

W H I T E P A P E R

Die Casting's Advantages Over Plastic Components



Die Casting's Advantages over Plastic Components

Die casting has a well-established reputation as an efficient, economical process that offers designers a variety of advantages for creating parts and components. These benefits often make die casting the obvious choice when selecting a manufacturing process for a particular part. However, sometimes designers must weigh the advantages of die casting against other processes, such as plastic injection molding.

Among the principal advantages when comparing die casting to plastics are that die casting produces stronger parts with closer tolerances that have greater dimensional stability. Die cast parts also have greater resistance to temperature extremes, superior electrical and thermal conductivity.

Adding to the value equation in favor of die casting is that the continuing increase in the price of oil is having a significant impact on the price of plastic feedstocks used in producing parts. As Purchasing magazine noted in an article in its February 2006 issue, "Any meaningful discussion relating to the price of resin really must start with a look at what is happening in the oil industry. As the price of crude continues to increase, the price of plastics that are produced from oil feedstocks must increase as well. The same holds true for those resins that utilize feedstocks from natural gas."

The Advantages of Die Casting

Die casting and plastic injection molding are both high-speed production processes. In both cases products are made by injecting a material into a die. Typically dies are made of steel, and the dies are capable of producing tremendous part quantities. Complex thin-walled parts with high levels of reproducibility are made by both processes as well. Even with all these similarities die casting has a number of significant advantages over plastic injection molding.

Strength, weight and heat tolerance – Often designs start with these primary material requirements. Many materials are deemed unsuitable by these criteria alone. Both die cast alloys and plastics have a very wide range of possible properties. However, common die castings alloys will have as good or in many cases much better strength, weight, and heat tolerance than average plastics. Using typical materials for each process typically results in cost reductions, shorter lead times, and less impact on the environment.

In the case of strength, Die cast parts are stronger than plastic injection moldings having the same dimensions. Table 1 shows three of the most common die cast alloys compared to ABS and Nylon 6 plastics. This table reveals

that all the die cast alloys are stronger than the plastic materials. Not only are they stronger, but in the case of aluminum and magnesium are 2-3 times stronger per pound than the listed plastics. This means thin wall die castings can be stronger and lighter than many plastic injection molded parts. Zinc is the densest material listed. High density may be preferred in some cases.

One other advantage of die casting alloys is their ability to tolerate higher temperatures than most plastics. A quick comparison of the melting temperature reveals this truth. The melting temperatures of die casting alloys are 2-3 times higher than the typical plastics in Table 1. In many applications plastic components are protected from heat sources. Using die castings some or all heat shielding can be removed. This can reduce weight and manufacturing costs.

Table 1:

	A380	ZINC 3	AZ91 D	ABS	NYLON-6
Density (g/cc)	2.76	6.6	1.83	0.805	1.145
UTS (Mpa)	324	240	234	31.5	70
Elongation (%)	3.5	16	3	2.4-110	10-120
E (Gpa)	71	85.5	44.8	1.7-6.0	0.4-0.8
Fatigue Str @5E8 (MPa)	138	56.5	97		
Conductivity (W/mK)	109	113	72.3	0.128-0.19	0.23-0.29
Melt Temp (°C)	593	387	596	160-274	190-238
Str/Weight	117.39	36.36	127.87	39.13	61.14

Alloy versatility – The table also illustrates another benefit of die casting – the well-documented properties of die casting alloys, allowing designers to conduct finite element analysis during the design process. This chart was adapted from NADCA's Product Specification Standards for Die Castings publication that provides different physical property criteria for evaluating a series of alloys.

The comparison shown above only includes popular, alloys with standard chemistries that are used in a wide range of designs. In reality there are many more standard alloys, as well as custom alloys, and new alloys being developed. Like plastics there is huge variety in the properties of these alloys. Software programs are now available to assist designers in finding to correct alloy formula for a specific task. NADCA, in conjunction with Worcester Polytechnic Institute WPI, has created i-Select AI software to help designers, product specifiers and die casters identify the alloy chemistry needed to meet a specific set of casting properties, such as density, thermal conductivity, ultimate tensile strength, tensile yield strength, ductility and elasticity.

Dimensional accuracy and stability – Die casting produces parts that are durable and dimensionally stable, while maintaining close tolerances. Plastic parts are more prone to warping and surface “sinking” in areas above ribs is far more prevalent. Creep resistance is also better with many die casting alloys. As the chart above shows, even stronger glass filled plastic has an elongation factor that is twice that of aluminum and magnesium alloys.

The modulus of elasticity for common die casting alloys ranges from 6.5 to 12.4 x 10⁶. This modulus is roughly 30 times common plastic modulus of 200,000 to 400,000 psi. The dimensional tolerances of both die castings and plastic injection molded parts are similar because both are made in a steel die. However, maintaining these tight tolerances is easier for large die cast components over plastics. This is due to die casting alloys having a significantly higher stiffness.

Multiple finishing techniques – One major design consideration is perceived quality. Although a material will perform admirably in its applications, the product can be perceived as substandard if it feels “cheap”. Die cast parts can be produced with smooth or textured surfaces, and they are easily plated or finished with a minimum of surface preparation. The high density of zinc imparts a feeling of permanence and a solid product. Some finishes make zinc look and feel like steel. Aluminum can be anodized, powder coated, and chromed to make it appear however the consumer would like.

Also, parts may be cast with lettering or ornamentation that permits finer details and greater resistance to wear than plastic parts. These details require no secondary finishing operations while providing details that say “Quality” to consumers.

Shielding and thermal management – Since die castings are metal they are very conductive of both electricity and heat. Electrically die cast alloys are many millions and sometimes billions more conductive than plastics. This means that die casting alloys can do a very good job of shielding components from external electrical noise.

On the thermal side die cast alloys are roughly 1000 times more conductive than plastics. This property opens many possibilities to a designer. It means that thermal management of electronic components can be cast directly into their case. Another example would allow improved heat exchange in engines. One can think of many more examples where increased thermal conductivity is beneficial.

Tooling costs – Die casting and injection molding have similar tool costs and lead times to produce tooling, so this is simply not a competitive factor when choosing between the two processes. A common misconception is that plastics tooling is less expensive, which is not the

case. In fact, as glass reinforced plastics, such as plastic 6, may be harder to process and create more tool wear than some die casting alloys.

Recyclability – More than 95% of the aluminum die castings produced in North America are made of post-consumer recycled aluminum. Since the production of recycled aluminum alloy requires less energy than producing alloy directly from ore or other methods, there is a dramatic conservation of nonrenewable energy resources. The opportunity to recycle obsolete or worn out parts is also a critical factor for companies focusing on “end-of-product-life” planning. More than 85% of the aluminum in a car is currently reclaimed and recycled, while much of the plastic in a scrapped vehicle is treated as “fluff” and sent to waste dumps. Even when plastics are recycled, results may be unpredictable. Unlike recycled metals, the effects of temperature, time and the environment can degrade the potential performance of a recycled engineering thermoplastic.

Carbon Footprint – Everyday the carbon footprint of a component is increasingly more important to evaluate and reduce. As regulations are written and enforced reducing the carbon footprint has the potential to greatly reduce the manufacturing cost of a component. A study in 2008 evaluated the carbon footprint of a 4-cylinder engine cam cover. This cover was analyzed for 30% glass filled nylon, A380 Aluminum, and AZ91D Magnesium. It was found that producing the plastic for the part created 10 times more per pound carbon equivalent emissions than creating the aluminum does. Magnesium produced much more carbon equivalent emissions because current technology utilizes SF₆ which is an extremely potent green house gas. In the future as SF₆ use is reduced magnesium will have a very small footprint.

Over the entire life of the cam cover it was estimated that the aluminum part results in 5 kg less carbon emissions per kg of aluminum than the nylon cover. It was noted in this report that this aluminum has a huge advantage over other materials because of its recyclability. Magnesium would see similar low carbon footprints with increased recycling and decreased use of SF₆.

Product Examples

Specific examples of the advantages of die casting compared with plastics are illustrated by recent winners of NADCA's International Die Casting Competition. In each case, the designs show the primary benefits of die casting and in some instances demonstrate multiple advantages.

Cam cover – Toral Cast Light Metal Technologies, Concord, Ontario, Canada, produced the die cast aluminum cam cover to replace plastic cam covers on GM inline 4-cylinder engines. The aluminum cam cover provides

structural integrity at elevated temperatures (up to 150 degrees C/300 degrees F) and better sealing to prevent oil leakage, plus it requires fewer fasteners, which reduces overall manufacturing costs. The cam cover, now 100% recyclable, was cast using an innovative three plate die with a central gating system, allowing the most favorable flow and solidification patterns.

Conclusion

These are just some examples of the many ways OEMs are using die casting to replace existing processes. Many designers evaluate the various process factors based on their own experience or in conjunction with their suppliers. The North American Die Casting Association (NADCA) also provides on-site seminars to help OEM designers capitalize on today's advanced die casting capabilities for component designs. The "Creating Value with Die Casting" seminars analyze current processes to determine where die casting can help reduce costs and improve the final product. ■

About NADCA

Headquartered in Wheeling, IL, The North American Die Casting Association (NADCA) acts as the voice of the die casting industry, representing more than 3,100 individual and 300 corporate members in the United States, Canada and Mexico. NADCA serves the industry by providing industry news, technical information, networking opportunities, publications and trade events. NADCA is committed to promoting industry awareness, domestic growth in the global marketplace and member exposure.



NORTH AMERICAN DIE CASTING ASSOCIATION

241 Holbrook Drive Wheeling, IL 60090

Tel: 847.279.0001 Fax: 847.279.0002

Email: oem@diecasting.org

www.diecasting.org