EFFECT OF PROCESS PARAMETERS ON SURFACE ROUGHNESS PRODUCED BY TURNING BORING OPERATION

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DEDICATION

First of all, all the praises and thanks be to Allah S.W.T for His Love,

This thesis is dedicated to my family,

To my beloved parents,

Mohamed bin Samat, Che Wa bt Yussof

My supportive wife,

Asehara bt. Meor Ahmad

My wonderful brothers and sister,

Wan Abd Ghani Mohamed, Mazzlan Mohamed, Razman Mohamed, Siti Asiah Mohamed, Badruldin Mohamed, Mohamed Kamal Mohamed

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ABSTRACT

Critical quality measure and surface roughness (Ra) in mechanical parts depends on turning parameters during the turning process. Researchers have predicted and developed various models to determine the optimum turning parameters for the required surface roughness. The main objective of this study is to investigate the different cutting tool length parameter effect of surface roughness in CNC Turning boring operation for an aluminium 6061 workpiece. A fractional factorial design is use to evaluate the effect of five (5) independent variables (cutting speed, feed rate, depth of cut, tool length and diameter of boring bar) on the resulting first cut surface roughness (Ra). Vibration or chatter in internal turning operation is a frequent problem affecting the result of the machining and in particularly, the surface finish. This study found that using short tool length always produce a good surface roughness and that only slight improvement on surface roughness can be achieved by properly controlling the cutting parameters and/or the diameter size of boring bar. This study also found that using a long tool length may result in vibration that could be efficiently controlled by the use of larger diameter size of boring bar. With such a long tool length, the cutting variables become important factors to control in order to significantly improve surface roughness result with both diameter sizes of boring bars. A highly accurate prediction model for surface roughness is proposed for each types of boring bar.

ABSTRAK

Ukuran kualiti yang kritikal pada kesudahan permukaan (Ra) adalah bergantung kepada parameter pemesinan semasa proses pemesinan larik dilakukan. Para penyelidik telah membuat jangkaan dan berbagai model baru dibangunkan bagi parameter yang optimum untuk kesudahan permukaan yang dikehendaki. Objektif utama penyelidikan ini adalah untuk menyelidiki tentang perbezaan panjang matalat boleh memberi kesan kepada kesudahan permukaan di dalam operasi melubang bahan aloi aluminium 6061 pada mesin CNC larik. *Fractional factorial design* digunakan untuk menilai kesan lima (5) parameter bebeza (kadar pemotongan, kadar hantaran, kedalaman pemotongan, panjang tool dan diameter matalat melubang) ke atas nilai kesudahan permukaan pada pemotongan yang pertama. Getaran adalah masalah yang sering berlaku dalam operasi melarik profil dalam dan memberi kesan pemesinan yang besar pada kesudahan permukaan. Dalam penyelidikan ini didapati penggunaan matalat yang pendek akan sentiasa memberikan kesudahan permukaan yang baik dan kesudahan permukaaan akan boleh dipertingkatkan lagi dengan mengawal keadaan pemotongan dan saiz diameter matalat melubang. Dengan menggunakan matalat yang panjang, didapati pembolehubah bagi pemotongan menjadi faktor yang utama untuk dikawal bagi memberikan kesan utama dalam memperbaiki kesudahan permukaan bagi kedua-dua saiz matalat melubang. Model jangkaan yang berketepatan tinggi untuk kesudahan permukaan telah dicadangkan untuk setiap saiz matalat melubang tersebut.

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LIST OF SYMBOLS

ANOVA	-	Analysis of Variance
Al	-	Aluminium
ECEA	-	End Cutting Edge Angle
SCEA	-	Side Cutting Edge Angle
Sqrt	-	Square root
doc	-	Depth of Cut
cs	-	Cutting Speed
f	-	Feed rate
bd	-	Bar Diameter
bl	-	Bar Length
F	-	Force
Fc	-	Cutting Force
Ft	-	Tangential Force
Fr	-	Radial Force
N	-	Revolution per Minute
Ra	-	Surface Roughness
T	-	Tool Life
V	-	Cutting Speed
C	-	Taylor's constant
n	-	Taylor's exponential
α	-	Rake Angle
Ø	-	Diameter
υ	-	Cutting Velocity

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CHAPTER 1

INTRODUCTION

1.1 Background

In machining operation, the quality of surface finish is an important requirement of many bored work pieces and parameter in manufacturing engineering. It is characteristic that could influence the performance of mechanical parts and the production cost. Various failure, some time catastrophic, leading to high cost, have been attribute to the surface finish of the component in question. For these reasons there have been research developments with the objective of optimizing the cutting condition to obtain a surface finish.

During an internal turning operation, the cutting tool and the boring bar are subjected to a prescribed deformation as a result of the relative motion between the tool and work-piece both in the cutting speed direction and feed direction. As a response to the prescribed deformation, the tool is subjected to traction and thermal loads on those faces that have interfacial contact with the work-piece or chip. In the metal-cutting process, during which chips are formed, the work-piece material is compressed and subjected to plastic deformation.

In internal turning, the metal-cutting process is carried out in pre-drilled holes or holes in cast, etc. The dimensions of the work-piece hole generally determine the length and limit the diameter or cross-sectional size of the boring bar. Usually, a boring bar is long and slender and is thus sensitive to excitation forces introduced by the material deformation process in the turning operation. The boring bar is generally the weakest link in the boring bar – clamping system of the lathe. The boring bar motion may vary with time. This dynamic motion originates from the deformation process of the work material. The motion or vibration of the boring bar influences the result of the machining in general, and the surface finish in particular.

With external turning, the tool overhang is not effect by the length of work piece, and the size of tool holder is selected to withstand the forces and stresses which arise during the operation. With boring – internal turning, the choice of tool very much restricted by the component's hole diameter and length, as the depth of the hole determines the overhang.

A general rule, which applies to all machining is to always minimize tool overhang and to select the largest possible tool size in order to obtain the best possible stability and thereby accuracy. The stability is increased when the larger boring bar diameter is used, but possibilities are often limited, since the space allowed by the diameter of the hole in the component must be taken into consideration for swarf evacuation and any radial movement.

The limitation with regard to stability in boring mean that some extra care must be taken with production planning and preparation. Selecting the right boring bar for the operation , applying it correctly and clamping it properly has considerable effect on keeping tool deflection and vibration to a minimum and consequently the quality of the hole being machined.

Previous studies proved the significant impact of DOC, machining speed, and rake angles on surface roughness. The few studies that have studied boring bar length that effect of cutting stability or vibration during boring operation. But very few researchers have studied the interaction effect of boring bar length and bar diameter. The combination of both of these factors suggests a significant weight in the relationship. All the previous studies on predicting surface roughness have not included boring bar diameter as a major factor that affects surface roughness.

1.2 Problem Statement

The determination of optimal cutting condition for specified surface roughness and accuracy of product are the key factors in the selection of machining process. In Turning operations, and especially boring operations, are associated with serious vibration-related problems. To reduce the problem of vibration and ensure that the desired shape and tolerance are achieved, extra care must be taken with production planning and in the preparations for the machining of a work-piece. A through investigation of the vibrations involved is therefore an important step toward solving the problem.

Researches have been done to improve cutting tool material, tool geometry and cutting parameter to optimize the machining process. The diameter and length of boring bar are the most important factor has to be considering in boring operation, following the other cutting parameter such as cutting speed, feed rate and depth of cut. The wrong selection of combination cutting parameter will occurs the bad cutting condition e.g. vibration that effect the poor surface finish. Different workpiece material with different property and microstructure give different effect to the cutting tool performance. In lathe boring operation, we found no adequate empirical model for prediction of surface roughness.

In turning operation, the performances of cutting tools are depending on a few cutting conditions and parameters. The proper selection of feed rate has direct effect to the product surface roughness. Turning process by maximizing cutting speed and depth of cut will optimize the cutting process and minimize the production cost. The tool life, machined surface integrity and cutting forces are directly dependent on cutting parameters and will determine the cutting tool performances. The study of surface roughness form will resolve the characteristic and phenomena happening during the machining process. The questions to be answered at the end of the study are how does the boring bar tool length and diameter influence the surface roughness during internal turning operation?

1.3 Objective of the Study

The study was carried out to evaluate the effects of different cutting tool length on workpiece for internal cutting profile with turning operation, where the surface roughness values were statistically comparable and to find out the optimum cutting condition by analyzing the different cutting tool length to get the lowest surface roughness in turning an Aluminium alloy 6061 solid bar.

Objective of this study are follow:

- To evaluate the effects of different process parameter on internal turning operation.
- To develop a mathematical model for predicting surface roughness for internal turning operation by using design of experiment approach.
- Study the initial tool wear during internal turning operation.
- Study of chip formation to relate the reaction occurring between cutting condition and chip during cutting.

1.4 Significance of the Study

Machining operations tend to leave characteristic evidence on the machined surface. They usually leave finely spaced micro-irregularities that form a pattern known as surface finish or surface roughness. The quality of the finished product, on the other hand, relies on the process parameters; surface roughness is, therefore, a critical quality measure in many mechanical products.

In the turning operation especially boring operation, chatter or vibration is a frequent problem affecting the result of the machining, and, in particular, the surface finish. Tool life is also influenced by vibration. Severe acoustic noise in the working environment frequently occurs as a result of dynamic motion between the cutting tool and the workpiece. In order to achieve sufficient process stability, the metal removal rate is often reduced or the cutting tool changed. But as productivity is normally a priority in manufacturing, this is the wrong route to go.

Instead the means of eliminating vibration and being able to machine at high rates should be examined. For these reason there have been research development with the objective of optimising cutting condition to obtain a surface finish with making the process more stable. To study the optimum tool length and diameter of boring bar used during cutting process will reduce the machining cost by reducing of changing the cutting tool and to increase the metal removal rate.

1.5 Scope of the Study

The study has been conducted on the following scopes:

(i) CNC Turning machine will be employed.

(ii) Aluminum alloy solid bar Al 6061 will be used as workpiece material.

(iii) Two different diameters boring bar size 16 .0 mm and 12.0 mm with carbide cutting tool insert will be used at various tool lengths.

(iv) Cutting speed, feed and depth of cut are the other process factors investigated.

(v) Performance will be primarily in terms of surface roughness, chip formation and initial tool wear will also be briefly discussed.

(vi) Design of Experiment technique will be used

1.6 Overview of the Methodology

The following methodology has been used as a guide in the study to achieve the study objectives.

(i) Selecting the proper cutting parameters based on literature reviews and manufacturer recommendations.

(ii) Plan and design reliable experimental techniques.

(iii) Workpiece preparation

- Using CNC Turning and purpose tooling to machine the workpiece.

(iv) Experimental trials consisting of:

- Surface finish measurement using stylus instrument.
- Chip morphology and tool wear mechanism studies using microscope

(v) Data analysis and validation.

- Evaluate the effect of tool length on the surface finish
- Evaluate the effect of diameter boring bar on the surface finish
- Evaluate the initila tool wear
- Evaluate the of chip formed produce by internal turning process

1.7 Thesis Organization

The thesis is divided into six chapters. Chapter 1 provides a general overview of the study. Chapter 2 was organized to summarize the literature reviews of the related topic to guide the study towards achieving the objective. The experimental set up and techniques used are explained in Chapter 3. All the experiment data and result will be presented in Chapter 4. Chapter 5 will discuss the results and comparison will be made to the work done in previous research. The conclusions of the study and the recommendations for future work will be given in chapter 6