

THE EXPERIMENTAL STUDY OF EFFECT OF GRINDING PROCESS ON
THERMAL AND SURFACE ROUGHNESS

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I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Grinding is one of the important finishing machining operation. It is applied at the last stage of manufacturing process so that the high dimensional accuracy and desirable surface finish product can be achieved. However, there is a lot of problem occur in order to achieve the high dimensional accuracy and desirable surface finish. For examples, surface burning due to excessive heat produce and undesirable surface finish outcomes. The work presented in this paper aims at evaluating the surface temperature after grinding as well as the surface finish of the Stainless Steel AISI 304 grinds with Aluminium Oxide wheel by study the effect of the independent variable such as depth of cut (μm), table speed (m/s), and grinding passes. This experiment is held in two conditions which are dry and wet grinding with every condition is 18 runs of experiments. Soluble oil is used at wet grinding. The grindability results have shown that while dry grinding generates higher surface temperature and higher surface finish of the Stainless Steel workpiece rather than wet grinding. In comparison with independent variables, it is found that, the depth of cut can be labelled as the predominant effect to the rise of surface temperature and higher surface roughness of the Stainless Steel workpiece for both conditions. At the constant depth of cut, varied table speed and grinding passes, it is found that at the lowest table speed will generate higher surface temperature and smoother surface roughness for both of the experiments. In the case of grinding passes, higher surface temperature and smoother surface roughness is generated at the higher number of grinding passes for both the experiments. By the end of the thesis, grinding in wet operation, with lowest depth of cut ($10 \mu\text{m}$), minimum table speed (10 m/s) and higher grinding passes (2 passes) are recommended to grind Aluminium Oxide wheel with Stainless Steel AISI 304 to obtain the satisfied surface temperature ($30.4 \text{ }^\circ\text{C}$) and surface roughness ($1.433 \mu\text{m}$).

ABSTRAK

Penggilingan adalah satu operasi pemesinan terakhir yang sangat penting. Proses ini dilakukan pada akhir sesebuah proses pembuatan bagi memastikan tahap kejitaan dimensi yang tinggi serta hasil permukaan yang diinginkan. Walaubagaimanapun, terdapat beberapa masalah yang berkemungkinan berlaku dalam usaha mendapatkan tahap kejitaan dimensi yang tinggi serta hasil permukaan yang diinginkan. Sebagai contoh, permukaan yang terbakar hasil daripada pengeluaran haba yang berlebihan dan hasil permukaan yang tidak diinginkan. Hasil kerja yang dibentangkan dalam thesis ini bertujuan untuk menilai suhu dan hasil permukaan Besi Tahan Karat AISI 304 selepas digiling dengan penggiling Aluminium Oksida dengan mengkaji efek daripada pemboleh ubah yang tidak bersandar seperti kedalaman potongan (μm), kelajuan meja (m/s) dan juga nilai laluan gilingan. Eksperimen ini dijalankan dalam dua keadaan berbeza iaitu giling kering dan giling basah dengan 18 ujikaji bagi setiap keadaan. Bagi gilingan basah, pelarut minyak akan digunakan. Keputusan gilingan menunjukkan suhu permukaan dan kekasaran hasil permukaan besi tahan karat adalah lebih tinggi untuk gilingan kering berbanding gilingan basah. Perbandingan untuk pemboleh ubah yang tidak bersandar, menunjukkan kedalaman potongan memberikan efek yang paling dominan kepada kenaikan suhu permukaan dan kekasaran yang tinggi kepada permukaan besi tahan karat untuk kedua-dua keadaan. Pada kedalaman potongan yang tetap, dengan mengubah nilai kelajuan meja serta laluan gilingan menunjukkan pada kelajuan meja minimum, suhu permukaan besi tahan karat adalah lebih tinggi dan kekasaran permukaan yang agak rendah untuk kedua-dua keadaan. Dalam kes laluan gilingan pula, menunjukkan hasil suhu permukaan agak tinggi dan kelicinan yang rendah dihasilkan untuk kedua-dua eksperimen. Pada akhir tesis ini, satu cadangan dikemukakan bahawa gilingan basah, nilai potongan lebih kecil ($10 \mu\text{m}$), nilai kelajuan meja yang rendah (10 m/s) serta nilai laluan gilingan yang tinggi (2 laluan) dipilih untuk menggiling bahan kerja Besi Tahan Karat AISI 304 dengan penggiling Oksida Aluminium untuk menghasilkan suhu permukaan ($30.4 \text{ }^\circ\text{C}$) dan hasil permukaan ($1.433 \mu\text{m}$) yang memuaskan.

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LIST OF SYMBOLS

$\%$	Mathematical Symbols (Percentage)
D	Depth of Cut
d	Wheel diameter
V	Wheel Speed
v	Workpiece Speed
μm	Micronmeter
Ra	Roughness Average
Rq	Root Mean Square Roughness
mm	Milimeter
m/s	Meter per seconds
lc	Contact Length
J	Joule
$^{\circ}C$	Degree Celcius

LIST OF ABBREVIATIONS

AISI American Iron & Steel Institute

ANOVA Analysis of Variance

DOE Design of Experiment

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Grinding is one of the abrasive machining that always to achieve high enough dimensional accuracy and/or good quality surface finishes. Grinding is a process which transmits power and generates friction. During this process, the excessive power and friction might cause the workpiece to accept the excessive temperature. This workpiece damage is notable as workpiece burn.

The excessive temperature may lead to the workpiece burning. It prevents to obtained high dimensional accuracy and desirable surface finish of the products.

1.2 PROJECT BACKGROUND

In this project, a number of Stainless Steel AISI 304 workpiece is grinded with Aluminum Oxide wheel. This experiment will be held in two conditions which are dry and wet. Two machining parameters which are depth of cut and table speed as well as grinding passes are varied during this experiment. Mixed level design method is used to assist in design of experiment. By using mixed 2 and 3 level designs, it will yield 18 runs of experiments for every condition. The surface temperature is measured by thermometer infra red and the surface roughness is measured using Mahr S2 Perthometer. STATISTICA software will be used for analyzing data obtained.

1.3 PROBLEM STATEMENT

Grinding is a process typically used for finishing process. Machining process without undergo finishing process cannot achieve high enough dimensional accuracy and/or good quality finish. Grinding is a process to maintain quality, but in the way around, doing some mistakes will be affect directly to cost of operation.

Problem always occur during grinding process is workpiece burning. It is contribution from the excessive temperature of the workpiece during grinding. These phenomenon is an obstacle to obtain desired surface finish and also dimensional accuracy.

The selection of abrasives and process variables, including condition of grinding, is important in order to obtain the desired dimensional accuracy and surface finish. Otherwise, workpiece surface is damaged such as burning.

Grinding process is one important process for finishing. It is important to know the finishing operation available for improve surface finish. This is because it might contribute significantly to the operation cost.

1.4 PROJECT OBJECTIVE

- (i) To study the effect of process variable such as depth of cut, table speed and grinding passes to the surface temperature.
- (ii) To study the effect of process variable such as depth of cut, table speed and grinding passes to obtain good surface finish.

1.5 PROJECT SCOPE

- (i) A number of circular cross sectional are of Stainless Steel AISI 304 is grinded with Aluminium Oxide wheel.
- (ii) The process variables do used are depth of cut and table speed as well as grinding passes.

- (iii) Surface temperature after grinding is obtained using thermal infra red. Surface roughness is measured using Mahr S2 Perthometer.
- (iv) Mixed 2 and 3 level design method is utilized in order to assist in design of experiment. Three factors are chosen which are depth of cut, table speed as well as grinding passes. Depth of cuts and table speed contains 3 levels while grinding passes only 2 level and overall runs of experiments are 18.
- (v) Two conditions of grinding are chosen dry and wet.
- (vi) STATISTICA is used to process data obtained.

1.6 SUMMARY

In this chapter, it is generally about the project background, problem statement, project objectives as well as scope of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is written to review some information regarding to the grinding process. It also inserted some previous study by the researcher. This chapter is held to expose writing and figuring out important message from journals and books.

2.2 HISTORY OF GRINDING

The earliest practical in abrasive can be traced back to Neolithic times. The Neolithic times also known as New Age Rock. The primitive operations were mostly limited to hand –held operations because of lacking in machine tool technology. Grinding is introduced to manufacturing for more than 100 years. An early device for dressing a sandstone grinding wheel was patented by Altschner in 1860.

2.3 THE GRINDING PROCESS

Grinding Process utilizes hard abrasive particles as the cutting tool. It was started when a prehistoric man want to sharpen his knife by rubbing against the gritty stone. Manufacturing process nowadays rely to the grinding process. It was recorded as 20-25% expenditure just on for finishing process from total machining operations in industrialized countries. At every stage of production, the finishing operation always required grinding operation especially which owe their precision.

The uniqueness in grinding process is found in its cutting tool. Generally, grinding wheels and tools are composed of two materials- tiny abrasive particles called grains and grits. By the emergence of high technology and knowledge, modern grinding wheels are fabricated by cementing together abrasive grains, usually from man-made materials, with a suitable bonding material.

The primary purpose of grinding process is regarding to final machining operation. It is an appropriate way to get smooth surface and fine tolerances. There is no other machining operation can compete with the precision of grinding process. On the other hand, the heavy duty grinding is functional to remove material quickly and efficiently with a little concern in surface quality.

Grinding operation can be found in numerous types. It is according to the shape of wheel and kinematics motions of the workpiece and wheelhead. Common grind machining that is available is cylindrical grinding. Another are that is virtually unchallenged with other machining operation is their extreme hardness or brittleness. Some of the method cannot be efficiently shaped just like grinding. In industrial, finish grinding is quiet costly rather than other machining operation, per unit volume of material removal. Owing to the development of method for more precise casting and forging closer to the final configuration (net shape production), the cost of grinding process has become more economical.

2.4 MECHANISM OF GRINDING PROCESS

Grinding is a process that involve an abrasive particle are contained in a bonded grinding wheel which is rotated at high speed to remove material . Grinding can be likened to the milling process especially to the cutting. Cutting occurs on the either the periphery or the face of the grinding wheel, similar to peripheral milling and face milling. However, there will be the differences between them:

- (i) The abrasive grains in the wheel are much smaller and more numerous than the teeth on a milling cutter.
- (ii) Cutting speed is higher to the grinding machining compared to milling.
- (iii) The abrasive grit in grinding wheel are randomly bonded and posses very high negative rake angle.
- (iv) A grinding wheel is self sharpening.

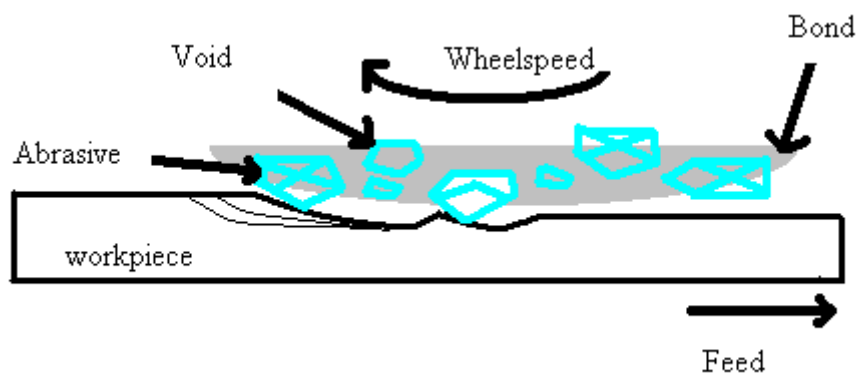


Figure 2.1: Magnified view of a grinding wheel during cutting action

Figure 2.1 shows the magnified view of grinding wheel. During cutting, some of the grains will not projected out to the workpiece because of the random position and orientation of the grains in the wheel. Types of grain action can be classified into three which are:

- (i) Cutting – grit projects enough into the surface to form a chip and remove material. Chips are formed positive rake angles, larger depth of grit

penetration, higher speed with less ductile materials. Figure 2.2 shows the cutting action in grinding process (Black and Kohser, 2000).



Figure 2.2: Cutting action

- (ii) Plowing – grit project into the work, but not cutting instead, the work is deformed and energy is consumed without remove any material. Figure 2.3 shows the plowing action in grinding process (Black and Kohser, 2000).

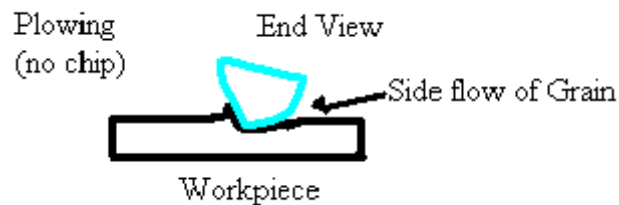


Figure 2.3: Plowing action

- (iii) Rubbing – grit contacts the surface during its sweep, but only rubbing friction occur, energy is consumed without perform any removal material. Figure 2.4 shows the plowing action in grinding process (Black and Kohser, 2000).

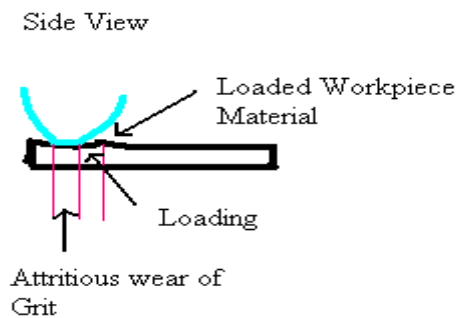


Figure 2.4: Rubbing action

2.5 THERMAL ANALYSIS

During grinding, power and energy is transmitted as well as heat is generated at the contact zone of the workpiece and grinding wheel. The sliding/friction may rise a variety mode of modes of metal removal. Such modes include the one by plastic grooving which is relatively affect surface roughness. It is sensitive to material properties such as hardness, fatigue strength, toughness, the operative values of which being dependent on the strain, strain rate, and temperature generated in the contact zone. An excessive heat generates will affect to the surface roughness (Kalpakajian, 2006). The localization of heat influenced by thermal conductivity of material is another factor which is likely to affect wear and surface roughness.

2.6 PREVIOUS OF THERMAL ANALYSIS

2.6.1 Carslaw and Jaeger

An analysis of moving heat sources on 1942. Fourier Law of heat conduction is applied to sliding plane heat source. This situation provides the basis for almost all analyses of conduction of heat into the workpiece. The solution relates the heat flux entering the workpiece and the temperature within and on the workpiece (Rowe, 2001).

2.6.2 Outer and Shaw

Energy of grinding is assumed to dissipate at the shear plane. The workpiece is modelled as sliding heat source at the shear plane so that part of the heat is conducted into the workpiece and part into the chip. Sliding also takes place between the chip and abrasive grain so that, part of the heat is conducted into the grain (Rowe, 2001).

2.6.3 Hahn

Reflects from Outer and Shaw. Hahn reasoned from energy consideration. The principal heat generation is at the grain-working rubbing surface. This follows because the shear plane energy assumption cannot account for the much larger energy experienced in practice (Rowe, 2001).

2.6.4 Malkin

Both shear plane and wear flat energies are important. There is a limit the shear zone energy which can be carried away by the chips. Limit means the melting energy and for ferrous materials is approximate 6 J/mm^3 . The total grinding energy converts to heat. It is assumed to be safe if the total grinding energy much bigger than melting energy. However, in deep grinding the assumptions might not be safe since the total energy may be of the same order and only slightly greater than melting energy (Rowe, 2001).

2.6.5 Des Ruisseaux and Zerkle

Analyze that the heat convected from the workpiece by the grinding fluid. In this case, it is necessary to imagine that some of the heat convected into the workpiece at the grain contact position is quickly conducted out of the workpiece again (Rowe, 2001).