UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DETERMINATION OF THE OPTIMUM DESIGN PARAMETERS FOR A FAMILY MOULD

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

by

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MAY 2010

DECLARATION

I hereby, declared this report entitled “Determination of The Optimum Design Parameters for a Family Mould” is the results of my own research except as cited in the reference.

Signature : …….....

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Date : 14 MEI 2010

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TAJUK: DETERMINATION OF THE OPTIMUM DESIGN PARAMETERS FOR A FAMILY MOULD

SESI PENGAJIAN: 2009/2010

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ABSTRACT

There are various problem have been found in the plastic injection recently. One of the major obstacles is in the mould designing due to lack of understanding of the flow behaviour of plastic mould that resulting in over-packing, short-shot or any other defects on the part. In this project, the idea is to determine optimum design parameters for a family mould by implemented the simulation study using different parameters in the designs made with two different types of level for each parameter. For experiment, two main designs (Design A and Design B) with four different parameters (sprue, runner, gate and cold slug) have been designed by using application of SolidWorks. The seat belt buckle is used as the family mould parts of this study. The approach of Design of Experiment (DOE) was used to define the number of experiment need to conduct. In this work, sixteen experiments have been performed by using Moldflow Plastic Insight (MPI) Analysis software. Three elements of analysis; fill time, deflection and volumetric shrinkage were selected as case study to determine the best design of the family mould. Ranking method was used to determine best design of the experiment analysis. From the analysis result, Experiment 3 was defined as the best family mould design due to its balancing result of filling time, deflection and volumetric shrinkage. Consequently, there are no exact equations describing the relationship between sprue, runner system, gate and cold slug in the mould design and analysis. It depends on many factors such as shape and size of the plastic part, used materials, or the limitation of mould design.

ABSTRAK

Terdapat pelbagai masalah ditemui didalam proses penyuntikan acuan plastic. Salah satu daripada puncanya adalah disebabkan oleh kurangnya pemahaman mengenai perilaku aliran plastik didalam acuan yang mengakibatkan terjadinya *over-packing, shot-shot* dan lain-lain kecacatan kepada produk yang dihasilkan. Idea utama projek ini adalah untuk menentukan rekabentuk terbaik bagi *family mould* dengan menerapkan kaedah eksperimen dimana parameter berbeza digunakan bagi dua rekabentuk acuan. Bagi menjalankan eksperimen, dua rekabentuk acuan yang berbeza (*Design A dan Design B)* dengan empat parameter berbeza *(sprue, runner, gate dan cold slug)* telah dibuat dengan menggunakan aplikasi SolidWorks. Pengancing tali keledar telah digunakan sebagai objek rujukan didalam projek ini. Pendekatan *Design of Experiment (DOE)* telah digunakan bagi menentukan jumlah eksperimen yang perlu dilakukan. Didalam projek ini, 16 eksperimen telah dijalankan menerusi perisian *Moldflow Plastic Insight (MPI) Analysis*. 3 elemen utama didalam analisa *(fill time, deflection dan volumetric shrinkage)* telah digunakan sebagai asas untuk menentukan rekabentuk terbaik *family mould*. Kaedah susunan atau kedudukan telah digunakan untuk menentukan eksperimen terbaik. Eksperimen 3 telah dipilih sebagai yang terbaik kerana menunjukkan keputusan yang seimbang bagi ketiga-tiga elemen analisa. Secara dasarnya, tiada persamaan yang tepat untuk menggambarkan kaitan diantara *sprue, runner system, gate dan cold slug)* didalam rekabentuk dan analisis bagi acuan. Keadaan ini bergantung kepada banyak faktor seperti bentuk dan saiz objek plastic, bahan yang digunakan atau had-had yang terdapat didalam rekabentuk acuan.

DEDICATION

This report is dedicated

to My Father and late Mother,

both the *NOOR* of my eye

for every possible kind of help & support.

ACKNOWLEDGEMENT

In The Name of Allah Almighty and The Most Merciful and Blessing

Be Upon His Messenger Prophet Muhammad S.A.W and His Companions

I am thankful to Allah the Almighty for His divine inspirational guidance, which had helped me in completing this final year project. I am indebted to the following colleagues for their advice, assistance, and support: Mr. Zolkarnain Marjom (my supervisor), Mr. Tajul Ariffin (Design Manufacturing Head of Department), and Mr. Fauzi Packeer. Thanks also to FKP lecturers for their advice and support about Final Year Project (PSM). I am grateful to my dear BMFR colleagues for their support and encouragement. I want to thank to my father, for warmth and unwavering support. Thanks go out to Kerol, Jdy and Adha for their supporting and understanding. I want to thank to my brother and sister for supporting and unstoppable courage. I must thank to my lovely friends Ain for her support, advice and understanding.

Last, I don't know how to thank my brother, Abang Ngah, for his kindness and grace, for his advice and helping. For your patience and understanding, I will always remembered and appreciate.

Thanks & Best Regards

FIRDAUS HAKIMI HASSAN

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LIST OF ABBREVIATIONS

CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CAM	-	Computer Aided Manufacturing
CATIA	-	Computer Aided Three-dimensional Interactive Application
DFAIT	-	Department of Foreign Affair and International Trade
DOE	-	Design of Experiment
MPI	-	Moldflow Plastic Insight
PP	-	Polypropylene
PSM	-	Projek Sarjana Muda
PVT	-	Pressure versus Time
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1
INTRODUCTION

Supporting most manufacturing processes, mould design, manufacturing and moulding industries are backbones of whole manufacturing industry sector. Similar to other product design, it has been found that the overall mould design plays a decisive role in mould quality, manufacturing cost and project duration. The overall mould design dedicates the cavities layout, number of mechanisms for undercut related operations, the pieces of mould cores or sub-inserts, size of the mould base and so on; it also affects the downstream manufacturing process.

1.1 Background of the Study

The mould industry becomes very high market in this worldwide. A lot of products had been made using mould design concept. The mould and die sector is the leading engineering supporting industry in the country. There are about 350 companies currently employing approximately 14000 workers of which 50% of them are in the skilled and professionals categories (Anonymous, 2003). The industry trend is expanding to continue especially where increasing demand for mould making machinery is expected to continue with increasing plastics consumption rates in developing countries. The strong export growth observed in recent years is expected to continue as Malaysian companies improve their competitive position by further developing their skilled workforces and investing in leading technologies (Anonymous, 2003).

With the capabilities and influences of the mould making technology in this manufacturing industry, there are many studies that had been made to investigate or study about mould design and mould manufacturing process. It is important for a

design engineer to investigate and define the details about mould design. There are lots of requirements needed to be fulfilling in order to design and fabricate the mould and various parts of the mould depend on the technique adopted for its manufacturer.

The problem of mould design occurred in automotive industry. This is because this industry used hundreds of various plastic parts. In this study, seat belt buckle is used as reference part in designing of family mould because it was builds up from three different shape components that related to this family mould study.

Family moulds are designed with multi-cavities so that it is possible to produce several components from the same family group with one shot. These tools are not very popular within the production department because the setter only has a narrow set-up span available. If varying-sized components are to be injection moulded in the same process, it is inevitable that the machine has to be compromise when optimising the parameters because the data set has to be suitable for all the parts to be injected.

The mould designer, along with the buyer sees this a little differently. Family moulds are an economical alternative because several parts of the same family group are produced with one shot and thus they are made available at the same time. This simplifies the logistics, because there is no longer any requirement for parts which have been produced at the different times and at different production sites to be brought together for assembly. Advantages are also apparent for parts produced with self-coloured material, as the components produced within the same process are identically colour-matched.

The difficulties in setting the parameters can be addressed by a sophisticated hot runner technology, which, however, will result in both developments and hot runner cost inflation. Kudlik (2003) describes in detail the advantages of family moulds which proved to be decisive factor for building a family mould in one particular project. However, it is not without self- criticism that he describes how type of mould has performed. He states one crucial disadvantage in the design is that if one part is scrap, re-production for completion of multi-part groups proves costly.

This study also included in the approach of Design of Experiment (DOE) as a tool in defining the number of experiment needed to conduct for a family mould plastic analysis. Further analysis has to be carried out to ensure the validity of the process. DOE is a method or tool where the team identifies the parameters that can be controlled and the noise factors it wishes to investigate. The team then designs, conducts, and analyzes the experiments to help to determine the parameters set-points to achieve robust performance (Ulrich and Eppinger, 2003).

1.2 Problem Statement

Various problems have been found in the plastic injection industry recently. One of the major obstacles is in designing a family mould due to lack of clear understanding of the flow behaviour of plastic in the mould resulting in over-packing, short shot or any other defects on the parts. Determination of optimum design conditions is vital to define the best design for family moulds. The overall mould design dedicates the cavities layout, number of mechanisms for undercut related operations, the pieces of mould cores or sub-inserts, size of the mould base and so on; it also affects the downstream manufacturing process.

The runner-system design is of great importance to achieve a successful injection moulding process of a family mould with multiple cavities. The difference between the filling times of all cavities can be taken as the objective function to be minimized because if all cavities are filled simultaneously, the pressure and temperature variations should be a minimum. The purpose is to fill all cavities at the same instant under the same conditions in order to prevent flashing of the mould and to produce parts of improved and uniform quality. Other than that, the deflection and volumetric condition are very important to ensure the efficiency of mould plastic part can be achieved and there is no problem occurred during the injection moulding process. All the design parameters of family mould will be selected in order to define and determine the optimum design parameters of family mould using DOE approach and the experiment conducting using Moldflow Plastic Insight (MPI) Analysis.

1.3 Objectives

The objectives of this study are:-

1. To identify the mould design requirements and define the best design of family mould using standard specification.
2. To analyze the significant parameters considered in designing and fabricating family mould.
3. To determine the optimum design parameters for a family mould using DOE approach and run the plastic mould analysis based on three elements of analysis; fill time, deflection and volumetric shrinkage.

1.4 Scope of the project

In this project, several tools and equipments will be used in order to fulfil the objectives that have been stated earlier. The determination of optimum design parameters of family mould will be used on 80 tones Injection Moulding Machine in UTeM's laboratory. The design process might be used the application of CAD (Computer Aided Design) software to develop or alteration process of a 3D solid modelling to the core and cavity with additional element for a complete family mould design such as water connection, chamfer and adjustment to the sprue.

The CAD approach that will be used in this project design is SolidWorks and the application of DOE (Design of Experiment) will be carried out to select the proper parameter and defining the number of experiment needed to conduct in family mould plastic analysis. The design then will be analyzed with Moldflow Plastic Insight (MPI) Analysis software to get the responds and feedback in order to define the best design from the experiment.

1.5 Importance of the Project

The mould making is become important because most of the organization facilities are theoretically claimed to have the facilities to follow in the development of mould making. According to its influence to the industry, a family mould of seat belt buckle is analyzed by combining the concept of reverse engineering, DOE and mould making technique. The facilities can be utilize and tested on its capabilities of producing mould by applying tools and other resources if necessary.

In this project, the process of determining the optimum parameters of family mould will be carried out by using the DOE approach and Moldflow Plastic Insight (MPI) Analysis software. Most of the purpose is to run experiment and analyse the result in order to define the best design of family mould.

This project is important to ensure that the mould fabrication process can be done based on the study. The process of verifying the dimension and important element must be done according to standard requirement that must be followed to design mould and hen fabricate the mould with the facilities provided in UTeM's laboratory. This approach can give the chance to the researcher to show the ability of ascertain according to the task given (CAD drawing). The process of verify the part dimension is not easy because of complicated shape and small part. So, this project definitely need a lot of efforts to be given to get accurate data and approval information from various references such as books, journals, and discussion to the expert person in this mould design industry.

1.6 Organization of the Report

Chapter 1 – Introduction

The overall review of this research study is mentioned in this chapter. The importance and benefits, objectives and scope of the project are also described in this chapter.

Chapter 2 – Literature Review

This chapter describe about the source and study of mould design and the DOE approach. The techniques and tools used in this project also mentioned in this chapter.

Chapter 3 – Methodology

This chapter shows how the process of mould design is being applied according to the requirement, equipments, and methods used. The process flow for the project that will be done also recorded in this chapter.

Chapter 4 – Family Mould Plastic Analysis

This chapter shows the flow, requirements or steps procedures to conduct analysis in Moldflow Plastic Insight (MPI) software.

Chapter 5 – Result and Discussion

This chapter described all analysis, the results and data recorded in the Moldflow Plastic Insight analysis. Determination of best design also is discussed in this chapter.

Chapter 6 – Conclusion and Recommendation

This chapter described about the final finding of the project and conclude the entire objective either achieves or not. The recommendation for future works also covered in this chapter.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter describes about the surveys scholarly articles, books and other sources for examples dissertations, conference proceedings and so on that relevant to a particular issue that is on how mould is designed. Besides that, this chapter also describe about of research of theory which is divided into two parts, broad area broad focus area and also providing a description of the project. For example, the comparison between existing moulds design before with the new one that will be analyzed, relationship between DOE with this project and also the specification data for injection moulding machine. Finally, the summary and critical evaluation of each work will be carried out. The purpose to have this literature review is to offer an overview of significant literature published on related topic.

2.2 Plastic Injection Moulding

Injection moulding is the most commonly used manufacturing process for the fabrication of plastic parts. A wide variety of products are manufactured using injection moulding, which vary greatly in their size, complexity, and application. The injection moulding process requires the use of an injection moulding machine, raw plastic material, and a mould. The plastic is melted in the injection moulding machine and then injected into the mould, where it cools and solidifies into the final part (CustomPartNET, 2007).