Faculty of Manufacturing Engineering

EFFECT OF LATHE MACHINING PARAMETERS ON MACHINING CHARACTERISTICS TOWARDS MILD STEEL (AISI 1020) USING RSM

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(Manufacturing System Engineering)

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DECLARATION

I declare that this thesis entitled "Effect of Lathe Machining Parameters on Machining Characteristics Towards Mild Steel (AISI 1020) Using RSM" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Mohd Sufriansyah bin Mansoor

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Manufacturing System Engineering).

Signature :.....

Supervisor Name : Assoc. Prof. Ir. Dr. Mohd Amran Bin Md Ali

Date :.....

DEDICATION

To my wife Nur Shahirah binti Mat Sharf, my beloved parents Haji Mansoor bin Haji Kadir and Hajjah Mumin binti Haji Madia.

ABSTRACT

This project investigates the effect of lathe machining parameters on machining characteristics towards mild steel (AISI 1020) using Response Surface Method. The machining parameters selected on the experimental project are cutting speed (75m/min – 125m/min), feed rate (0.2mm/rev – 0.4mm/rev) and depth of cut (0.1mm-1.5mm). RSM using Box-Behnken was used to determine the most influential paremeters affected on the experimental response, investigate corelation between process parameters towards response and also to determine the optimum cutting parameters value that give minimum surface roughness and maximum material removal rate and hardness. There were 17 numbers of experiment has been conducted using the CNC lathe machine. The result collected was to optimize using RSM meanwhile P-value and R-squared were calculated using analysis of variance (ANOVA). From the result analysis obtained feed rate was the most influential parameters towards the surface roughness which contributes 53.88% of effect. Further, depth of cut and cutting speed are the most significant factor affected the material removal rate and hardness which contributes 66.78% and 37.40% of effect respectively. Interaction between process parameters was obtain and analyse towards surface roughness, material removal rate amd hardness. It found that, surface roughness value is decrease when the machine parameters at high cutting speed with low feed rate and depth of cut. Furthur, material removal rate increase when the machine parameters are at high cutting speed, feed rate and depth of cut. Meanwhile, when the machine parameters of cutting speed, feed rate and depth of cut are at middle value, the hardness value is significantly at highest value. Lastly, multiple optimization is perform and it shows that The combination of 101.2626 m/min cutting speed, 0.2444 mm/rev feed rate and the depth of 1.5 mm has a desirability of 0.6982 and the predicted values of MRR, surface roughness and hardness are 240.3743 g/min, 2.0669 µm and 44.3187 HRA respectively. Thus, all the objective of this project is achived and the optimal parameters are suceffully obtained to increase efficiency of machining process.

ABSTRAK

Kajian ini adalah mengenai kesan parameter mesin larik terhadap ciri-ciri pemesinan keluli lembut (AISI 1020) dengan menguunakan kaedah "response surface" (RSM). Pemboleh ubah mesin yang digunapakai adalah kelajuan pemotongan (75m/min – 125m/min), kadar suapan pemotongan (0.2mm/rev – 0.4mm/rev) dan kedalaman pemotongan (0.1mm-1.5mm) manakala tindak balas mesin yang dikaji adalah kekasaran permukaan, kadar pembuangan bahan kerja dan kekerasan. Box bakhen response surface method digunapakai dalam ujikaji untuk menentukan pemboleh ubah yang paling mempengaruhi setiap tindak balas kajian, untuk mengkaji korelasi di antara pemboleh ubah terhadap tindak balas kajian dan untuk menentukan nilai pemboleh ubah mesin larik yang menghasilkan tindak balas yang optimum iaitu kekasaran permukaan yang rendah serta kadar pembunagan bahan kerja dan kekerasan bahan yang tinggi. Dalam ujikaji ini, terdapat 17 ujikaji yang akan dilakukan mengunakan mesin larik CNC. Hasil kajian yang diperolehi di optimumkan dengan menggunakan analisis rsponse surface dimana nilai "P-value" dan "R-squared" diperolehi menggunakan analisis ANOVA. Hasil kajian menunjukkan kadar suapan pemotongan adalah pemboleh ubah yang paling mempengaruhi kekasaran permuakaan dimana ianya menyumbang sebanyak 53.88% kesan. Manakala, pemboleh ubah kedalaman pemotongan dan kelajuan pemotongan adalah pemboleh ubah yang paling mempengaruhi kadar pembuangan bahan kerja dan kekerasan dengan masing-masing menyumbang 66.77% dan 37.40% kesan terhadap pemboleh ubanh masing-masing. Hubung kait diantara pemboleh ubah terhadap hasil tindak balas turut dianalisa. Hasil dari anasia mendapati nilai kekadaran permukaan akan menigkat jika pemboleh ubah kelajuan pemotongan adalah tinggi dan jika pemboleh ubah kelajuan kadar suapan pemotongan dan kedalaman pemotongan adalah rendah. Seterusnya, kadar pembuangan kerja akan meningkat dengan kesemua nilai pembolehubah adalah tinggi. Sementara itu, kekerasan bahan kerja akan berada pada tahap tinggi apabila nilai pemboleh ubah adalah diantara nilai maximum dan minimum bagi setiap pemboleh ubah. Diakhir sekali, semua pemboleh ubah dioptimumkan dan menunjukkan dengan gabungan 101.2626 m/min kelajuan pemotongan, 0.2444 mm/rev kadar suapan dan kedalaman pemotongan sebanyak 1.5 mm mengasilkan tahap "desirability" sebanyak 0.6982 dan nilai ramalan tindak balas untuk kekasaran permukaan, kadar pembunagan bahan kerja dan kekerasan masing- masing adalah 240.3743 g/min, 2.0669 µm and 44.3187 HRA. Kesimpulannya, objektif untuk kajian ini adalah tercapai dan nilai pemboleh ubah yang optimum dapat menikgkatkan kecekapan process memesin.

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"Bismillahirrahmanirrahim"
"In the name of Allah, The Most Beneficent, The Most Merciful"

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v	-	Cutting speed
f	-	Feed rate
d	-	Depth of cut
D	-	Diameter of Workpiece
N	-	Spindle Speed
Ra	-	Arithmetic Average of Surface Roughness
L	-	Sampling Length
Y	-	Ordinate of the profile curve
W1	-	Initial Weight
W2	-	Final Weight
T	-	Machining Time

LIST OF ABBEREVIATIONS

AISI	-	American Iron and Steel Institute
SAE	-	Society of Automotive Engineers
RSM	-	Response Surface Methodology
CNC	-	Computer Numerical Control
HSS	-	High Speed Steel
CVD	-	Chemical-Vapor Deposition
PVD	-	Physical-Vapor Deposition
ANN	-	Artificial Neural Network
GA	-	Genetic Algorithm
DOE	-	Design of Experiment
MRR	-	Material Removal Rate
GDP	-	Gross Domestic Product

CHAPTER 1

INTRODUCTION

This chapter explains the introduction of the research project. Further, it explains the problem statement, objectives and scopes of the research project.

1.1 Background of study

Manufacturing is known as a process of converting the raw material into product that involves various manufacturing activities. Manufacturing industries undergoes rapid increasing of development where manufacturing industries contribute to the development of economics and emerging or new developed market. Other than that, manufacturing industries also contribute to the Gross Domestic Product (GDP), external trade and job creation (Lai Wan, 2016).

One of the important considerations in manufacturing operation is surface integrity. Surface integrity is important because it influence the fatigue strength, corrosion resistance, etc. Mechanical properties, metallurgical properties, chemical properties and topological feature are also described by surface integrity. Surface integrity achieved by any means of machining process was related to the quality and performance of the product. The functional performance of a manufactured component is heavily influenced by the reliability and quality of the surface produced both in terms of topography and as well as metallurgical and mechanical state (M'Saoubi et al. 2008).

Surface texture is defined by lay, surface roughness and waviness. Surface texture is important to control the friction of part where, influence of surface texture to friction has been widely studied. The most characteristic of surface texture studied is surface roughness. Machining process such as lathe machining that involves contact between tool and the material to remove the surface of material will generate various surface integrity and surface texture profile. The lathe process was generally involved the cutting tool is feed towards the rotating material and when contact between cutting tools and material will remove the material from the surface of contact. Parameters of machining process such as cutting speed, feed rate and depth of cut are largely studied in order to select and optimize the process parameters that would affect the surface roughness.

The aim of this project is to investigate the effect of machining parameters of lathe machining process on surface roughness, material removal rate and hardness of mild steel AISI 1020 using Box-Benhken Response Surface Method.

1.2 Problem Statement

One of the most important characteristic of quality in manufacturing of a product is a surface finish. Manufactures ideally want to produce high quality product on a short time and low cost possibly. Surface roughness R_a, is an important measurement of product quality because surface roughness influences the performance of mechanical parts as well as production cost (Rawangwong et al. 2014).

One of the most common material removal processes is turning process. Turning process able to produce a good surface quality product as well as the process of material removal rate is faster and also without affecting the hardness of the material. Cutting parameters such as speed, depth of cut and feed rate are factor that can affect the surface

roughness, material removal rate and hardness of the product. These cutting parameters widely studied for investigating surface roughing (Kumaragurubaran et al. 2013).

On reality, selecting the desired value of cutting parameters usually based on experience or just following the manual book (Sahoo, 2011). Hence, the result of surface roughness, material removal rate and hardness value obtain could be varied depending on operator experience. Also, to obtain a certain value of surface roughness, material removal rate and hardness there are a need to use try and error approach, where it could affect to the increasing cost of operating.

In order to save some valuable resources, there are needs to have a standard approach on how to determine the most suitable cutting parameters that can give the desired surface roughness, material removal rate and hardness value. Therefore, a study on how the surface roughness, material removal rate and hardness value affected by the cutting parameters is popularly studied. Besides that, to determine the desired surface quality in term of surface roughness, selection of suitable cutting parameters must be taken into considerations without compromising the material removal rate and hardness of the material. The relationship between cutting parameters such as cutting speed, feed rate and depth of cut towards the surface roughness, material removal rate and hardness is important to understand.

1.3 Objectives

The main objective of this project is to investigate the performance of lathe machining parameters on machining characteristics for mild steel AISI 1020 using Box-Benhken Response Surface Method. The sub-objectives of the research are;

i. To determine the most influential process parameters (cutting speed, feed rate and depth of cut) that affected the experiment response (surface roughness, material removal rate and hardness).

ii. To investigate the interaction between process parameters towards the experiment response.

iii. To optimize machining parameter setting using Box-Benhken Response Surface Method using single and multi-objective optimization.

1.4 Scope of Study

The scope of this research is to study of surface roughness, material removal rate and hardness of machined mild steel (AISI 1020) in turning process. Parameters that evaluated to obtain the surface roughness are cutting speed, feed rate and depth of cut. Where, all the value of depth of cut, cutting speed and feed rate is varied. The experimental matrix is design using response surface method.

1.5 Significant of study

This research aims to enrich the understanding and knowledge regarding the lathe machining parameters towards the surface roughness, material removal rate and hardness of workpiece. The following contributions that will get form the research are listed:

i. Analysis of the most influential parameters contributes towards surface roughness, material removal rate and hardness of mild steel AISI 1020.

ii. Selecting the machining parameter value that will yield towards better surface roughness, material removal rate and hardness is easy.

iii. Does not require trial and error process for getting expected surface roughness, material removal rate and hardness value.

iv. Mathematical equation for prediction of surface roughness, material removal rate and hardness can be used in future.

1.6 Project Organization

This report project consists of five chapter which in Chapter 1 describes the background of the project, problem statement, objectives and scopes of the research project. After that, in Chapter 2 reviews the literature which relevant to the previous and present study of optimizing lathe machining process towards mild steel material. Next, the experimental setup, workpiece and equipment preparation, experimental parameters used for lathe machining of mild steel are explained in Chapter 3. In Chapter 4, the result is analyzed and discussed regarding to the project. Lastly, in Chapter 5, explains the overall findings of the project and suggestion for future work.

CHAPTER 2

LITERATURE REVIEW

This chapter explains the fundamental information related to this project. Related aspect of the project reviewed and discussed are workpiece materials, turning process, cutting parameters, type of cutting tools materials, surface integrity such as surface roughness and appearance and finally, the experimental matrix using Box-Benhken of response surface methodology (RSM).

2.1 Mild Steel Material

Mild steel, is now the most common form of steel because of the low price of mild steel while it provides material properties that are acceptable for many applications (Butola et al. 2017). Mild steel or known as low carbon steel which is an AISI grade 1005 through 1025 is one of the important carbon steel among all carbon-based steel. It contains only a small percentage of carbon (low carbon steel) and is strong and easily worked but not readily tempered or hardened. Normally mild steel containing less than 0.25 percent carbon and 0.4%-0.7% manganese, 0.1%-0.5% Silicon and others elements which makes it more ductile and less hard thus, rendering it unsuitable for structural work.

American Iron and Steel Institute (AISI) and Society of Automotive Engineers (SAE) are the two major numbering system used by steel industry. The first designation of digit in AISI and SAE system for carbon steel are one (1). For example of AISI 1018, the first tow digit which is 10xx is representative of plain carbon and the last two digit of 1018