UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF COOLING SYSTEM FOR TWO PLATE MOULD

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

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Produktiviti adalah aspek yang penting dalam proses pengacuan suntikan. Fasa penyejukan adalah fasa yang kritikal dalam proses tersebut dan ia boleh mengaruhi pada produktiviti pengacuan, sebaik-baiknya pada kualiti produk acuan secara berterusan. Penyejukan menduduki bahagian yang terbesar (80%) dalam kitaran pengacuan suntikan. Oleh itu, mustahak merendahkan penyejukan masa kepada miniumum untuk meningkat pengeluaran acuan. Objektif projek ini adalah mereka saluran penyejukan untuk menurunkan masa kitaran dan meningkatkan produk kualiti. Proses penyejukan berkaitan rapat dengan pemindahan haba yang terdapat dalam acuan. Selain itu, proses penyebaran haba di dalam acuan perlu difahami dengan jelas untuk mereka bentuk saluran penyejukan yang sesuai pada acuan. CAD model acuan dilukiskan dengan Solidworks. Sebelum acuan dilukis dengan "Mold Tools", draf analisis perlu dianalisiskan. Analisis kesan penyejukan bagi dua plat acuan punya produk yang sedia ada perlu dianalisi dengan Moldflow. Diameter penyejukan saluran yang besar hanya guna masa yang pendek untuk mencapai suhu ejekan, tetapi ini akan merendahkan nombor Reynold. Demi mendapatkan nombor Reynold yang stabil, sistem penyejukan pelbagai siri adalah sistem penyejukan yang terbaik. Tambahan, reka bentuk sistem penyejukan ini mempunyai nombor Reynold yang lebih tinggi (47236) daripada reka bentuk sistem penyejukan yang selari (4249.5). Tetapi, reka bentuk pelbagai siri mengambil masa yang lebih panjang untuk mencapai suhu ejek (15.10s) daripada reka bentuk yang selari (15.04s). Selepas pengoptimumkan parameter proses, reka bentuk pelbagai siri hanya mengambil masa 13.40s untuk mencapai suhu ejek.

ABSTRACT

Productivity is an important aspect of injection moulding process. The cooling stage is a critical stage in such process, and has a direct influence on the mould productivity, as well as on the quality of the moulded parts. A substantial portion of the total moulding cycle (e.g., as much as 80%) could be required for cooling. Therefore, for high-production moulds, it is imperative that the cooling time is reduced to a minimum. This project aims to design the cooling channel for the core and cavity inserts for reducing cycle time and improving part quality. Cooling is related to the heat transfer in the mould, thus heat flow process inside mould plate need to know well for designing suitable cooling channel layout for the inserts. The mould insert CAD model is draw by Solidworks, where the draft analysis is analysed before "Mold Tools" is used to created the mould. Cooling effect is analysed using Moldflow software for existing product of two plate mould. The cooling channel within larger diameter can shorter the time to reach ejection temperature, but will reduced the Reynolds number. Based on the analysis studied result, the multiple series layout is the best cooling channel system recommended for this type of mould. This type of cooling system layout design are able to generate 47,236 of Reynolds number higher than parallel layout design which is 4250 only. Multiple series layout design consumes longer time which about 15.10 sec or 0.6 sec higher than parallel layout design to reach the eject temperature. Followed by process parameters optimization, the time taken to reach eject temperature can be improved from 15.10 sec to 13.40 sec or 11% for multiple series cooling layout design.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	-	Acrylonitrile butadiene styrene
HDPE	-	High-density polyethylene
LDPE	-	Low-density polyethylene
PP	-	Polypropylene
PE	-	Polyethene
et al.	-	and others
Re	-	Reynold number
FYP	-	Final year project
CAD	-	Computer-aided design
CMM	-	Coordinate Measuring Machine

CHAPTER 1
INTRODUCTION

1.0 Introduction

Nowadays, plastic is a common material used to make the product. The products in our surrounding, most products are made by plastic material. Many products that are made by other materials are replaced by the plastic material. According Moayyedian, et al. (2015), the plastic material is the highest consumption weight in the world compare to other traditional raw materials. For example the ceramics cup is replaced by the plastic cup. The plastic material becomes familiar because its light weight characteristics and low cost. One of the method to produce the plastic products is carried out the plastic injection moulding process. Thus, the plastic injection moulding process is very important for producing the plastic parts. Injection moulding is the manufacturing process that is able to produce products in very large production volume. Although the capital investment of injection moulding is very high, but its ratio of capital investment to total manufacturing cost is low, thus nowadays, the manufacturers are more prefer to use injection moulding.

The repeatability and the precision of the injection moulding is very high. The injection moulding is able to produce same products in long production time, and able to get the precise dimension of the products. It has high productivity. However, the injection moulding could bring some defects, which is reduced the quality of the product. The defects may cause by some factors, such like parameter of the process, design of part, design of mould insert, and design of cooling channel. The example of defects occur are ripples, flow marks, sink marks and voids, and delamination. All of these defects affect the appearance of the product. One type of the defect is not necessary caused by one reason, it may affected by a few of reasons. Thus, it is difficult to make sure that the reason cause the defect occur.

Injection moulding involves few main stage of processes such as clamping, filling and packing, cooling, and ejecting. The cycle time depends on these stage of processes time. The cycle time can affect the production volume of the machine. The longer the cycle time, the lower the production volume. Hence, the low cycle time is more preferred. In the cycle of the injection moulding, the cooling stage is take up the most space in the cycle among the other stages. According to Wang, et al. 21 February, 2014), the cooling process is take time more than 50% of the injection moulding cycle. Thus, the cooling stage is the most important process among the other stages.

The cooling process can affect the cooling quality of the products. The cooling process is related to the heat transfer from the melted plastic to the mould and surrounding. The temperature of the melted part is very high while the injection or filling and packing process is carry out. Thus, the cooling process needs to take long time to cool down the plastic for solidifying the plastic into the solid product. For reducing the cycle time, the cooling time must be reduced. However, the cooling time is depended on the time of the plastic is solidified. Ones the time of the plastic solidified is shorter, then the cooling time is decreased. Coolant is the best way to help the mould to transfer the heat from the melted plastic to the surrounding faster. Hence, the design of the cooling channel in the mould is required.

In this project, the cooling channel is designed for the two-plate mould for souvenir convocation, where the pen holder as the souvenir convocation. The design of the souvenir is according to the existing design, where the design of the pen holder is a “Keris Panjang” shape. This design is to symbolize the power of our University (UTeM). The design of cooling channel in the mould is needed for improving the effectively of the production and the quality of the souvenir convocation. The souvenir convocation is more concern in its surface appearance because it is a gift for the undergraduates who are graduated. The cooling channel has different layouts such as series, parallel, and combination of series and parallel. Different layouts have different effect for the cooling quality.

The aims of this project is to study the best design of cooling channel for the souvenir convocation. Moreover, this project is to design cooling system for two-plate mould. Moldflow software is used to simulate the desired cooling channel on the mould, then the best design is chosen.

1.1 Problem Statement

The technology injection moulding is more advanced now, however the cooling system is very crucial. According to Wang, et al. (21 February, 2014), the cooling process is take time more than 50% of the injection moulding cycle. Hence, the cooling system is very important in the injection moulding. In cooling stage, the parameter is important, but the design of cooling channel is also important. Agazzi, et al. (2012) stated that the solidification of the part is performed by cooling channels distributed in the mould. The suitable cooling channel design is very important, which will affect the moulded part in cooling stage. The worst design of cooling channel may cause the defect of the moulded part such as sink marks, vacuum voids, and warping. According to previous problem, the existing molten souvenir convocation is stick on the cavity. One of the reason is that the existing inserts are lack of cooling channel design. Based on the problems, the cooling channel is design to reduce the defect and the cycle time of injection moulding.

1.2 Objectives

- To optimise cooling channel layout design for reducing the cycle time of injection moulding
- To analyse cooling effect using Moldflow software for existing product of two plate mould

1.3 Scopes

The consideration in injection mould process is very large. For example the parameter of the feeding, the mould design, the cooling parameter, the cooling system design, and the part design, are needed to concern. Hence, this project only focus in some field. The bellows shown the scope of this project:

- To focus in the conventional cooling system
- The design construction will continue from previous work (Abdullah, 2016)
- To focus in core and cavity inserts only