UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF INJECTION MOULDING FEED SYSTEM OF AUTOMOTIVE PART BY USING TAGUCHI APPROACH

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

by

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920709-01-6600

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design and Analysis of Injection Moulding Feed System of Automotive Part by Using Taguchi Approach**

SESI PENGAJIAN: **2014/15 Semester 2**

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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 in Manufacturing Engineering Technology (Product Design) (Hons.). The member of the supervisory is as follow:

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(ENGR. MOHD FAIZAL BIN HALIM)

ABSTRAK

Persaingan dalam industri automotif sedang berada di puncaknya. Dengan menghasilkan produk-produk automotif lebih cepat daripada yang lain, syarikat-syarikat automotif boleh kekal utuh dan meneruskan persaingan untuk terus berada di atas. Walau bagaimanapun, masalah-masalah yang dihadapi sewaktu fasa penyelidikan dan pembangunan (R&D) untuk satu produk baru seperti wujudnya kecacatan kritikal akan melambatkan masa perancangan, lalu memanjangkan masa penyelidikan dan pembangunan produk tersebut. Komponen plastik untuk automotif yang dihasilkan oleh proses pengacuan suntikan juga menghadapi masalah ini, di mana kecacatan sentiasa berlaku selepas produk tersebut dihasilkan. Oleh itu, tindakan perlu diambil untuk memastikan kecacatan ini dikurangkan atau dicegah pada peringkat awal. Dalam Autodesk MoldFlow Analysis, komponen yang ingin dihasilkan akan dianalisis, pengaliran cecair plastik ke dalam bahagian tersebut akan dikaji semula, dan kecacatan yang mungkin berlaku boleh diramal. Pendekatan Taguchi digunakan sebagai kaedah reka bentuk eksperimentasi (DOE) untuk reka bentuk bahagian dan sistem suapan yang optimum supaya reka bentuk terbaik digunakan. Bahagian automotif yang digunakan adalah mangkuk pengalas tangan pintu kereta dan kecacatan yang dianalisis adalah suntikan yang tidak mencukupi, garisan-garisan pertemuan aliran, dan udara yang terperangkap. Berdasarkan keputusan yang diperolehi, kes 5 dan 1 menunjukkan reka bentuk sistem suapan terbaik dengan kecacatan yang paling sedikit. Ini adalah disebabkan oleh diameter sistem suapan yang kecil, di mana dapatlah disimpulkan bahawa diameter sistem suapan memainkan peranan yang penting dalam mengurangkan kecacatan produk.

ABSTRACT

The competitiveness of automotive industry is going at its peak. By releasing automotive products faster than others, automotive companies can maintain strong and remain competitive to strive to the top. However, problems faced during the research and development (R&D) phase of new product such as the existence of critical defects will delay the planning time, thus lengthen the product development lead time. Plastic parts of automotive that are manufactured by injection moulding also faced this problem, where defects always happen after they are manufactured. So, actions must be taken to ensure the defects are reduced or prevented at the first place. In Autodesk Moldflow Analysis, the part will be analysed, melt flow will be reviewed and defects that may happen can be predicted. Taguchi approach is used as Design of Experimental (DOE) method to optimize the design of part and feed system to ensure the best design is used. The part chosen is car door trim armrest cup and the defects analysed are short shot, weld lines and air traps. Based on the results, Experiment 5 and 1 show the best feed system design with least defects. This is due to the smaller diameter of sprue, runner and gate, thus conclude that diameter of feed system plays important role in reducing mould defects.

DEDICATION

To both my parents, Jamaludin Bin Saedon and Siti Aidah Binti Sapuan,
I dedicated this for you.

ACKNOWLEDGEMENT

First and foremost, I would like to express my thanks to God because of His love and strength that He has given to me to finish this project report. I do thank for His blessings in my daily life, good health, healthy mind and good ideas.

To my parents who have always been so close to me that I will find them whenever I need them; Jamaludin Bin Saedon and Siti Aidah Binti Sapuan, millions of thanks for the unconditional love that both of you have given me till the first day I breathe until now. Your encouragements since my first step to school have always motivates me to set higher targets in my education level. Believe me; I could never have done this without both of your faith, support, and constant encouragement. Thank you for teaching me to believe in myself, in God, and in my dreams.

My big thanks go to both my supervisors in BDP 1 and BDP 2, Engr. Zolkarnain Marjom and Engr. Mohd Faizal Halim for their cordial support, valuable information and guidance, which helped me in completing this project through various stages. Without their untiring assistance, direction, encouragement, ideas and constructive criticism throughout this project, this project could not be done well.

Grateful thanks to other lecturers and technicians, who gave me the permission to use all required machinery and the necessary material to complete this project. For all I learned from them and for the help they gave me in sharing their understanding and experiences about the injection moulding process.

Last but not least, I would like to give my appreciation to all my colleagues for the continuous support they have given me and to be the place where I can share all my problems and excitement when doing this project.

And for those who involved directly or indirectly with my project, I would like to give my sincere gratitude for all the encouragement, insightful comments and aids throughout the progress of making this report.

I owe a big appreciation to all of you. Thank you very much.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	-	Acrylonitrile Butadiene Styrene
ACC	-	American Chemistry Council
BDP	-	Bachelor Degree Project
BMW	-	Bavarian Motor Works
CAD	-	Computer Aided Drawing
CSR	-	Corporate Social Responsibility
deg	-	degree
DOE	-	Design of Experimental
mm	-	millimeter
OA	-	Orthogonal array
PDCA	-	plan-do-check-act
rpm	-	rotation per minute
RIMAS	-	Research Institute for Managing Sustainability (Vienna University of Economics and Business Administration;Austria)
SEM	-	Scanning Electron Microscopy
S/N	-	signal-to-noise
U.S.	-	United States
UTeM	-	Universiti Teknikal Malaysia Melaka
3-D	-	3-dimension
5 S	-	seiri (sort), seiton (set in order), seisi (shine), seiketsu (standardize), and shitsuke (sustain)

CHAPTER 1
INTRODUCTION

This chapter will explain the overview of the study and the purpose of this study. The chapter includes the background of the study, the problem statement, objectives that are expected to be achieved and lastly the scope of the study that is going to be conducted.

1.1 Background of Study

Injection moulding is a type of manufacturing process where molten plastic is heated under given temperature and is forced into a mould cavity under pressure to give desired shape based on the mould itself. As for the injection mould, it refers to an arrangement of hollow cavity spaces constructed to the shape of preferred product in one assembly, with aim to produce plastic products, usually in mass production. The cavity space is made by female mould part known as cavity and male mould part known as core. Not all materials are suitable for injection moulding, as this process usually deals with thermoplastic materials, and also applicable to certain thermosets materials. (Herbert Rees, 2002)

Injection moulding is known as a net shape manufacturing process due to the reason that it pushes the melt polymer into an evacuated mould cavity before it is then being cooled to the desired shape. Injection moulding is an interesting process, whereby it capable of producing really complicated pieces with high tolerances profitably. Since the injection mould itself is a really complex system consist of multiple components that are subjected to many temperatures and cycles, an

appropriate injection mould should be designed, produced and commissioned. (David Kazmer, 2007)

Dr. William J. Schoech (1986) describes the demands of the use of plastics in automobile industry where it has steadily evolved since the 1930s. As designers became more alert of their design possibilities, plastics became the material of choice for the interior of the car. With the advent of engineering plastics, new and exciting applications are being developed for lighting systems, glazing, and exterior body panels. We can see the future industry for automotive assembly will be based on the space frame concept with engineering thermoplastic body panels. This flexible manufacturing concept will produce parts much more economically than before, and will incorporate just-in-time manufacturing techniques utilizing the injection moulding process.

Injection moulding offers great benefits in producing plastic parts of automotive. However, this type of manufacturing process also comes with its drawback, where the parts produced sometimes do not meet the standard requirement or have defects on them. These happens due to several reasons, in which there are three sources where the problem persists; the materials being used to make the part, the processing of the material in the mould and lastly the mould itself. Many companies are concern with these factors as they provide troubleshooting guide if ever one of these defects happen.

Table 1.1: Example of troubleshooting chart of injection moulding defects

TROUBLESHOOTING CHART

		MACHINE DEFECTS						PART DEFECTS													
Numbers indicate sequence of making corrective steps; Arrows indicate ↑ - Increase ↓ - Decrease ↕ - Balance/Vary		Excessive Flash	Oversized Part	Part Sticking	Short Shot	Sprue Sticking	Undersized Part	Black Spots, Brown Streaks	Blisters	Brittleness	Burn Marks	Cracking, Crazing	Delamination	Discoloration	Flow Marks	Jetting	Poor Surface Finish (Gloss)	Poor Weld Lines	Silver Streaks, Splay, Splash	Sink Marks	Voids	Warping
MACHINE VARIABLES	Backpressure	5↓			8↑			5↓	2↑	2↓				4↓						7↑		
	Inj. Forward (Booster) Time		2↓	3↓		3↓	3↑				4↓											
	Clamp Pressure	3↑	8↑																			
	Cylinder Temperature	2↓	5↓	6↓			6↑					2↑		2↓	1↑		3↑		3↓			
	Holding Pressure		4↓	2↓			4↑													3↑	3↑	
	Injection Hold Time	4↓		7↓	9↑	2↓	5↑											3↑				3↑
	Injection Pressure	1↓	3↓	1↓	2↑	1↓	2↑			4↓	5↓	5↓			4↑		2↑	1↑		2↑	2↑	4↕
	Injection Speed	6↓	1↓	8↓	6↑	5↓	1↑				1↓	1↕	4↕		5↕	1↓	4↑	5↑	4↓	6↑	6↓	
	Shot Size (Material Feed)				1↑															1↑	1↑	
	Melt Temperature				3↑			3↓	4↓	1↑	2↓		2↑			2↑		2↑		5↓	5↓	5↕
	Mold Cooling Time			4↑		4↓	9↓										8↑					2↑
	Mold Temperature	7↓	6↑	5↓	5↑		7↓		3↑		3↓	4↑	1↑		2↑	3↑	1↑	4↑	6↑	4↓	4↑	1↕
	Nozzle Temperature				4↑	6↕						3↑		3↓	3↑				5↓			
	Overall Cycle Time		7↓					4↓						5↓					7↓			
	Screw Speed								1↓	3↓										8↑		
MOLD VAR.	Change Gate Location								6							5	7	7		13	11	7
	Size of Gate				11↑		8↑				6↑			6↑	4↑				8↑	10↑	9↑	6↑
	Size of Sprue/Runner				10↑									7↑						9↑	8↑	
	Size of Vent	10↕			7↑				7↑		8↑			7↑			5↑	6↑				
OTHER ACTION	Check for Material Contamination							2		7			3	6					2			
	Check Fit of Mold Faces	9																				
	Clean Cavity Surface																6					
	Clean Mold Faces	8																				
	Clean Vents				12						7										7	
	Dry Materials								5	5		6	5					8	1	11	10	
	Regrind Quantity									6↓			6↓							12↓		
	Purge/Clean Screw & Barrel							1						1								

As defects continuously happen from time to time, there is a need to find solution to identify a variety of potential problems and improvements for a mould before it gets built. MoldFlow software is one of the solutions as it offers tools for injection mould design, plastic part design and also moulding design process. MoldFlow helps. The results are less risk involved, more time and money saved in adjustments and faster delivery. Using Moldflow, it helps to;

(a) Decrease investment costs.

(b) Decrease product development time.

(c) Decrease the problem to be born with the parts and mold will have.

(d) Decrease total development time and the amount of time in trying molds.

(e) Enhance the quality of parts.

(f) Increase the quality of finished good products.

Generally, the purpose of this study is to design one part of automotive that uses injection moulding and analyse the flow of the process to identify any defects that are likely to happen. As the goal of this study is to reduce the defects on the part, the part will be redesigned and reanalysed again from time to time. In the process to achieve the goal, literature reviews are collected and researched to find any valuable information related to the study and all data from the simulation will be analysed.

1.2 Problem Statement

Globalisation has resulted in a tough automotive manufacturing environment that is transforming at a rapid pace, resulting in increasing competition between worldwide and national car manufacturers. (Laura Peinke, 2011) The Queuing Theory describes how the amount of time spent for a project increasing as the utilization of resources (for example, employees in product development team) increases. This is proven by a survey done to hundreds of product development team, where the 'extra works' will lead to extreme delays. (Stefan Thomke and Donald Reinertsen, 2012) The poor design of mould and feed system plays big role in the existence of moulding defects because defects in moulding often occur in a condition such as the unbalance feed system and the improper design of mould beside using the moulding machine that is not suitable. (David Kazmer, 2007) In this case, moulding defect in a finished product will add that 'extra works' thus increase the product development time, making the product to be released longer than expected. Because of this reason, actions need to be taken considerably to ensure such defects likely to happen can be avoided or reduced, so there will be no unexpected delay throughout the process of releasing the finished products.

1.3 Objectives

The general objective of this project is to reduce mould defects of an automotive part. For the specific objective, this project aims;

- To study the mould and feed system requirements
- To examine the defects that may happen on the moulding part
- To determine the cause of defects in injected moulding part
- To design and optimize the feed system of chosen injected moulding part

1.4 Scope

The scope of research for this project is only focused on;

(a) The assign of car door trim armrest pocket of Perodua Kancil as the chosen moulding part

(b) The three elements in feed system of three-plate mould which is the gate, runner and sprue

(c) The setting of fixed machine parameter and material selection like the one available in Faculty of Engineering Technology, which is the machine of Zhafir VE1200-210h and the material of ABS resin Toyolac from Toray Plastic Malaysia

CHAPTER 2
LITERATURE REVIEW

This chapter explains about all findings obtained from many literature reviews, which may come from the internet, journals, articles and books about the topic related to this study. This section includes findings about the overview of automotive industry, injection moulding machine, process and defects, and lastly about the method in this study.

2.1 Issues

The automotive industry is a growth industry. It has broken record after record in recent years, with no end in sight. Sales and production in China are booming. On the other side of the globe, a strong recovery in the US continues to surpass expectations. But along with record growth, the industry is also facing unprecedented challenges.

2.1.1 The Competitiveness of Automotive Industry

Globalisation has resulted in a tough automotive manufacturing environment that is altering at a fast pace, resulting in a rising competition between worldwide and national car manufacturers. (Laura Peinke, 2011) In a research of the key trends and policy decisions that affect the automotive industry, which was published at the beginning of 2011, the research and consultancy firm, Frost & Sullivan (2011) claimed that globalisation has placed cost burdens on producers,

needing them to outsource the lower cost of manufacturing processes, while at the same time placing the increasing priority towards the quality and productivity measures.

Not only that, Peinke (2011) also stated that the investment in automotive industry is increasing day by day as more investors starting to see the bright future in this industry, where the local market has seen this increasing of investment in industry development over the past decade owing to a solid political and economic environment in the mid to late 1990s. The overseas firms invested in big assembly companies and the industry had transformed from 37% of foreign ownership to almost 85% foreign ownership by the year of 2006. This changing of ownership happens to companies such as BMW and Mercedes Benz.

We can see from this article that the competitiveness of automotive industry has growing stronger until now, and this pattern has been seen by many investors as the way to boost up their economic life by investing to the automotive industry. As for the industry itself, the large investments have been, and will always continue to be, an essential factor to drive the automotive industry forward. Also, as the competitive of automotive industry is going stronger, so as to the product development process of the industry to ensure the production going smoother and faster.

2.1.2 The Need of Plastic Material in Automotive Industry

More demonstration of the abilities of plastic is required to enlarge its use in the automotive industry. American Chemistry Council (2014) made its first roadmap in 2001, and last updated it in 2009, entitled “Plastic and Polymer Composites Technology Roadmap for Automotive Markets”, where it is planned to set a framework for growing the penetration of plastics and polymer composites in the automotive industry, with its priority on light weighting and meeting fuel efficiency standards. Due to this fact, automotive manufacturers are increasingly looking to

these materials as an alternative to existing materials such as conventional steel due to the reason that plastic is lighter than such existing materials.

Matthew Marks (2014) claimed that in his 20 years of experience being involved with automotive industry, the use of plastic in automotive applications has increase to 50%, but still, people don't fully realize the potential beneath this material because automotive industry before this has evolved with the use of metals, mostly. The important issue is to show the engineers what they can do with this material, which it provides less weight to make product lighter, with the low specific gravity, high strength and high stiffness. He also identified the encounters in the perception that plastic are not the best material, so the need to advance the better tools to model plastic designs will help to change this perception.

We can see that as time passes by, plastic material has been the material of chosen for the automotive industry, and we can see the example of its application in the interior of the car, such as the dashboard, meter panel cover and also the light cover. The increasing demands of plastic material also increase the demand of better manufacturing process of it, and that will be explained in the next literature review.

2.1.3 The Increasing Demands of Injection Moulding in Automotive Industry

The demand of plastic material has increasing and more demonstration of the abilities of this material is required to enlarge its use in the automotive industry. (American Chemistry Council, 2014) According to this statement, we see that the usage of plastic material has growing in the automotive industry, making the production of plastic increasing. Erik Lokensgard (2010) did a research on the plastic production rate for automotive industry in United States. The outcome of his research shows that plastic production increased steadily since 1980s and has grown to 0.5% each year starting from 2002. This is the statement that proved the one about the demands of plastic material in automotive industry.