EFFECT OF CARBON NANOFIBER (CNF) NANOFLUID ON TURNING OF D2 STEEL

TASNIM BT KAMAR DIN @ KAMARUDDIN
B051210148

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

by

TASNIM BT KAMAR DIN @ KAMARUDDIN

B051210148

921127- 03-6198

FACULTY OF MANUFACTURING ENGINEERING

2016

DECLARATION

I hereby, declared this report entitled "Effect of Carbon Nanofiber (CNF) nanofluid on Turning of D2 Steel" is the results of my own research except as cited in references.

Signature	**:**	**…………………………………………………….**
Author's Name	**:**	**…………………………………………………….**
Date	**:**	**…………………………………………………….**

APPROVAL

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

……………………………………………

(Dr. Liew Pay Jun)

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(Dr Liew Pay Jun)

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(Dr. Mohd Amri bin Sulaiman)

ABSTRACT

This study, investigated the surface roughness of D2 steel and tool wear of cutting tool using carbon nanofiber (CNF) nanofluid. It is also about the comparison between the machining performances using two different coolants which are pure deionized water and CNF nanofluid. In this experimental study, PVD coated carbide TiAlN used as cutting tool and D2 steel used as workpiece. The conventional semi auto lathe used in this experiment was GATE G-410-TCV. The cutting speed (m/min), depth of cut (mm) and feed rate (mm/rev) were the constant variable. While, the varied of volume fraction of CNF was the variable. The measurement of surface roughness and tool wear were measured by using portable surface roughness HT/04/538(3) and microscope Meiji Zoom Stereo Microscope Set respectively. Statistical analysis has been done to identify the relationship between the surface roughness with varied of volume fraction of CNF and the relationship between the tool wear and varied of volume fraction of CNF. The analysis result shown that CNF nanofluid gives better surface roughness and tool wear compared to the pure deionized water. Without CNF in pure deionized water, the surface roughness value is at 2.77 µm, while at the optimum CNF concentration, 0.75% gives the surface roughness reading at 2.37 µm. Similar trends to tool wear value, without CNF concentration the tool wear is at 0.24 mm, while at the optimum CNF concentration, 0.75% the tool wear value decreased until 0.11 mm.

ABSTRAK

Kajian ini mengkaji tentang prestasi carbon nanofiber (CNF) nanofluid pada kekasaran permukaan dan nilai haus pada besi D2. Selain itu, untuk membandingkan prestasi pemesinan terhadap kekasaran permukaan dan nilai haus pada besi D2 menggunakan air tulen dan carbon nanofiber nanofluid. Proses yang digunakan dalam kajian ini adalah proses turning menggunakan mata alat karbida bersalut PVD dan besi jenis D2 sebagai bahan kajian. Proses turning ini menggunakan mesin larik semi auto GATE G-410-TCV. Kelajuan mesin (m/min), kedalaman pemotongan (mm), dan laju perjalanan dari bahan kajian (mm/rev) adalah parameter tetap dalam kajian ini. Manakala, kepekatan bagi CNF nanofluid adalah parameter yang berubah. Nilai kekasaran permukaan untuk besi D2 diukur menggunakan penguji kekasaran permukaan HT/04/538(3). Nilai haus untuk mata alat diukur mengunakan mikroskop jenis Meiji Zoom Stereo Microscope Set. Statistik analisis telah dijalankan untuk mengetahui hubung kait kesan coolant terhadap nilai kekasaran permukaan dan nilai haus. Keputusan analisis menunjukkan pengunaan CNF nanofluid berjaya mengurangkan nilai kekasaran permukaan besi D2 dan nilai haus pada mata alat, sekaligus menunjukkan pengunaan CNF nanofluid adalah lebih baik berbanding dengan pengunaan air tulen. Tanpa pengunaan CNF di dalam air tulen, nilai kekasaran pada besi D2 yang direkodkan adalah 2.77 µm, manakala nilai optimum adalah 2.37 µm, pada kepekatan 0.75% CNF. Begitu juga pada nilai kehausan mata alat. Tanpa pengunaan CNF di dalam air tulen nilai haus mata alat yang direkodkan adalah 0.24 mm, manakala nilai optimum adalah pada kepekatan 0.75% CNF yang mengurangkan haus mata alat kepada 0.11mm.

DEDICATION

To my beloved parents, Encik Kamar Din @ Kamaruddin Bin Noor, Puan Faizah Bt Awang and to all my dearest siblings.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

cm	Centimeter
m	Meter
ml	Millimeter
min	Minutes
µm	Micrometer
CBN	Cubic Boron Nitride
CNF	Carbon Nanofibre Nanofluid
CVD	Chemical Vapor Deposition
PVD	Physical Vapor Deposition
PVP	Polyvinylpyrrolidone
TiAlN/ AlCrN	Titanium Aluminium Nitride / Aluminium Chromium Nitride
V_{avg}	Tool wear average

CHAPTER 1

INTRODUCTION

This section basically describes the introduction of the project. In this chapter, background of study, problem statement, objectives and the scope for this project briefly explained. This project is the experiment on turning process using carbon nanofiber (CNF) nanofluid as coolant.

1.1 Background

Turning is one of the basic processes of metal removal. Turning is the metal removal of external diameter of rotating cylindrical workpiece (Ahmed et al., 2015). It is suitable for producing shaft and axisymmetric components (Gowd et al., 2014). In the turning process, the friction interface between the cutting tool and workpiece generated heat affected the quality issue. Cutting fluid has been used to minimize the heat interface, the remove chips from cutting zone and lubricates the machining process. However, conventional cutting fluids brings the harm to human health and environmental during their use or disposal (Krishna et al., 2013).

From conventional cutting fluid, scientists has develops a new class of cutting fluid which is nanofluid. Nanofluid is a condensed nanometer sized particles (1-100 nm) suspended in base fluid. Base fluid can be oil, water or ethylene glycol (Birlik et al., 2013). The advantage of nanofluid, it has better thermal conductivity compared to conventional cutting fluid. It also can improve the surface finish and lubrication properties in machining.

1.2 Problem Statement

The contact between the cutting tool and workpiece caused friction, therefore produced heat to be generated. The heat generated in the cutting zone during turning will affect the workpiece quality and tool life. To reduce the immense of temperature in the turning process, cutting fluids acts as lubricant and coolants (Krishna et al., 2013). Cutting fluids are being use widely to carry away the heat in turning process, however the usage and the disposal of cutting fluids, threaten the human health and environmental pollution (Birlik et al., 2013).

Apart from the friction issue, the cooling issue also gave the contribution to the heat generated. Coolants and cooling strategies are just as important for the cutting process as the materials and tools themselves but do not get enough attention. There is an enormous potential for savings such as increase of the productivity and efficiency. The appropriate selection or combination of coolant strategy and coolants has furthermore enormous influence on various parameters of the surface quality and safety at work. Fluids have lower thermal conductivity as compared to solids (Prabhu et al., 2012). Therefore, the new class of cutting fluid which is nanofluid, combination of nanoparticles and base fluid were the best solution. Prasad et al., (2013) mentioned that to achieve high cooling ability with minimum quantity lubrication, nanofluid must be chosen. In order to solve this problem, in this study, carbon nanofiber nanofluid (carbon nanofibers mixed with deionized water) used as a cutting fluid in the operation of turning of D2 steel.

1.3 Objectives

The main purpose of this study is to do an experiment investigation of turning process using CNF nanofluid.
There are two objectives of this study:

a) To investigate the performance of tool wear and surface roughness using CNF nanofluid and deionized water.

b) To compare the machining performance using CNF nanofluid and deionized water.

1.4 Scope

This project focused on investigation of CNF nanofluid in turning of D2 steel. The performance of nanofluid (carbon nanofibers mixed into conventional cutting fluid) during turning of D2 steel were investigated, for the tool wear, and surface roughness of D2 steel. The cutting tool PVD coated carbide of TiAlN was used in this experiment. Conventional semi auto lathe machine used for the process of turning on turning D2 steel. Digital dispensing pump was used to control the flow rate of carbon nanofibre nanofluid on turning process. Depth of cut, feed rate and cutting speed were the constant parameter while the volume fraction of CNF were the variable parameter. The type of cutting fluid used during the turning process is CNF nanofluid (carbon nanofibers mixed with deionized water) and deionized water. Stereo Optical Microscope were used to capture the picture of tool wear as well as measured the tool wear length. Portable surface roughness tester were being used in this study the surface roughness on D2 steel after undergo the turning process.

CHAPTER 2

LITERATURE REVIEW

This chapter explains literature review regarding to the study and related to the objectives and scope of the project.

2.1 Turning

Turning is a basic machining process to produce parts which round in shape. The turning process means the part is rotating to the stationary tools (Kalpakjian, 2010). The product produced by turning can be small or large. The smallest product that can be made by turning process is miniature screw, while the large products that possible to be made by turning process are pistons, cylinders, and gun barrels. According to Ahmed et al. (2015), in turning process, the workpiece will rotates to the stationary tool for removal of metal. Turning process is shown in Figure 2.1.

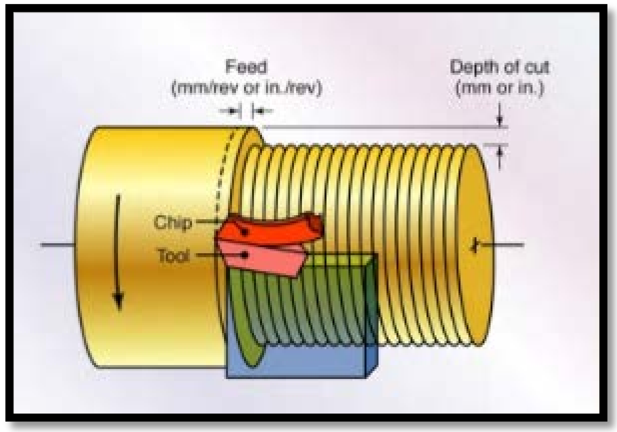

Figure 2.1: Turning process (Kalpakjian, 2010)

2.1.1 Hard Turning

Hard turning is a machining process of ferrous material hardness above 45 HRC. The growth of hard turning triggers the advent of new advanced tools such as Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Cubic Boron Nitride (CBN) and ceramic tools (Bh et al., 2014). Machining steel with hardness 45- 65 HRC using polycrystalline cubic boron nitride (PcBN) is categories as hard turning (Kalpakjian, 2011). Hard turning gives a better and excellence dimensional accuracy, surface finish, and surface integrity. Applications of bearings, gears, shafts and other mechanical components were categories under hard turning. According to Sahoo et al. (2012), the advantages of hard turning in terms of reduction of cost per product, better surface finish, can be produced under high productivity, and the cost for equipment can be reduced. Machining of hard materials (45-68 HRC) is a significant research field in the modern manufacturing technology. Hard cutting provides economical way to finish hard surfaces as an alternative process to grinding. Parts with hard turning gives surface roughness, shape and dimensional tolerances is identical to grinding. Apart from that, hard turning does better from grinding in terms of high flexibility and able to cut complex geometries (Oliveira et al., 2009). Hard turning is continuous process of chip removal according to the tool engagement and thermal loads, but also dynamic undertaking the uncut chip area and depth of cutting in particular.

Main advantages of hard machining are the ability to produce complex shapes, good surface roughness, higher material removal rate, reducing of finishing time, cost reduction, and offsetting the environmental concerns by dry machining (Tang et al., 2011).

2.2 Studied on Turning Parameter

Machining is a process of removal metal. Cutting speed, depth of cut, feed rate is a parameter that will affect the dimensional accuracy of workpiece. Major factors affecting cutting forces include tool or work material properties, cutting process parameters (chip load and cutting speed), and tool geometry (Zhang et al., 2015).

2.2.1 Cutting Speed

According to Sahoo et al. (2013), cutting speed is the most important parameter that affecting the behavior of cutting tool. Prasad et al. (2013) also states the same conclusion about cutting speed that gives big impact for tool wear. Apart from that, Sahoo et al. *(*2013) also mentions that cutting speeds can give affects to productivity in industrial sector as reflections toward the application of coated and uncoated carbide insert in turning. Debnath et al., (2015) reports the effect of cutting speed in tool wear by 43.1 %. Singh et al. (2015) revealed that mass of D2 steel loss with the increase of cutting speed. In study of cutting force characteristic in hard turning, Oh (2014) claims cutting speed affecting the cutting force in machining.

2.2.2 Feed Rate

Under hard turning, values of hardness over 45 HRC, the preferred feed rate is 0.05 – 0.2mm/rev (Rashid et al., 2013). While feed rate for turning of D2 steel is between the ranges of 0.10 – 0.2 mm/rev (Sharma et al., 2015). According to Debnath et al., (2015), feed rate is the most significant parameter that affecting the surface roughness.

2.2.3 Depth of Cut

Bh et al., (2014) points out that during hard turning process on turning D3 steel, depth of cut is the most compelling parameter contributes to the tool wear. Kopac et al., (2006) notices that depth of cut influencing the cutting stability in study of dynamic instability of the hard turning process.

2.3 Studied on Cutting Fluids

According to Kalpakjian (2011) the effectiveness in machining operations depends on method application, types of cutting fluid and types of machining operation. The tool workpiece friction will increase, if no cutting fluid at the process machining (Chinchanikar et al., 2015). Cutting fluid is a fluid that functions to be a lubrication and heat dissipation during metal cutting operations. It is important in assist the machining process (Sharma et al., 2015). Basically cutting fluid functions to:

1. Cools the cutting zone.

2. Reduce the tool life.