INVESTIGATE SURFACE INTEGRITY WHEN MACHINING FC300 CAST IRON USING UNCOATED CARBIDE BALL END MILL: STUDY OF SURFACE PROFILE

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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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Signature	:	
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Date	:	6 JUNE 2013

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:

……………………………….

ABSTRAK

Tujuan kajian ini adalah untuk mendapatkan parameter yang optimum untuk pemesinan FC300 ‘cast iron’ dalam konteks kekasaran permukaan dan tekstur permukaan. FC300 ‘cast iron’ merupakan satu bahan yang selalu digunakan didalam industri pembuatan acuan. Parameter yang akan dinilai berdasarkan 6000 - 9000 rpm kelajuan pemutaran, 4 - 7 m/min kadar suapan dan dengan nilai yang sama untuk pemotongan dalaman sebanyak 0.01mm. Didalam kajian ini, pemesinan dijalankan menggunakan mesin ‘milling’ didalam keadaan kering dan alat pemotongan yang akan digunakan ialah ‘uncoated carbide ball end mill’ dengan diameter 32mm. Prestasi integriti permukaan FC300 ‘cast iron’ akan diambil kira oleh mesin kekasaran permukaan dan mesin permukaan profil dengan menggunakan ‘Scanning Electron Microscope’ (SEM). ‘Response Surface Methodology’ (RSM) telah digunakan untuk mengkaji optimum parameter pemotongan di dalam konteks untuk mendapatkan permukaan yang baik. Kajian ini akan menyediakan maklumat yang berguna tentang parameter pemotongan yang sesuai untuk FC300 ‘cast iron’ dengan cekap.

ABSTRACT

The aim of this research is to obtain the optimal parameters for machining FC300 cast iron interns of surface roughness and surface texture. FC300 is a material that frequently used in die industry. The parameters that will be evaluated are based on the 6000 – 9000 rpm spindle speed, 4 – 7 m/min feed rate and with constant depth of cut 0.01mm. In this research, the machining conducted by using CNC milling machine under dry condition and the cutting tool that will be used is uncoated carbide ball end mill with diameter 32mm. The performance of surface integrity for FC300 cast iron will be measure by surface roughness machine and surface profile using Scanning Electron Microscope (SEM). Response Surface Methodology (RSM) was used to evaluate the optimum cutting parameter in order to obtain a better surface finish. This research will provide useful information about the suitable cutting parameter to machining FC300 cast iron efficiently.

DEDICATION

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

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Anova	-	Analysis of Variance
Cbn	-	Cubic Boron Nitride
CNC	-	Computer Numerical Method
EDM	-	Electric Discharge Machine
HSM	-	High Speed Machine
HSS	-	High Speed Spindle
MMSB	-	Miyazu Malaysia Sdn Bhd
MRR	-	Material Removal Rate
Ra	-	Arithmetic Average
SEM	-	Scanning Electron Microscope
Rpm	-	Revolution per Minute
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1
INTRODUCTION

1.0 Introduction

The manufacturing process of stamping die is one of the most demanding tasks in manufacturing engineering. The stamping die must have a high material hardness (good impact resistance), not easily deformed under certain temperature and the most important thing have a short lead time in order to manufacture the die. At the same time, cost to make the stamping die must be the cheapest price as well as emphasizing the maximum possible level of quality, because quality requirements become more and more important due to competition and quality awareness. In Malaysia, one of the associated companies in the stamping die manufacturing is Miyazu Malaysia Sdn Bhd (MMSB). MMBS was established in 1991 and is one company known for specializing in manufacture of stamping die, particularly in processing automotive body part. Example of die automotive body part supplies by MMBS are for Proton, Perodua, Honda, Isuzu, Lotus, Nissan, Mazda, Peugeot, Subaru and Toyota.

There are a lot of materials that used to produce a stamping die for manufacturing applications; one of the examples is cast iron. The term cast iron refers to a family of ferrous alloys composed of iron, carbon (ranging from 2.11 % to about 4.5%), and silicon (up to about 3.5 %) [Kalpakjian (2010)]. This material has high carbon content makes it easily to cast into a complex shape and machined, excellent wear resistance and high hardness. The melting point of this material is between 1147 - 1250°C, which is substantially lower than the melting point for mild steel [Srivastava

(2011)]. In this research, the grade of cast iron is FC300 in the Japanese Industrial standard (JIS G5501) code will be use. The mechanical properties of the FC300 cast iron are depending on the metal matrix as well as on the format and quantity of the graphite. On the other hand, FC300 cast iron with totally pearlitic structure provides more mechanical properties, a good surface finish and higher hardness. Another important characteristic for FC300 cast iron is good leaking resistance, because its properties can accommodate 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 (2009)].

In machining stamping die, one of the important characteristic is 'Surface Integrity'. Surface integrity is an important consideration in stamping die manufacturing, because it influences such properties as fatigue strength and they control the strength and performance of structural components [Kalpakjian (2010)]. In other words, stamping die must be free from scratch, pores, pitting, pin hole and etc, because fine surface finish is essential not only to provide accurate and stringent tolerance for complex stamping product but also provide optimum heat transfer during quenching process. In order to get a better surface integrity at stamping die, the stamping die will be machining at High Speed Machining (HSM) and then is polished manually in order to get good surface finish and texture.

The focus of this study is to analyze what is the optimum cutting parameter for FC300 cast iron by using High Speed Machining to get a fine surface integrity for stamping die application. This study will be cover cutting speed (v) from 6000rpm to 9000 rpm and feed rates (f) from 4 m/min to 7 m/min for cutting parameter. The works will be carried out in close cooperation with the Miyazu Malaysia Sdn. Bhd (MMBS). Results that gain from this analysis will provide useful information about what is the best cutting parameter to manufacture one stamping die, in order to get a good surface finish and texture without no need anymore manual polishing. The data obtained also will be useful as reference materials for machinist in planning their machining in order to produce maximize surface quality, reduce processing steps and hence minimize operational cost.

1.1 Objective

The overall aim of the research is to study the optimum parameter for machining FC300 cast iron. The aim can be resolved into the following specific objectives:

a) To evaluate the optimum cutting speed and feed rates when machining FC300 cast iron based on surface roughness.
b) To analyze the effect of cutting parameter interaction on surface roughness during machining of FC300 cast iron.
c) To analyze the surface integrity using the different cutting parameter during machining FC300 cast iron.

1.2 Problem Statement

Process for manufacturing die requires a several step in order to make it. The first step is rough machining, where the workpiece material is removed as quickly as possible. The second step is semi finishing, where machining is carried out to ensure consistent material removal rate and the lastly is polishing. Generally, this entire step requires a long lead time and requires a lot of skilled workers. In Miyazu Malaysia Sdn Bhd, all die that was made is machining by using one cutting parameter, which are cutting speed at 6000rpm and feed rates is 5.5m/min. After semi finishing, MMSB was hiring a three worker to polish the dies manually until the die surface produce a good surface. In this cases, MMSB found that the process polishing have some problem such as a human error where the polishing not consistence at all side.

Besides require a long lead time in the die manufacturing process. Workers that assigned to do polishing the die show a situation that is not ergonomic, where workers have to bend its body while this polish process take place. This will give ergonomic hazard to the worker, if this type of work is continuous and better ergonomic process is not taken into account. Ergonomics it is important because it studies and finds ways to make workers more comfortable and satisfied. With proper use, absences are decrease and productivity will increase and can give a lot of benefit to organization and human.

Therefore, this research is done to get the optimization cutting parameters for MMSB and indirectly will get a good surface finish and texture. Thus, the time required to polish the die after machining will reduce if surface of the die is not too very rough, and at the same time will reduce the cost of manufacturing die, because polishing process gives high costs as its vulnerable to human error.

CHAPTER 2
LITERATURE REVIEW

2.1 Machining

Machining is a term used to describe a variety of material removal processes in which a cutting tool removes unwanted material from a workpiece to produce the desired shape. The workpiece is typically cut from a larger piece of stock, which is available in a variety of standard shapes, such as flat sheets, solid bars, hollow tubes, and shaped beams [Kadirgama (2009)]. Machining also covers several processes, which can be divided into the following categories [Madraj (2001)]:

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

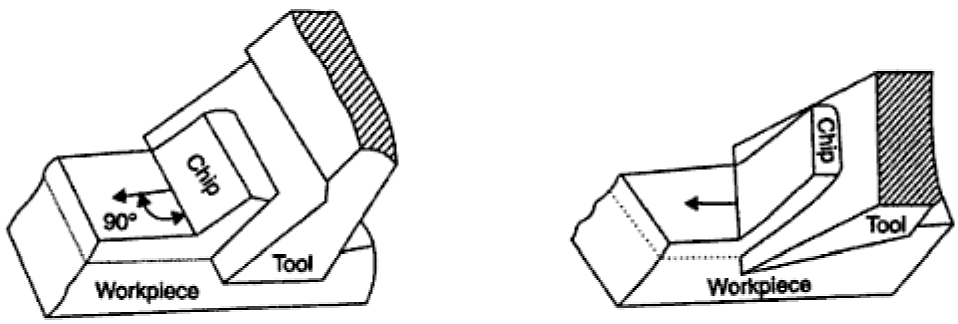
b) Nontraditional processes - various energy forms other than sharp cutting tool to remove material.

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

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

On the basic of the angular relationship between the cutting velocity vector and the cutting edge of the tool, different metal cutting process can be classified into two broad categories, which is (i) orthogonal cutting and (ii) oblique cutting as show at

Figure 2.1. In orthogonal cutting, the cutting edge of the tool is perpendicular to the cutting speed direction [Junega and Sekhon (2003)]. The process of orthogonal cutting is the tool is pushed into the workpiece, a layer of material is removed from the workpiece and it slides over the front face of the tool called rake face. When the cutting edge of wedge is perpendicular to the cutting velocity, the process is called orthogonal cutting. Meanwhile in oblique cutting, the angle between the cutting edge and cutting velocity is different from 90° and the cutting edge of the tool is not perpendicular to the cutting velocity but set at angle with the normal to the cutting velocity [Rajput (2007)]. The different between orthogonal and oblique cutting is show at Table 2.1.



(a) **(b)**

Figure 2.1: (a) Orthogonal Machining (b) Oblique Machining [Rajput (2007)].

Table 2.1: Different Between Orthogonal and Oblique Machining [Rajput (2007)].

No	Aspects	Orthogonal Cutting	Oblique Cutting
1	Inclination of the cutting edge of the tool.	Perpendicular to the direction of tool travel.	Inclined at an angle with the normal to the direction of tool travel.
2	Clearance of the workpiece width by the cutting edge.	The cutting edge clears the width of the workpiece on either ends	The cutting edge may or may not clear the width of the workpiece.

3	The chip movement.	The chip flows over the tool face and direction of chip flow velocity is normal to the cutting edge. The chip coils in a tight flat spiral.	The chip flow on the tool face making an angle with the normal on the cutting edge. The chip flows sideways in a long curl.
4	Number of components of cutting force acting on the tool.	Only two components of the cutting force act on the tool. These two components are perpendicular to each other and can be represented in a plane.	Three components of the force act at the cutting edge.
5	Maximum chip thickness occurrence.	Maximum chip thickness occurs at its middle.	The maximum chip thickness may not occur at middle.
6	Tool life.	Less	More.

2.1.1 Factor That Influence Machining

There are many factors that can influence machining operation (Table 2.2); it can be classified into two sections which is independent variable and dependent variable [Kalpakjian (2010)]. Meaning for independent variable is variable that can control and choose in cutting process, example:

a) Tool material and coatings
b) Tool shape, surface finish and sharpness
c) Workpiece material and condition
d) Cutting speed, feed and depth of cut
e) Cutting fluid

f) Characteristic of the machine tool
g) Workholding and fixturing

Dependent variable in cutting is those that are influenced by changes in the independent variable listed above and include:

a) Type of chip produced
b) Force and energy dissipated during cutting
c) Temperature rise in the workpiece, the tool and the chip
d) Tool wear and failure
e) Surface finish and surface integrity of the workpiece

Table 2.2: Factors Influence Machine Operation [Kalpakjian (2010)].

Parameter	**Influence 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 workpiece; may cause thermal damage to workpiece