UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MANUFACTURING, ASSEMBLY AND TRIAL OF CORE AND CAVITY PLASTIC INJECTION MOULD FOR TWO-PLATE FAMILY MOULD TESTING SPECIMENS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering Faculty of Manufacturing Process (Hons.)

by

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DECLARATION

I hereby, declare this report entitle “Manufacturing, Assembly and Trial of Core Plastic Injection Mould for Two-Plate Family Mould Testing Specimens” is the result of my own research except as cited in the reference

Signature :……..

Author’s Name :……..

Date :……..

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering (Process) (Hons.). The member of the supervisory is as follow:

……..

(Dr. Mohd Amran Bin Md Ali)

ABSTRAK

Projek ini dijalankan dengan tujuan untuk memahami proses mereka bentuk dan memesin plat acuan *core* dan *cavity* untuk dua plat *family mould*. Tujuan utama projek ini ada untuk menambah baik acuan lama dengan mereka bentuk dan fabrikasi dua plat *family mould* yang mengandungi empat bahan ujian iaitu *tensile*, *flexural, impact*, dan *hardness*. Kaedah pemesinan utama yang digunakan adalah *CNC Milling* dan mesin yang digunakan adalah model Hass VF-1 yang terdapat di makmal pembuatan UTeM. Proses mereka bentuk dibuat dengan menggunakan bantuan perisian AutoCAD di mana ia menghasilkan lukisan kejuruteraan dua dimensi (2D) untuk acuan tersebut. Dengan menggunakan perisian EdgeCAM, lukisan 2D tadi di ubah menjadi tiga dimensi (3D) dan program arahan untuk mesin turut di hasilkan untuk di hantar kepada mesin untuk proses fabrikasi. Proses fabrikasi dimulakan dengan menebuk lubang untuk pin *ejector*, pembentukan *profile* bahan ujian, dan *runner* untuk acuan di mana ia dimulakan pada plat *core*, di mana proses pemesinan dimulakan pada plat acuan *core, cavity, backup* dan *ejector*. Mould yang telah siap kemudiannya di pasang pada semua komponen acuan untuk melakukan percubaan dan hasilnya bahan ujian berjaya di buat melalui proses *injection moulding* dengan mengaplikasi parameter untuk acuan lama. Dengan itu dapat disimpulkan bahawa untuk meningkatkan kualiti dan mengurangkan ketidaksempurnaan, parameter untuk acuan baru harus di ubah mengikut kesesuaian acuan baru.

ABSTRACT

This project is conducted to study about the design and machining process of fabricating core and cavity plate for two-plate family mould. The main purpose of this project is to improve the current mould by redesigned and fabricated the two-plate family mould that contain four testing specimens of tensile, flexural, impact, and hardness test. The main machining method to fabricate this mould is through CNC milling machine where the machine model that used are Hass VF-1 allocated in UTeM. The mould design is created with AutoCAD software where the 2-dimensional (2D) diagram visual is produced. It is then converted into 3-dimensional (3D) by using EdgeCAM and the G-Code for the CNC Milling machine is generated together with the drawing. The machining process started with the machining of ejector holes, the profiles, and finally the runner where the machining began with the core plate, cavity, backup and end at ejector plate. The mould was then assembled and a trial test run was conducted whether the mould produced the test product and it's a success on first trial with the same parameter for the old mould. Thus, it can be concluded that by improving the parameter of the injection moulding for the new mould, the quality of the product can be improved and defects can be minimized.

DEDICATION

To my beloved parent, Mohamad Kasim Bin Arbain and Hasipah Binti Siri, my lovely sibling Khuwailid Ridha Bin Mohamad Kasim, Khamiludeen Redhwa Bin Mohamad Kasim and my only beautiful sister, Khairuneeza Nur Alia Binti Mohamad Kasim, and all my loyal friend, all of tour love and prayer are my driving source and your guidance is enlightment to me.

Thank you everyone for the support, guidance, prayer, help and cooperation, directly or vice versa.

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Bismillahirrahmanirrahim

In the name of Allah, the most gracious and the most merciful,

Alhamdulillah and praise to Allah S.W.T. for the bless and enlightment that given to me to complete my Final Year Project (FYP) from the beginning of my step until end of my journey. The journey was hectic and full of challenges but Alhamdulillah every problems faced, has the solution thank, than to Allah, and everyone that help me all the way. First of all, an infinite thanks for Dr. Mohd Amran Bin Md. Ali, my supervisor for the guidance all the way in making this project a successful project. He has been my major enthusiast and reference for this project.

Not to forget, a million thanks to my loving parent for the non-stop support and prayers all across the sea, from the beginning of my journey until now. Without them I wouldn't be here today. Special thanks dedicated to all the technicians and stand of UTeM especially Faculty of Manufacturing Engineering for their support and help along the way. Last but not least, to all my friend that being supportive from start until now. Thank you to all of you.

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ASMT	-	American Society for Testing and Materials
CAD	-	Computer-Aided Design
CAM	-	Computer-Aided Manufacturing
CATIA	-	Computer Aided Three-dimensional Interactive Application
CNC	-	Computer Numerical Control
EDM	-	Electric Discharge Machine
G-Code	-	Programming language
HDPE	-	High-density polyethylene
HSS	-	High Speed Steel
PP	-	Polypropylene
psi	-	pound per square inch

CHAPTER 1
INTRODUCTION

This chapter includes the introduction of the background of project for manufacturing the two-plate injection mould, the problem statement of the project, its main objective that should be archived and the project scope.

1.1 Background of Project

Injection moulding is one of the near nett process machining where little amount of secondary process is involve. Usually this process will produce excess of runner where the molten material such as molten polymer is injected into the mould to form desire shape. Ghosh (2011), stated that this process is subjected to high pressure so that the melted thermoplastic is injected by plunger action with the help of plunger system. The material is first heated in a heating barrel where it is molten and mixed with additive such as colouring before the molten material is compress and forced into the mould by the ejector through the mould cavity and the molten material is let to cool off and harden before ejected from the mould. Injection moulding is commonly used in the manufacturing industries where it can produce a variety of product from the smallest part such as plastic nut and bold, to the largest parts such as car dashboard.

The mould usually made by the mould maker with from several metal material type as an example steel or aluminium where the mould is precisely machined with several machining including CNC Milling and EDM machining to form a feature of the desired parts. The complexity of the mould design is depend to the customer

desire where the mould is first design with CAD software and the detailing is studied to overcome the machining problem and could produce the desire output. Thus, a proper research and study should be conducted to produce the optimum output can be archived.

There a several type of injection moulding mould available in the industries and in this case study a family moulding is conducted to study the design of the family moulding mould. Family mould is a mould where the mould consist more than one product design in the injection mould plate.

1.2 Problem Statement

The product from injection moulding is produce from the profile that fabricated on to the mould where it consist a single or multiple parts of the product. For this project, a family mould is selected to be fabricated where it consist four test specimens. The challenge is to obtain the location of the original ejector hole on the tensile (ASTM D638) profile and redesign the existing profile to fit another three new profile of flexural (ASTM D790), impact (ASTM D256), and hardness (ASTM D785). Beside that the location of the new profile must be suitable to ensure the extra ejector hole won't be fabricate through the plate cooling line. Another than that, the mould should be able to be assemble with existing mould base besides producing all the testing specimen. This project is conducted in manufacturing lab at Faculty of Manufacturing UTeM, Durian Tunggal Melaka where test sample are produce by themselves. The problem is only tensile test specimen is made by using injection process. For flexural, hardness, and impact, hot compression technique is used to generate the specimen. Thus the mechanical properties of this sample may be vary due to different manufacturing process involve. To counter that problem, a two-plate family mould should be fabricated containing all four test specimens.

1.3 Objective of Project

There are several sub-objective should be archived in this project such as:

i. To design a mould that consist four testing design, that is dumbbell shape for tensile test, coin shape for hardness test, plate shape for flexural test, and plate with notch for impact test.
ii. To machine the mould with CNC to produce the four shape required.
iii. To assemble the mould cavity and core plate to the mould base with ease.
iv. To run trial for the mould and produce all of the testing product.

1.4 Scope

This project focus is on redesign and fabricate the existing two-plate family mould of two tensile specimens into the new mould plate that consist 4 test specimens of tensile, flexural, hardness, and impact test. The design of the mould will be visualized by using AutoCAD software where the dimension of the test specimen is gather from the ASTM standard for test specimen. The main machining process to fabricate this mould is CNC milling and the G-Code is generated by using EdgeCAM software. The final stage of this project is to ensure the mould plate could be fitted to the base plate with ease.

1.5 Organization of the Report

To ensure the objective of this project is archived, there are 5 segment that consist in this project.

1. Chapter 1 explain the introduction of the report. This chapter include background, problem statement, objectives and project scopes.
2. Chapter 2 justify the literature review. It describe the theory that related with this project. The review provide very informative information and important knowledge related.

3. Chapter 3 discuss the methodology. It cover all the procedure and progress of the project from start until end including using software and machining process that involve during the project.
4. Chapter 4 display the result and discussion of the project and explain the comparison of results.
5. Chapter 5 summarized the result and discussion, as well conclude the whole project and recommended for further study in the future.

CHAPTER 2
LITERATURE REVIEW

This chapter presents of review the theories involved in this project beside describe the basic of injection moulding process. Beside that the machining is be explained alongside the designing step of the mould, type of mould and its material and the machining process that involved in this mould fabrication.

2.1 Injection Moulding

Injection moulding is a process where high pressure molten plastic is injected into a mould cavity which will forced the molten plastic to fill the negative part of the product on the cavity thus producing the complete positive component. Injection pressure usually measure in pound per square inch (psi) unit. The mould need to be securely clamp due to high pressure from the injector.

Plastic injection moulding machines composed of three components such as the injection unit, the clamping unit and the control system. In the injection unit section, it will melt and injects the polymer. At the same time, the clamping unit supports the mould, opens and closes the mould and clamping unit also has the part ejection system. By using the same clamping unit, different injection unit also can be assembled Harper (2000).

Once the molten material is injected, it is then allowed to cool down and solidify in the cavity for some prior of time. The mould is then released and open to eject the product. While this may consider simple if viewed through naked eyes, the process actually involve variant of individual operations and parameters that must be

precisely controlled to produce high quality product with minimal possible cost. Besides, the process is very fast where it take less than a minute to complete a full cycle of the manufacturing process. By locating multiple cavity image on the mould, the output may increase at the same time (Bryce, 1998). The schematic diagram of plastic injection machine is shown in Figure 2.1.

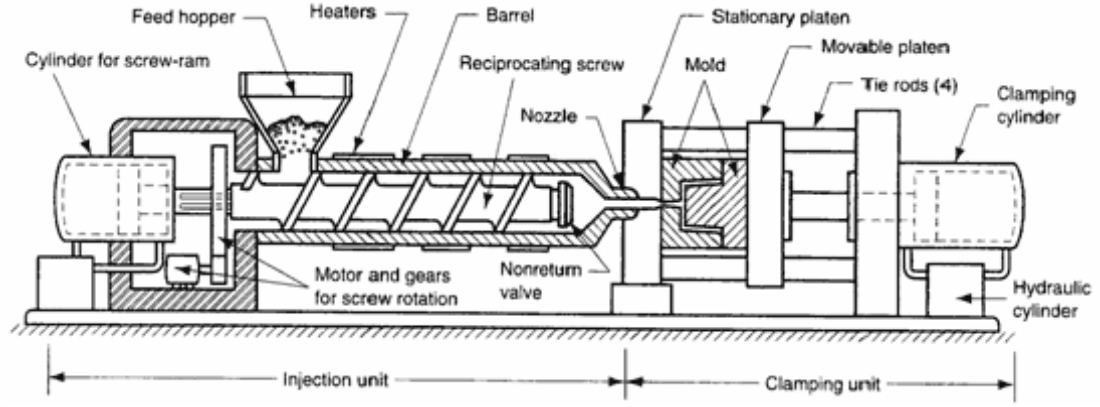

Figure 2.1 Schematic diagram of plastic injection moulding machine.
(http://www.xcentricmold.com/aboutinjectmold.php)

Rosato (2003), state that the mould design is determine by product design and requirement. Some mould are built with standard parts and use different core and cavity insert so that the cost can be minimized in manufacturing many variant design of product. Many cavity may be provided in mould to reduce the cost while maintaining the production rate output. Thus, the more cavity produce in a mould, the more complex the moulds will be.

2.2 Mould Base

Injection mould main purpose is to shape the melted plastic into desired shape then solidify the molten plastic before it is ejected and product is produce. There are two sets of components in the mould that is cavity & core and base where the cavity & core is mounted onto. Figure 2.2 below shows the basic mould base that generally used in industries.

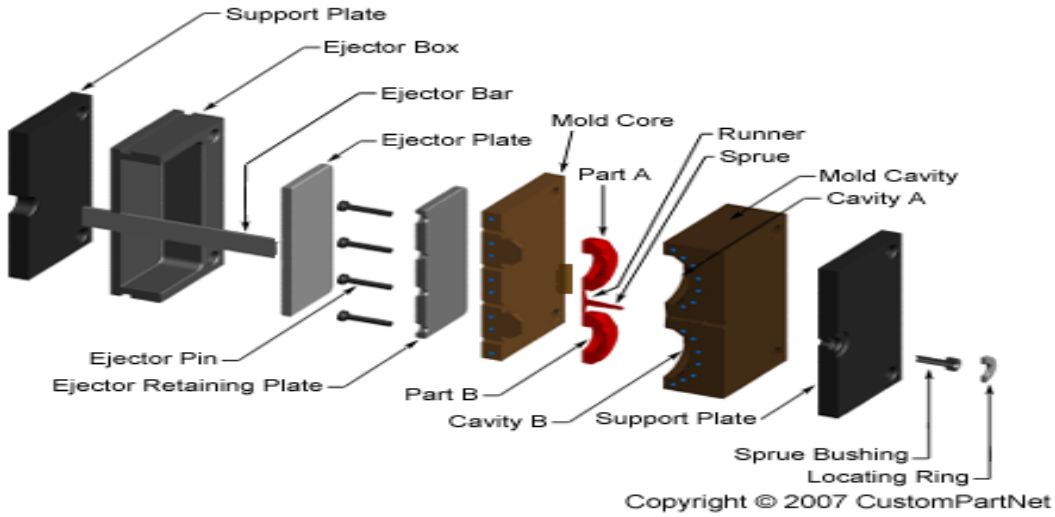

Figure 2.2: Basic Mould Base (CustomPartNet, 2007)

The machinery capacity requirement and the number of cavities in the mould are limited by its size and weight of parts to be moulded. Large clearance between the machines tie-rods are required corresponded to large exterior dimension of a single-cavity mould in the fabrication of large moulding parts. The number of cavity in multi-cavity mould are limited by the machine tie-rod clearance.

A mould has to be designed with capability to absorb the forces of clamping, injection, and ejection safely. Moreover, for obtaining the uniformity of product quality in continuous production cycles, the flow conditions of the plastic path had to be proportioned acceptably. The mould has to be able to absorb the heat from the plastic effectively while the solidification of the plastic product must be at controlled rate (Rosato, 2003).

2.3 Mould Material

Campo (2008), state that common type of material for injection mould are steel. There a many type of steels based on the composition of its alloying elements. Steels usually are able to withstand a range of pressure from about 207 MPa up to over 2068 MPa. It also can withstand extreme temperature up to 1093 C. Steel are

classified into vary of type according to its chemical composition, heat treatment method, mechanical properties, thermal properties, surface finishing and many more.

The mould material usually focus on two main parts that is base plate, and core & cavity plate. The variation of material that available on the industries can provide many type of mould based on custom requirements that provide custom desired properties. For this mould, Plastic Injection Moulding Volume 3(Bryce, 1998) is used as reference and guideline to determine what type of material should be choose to fabricate the mould.

2.3.1 Mild Steel

The most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications, more so than iron. Low-carbon steel contains approximately 0.05–0.320% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing

2.4 Mould Material Properties

Below are the mechanical properties of Mild steel.

Table 2.1: Mechanical properties of Mild steel

Material Type	Mild Steel
Young Modulus ($N.m^2$)	2.1×10^{11}
Poisson Ratio	0.28
Density ($Kg.m^{-3}$)	7860
Thermal Expansion (K)	1.17×10^{-5}
Yield Strength ($N.m^2$)	3.7×10^{8}

2.5 Type of Mould

In industries there are many demand and consideration upon producing plastic product that required different type of mould. Generally there are six types of injection mould that available for plastic injection that is two-plate mould, three-plate mould, hot-runner mould, insulted hot-runner mould and stacked mould. Greener and Wimberger Friedl (2006), has provide the detail of the mould types for further study and review.

2.5.1 Two Plate Mould

This is the most common and basic type of injection mould that is selected for this project of family mould. This mould contain two-plate mould section where the core and cavity are mounted on either plate and it is fastened and secured to the press platens. Mould can contain a single cavity or multiple cavities to produce one or many part in a single shot. Figure 2.3 below shows the two-plate mould.

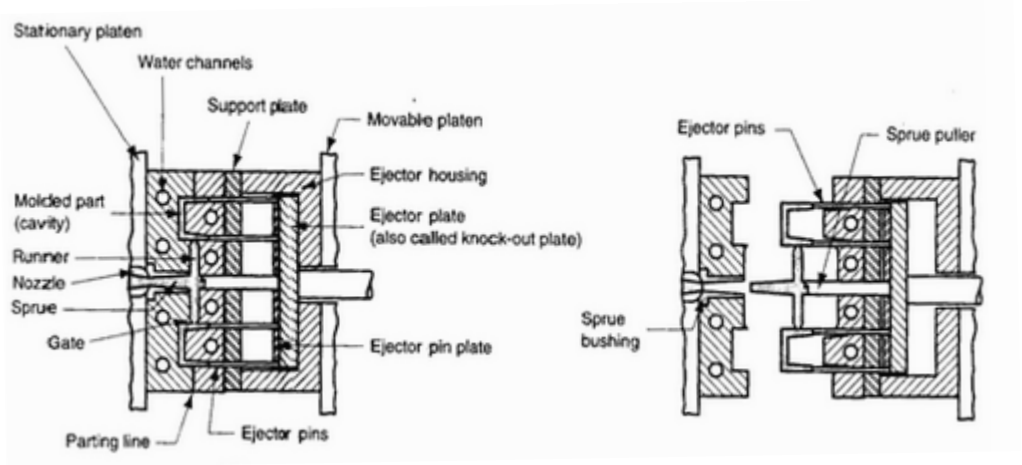

Figure 2.3 Two-plate mould (http://www.sinotech.com/injectionMolded.html)

2.5.2 Three-Plate Mould