DESIGN AND ANALYSIS OF TWO PLATE MOLD INSERT FOR DOG BONE SPECIMEN

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Thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
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NOVEMBER 2009
SUPERVISOR’S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature
Name of Supervisor: EN. ASNUL HADI BIN AHMAD
Date:

STUDENT’S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature
Name of Student: MOHD ALIFF BIN MOHD RADZI
Special to my beloved Ma & Abah,
Mohd Radzi Bin Mohd Datar and
Tuan Fatimah Binti Tuan Hamzah
ACKNOWLEDGEMENTS

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The Author acknowledges sincere indebtedness and gratitude to The Author parents for their love, dream and sacrifice throughout their life. The Author also feel grateful to Pok Tar where helps and allows The Author done this study property with help and prays to make this work possible with blessing of Allah S.W.T. The Author cannot find the appropriate words that could properly describe the appreciation for their devotion, support and faith in ability to attain the goals. Special thanks should be given to final year students members. The Author would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.
This thesis deals with durability assessment for design and analysis of two plate mold insert for dog bone specimen using selected sample. The objective of this thesis is to design two plate mold insert and analyze the material flow of the selected product. The thesis describes the material flow analysis to analyzed the material flow in the part and identify the best gate locations of the components. Acrylonitrile butadiene styrene (ABS) materials were studied in this thesis as sample of material and it is commonly used in industry and lab. The structural three-dimensional solid modelling of two plate mold was developed using the computer-aided drawing software. The strategy of analysis model was developed. The material flow and gate location analysis was then performed using Moldflow Plastic Insight software. The analysis model of the components was analyzed using the two cavities with cold runner design. Finally, the orientation skin for 21 number of different gate location is analyzed. From the results, it is observed that the analysis using Moldflow material flow analysis show the different orientation skin for different gate locations. The gate locations is constrain at the middle of the part where the area that would be test for the specimen. The orientation skin at the both sides of the part is same but only change the length of runner. The increase of length of runner will increase the projected area, the clamping force, filling time and the material waste. So that, the best locations of gate is at the nearest or as short as it can for runner length to be design. But, the first priority is the orientation skin for the material flow. The orientation skin should be same at the middle of part which is parallel to the strength that would be applied on testing. The final design was done in solid modelling and details drawing using SolidWorks software. The results can also significantly reduce the cost and time to fabricate the insert. That is also can be a reference for the future works of fabrications.
ABSTRAK

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E   Analysis Procedure (Step 1-23)  
F   Type of Gates  
G   Runner cross-section Data  
H   Results of Analysis  
I   CAD Data (3D Drawing)  
J   Tensile Testing Of Plastics
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<td>HDPE</td>
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<td>Society of Automotive Engineers</td>
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SAN  Styrene-Acrylonitrile

\( t \)  Thickness

\( W \)  Width

\( 3D \)  Three Dimensions
CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Plastic injection molding is one of the most important polymer processing operations in the plastic industry today. The plastic industry that is injection molding process and involving manufacturing has high growth potential. Most of the products are made from plastic material. The aim of this project is to design and analysis of two plate mold insert for Dog Bone tensile test specimen. This work is concerned with the design, analysis, and simulation two plate molds insert for plastic injection molding.

In designing mold insert for injection molding, the accuracy in making mold is very important in order to reduce the cost also to prevent mold easily broken. Previously, the engineer or designer of mold used manual analysis to the mold. But, nowadays the technology becomes more advances and the analysis replaced by software that can simulate the mold that want to fabricate.

The insert for two plate mold will design with two cavities of Dog Bone tensile test specimen. The designs are completely investigate on number of cavity, number of gate, runner system, and gate mechanism for dog bone tensile test specimen insert. The design is focus on the application of product that has some limitation when propose the design.

This project concern with two software which is Computer Aided Design (CAD) and Computer Aided Engineering (CAE) Moldflow Plastic Insight (MPI). The design two plate mold insert start with draw the dog bone specimen which is follow the
American Society Test Method (ASTM) specification and size. Then one sample size of
dog bone specimen is choosing for the sample of study. This drawing stage is by using
the CAD software which is SolidWorks. The mold based drawing also require with
suitable size for twin cavities of dog bone specimen. This mold based is follow as the
original dimension in the lab.

Then, the simulation and analysis of the design will investigate by using CAE
software which is Moldflow. This software is to analyze the material flow and to
determine the best gate location for desire mold insert. The analysis is run to the
drawing of dog bone specimen where the design as their shape and dimensions. The
analysis is limitation on one sample of selected material which is Acrylonitrile-
butadience-styrene (ABS) and the gate could not be place at the test area on the
specimen. This software will show the effect of gate location with desire runner size to
the orientation skin on product (dog bone specimen) and the other parameter such as the
fill time, and the defect if appear. This software is as a guide to change and choose the
best and correct parameter to the mold insert design. This step is the normally way to
eliminate the rework cost and time as all the possible errors are being eliminated before
it actually occurs in actual production or machining process.

The final result of analysis will conclude as final design with details dimensions
and size of mold insert. All the finding will draw in the SolidWorks as a completed
design includes 3D modeling, details dimensions and suitable and recommended
parameter for dog bone tensile test specimen.

1.2 PROBLEMS STATEMENTS

Mold is an expensive device that used for plastics process. The mold design
should be precise, accurate and effective in dimensions to reduce the cost and possible
defect that can occur on product. This project decided based on the problems occur
which are;

- Parts has a defect caused by the Injection Mold Design
• More than three time mold testing require to balancing material flow into the part especially in multi-cavities and family mold.
• High costs on mold insert fabrication.
• Precise and accurate dimensions of mold insert design require as desire product shape.
• The gate location is effected to reduce the defect on product or parts.

All the problems that were occurring during designing process should be solving properly. Previously, the engineer and designer solve all the problem and difficulties by get the reference or guidance from the past experience of earlier mold design and by experienced engineers. The technology today has helps the engineer to solve all the problems. This is come by using computer software where help the engineer easily change or determine the optimum gate size, gate location and so on. This is directly will reduce the time and cost of production.

1.3 PROJECT OBJECTIVE

The objectives of this project are:

1. To design Two Plate Molds insert for injection molding process.
2. To determine the best material flow for twin cavities to reduce the friction flow during injections.
3. To determine the best gate location for less defect to test specimen.

1.4 PROJECT SCOPES

The Scopes for these projects generally focus on designing using CAD software (SolidWorks) and analysis using CAE software (Moldflow) which is to find the best design of mold insert as steps before fabrication. Firstly, the focus of analysis is the dog bone specimen. This specimen used as a tensile test specimen where follows the standard of American Standard Test Methods (ASTM). The sample size and type was choosing based on that standard of ASTM.
Next, this study used the specify CAE software for analysis the material flow which is Moldflow Plastic Insight (MPI). MPI with 5.0 versions used to determine the best gate location for the dog bone specimen. This software will show how the material flows into the parts in order to determine the best location for the design.

This study was focus on design the best gate location for twin cavities of dog bone specimen insert. This design is to reduce the possibility defects that can occur and to have the effective design with less of product defect after mold insert fabrication. All the design was focused for two plate mold as the title of this study.

Lastly, the analysis was performed by using selected engineering material which is Acrylonitrile Butadiene Styrene (ABS). This material selected for one sample of material for analysis and that is suitable for many applications for engineering works.

1.5 PROJECT PLAN

Gant chart for the project plan can be referring to appendix A1 for Gant Chart PSM I and appendix A2 for Gant Chart PSM II.

This “Projek Sarjana Muda” (PSM) consists of two parts which are PSM 1 and PSM 2. That is separate for first semester with PSM 1 and continues with PSM 2 on second semester. PSM1: At beginning with receives the title of project from supervisor and supervisor gives briefly explanations about that PSM title given. Supervisor give briefly guide to make the schedule or task planning for the whole works for PSM. Schedule management is needed for this project to make sure the project running in progress. Then, discussion with supervisor start focused on the project title about the objective, problem statement, and scope of project. Next, the project progress continue by start finding the information data and all related information to the project title by reverse engineering study and literature review from web sites, journal, reference books, supervisor and other relevant academic material that related to this project. To get the clear view and very understand about the project, it is require studying more on material that related to the project topic and spend more than two week to make a literature review. The process of literature review in continuously move from one thing to another.
Continuing the progress, all the literature review related need to collect and get focused to reduce the scopes of works. The literature review requires the information and material about injection mold, mold components, injection mold design, mold based, gating system, runner system, and the software that is required for this project. The progresses continue with product or parts selection as a sample of product study for this project. The sample of product which is Dog Bone tensile test specimen was choosing. This product, scopes to standard dimension and shape follow the American Society Test Method (ASTM) standard. Next, based on the size of selected product, the suitable mold based size is determined which is available on our lab. The selected and most suitable mold based is selected and do the dimensioning details with all components. These task will performed with suitable tools and equipments which are ruler (mm), venire caliper and measuring tape (mm). All this dimensions is used as references to redraw in CAD software to do the modeling and analysis by CAE Moldflow Software. Next, drawing of selected sample of product and mold based as a modeling and for analysis and design details. All these drawing were draw by CAD software which is SolidWorks. This drawing is details with dimension as actual size as an original product. The dimension was following the current parts and also gets the reference of dog bone by ASTM standard. Next, the process continues with the material selection as sample of product material to analyze the material flow. This material is scopes to engineering plastic material which is using Acrylonitrilebutadieneestryene (ABS) material. All the information and data collection and parameter require for this project progress will recorded as a reference for the analysis task on PSM 2. After that, task is preparation of progress presentation and report writing chapter one, chapter two and chapter three as a complete task for PSM 1. These tasks take two week to be finish. In the presentation, the information and flow of project was explains to the panels. That is details with project objective and scope that focus in. On that particular week, preparations also include the slide presentation for the PSM 1 work progress presentation.
PSM 2: The project task for PSM 2 will continue follow as the planning. The actual work and planning for PSM 2 were present at the beginning of the semester. Project progress will be continuing with design the mold insert for dog bone tensile test specimen. The designs start with determined the suitable runner system for dog bone mold insert. The runner system will determine on the diameter and shape of cross-section that is recommended and suitable as desire shape and size of dog bone specimen. Next is determining the gating systems which are gate type, gate size and gate location. Type of gate that will choose is based on the type of injection mold which is two plate molds. Then the gate is selected for surface gate. The gate dimension will determined based on the finding of type of gate selection. The types of gate will selected and evaluate from several gate type that is possible for two plate mold. The final stage on gate mechanism is the gate location. Next, the task continue with determine the possible gate location for selected product (dog bone). This process requires the software support to determine the best gate location for the dog bone part. This process will run in several times with various locations to determine the most suitable location. The sequence of analysis that will use is flow analysis to see the material flow in the part. This process will details investigate in order to suite the applications and usage of the part (dog bone). This process will take a few weeks to done it but it need to make in fast for continue on next task. The data and result from the analysis will be as the references to continue the design of mold insert of product (dog bone). The parameters and data used are recorded in the table for proper reference and guides line. This stage is to do the modeling of the inserts how it will machine or fabricated to the mold based. This modeling can give the clear view of actual insert design like real. This modeling also can be the benchmark of improvement in complete mold constructions for two plate mold of dog bone insert. This task will performed with complete dimensioning and drawing details as final works.

This is also important to avoid the ejector pins are located at wrong placed that will cause the defect to the product during ejection process. The suitable number of ejector pins also can be determined after the solid modeling of complete design.

The data and information will record as a result achieved. This result includes the gate location, ejectors pins location, numbers of ejector pins, suitable runner size
and some conclusion and discussion. This result achieve will be as a reference to future works which is fabrication as a real products.

This is how the engineer or mold insert fabricate person do to avoid the mold broke after fabrication done. This stage will observe the result that is capable for best location of gate and runner size for our sample project.

Lastly, the final report writing and prepare the presentation. This takes about one to two weeks to arrange and accomplish. A report is guided by FKM thesis format and also guidance from supervisor. All task scheduled is take around two semesters to complete. Before the complete report submission, we need to present all the results achieve from PSM 2 to the panel. The project will evaluate and have some comment for make a little bit modification for report done.
2.1 INTRODUCTION

The best way is the molds and parts designer must have a good knowledge on the basic of injection molding process. It will help them to design for manufacturer and not just a design which is very nice but it cannot be manufactured. The basic theory of plastic injection molding including the injection molding machine, injection molding process, injection molds, type of gates, plastic material, plastic parts design guideline, and machining process in molds fabrications will discuss details in this chapter.

2.2 INJECTION MOLDS

2.2.1 Types of Injection Molds

The molds are the most important component of the injection molding process. It will determine the finish size of the parts that is producing, the surface finish of the final product and dictate just how well the injection molding process will run (L.Sors and I.Balazs. 1989).

2.2.1.1 Cold Runner Injection Molds

The majority of plastic injection molds built using the cold runner type. In a cold runner mold, the plastic melt is injected into the mold through a sprue and runner where it enters each cavity in the mold. During the cooling stage of the injection molding cycle, the plastic in the cavities, sprue and runner solidify. The sprue and runner become
scrap in this type of injection mold. They are then ground into small pieces or pellets and mixed with the virgin plastic for reuse. Cold runner injection molds are more economical to build than hot runner molds, however they can be less economical to run if the amount of plastic in the sprue and runner exceeds 35% of the plastic that is injected into the part cavities (L. Sors and I. Balazs. 1989).

2.2.2 Two and Three-Plate Molds

Mold for plastic injection molding can be categorized into two main categories that are two plate mold and three plate mold. Each type has a different design, function and structure. The selection types of mold depend on types of product, function and production capacity. The cost of mold fabrication also depends on the types of mold. This study will discuss details on two-plate molds.

2.2.2.1 Two-Plate Molds

This kind of mold is used for parts that are typically gated on or around their edge, with the runner in the same mold plate as the cavity. Two-plate mold can divided into 3 category that is cold runner, hot runner and conventional. Figure 2.1 shows the two-plate mold which are separated by one line called parting line into two side, core side and cavity side. Core side content ejector pin, core insert which is moving after plastic inject into the mold and the ejection bar will push the ejector pin and the ejector pin then push the part out from the mold. Cavity side is a fixed side, not moving and content feed system (sprue, runner and gate). Plastic material will injected from the machine nozzle into a sprue bush and through the runner to the cavity. Mold temperature controlled by temperature controller. That have 5 medium usually used to control the mold temperature that is chiller (3°C to 35°C), normal water (35°C to 45°C), hot water (45°C to 90°C), hot oil (90°C to 250°C) and ethylene glycol (90°C to 250°C) (A.B. Glanvill and E.N. Denton. 1985).