TOOL WEAR AND WEAR PROGRESSION OF UNCOATED CARBIDE IN TURNING TITANIUM ALLOY Ti-6Al-4V ELI UNDER VEGETABLE OIL BASED CARBON NANOFIBER

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TOOL WEAR AND WEAR PROGRESSION OF UNCOATED CARBIDE IN TURNING TITANIUM ALLOY Ti-6AI-4V ELI UNDER VEGETABLE OIL BASED CARBON NANOFIBER

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

by

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Date : ....

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory committee are as follows:

……………………................................

(Dr. Mohd Amri Bin Sulaiman)

ABSTRAK

Titanium alloy popular dengan kriteria mempunyai rintangan kakisan yang baik, kekuatan yang tinggi dan juga biocompatibility. Disebabkan kelebihan titanium alloy, ia menyebabkan titanium alloy sukar untuk dimesin, menghasilkan suhu yang tinggi di zon memotong semasa pemesinan dan jangka hayat alat pemotong yang singkat. Untuk mengatasi masalah ini, pelbagai jenis cecair penyejuk telah dicadangkan termasuk minyak masak sayur-sayuran dan nanotube karbon. Banyak kajian dijalankan sebelum ini dan tiada lagi penyelidikan mengenai nanofiber karbon. Dengan menggunakan penyejuk yang dicadangkan, jangka hayat mata alat dan perkemangan kerosakan mata alat semasa pemotongan diperhatikan. Titanium alloy Ti-6AI-4V ELI digunakan sebagai bahan kerja ujikaji, karbida tidak bersalut sebagai alat memotong. Tool maker dan mikroskop stereo digunakan untuk menyemak dan merekodkan bacaan. Design Expert perisian digunakan untuk menentukan jumlah experimen untuk dijalankan dan ANOVA analisis digunakan untuk menganalisis data. Parameter pemotogan yang digunakan adalah kelajuan memotong, kadar suapan dan kedalaman pemotongan. Kelajuan pemotongan yang digunakan ialah 100 m / min, 120 m / min dan 140 m / min, kadar suapan yang digunakan ialah 0.15 mm / put, 0.17 mm / put dan 0.20 mm / put manakala, kedalaman pemotongan adalah tetap dengan 0.35 mm. Selain itu, model matematik boleh dihasilkan daripada ANOVA analisis serta nilai kesilapan antara teori dan sebenar dapat dikenal pasti. ANOVA analisis juga memperlihatkan kelajuan pemotongan memberi banyak sumbangan kepada jangka hayat alat emotongan berbanding kadar suapan. Kelajuan pemotongan ialah 100 m/min dan kadar suapan ialah 0.15 mm/put boleh menghasilkan optimum jangka hayat alat pemotongan selama 62.78 minit. Hasil daripada ujian yang dijalankan, jika kelajuan pemotongan yang digunakan tinggi dan kadar suapan tinggi kadar jangka hayat alat pemotongan akan berkurang. Manakala untuk kadar suapan dan kelajuan pemotongan yang rendah menghasilkan jangka hayat alat pemotongan yang panjang.

ABSTRACT

Titanium alloy is mostly known have good corrosion resistance, high specific strength and also biocompatibility. Because of the titanium alloy capabilities, it caused titanium alloy is difficult to machined, produce high cutting temperature at cutting zone during machining and shorter life of cutting tool. To overcome this problem, before this many type of coolants has been proposed and including to vegetable oil based nanofluid. Vegetable oil that mixed with carbon nano tube is widely researched before and there is no research about carbon nano fiber. By using the proposed coolant, the tool life and wear progression is being observed during machining. Titanium alloy Ti-6AI-4V ELI is used as workpiece, uncoated carbide insert as cutting tool. Tool maker and stereo microscope are used to check and record the reading of tool wear. Design of Expert is used to determine the total experiment need to be run and ANOVA analysis is used to analyse the results. The cutting parameter that is being highlighted is cutting speed, feed rate and depth of cut. Cutting speed used is 100 m/min, 120 m/min and 140 m/min, the feed rate used is 0.15 mm/rev, 0.17 mm/rev and 0.20 mm/rev while, the depth of cut is constant with 0.35 mm. At the end, from the ANOVA analysis also the mathematical model can be develop and the error between theory and actual can be identified. ANOVA analysis also shows the most contribution to the results is cutting speed rather than feed rate. Cutting speed is 100 m/min and feed rate is 0.15 mm/rev can give the optimum tool life with 62.78 minutes. From the results, it shows that, if the cutting speed and feed rate high, the cutting tool life is short. While, the low feed rate and cutting speed will produced longer tool life.

DEDICATION

Only
my beloved late father and late brother, Jahari and Khairul Anuar
my appreciated mother, Rohani
my adored sister, Azizi, Norizan, Azila, Anis and Shakira
for giving me moral support, money, cooperation, encouragement and also understandings
Thank You So Much & Love You All Forever

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
Ti-6AI-4V ELI	-	Titanium Alloy Extra Low Interstitial
ASM	-	Advanced Semiconductor Materials
CNC	-	Computer Numerical Control
MQL	-	Minimum Quantity Lubrication
HPC	-	High Pressure Coolant
CVD	-	Chemical Vapor Deposition
PVD	-	Physical Vapor Deposition
BUE	-	Bulit-up Edge
SiC	-	Silica Carbide
SDS	-	Sodium Dodecyl Sulfate
SDBS	-	Sodium Dodecyl Benzene Sulfonate
CTAB	-	Hexade Cyltrime Thylammonium Bromide
CTAC	-	Cetyltrime Thylammonium Chloride
CNT	-	Carbon Nanotube
CNF	-	Carbon Nanofiber
DOE	-	Design of Experiment
SEM	-	Scannning Electron Microscope
AISI	-	American Iron Steel Institute

LIST OF SYMBOLS

K	-	Kelvin
°C	-	Degree Celcius
s	-	seconds
nm	-	nanometer
µm	-	micrometer
rpm	-	rotational per minutes
mm	-	milimeter
mm/rev	-	miilimeter per revolution
g/cm^3	-	Gram per centimetre cube
s/cm	-	Seconds per centimetre
W/m.K	-	Watt per metre Kelvin
HV	-	Hardness Value
D	-	Diameter
N	-	Rotational speed
V	-	Cutting speed
v	-	Feed rate
f	-	feed
d	-	Depth of cut
Fc	-	Cutting force
Ft	-	Thrust force
Fr	-	Radial Force

CHAPTER 1

INTRODUCTION

This chapter covers the background of study, problem statement, objectives, and scopes of this project. The chapter overview is also included in this chapter.

1.1 Background Of Study

In the manufacturing industry, machining is widely used in the metal shaping process. There are many operations in the machining process like turning, milling, boring, drilling and others. Among all the operations, the most important operation still the turning because it has the most varied of conditions in operation (Sharma, 2009). Turning operation is a machining process which a single-point tool to remove material from surface of rotating workpiece. In this operation, there are several operations related to turning like facing, taper turning chamfering, parting off, threading boring, drilling and knurling. The cutting tools used is the uncoated carbide where it is widely used nowadays because the capability of this cutting tool. This type of cutting tool also gives better performance rather than coated type because of less chemical reactions with the workpiece material (titanium alloy) during cutting process (Tanaka, 2016).

The output of the study is focusing on tool life and wear progression on uncoated carbide insert during turning process. One of the factors that affected of the tool life is heat generated during the turning machining. In order to reduce this problem, the project will be done along with vegetable oil that act as coolant. There has been stated that vegetable oil is very attractive substitutes for petroleum-based oils. It is because they are environmentally friendly, renewable, less toxic and readily biodegradable that are potential for the use in industry as lubricants (Shahidhara and Jayaram, 2010)

The material will be used in this project is titanium alloy (Ti-6AI-4V). Titanium alloy (Ti-6AI-4V) is applied to the rotating components like jet-engine blades and gas turbine parts, aerospace component like pressure vessel and also in aircraft structural application. This application requires some characteristic of materials used such as high specific strength, superior heat resistance and corrosion resistance (ASM International, 2000) (Yildiz, 2008). From the characteristics that have been stated, it makes this type of material is hard to be machined. Therefore, the tool life and wear progression will be analyzed after the material being machined with vegetable oil based carbon nano fiber that used as a coolant.

1.2 Problem Statement

During machining, coolant used to cool the workpiece and also to lubricate the surface of materials. To decrease the friction between tool and workpiece and protect the workpiece from corrosion, coolant is used.. Flood coolant is the common coolant used in the industries and it already known that it does not good for health and high cost in maintenance handling. Then, the machining will be used is CNC turning and used uncoated carbide insert as cutting tool. From research before, titanium alloy has high specific strength, good corrosion resistance, superior heat resistance and it causing hard to be machined (Hong *et al*., 2016). Because of their properties, the cutting tool life is short and the temperature at cutting zone is high that can affect the material properties. Vegetable oil mixed with carbon nano fiber act as coolant is being used and the effectiveness of this coolant has been observed. Considering the cutting parameters, coolant and material used, the tool life and tool wear is being observed.

1.3 Objectives

The objectives of this project are:

- To investigate and analyze the tool wear progression on carbide tool.
- To develop mathematical model for tool life of carbide insert during Turning Ti-6Al-4V ELI under vegetable oil.mixed with carbon nano fiber

1.4 Scope

There are some requirements that need to be considered while doing the project to make sure it is still in the scope. First of all is the machine that being used for the turning operation is the CNC lathe machine that functions by reducing the diameter of the material. Then, the cutting tool used must be considered where the type of cutting tool used can contribute to many affects. For this project the cutting tool used is uncoated carbide insert by considering the material tested. Meanwhile the worpiece for this project is Titanium Alloy (Ti-6Al-4V) ELI that has high strength and great thermal properties. Other than that, the cutting parameters that will include is feed rate, cutting speed and depth of cut. Vegetable oil mixed with carbon nano fiber will be used for cooling purposes while doing the turning operation.

1.5 Project Significance

This project is relevant due to the problem statement that has been stated before. The vegetable oil mixed with arbon nano fiber that act as coolant can improve the quality of the product where it can reduce the defect. Besides that, there are many advantages of this cooling type where it is very environmentally friendly, renewable, less toxic and readily biodegradable. According to this benefit, vegetable oil can be solution contribute to the industry. The cost of this lubricant is cheap for the production floor and besides that, better quality of production and increase the production can be achieved.

1.6 Organization Of Report

Chapter 1 covers the introduction of this investigation. It contains the general information about the investigation, problem statement, objectives, and scope of the project.

Chapter 2 covers the literature review of this project. It contains the literature review for turning, CO_2coolant, cryogenic machining and studies on cutting fluid.

Chapter 3 contains the methodology of this project. It contains flow chart, literature review, execution of the experiment, data collection and data analysis.

Chapter 4 contains the result and discussion of this project. The data from the experiment is collected and analyzed.

Chapter 5 covers the conclusion of this investigation. This chapter also covers the recommendation for the future work and sustainability.

CHAPTER 2

LITERATURE REVIEW

This chapter contains the literature review that based on the objectives and scope of the project. This chapter is conducted in order to complete this research. This chapter contains turning operation, cutting fluid, titanium alloy and cutting tool used during the machining process.

2.1 Machining Process

Machining processes consist of cutting, grinding, and quite a lot of non-mechanical chips less processes, are acceptable or even necessary for the following basic reasons. Nearer dimensional tolerances, surface roughness, or surface-finish characteristics can also be required than being available through casting, forming, powder metallurgy, and different shaping techniques and part geometries might also be too complicated or too expensive to be manufactured via different processes. However, machining processes inevitably waste material in the form of chips, manufacturing charges might be low, and unless carried out properly, the processes can have detrimental effects on the surface properties and overall performance of parts. Traditional machining processes consist of turning, boring, drilling, reaming, threading, milling, shaping, planning, and broaching, as well as abrasive processes such as grinding, ultrasonic machining, lapping, and honing. Advanced processes encompass electrical and chemical means of material removal, as well as the use of abrasive jets, water jets, laser beams, and electron beams (Serope, 2006).

2.2 Turning Process

Turning process is the process where the extra material from the rotating surface is removed where other meaning is to reduce the diameter of a workpiece, to get the particular dimensions and produce a smooth surface. Commonly, the enactments of cutting technology are contingent on the cutting tools geometry, tool materials, cutting parameters and efficiency of the process. It is used for machining of furthermost of the materials as well as ferrous, non-ferrous metal and their alloys, heat treated metals and alloys, ceramics and composites (Monika *et al*., 2016).

Other research stated that turning can operate the variable types of metallic and non-metallic materials and also it's proficient to create circular parts with straight or various profiles. The cutting tools used either single point or form tools. Lathe is the most common machine tool used which it is modern lathes that include computer controlled and also can achieve greater production rates with small labor. The basic operation of lathe is workpiece placed in the chuck and rotates a cutting tool that moves along the length of the piece at a certain feed rate. Then, it removes the material at a radial depth which means, of decreasing the diameter until the desired measurement. Bed, headstock, tailstock, and carriage are the main parts contain in the basic lathe (Serope *et al*., 2014).

Turning is one of the basic machining that being made by another process such as casting and it is capable to perform certain machining operations that can produce a variety of shapes. This process is carried out by lathe and also very versatile. Below is the machining operation that can produce by the turning process:

Table 2.1: Machining operation that can produce by the turning process (Serope *et al*., 2014)

Machining operation	Description
Turning	To produce straight, conical, curved, grooved workpieces through shafts, spindles and pin.
Facing	To produce a flat surface at the end of the part and perpendicular to its axis, parts that are assembled with other components, face grooving for such applications as O-ring seats.
Boring	To enlarge a hole or cylindrical cavity made by a previous processor to produce circular internal grooves
Drilling	To produce a hole which then may be followed by boring it to improve its dimensional accuracy and surface finish
Parting	To remove a piece from the end of a part, as is done in the production of slugs or blanks for additional processing into discrete products
Threading	to produce external or internal threads
Knurling	to produce a regularly shaped roughness on cylindrical surfaces, as in making knobs and handles

2.3 Vegetable oil

Researcher has stated that most of cutting fluids used is not biodegradable and contain various components. Then, because of that it can cause the environmental and also health hazard. Dangerous biocides can be presented when the dangerous bacteria grow and also mix with the shop floor environment (Ibrahim *et al*., 2014). Coolant or lubricant plays important roles in machining process where can affected the cutting tool wear and on the friction between the chip and tool. This is because the high temperature produced at the cutting zone during turning machining. High cutting temperatures during machining process can produced aggressive adhesion wear at the tool surface. It has been stated that heat can be removed by carrying away during machining from the cutting tool when the cutting fluid is applied. By using vegetable oil as cutting fluid, it shows that it is antiwear and friction, scuffing load capacity and fatigue resistance. Excellent lubrication properties is displayed that using vegetable oil as cutting fluid (Lawal *et al*., 2013).