UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SURFACE AND SUBSURFACE ANALYSIS IN GRINDING PROCESS

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

By

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I hereby, declared this report entitled "Surface and subsurface analysis in grinding process" is the result of my own research except as cited in references.

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APPROVAL

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ABSTRACT

The main aim of this study is to investigate the surface and subsurface quality of a grinding process. Surface roughness and subsurface morphology is the most critical quality measures in mechanical products. As competition among industries grows rapidly, customers have highly demand on quality surface roughness and subsurface. In metal manufacturing industries, grinding is one of the most popular methods of machining hardened materials. The use of coolant and machine vibration is identified as factors influencing the surface roughness besides the machining parameters and type of material. The parameters choose in this study are depth of cut and feed rate and the workpiece material is mild steel AISI 1020. The full factorial Design of Experiment (DOE) method is used to study the effect of machined parameter on surface roughness. The result of surface roughness was analyzed using MINITAB software. All of the specimens were machined using surface grinding machine. Surface roughness was analyzed using portable surface roughness. The surface morphology is analyzed by using image analyzer and Scanning Electron Microscope (SEM). From the results, it shows that the highest Ra value obtained is 0.58µm at the feed rate of 50 mm/min and depth of cut 2.0µm whiles the lowest Ra value obtained is 0.20µm at feed rate of 90 mm/min and depth of cut 10.0µm. Surface roughness was found to be influenced by feed rate rather than depth of cut. Dry grinding shows high surface roughness value compare to using coolant.

ABSTRAK

Tujuan utama kajian ini adalah untuk mengkaji kekasaran permukaan dan morfologi permukaan di dalam process pengasahan. Kekasaran permukaan dan permukaan bawah adalah ukuran kualiti yang kritikal di dalam kebanyakan produk mekanikal. Persaingan dalam industri yang semakin berkembang maju menyebabkan para pengguna mementingkan kualiti kekasaran permukaan dan permukaan bawah. Dalam industri pembuatan logam, pengasah permukaan adalah salah sebuah kaedah terbaik yang digunakan untuk mengasah bahan kerja yang keras. Penggunaan cecair penyejuk dan getaran mesin adalah faktor yang mempengaruhi kekasaran permukan disamping parameter pemesinan dan jenis bahan kerja. Parameter yang dipilih dalam projek ini adalah kelajuan pemakanan (feed rate) dan kedalaman pemotongan pengasahan (depth of cut) mesin permukaan. Selain itu, bahan yang dipilih adalah keluli sederhana (mild steel) AISI 1020. Projek ini mengaplikasikan kaedah rekabentuk eksperimen untuk mengkaji kesan parameter pada kekasaran permukaan. Hasil kekasaran permukaan akan dianalisa menggunakan perisian MINITAB. Semua spesimen dimesin menggunakan mesin pengasah permukaan. Kekasaran permukaan dianalisis menggunakan mesin kekasaran permukaan dan morfologi permukaan dianalisis menggunakan pengimbas mikroskop elektron (SEM). Keputusan analisis menunjukkan kekasaran permukaan paling tinggi adalah 0.58µm pada nilai pemakanan (feed rate) 50mm/min dan kedalaman pemotongan (depth of cut) 10µm. Kekasaran permukaan menunjukkan ianya dipengaruhi oleh nilai pemakanan berbanding kedalaman pemotongan. Proses pengasahan tanpa cecair penyejuk menunjukkan nilai kekasaran permukaan yang tinggi berbanding menggunakan cecair penyejuk.

DEDICATION

Special thanks for my supervisor, Dr Ahmad Kamely Bin Mohamad

For my beloved parent, my brother and my sister.

Especially for my special one who believing in me and supporting everything I do.

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LIST ABBREVIATIONS

DOE	-	Design of Experiment
UTeM	-	Universiti Teknikal Malaysia Melaka
PSM	-	Projek Sarjana Muda
HSG	-	High Speed Grinding
ANSI	-	American National Standard Institute
ASTM	-	American Society for Testing and Materials
ISO	-	International Standard Organization
Ra	-	Roughness average
AA	-	Arithmetic average
CLA	-	Centre line average
Rz	-	Arithmetic mean
RMS	-	Root mean square
HAZ		Heat Affected Zone

CHAPTER 1

INTRODUCTION

1.1 Background

Grinding is one type of machining processes which utilizes hard abrasive particles as the cutting medium. Grinding is traditionally regarded as a final machining process in the production of components requiring smooth surfaces and fine tolerances. Nowadays, grinding is a major manufacturing process which accounts for about 20-25% of the total expenditures on machining operations in manufacturing countries (Malkin, 1998). When compare grinding machine and lathe machine, there are many major different especially type of operations. As we know, grinding machine is used to perform a grinding process. The selection of the grinding process is depends on part shape and size, ease of fixturing and the production rate required. Grinding operations are carried out with a variety of wheel and workpiece configurations. The basic types of grinding operations are surface grinding, cylindrical grinding, internal grinding and centerless grinding (Kalpakjian, 2001). Surface grinders are the largest percentage of user in manufacturing industries compare with other type of process in grinding. For the lathe machine, it's still known as the oldest machine tools, simple and versatile machine. The operation process on the lathe machine required a skilled machinist because all controls are manipulated by hand. The type process can be done by lathe machines are turning, boring, drilling, milling, planning, shaping, broaching and sawing.

The important aspect in selection of grinding machine is grinding wheel. The type of grinding wheel used for a certain application can greatly influence the quality of surfaces produced, as well as the economics of the operation. The selection process on wheels not only the shape of wheel and part to be produce, but it also consider on characteristics of the workpiece material as well. The grindability of materials consider such as the quality of the surface produced, surface finish, surface integrity, wheel wear, cycle time and overall economics. In manufacturing industries today, the using of ceramics as grinding wheel increase relative ease using diamond wheel. The ability of this wheel material is possible to produce continuous chips and good surface integrity in grinding (Malkin, 1998). The ceramic chips sizes are typically 1 μm-10 μm (40μin-400μin). There are also has another various type of materials that recommends for grinding wheels like Aluminum, Brass, Bronze, Cast iron, Carbides, Ceramics, Copper, Nickel alloys, Nylon, Steels, Titanium and Tool steels. These recommendations materials vary significantly, depending on material composition, grinding operation and grinding fluids used.

As equipment in manufacturing machining, grinding machine also has advantage and disadvantage. The grinding machines are available for various workpiece, geometries and size. But, for the lathe machine the workpiece with cylindrical shape only available to be machining on lathe machine. In production, grinding machine now was completed with computer controlled. It has features such as automatic workpiece loading and unloading, clamping, cycling, gaging, dressing and wheel shaping. Beside that, grinders also equipped with probe and gages for determining the relative position of the wheel and workpiece surface. For the limitations of grinding machines, grinding requires much energy than turning process. So, thermal and other damage to the workpiece surface is more likely to occurred and cutting fluid is necessary than machine tool more expensive. It is evident that the competitive position of hard turning verse grinding must be evaluated individually for each application and in terms of product surface finish and integrity, quality and overall economics.

For grinding mechanisms, High Speed Grinding (HSG) is one of the most popular processes in manufacturing industries. To reduce the cycle time, high speed grinding is needed for a certain process. High speed grinding has been used in certain process that need to remove material as quickly and efficiently as possible with little concern for surface quality. In gathering a good surface finish, grinding machining used in the production and is important part of the machine tool trade to improved machine construction has permitted the production of parts to extremely fine tolerances with improved surface finish and accuracy of the finish product (Krar, 2006). In the HSG, the parameter can be observed like surface roughness, speed, depth of cut and feed rate. According to Kalpakjian (2001), increase the wheel speed, depth of cut and wheel diameter will increase temperature. But, temperature decreases with increasing workpiece speed. So, temperature rise in grinding is an important consideration because it can adversely affect the surface quality and cause residual stresses on the workpiece.

1.2 Problems Statements

The quality of a machined surface is becoming more and more important in order to satisfy the increasing demands of sophisticated component performance, longevity, and reliability. An understanding of surface integrity provides much advantage in avoiding failures, enhance component integrity and reduce overall costs. Although considerable research has been done on high speed grinding, there is hardly any research following on the AISI D2 cold work tool steel. Many researchers have shown that grinding process can induce white layer. The presence of white layer in HSG and it causes still be a great concerns in the machining industries and academia because the effect of the white layer on a components service life has not yet been clarified as understood at present.

1.3 Objectives

The objectives of this research are:

i. To study the influence of heat on the surface morphology in grinding process.
ii. To find the significant machining parameters (depth of cut and feed rate) that influence machining characteristics through (DOE).
iii. To analyze the data from the experiment using MINITAB software.

1.4 Scope of Study

This research will involve experimentation by machining parts using surface grinding machine in UTeM machine shop. The grinding parameter that had been used was feed rate and depth of cut and the material that had been choose for this analysis is Mild Steel AISI 1020. The process of the experiment had been analyzed under the process of using coolant and without using coolant. After the machining process, all those specimens will be analyzed by using the portable roughness measuring machine. The specimens will also be analyzing using optical microscope for analyzing the effect of Heat Affected Zone (HAZ). Besides, the result of the specimen microstructure will be compare with microstructure of other specimens which by using differences parameter. The result of surface roughness had also been analyzed by using Design of Experiment (DOE) method. Through this method, the data is analyzed using the full factorial design.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to High Speed Grinding

High speed grinding is one type of process in manufacturing industries to reduce the production time. It is required in a certain process and material. HSG could be an economic strategy for achieving high efficiency in machining process. Applications of high speed grinding have expanded the field of grinding from traditional finishing operation to now more widely employed high-performance machining. In this way, high performance grinding corresponds to the dual attributes of high efficiency and high precision, which are required for competitive grinding processes.

HSG is characterized by efforts to improve the economics of the process by increasing material removal rates and simultaneous improvements of process stability, capability and machining quality (Kopac *et al.*, 2006). Besides that, in technological terms HSG refer to high productivity grinding in order to reduce the machining time while maintaining the same level of quality and high quality grinding in order to enhance machining quality while maintaining a constant machining capacity. As a theoretical, an increase in wheel speed results in a reduction in maximum chip thickness and hence grinding force which should promote ductile flow by reducing the tendency for brittle fracture (Huang, 2002). In his research, Huang (2002) used Silicon nitride with resin bond diamond wheel as a material. High wheel speeds will introduce other factors such as vibration and wheel wear. In addition, the wheel speed and other grinding parameters will be effect on the surface quality. Beside that, the effect of vibration by the unbalanced wheel at high speeds will affect the surface roughness quality.

Surface grinding was employed in a down grinding mode. The effect on grinding performance is caused by various wheel speeds, wheel depths of cut and feed rates. According to Huang *et al*. (2001), he claims the lowest speed is 40m/s and the highest speed is 80m/s and above. Increasing the wheel speed substantially reduced the maximum chip thickness during grinding, which resulted in a lower grinding force (Huang, 2002). In addition, it was also seen that the depth of cut had an importance influence on the grinding force. A larger depth of cut led to a higher grinding force. According to Huang (2002), it was found that higher grinding speed caused less subsurface damage because a smaller grinding force was associated with the grinding process. So, the application of high wheel speeds was useful to compensate for the subsurface damage caused by high speed grinding and also has many advantages to manufacturing industries.

2.1.1 Advantages of High Speed Grinding

High speed machining, like the grinding of hard materials at higher speeds increasingly applied in the manufacturing industries. This technology is possible to execute final machining operations without consequent grinding or similar finishing operations. This machining process can produce high productivity, good surface finish quality and higher dimensional tolerances. In this way, an increased cutting speed is prerequisite for increased productivity. The tool life of high performance grinding wheels also increased. The grinding tools for HSG are subjected to special requirements in terms of their operational speed and resistance to wear and fracture (Kopac *et al*., 2006). Besides that, high speed grinding more efficiently and can save production time. It is also suitable used for finishing process. High sped grinding also can improve product quality in combination with increased throughput and reduced production time. HSG can maintain the machine tool reliability and in-process sensing product quality. Also, the increase in the cutting speed is expected to cause a reduction in cutting forces (Bosheh *et al*., 2005).