UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

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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I hereby, declared this report entitled "Investigate Surface Integrity When Machining FC300 Cast Iron Using Uncoated Carbide Ball End Mill: Study of Subsurface Micrograph" is the results of my own research except as cited in references.

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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 follows:

………………………………

(Official Stamp of Principal Supervisor)

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji integriti FC300 ‘cast iron’ selepas proses pemesinan 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 0.1mm. Didalam kajian ini, percubaan pemesinan akan 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 subpermukaan mikrohardness dan subpermukaan mickostructure. 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 study the surface integrity of FC300 cast iron after machining in terms of subsurface microstructure and subsurface microhardness. FC300 is a material that frequently used in die industry. The parameters that was evaluated are based on the 6000 – 9000 rpm spindle speed, 4 – 7 m/min feed rate and with a constant depth of cut 0.1mm. In this research, the machining trial was conducted using a CNC milling machine under dry condition and the cutting tool that is used was uncoated carbide ball end mill with diameter 32mm. The performance of surface integrity for FC300 cast iron was measured and analysed in regards towards the subsurface microhardness and subsurface microstructure. This research will provide useful information about the suitable cutting parameter to machining FC300 cast iron efficiently.

DEDICATION

First and foremost, , I would like to express my greatest appreciation to Universiti Teknikal Malaysia Melaka for giving me the opportunity to undergo my final year "Projek Sarjana Muda" under the supervision of Dr. Mohd Hadzley Bin Abu Bakar. A special thank you also goes to my supervisor Dr. Mohd Hadzley Bin Abu Bakar for his dedication and guidance during the period of undergoing my project. Last but not least, I want to thank my mom and dad for their support as well as to all my friends who never give up encouraging me to complete this report.

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LIST OF ABBREVIATIONS

MMSB	-	Miyazu Malaysia Sdn Bhd
UTeM	-	Universiti Teknikal Malaysia Melaka
ASTM	-	American Society for Testing and Material
JIS	-	Japanese Industrial Standard
SEM	-	Scanning Electron Microscope
Cbn	-	Cubic Boron Nitride
CNC	-	Computer Numerical Method
HSM	-	High Speed Machine
HSS	-	High Speed Spindle
MRR	-	Material Removal Rate
Ra	-	Arithmetic Average
Rpm	-	Revolution per Minute
HIP	-	Hot Isostatic Pressing
CVD	-	Chemical Vapor Deposition
PVD	-	Physical Vapor Deposition
WC	-	Tungsten Carbide
TiN	-	Titanium Nitride
TiC	-	Titanium Carbide
CI	-	Cast Iron

CHAPTER 1

INTRODUCTION

1.1 Introduction

A die is basically a tool that can be used in the industry especially in the manufacturing industry either to cut or shape the material using a press. In nowadays technology, product that can be made from dies range from a simple pin clip to a more complex geometry figure such as a body car used in the automotive industry. In the automotive industry for example, there are two most common die operation used which is bending where it may create a curved bend such as for the door part of the car and other operation is known as blanking where the process will produce a flat piece of material by cutting the desired shape according to the customer specification in one operation.

Nowadays, processing of a die to be used in the manufacturing industry is very complicated and hard to produce. Among the constraints is its high material hardness, short lead time and also its complex work piece geometry due to the demands of the customers. In addition, the aspect of quality becomes a hot issue due to intensified competition and quality awareness. Miyazu Malaysia Sdn. Bhd. (MMSB), located at Tanjung Malim, Perak has a core business which closely related to the manufacturing of die. This company specializes in automotive tooling engineering and also design and manufacturing services. One of its great achievements until present is that this company is currently the leading of die provider for Proton cars. With over two decades of experience in the manufacturing of die, sharing of knowledge and technology with

MBSB will benefit many people especially those who involve in the research of die machining in general.

Among the most widely used material in stamping die application is cast iron. Cast iron is a type of iron-carbon cast alloy with various elements on it that is made by remelting scrap, pig iron, and other addition. For differentiation from steel and cast steel, cast iron is defined as a cast alloy with a carbon content (min 2.03%) that ensures the solidification of the final phase with a eutectic transformation. Usually, normal grade of cast iron is widely used as an engineering material even though it is quite brittle and are not strong enough. It is due to other aspects such as very good machinability, ease of melting and casting, cheap prices, ability to resist wear and compressive strength and last but not least is that it has high amount of fluidity which makes it easy to cast into a complex shape. In this research, the grade of cast iron that will be used is FC300 according to the Japanese Industrial standard (JIS) code G5501. In general, due to the presence of more refined graphite and the matrix which is essentially pearlite, it gives this FC300 more mechanical resistance and because of that, it gives a better surface finish and higher hardness. Other than that, one of the most important aspects of this FC300 is its ability to resist leaking. This characteristic is very crucial to some application that applied hydraulic components subjected to high pressure such as valve bodies, manifolds, heads, caps and plungers. With regards, according to the American Society for Testing and Material (ASTM) A48, class 40, the specification is similar to it.

Machining with high speeds (HSM) is one of the modern technologies, which in comparison with conventional cutting enables to increase efficiency, accuracy and quality of work pieces and at the same time to decrease the costs and machining time (Schulz, 1992). Practically, it can be noted that HSM is not simply high cutting speed. It should be regarded as a process where the operations are performed with very specific methods and production equipment (Coromant, 1999). Basically the main process that involves in HSM has considerably higher feedrates and cutting speed compared to conventional machining such as lathe and milling machine. Among the main contributes of HSM is the reduction of maximum surface roughness when applied it to the finishing operation of die’s machining. In addition, HSM also offers other advantages such as shorten the production time and increase the accuracy of machined parts. Due to the fact, the material removal rate in high speed machining can be 5–10 times higher than conventional machining and the process also capable of reducing machining lead-time. In the nutshell, by using HSM, not only it will reduce the manual polishing but also the surface finishing can be greatly improved.

Thus, the aim of this project is to study the best parameters to be used when using FC300 cast iron to produce fine surface integrity for the application of die stamping. In this research, a 5-axis CNC milling machine was used and for the surface finish of FC300 cast iron, it undergone different cutting parameters of cutting speed (v) and federates (f) while for the depth of cut, it is constant. The works was carried out in close cooperation with the Miyazu Malaysia Sdn. Bhd. The understanding and correct use of the cutting parameters in high speed machining lead to better understanding in surface integrity of cast iron which is through to the step by increase a cutting speed and feed rate .By the end of the day, the data gathered from the experiment was used to provide sufficient information in order to get fine surface finishing during machining die based material without having secondary work such as polishing. In addition, the data obtained can be used to help machinist and another researcher in the future in order to get a better surface finish, less working processing and also optimizing the operational cost.

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1.2 Objective

The overall aim of this research is to study the surface integrity of FC300 cast iron. The aim can be resolved into the following specific objectives:

a) To analyze the surface integrity of FC 300 cast iron after machining based on:
   i) Subsurface microstructure and
   ii) Subsurface microhardness

1.3 Problem Statement

In order to fabricate molds and die, several processing steps need to be done such as initial rough machining where the excess material was removed quickly and then it undergoes a semi finishing where the process will ensure a consistent material removal rate of the materials. Then it will undergo some machining processing where at this step it will have a good dimensional accuracy and better surface finish before it undergo the last processing which is polishing that will ensure the surface of the material become shiny and high quality of surface finish. The overall process required a certain amount of time and more workers need to be hired thus result in higher cost operation. Basically, the entire machine at MMSB that involved with the manufacturing of dies was machined by using a constant parameter which is feed rates of 5.5 m/min and also cutting speed of 6000 rpm. In addition, MMSB has to hire three personnel to polish the dies manually after the semi finishing process in order to get a fine surface finish. In such cases, there are certain problems that MMSB had detect regarding on human error where as the polishing is not uniform at all side.

As getting inspiration from this kind of situations, this paper consists of research that was done to eliminate or reduce the step for manufacture stamping die. This research paper can contribute some useful information to obtain fine surface finishing during machining die application without required polishing activities. Furthermore, the data obtained also can be used to help machinist and another researcher in the future in order to get a better surface finish, less working processing and also minimizing the operational cost.

CHAPTER 2
LITERATURE REVIEW

2.1 Machining

Machining can be defined as the process of removing material from a work piece in the form of chips. The term metal cutting is used when the material is metallic. Most machining has very low setup cost compared to forming, molding, and casting processes. However, machining is much more expensive for high volumes. Machining is necessary where tight tolerances on dimensions and finishes are required.

This metalworking technique actually involves many types of processes that can be used to give metal the desired shape and finish. These techniques are often divided into four categories, and may be used together to produce a single product. Drilling is one of the most basic types of machining. During the drilling process, workers use a metal bit to cut holes in the metal. For example, drilling may be used to cut holes for fasteners in a metal kick plate used to protect a door.

2.1.1 Dry machining

Dry machining is ecologically desirable and it will be considered as a necessity for manufacturing enterprises in the near future. Industries will be compelled to consider dry machining to enforce environmental protection laws for occupational safety and health regulations. The advantages of dry machining include: non-pollution of the atmosphere (or water); no residue on the swarf which will be reacting in reduced disposal and cleaning costs; no danger to health; and it is non-injurious to skin and is allergy free. Moreover, it offers cost reduction in machining. (Narutaki et. al, 1997)

The various possible routes to achieve clean machining processes were analyzed and discussed by Byrne, 1996. Elimination of the use of cutting fluids, if possible, can be a significant incentive. The costs connected with the use of cutting fluids are estimated to be many more times than the labor and overhead costs. Hence the implementation of dry machining will reduce manufacturing costs. In the manufacturing industry, cutting fluids help to remove the heat generated due to friction during cutting to achieve better tool life, surface finish and dimensional tolerances prevent the formation of built-up edge and to facilitate the transportation of chips. Coolants are essential in the machining of materials such as aluminium alloys and most stainless steels, which tend to adhere to the tool and cause a built-up edge. At the same time, the coolants produce problems in the working environment and also create problems in waste disposal. This creates a large number of ecological problems, but which in turn result in more economical overheads for manufacturing industries. If industries were to practice dry machining, then all of the above-mentioned problems should be addressed satisfactorily. The cutting fluid industries are reformulating new composites that are more environmentally friendly and which do not contain Pb, S or Cl compounds. (Santhanakrishnan, 1994)

Consumption of cutting fluids has been reduced considerably by using mist lubrication. However, the mist in the industrial environment can have serious respiratory effects of the operation. The use of cutting fluids will be increasingly more expensive as stricter enforcement of new regulation and standards are imposed, leaving no alternative but to consider dry machining. Many metal-cutting processes have been developed and improved based on the availability of coolants. It is well known that coolants improve the tool life and tool performance to a great extent. In dry machining, there will be more friction and adhesion between the tool and the work piece, since they will be subjected into higher temperatures.

This will result in increased tool wear and hence reduction in tool life. Higher machining temperatures will produce ribbon-like chips and this will affect the form and dimensional accuracy of the machined surface. However, dry cutting also has some positive effects, such as reduction in thermal shock and hence improved tool life in an interrupted-cutting environment. (Sreejith and Ngoi, 1999)

2.1.2 Elements of machining

The complete machining process is composed of four elements; Fig. 2.1.

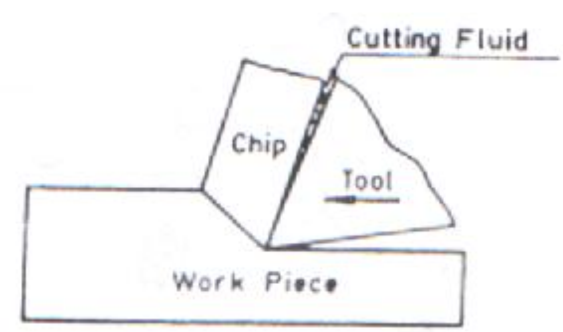

Figure 2.1: Elements of machining process (Krar and Check, 1997)

1. **Workpiece** – besides, it also includes prime-mover and work holding devices.

2**. Tool**- it also includes tool holding devices.

3. **Chip** and

4. **Cutting Fluid**

The associated fields of interest related with above four factors are: