UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN, ANALYSIS AND SIMULATION OF CASTING DEFECT ON WATER PUMP HOUSING USING CASTING SIMULATION SOFTWARE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering Technology (Product Design) with Honours

by

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Date : ………………………

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

……………………………….

(EN. MOHAMAD RIDZUAN BIN MOHAMAD KAMAL)

ABSTRACT

The purpose of this study is to determine casting defect on aluminium alloy of automotive water pump housing. Furthermore, the aims of this project also are to design, analysis and simulate the product by using Solidwork and AnyCasting simulation software. Through the simulation, the quality of the product can be investigated. Parameters such as solidification time, filling time and particle tracing are the main influence to the micro shrinkage, retain melt volume and cooling curve of the product. Although the main parameter is influence the quality, but there are some sub-parameter that influences the result such as die temperature, pouring temperature and number of gate. Two design of water pump housing were investigated in this project. In order to obtain the best design of water pump housing, design 2 was more relevant compared to design 1 although the filling time of design 1 is shorter which 0.26218 second respectively 5.5722 second.

ABSTRAK

Tujuan kajian ini adalah untuk menentukan kecacatan pada aloi aluminium bagi produk perumahan pam air automotif. Tambahan pula, matlamat projek ini juga untuk merekabentuk, analisis dan simulasi produk dengan menggunakan Solidwork dan perisian simulasi AnyCasting. Melalui simulasi ini, kualiti produk boleh ditentukan. Parameter seperti masa pemejalan, mengisi masa dan mengesan zarah adalah faktor utama kepada pengecutan mikro, mengekalkan jumlah mencair dan graf penyejukan produk. Walaupun parameter utama mempengaruhi kualiti, tetapi terdapat beberapa sub-parameter yang mempengaruhi keputusan seperti suhu acuan, suhu mencurah dan bilangan get. Dua reka bentuk pam air perumahan telah disiasat dalam projek ini. Dalam usaha untuk mendapatkan rekabentuk yang terbaik pam air perumahan, reka bentuk 2 adalah lebih relevan berbanding dengan reka bentuk 1 walaupun masa pengisian reka bentuk 1 adalah lebih pendek iaitu 0.26218 saat dan 5.5722 saat.

DEDICATIONS

To my beloved parents

En Mohd Arif Bin Muda and Pn Juliha Bt Ab Razak

My talented supervisor

En Mohamad Ridzuan Bin Mohamad Kamal

My supportive co-supervisor

Cik Nur Farah Bazilah Bt Wakhi Anuar

My beloved and caring

Siblings and the one

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CHAPTER 1

INTRODUCTION

1.0 Background

The water pump housing is a simple centrifugal pump driven by a belt connected to the crankshaft of the engine. The pump circulates fluid whenever the engine is running (D.R. Dolas et al, 2014). This project used an ADC 12 aluminum alloy as a material for casting process on water pump housing. In fact, die casting properties with satisfactory heat, wear and corrosion resistance currently used automotives engine parts.

Casting is a one solution to mass production of aluminum alloy parts. It beginning with pouring metal into a mould with a cavity of the shape that wants to produce, and allowing it to solidify. The solidified object is called the as cast. Additionally, the standard moulds made from two clamp plates, two cavity plates, guiding elements between them, an optional back plate, an ejector retaining plate and an optional set of buffer plates. Castings have capabilities to create complex part of geometries complete internal and external shapes. It also can be used either for large or small parts. However, unfilled, porosity, turbulent flow and other casting defects give a limitation to the casting quality. With the same concept design, the defects can be reduce by adjust the runner and the overflow at the mold.

The use of computer simulation nowadays widely used to improve the quality of goods produced by applying a factor of cost savings, time and can produce optimal output. In this project, water pump housing has been designed to simulate filling and solidification pattern in aluminum casting with AnyCasting software.

Using this software, the parameter of the aluminum casting product can simulate and obtain the results by analysis. The result produced by simulation is represent whole experiment data, but it not 100% same with an actual condition because setup parameters based on value given in manual book.

1.1 Problem Statement

Water pump housing usually made from aluminium casting process. Important to realize in order to reduce cost mostly industry implement several trial before go to a mass production. In other words, the trial can be physical or virtual. After finished the design, the simulation will be use and obtain the analysis data from the simulation. Therefore, this project was design, analysis and simulate of casting defect on water pump housing using casting simulation software.

1.2 Objective

The objectives of this project are:

1. To determine casting defect on water pump housing.
2. To design and analysis of die casting parameter using AnyCasting software.
3. To simulate the design using AnyCasting software.

1.3 Scope

The scopes of this project are:

1. Altering water pump housing part using Solid Work software.
2. Simulation and analysis process the design using AnyCasting software.
3. Use a commercial Alloy such as ADC 12 to run the simulation.

CHAPTER 2

LITERATURE REVIEW

2.0 Die Casting

Die casting is a one of types in manufacturing process. Other than that, sand casting, investment casting also types of casting process. Pressure Die Casting (PDC) is a process to produce a part or component which is have a complex geometrically by molten metal is injected die casting machine under force using considerable pressure into steel mould or die to form products (Irshad A, 2012).

In industry PDC usually proficiency in automotive, electronic, medical equipment, and telecommunication industry. However, the overall process is the same way only the difference is in the process of injecting metal into moulds. There are two types of die casting hot chamber and cold chamber. Cold chamber also known as High Pressure Die Casting (HPDC) and hot chamber known as Low Pressure Die Casting (LPDC). Both of types will solidifies immediately change to output product.

2.0.1 Low Pressure Die Casting (LPDC)

Hot chamber machines are used primarily for zinc, copper, magnesium, lead and other low melting point alloys that do not readily attack and erode metal pots, cylinders and plungers. The differences between hot chamber and cold chamber process only at the process before injection section. The metal for hot chamber process is melted in an open holding pot where it placed in a furnace. It’s melted under the set temperature.

After that, the molten metal flow into plunger, inlet and shot chamber powered by hydraulic pressure. Next the molten metal has been injected into the die through a gooseneck section. By using plunger, functional for compress the molten metal through the shot section into the injected sleeve. While the casting solidifies, the plungers stay the position for holding the pressure. After solidification, clamping unit takes over and the part was ejected while the hydraulic systems retract the plunger. Figure 2.1 show the hot chamber die casting machine.

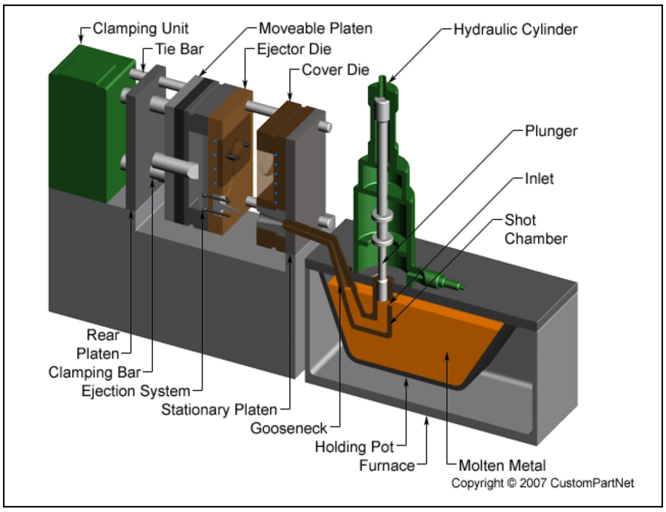

Figure 2.1: Hot Chamber Die Casting Machine
(Source: <http://www.custompartnet.com/wu/die-casting> 20/02/15)

2.0.2 High Pressure Die Casting

High pressure die casting (HPDC) or cold chamber machines are used for alloys such as aluminium and other alloys with high melting temperature. The molten metal is poured into a "cold chamber," or cylindrical sleeve, manually by a hand ladle or by an automatic ladle. The metal will through a pouring hole and directly to injection system because cold chamber machine no have gooseneck section. By using plunger, it’s functional for compress the molten metal through the shot section into the injected sleeve. While the casting solidifies, the plungers stay the position for holding the pressure. After solidification, clamping unit takes over and the part was ejected while the hydraulic systems retract the plunger.

Compared with Low Pressure Die Casting (LPDC), HPDC are excellent accuracy in dimensional, have a good finishing and no need machining accept for removal the overflow and runner. Figure 2.2 show the cold chamber die casting machine. HPDC machine size has range between 400 to 4000 tones. Usually HPDC have a few benefits:

- Excellent dimensional accuracy
- Mostly any metal can be cast
- Have a good finishing
- Suitable for complex part

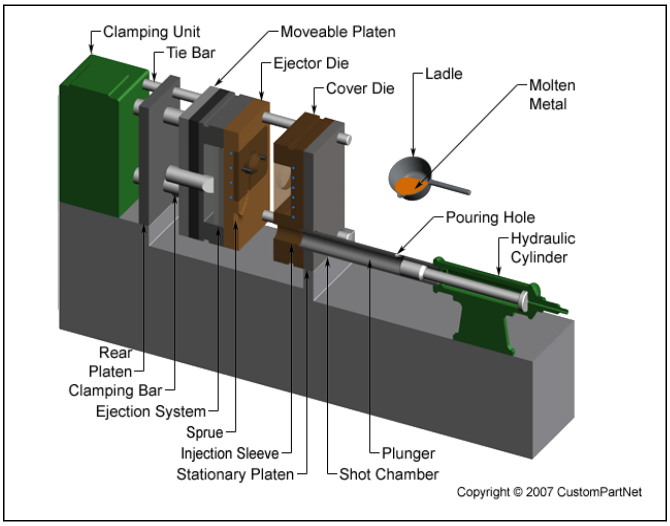

Figure 2.2: Cold Chamber Die Casting Machine
(Source: <http://www.custompartnet.com/wu/die-casting> 20/02/15)

2.0.3 Machine Specification

Hot chamber and cold chamber machine categorized as tons of clamping force. The forces focus at injected area and die area. The bigger part will require more tonnage machines. The size of the part must also comply with other machine specifications, such as maximum shot volume, clamp stroke, minimum mould thickness, and platen size. Table 2.1 shows the machine specification for hot chamber and cold chamber.

Table 2.1: Machine Specification

Type	Clamp force (ton)	Max. shot volume (oz.)	Clamp stroke (in.)	Min. mold thickness (in.)	Platen size (in.)
Hot chamber	100	74	11.8	5.9	25 x 24
Hot chamber	200	116	15.8	9.8	29 x 29
Hot chamber	400	254	21.7	11.8	38 x 38
Cold chamber	100	35	11.8	5.9	23 x 23
Cold chamber	400	166	21.7	11.8	38 x 38
Cold chamber	800	395	30.0	15.8	55 x 55
Cold chamber	1600	1058	39.4	19.7	74 x 79
Cold chamber	2000	1517	51.2	25.6	83 x 83

2.1 Process Cycle

The process cycle for die casting consists of five main stages, which are explained as Figure 2.3.

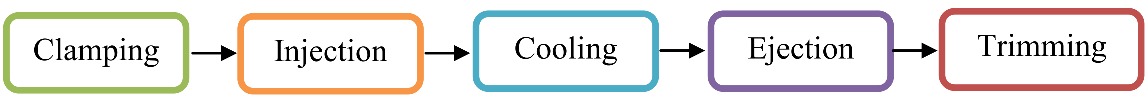

Figure 2.3: Process Cycle Die Casting

2.1.1 Clamping

The first step is the preparation and clamping of the two halves of the die. Each die half is first cleaned from the previous injection and then lubricated to facilitate the ejection of the next part. The lubrication time increases with part size, as well as the number of cavities and side-cores. Also, lubrication may not be required after each cycle, but after 2 or 3 cycles, depending upon the material. After lubrication, the two die halves, which are attached inside the die casting machine, are closed and securely clamped together.

Sufficient force must be applied to the die to keep it securely closed while the metal is injected. The time required to close and clamp the die is dependent upon the machine - larger machines (those with greater clamping forces) will require more time. This time can be estimated from the dry cycle time of the machine.

2.1.2 Injection

The molten metal, which is maintained at a set temperature in the furnace, is next transferred into a chamber where it can be injected into the die. The method of transferring the molten metal is dependent upon the type of die casting machine, whether a hot chamber or cold chamber machine is being used. The difference in this equipment will be detailed in the next section. Once transferred, the molten metal is injected at high pressures into the die. Typical injection pressure ranges from 1,000 to 20,000 psi. This pressure holds the molten metal in the dies during solidification.

The amount of metal that is injected into the die is referred to as the shot. The injection time is the time required for the molten metal to fill all of the channels and cavities in the die. This time is very short, typically less than 0.1 seconds, in order to prevent early solidification of any one part of the metal. The proper injection time can be determined by the thermodynamic properties of the material, as well as the wall thickness of the casting. A greater wall thickness will require a longer injection time. In the case where a cold chamber die casting machine is being used, the injection time must also include the time to manually ladle the molten metal into the shot chamber.

2.1.3 Cooling

The molten metal that is injected into the die will begin to cool and solidify once it enters the die cavity. When the entire cavity is filled and the molten metal solidifies, the final shape of the casting is formed. The die can not be opened until the cooling time has elapsed and the casting is solidified. The cooling time can be estimated from several thermodynamic properties of the metal, the maximum wall thickness of the casting, and the complexity of the die. A greater wall thickness will require a longer cooling time. The geometric complexity of the die also requires a longer cooling time because the additional resistance to the flow of heat.

2.1.4 Ejection

After the predetermined cooling time has passed, the die halves can be opened and an ejection mechanism can push the casting out of the die cavity. The time to open the die can be estimated from the dry cycle time of the machine and the ejection time is determined by the size of the casting's envelope and should include time for the casting to fall free of the die. The ejection mechanism must apply some force to eject the part because during cooling the part shrinks and adheres to the die. Once the casting is ejected, the die can be clamped shut for the next injection.

2.1.5 Trimming

During cooling, the material in the channels of the die will solidify attached to the casting. This excess material, along with any flash that has occurred, must be trimmed from the casting either manually via cutting or sawing, or using a trimming press. The time required to trim the excess material can be estimated from the size of the as cast envelope. The scrap material that results from this trimming is either discarded or can be reused in the die casting process. Recycled material may need to be reconditioned to the proper chemical composition before it can be combined with non-recycled metal and reused in the die casting process.

2.2 Die Design

In addition, die design have a many types of channel. Every single design issues must be considered in the design of the dies. The most important is the design of die must justify to allow the molten metal flow or through easily into all cavity. As known, die casting produce a complex geometry part so the design must be considered for any complex features on the part such as undercuts which will required additional die pieces.

Other than that, die should be designed with as uniform a thickness as possible because most of part through the side of the die. There known as slides or side actions. Equally important in designing the dies is material selecting. Under high temperature, the die must have excellent materials. For example, steel having a low carbon it can help to prevent cracking and are more resistant. Other common materials for dies include chromium, molybdenum, nickel alloys, tungsten, and vanadium. Table 2.2 shows description of material properties.