NADCA DESIGN

NORTH AMERICAN DIE CASTING ASSOCIATION

Die Casting Advancements

> **Building on processes developed in the previous century, Herman Doehler invented modern high pressure die casting (HPDC) as we know it when he patented the first true die casting machine in 1907.**

The process was originally used almost exclusively for manufacturing typesetting pieces, utilizing malleable materials with low melting points, such as zinc, to create products. From typesetting pieces, die casting moved on to produce phonographs, cash register components, and today, many components for the automotive industry.

Die casting, the process through which molten metal is forced into a steel mold through hydraulic or pneumatic pressure before cooling and creating a final product, produces a higher volume of parts per year than any other metal casting process.

The process' benefits are wide ranging, and accommodate seemingly paradoxical needs: lightweight but stiff, ductile but strong, long-lasting, consistent, and versatile. Furthermore, the number of different alloys suitable for die casting is impressive. Not only are lead and tin still used in the process, but copper, magnesium, aluminum, and zinc are all now commonly used. Each alloy has its own strengths and applications.

Advancements in Die Casting Technology for the Automotive Industry

Though the list of uses for HPDC is constantly growing, the number of applications surged beginning with the Great Recession of 2008. This growth is expected to continue, with components designed as die castings projected to grow faster than those designed for other casting processes.

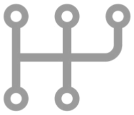
Today, the automotive industry accounts for more than half of the die casting industry's current output, a growth attributable to a variety of factors. One cause has been automotive designers' realization that the properties they need to satisfy crash and safety-critical application requirements can be achieved by high quality high pressure die castings. Die casting also allows for high degrees of dimensional repeatability, cost efficiency, and superior finish.

A larger, underlying reason for the growth of die cast parts in the automotive industry is the growing interest in improving fuel consumption, which can be accomplished by reducing the weight of vehicles. In fact, trends in engineering place a focus on lightening the weight of vehicles. Other emphasis lies on retained stiffness, more electronic safety protections, and smaller carbon footprints with maximized internal space.

Simultaneous to these benefits are the positive side effects of less overdesign for crash, the need for smaller engines and powertrains, and changes in frame design and collision scenarios.

Replacing steel structural components with lighter aluminum components accommodates the complex geometries and thin-walled sections that components in the automotive field require. Forgings, ferrous castings, stamping, and weldments are a handful of the processes replaced by die casting components for structural applications.

The three vehicle systems where most high-pressure die casting weight resides are:



Transmissions and Driveline

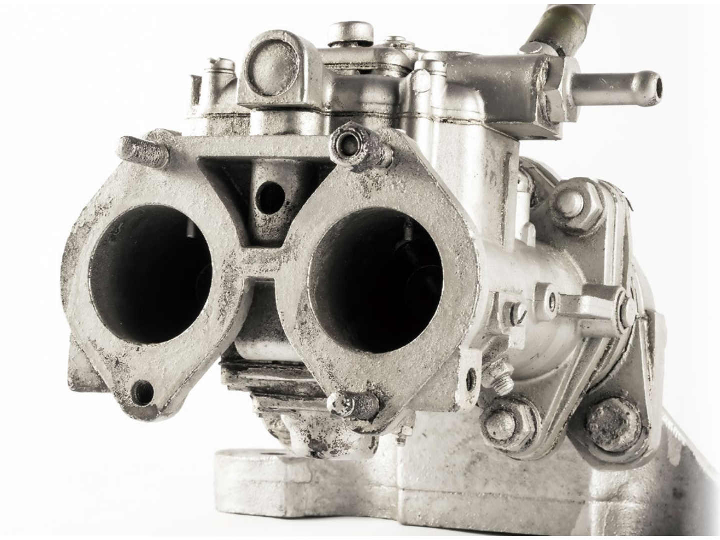
Engines

Heat Exchangers

Experts forecast significant growth in aluminum content in the next decade.

Avoiding Material Challenges

One of the greatest strengths of die casting is that it is not subject to the limitations in materials that other metalworking techniques face, allowing for the use of a tremendous number of different alloys. Each material has strengths and weaknesses that they lend to die castings, so it is important to choose the right one for your automotive application.



For example, lead, tin, and zinc, the original die casting materials, are still in use today. They have low melting points and high malleability, which makes them easy and inexpensive to work with — those same properties also make them incompatible with most, if not all, automotive applications, which require strength, heat resistance, or both.

On the other hand, aluminum and magnesium make for excellent die cast automotive parts, particularly structural components traditionally machined from steel sheet. Despite being considerably lighter than steel, both aluminum and magnesium have high strengths and strength-to-weight ratios, making die castings of these materials ideal structural steel replacements.

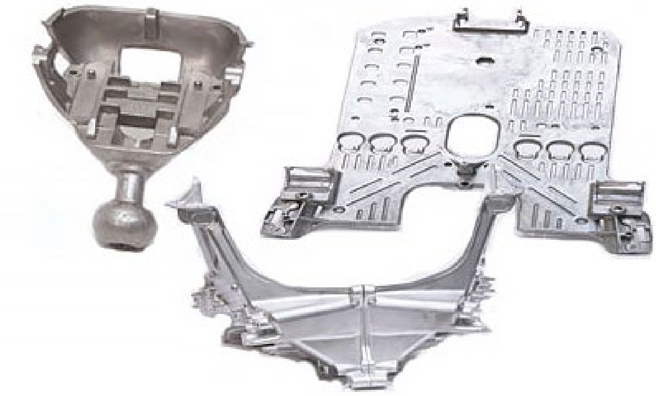
There is also a constantly evolving, growing list of alloys designed for use in die casting. This alloy creation process dates back to the invention of die casting itself — early on, iron was added to softer materials in order to reduce the incidence of die soldering, despite the fact that this addition weakened the materials' physical properties.

This practice of adding iron continued when aluminum became the die casting material of choice. However, the recent discovery that the addition of strontium to die casting alloys protects against die soldering has allowed for a reduction in iron levels; this change naturally led to the strengthening of die cast aluminum parts.

Before the incorporation of strontium, there were workarounds to the iron issue. One was the use of low pressure and permanent mold casting processes for parts in strength-critical applications. The process worked, but was slower than HPDC and generated bulky, heavy castings — a serious impediment for an industry seeking sleekness and weight loss.

One newer alloy particularly well suited to HPDC automotive applications is aluminum modified A380, development of which was contributed to by research and development projects funded by the North American Die Casting Association (NADCA). A low iron and high copper alloy to which strontium can be added, A380 features more elongation than other alloys, as well as good tensile, yield, impact, and sheer strengths.

Lower iron content due to strontium can significantly increase the life of a casting. Fatigue tests conducted on identical engine bed plates made from aluminum alloy XK360 — one bed die cast from a high-iron version of the alloy, the other die cast from a strontium-added low-iron version — showed drastic results. The engine bed plate made from the low-iron XK360 showed stress points with 100 times increased lifespan.



Technologies and Procedures

As die casting alloys improve, so too do die casting technologies and related procedures. From the modern HPDC process, three unique die casting methods have emerged.

Squeeze Casting - Semi-Solid Metal Casting - Vacuum Die Casting

are all actively used in high integrity, high volume commercial production, and they all work to remedy die casting defects — namely air entrapment, gas porosity, and solidification shrinkage — that are particularly worrisome for automobile manufacturers.

Air entrapment is very detrimental to structural strength. Squeeze casting, with its larger gate areas, discourages air entrapment by allowing for planar die filling. Equally harmful to the performance of die cast parts is porosity. Vacuum die casting, wherein a vacuum system extracts air from a die cavity as it is filled, decreases air entrapment — it also allows for lower temperature molten metal and more efficient cavity filling.

As injected metal cools in the mold, the gases it absorbed while in a liquid state are released and become trapped. Because the exterior of a die casting cools first, it has a fine microstructure, low porosity, and higher strength, while the core of the part is left with a drastically higher porosity — this is known as the skin effect. This inhomogeneous porosity distribution undermines the integrity, strength, and other properties of a die cast part.

Semi-solid casting solves this issue. A semi-liquefied, as opposed to fully liquefied, metal is used. The metal absorbs less gas before injection, consequently releasing less during cooling. The result is die cast parts with extremely low rates of porosity.

Aside from the updated HPDC methods themselves, advancements are being made in the ancillary technologies that go along with them. For one, conformal cooling systems are becoming more prevalent. In conformal cooling, special channels surrounding the primary part cavity are included in a die. The channels can be filled with coolant, yielding a number of benefits: more uniform cooling, which leads to lower porosity; stronger, higher quality parts; and reductions of cycle times that can reach 30% or even more, hugely important for the fast-paced, high-volume automotive industry.

Beyond that, general process controls for conventional HPDC and emerging HPDC methods alike are advancing. They are helping die casters decrease defect rates, improve various strength values, and manufacture parts with thinner walls and more complex geometries than ever before.

These types of technological advances are driven, in part, by global benchmarks for quality, reliability, and efficiency. They are supported by further research and development, simplified and improved testing procedures, and commitment to broad-based training of new die casting professionals that hightlights all new and emerging technologies.

Learn More with NADCA

The North American Die Casting Association (NADCA) has been the leading die caster representational body in the United States since 1989, when the American Die Casting Institute (ADCI) and the Society of Die Casting Engineers (SDCE) merged.

Today, we are actively engaged in not only representing more than 500 die casters from the United States, Canada, and Mexico, but in providing valuable educational resources, and in funding innovative research and development initiatives, where we are at the forefront of the development of high integrity die casting methods. The automotive industry, readier than ever to look into cost effective, light-weight substitutions of traditional structural steel, has been one of our primary focuses.

To learn more about different high integrity die casting methods and for help in determining whether they may be right for your next die casting project, contact NADCA today.

Contact NADCA

View Product Specifications for Die Castings

NADCA DESIGN
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