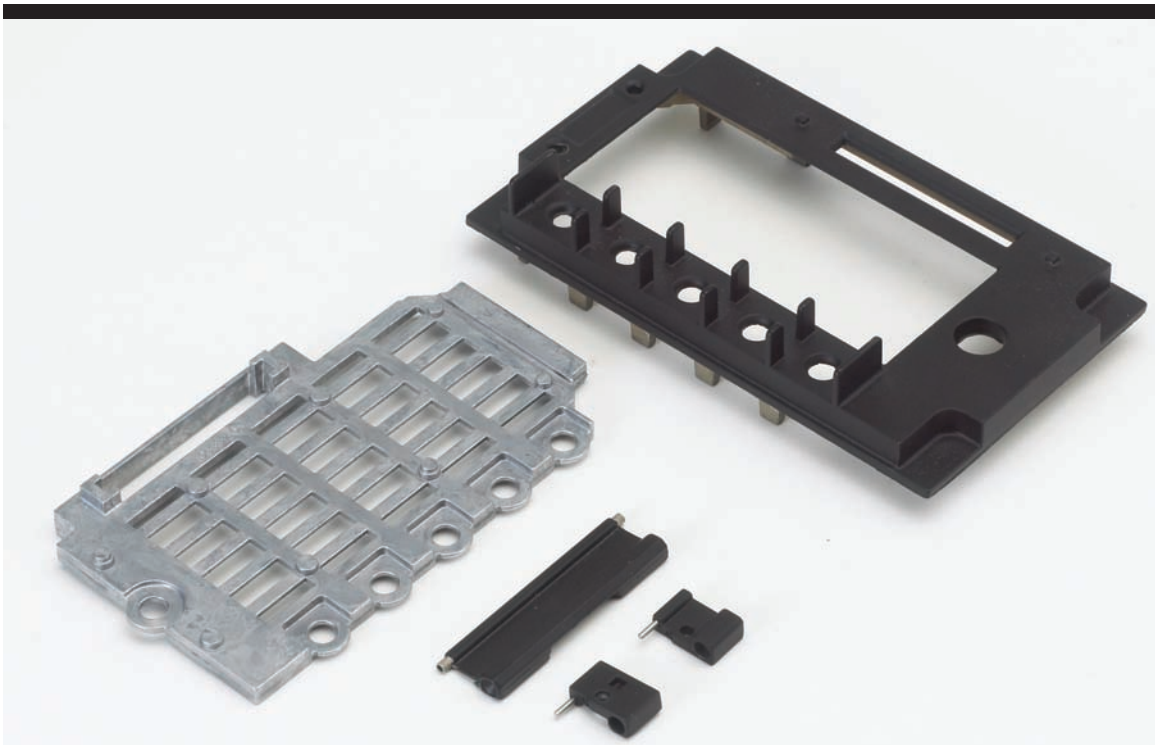
ALLOY DIE CASTING

ULTRACAST, INC.

METAL PARTS:
AN OVERVIEW OF PRODUCTION METHODS



Technical Report

INTRODUCTION

Few manufacturing techniques can rival traditional machining for producing extremely close-tolerance, complex metal parts with excellent surface characteristics. With today's extensive computer-controlled automated machining centers, OEMs have the ability to cut, drill, mill and grind 3-D shapes of infinite variety with a die maker's touch, at speeds never before possible.

Even so, conventional hog-out machining is a relatively slow process compared to other manufacturing techniques, and it typically produces significant scrap from the various metal removal steps. The capital equipment is also very expensive, with large CNC machines easily costing hundreds of thousands of dollars and requiring a highly-trained employee to program, run and maintain.

True part cost is typically the reason an OEM investigates alternative production methods. In general, the more complex the shape (and the more machining that's required to produce it), the greater the potential benefit from switching to a cast or molded component. The earlier in the product life cycle that a change from machining is made, the more value there is likely to be.

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PRODUCTION METHODS

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 cools sufficiently to solidify. Using computerized controls, modern die casters can produce high-precision, high-strength components with very short production cycles. When comparing the most common production methods for small and medium-sized designs, the primary advantages of high pressure die casting include low unit price, rapid production and excellent physical properties of the finished part.

Die casting delivers tight tolerances and outstanding repeatability, allowing parts to be cast to near-net shape and frequently reducing the number and complexity of secondary finishing operations. In fact, few other casting processes allow such a wide variety of shapes, intricacy of design or closer dimensional control. Tooling costs and lead times are generally higher than other casting / molding techniques, but die casting can deliver production rates that allow payback many times over a product's lifespan. For more information, see: www.alloydie.com.

Similar to die casting, **FOUR-SLIDE CASTING** involves molten metal delivered into a die cavity to form a part. Designed primarily for zinc alloys, the process uses four perpendicular slides -- movable tooling components that index toward the center of the cavity when the die is closed and filled. The result is a tightly controlled, high-speed process that can yield thin-walled components so complex they would need to be assembled from two or more pieces if alternative casting methods were used. The technique can produce very thin sections, often .020" or even less, and part tolerances of ± .001" are not uncommon. Four-slide casting is so precise that most parts have little or no flash, helping to reduce secondary operations. The tooling tends to be somewhat less expensive than aluminum die cast tools, partly as a result of its smaller size and the elimination of trim tooling.

SAND CASTING is a means of producing rough metal castings using a sand mold that is formed around a replica of the object to be cast and then removed once the sand has been compacted. From the part blueprint, a skilled patternmaker builds a model of the object to be produced, often using wood, metal, or some type of plastic. Once the sand is compacted, the pattern is removed and molten metal is poured inside. When the metal has filled the mold and sufficiently cooled, the sand mold is broken to extract the metal part. Sand casting is well suited to large parts with loose tolerances and low production volumes. Commonly used in the decorative iron industry, sand castings can be made from ferrous metals and non-ferrous alloys that are not suitable for die casting. It is also used for non-load bearing parts made from aluminum. Sand cast tooling is inexpensive, and part prices are typically moderate.

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Like sand casting, **PLASTER CASTING** is typically a lower-volume production method that offers excellent design freedom and low tooling costs. Often employed for prototyping, the process involves a master pattern to create single-use tools. A plaster-like material is poured into the two halves of the tool and allowed to dry, then extracted. The resulting mold is baked, then the two halves are clamped together. Molten metal is poured in, and the applied vacuum helps quickly draw the liquid into all areas of the cavity before it can cool enough to solidify.

When the part solidifies, the mold is removed with water, which allows the process to cast thin-walled parts, undercuts and other shapes that cannot be achieved using a steel tool. Another advantage is reduced porosity as a result of the vacuum, which contributes to a very fast fill and a grain structure that delivers excellent strength. Tooling is relatively inexpensive, usually requiring just a few days to create a master tool. Plaster casting is a labor-intensive manufacturing process, however, best suited for low volume requirements. Price per part is typically high. For more information, see: www.ultracast.com.

The **INVESTMENT CASTING** or "lost wax" process of forming metal wax patterns made from the article to be cast and then dipped into a ceramic slurry, which turns into a shell when dried. The shell is then baked, causing the wax to melt out. Molten metal is poured into the hollow shell and allowed to cool, and the ceramic shell is broken away. The result is a metal casting that has the detail and precision of the original wax pattern. The primary advantage of investment casting is low tool cost, but parts are typically expensive. The labor-intensive process requires a physical model for every casting, and is generally well suited only for low-volume production.

PERMANENT MOLD CASTING is a gravity-fed process that employs a casting die typically made from iron or steel, often in conjunction with metal or sand cores. The method involves pre-heating the 2-piece mold, then pouring in molten metal and cooling it sufficiently to permit solidification and removal. Because of the density of the gravity-fed pour, permanent mold castings can often be made stronger than either die castings or sand castings. Semi-permanent mold casting, which uses expendable cores of sand or some other material, is used when permanent cores would be impossible to remove from the finished part, allowing the process to yield shapes not attainable with die casting techniques.

FORGING is a process that uses both heat and pressure to form parts out of a solid slug of metal using a 2-part die. The die is heated, and a hot slug is placed in the lower half of the die cavity. With a downward stroke of the forging ram, the upper die is forced against the slug under great pressure to form the part. Forging delivers parts that are dense and strong, with the physical properties of wrought alloys. They can also be produced in ferrous metals and other alloys and sizes that are not attainable by die casting.

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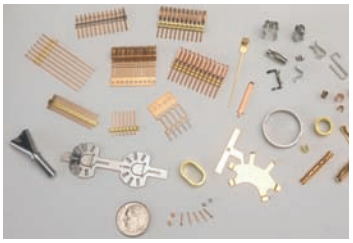

The **METAL STAMPING** process typically involves roll, sheet or plate stock, which is either stamped on a press using dies and punches or pulled into shapes on hydraulic deep drawing machines. The process may involve a single operation or many small steps (progressive stamping). In a progressive operation, each step produces a gradual change in the part: piercing or enlarging a hole, trimming an angle, creating a radius, etc. By nature, stamping is a subtractive process that creates significant waste. From each hole or punched dimension, scrap is created that must be collected and sent to a metal reprocessor. Stampings can be made of steel and other metals not suited to casting, and they deliver the physical properties of wrought metals.

SCREW MACHINING is another technique for manufacturing certain metal components, essentially by using an automated turret lathe designed to make turned parts such as threaded rod and fasteners in large quantities. CNC turning centers offer versatile capabilities and rapid setup that can often produce prototypes faster than a screw machine, but typically cannot match its high-volume capability for production. Like stamping operations, screw machined parts produce a significant amount of waste, but they can be manufactured from steel and alloys which cannot be die cast. They offer the properties of wrought metals, and tooling costs are usually moderate.

CONCLUSION

There are many production methods for efficient manufacturing of metal parts to replace complex machined components, and each has benefits and limitations. An experienced and trusted supplier should be knowledgeable about any of them, and able to provide advice on which technique best matches a customer's needs for a given part design. Choosing the optimum production method will depend on a number of factors, including the part's shape and physical dimensions, volumes needed and product life cycle, as well as strength and surface finish requirements.

Early involvement by the manufacturing firm can help identify potential savings that may not be apparent to an untrained eye. A full-service, customer-focused manufacturer will have qualified engineers on staff to offer assistance in selecting the right process, providing sound advice on what technique will produce the greatest benefit in a given situation, even if it happens to be a service that firm does not offer.

Production Method	Part Cost			Tooling Cost			Lead Time			Mechanical Properties		
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Die Casting	●					●			●			●
Sand Casting		●		●			●				●	
Investment Casting			●		●			●			●	
Permanent Mold Casting		●				●			●		●	
Forging		●			●				●			●
Metal Stamping	●					●			●			●
Screw Machining		●		●				●				●
CNC Machining			●	●			●					●

For more information, call (714) 521-9800 or email sales@alloydie.com

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