pdfs/metalcasting_aluminun_overview.pdf>.

^{iv} Office of Industrial Technologies. Efficient Process Heating in the Aluminum Industry. Jan. 2006. 13 July 2009 <<http://www.oit.doe.gov>>.

^v Using AFS 2002 Forecast & Trends, the ratio of metal casting shipments (NAICS 3315) to captive foundry casting production was calculated. This ratio was applied to industry energy consumption for NAICS 3315, *2002 Manufacturing Energy Consumption* report, U.S. Department of Energy, Energy Information Administration tables 1.2, to estimate energy consumption in captive foundries.