ALLOY DIE CASTING

ULTRACAST, INC.

PRECISION DIE CASTINGS
PART SELECTION & DEVELOPMENT

Technical Report

HOW TO IDENTIFY DIE CASTING OPPORTUNITIES

Component manufacturers and OEMs have used die casting for more than a century to produce complex, repeatable metal parts at greater speed and a fraction of the cost of traditional hog-out machining. No other mass production technique can deliver such a wide range of complex metallic shapes within such close tolerances, allowing manufacturers to develop intricate designs that can be cast to near finish dimensions, often requiring little or no machining other than simple flash removal. The challenge for many engineers is recognizing candidate parts that could be manufactured efficiently via die casting to deliver a net cost savings, and also understanding the capabilities and limitations of the die casting process.

The vast majority of die cast parts are made from aluminum alloys, although zinc, copper, lead, tin and magnesium are also used for specific applications. Aluminum offers excellent dimensional stability and a smooth surface finish, and many of its alloys are well suited to die casting. Most die cast parts are specified as replacements for machined parts or other casting methods, typically achieving significant cost savings through faster production and/or eliminating secondary operations such as milling, drilling and mechanical fastening.

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The die casting process allows a wide variety of shapes, intricacy of design and close dimensional control.

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INTRODUCTION

The die casting process consists of injecting molten metal into a reusable steel die (cavity) at high speed, then holding it under pressure until it solidifies into a net shape metal part. Using computerized controls, modern die casters can produce high-precision, high-strength components with very short production cycles. Of the most common production methods for small and medium-sized parts, the primary advantages of high pressure die casting are low piece price and physical performance. In fact, no other casting process allows a wider variety of shapes, greater intricacy of design or closer dimensional control.

SELECTION CRITERIA

Identifying candidate parts for die casting involves several factors. One of the first considerations is the physical dimensions of the part. Die casting can readily produce components with a wall thickness of .060" and even less, while holding a dimensional stability of around +.002" for the first inch and approximately +.001" for every linear inch thereafter. There are limits to the shapes die casting can achieve, however. Sharp corners and undercuts can be difficult or impossible, while radii and custom shapes can be easily formed.

Typically, the more complex the shape (and the more machining that's required to produce it), the greater the potential benefit from die casting. Smaller parts are easier to cast in very thin sections. The larger the area, the more difficult it becomes to maintain a thin wall without strengthening ribs or other features that will aid in filling, as the metal begins to solidify before the cavities are completely loaded, even in a heated tool.

Physical size limits depend on press tonnage. Most die casters specialize in a range covering 400-500 tons, while larger suppliers will have capabilities spanning 1,000 tons or more. A large press (1,300 tons) may be able to produce aluminum parts as large as 600 square inches, depending on the geometry, and simple designs more than 5 feet long have been successfully die cast. Smaller presses can accurately manufacture components as tiny as the teeth on a zipper.

By nature, die casting delivers excellent dimensional repeatability, but many end users are finding that testing and quality control issues are a significant challenge when production is outsourced internationally. Engineering changes in particular can be difficult with an overseas supplier. In selecting a die caster, specifiers should look for extensive test and measurement capabilities, including real-time x-ray for initial part qualification and ongoing quality control.

Another factor is volume. A manufacturer needing just a few hundred units per year of a fairly simple part would find it unlikely to be cost effective to die cast it. In contrast, a complex design that requires a number of operations when made via traditional machining might deliver a quick payback through die casting, even in modest volumes. Production rates generally far outstrip any other casting method, with cycle times frequently under a minute.

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A large die casting press can produce parts as large as 600 square inches.

Very large castings weighing several pounds may require as little as 2-3 minutes, demonstrating that die casting is the fastest available technique for manufacturing precise non-ferrous metal parts. An experienced die caster will also have mastered the art of quick tool changeovers, helping to minimize set-up costs and lead times. While many casting shops seek only large-volume production work, others concentrate on highly-engineered, complex designs.

In some applications, strength can be an issue. Die castings cannot match the physical properties of wrought alloys, but most parts are able to compensate for any compromise in material strength with minor design alterations, such as strengthening ribs. When greater strength or durability is required from a specific section of a part, inserts can be cast directly into a component to deliver the physical properties needed. A slug of raw material is usually loaded into the tool, and molten metal is cast around it. For high-strength applications, steel is often used, while critical zero-porosity requirements can be met by using a slug of aluminum, which can be machined without uncovering any porosity and offers weight and cost advantages. Pressed-in helicoils, bearings or bushings are also common to replace machined or mechanically fastened components.

Typically, the more complex the shape, the greater the potential benefit from die casting.

Finishing operations are another factor when considering a switch to die casting. Ideally, the part and tool design should produce a component that's close to finish dimensions, to minimize subsequent machining. Typically, the more complex parts offer the greatest opportunity for cost savings, as die casting can often eliminate several secondary operations required to complete a machined component.

When additional machining, surface finishes or very close tolerances are needed, a competent die caster will have in-house capabilities for drilling, tapping, milling, grinding, deburring and other operations. The most capable suppliers will have extensive CNC facilities for rapid production, as well as trained toolmakers on staff to ensure part quality and help extend tool life.

Die cast parts can be cleaned and treated with any of a number of protective coatings, such as chemical film, anodizing, chrome or other plating. Surface enhancement can be achieved through impregnation, which seals porosity voids that occur naturally in any casting process, especially after machining. Cosmetic options include painting, powder coating and blast finishing. Many die casters will have some in-house capabilities for labeling and ink stamping, but most firms will subcontract extensive marking or silk screening projects.

ENVIRONMENTAL IMPACT

The die casting industry as a whole is based on a system of recycling. The metal alloys commonly used by die casters are produced from recycled raw materials, manufactured with far less energy than that required for virgin alloys. In fact, it's been estimated that more than 95% of the aluminum die castings produced in North America are made from post-consumer recycled aluminum, helping to keep the aluminum content of municipal solid waste to less than 1%.

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Die castings are not typically considered as hazardous waste, and pose few problems in handling or reprocessing. The scrap from a casting run is captured for subsequent re-use, whether it's re-melted for casting additional parts or re-alloyed for manufacturing high-performance components. Even so, among the challenges faced by die casters is the amount of paperwork required to comply with the growing number of federal environmental regulations. The constant effort to stay current with new rules and requirements is particularly troublesome for smaller firms with limited resources.

Valve bodies, pump housings and enclosures of many types can be successfully die cast to save machining time and reduce costs.

DESIGN

In order to extract maximum benefit from the die casting process, it's important to involve the die cast engineer as early as possible in part design and development. Early consultation will help the caster to optimize part design, avoid tooling problems and foresee potential manufacturing issues, giving the tool designer the opportunity to build dimensional accuracy and longevity into the die, while locating gates, runners and slides for maximum efficiency and minimum porosity.

Early involvement by the die casting firm can also help identify potential savings that may not be apparent to an untrained eye. Certain parts may offer an opportunity for savings through a multi-cavity die, for example, in which more than one identical part is cast at a time, or a family die producing two mating parts in a single cycle.

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In some cases, parts with similar geometries can be cast using replaceable inserts or slides, allowing the use of shared tooling to reduce costs. With optimum gate placement, tool designers can help avoid premature wear and prolong die life. In critical areas, replaceable tooling components can be designed so that when the tool does begin to wear, a slide or insert can be changed without having to replace the entire tool.

TYPICAL APPLICATIONS

There are several industries which have long histories with die cast parts, including automotive, aerospace and medical. The process has been used to manufacture enclosures and housings of many types, pump components, valve bodies, connectors, fan shrouds, levers, covers, heat sinks and countless other designs. In general, engineers look for parts with low to moderate strength requirements, including tensile strength under 45,000 psi and yield strength less than 22,000 psi.

In the automotive industry alone, it's estimated that nearly 300 pounds of aluminum castings are currently used per vehicle, an amount likely to rise with the increasing emphasis on weight and fuel economy. In fact, NADCA states that 90% of all finished products already contain one or more castings. Volumes range from just a few hundred parts per year to more than a million.

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