EFFECT OF CUTTING PARAMETERS ON THE SURFACE INTEGRITY OF GROUND AISI 1148 STEEL

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A project report submitted in partial fulfillment of the requirements for the award of the degree of Master of Engineering
(Mechanical – Advanced Manufacturing Technology)

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MAY 2010

To my beloved parents, wife and son

ACKNOWLEDGEMENT

My deepest gratitude is extended to my supervisor Professor Dr. Noordin Mohd Yusof for the excellent guidance and supervision. The Director of Kolej Kemahiran Tinggi MARA Balik Pulau, Puan Hajah Rosminah bt Mohd Hussin for the understanding and support. My thanks also go to my parents Mr Ismail Ibrahim and Mrs. Esah Loman for the endless motivation and moral support. Not to forget thanks also goes to my beloved wife and new born son, Mrs Hartini bt Ab. A'ala and Muhammad Rizq Hakim b Mohd Rozaimi, who always stands by my side along this remarkable journey. Thank you very much.

ABSTRACT

This work outlines the effect of grinding cutting parameters on the surface integrity namely surface roughness and the surface hardness of AISI 1148 steel during surface grinding. The fundamental concept was that during grinding process, the heat dissipated in the cutting area is used to induce heat treatment of the AISI 1148 steel. ANOVA analysis was then utilized in order to process the data. The cutting parameter involved were work speed, infeed, cross feed and coolant flow rate. The influences of the cutting parameters toward surface roughness and surface hardness had been determined. The data obtain used as input to the statistical analysis software which is Statease.version 8 The ANOVA with full factorial is applied. From the data analysis, it seem that for surface roughness, the most significant cutting parameters were work speed and cross feed. Then for surface hardness, the significant cutting parameters were work speed, cross feed and infeed.

ABSTRAK

Kajian ini adalah mengenai kesan pembolehubah pemotongan pada proses lelasan terhadap integriti permukaan iaitu kekasaran permukaan dan kekerasan permukaan besi AISI 1148. Ini berlandaskan terhadap kefahaman bahawa semasa proses lelasan, haba yang terjana digunakan untuk melaksanakan proses rawatan haba terhadap besi AISI 1148. Data yang diperolehi kemudian di analisis menggunakan pendekatan ANOVA. Pembolehubah pemotongan yang dikaji adalah kelajuan bahan kerja, kedalaman pemotongan, kelajuan rentasan bahan kerja dan kadar aliran cecair penyejuk. Pengaruh pembolehubah – pembolehubah berikut kemudiannya dikenalpasti. Data kemudianyan dianalisis menggunakan perisian statistik Statease versi 8. Kaedah analisis data ANOVA dengan *full factorial* digunakan. Daripada analisis data yang diperolehi, bagi kekasaran permukaan, kelajuan bahan kerja dan kelajuan rentasan bahan kerja adalah pembolehubah pemotongan yang paling signifikan. Manakala bagi kekerasan permukaan, kelajuan bahan kerja, kelajuan rentasan bahan kerja dan kedalaman pemotongan merupakan pembolehubah pemotongan yang paling signifikan.

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LIST OF ABBREVIATIONS AND SYMBOLS

P_g	-	Proportion of abrasive grains in the total wheel volume
P_b	-	Proportion of bond material
P_p	-	Proportion of pores (air gaps)
ANOVA	-	Analysis of variance
t	-	Chip thickness
u	-	Specific grinding energy
F_t	-	Tangential grinding force
F_H	-	Horizontal grinding force
F_V	-	Vertical grinding force
V	-	Cutting speed
v	-	Workpiece speed
d	-	Infeed
b	-	Width of the cut
F	-	Wheel speed
D	-	Wheel diameter
θ_d	-	Mean surface temperature
pC	-	Volume specific heat
V_w	-	Volume remove
V_s	-	Volume of the wheel wear
TTT	-	Time-Temperature-Transformation
FCC	-	Face centered cubic
BCC	-	Body centered cubic
CCT	-	Continuous cooling transformation
N	-	Number specific to the Rockwell hardness scale
h	-	Permanent depth of indentation

S	-	Scale unit, specific to the Rockwell hardness
HB	-	Hardness Brinnel
HV	-	Hardness Vickers
HPD	-	Depth of hardness

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CHAPTER 1

INTRODUCTION

1.1 Background

Grinding is a complex metal cutting process, which for many centuries has been perfected via study and complex analytical approach. It is well known that this machining process consume more energies compare to another machining methods. Generally, grinding process is closely related to the main objective as the best cutting method to produce a dimensionally and geometrically accurate workpiece. The relationship between cutting condition and the surface finish of the workpiece has been establish and verified through series of studies.

Recently, a vast study on the heat dissipation and the effect on the microstructure level of material has been explored. A prominent study by E. Brinksmeler et al (1996), try to integrate production line in manufacturing industries with grinding possibilities to produce superficial hardening in order to cutting manufacturing cost. A new term has been introduced in his study paper namely grind-hardening. If we focus on microstructure level, Grind-hardening is based upon martensitic phase transformation by short time austenization of a surface layer with following self quenching. However, up until now, the component that were grind

hardened are mostly characterized by compressive residual stresses in the surface layer (E. Brinksmeler et al, 1996). An attempt also has been made by O. Zurita et al (2002) to discover the influence of the cutting parameters on the superficial hardening of AISI 1045. She comes out with a conclusion that the increasing value of parameters lead to the higher superficial hardening on the workpiece. Other study (P. Krajnik, 2005), design the grinding factors based upon surface methodology or classically design of experiment. Superficial hardness is closely related to the amount of the residual stresses on the material surface during machining. Y. Matsumoto (1991) demonstrates that the residual stresses are mainly by; (1) martensite transformation near the surface (2) the plastic flow of the material on the surface and adjacent areas due to thermal stresses cause by heat generated during the process (3) plastic deformation due to the cutting forces of the grain on the surface of workpiece.

In spite of that, a question related to the optimum grinding cutting parameters which can induced superficial hardening together with great surface roughness were never being answered.

Therefore, this study work have been propose in order to determine the optimum parameter and co relation between good surface roughness and the superficial hardness of the workpiece.

1.2 Problem Statement

As we all known, grinding is complex cutting process with large number of interacting parameters. Its can be classified into four type (4). First, wheel characteristic; which is include wheel diameter, grit type and size, wheel grade, structure, bond, dressing method, degree of wheel balance. Second was the work characteristic, which is including workpiece hardness, structure and chemistry. The

third was machine characteristic, which is spindle abd table stiffness, damping and dynamic characteristic. The fourth is operating condition which would be the concern parameters in this study include wheel speed, feed, depth of cut and coolant flow rate.

Several information has been extracted from previous study. a carbon content is crucial to induce the superficial hardening process to take place in grinding. It is also suggested that the severe cutting condition will assist in martensite formation in microstructure level of workpiece. Workpiece with high carbon content will be applied in this study. In addition, a good surface finish is also a response to the experiment done. How the cutting parameters influence the value of the surface roughness and the surface hardness will be determine through the study work. Furthermore, what are the optimum value to achieve the best for both response.

1.3 Objective of the Study

The study was carried out to investigate the effect of the operating condition which are wheel speed, feed, depth of cut and coolant flow rate upon surface integrity of the workpiece (AISI 1148). The surface integrity involve are surface roughness and superficial hardness of the workpiece.

The objectives of this study are:

I. To investigate the effect of the operating condition which are workpiece speed, infeed, crossfeed, coolant flow rate on the surface roughness and surface hardness of ground AISI 1148 steel.
II. To identify and determine the significance parameters that influences the responses.

1.4 Significance of the Study

The industries request upon good surface finish component with high hardness has pushed the researchers to come out with the optimum condition in grinding technology. The best value which can compensate both surface roughness and surface hardness must be determine for every metal and non metal. A grind process not yet being closely discovered and understood. This study will contribute to the knowledge of understanding the surface roughness and possibility to induce the superficial hardening by together with good surface finish in component. It will also indirectly contribute to the industry in term of cutting the cost of hardening process which can be integrated in the operation line.

1.5 Scope of the Study

This study is limited within the scope listed;

I. AISI 1148 steel will employed as a workpiece material.
II. Surface roughness tester machine brand Mitutoyo SJ-400 will be employed.
III. Grinding wheel aluminium oxide with the marking system A60M5V will be employed.
IV. Vickers microhardness tests will be employed to determine HV values of the workpiece.
V. The experiments will be limited to surface grinding
VI. The wheel and machine characteristic are not factors to be considered in this experiment.
VII. Classic DOE through Statease software will be utilized.

1.6 Organization of Project Report

The Project report can be summarized into five chapters which are Introduction, Literature Review, Research Methodology, Result and Discussion and finally, Conclusions and Recommendations. Chapter 1 (Introduction) is on the background, the rationale and significant of the research, problems statement and scopes of the research. It is followed with the chapter 2, which is Literature Review, it is the accumulation of the related literature regarding of the research. The literatures are on grinding, material properties, the science of heat treatment on metal and mechanic of metal cutting. Chapter 3 (Research Methodology) is on the experiment set up and experiment procedures. It is also on the specifications of the related measuring equipments. Chapter 4 is on Results and Discussion. It is the detail of the ANOVA analysis by utilizing Statease version 8 statistical software. The discussion on data and analysis by the ANOVA. Finally, Chapter 5 is on Conclusions and Recommendations. It is consist of the conclusions due to the research and the suggestions for future research.