DESIGN OPTIMIZATION OF EXTERNAL COOLANT FILTER FOR METAL MACHINING MACHINE

AIMADUDDIN AZFAR ABD. BASHIR

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SUPERVISOR'S DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature :.....

Name of Supervisor :.....

Date :.....

DECLARATION

I hereby declare that the work in this thesis entitled " Design Optimization of External Coolant Filter for Metal Machining Machine" is my own except for summaries and quotations which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: ……..

Author: AIMADUDDIN AZFAR B. ABD. BASHIR

Date: …….

DEDICATION

To Ibu and Ayah, I did my very best and I hope I make you proud.

I dedicate my thesis to my beloved parents

ACKNOWLEDGEMENT

I would like to express my heartfelt appreciation to my supervisor Mr. Febrian bin Idral for giving me this opportunity to conduct and complete my final year project. He never hesitated to give me advice and guidance whenever I was confronted by problems. Furthermore, I am extremely thankful for his patience and advice while leading me in this project.

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ABSTRACT

Machining has been one of the fundamental processes in engineering when it comes to metal processing as well as product forming. Machining process can be briefly described as the process of removing material from a work piece. This study focuses on designing and optimising the selected design of an external coolant filter for metal machining machine. The use of coolant in metal machining process is to obtain a higher quality surface finish. Without proper handling of the coolant in use, the workpiece may even be damaged. The design of the external coolant filter was made in reference to an existing product. In order to prevent this from happening, analysis had been done. By using thermal equilibrium concept, the temperature can be controlled. Aside from that, particle size during machining process was also considered, resulting in the best filtration media selection.

ABSTRAK

Proses pemotongan menggunakan mesin merupakan salah satu proses terpenting di dalam proses yang melibatkan pemprosesan besi dan juga pembentukan produk. Proses ini boleh dinyatakan sebagai proses membuang bahagaian dalam bentuk serpihan berskala kecil dari bahan yang diproses. Kajian ini memfokus pada mereka bentuk dan mengoptimumkan rekaan tersebut bagi kegunaan mesin pemproses besi. Penggunaan penyejuk dalam proses tersebut adalah untuk mendapat kualiti pemprosesan yang lebih tinggi. Tanpa pengendalian penyejuk yang betul, bahan yang diproses juga berkemungkinan untuk rosak dari proses. Rekabentuk penapis tersebut dibuat dengan rujukan dari produk sedia ada. Bagi mencegah kerosakan dari berlaku, analisa telah pun dilakukan. Dengan mengaplikasikan konsep kesamaan termal, suhu sejuk penyejuk dapat dikawal. Selain itu, saiz serpihan yang terhasil dari proses tersebut juga telah diambil kira sekaligus menentukan media penapis yang terbaik bagi proses tersebut.

CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

$\dot{Q}_{conv}$	-	Convection Energy
η_{th}	-	Efficiency
℃	-	Degree Celsius
As	-	Surface area through which convection takes place
E	-	Energy
h	-	Convection heat transfer in W/m2. C
K	-	Thermal conductivity of material
Kg	-	Kilogram
L	-	Length
r	-	Radius
T∞	-	Surrounding temperature
Ts	-	Surface temperature

LIST OF ABBREVIATIONS

AiRTX	-	Air Research Technology Company
ANSYS	-	Analysis of System Software
ASTM	-	American Society for Testing and Materials
CAD	-	Computer Aided Drawing
CATIA	-	Computer Aided Three Dimensional Interactive Application

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Machining has been one of the fundamental processes in engineering when it comes to metal processing as well as product forming. Machining process can be briefly described as the process of removing material from a work piece which includes the process such as cutting, grinding, honing and drilling by using machine tools in order to obtain the desired shape. In high-speed machining, the most dramatic increase in applications are detected to be in the manufacturing of aluminium components at which the volumetric material removal rates can be extremely high which approaches thousands of cubic centimetres per minute (Davis and Burns,2001). Generally, every process of machining for example cutting process is the result of dynamic interactions between 3 elements which are present during the process which is the machine tool, the cutting tool as well as the work piece (Balachandran, 2001).

Extensive research on machining was made and it was discovered that these processes are affected by static and dynamic effects which causes the machining system to deviate from the desired geometry. Some of the factors contributing to these effects includes slide speed variations of chips formed and stick-slip friction of the chips (Balachandran, 2001). In order to get a smooth surface finish with respect to the tolerance of in-house quality specifications, these

problems were reduced by the application of coolant in machining process. Coolants functions as cooling and lubrication system in machining processes, as well as improving the surface quality of the work piece by constantly removing fine chips from the tool and the cutting zone. Coolants also helps in prevention of the chips to be welded on the cutting tool which in time will affect the surface quality (Childs T et. al, 1988).

In general, a coolant flows from the reservoir to the pipelines within the machinery and then through pipes in the working space of a machine which it will execute the cooling processes and then reabsorbed into the reservoir via sinkhole in the workspace. That being said, the chips which were swept away from the work piece and the tool will flow alongside the coolant into the reservoir. Coolants shows signs of contamination when it turns brown. In machineries which uses coolant, most often the cause to the colour change is deep within the reservoir at which sludge starts to form. This dissertation discusses on a design which will elongate the life time of a coolant within a machine by the use of an external filter

1.2 Problem Statement

A metal machining machine was running for 24 hours a day for Panasonic Air Conditioning Malaysia Sdn. Bhd. in order to achieve the target production rate per day. The parts which were processed was in variety of shape and undergoes different processes. Some undergoes drilling while some undergoes milling and lathe process. A few examples of these parts are the cylinder, piston as well as the upper and lower bearing of an air conditioner compressor. Often companies tend to maximize the capabilities of each machine in order to be cost effective. As the machines are running non-stop, the contents of the coolant used becomes contaminated with chips and burrs from previous processes which in time will affect the quality

of the finishing of the product as well as the tool life. Most of the machines used are back dated and roughly aged in between 20 to 10 years old. The pre-installed filter on the machines were not able to filter contaminants thoroughly which then results in formation of metal sludge. This leads to high cost consumption on maintenance. The challenge then comes on keeping the coolant at optimum level in order to elongate the tool life while producing high quality product finish. This dissertation discusses on design optimization of the current filter at which the outcome of this research is targeted to be an external stand-alone filter which is able to filter the coolant flow thoroughly and at the same time reduces heat level of coolant flow.

1.3 Objective Study

1. To design an external stand-alone type external coolant filter for a 24 hours working machine
2. To ensure the reduction in temperature of the coolant up to 5%

1.4 Scope Project

1. To design and develop a 3D solid modelling of the overall system of the external coolant filter by using CAD software such as CATIA V5R20.
2. To optimize the design of the external filter and system in order to gain the most optimum performance by reducing heat
3. To reduce coolant heat level and ways to reduce them through the heat exchanger

1.5 Methodology View

In the initial stage, this project which is design optimization of external coolant filter for metal machining machine was studied on the basis of coolant flow in a metal machining machine. This later on move to the effect and importance of coolant usage when machining metals. Then the design specifications of the external coolant filter which includes the size, flow process and material selection is determined with reference to an existing product. These specifications should be followed for safety, precaution and hazard purposes. This project then proceeds to the construction of 5 conceptual designs according to the project's requirement as well as the filter's criteria. The proposed design was then evaluated by using Weighted Selection Method, followed by the matching of parts by using Pugh Selection Method in order to produce 3 best designs. These designs are then converted into 3-Dimensional models by using CATIA V5 R20 software. Considering the flow and the temperature of the coolant in the machine, the temperature drop effectiveness of the filter is analysed by using ANSYS software. The same thing is done for the flow of coolant within the designed filters as whole. Finally with reference to the analysed results, the best design was selected and improvised in order to fulfil the criteria needed with an appropriate factor of safety.

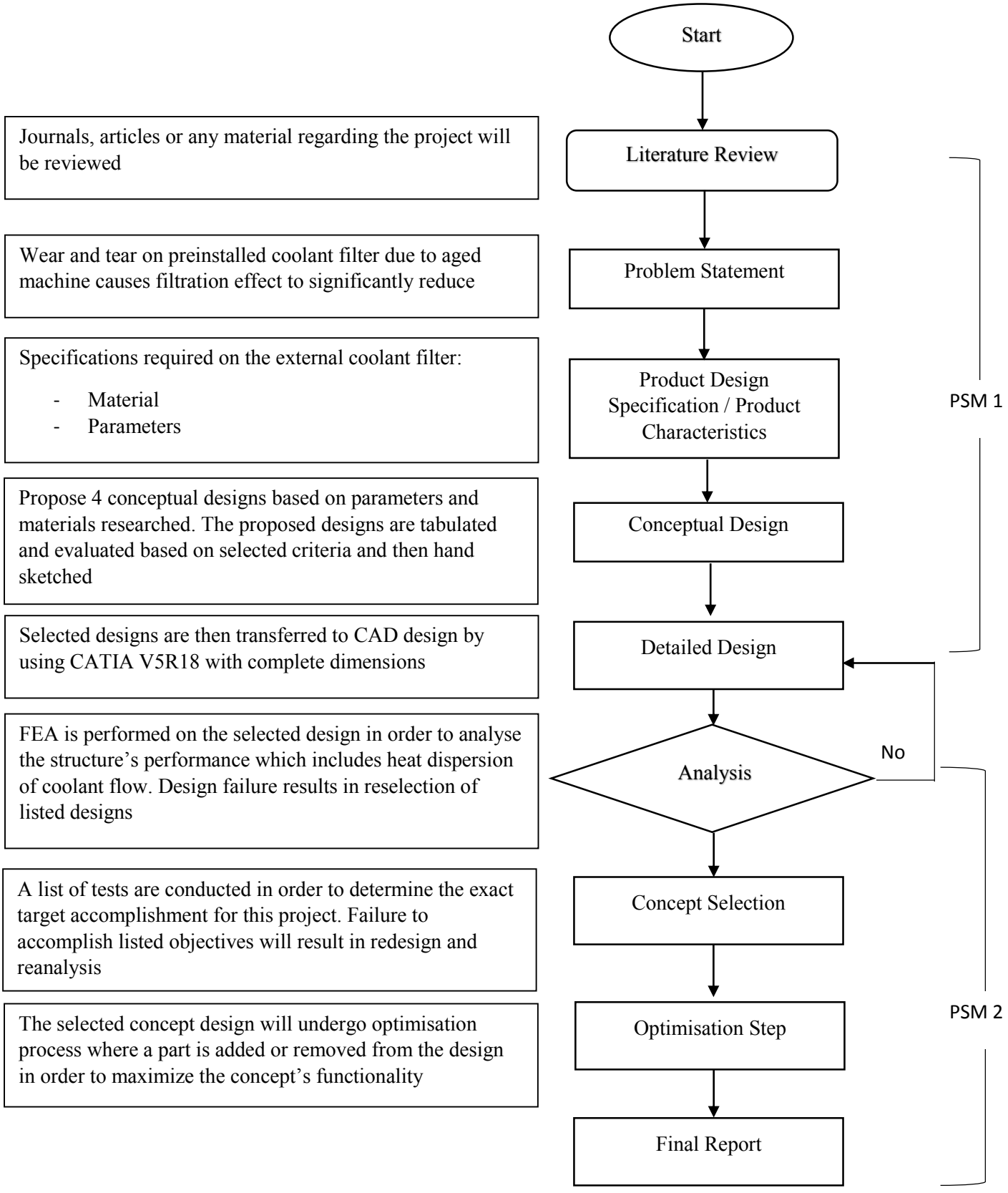

Figure 1.1: Overall project flowchart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Literature Review

This section explains the literature review of metal machining issues which are related to surface finish in general. This later on moves to coolant issues in industrial manufacturing sectors revolving around filtering and flow systems in a coolant filter. The explanation continues to the process of designing and flow analysis of the filter by generation and evaluation of the designed concept. The source of information and data was collected from various sources which includes academic journals, produced product specifications as well as books.

2.2 Metal Machining

Metal machining is one of the processes categorised under machining. It is a process where metal raw piece of materials are removed or cut into a desired geometry by a controlled material removal. These processes are nowadays known as subtractive manufacturing. The "controlled" term used in the definition is a variable which are controlled by many factors during the process which includes type of tool used, spindle speed during cutting as well as

feed removal rate. There are however other methods which are used in order to process selected raw metals such as flame cutting and plasma cutting. Generally there are 3 types of metal machining which are widely used until today. These classifications include turning, milling and drilling while other operations can be considered as miscellaneous or as a sub category from the main 3 processes including shaping, boring, planning, broaching and sawing. Going through the 3 processes stated; turning processes are operations where the workpiece are rotated in order to remove materials. Millings however are operations which contradicts turning. In milling the tool rotates against the workpiece while drilling is an operation of producing holes or refining them by using rotation cutter tool. Figures below shows some common machining processes.

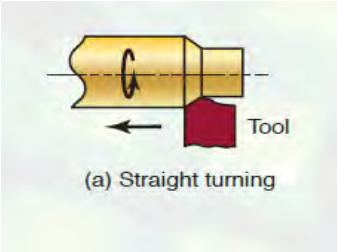

Figure 2.1: Straight turning motion

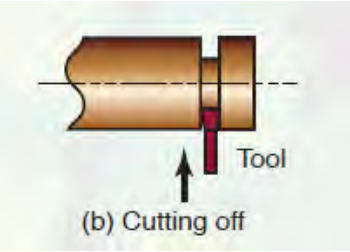

Figure 2.2: Cutting process by turning

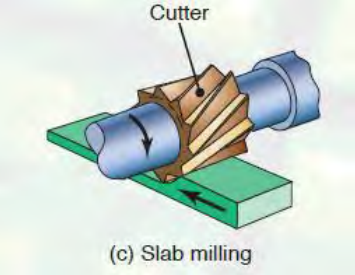

Figure 2.3: Slab milling process

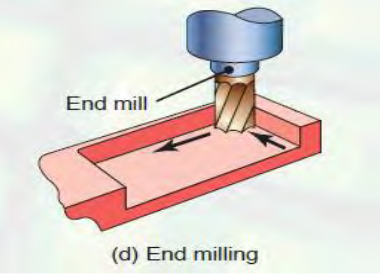

Figure 2.4: Milling motion

(Source: Chockalingam, P., Kuang, K. C., & Vijayaram, T. R. (2013))

Nowadays, instead of being manually steered, materials are often processed in an orderly manner with the help of programmable logic controller (PLC). PLC helps in navigating