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A CASE STUDY ON SIGNIFICANCE OF DIE CASTING IN AEROSPACE APPLICATION

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Abstract

Die casting is a very old manufacturing process in which implementation of new technology leads to more flexible, innovative and enhanced properties in aerospace applications. This paper contains collection of various aerospace parts like in a military aircraft the infrared system, engine components like front frame, tail rotor gearbox housing, door panel latch housing, ball housing, wheel cover outer and inner hub, piston casting, back plate part, fire sensing part, impeller part, aerospace parts like lens, spacer ring, knob, valve, valve cap, propeller tip, fuel door cover, etc are manufactured by using die casting process and there are a number of die casting processes such as high pressure die casting, low pressure die, gravity die casting and squeeze casting process. The significance of the process and the part to be manufactured depends on various factors like material type and its properties for specific applications.

Keywords: Die Casting; aerospace; Cold and Hot Chamber Casting.

1. Introduction

Die casting is one of the most economical casting processes for manufacturing precision shaped parts in mass production. Die-cast components are being used increasingly in the aerospace, automobile, electronic and other industries because of their premium quality, low cost, and low weight. The demand for lightweight, high performance and high temperature materials for advanced structural applications is increasing in many industrial sectors. [1] Die castings produced have the advantages minimum allowances on machined surfaces, high dimension accuracy of a complete series, high surface quality, die casting with small thickness of walls having uneven shape, high productivity of die castings production. Die casting is a process, in which the molten metal is injected into the mold cavity at an increased pressure up to 200 MPa. Die casting is a highly productive method of casting parts with low dimensions tolerance and high surface quality. [2] Manufacturing process selection is the task of choosing a method for transforming a set of material into a given shape using one or more processes. The kingdom of processes contains broad families such as casting, deformation,

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molding, machining, etc. each family contains many classes; casting contains sand –casting, die-casting, and investment casting, for instance. [3] Aircraft structural design is a subset of structural design in ships, land vehicles, bridges, towers, and buildings. All structures must be designed with care because human life often depends on their performance. Structures are subject to one-way and oscillating stresses, the latter giving rise to fatigue. Metal structures are subject to corrosion, and some kinds of corrosion are accelerated in the presence of stress. Choosing the right manufacturing process for making a component is an important consideration at the early stages of design. In metal casting process, there are over forty different processes with different capabilities. A designer can benefit from knowing the manufacturing process alternatives available to him. Inaccurate process selection can lead to financial losses and market share erosion. The kingdom of processes contains broad families such as casting, deformation, molding, machining, etc. each family contains many classes. Casting contains sand casting, die casting, and investment casting, for instance. [3] Each casting process has its own possible production rate or an economical range of production rates although individual rates will differ depending on process capability. For example die casting can produce parts at a rate of thousands per hour while the cycle time for sand casting is typically take long time to produce limited parts than die casting. [3] Die casting is a process for producing castings by die casting machines, where molten metal is injected into a permanent mould at high speed (10 - 100 m/s) and under high pressure as shown in figure 1. Die casting is a highly productive method with low dimensions tolerance and high surface quality. The quality of the castings filled under pressure is influenced by many technological factors like speed of pressing during the cycle of casting, after pressure, the temperature of cast alloy, the temperature of the filling chamber, and the temperature of a mould. [4] Commonly used in the aerospace, transport and telecommunication industries, they are valued for their lightweight and range of special properties. Alloys can be custom-made for different applications to meet specific requirements such as impact absorption, acoustic properties or the ability to withstand high temperatures. Recent efforts have been initiated to apply the die casting process to the production of components for use in the aerospace industry using titanium, nickel and cobalt based alloys. [5] In this paper the significance of die casing and its processes in detail were discussed.

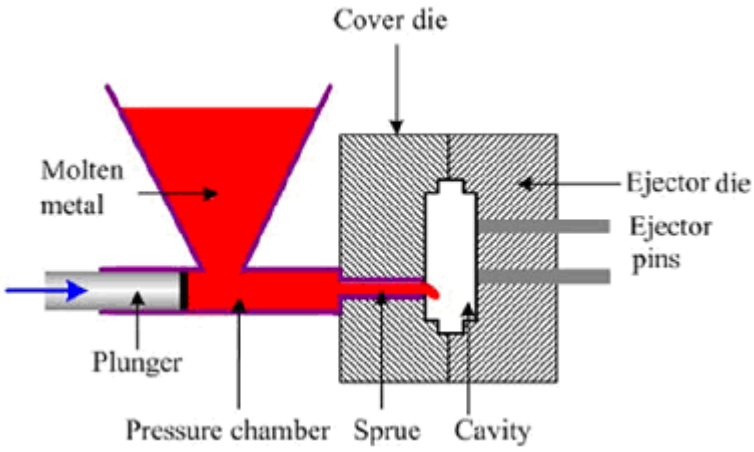

Figure 1: Schematic View of Die Casting Process

2. Classification of Die Casting Processes:

It is a popular manufacturing process for casting metal products. There are two main die casting process types and several variations in process design. All die casting process types are designed with the same goal and cast a mold using injected molten metal. Depending on the type of melted metal, part geometry and part size, different die casting processes can deliver superior results over alternative methods. The two main types of die casting processes are gravity die casting and pressure die casting.

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In gravity die casting as shown in figure 2, molten metal or semi molten metal is either poured under gravity which is known as gravity die casting. It represents proven and absolute precision technology for the production of large batch quantities. This process is used in carousel casting units or in shuttle technique particularly for the manufacture of engine castings. Gravity die casting is the simplest die-casting process. It can also be automated with either horizontally or vertically-parted dies. Good quality castings can be produced if sufficient care is taken to design running and gating systems which minimize surface turbulence in the metal as it flows into the die.

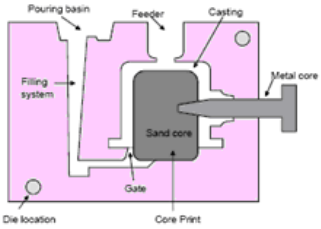

Figure 2: Gravity Die Casting

When molten metal is forced into mold cavities at high pressure is shown in figure 3 it is known as die casting. These molds cavities, called dies, can be designed to produce complex shapes with a high degree of accuracy and repeatability. Parts can be sharply defined, with smooth or textured surfaces, and are suitable for a wide variety of attractive and serviceable finishes. Parts can be as simple as a sink faucet or as complex as a connector housing.

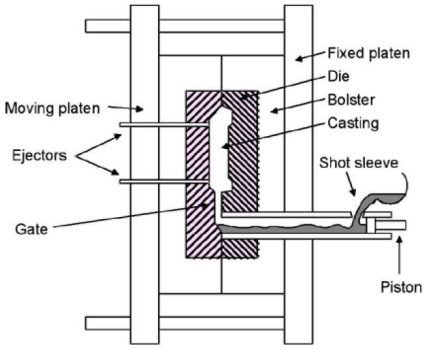

Figure 3: Die casting (high pressure)

In pressure die casting, molten or semi molten metal is forced under pressure (20 to 200kgf/cm^2) into a die and pressure is maintained till solidification stage, such casting is said to be pressure die casting. As metal flows under high pressure in pressure die casting, within a fraction of second the fluid alloy fills the entire die including all minute cavities; therefore the intricate casting can be produced successfully.

There are two basic types of die casting machines namely hot chamber machines and cold-chamber machines as shown in figure 4. These are rated by how much clamping force they can apply. Typical ratings are between 400 and 4,000 st (2,500 and 25,000 kg).

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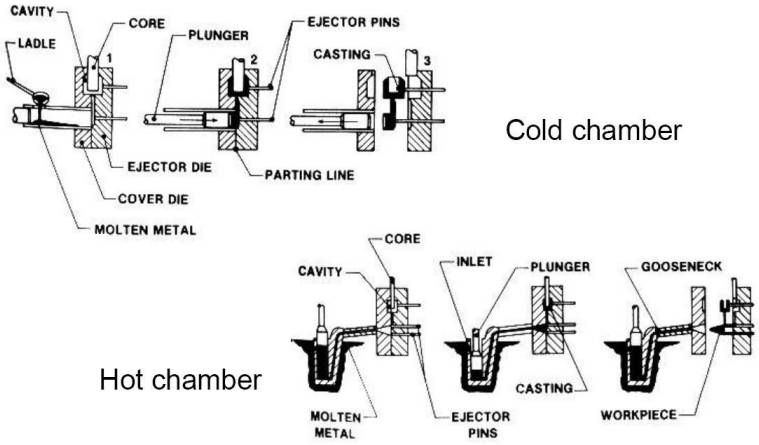

Figure 4: Hot and Cold Chamber Die Casting

The Squeeze Casting Process as shown in figure 5 was developed to counter unsoundness in die castings. Metal is introduced into an open die, just as in a closed die forging process. The dies are then closed. During the final stages of closure, the liquid is displaced into the further parts of the die. No great fluidity requirements are demanded of the liquid, since the displacements are small. Thus forging alloys, which generally have poor fluidities which normally precludes the casting route, can be cast by this process. This is a unique advantage enjoyed by Squeeze Casting. For this reason, it is sometimes known as Squeeze Forming, to emphasize its similarity to forging processes. The other great advantage of Squeeze Casting is of course the potential of the process to produce products which are effectively perfectly sound.

Figure 5: Squeeze Casting

3. Various aircraft parts manufactured by using Die Casting Processes:

The various aircraft parts manufactured by using die casting processes are like infrared system, engine components in a military aircraft, aircraft engine front frame, tail rotor gearbox housing, aerospace engine access door panel latch housing, etc. as shown in figure 6.

Figure 6: Some parts of aircraft

The other aerospace applications like aircraft housing part, ball housing and wheel cover outer hub, ball housing support, piston casting, back plate part, wheel cover inner hub, fire sensing part, impeller part. Aerospace lens, spacer ring, knob, valve, valve cap, propeller tip, fuel door cover, etc. as shown in figure 7.

Figure 7: Some parts of aerospace applications

3. Die casting process in aerospace technology:

The majority of non-ferrous castings are made in a wide variety of aluminium alloys and this is followed in importance by zinc alloys. Only relatively limited tonnages of castings are made in magnesium alloys because of their cost. These are mainly produced using die casting, sand casting and investment casting, with smaller tonnages being cast using squeeze casting and the *lost foam* process. There are a number of die casting processes, as summarized in figure 8. High pressure die casting is the most widely used, representing about 50% of all light alloys casting production. Low pressure die casting currently accounts for about 20% of production and its use is increasing. Gravity die casting accounts for the rest, with the exception of a small but growing contribution from the recently introduced squeeze casting process.

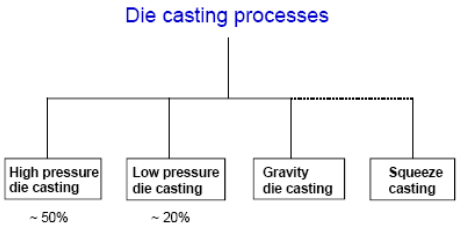

Figure 8: Die Casting Processes

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The die casting processes are limited by their poor productivity since it is necessary to wait for the metal to solidify before the die can be opened. As an example, the cycle time for producing a typical die-cast cylinder head is about 5 - 7 minutes, although this can be as long as 15 minutes for larger variants. Ideally, therefore, die casting should be restricted to thin walled components. The other limitations with all forms of die casting are the high cost of the dies themselves and their limited lives as a result of thermal fatigue which causes craze cracking of the working faces.

4. Conclusion:

The die casting is a better process in the field of aerospace applications to improve the properties. Various parts of aerospace applications can be manufactured using die casting process. The significance of the die casting process lies in selection of process type and its material.

References:

[1] Yatin H. Chauhan , Dr. Jyoti V. Menghani "Light Weight Metal And Titanium Metal Metrix: A Review" International Journal of Emerging trends in Engineering and Development, Issue 2, Vol.4 (May 2012).

[2] Stefan GASPAR "Technological Factors Of Pressure Die Casting" Annals Of Faculty Engineering Hunedoara – International Journal Of Engineering, Volume 9, 2011.

[3] Kasim M. Daws , Zouhair I. AL-Dawood , Sadiq H. AL-Kabi "Selection of Metal Casting Processes: A Fuzzy Approach" Jordan Journal of Mechanical and Industrial Engineering Volume 2, Number 1, March. 2008,Pages 45 – 52.

[4] Darina Matisková , Štefan Gašpar , Ladislav Mura "Thermal Factors of Die Casting and Their Impact on the Service Life of Moulds and the Quality of Castings" Acta Polytechnica Hungarica Volume 10, Number 3, 2013.

[5] John J. Schirra, Christopher A. Borg and Robert W. Hatala – Pratt & Whitney, East Hartford, CT, "Mechanical property and microstructural characterization of vacuum die cast superalloy materials", TMS (The Minerals, Metals & Materials Society), 2004.