Faculty of Manufacturing Engineering

THE EFFECT OF SYNTHETIC SOLUBLE CUTTING FLUID PRESSURE TOWARDS MACHINABILITY USING STAINLESS STEEL 304 WITH COATED CEMENTED CARBIDE INSERT

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ABSTRACT

This thesis presents the effects of cutting fluid pressure towards various orifice nozzle sizes on the cutting performance. The cutting fluid is being used in metal cutting to optimize the process of machining operation. It has a significant role on shop floor productivity, tool life and quality of work. The objective of this study is to investigate the effects of various cutting fluid pressures on the machining of stainless steel AISI 304 and evaluate the influence of the cutting performance on machining parameters such as tool wear, tool life, chip formation and surface roughness on the process of metal cutting. Stainless steel AISI 304 and coated cemented carbide $Al_2 O_3$ insert were used as a work piece material and cutting tool respectively. The experiments were carried out on CNC Lathe machine with 2 axes movements using various orifice nozzle sizes with cutting fluid type, synthetic soluble oils as a coolant. The acquired results showed that the coated cemented carbide $Al_2 O_3$ insert gives the good overall performance in terms of tool life with the smallest orifice size. The cutting speed has great influence in the performance of coated cemented carbide insert. The tool life decreases with increases of the cutting speed. It can be seen that the maximum flank wear is the dominant failure mode when the orifice size increases during machining stainless steel AISI 304. This study can support the future exploration of dimensional accuracy, productivity and the cutting condition optimization.

ABSTRAK

Penyelidikan ini adalah untuk mengkaji kesan dari tindakan pemotongan tekanan bendalir dengan berbagai saiz lubang nozel pada pemotongan bendakerja. Bendalir digunakan untuk memaksimakan jangkamasa proses pemotongan logam kerana ia mempunyai daya yang cukup besar untuk mengekalkan ketahanan jangka hayat mata pemotong, produktiviti dan kualiti pemotongan tersebut. Fungsi utama kajian ini adalah untuk menyelidik tindak balas tekanan bendalir terhadap pemotongan Stainless Steel AISI 304 dan menilai pengaruh prestasi pemotongan terhadap parameter mesin seperti jangka hayat mata pemotong, pembentukan serpihan logam dan kekasaran permukaan pada logam tersebut. Logam Stainless Steel AISI 304 digunakan sebagai bendakerja dan mata pemotongan bersalut cemented carbide Al_2 O_3 digunakan sebagai mata alat. Penyelidikan ini menggunakan mesin CNC Larik yang mempunyai dua paksi pergerakan yang mempunyai berbagai lubang saiz nozel untuk mengeluarkan tekanan bendalir. Daripada kajian mendapati alat pemotong yang bersalut cemented carbide Al_2 O_3 menghasilkan keputusan yang sangat memberangsangkan dari segi jangka hayat dengan mengunakan saiz lubang nozel yang kecil. Kelajuan pemotongan mempunyai pengaruh yang amat tinggi terhadap mata alat pemotong dan jika kelajuan ini meningkat, jangka hayat mata alat pemotong akan menurun. Kehausan pada mata alat pemotong juga mempunyai peranan yang amat luas didalam kegagalan proses pemotongan apabila mengunakan saiz lubang nozel yang lebih besar semasa pemesinan stainless steel AISI 304. Keputusan dari kajian ini juga boleh digunapakai didalam kajian seterusnya untuk mendapatkan ketepatan dimensi, produktiviti dan pemotongan dalam kondisi yang optima.

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I declare that this thesis entitle "The effects of synthetic soluble cutting fluid pressure towards machinability using stainless steel 304 with coated cemented carbide insert" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

I specially dedicate this work to for my beloved parents, who have always been there for me and always pray the best for me. my friends who has support me. Also, I would like to forward my appreciation towards my younger sister and elder brother who have supported me in completion of the thesis.

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LIST OF ABBREVIATIONS AND SYMBOLS

d	-	Depth of cut
C	-	Taylor's constant
D	-	Diameter
N	-	Revolution per Minute
n	-	Taylor's exponential
Ra	-	Surface roughness
T	-	Tool Life
V	-	Cutting speed
H.S.S.	-	High speed steel
M/min	-	Meter per minute
in/rev	-	Inches per minute

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CHAPTER 1

INTRODUCTION

1.1 Background

The development of accurate and reliable machining processes has received considerable attention from both academic researchers and industry practitioners in recent years. Machining process is an important element in manufacturing industry. Most of the consumer products have gone through the machining process either directly or indirectly. This trend has driven to a large extent the need for analytical/numerical tools capable of predicting the machining process performance (e.g., chip shape, tool wear, tool life, and surface finish, etc.) to enable simultaneous engineering of products and machine process. Traditionally, the techniques used in industry are based on past experience, extensive experimentation and trial-and-error. Such an approach is time consuming, expensive, and lack of a rigorous scientific basis. The work described in this analysis offers a comprehensive, scientifically based analysis method which provides a useful guideline for machining process design and analysis (Venkatesh, 1987, Kalpakjian, 1995).

Normally, the process of machining faces difficulties in selecting an optimum speed, feed, coolant condition, geometry of the cutting tool and other parameters where it can affect the chip shape, tool wear, surface finish and tool life.

Stainless steel AISI 304 is well-known for its toughness, hardness and resistance to corrosion. It has a good corrosion resistance to the food environment, oxidizing solution and most organic chemicals. Commonly used applications are valves, aerosols, finger pumps and aerospace industries (Ezugwu et. al, 2003). The corrosion resistance is higher after passivation. The work piece has a hardness of about 25 to 39 HRC. Machining Stainless steel AISI 304 presents significant problems since this material possesses high strengths which is maintained even at the elevated temperatures prevalent during machining. Stainless steel is very chemically reactive and therefore, has a tendency to weld to the cutting tools during the machining process. All these contribute to rapid tool wear and short tool life (Rochim, 1993).

Most of the researches are focused on the depth of cut, cutting speed and feed rate during the cutting tool process. These are the main parameters that will affect the wear rate but researches fail to go in-depth to the overall performance on the surface finish, flank wear, tool life and chip formation towards cutting fluid pressure. In this study, the investigation on the influence of various orifice size coolant nozzle pressure over the range of turning operation parameters on stainless steel AISI 304. The effectiveness of the various orifice size coolant nozzle pressure systems is evaluated in terms of chip shape, tool life, tool wear, surface roughness and surface integrity (microstructure and micro hardness).

1.2 Statement of problem

CNC machining and Conventional machining processes are still popular because the rate of material removal is high. Researches have been done to improve the cutting tool material, tool geometry and cutting parameter to optimize the machining process. Different workpiece material with different property and microstructure gives different effect to the cutting tool performance. No general equation can be used to closely estimate the tool life for a given tool grade, cutting condition and workpiece material.

In turning operation, the performance of cutting tool depends on several cutting conditions and parameters. The proper selection of feed rate, cutting tool, depth of cut and the type of material used has direct effect on the product surface finished. Eventually, it is difficult to select optimum cutting parameters towards a certain materials due to new development of materials. Cutting fluid pressure could be used as one of the cutting parameter to improve the cutting condition. Turning process by maximizing cutting speed and depth of cut could optimize the cutting process and minimized the production cost. The tool life, surface integrity and tool wear are directly dependent on cutting parameters and determined the cutting tool performance. The research of chip morphology, tool wear and wear mechanism under microstructure level will determine the characteristic during the machining process.

1.3 Significance of Study

The optimization of metal removal rate for specified surface roughness and accuracy of products are the key factors in the selection of machining process. The rapid developments of the parameter in metal cutting, high strength and hardness workpiece materials used in the industries have pushed the tool manufacturers to develop and invent new cutting tools and cutting methods. The proper selection of machining parameters during turning in metal cutting will increase productivity. The characteristic of tool failure mode, wear mechanism and surface roughness, must be properly understood. From this research, cutting fluid pressure with various nozzle sizes is one of the method produce a good quality, optimum tool wear, cutting speed and feed rate on metal cutting process. These experimental results are expected to contribute and improve the machining process to the industries such as shipping, automotive, offshore oil and gas production, power plants, coastal industrial plants and knowledge of metal cutting.

1.4 Objectives of Study

(i) To investigate the effects of various cutting fluid pressure on the machining of stainless steel AISI 304.

(ii) To evaluate the influence and effects of cutting fluid pressure on the cutting performance on the tool wear, tool life, chip formation and surface roughness.

1.5 Overview of the thesis

The entire thesis is organized into five chapters. Chapter 2 reviews the fundamentals of turning process, cutting tools in turning, tool wear, surface roughness, tool life, chip formation and cutting fluid pressure. Chapter 3 presents the phase of the methodology along with the experiment procedure and analysis methods. Chapter 4 presents the analysis of the experiments and discussed the results in details. Chapter 5 summarizes the research, outcomes, conclusions, and recommends directions for further studies.