UNIVERSITI TEKNIKAL MALAYSIA MELAKA

COMPARISON STUDY OF MACHINIBILITY PERFORMANCE BASED ON CNC AUTOMATED COOLANT SUPPLY SYSTEM

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

by

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I hereby, declared this report entited "Comparison Study Of Machinibility Performance Based On CNC Automated Coolant Supply System" is the result of my research as cited in references.

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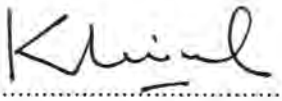
APPROVAL

This reported is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons) The member of the supervisory committee are as follow:



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Encik Khairol Anuar Bin Rakiman

ABSTRACT

CNC machine is an industrial manufacturing machine that is used to improve quality and productivity of a product. There are two basis ways of applying coolant which are dry machining and wet cooling machining. Therefore, some researches had been done in order to obtain information about the method involved. It had been found that there are disadvantages to both techniques and this had affected to the workpiece, tooling, health and also environment. Moreover, the used of wet cooling technique causes waste and increasing productivity cost. This is because only 10% to 15% of coolants is able to play their role when it is supplied to the tool and workpiece to decrease the temperature, and the other percents of coolant is not be used. Hence, the idea of using PLC that inspired the control system of coolant supply plays the main role in developing the modern technology and industry. The purpose of this project is to develop the time-based coolant supply system and to test the performance of the machining through the surface roughness of the workpiece. The structure of this project involved development in software and hardware. The adjusted device to control the coolant supply is used by applying a washing machine inlet control valve. Next, the used of PLC is to open and close the valve. The experiment started by testing the performance which are tool speed, depth of cut and feed rate of the machine with unloaded coolants by using 5s interval time to confirm the functionality of the system. Then, it is tested with flooded coolant with combination of parameters. Lastly, 8 interval times are used to run Experiment 2 and Experiment 3. The performance of each time interval between 2s to 25s of coolants supply is analysed in term of the surface roughness of workpiece and tool wear. Average data of the analysis setup is then obtained to plot the graph in order to get the best interval time in term of surface roughness with optimum conditon of speed, depth of cut and feed rate.

ABSTRAK

Mesin CNC merupakan industri mesin pembuatan yang digunakan untuk meningkatkan kualiti dan produktiviti sesuatu produk. Terdapat dua cara biasa untuk mengaplikasikan sistem penyejukan ini iaitu melalui teknik pemesinan kering dan pemesinan basah. Oleh itu, beberapa kajian telah dilakukan untuk mendapatkan maklumat mengenai beberapa kaedah yang terlibat. Dalam kajian ini, didapati bahawa terdapat kelemahan untuk kedua-dua teknik tersebut memberi kesan terhadap bahan kerja, peralatan yang digunakan, kesihatan, serta alam sekitar. Selain itu, penggunaan teknik pemesinan basah akan menyebabkan pembaziran dan meningkatkan kos pengeluaran. Ini kerana, hanya 10% kepada 15% cecair sahaja yang memainkan peranan mereka untuk mengurangkan suhu mata alat serta bahan kerja. Oleh yang demikian, idea penggunakan PLC untuk menggantikan penyejuk manual kepada automatik telah diilhamkan sebagai sistem kawalan dan ianya amat memainkan peranan didalam sektor pembangunkan industri dan teknologi moden. Tujuan utama projek ini adalah untuk membina sistem penyejukan berasaskan masa dan untuk menguji prestasi mesin melalui kekasaran permukaan bahan kerja. Selain itu, struktur projek ini melibatkan penyediaan 'software' dan 'hardware'. Masa diselaras untuk mengawal pengeluaran cecair bagi menyejukkan bahan kerja serta mata alat. Ia dikawal menggunakan inlet mesin basuh. Seterusnya, PLC digunakan bertujuan untuk membuka dan menutup injap. Eksperimen ini dimulakan dengan menguji prestasi mesin dengan menggunakan kelajuan, kedalaman pemotongan serta kadar suapan. Kemudian, eksperimen diteruskan dengan penggunaan cecair melalui beberapa jenis penggabungan 'parameter'. Akhir sekali, 8 masa yang berbeza telah digunakan untuk menjalankan Eksperimen 2 and Eksperimen 3. Prestasi untuk setiap masa daripada 2s kepada 25s yang digunakan dianalisa dari segi kekasaran permukaan dan penggunaan alat. Purata data setup analisis kemudiannya diperolehi dengan memplot graf bagi mendapatkan selang masa yang terbaik untuk memperoleh keadaan optimum bagi kelajuan, kadar suapan (feed rate) dan kedalaman pemotongan.

DEDICATION

This report is dedicated to my beloved parents, Wan Md Hatta Bin Wan Ahmad and Marini Binti Wan Ibrahim as well as my caring and supportive family members who has always stood by my side in facing the circumstances. Besides, a highest gratitude to my project Supervisor, Encik Khairol Anuar Bin Rakiman, lecturers and friends that always give me a useful guidance and show me the correct paths from the beginning to the end of the project.

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LIST OF ABBREVIATIONS

CNC	-	Computer Numerical Control
NC	-	Numerical Control
PLC	-	Programmable Logic Control
MQL	-	Minimal Quantity Lubrication
AL	-	Aluminium
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
G-code	-	Preparatory Code
LED	-	Light Emitted Diode
USB	-	Universal Serial Bus
PC	-	Personal Computer
AC	-	Alternating Current
DC	-	Direct Current
CPU	-	Central Processing Unit
2D-2	-	Dimensional
I/0	-	Input and output
ECU	-	Engine Control Unit

LIST OF SYMBOLS

%	-	Percent
Mpa	-	Mega Pascal
M/min	-	Meter per minute
Mm	-	Milimeter
mm/rev	-	Milimeter per Revolution
rpm	-	Revolution per Minute
µm	-	Micrometer
ml	-	Mililiter
s	-	Second

CHAPTER 1
INTRODUCTION

The overview of this chapter explains about Computer Numerical Control (CNC) machine, the cleaner application software and a method to be applied in the coolants system. Next, the used of PLC is explained in order to replace the conventional method. After that, the problem statement, objectives and scopes are discussed.

1.1 Background

Development of Computer Numerically Controlled (CNC) machine is a tremendous contribution to the manufacturing industries (Ansar *et al.*, 2016). The programmable language which is controlled by the new CNC machines had an ability to carry out a wider variety of tasks with greater accuracy. The performance of the machines allowed high automated control, which can improve the productivity of the product. There are a few technologies used in metal cutting machine (CNC machine) for example milling, lathe and turning machine. Ansar *et al.*, (2016) stated again that to increase the flexibility of the machine in handling a variety of components and to finish them in a single set-up on the same machine, CNC concept was applied to develop a CNC machining centre for machining prismatic components combining operations for example milling, drilling, boring and tapping. Therefore, the process with high machining speed, small amount of feed rate and large depth of cut can generate heat in profusion and increase the cutting temperature in machining.

The increasing of heat due to friction and energy lost can lead the cutter to be unsharpened and it will affect high power usage and poor in surface finishing. In other hands, the poor coolant cause of the low thermals conductivity in air surrounding. According to

Dhar & Kamruzzaman (2007) the increasing of temperature induces accelerated tool wear and deteriorates the surface quality . Then, it was supported by Mia and Dhar (2015) that it will reduce tool wear, prolonged tool life, improved surface finish and integrity of the lessened cutting temperature when the coolant is used. Thus, the coolant system is necessary as a safeguard to a system from overheating and to remove excess heat at the workpieces. It is needed to get the desired size control and shape of the workpiece. The most function of the coolant system is to cool and to lubricate machines and cutting tools.

Generally, the common coolant types that are used in manufacturing are cutting oils and cutting fluid. The interface between tool's cutting edge and the chip at the cutting stage are prevented using the cutting fluid which is also fluid that is used in the coolant system at CNC machine. This heat was prevented by preventing friction at this interface. It was stated by Courbon *et al.* (2009) that the accredited of favourable thermos-mechanical interaction crafted by the acted coolant for the foregoing benefits. Later than, it was clearly explained by Mia and Dhar (2015) that these benefits are diminished by environmental degradation and poor health condition of human operator triggered of the environmentally in-compatible coolant. In heat generated 80% of it was carried by chips while other 20% use coolant to take away.

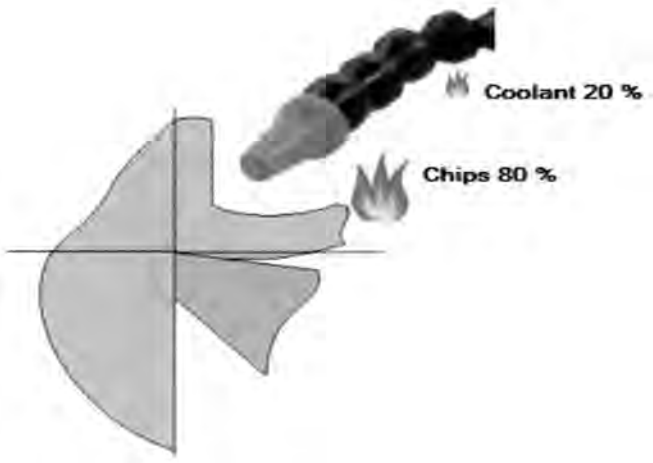

Figure 1.1: Percentage of the heat generated (Source: http://cadem.com/cncetc/cnc-machining-coolant/

Next, the serious issues about health, environment and economy had been affected by the use of coolant fluids. Therefore, a few methods need to be obtained to investigate this problem. To investigate the problems, minimal quantity lubrication (MQL) is used

regarding the surface roughness, tool wear, temperature deviation, depth of cut and the amount of the coolant system used. The process of applying minute amounts of high-quality lubricant directly to the cutting tool or workpiece is call as MQL. According to a study of Unist (2012) stated that, Ford saw a 13% decrease in overall cost after the implementation of MQL. After that, it was stated again that this decrease in costs was due to better cutting tool life, a significant fluid reduction, reduced costs of coolant handling, decrease maintenance and an increase of machine uptime. Moreover, MQL minimizes environmental impact by reducing fluid usage and decreasing the need for coolant treatment and disposal.

Figure 1.2: Coolant system (Source: http://cadem.com/cncetc/cnc-machining-coolant/)

With the details concepts of MQL application, it has sparked the idea in this research work because the application of MQL refers to a small amount of cutting fluid with the form of mist rather than flooding the workpiece. This option can reduce waste and minimize the production cost. The aim of this project is to program Programmable Logic Controller for an automated coolant supply system in CNC turning machine as well as to analyse the performance of automated coolant system in CNC turning machine in term of surface roughness and tool wear.

1.2 Motivation

This project is an inspiration to improve the wet cooling technique. The wet cooling technique has been widely used in the past with an application of a stable flow of the coolant to the tool and workpiece. It is clearly seen that this system produced a lot of waste when large amount of fluid being projected to the workpiece. In addition, it only needs a small amount of the coolant to cool down the temperature of the tool and workpiece. Moreover,

continuous flow of the coolant causes the increase in production cost because the coolant has to undergo recycle frequency in 2 to 3 weeks' time. Due to the particular disadvantages, the student research had been done before using the idea of MQL method with the help of PLC. The time-based coolant supply was built to increase the recycle lengthen of the coolant while it will reduce the cost. Hence, continuous research need to be implemented to study the interval time that give the best value of the surface roughness.

1.3 Problem Statement

Basically, the conventional of CNC machines use a wet cooling method to reduce the heat and excess chips at the workpiece. However, in this study there are three major problems that exist when the wet cooling method is apply. Firstly, the production cost increase due to the continuous flow of the coolant in the system. This causes the shorten time for the coolant to be recycled. Then, a large amount of fluid is being projected to the workpiece and this produces a lot of waste since they only need a small amount of the coolant. Moreover, the use of excessive coolant in an extended period can affect health and environment. The increasing of heat due to friction and energy lost can lead the cutter to be unsharpened and it will affect high power usage and poor in surface finishing. Therefore, MQL method and the development of PLC to control time-based coolant supply is used to minimize the problems.

1.4 Objective

The objective of this project:

i. To program Programmable Logic Controller for an automated coolant supply system in CNC turning machine.

ii. To analyse the performance of automated coolant system in CNC turning machine in term of surface roughness and tool wear.

1.5 Scope

The scope of this project:

i. Using Haas SL-20 CNC turning machine.

ii. Using Omron CP1E to program the PLC.

iii. CNC Laboratory room as a workplace to do the experiments.

iv. Workpiece will be AISI 304L only, other types of workpiece material will not be considered.

v. The cutting fluid used is Al Soluble Extra and other types of cutting fluid will not be considered.

1.6 Report Structure

There are five chapters that covered the report structure including introduction, literature review, methodology, result and analysis. The first chapter is chapter 1 that explained about the introduction for the whole project. A background of the project, the motivation, objectives, problem statement and scope of this project had been covered. Chapter 1 had been seen importance since it is needed to give a brief idea for the other chapters.

Next, chapter 2, Literature Review is displayed about the past study from a lot of resources such as journals, articles, books and internet that supports the topic of this research project. A few techniques to apply coolants are explained in this chapter. Moreover, the idea to use PLC and their benefits will be discussed.

Chapter 3, Methodology explained detailed about the techniques and method used to collect data. Then, a flow chart is constructs to conduct the overall flow of this project to get

an idea for the working flow progress. The procedure in building PLC controlled in the automated coolant system is explained clearly by studying the ladder logic and ladder diagram.

Chapter 4, Result and Analysis involve the development of hardware and software. Then, the collection of data will be analysed and utilised. The best interval time need to be evaluate in term of surface roughness and tool wear. The average value of the result gain form the experiments are calculated and the graph are plot.

Chapter 5 concludes the objectives of this research project. The results obtained from the data and analysis will show the performance of the machine and the achievements of this research project. Also, the recommendations for future works to increase the machinability are suggested.

CHAPTER 2
LITERATURE REVIEW

In this chapter, there will be a brief explanation of the related topic of this research project. History of CNC machine, differences method to apply coolant and importance of using control system as an option to replace the conventional method are described. The evidence that comes from the problems statements are supports by the literature review that will be explained in the following below.

2.1 Computer Numerical Control (CNC) Machine

Nowadays, one of the most modern intelligent system and machining technologies that easy to handle a device and can perform multiple machining tasks is Computer Numerical Control (CNC) Machine (Ambrizal *et al.* 2017). It is produced based on the basic concept of Numerical Control, NC which is started with the idea of automation tooling in machinery system that then fulfils the requirement of the ideas in programming logic. Ansar *et al.* (2016) stated that the development of NC machine tools has allowed the designer to shed some of his chain, which inhabited him while using conventional machines. The control of this machine followed certain points and was design based on manufacturing tools machines and motors for the movement. After that, the advanced computer technology had built the computer numerical control. Example of CNC machine frame is shown in Figure 2.1.

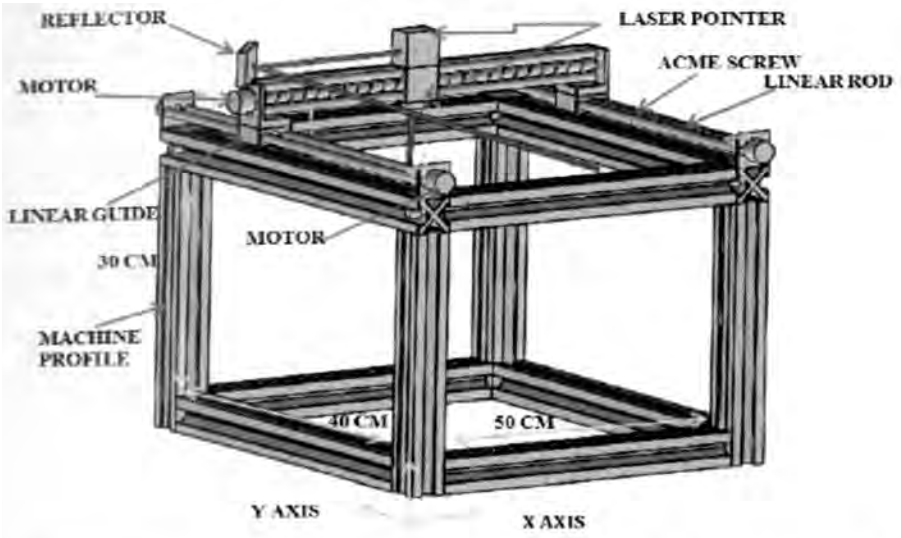

Figure 2.1: Isometric view of CNC machine frame (Source: Ambrizal *et al.*, 2017)

CNC machine consists of a microcomputer that performs controller unit of the machine. The functions of the computer are to control, automate as well as monitoring the movement of the machine axes, workpiece and tool. With the works of drive components and a few motors, CNC machine controller can be used to drive directly to the motion of machine axes and calculated the programming motion in the system. Ambrizal *et al.* (2017) claimed that the system is built to allow users to perform the motion of tools and parts through numerical data. CNC machine performance can be reached using differences parameter including tool wear, surface roughness and chips formation. Some advantages of the CNC machine are:

- High precision and accuracy
- Good manufacturing flexibility
- Non-stop working hours
- Minimized human errors

Some of the machine tools that run on CNC machine are milling, lathe and drilling machine while the purpose of using this machine is to remove excess metal in order to get a perfect shape. According to Chiu and Lee (2017) the indicators or product quality of milling