WHITE PAPER

For Efficient Manufacturing, Look to Die Casting

NADCA

North American Die Casting Association

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The ecological impact of modern society has become a major issue in today's world. Buzzwords like green jobs, renewable energy, greenhouse gases, and more are taught in schools, discussed in business, and used political speeches. Many of these concepts are built on the idea of sustaining modern society with renewable energy sources, foods, and products. In manufacturing, process efficiency is the best way to reduce the impact on the environment and sustain production. Die casting sustainably produces cast products with recyclable materials, while conserving energy, and creating a small carbon footprint. In addition, the die casting supply base in the US is continually improving its efficiency making it an increasingly sustainable process.

Recyclable Materials

Aluminum, magnesium, and zinc are the three most common die casting materials. All three elements are in the top 25 most abundant elements in the earth's crust. Magnesium for example is the 8th most abundant element on Earth, and aluminum is the 3rd most abundant element. The dies for die casting are made of steel. The primary element in steel is iron which is the 4th most abundant element. This means there is a large and readily available supply of the materials used in die casting. Figure 1 shows the size of the world zinc reserves compared to the zinc demand. The most recent data in 2007 indicates that the reserves contain enough material to satisfy over 50 years of demand without recycling any zinc products.

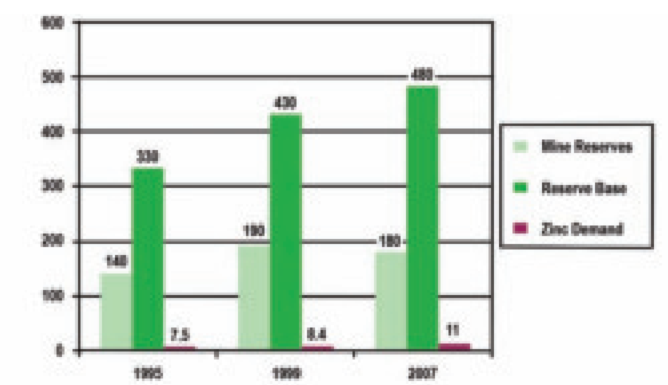

Figure 1 – Zinc reserves compared to zinc demand (Green & Wesemael, 2009).

Regardless of their abundance, truly sustainable and efficient manufacturing materials must be recyclable. All die casting metals can be recycled and reused with no loss in material properties. The result is that a vast majority of die castings are made with post consumer metals. This is also known as secondary metals. For example, over half the aluminum produced in the U.S. in 2003 was from recycled aluminum, and roughly 95% aluminum die castings are made from recycled aluminum. This has lead to aluminum occupying less than 1% of municipal solid waste.

Not only is this an efficient use of the mass of aluminum, but also it is recycled with shocking efficiency compared to producing virgin materials. This is evidenced by the fact that producing secondary aluminum ingots consumes 6% of the energy required produce primary aluminum ingots (BCS). It has been estimated that $167x10^9$ kWh were saved in 2003 by using secondary aluminum. This is equivalent to 19,100 MW of electrical generation capacity saved. It is expected that secondary aluminum will continue to expand rapidly. This will be driven by the long life aluminum intense products, such as cars and building frames, reaching their end of life.

Not only are the cast materials recyclable, but the dies themselves are recyclable as well. Dies in the die casting process are made of tool grade steel. When the dies are no longer needed, or when they reach the end of their life, the tools are sent to a steel mill. The steel is then remelted, refined, and forged into new feedstock for new dies.

Energy Conserving

Since the molds are reusable and it is a high production rate process die casting lends itself to efficient use of energy. Other casting processes utilize expendable molds of sand. Creating these molds can use up to 7% of the tacit energy for producing castings. In die castings the dies can be used to produce over 100,000 castings. This makes the energy use for tooling small in die castings.

Die casting is the most energy efficient casting process for producing non-ferrous metal castings. This fact is shown in Table 1. Less energy is consumed producing an aluminum die castings than using the permanent mold, sand, and lost foam casting processes. This implies that the most efficient way to produce aluminum castings is with the die casting process.

Table 1 – *Tacit energy consumption in metal casting facilities (Schifo & Radia, 2004).*

Casting Process	Tacit Energy (10^3 Btu/lb)
Al Die Casting	27.5
Mg Die Casting	30.8
Zn Die Casting	10.6
Al Permanent Mold/Sand	45.2
Al Lost Foam	37.2
Copper-Base: Sand	17.0

The data also shows there is an opportunity for further refinement to reduce the energy use in die casting facilities. For example new furnace technologies have effectively doubled the melting efficiency in many facilities. Modern die casting furnaces can now melt with a thermal efficiency of 45% utilizing natural gas. Electrical furnaces are now achieving demonstrated efficiencies as high as 70%. The next generation of furnace technology will utilize electricity and have efficiency of 90% or higher. The transition to electrical energy will be critical for maintaining the sustainability of die castings. This is because the electricity can be utilized from renewable power sources. This cannot be said for natural gas.

Carbon Footprint

Another powerful way to understand the efficiency of die casting is to look at carbon footprints. A small survey was conducted in 2009 that examined the carbon footprint of the die casting industry (Monroe, 2010). The respondents accounted for approximately 10% of the industry and the results are presented in Figure 2. The survey found that over half the industry produced less than 4 pounds of CO_2 for each pound of die casting shipped. The more important figure was the industry best practices. The best practices, defined as the top 10%, achieved a carbon footprint of 1.14

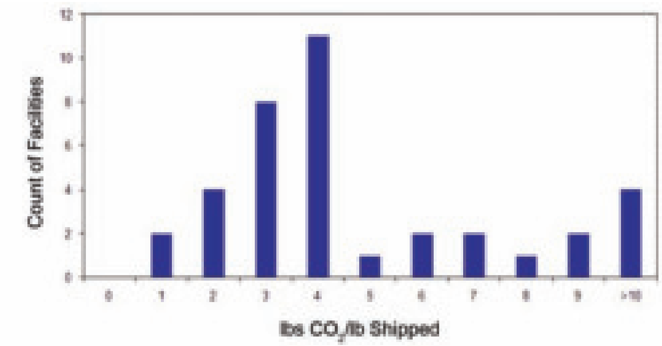

***Figure 2** – The pounds of CO_2 emitted at die casting facilities compared to the pounds of die castings shipped (Monroe, 2010).*

pound of CO_2 per pound shipped.

To put the best practice carbon footprint in perspective it can be compared to the carbon footprint of producing a plastic component. A full life cycle analysis of a plastic component compared to aluminum and magnesium die castings was completed in 2008. This found that the carbon footprint of producing an injected molded plastic component was 1.6 pounds of CO_2 per pound shipped. This means that the best practices in die casting produces less carbon emissions than a similar plastic component. As the industry moves to electrical forms of melting, there is an opportunity to completely eliminate the carbon footprint of die castings.

Continually Improving

As an industry, the die casting process is continually being improved. Some of these improvements have been listed above. Others include increasing the die life, which reduces further the energy and carbon footprint of the process. Also, castings are being optimized to improve yields. This has a dramatic effect on the energy savings with it being 30% in some cases. These types of improvements are shown most clearly by the productivity enhancements in the industry over the last ten years, Figure 3. This

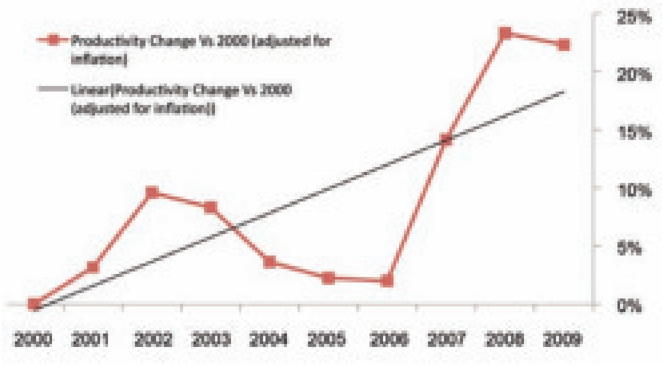

***Figure 3** – Productivity change Vs 2000 in die casting facilities in the United States.*

graph shows that die casters have improved their productivity by over 20% when compared to the year 2000. This dramatic improvement is the result of increased efficiency and use of technology throughout the industry.

Productivity enhancements are not the only continuously improving portion of the industry. High performance die casting alloys have been developed and they are continually being refined. These alloys can achieve superior performance while maintaining their recyclability. Most high performance alloys cannot be recycled because of purity issues. This means that the recycled high performance alloy will not achieve equivalent properties to the virgin alloy. The high performance die casting alloys have the opportunity to replace the energy inefficient alloys being used today.

Conclusions

Die casting remains the most efficient process for producing aluminum, zinc, and magnesium castings on a moderate to large scale. As the industry utilizes recently developed furnace technologies, its already high energy efficiency will be further improved while its carbon footprint is reduced and possibly eliminated. Technology continues to drive these efficiency gains through dramatic improvements in productivity.

The industry continues to be committed to finding cost effective and sustainable process improvements. These efforts are largely led by NADCA's research and development efforts. NADCA will continue to support the development of technologies that will keep die casting as the most efficient and sustainable metal casting process.

Works Cited

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