OPTIMIZATION OF MOLDING PARAMETER EFFECT TO WARPAGE OF CAR DASHBOARD BASED ON PLASTIC FLOW SIMULATION SOFTWARE

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Thesis submitted in fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering

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NOVEMBER 2009
SUPERVISOR DECLARATION

I hereby declare that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature : …………………………..
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Position : Lecturer of Faculty Mechanical Engineering
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: MOHD ZAHIRUDDIN BIN AZRI
ID Number: MH06069
Date: 20 NOVEMBER 2009
DEDICATION

Another turning point,
A fork stuck in the road.
Time grabs you by the wrist,
Directs you where to go.
So make the best of this test,
And don't ask why.
It's not a question
But a lesson learned in time.
It's something unpredictable,
But in the end is right.
I hope you had the time of your life

Especially dedicated to
My beloved mother and father
ACKNOWLEDGEMENTS

First and foremost, I want to thank Allah S.W.T, for giving me the source of power, knowledge and strength to finish the project and dissertation for completing my Bachelor of Mechanical Engineering final year project. By gradually following the plan of optimization of molding parameter effect to warpage of car dashboard based on plastic flow simulation software, I’ve manage to fulfill my responsibility to this project.

I would like to express my gratitude to my supervisor Madam Siti Haryani Bt. Tomadi for her wisdom, endurance and encouragement during her supervision period. She motivates me about the importance of constant and gives me her outstanding professional conduct. I appreciate her consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for her progressive vision about my training in science, his tolerance of my naive mistakes, and her commitment to my future career. I also sincerely thanks for the time spent proofreading and correcting my many mistakes. I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. My sincere thanks go to all my lab mates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. And also thanks to Dean Faculty of Mechanical Engineering, Associate Prof. Dr. Rosli Bin Abu Bakar for his advice and suggestion. I also sincerely thanks for the time spent proofreading and correcting my many mistakes.

I would also like to acknowledge with much appreciation the crucial role of the staff in Mechanical Laboratory, who gave a permission to use the computer laboratory to design and run the analysis and also the plastic laboratory to make mould measurement and to use all the necessary tools in the laboratory. Special thanks too goes to Mr. Azizuddin Bin Abd Aziz against as the Final Year Coordinator, who has give some advice and share his knowledge on this final year project.

Many thanks go to all the supervisors who have given their full effort in guiding the through on the project progress. I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this project.
ABSTRACT

This thesis present about the optimization of molding parameter effect to warpage of car dashboard based on plastic flow simulation software. The objective of this project is to study, analyze, and optimize the parameters that effect to warpage with using plastic flow simulation software. This project using the manual measurement after the original method using 3D scanner cannot be done because of the technical report. The measurement uses the tools from the Faculty of Mechanical Engineering Laboratory such as ruler, vernier calliper, threads, and protractor. Then, draw the dashboard in SolidWork 2008. Using MoldFlow Plastics Insight (MPI) 5.0 software, the injection molding parameters are optimized to get the best parameters to minimize warpage. The small changes of molding parameters will give higher impact to the plastic characteristics. The comparison between the types of analysis will be made. The comparison is between the deflections, fill times, and volumetric shrinkage including air traps and weld lines. As the conclusion, the changes of molding parameters will affect the warpage of the car dashboard.
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**LIST OF SYMBOLS**

- $^0\text{C}$: Degree Celsius
- %: Percent
- MPa: Mega Pascal
- cm$^3$/s: Centimeter cubic per second
# LIST OF ABBREVIATIONS

<table>
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<tr>
<td>DOE</td>
<td>Design of experiment</td>
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<tr>
<td>ABS</td>
<td>Acrylonitrile-butadiene-styrene</td>
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<td>Computer aided drawing</td>
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CHAPTER 1

INTRODUCTION

The sole purpose of this project is to optimize molding parameter effect to warpage of car dashboard based on plastic flow simulation software. The basic perspective of this project is injection molding. The definition of this word is shape-forming process in which molten metal or plastic is injected into aluminum, ceramic, or steel molds (shaped like the end product) and squeezed under high pressure. Injection molding is employed mainly in the production of solid objects.

Therefore, as a student of mechanical engineering of University Malaysia Pahang, this project exposes student the field of manufacturing engineering as part of mechanical engineering. The optimization of molding parameter is the first step to make product better.

1.1 BACKGROUND OF PROJECT

There are several steps to finish this project. Firstly, focus on injection molding process. Injection molding is the molten plastic is injected into the mold cavity to form shape with high pressure and high temperature and hold it there until the parts are cool and stiff enough to be removed from the die.

The second step is molding parameters. In this case study, focus on four (4) molding parameters that needed in the injection molding. There are flow rate, injection pressure, mold temperature, and melt temperature. These molding parameters will give effect to the plastic depend on how it will be control. So, the small changes of molding parameters will give significant impact to the plastic characteristics.
Warpage is a distortion where the surfaces of the molded part do not follow the intended shape of the design. Warpage relates to the distortion induced by the inhomogeneous shrinkage and relaxation of residual stress in the part once outside the mold, shrinkage expresses the overall dimensional change as the unconstrained part cool down to ambient temperature. [1-4]

There are many molding parameters effect to warpage such as mold cooling, part and mold designs, and process conditions, injection pressure, back pressure, melt temperature and mold temperature. In this case study, the molding parameters that considered are stated before; flow rate, injection pressure, mold temperature, and melt temperature. All these parameters must be calculated to get the best plastic with lowest warpage compare than before.

In this case study, the needed is optimizing molding parameter effect to warpage of car dashboard based on plastic flow simulation software and reverse engineering method. Reverse engineering means that the process of duplicating an existing part, subassembly, or product, without drawings, documentation, or a computer model. It also defined as the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation. It often involves taking something apart and analyzing its workings in detail, used in maintenance or to try to make a new device or program that does the same thing without copying anything from the original. It’s used to make car dashboard more stable in contain, strength, and brittle with minimum failure. [13, 14]
1.2 OBJECTIVES

The objectives of this case study are to:

1. Study the parameters effect in injection molding to car dashboard
2. Analyze the effect of molding parameters such as melt flow rate, injection pressure, mould temperature and melt temperature to warpage of car dashboard.
3. Optimize the molding parameters by using plastic flow simulation software in order to get a good result.

1.3 PROJECT SCOPES

To start of this project, a thoroughly research of review is done with the means of the internet, books, available published articles and materials that related to the title and supervisor’s guidance. This is a continuing progress until sufficient knowledge is attained to complete the project.

The original idea of this project is using the reverse engineering in 3D scanning existing product in laboratory which is car dashboard. Unfortunately, the 3D scanner in the Faculty of Mechanical Laboratory cannot be used because of the technical problem. Due to that problem, this project changed to the manual measurement method.

Next is modeling the product in design software. For this project, the software called SolidWorks is chosen. SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and was developed by SolidWorks Corporation. The reason using this software are solid-based solid modeler, utilizes a parametric feature-based approach to create models and assemblies. [8, 9]

Here, parameters refer to constraints whose values determine the shape or geometry of the car dashboard. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent. Building a model in SolidWorks usually starts with a 2D sketch. The sketch consists of geometry such as points, lines, arcs, conics, and splines. Dimensions are added to the sketch to
define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch. [8, 9]

After do the car dashboard shape and it will analyze by using plastic flow software. The flow analysis software can predict the flow of plastic throughout the injection molding cycle to ensure that acceptable parts are designed for the manufacture. Using flow analysis, the optimizing gate locations and processing conditions assess possible part defects, and automatically determine the dimensions for a balanced feed system by considering the low effects resulting from differential mold-block temperatures and asymmetries in part geometry. One can also determine the optimum set-up for polymer valve gate timing sequences and determine whether hot or cold runners are appropriate.

Then optimize using mold flow software. Once the plastics injection and packing phases have been optimized, cooling circuits and a mold block- including mold inserts- can be modeled around a part for a mold cooling analysis. The mold design can be optimized by adjusting the size and locations of cooling circuits, as well as modifying circuit and coolant processing parameters. All the benefits of mold cooling analysis can be applied to gas injection molded parts as well.

Finally the molding process optimization can be done by using proper method and processing condition. Thus, the molding process will produce better product in a process.
1.4 PROBLEM STATEMENT

From research that have been done, determine optimal process parameter settings critically influence productivity, quality, and cost of production in the plastic injection molding industry. Previously, production engineers used trial-and-error method to determine optimal process parameter setting for plastic injection molding. However, this method is unsuitable in present plastic injection molding because the increasing complexity of product design and the requirement of multi-response quality characteristics. This research presents an approach in plastic flow software for the optimization of the parameters effect to the car dashboard.

In this project, what is needed is to use the plastic flow simulation software. This software includes all the information that needed in optimizing the warpage of car dashboard. After get the best result, the values of the parameters are applied to production line using injection molding. All these thing are very important to make sure that product can have long life time depends on its strength, capability working with higher temperature and vibration.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

For the injection molding cycle to begin, four criteria must be met: mold open, ejector pins retracted, shot built, and carriage forward. When these criteria are met, the cycle begins with the mold closing. This is typically done as fast as possible with a slow down near the end of travel. Mold safety is low speed and low pressure mold closing. It usually begins just before the leader pins of the mold and must be set properly to prevent accidental mold damage. When the mold halves touch clamp tonnage is built. Next, molten plastic material is injected into the mold. The material travels into the mold via the sprue bushing, and then the runner system delivers the material to the gate. The gate directs the material into the mold cavity to form the desired part. This injection usually occurs under velocity control.

When the part is nearly full, injection control is switched from velocity control to pressure control. This is referred to as the pack/hold phase of the cycle. Pressure must be maintained on the material until the gate solidifies to prevent material from flowing back out of the cavity. Cooling time is dependent primarily on the wall thickness of the part but also depends on the material being molded. Production molding usually requires faster cooling. Water is often channeled throughout the dies to produce faster cooling times. During the cooling portion of the cycle after the gate has solidified, plastication takes place.
Plastication is the process of melting material and preparing the next shot. The material begins in the hopper and enters the barrel through the feed throat. The feed throat must be cooled to prevent plastic pellets from fusing together from the barrel heat. The barrel contains a screw that primarily uses shear to melt the pellets and consists of three sections. The first section is the feed section which conveys the pellets forward and allows barrel heat to soften the pellets. The flight depth is uniform and deepest in this section. The next section is the transition section and is responsible for melting the material through shear. The flight depth continuously decreases in this section, compressing the material. The final section is the metering section which features a shallow flight depth, improves the melt quality and color dispersion. At the front of the screw is the non-return valve which allows the screw to act as both an extruder and a plunger. When the screw is moving backwards to build a shot, the non-return assembly allows material to flow in front of the screw creating a melt pool or shot. During injection, the non-return assembly prevents the shot from flowing back into the screw sections.

Once the shot has been built and the cooling time has timed out, the mold opens. Mold opening must occur slow-fast-slow. The mold must be opened slowly to release the vacuum that is caused by the injection molding process and prevent the part from staying on the stationary mold half. This is undesirable because the ejection system is on the moving mold half. Then the mold is opened as far as needed, if robots are not being used, the mold only has to open far enough for the part to be removed. A slowdown near the end of travel must be utilized to compensate for the momentum of the mold. Without slowing down the machine cannot maintain accurate positions and may slam to a stop damaging the machine. Once the mold is open, the ejector pins are moved forward, ejecting the part. When the ejector pins retract, all criteria for a molding cycle have been met and the next cycle can begin.¹¹

The basic injection cycle is as follows: Mold close – injection carriage forward – inject plastic – metering – carriage retract – mold open – eject part(s) Some machines are run by electric motors instead of hydraulics or a combination of both. The water-cooling channels that assist in cooling the mold and the heated plastic solidifies into the part.
Improper cooling can result in distorted molding. The cycle is completed when the mold opens and the part is ejected with the assistance of ejector pins within the mold.

The raw material for injection molding is most commonly supplied in pellet or granule form. Pellets are poured into the feed hopper, a large open bottomed container, which is attached to the back end of a cylindrical, horizontal barrel. A screw within this barrel is rotated by a motor, feeding pellets up the screw's grooves. The depth of the screw flights decreases toward the end of the screw nearest the mold, compressing the heated plastic. As the screw rotates, the pellets are moved forward in the screw and they undergo extreme pressure and friction which generates most of the heat needed to melt the pellets. Electric heater bands attached to the outside of the barrel assist in the heating and temperature control during the melting process.

The channels through which the plastic flows toward the chamber will also solidify, forming an attached frame. This frame is composed of the sprue, which is the main channel from the reservoir of molten resin, parallel with the direction of draw, and runners, which are perpendicular to the direction of draw, and are used to convey molten resin to the gate(s), or point(s) of injection. The sprue and runner system can be cut or twisted off and recycled, sometimes being granulated next to the mold machine. Some molds are designed so that the part is automatically stripped through action of the mold.

Optimizing the parameters for injection molding will ensure quality products, with minimum of molded-in-stress, at lower manufacturing cost. All parameter adjustment will have an effect (positive or negative) on the physical and aesthetic properties of the molded product. Understanding this relationship allows the molder to manipulate the properties to meet specific requirement establish for the product.