UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON TOOL WEAR CHARACTERISTICS WHEN MACHINING FC 300 GRAY CAST IRON WITH UNCOATED CARBIDE FLAT END MILL

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

By

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APPROVAL

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………………………………

(Project Supervisor)

ABSTRAK

Kertas kerja ini mendedahkan kajian mengenai sifat-sifat haus pada penggunaan mata alat ketika proses pemesinan dijalankan ke atas FC 300 ‗gray cast iron‘ dengan menggunakan alat pemotongan ‗flat end mill‘ karbida yang tidak bersalut. Kajian ini bertujuan untuk mendapatkan kelajuan pemotongan yang optimum untuk pemesinan FC300 ‗gray cast iron‘ dalam konteks kehausan dan tempoh hayat alat pemotongan. Parameter pemesinan telah dinilai berdasarkan pada 4000, 4500, 5000, 5500 dan 6000 rpm kelajuan putaran dengan menggunakan nilai yang sama untuk 0.2 mm pemotongan dalam dan 100 mm/ min kadar suapan. Dalam kajian ini, operasi pemesinan dijalankan dengan menggunakan mesin penggilingan CNC dalam keadaan kering dan alat pemotong yang telah digunakan adalah ‗flat end mill‘ karbida yang tidak bersalut dengan diameter 5 mm. Setiap alat pemotong telah diuji dalam masa 10 minit masa pemesinan dengan kelajuan putaran yang berlainan. Prestasi alat pemotongan yang menjalani proses pemesinan ke atas FC300 ‗gray cast iron‘ telah dianalisa dan diukur dengan menggunakan stereo mikroskop dan Mikroskop Imbasan Elektron (SEM). Pangkalan data tentang kehausan dan tempoh hayat alat pemotongan telah diperolehi pada akhir eksperimen ini. Kajian ini juga telah memberikan maklumat yang berguna mengenai parameter pemotongan yang sesuai untuk pemesinan FC300 ‗gray cast iron‘ secara efisien serta garis panduan pemesinan yang betol dari segi tempoh hayat dan kawalan kehausan alat pemotongan.

ABSTRACT

This paper presented an investigation of tool wear characteristics when machining FC 300 gray cast iron with uncoated carbide flat end mill. This research is aimed to obtain the optimal cutting speeds for machining FC300 cast iron in terms of tool wear and tool life. The machining parameters were evaluated based on the 4000, 4500, 5000, 5500 and 6000 rpm cutting speeds with constant parameters, 0.2 mm of cutting depth and 100 mm/min of feed rate. In this research, the machining operation was conducted by using CNC milling machine under dry condition and the cutting tool used was uncoated carbide flat end mill with diameter 5 mm. Each cutting tools with varying cutting speeds were tested within 10 minutes of machining time. The performance of cutting tool when undergo the machining process of FC300 gray cast iron were analyzed and measured by using stereo microscope and Scanning Electron Microscope (SEM). The database of tool wear and tool life were obtained at the end of this experiment. This research provided useful information about the suitable cutting parameter to machining FC300 cast iron efficiently as well as a guideline to machine FC 300 gray cast iron for acceptable tool life and control wear behaviour.

DEDICATION

For my beloved parents and siblings.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BUE	-	Built-Up Edge
ISO	-	International Organization for Standardization
JIS	-	Japanese Industrial Standard
MMSB	-	Miyazu Malaysia Sdn Bhd
Rpm	-	Revolution per minute
SEM	-	Scanning Electron Microscope
WC	-	Tungsten Carbide
WEDM	-	Wire Electron Discharge Machine

CHAPTER 1

INTRODUCTION

The introduction elaborates the main idea of the project whereas it introduces the title, the project background, objectives, problem statement and scope of the project. The specification of the study are enlighten in this chapter as guidance and information about this project.

1.1 Background of Project

In any industries involving manufacturing processes, machining is deemed to be the most important process since plethora of metal products have been produced by performing the machining process. In general, machining implicates a process of metal cutting or to be more specific, it may be defined as the material removal from the work piece. Since new innovation has been comprehensively developed in late decades, rather than customary machining, progressed machining has been took set which is more savvy, adaptable and high throughput assembling methods for delivering high exactness and superb discrete metal parts for the aviation, car, also die and mold production (De Ciurana et. al., n.d).

In machining, there are several processing types that have been applied in manufacturing processes. By identifying with that, milling is among of the techniques that are huge in machining and even thought to be a standout amongst the most adaptable ordinary machine devices with the capacity of an extensive variety of metal cutting (Dhar, n.d). By definition, it is depicted as the methodology of removing material by bolstering a work piece past a turning numerous tooth cutter. Processing is normally used to deliver parts that are not pivotally symmetric and have numerous features incorporate gaps, spaces, pockets, and even three dimensional surface forms. Therefore, cutting tool is the most necessary tools in order to perform the milling operation. According to Schneider (2010), there are various types of cutting tool provided in respect to milling process. It is created in a wide size ranges to make milling a versatile machining process. Amongst them are end mill which is regarded as one of the indispensable tools in the milling processing. End mills are usually performed for facing, slotting and profile milling in order to produce flat and groove surface.

Despite of that, the application of milling process is broadly practiced in industry of making mold and die. Milling tools eliminate most of the material parts and then forming a work piece to a die or mold part. In addition, it is utilized in producing large and small die with variety features and complicated shapes. Basic examples include the milling of flat surface, indexing, gear cutting furthermore the cutting of spaces and key-ways.

In manufacturing of die, one of the materials used is FC300. FC300 is a type of gray cast iron used in metal cutting process. In FC300 manufacturing, there are many sub processes can be conducted for instance parting, slotting, grooving, flattening and curving. According to Tupy (n.d), the mechanical properties of the FC300 cast iron are depending on the metal matrix and graphite. Since it is iron with more refined graphite and totally pearlitic structure, giving it advantages on a better surface finish and a higher hardness. Meanwhile, it also good resistance to leaking since its properties can withstand to a high pressure and usually been used in production of valve bodies, heads, caps and plungers. FC300 cast iron specification is similar to ASTM A48, class 40 (Fujii et. al., 2009).

Furthermore, all cutting tools that are used in the manufacture of FC300 can be found in an assortment of materials. It will focus the cutter's properties and the work piece materials for which it is best suited. These properties incorporate the cutter's hardness, durability, and imperviousness to wear. One of the cutting tools is carbide flat end mill. Carbide can run much speedier on account of the material's amazing hardness. This permits the cutter to withstand high cutting temperatures and gives incredible wear resistance (Enco, n.d). However during machining FC300, it is still not well investigated the surface and tool wear characteristics.

Hence, this study will investigate the machining characteristics of FC300 when machining with uncoated carbide end mill. The focus of this study is to investigate the wear characteristics during machining with uncoated carbide flat end mill. The methodology that will be used to carry out this project is experimental procedures. In the experiment that is soon to be conducted, the tools have to undergo a machining test at various parameters before analysis can be done. The evaluation of machining performance of the cutting tools mentioned above is depends on the tool wear and tool life and being examine using scanning electron microscopy (SEM).

1.2 Problem Statement

In any manufacturing process, tool wear is undesirable and hard to be prevented. Parameters incorporate cutting speed, feed rate, tool material, cutting depth, coolant and work piece may impact the machining execution and tool life (Anlagan, 2005). Amid machining, cutting tool is normally exposed to high temperature, contact stresses and sliding along the tool-chip interface and along the machined surface. As a consequence, tool wear will arise and adversely affected the machining performance (Kalpakjian and Schmid, 2001).

In similar to the case when machining FC 300 gray cast iron with uncoated carbide flat end mill, the occurrence of tool wear may give bad influences on the machining operation. Since FC 300 gray cast iron is known as a very hard and tough material, thus it is very difficult to be machined (Tupy, n.d). So, the inappropriate cutting parameter applied during the manufacture of FC 300 gray cast iron has consequently affected the cutting tool performance in terms of high tool wear and shortest tool life. Moreover, tool wears like flank wear, crater wear and central wear are frequently develop on the cutting tool which is affecting on the tool life of cutting tool. Even though, carbides tools are able to perform the machining over a high temperature as well as provide excellent wear resistance, but there is still limitation of machining and milling established in die of FC300 in which the tool wear characteristics is still not been well investigated. Therefore, this study will involve the research regarding the wear mechanism and tool life by varying the cutting speeds when machining FC300 gray cast iron with uncoated carbide end mill.

1.3 Objective of Project

The specific objectives for analysis performance of uncoated carbides flat end mill in milling with FC 300 gray cast iron in this project are:

(a) To evaluate the tool life of uncoated carbide cutting tool according to cutting parameter when machining FC 300 gray cast iron.
(b) To examine the type of failure modes when machining FC 300 gray cast iron according to the view angle.
(c) To analyze the mechanism of wear when machining FC 300 gray cast iron with uncoated carbide flat end mill.

1.4 Scope of Project

The extent of this project is to perform machining operation for FC 300 gray cast iron with uncoated carbide flat end mill tool by utilizing a 3-axis CNC Vertical Milling. The parameters differing are cutting speed, in the interim feed rate and cutting depth are kept consistent. This research is carried out with the mean to assess the execution of uncoated carbide tools when end milling of FC 300 gray cast iron at various cutting speeds. The impact of the different range in cutting speeds on the tool wear and tool life will be investigated.

CHAPTER 2

LITERATURE REVIEW

This chapter elaborates the meanings and information regarding the project where it informs on the details of the project. The idea, data and information are collected from various resources in order to understand the concept and useful information or knowledge for the project.

2.1 Machining

Machining is very practicable to extensive range of work materials and frequently utilized to metals. On the other hand, it can be described as a process to remove excess material in the form of chips that could be achieved by a sharp cutting tool in purpose of to obtain the desired shape (Molian, 2006). Pursuant to Ruiz 2007, variety of part shapes and special geometry features can be produced by machining as well as giving a good result in term of dimensional accuracy and surface finish.

Even though, most machining obliges low set-up expense contrasted with forming, molding, and casting processes but for high volumes, it is substantially more expensive. Machining is fundamental where tight tolerances on dimensions and finishes are required. In addition, Madraj (2001) had stated that machining likewise covers a few processes, which can be partitioned into the accompanying classes:

(a) Abrasive processes is a material removal by hand, abrasive particles, example grinding.

(b) Non-traditional processes have various energy forms other than sharp cutting tool to remove material.

(c) Advanced machining processes that utilize electrical, chemical, thermal, and hydrodynamic methods, as well as lasers.

(d) Cutting includes single point or multipoint cutting tools with a clearly defined tool shape.

2.1.1 Elements of Machining

According to Kalpakjian and Schmid (2001), there are several primary elements in the following below that are required for a machining process.

(a) Work piece: Its shape and size for continuous and intermittent cutting, the chemical composition, mechanical properties and metallurgical properties.

(b) Tool: Material and geometry

(c) Chip: Types of chips and their geometry

(d) Cutting fluid: Its chemical composition, rate of flow and the mode of application.

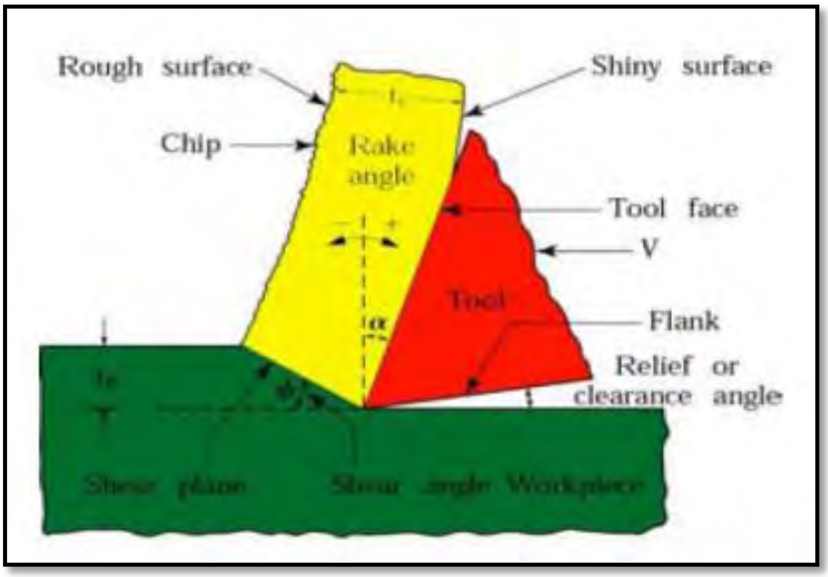

Figure 2.1: Deformation of material in machining (Ruiz, 2007).

Figure 2.1 shows a schematic illustration to represent the nomenclature of the machining process. The undeformed chip thickness *t1* is the value of the depth of cut, while *t2* is the thickness of the deformed chip after leaving the work piece. The major deformation starts when the cutting tool, in a rake angle, α, shears the metal to form an angle of shear, *Ø*, at a specific cutting speed, *V,* and feed rate, *f*. The deformed chip is separated from the parent material by fracture to remove the excess stock of the parent material to create a finished work piece of the required dimensions (Schneider, 2005).

2.1.2 Classical Metal Machining Process

Metal cutting processes may be divided into two categories which are differing in term of angular relationship between the cutting velocity vector and the cutting edge of the tool. Both of them are orthogonal cutting and oblique cutting as represented in Figure 2.2.

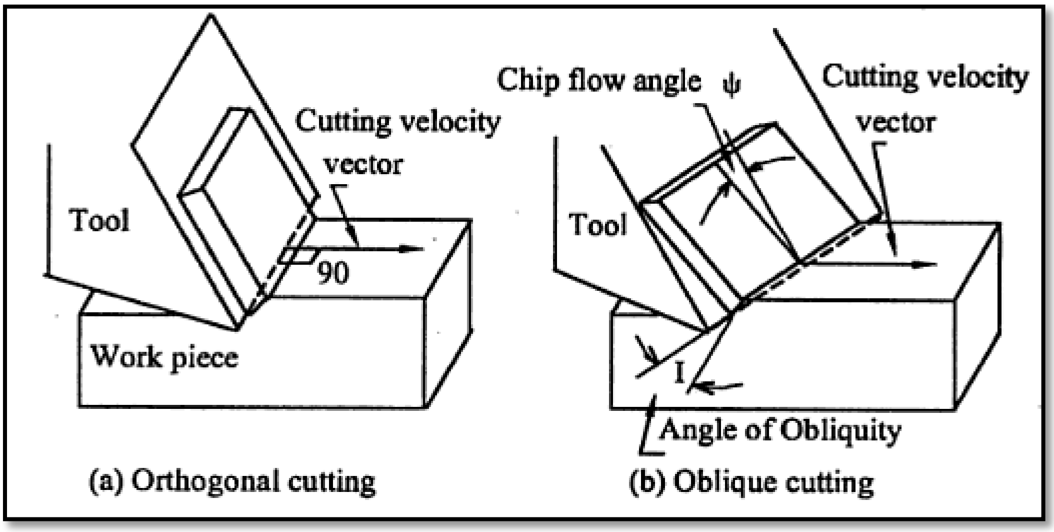

Figure 2.2: Chip flow in orthogonal and oblique cutting (Juneja and Seth, 2003).

Krar and Check (1997) had differentiated the orthogonal cutting with oblique machining in their book based on approach angle. In orthogonal cutting, the approach angle is 90° while oblique machining describes the process when the approach angle is not equal to 90°.

In spite of that, Junega and Sekhon (2003) additionally guaranteed that the cutting edge of the tool in orthogonal cutting is perpendicular to the cutting speed direction. Then in sideways cutting, the angle between the cutting edge and cutting velocity is not quite the same as 90° and the cutting edge of the tool is not perpendicular to the cutting velocity however set at angle with the normal to the cutting velocity. Also, Rajput (2007) had effectively investigated the contrasts in the middle of orthogonal and oblique cutting in term of tool life. In his findings, he identified that oblique cutting is more efficient since its tool life is higher than orthogonal cutting.

2.1.3 Factors Affecting Machining

Machining operation may be influenced by variety of factors. Kalpakjian and Schmid (2010) had studied about the possible factors that may give a negative performance of machining. In his studies, he had successfully classified these factors into two sections that are consisting of independent variable and dependent variable. Independent variable is referring to a variable that can be controlled and chosen in cutting process. Amongst them are (i) tool material and coatings, (ii) tool shape, surface finish and sharpness, (iii) work piece material and condition, (iv) cutting speed, feed and depth of cut, (v) cutting fluid, (vi) features of the machine tool as well as (vii) work holding and fixturing.

On the contrary, dependent variable is comprises of factors that may be influenced by changes. The examples of dependent variable include (i) type of chip produced, (ii) force and energy dissipated during cutting, (iii) temperature rise in the work piece, the tool and the chip, (iv) tool wear and failure and also (v) surface finish and surface integrity of the work piece. Table 2.1 shows elements that affecting machining operation.

Table 2.1: Elements affecting machining operation (Kalpakjian and Schmid, 2010).

Element	Impact and interrelationship
Cutting speed, depth of cut, feed and cutting fluid.	Forces, power, temperature rise, tool life, type of chip, surface finish and integrity.
Tool angles	As above, influence on chip flow direction, resistance to tool wear and chipping.
Continuous chip	Good surface finish, steady cutting force, undesirable especially in automated machinery.
Built up edge chip	Poor surface finish and integrity; if thin and stable, edge can protect tool surfaces.
Discontinuous chip	Desirable for ease of chip disposal; fluctuating cutting forces; can affect surface finish and cause vibration and chatter.
Temperature rise	Influences tool life, particularly crater wear and dimensional accuracy of work piece; may cause thermal damage to work piece surface.
Tool wear	Influences surface finish and integrity, dimensional accuracy, temperature rise, forces and power.
Machinability	Related to tool life, surface finish, forces and power, and type of chip.