INVESTIGATION OF TOOL WEAR CHARACTERISTICS FOR NUMERICAL CONTROL SCULPTURE (NCS) MACHINE

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Investigation of Tool Wear Characteristics for Numerical Control Sculpture (NCS) Machine

Thesis submitted in accordance with the requirements of the Universiti Teknikal Malaysia Melaka for the Degree of Bachelor of Engineering (Honours) Manufacturing (Design)

By

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ABSTRACT

This paper presented an investigation of tool wear characteristic based on the machining process on Numerical Control Sculpture (NCS) machine. Typically time is the major parameter or indicator being used in measuring the progress of machine capability. The technicians in Fujitsu Component (M) Sdn. Bhd. approximately indicated that the maximum wear occurred on cutting tool during 2 hours of machining time. But in certain cases, there are cutting processes than can run more than 2 hours without changing the wear cutting tool with the new one. For that matter, the factors that can contribute to the wear phenomena are the machining parameters, machining condition, type of cutter, machining material and the shape of work material are investigate. Referring to the technician's assumption, so there are 4 different gaps of time have been chosen beginning from 35 minutes, 70 minutes, 105 minutes and 140 minutes. Instead of checking the cutting tool life, the surface quality of the work material will also be analyzed based on surface roughness measurement as affected from 2 types of cutting tool from different material properties. Entirely this investigation consists of 32 pieces of cutting tool from different shape and material, and 32 pieces of work material from 2 different type of material, Copper Tungsten and Mild Steel SS 41. The obtain results shows the wear mechanism occurred earlier during 105 minutes, less than expected and become more critically when it reached to 140 minute or greater than 2 hours. Additionally, Carbide proved to be the most hardest and high quality cutting tool rather than High Speed Steel (HSS). The overall result have shown that after 2 hours of cutting time, the cutting tool should be replaced with the proper and appropriate one as to match with the required cutting conditions and parameters.

ABSTRAK

Tesis ini mendedahkan kajian berkenaan sifat – sifat perkakas pemotongan berdasarkan proses pemesinan yang dijalankan menggunakan mesin Numerical Control Sculpture (NCS). Secara amnya, masa adalah merupakan parameter utama yang biasa digunakan bagi mengukur tahap kemampuan sesuatu mesin. Juruteknik di Fujitsu Component (M) Sdn. Bhd. menganggarkan bahawa kadar kehausan maksimum ke atas perkakas pemotongan berlaku dalam tempoh 2 jam masa pemesinan. Walaubagaimanapun dalam sesetengah kes, terdapat proses pemotongan yang boleh berlangsung lebih daripada 2 jam tanpa perlu penggantian perkakas pemotongan yang tumpul kepada yang baru. Disebabkan perkara itu, beberapa faktor yang menyumbang kepada berlakunya fenomena kehausan seperti parameter pemesinan, keadaan pemesinan, jenis – jenis perkakas pemotongan, bahan kerja dan bentuk bahan yang dimesin juga dikaji. Berdasarkan anggaran juruteknik tersebut, maka terdapat 4 jarak masa yang telah dipilih bermula daripada 35 minit, 70 minit, 105 minit dan 140 minit. Selain kajian terhadap kadar kualiti perkakas pemotongan, kualiti permukaan bahan kerja juga dianalisis berdasarkan pengukuran kekasaran pada permukaan kesan dari 2 jenis perkakas yang berlainan kandungan bahannya. Secara keseluruhan kajian ini melibatkan 32 jenis perkakas pemotongan yang terdiri dari 2 jenis bahan yang berbeza, dan 32 bahan kerja yang juga terdiri dari 2 jenis bahan yang berbeza iaitu Copper Tungsten dan Mild Steel SS 41. Keputusan yang diperolehi menunjukkan mekanisma kehausan berlaku awal ketika minit ke 105 iaitu kurang dari jangkaan dan menjadi lebih kritikal apabila mencapai 140 minit atau lebih dari 2 jam. Sebagai tambahan, dapat dibuktikan Carbide adalah perkakas pemotongan yang paling keras serta berkualiti berbanding dengan High Speed Steel (HSS). Keseluruhannya, perkakas pemotongan perlu diganti baru selepas 2 jam masa pemesinan bersesuaian dengan keadaan serta parameter ketika pemotongan.

DEDICATION

For my beloved Father and Mother who always encourage and give all the support that I really need during accomplish this thesis.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

NCS	-	Numerical Control Sculpture machine
FCM	-	Fujitsu Component (M) Sdn. Bhd.
SEM	-	Scanning Electron Microscope
SS 41	-	Material Code for Mild Steel
HSS	-	High Speed Steel
NC	-	Numerical Control
CBN	-	Cubic Boron Nitride
EDM	-	Electric Discharge Machine
CNC	-	Computer Numerical Control machine
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
DTI	-	Dial Tester Indicator
µm	-	Micrometer
Ra	-	Roughness Average @ Arithmetic Average
rpm	-	Revolution per minute
mm	-	Millimeter
min	-	Minute

CHAPTER 1
INTRODUCTION

1.1 Background

Nowadays there are so many types of cutting tool in the market all around the world. In the past few years, only certain cutting tool that exists in the catalogue of tool manufacturers with the similar name of cutting tool like flat cutter or ball cutter. But these days, more than 10 or even hundreds cutter with the name flat cutter in front of it, have so much with its various shape, consists differ material and for sure with so much variety in its application. This situation comes consistent with the daily improvement from all the tool manufacturers in the metalworking industry as the machines technology always comes forward very fast and all the machining process has to be done in time with absolutely high quality in its product.

In this case, a whole lot more can be seen especially when it is related with manufacturing of cutting tool in globally. Each and every cutting tool that has been developed must has its specific applications. As it always correlated with the shape of material that has to be cut, type of the material, cutting conditions, cutting parameters and cutting process itself, as usual are divide into two processes, roughing and finishing. When a tool change is needed or anticipated, a performance comparison should be made before selecting the right tool for the job and in this case the phrase “the most expensive tool is always the best tool” should be considerate more. The best tool is the one that has been carefully chosen to get the job done quickly, efficiently and economically.

1.2 Problem Statements

Wear phenomena has always been a nightmare in the industrial environment, especially when it involved with machining process as it absolutely affecting the quality of a part. In the present days, with so many modern and high technologies machines are developed everyday, mostly every part product are machined by a high technology machine and running the whole cutting process without being observed by a human being. In that matter, if once the wear occurred on the cutting tool, the technicians won't realize it until the whole process is completely done. The consequences from this incident, is it will cause a mess of the quality surface material and the most bad news is, it won't obtain the exact and accurate dimensions, yet far from the part tolerances.

As getting inspirational from this kind of situations, this paper are consists research of this wear mechanism and in the mean time includes the investigation of wear characteristics on cutting tool that emerge on a high technology and NC type machine. This machining experimentation is carried out using a CNC Milling machine or its original name is Numerical Control Sculpture (NCS) machine. Moreover, this machine runs based on NC program, have the ability to cuts various shapes on a material and can runs in a longer period of time. The NC programmer is developed based on design of the material shape that are adapt from EDM electrode of Keytop using a CAD/CAM program called I-Deas.

This collaboration project is held with the company that produces computer and electronic components; keyboard for desktop computer and laptop, mouse and relay. Fujitsu Component (M) Sdn. Bhd. is a very well known company especially in the quality of its product and great reception from all customers all over the world. The products from this company are among the highest choice from customers as Fujitsu have already built their names long enough. Besides that, the company has been certified with ISO 9001, QS 9000 and ISO 14001. All the staffs here are committed to their work, very innovative and professional worker and have a very good teamwork between staff.

1.3 Objectives of the Research

The main objective of this research is to investigate optimum parameter for NCS:

a) Tool life (machining time capabilities before maximum wear)
   According to Mr. Rosni b. Sulaiman (technician incharge of machines in 3rd process room) approximately maximum tool wear occurred at 2 hours machining duration in usual machining process. But in details there is still no clear description whether on that time, maximum tool wear really occurred or not. For that matter, this research paper is developed to investigate the characteristic of tool wear according to cutting time transition. The experiment will be conducted using Scanning Electron Microscope (SEM) in Metrology Lab in UTeM.

b) Surface quality according to the cutting time and tool wear.
   On the same time, the visual of surface machined also can be investigate according to the cutting time based on the effects of the cutting process between the cutting tool and the machining material. From here, the differences can be seen between the wear cutting tool and the good one.

Other objectives of the experiment to be achieved are:

a) To determine the main reason that causing the wear to occurred on the cutting tool during machining process.
b) To explore the characteristics and properties of material used in each cutting tool, including the work material.
c) To know the exact and applicable specification of cutting tool for certain type of machining material.
d) To differentiate which cutting tool best for producing clean and clear surface during machining process.

Universally, there are two major types of cutting tool that have been used widely in the field of manufacturing industries. First are flat end mill and the other one is ball end mill. There are also a thousands cutter are made by the tool manufacturers nowadays with so much applications and the ability in different kind of cutting conditions, but most of it are inspired by these, flat and ball cutter. Both of this type of cutter plays a huge role on the metalworking industry as it contribute a lot more on the manufacturing process especially in the making of mold and die component.

Each cutter are applied on different ways of cutting mechanism and when it comes to cutting process, each cutter can provides its own ability based on the shape of the part that needed to be cut. In this research paper, both type of cutter are chosen in this experiment as both of it are used widely in the electric and electronic company mainly in the manufacturing of die and mold in their production department. These cutters come with two different properties of material, carbide and High Speed Steel (HSS) as these materials can be applied on different process with different type of machining material.

In further view of this wear investigation, 32 cutters were used in order to find out the effects of the wear mechanism on the cutters from different aspect. In this case, there are 2 different type of work material, SS 41 and Copper Tungsten, different machining parameters, cutting tool material, and the cutting time. The machining time for this experiment are made in 4 gaps of time, 35 minutes, 70 minutes, 105 minutes and 140 minutes as already marked before that based on the assumption, the wear phenomena occurred in 120 minutes or 2 hours of machining time.

From this parameters, analysis will be made using Scanning Electron Microscope (SEM) and this including surface roughness of the work material based the effects of wear from the cutting tool. Resulting from the analysis, a conclusion can be made based on which condition the wear can occurred as there are many point of view to show exactly what causing the wear phenomena.

CHAPTER 2
LITERATURE REVIEW

2.1 Cutting Tool

Success in metal cutting depends on selection of the proper tool (material and geometry) for a given work material. A wide range of cutting tool material is available with a variety of properties, performance capabilities and cost. These include high carbon steels and low / medium alloy steels, high speed steels, cast cobalt alloys, cemented carbides, cast carbides, coated carbides, coated high speed steels, ceramics, cermets, whiskereinforced ceramics, sialons, sintered polycrystalline cubic boron nitride (CBN), sintered polycrystalline diamond and single crystal natural diamond.

The tool materials are ranked by the maximum cutting speed needed to machine a volume of steel materials, assuming equal tool lives. As the speed increases, so does the material removal rate. The time required to remove a given unit volume of material therefore decreases. The cutting tool material, cutting tool parameters and tool geometry selected directly influence the productivity of the machining operation. The elements that influence the decision are work material characteristics (chemical and metallurgical state), part characteristics (geometry, accuracy, finish and surface integrity requirements), machine tool characteristics, including the work holders (adequate rigidity with high horsepower, and wide speed and feed ranges) and support systems (operators ability, sensors, controls, method of lubrication and chip removal).