INVESTIGATION ON SURFACE ROUGHNESS OF MILD STEEL USING COATED CARBIDE CUTTING TOOLS

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SUPERVISOR'S DECLARATION

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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STUDENT'S DECLARATION

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

This paper presents an investigation on surface roughness of mild steel operation using coated carbide cutting tools. There are three objective of this project that needs to be accomplished. First is to investigate the effect of various cutting condition for surface roughness and second is to find the factors or variable that mostly affects the surface roughness of mild steel. Comparing the surface roughness value between exact experiment and prediction is the last objective that must been done. The work piece is been turning for 9 parts due to 9 experiment for each cutting parameters that had been set before. After gathered all data or value that needed, two analysis are been performed. From the ANOVA analysis, the cutting speed is proving to be the most affect variable than depth of cut. The P-value indicated that cutting speed is significant than depth of cut with using 95% confident intervals. The analysis from ANOVA also indicated the best parameter use for turning at 50mm diameter mild steel. The results from multiple regression analysis shows that the predicted value almost same with experimental value, means the equation generated is 95 % accuracy.

ABSTRAK

Kertas ini menyajikan siasatan terhadap kekasaran permukaan besi baja operasi menggunakan alat pemotong karbida berlapis. Ada tiga tujuan dari projek ini yang perlu diselesaikan. Pertama adalah untuk meneliti kesan daripada memotong berbagai keadaan untuk kekasaran permukaan dan kedua adalah untuk mencari faktor-faktor atau pembolehubah yang sebahagian besar mempengaruhi kekasaran permukaan besi baja. Membandingkan nilai kekasaran permukaan antara percubaan dan perkiraan yang tepat adalah tujuan terakhir yang harus sudah dilakukan. Bahan kajian yang telah berubah selama 9 bahagian kerana hingga 9 percubaan untuk setiap memotong parameter yang telah ditetapkan sebelumnya. Selepas mengumpul semua data atau nilai yang diperlukan, dua analisis yang telah dilakukan. Dari analisis Anova, pemotongan membuktikan kelajuan menjadi pembolehubah yang paling mempengaruhi daripada kedalaman potong. Nilai P menunjukkan bahawa kelajuan pemotongan signifikan dari kedalaman dipotong dengan menggunakan interval 95% keyakinan. Analisis daripada Anova juga menunjukkan parameter terbaik digunakan untuk diameter 50mm berputar pada besi baja. Keputusan daripada analisis regresi berganda menunjukkan bahawa nilai ramalan hampir sama dengan nilai percubaan, bererti persamaan yang dihasilkan adalah 95% ketepatan.

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LIST OF SYMBOLS

Vc	Cutting speed (m/min)
Fr	Feed rate (mm/rev)
HB	Brinell hardness
P	Probability
Ra	Average surface roughness
D	diameter

LIST OF ABBREVIATIONS

μm	Micro meter
DOE	Design of Experiment
Vs	Versus
ANNOVA	Analysis of Variance
DOC	depth of cut

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Investigation on surface roughness of mild steel using coated carbide cutting tools is the topic that related to machining itself. Measuring in machining and an effective parameter is one of the most common performances in the surface roughness. Surface roughness has been known as an important design feature in many situations such as parts subject to fatigue load, precision fits, fastener holes and esthetic requirements. Other than that, surface roughness imposes one of the most critical constraints for selection of machines and cutting parameters in process planning.

The surface parameter used to evaluate surface roughness in this research is the roughness average (Ra). The surface roughness models developed by Dickinson (1968), Fischer and Elrod (1971) considered the effect of feed rate and nose radius based on the motion geometry in a turning process. These models concluded that the effect of cutting speed is insignificant. However, different conclusions were presented in Shaw (1966), Hasegawa et al. (1976), Sundaram and Lambert (1979), Boothroyd and Knight (1989), Feng (2001), and Feng and Hu (2001). They demonstrated that cutting speed had a significant impact on surface roughness. The depth of cut was considered into their mathematical models by Karmakar (1970), and Sundaram and Lambert (1981). Miller et al. (1983) considered the effect of cutting fluid on surface roughness. Although a qualitative analysis of machining variables of speed, feed and depth of cut on the surface roughness has been widely available in the literature, very few comprehensive predictive models have been developed.

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1.2 OBJECTIVE

The objectives of this project are:

- To investigate the effect of various cutting condition for surface roughness.
- To find the critical factors or variable that mostly affects the surface roughness.
- To compare surface roughness value between exact experiment and prediction.

1.3 PROBLEM STATEMENT

In the recent CIRP working survey found that in the USA the correct cutting tool is selected less than 50% of the time, the tool is used at rated cutting speed only 58% of the time. The same has been found in an earlier survey of cutting regime selection on machine tools in the American aircraft industry showing that selected cutting speeds are far below the optimal economic speeds (Armego 1996).Its means that the manufacturing industry is struggle and constantly striving to decrease its cutting cost and increase the quality of the machined parts and surface roughness as the demand for high tolerance manufactured goods is rapidly increasing. (Bhattacharya, Das, Majumder, Batish 2008)

1.4 PROBLEM SOLVING

There are many ways to overcome above problem. One of the ways to solve that problem is by optimize the cutting condition or using exact parameters for certain process. Thus, the manufacture can improve the quality and productivity of the product with minimum cost and time.

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1.5 PROJECT SCOPE

- To concentrate on surface roughness.
- For the turning process, the constant parameter such as work pieces use is mild steel ; depth of cut (0.5, 0.8, 1.1 mm); tool material Coated Carbide Tips; feed rate constant (Fr = 0.45 mm/rev), and the range of cutting speed V_C = (400, 500 ,600 m/min)
- The machine that will use is conventional lathe machine.
- Dry machining process.
- Using ANOVA method to find the most critical factors.
- Using Regression Analysis to predict value of surface roughness.
- Both analysis using MINITAB15.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The demand for high quality and fully automated production focuses attention on the surface condition of the product especially the roughness of the machined surface, because of its effect on product appearance, function, and reliability. For this reason it’s important to maintain consistent tolerance and surface finish. Also the quality of the machined surface is useful in diagnosing the stability of the machining process, where a deteriorating surface finish may indicate work piece material non homogeneity, progressive tool wear, cutting tool chatter and many more (Hayajneh 2007).

2.2 MILD STEEL

Mild steel is the most common form of steel as its price is relatively low while it provides material properties that are acceptable for many applications. That’s type of metal is include in low carbon steel group. These steels contain up to 0.30% carbon. The largest category of this class of steel is flat-rolled products (sheet or strip), usually in the cold-rolled and annealed condition. The carbon content for these high-formability steels is very low, less than 0.10% C, with up to 0.4% Mn. Low carbon steels suffer from yield-point run out where the materials has two yield points. The first yield point (or upper yield point) is higher than the second and the yield drops dramatically after the upper yield point. If low carbon steel is only stressed to some point between the upper and lower yield point then the surface may develop Luder bands. This type of carbon steel typical uses in automobile body panels, tin plate, and wire products.

2.3 SURFACE ROUGNESS

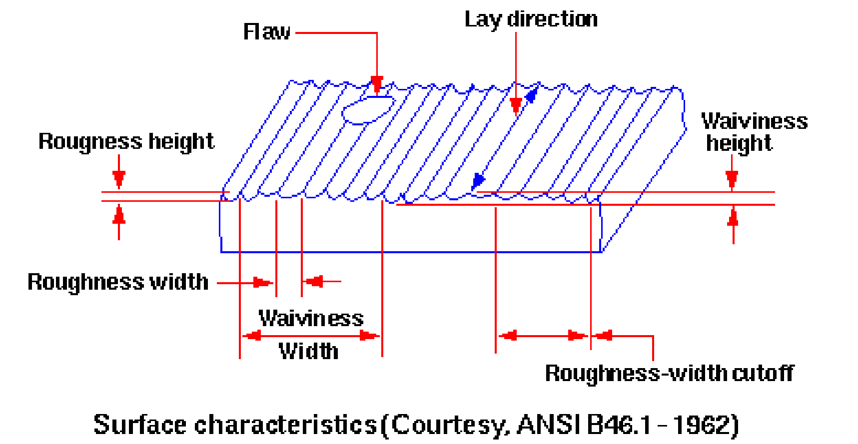

Figure 2.1: surface structure after cutting process**.**

Surface roughness is the measure if the finer surface irregularities in the surface texture. The final surface depends on the rotational speed of the cutter, velocity of traverse, feed rate and mechanical properties of work pieces being machined. Surface roughness also plays a significant role in determining and evaluating the surface quality of a product. Because surface roughness affects the functional characteristic of products such as fatigue, friction, wearing, light reflection, heat transmission, and lubrication, the product quality is required to be at the high level (Ibraheem 2007). While surface roughness also decreases, the product quality also increases. Figure 2.1 show the surface roughness structure after any cutting process with their terminology.

The surface roughness describes the geometry of the surface to be machined and combined with surface texture. The formation of surface roughness mechanism is very complicated and mainly depends on machining process (Benardos & Vosniakos, 2003; Petropoulos et al., 2006).

2.3.1 Surface roughness terminology

Roughness

-Roughness consists of surface irregularities which result from the various machining process. These irregularities combine to form surface texture

Roughness height

-It is the height of the irregularities with respect to a reference line. It is measured in millimeters or microns or microfiches. It is also known as the height of unevenness.

Roughness width

-is the distance parallel to the nominal surface between successive peaks which constitute the predominate pattern of the roughness.

Roughness width cut off

-is the greatest spacing of respective surface irregularities to be included in the measurement of the average roughness height. It should always be greater than the roughness width in order to obtain the total roughness height rating.

Lay

-the direction of predominant surface pattern produced and it reflects the machining operation used to produce it.

Waviness

-The irregularities which are outside the roughness width cut off values. Waviness is the widely spaced component of the surface texture. This may be the result of work piece or tool deflection during machining, vibrations or tool run out.

Waviness width

- Waviness height is the peak to valley distance of the surface profile, measured in millimeters.

2.3.2 Surface finish in machining

Ideal roughness

- is a function of only feed and geometry. It represents the best possible finish which can be obtained for a given tool shape and feed. It can be achieved only if the built-up-edge, chatter and inaccuracies in the machine tool movements are eliminated completely.

Natural roughness

- In practice, it is not usually possible to achieve conditions such as those described above, and normally the natural surface roughness forms a large proportion of the actual roughness. One of the main factors contributing to natural roughness is the occurrence of a built-up edge. Thus, larger the built up edge, the rougher would be the surface produced, and factors tending to reduce chip-tool friction and to eliminate or reduce the built-up edge would give improved surface finish.

2.4 TURNING CARBON STEEL

Turning is a widely used machining process in which a single point cutting tool removes material from the surface of a rotating cylindrical work piece. The lathe machine uses a single-point-cutting tool for a variety of turning, facing, and drilling jobs. Excess metal is removed by rotating the work piece over the fixed cutting tool to form straight or tapered cylindrical shapes, grooves, shoulders and screw threads. It can also be used for facing flat surfaces on the ends of cylindrical parts. The proper selection of cutting tools and process parameters for achieving high cutting performance in a turning operation is a critical task (Davim 2007)

Figure 2.2: conventional lathe machine

As for the carbon steel, its call the workhorse of the metalworking industry where carbon steel is by far the most frequently machined steel. For low carbon steel (Mild steel) are produced with 0.06 to 0.28 percent carbon and 0.25 to 1.00 manganese. When turned, low carbon steels produce long chips which will form built up edge on an indexable insert if a chipbreaker does not create a sufficient shear angle to curl the chip away from the insert rake face.

Low cutting speed is another cause of BUE, which acts as an extension of the cutting tool, changing part dimensions and imparting rough surface finishes. When that's the case, the cutting speed should be increased 15 to 20 percent or more until the surface finish improves. The appropriate cutting speed depends on the depth of cut, feed rate, cutting tool material and hardness of the work piece. Selecting the cutting speed is always a challenge. Usually, the depth of cut and feed rate are conservative parameters predetermined by whether it's a roughing, semi finishing or finishing operation (Isakov 2007). Table 2.1 indicated the recommendation or selection parameter for low carbon steel.

Table 2.1: table for low carbon steel

Brinell hardness (HB)	DOC (in.)	Feed rate (ipr)	Cutting speed (sfm)	Cutting tool material specification (ANSI*/ISO**)
85 to 125	0.300	0.020	550	CC-6/CP30
	0.150	0.015	700	CC-6/CP20
	0.040	0.007	1,050	CC-7/CP10
125 to 175	0.300	0.020	500	CC-6/CP30
	0.150	0.015	625	CC-6/CP20
	0.040	0.007	950	CC-7/CP10
175 to 225	0.300	0.020	450	CC-6/CP30
	0.150	0.015	550	CC-6/CP20
	0.040	0.007	850	CC-7/CP10

2.5 COATED CARBIDE CUTTING TOOLS

Carbide cutting tools are widely used in metal cutting industry for the cutting of various hard materials. While coating is also used on cutting tools to provide improve lubrication at the tool chip and work piece interfaces and also to reduce friction and will reduce the temperatures at the cutting edge. During machining, coated carbide tools ensure higher wear resistance, lower heat and lower cutting forces. So it will enabling them to perform better at higher cutting conditions than uncoated cutting tools (Sahin & Riza 2004).

2.6 SURFACE ROUGHNESS TESTER

In this experiment, the Mahrs perthometer is been used to evaluate surface roughness for material that been cutting from lathe process. This tools concept is powerful, modular measuring system for measuring surface roughness contours and topography. The Perthometer Concept Roughness and topography measuring station serves for determining all common surface texture parameters according to DIN EN ISO/JIS/ASME.

Figure 2.4: image of perthometer

2.7 ANALYSIS OF VARIANCE (ANOVA)

ANOVA was developed by the English statistician, R.A. Fisher (1890-1962). Thought initially dealing with agricultural data, this methodology has been applied to a vast array of other fields for data analysis (Keith M.Bower, Minitab Inc). This analysis is used to test claims involving three or more means. F-test is used to test a hypothesis concerning the means of three or more populations. In ANOVA, even three or more means are compared: variances are used in the test instead of means. 2 different estimates of the population variance of the F-test are made:

1. Between group variance
   -involving finding the variance for the means.
2. Within group variance
   -computing the variance using all the data and is not affected by the differences in the means.

Since variation is a large part of the discussion relative to quality, analysis of variation (ANOVA) is the statistical method used to interpret experimental data and make necessary decisions. ANOVA is a statistically based decision tool for detecting any differences in average performance of groups of items tested. ANOVA is a mathematical technique which breaks total variation down into accountable sources and total variation is decomposed into its appropriate components (Bhattacharya A., 2008)

Ozel et al.(2005) also conducted a set of analysis of variance (ANOVA) and performed a detailed experimental investigation on the surface roughness and cutting forces in the finish hard turning of AISI H13 steel. Their results indicated that the effect of work piece hardness, cutting edge geometry, feed rate and cutting speed on surface roughness are statistically significant besides the effect of two factor interaction of the edge geometry and the feed rate and the cutting speed and the feed rate are also important.

Escalona M., P. ,Cassier & Z. (1998) stated that the increase of the reed rate and depth of cut results in a decrease in the critical cutting speed which is defined as the cutting speed value above which poor quality and performance do not take place.Its mean that, surface finish is more directly affected by feed rate, tool nose radius and finally by the cutting speed.

2.8 MULTIPLE REGRESSION ANALYSIS

Regression analysis includes any techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. The goal of regression analysis is to determine the values of parameters for a function that cause the function to best fit a set of data observations that provided. In linear regression, the function is a linear (straight-line) equation.

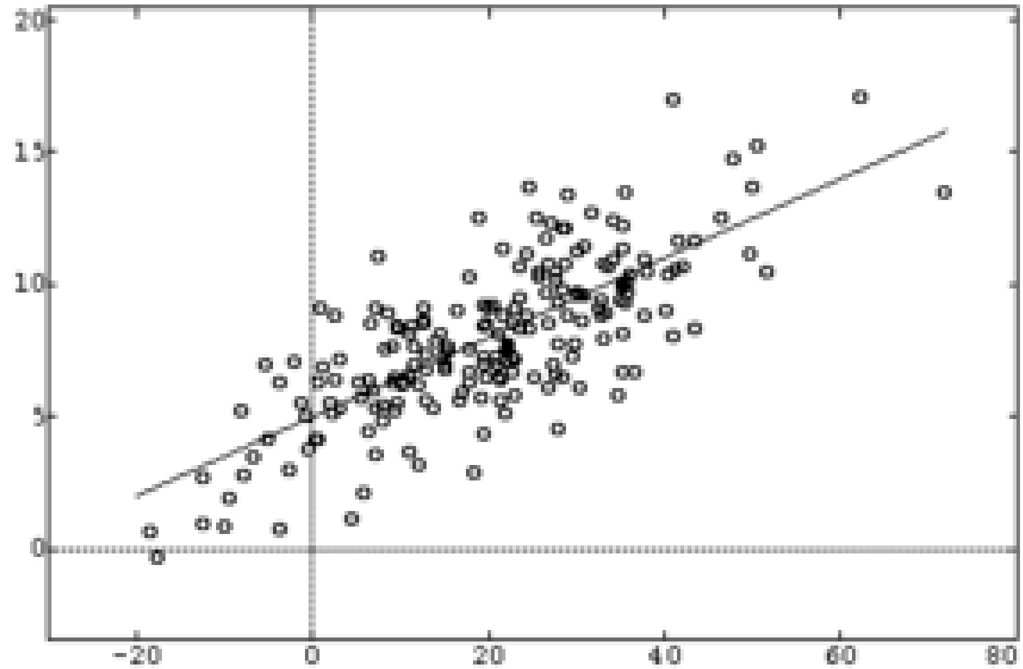

Figure 2.5: illustration of linear regression on data set

Figure 2.5 show the illustration of linear regression on example data set. It's indicated that the data have a relation that occurs to linear type and from there it can provide an equation that related to data taken.

One should develop techniques to predict the surface roughness of a product before turning in order to evaluate the robustness of machining parameters such as feed rate or spindle speed for keeping a desired surface roughness in increasing product quality. Researchers attempt to develop models which can predict surface finish of a metal for a variety of machining conditions such as speed, feed, and dept of cut. Reliable models would not only simplify manufacturing process planning and control but would assist in optimizing machinability of materials (Hayajneh, 2007).