UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TOPOLOGY OPTIMIZATION OF MOLD BASE STRUCTURE

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

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DECLARATION

I hereby, declared this report entitled "Topology Optimization of Mold Base Structure" is the results of my own research except as cited in references.

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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 Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

…….

En. Mohd Kamal Bin Musa

ABSTRAK

Pada masa kini, bahan-bahan plastik digunakan secara meluas dalam bidang industri acuan bagi menghasilkan komponen plastik. Pertumbuhan acuan industri semakin meningkat berikutan permintaan reka bentuk dan trend pada masa sekarang yang semakin kecil. Kebanyakan produk plastik menggunakan proses pengacuan suntikan. Walaupun produk ini dapat dihasilkan dengan cepat, tetapi ia mengambil masa yang lama untuk menukar '*Mold Base'* disebabkan oleh berat yang terlampau dan pada masa yang sama meningkatkan masa persediaan. Tujuan projek ini adalah untuk mengoptimumkan berat '*core*' dan '*cavity'* dengan kaedah '*topology optimization'* dengan menggunakan perisian ' *Solid Thinking Inspire 2016'*. Rekabentuk '*core*' dan '*cavity*' yang telah dioptimumkan adalah reka bentuk yang menggunakan data CAD iaitu perisian '*Solid work 2016'*. Semasa proses mengoptimumkan , semua parameter ditetapkan mengikut sifat-sifat dan ciri-ciri '*core*' dan '*cavity*'. Selepas 54 kali lelaran bagi proses menganalisis dan lebih daripada 10 kali lelaran untuk mengoptimumkan kedua-dua komponen, keputusan telah dijana dengan 54% daripada 'core' dan 20% daripada 'cavity' boleh dikurangkan. Kesimpulannya, dengan mengurangkan berat '*core*' dan '*cavity*' jumlah berat '*mold base'* turut dapat dikurangkan.

ABSTRACT

Nowadays, the plastic materials are widely use in industries molding to produce the component or parts. The industry mold was growth faster due to demand with the trend of consumer product designed that is getting smaller. Most of the plastic products are using the injecting molding process. Although the product was produce quickly, but it take a long time to change the mold base due to heavy weight of mold base and at the same time will increasing the setup time. The aim of this project is to optimizing the weight of core and cavity with topology optimization method by using the Solid Thinking Inspire 2016 Software. The optimizing design for core and cavity was design using the CAD data which is Solid Work 2014 software. During the optimizing process, all parameter was set according to the properties and characteristic of core and cavity. After 54 times iteration for analysis and more than 10 iterations to optimize both components, the results come out with about 54% of the original core and 20% of the original cavity materials can be remove. It can be conclude that, by reducing the core and cavity weight the total weight of mold base also can be reduce.

DEDICATION

This report is dedicated to Mr. Mohd Kamal Bin Musa and Engr. Mohd Faizal Bin Halim for without his early inspiration, coaching and enthusiasm, none of this would have happened. This dedication is specially dedicated to my parents Mr. Ramli Bin Abdullah and Mrs. Sabira Bt Matsa. I hope that this achievement will complete their dream that they had for me all those many years ago when they choose to give me the best education they could. This dedication is also dedicated to my beloved friends that have provided me with a strong love shield and always surround me and never lets any sadness enter inside. And also to techinician that helping me in completing this project especially Mr. Basri.

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Bismillahirrahmanirrahim,

Peace upon you, in the name of ALLAH, The Most Compassionate, The Most Merciful. Salawat and Salaam to our beloved Prophet, Nabi Muhammad S.A.W. With the completion of this thesis report, praise to Allah, by Him who given the chances and wisdoms.

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Last but not least, I would like to thank to laboratory assistant at plastic laboratory (Mr Basri) and all my colleagues that directly or indirectly help me for all this 4 years. May Allah give His blessing to all of us. Amin.

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CHAPTER 1

INTRODUCTION

1.0 Background of study

Plastic material is widely used in producing the plastic product from the bigger size into smaller part. The plastic now days, make life become easier and much comfortable. Injection molding machine had been use to manufactured the plastic product including a complex shapes or geometry shapes. The injection molding machine has divided into 2 sections that include injection unit and clamping unit. This clamping unit consists of mold base that use to produce the plastic product. It is include some element such as core plate, cavity plate, support plate, space plate and etc.

The support plate is play the important element in the mold base to ensuring the product was producing with the good shape without any defect. It is usually make up from the steel, carbon steel or aluminium with a solid structure that contribute to the heavy weight of mold base. Thus, the excessive weight of the mold base required redundant operator and increase set-up time.

This project is focusing the support plate and spacer block for two plate mold. The aim of this project is to reduce the weight of mold base through the topology optimization method via Solid Thinking software at the same time to increase the

productivity. Hence, the design modification and select the best result of support plate and spacer block will be carry out in order to achieve the less weight mold base.

1.1 Problem statement

The core and cavity plate are made from solid material such as aluminium, steel, carbon steel and copper alloy. This shape of the plate will be machine according to the size that required making a plastic product. Mostly of the core and cavity plate is heavy weight because of the solid structure. Besides that, mostly industry manufacturing purchased the mold based on the catalogue. That means, to producing the small plastic product it is not necessary to use the too heavy mold. The plastic industries and manufacturer always change the mold according to the customer demand. Thus, it will require a lot of time and more than one worker with help of machine to handle it. This situation will increase the set-up time and decrease the productivity due to the time that taken to for machine to stop operate is longer.

1.2 Objectives

To solve the problem statement above there are 3 main objective of this project which are:

- To identify the mold base components.
- To optimize the excessive weight of mold base structure using Solid Thinking Inspire 2016 software.
- To redesign the mold base components using Computer Aided Design (CAD)

1.3 Scope

This project is focusing on two plate mold that commonly used in manufacture industry to reduce the weight of core and cavity plate. There are certain element that will be used as a scope which is shape, size and structure of core and cavity. The material used for core and cavity plate block that have been optimized are same as the original material in the plastic laboratory at Faculty Engineering Technology which is S45C carbon steel to maintain the physical properties of the core and cavity plate .This project also focuses on Finite Element Analysis (FEA) which is using the Solid Thinking software to reducing weight through topology optimization.

CHAPTER 2

LITERATURE VIEW

2.0 Introduction of literature view

In this chapter, it will explain clearly about the mold base structure and clamping force that occur in the clamping unit which the function is to open and close the mold part. In process to produce this literature review, all information and theory regarding the injection molding machine, mold base structure, clamping unit, setup time for assemble and disassemble mold, injection molding material, CAD and CAE are gathering from many sources such as internet and book.

2.1 Injection molding technology

Injection molding is a method commonly used in the manufacture of plastics parts. It used to create variety of products such as bottle caps, automotive dashboards, some musical instruments and some plastic products which exist today. Most of the polymer (resin) used in the production of plastic products including thermoplastics, thermosets and an elastomer. Thermoplastics more often used as a raw material because it is chosen based on the strength and function required for the final part. However, a different material has different parameter for molding. In 1995, the different material available for injection molding has been increasing at average rate of 750 per year(Halsted 2012).The process beginning by melted the plastic in injection molding

machine. Then, the melting materials are injected into the mold until it fulfills the cavity part. The products were removed from the mold by ejector after molding the materials. The process is repeated until achieved the desired production.

The benefits of injection molding to produce the plastic parts are high producing rates, high tolerance, extensive variety of material can be utilized, low labor costs and minimal of scrap losses .

2.2 Injection molding machine

An Injection molding machine knows as injection press consists of four difference elements. All elements are function to produce the plastic products by the injection molding process. The clamping mechanisms open and close the mold base along the ejecting the parts. During the injection, the injection pressure happens on the internal may cause the surface cavity space tends to open the mold at the parting line. The clamping force was supply in the clamping mechanisms to keep the mold closed (Herbert Rees, 2012) Plasticizing unit is an exclusively an extruder that heat up the plastic material in the form of pellets with the required temperature to form a fluid for injection process. The injection unit is responsible to melt (under pressure) and injecting the materials into the mold. Injection pressure is knows as a pressure applied on the injection screw where it enters the machine nozzle. Thin-walled of product need higher injection pressures to ensuring that the cavities can fill before plastic freezes. Heavy-walled products required low pressure (50 to 100 MPa). There are two injection method for plastic injection molding which are :

a) Reciprocating screw (RS) machine
b) Preplasticizing (P) machine

a) Reciprocating screw machine

The Reciprocating screw also standing as a RS machine or single-stage injection units in injection machine. RS machine shown in figure 2.2 (a) is the plastic injection machine the combined the extruder and the injection unit into one unit. When the melt is prepared for the next injection the extruder screw is stopped then the screw is pushed forward to inject the melt in front of the screw tip. Some of the effect of changing shot size can be avoided by using RS machine which is it prepare a shot size greater than desired for the shot.

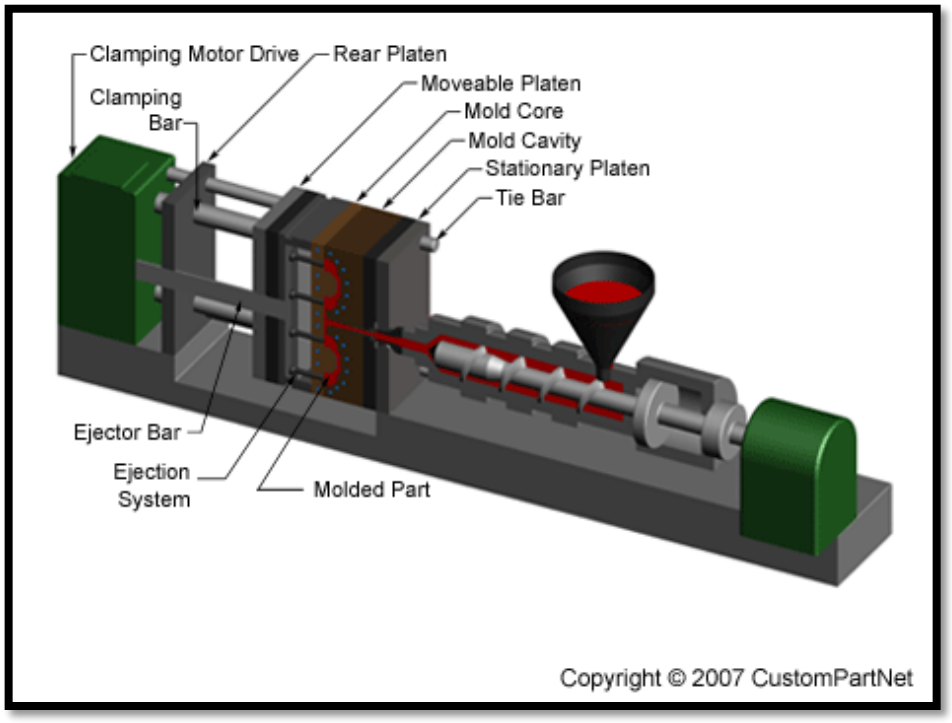

Figure 2.2 (a) : Reciprocating screw machine

b) Preplasticizing machine

The function of preplasticizing machine (P machine) systems is to separates the extruder and the injection unit. The materials is plasticizes by an extruder than it fills it at the injection cylinder of the injection unit. These machines shown in Figure 2.2 (b) also called as two-stage injection unit. Using this P machine, the produces melt is better mixed than the RS machine and can be held at lower temperature. The shot size in the injection pot will more accurate than the RS machine. (Herbert Rees, 2012)

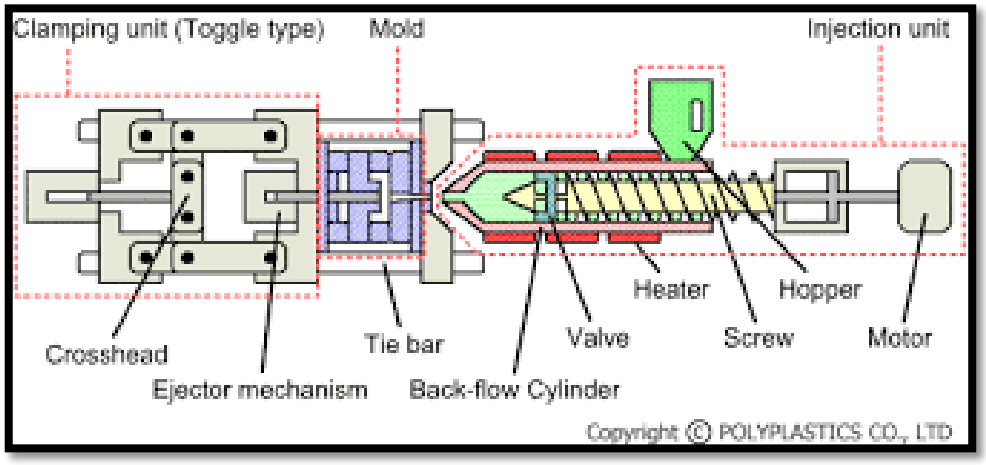

Figure 2.2 (b) : Preplasticizing machine

The clamping unit provides motion of closing and opening the mold base. It also generates the force that must be tightly to make sure there are no flash on the product during process filling the melt plastic into the core and cavity. There are three types of clamping unit that commonly used in plastic manufacturing industry; there are toggle clamps, hydraulic clamp and hydromechanical clamp. In the toggle clamp system the actuator moves the crossheads forward then the toggle links are extended to pushing the moving platen forward a closed position. In the started movement, the apply force and speed is low but it provide high speed and force at the different point in the cycle. The toggle clamps is suitable used in low-tonnage machine. The hydraulic clamps are often used on higher-tonnage injection-molding machines which in the range of 1300 to 8900

kN (150 to 1000 tons). Hydromechanical clamp are usually designing for injection mold machine that have weight more than 8900 kN (1000 tons) (Anon,2004)

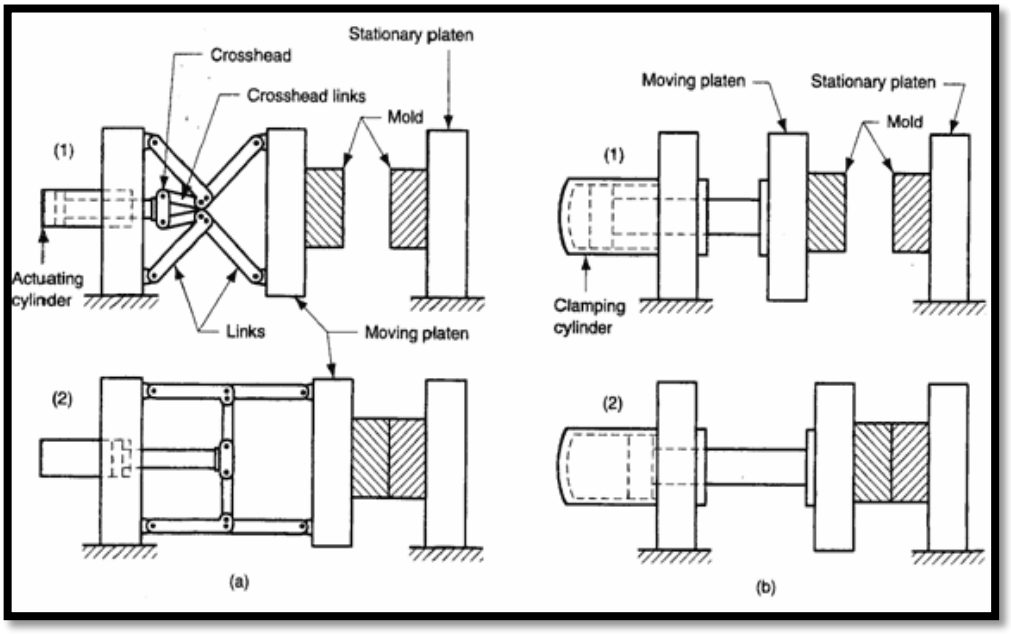

Figure 2.2 (c) : (a) Toggle clamp and (b) Hydraulic clamp

2.2.1 Injection molding cycle and process

The injection cycle is start from molding was opened, injection was carriage forward, injection plastic, metering, carriages withdraw, mold is opened and lastly part are eject from the mold. The molds are shut closed by electric or hydraulic clamp and force and pressure was apply to heated plastic in injection screw to take fulfil shape of the mold. Some machines are controlled by electric motor rather than hydraulic through pressure. The water-cooling channel help with cooling the mold and the heated plastic solidifies into the part. Incorrect for cooling can bring the molding become burnt. The cycle is finished when the mold opens and the part is ejected with the help of ejector pins inside the mold.

The plastic or resin for injection molding is usually in shape of pellet or granule and is softened or melted by heated and shearing force in a matter of seconds before being injected into the mold. Plastic pellets are filled the feed hopper which is the huge open bottomed holder to bolsters the granules down to the screw. The screw is rotate by a motor and then feeding pellets up the screw's grooves. The profundity of the screw flights diminishes towards the end of the screw closest the mold, packing the heated plastic. Due to the screw rotate, the pellets are pushed ahead in the screw and they undergo high pressure and friction. This process is important to generate heat for melting the pellets to producing the good surface or properties of parts. The channels through which the plastic streams toward the chamber will also solidify and forming an attached frame. This frame is consists of the sprue, cooling time and also impact of ejection mold.

2.2.2 Setup time in injection molding

Process changing the mold base takes a long time during the setup of injection molding machine. Changing the mold base involves some process which is transporting the mold base, removing the mold base, install the mold base and etc. According to the article (B.Kayis, 2012)**,** mention that total setup time the mold base for machine injection molding machine E1451 for producing a new product is 364 minute (6hrs 8min). The mold change on the E1451 includes 20 tasks such as installing closing device, changing nozzle, setup granulator and load program. Refer to their research, removing the mold base take about 30 minutes and installing the mold base about 45minutes. Besides, Kayis also mention that setup time have 3 main type including changing the colour, changing the mould and changing the insert. Changing the mold is the process changing one mold base to another mold base for producing the new plastic product while changing the insert of mold is only certain geometry change but the major section has same geometrical. The figure 2.2.2 (a) shows the variation from allocated setup time 11/2005 – 02/2006 from injection molding machine E1451. In table 2.2.2 (b) the

injection molding machine E802 produce the gat base in type of mold for about 8 minutes. Table 2.2.2 (c) shows that the task molds base changimg for injection molding machine E1451.

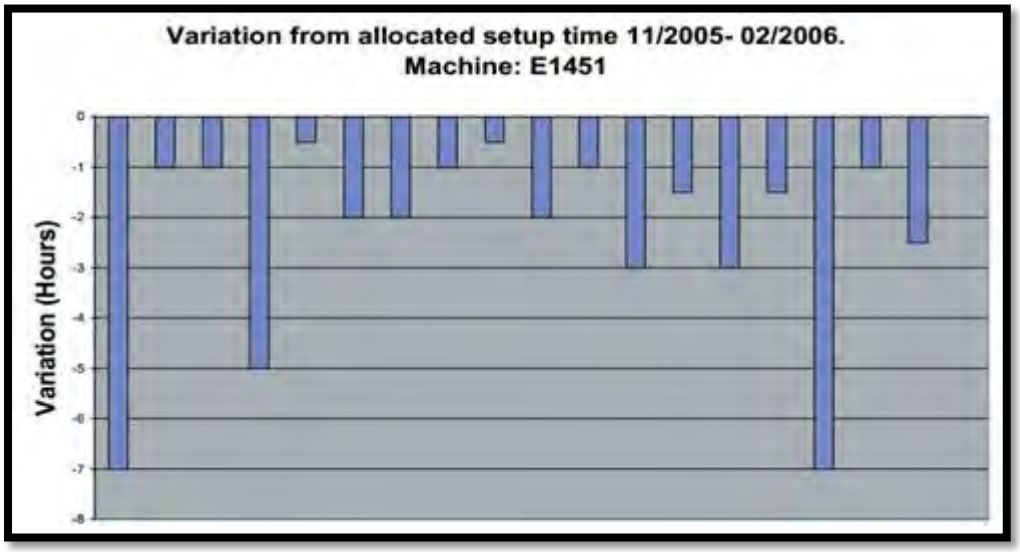

Figure 2.2.2 (a): Total Setup Time for Changing the Mold Base (Refer S.Kara)