UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE EFFECT OF DIFFERENT CUTTING TOOL MATERIAL TO THE SURFACE FINISH OF D2 TOOL STEEL IN DRILLING PROCESS

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering Technology
(Process and Technology) Honours

by

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FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Effect of Different Cutting Tool Material to the Surface Finish of D2 Tool Steel in Drilling Process**

SESI PENGAJIAN: **2015/16 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Process and technology) (Hons.). The member of the supervisory is as follow:

……

(Mohd Hairizal bin Osman)

ABSTRACT

This research was carried out to determine the Optimize Cutting Parameter for better Surface Finish in Drilling Proces of AISI D2 Tool Steel. This project is focusses on the drilling process on the AISI D2 Tool Steel by using CNC Milling machine with appearance of coolant. The aim of this project is to find the optimum cutting parameter condition in producing good surface finish in drilling process utilizing Taguchi method. The selected cutting speeds for the drilling process are 955m/min, 1273m/min and 1591m/min. For the feed rate, the parameters are 191mm/min, 381 mm/min and 636mm/min. The third parameter that will be considered in this project is types of the drilling tool which is High Speed Steel (HSS) coated with Titanium Nitride (TiN), High Speed Steel (HSS) coated with Titanium Carbon Nitride (TiCN) and High Spped Steel (HSS) uncoated. The machining processes were performed on the CNC milling machine. The surface roughness will be test by using Surface Roughness Tester Mitutoyo SJ-410. The value of S/N ratio and the value of mean surface finish will be obtained from the Taguchi method in Minitab software. ANNOVA analysis also conduct to investigate the drilling parameters significantly affected the performance characteristics. Lastly, the confirmation test is conducted to ensure the validity of the test result.

ABSTRAK

Kajian ini telah dijalankan untuk menentukan Optimum Parameter untuk mengkaji Kekasaran Permukaan dalam Proses Penggerudian pada bahan AISI D2 Tool Steel dengan menggunakan kaedah Taguchi. Projek ini memberi tumpuan kepada proses penggerudian di bahan AISI D2 Tool Steel dengan menggunakan mesin CNC Milling dengan kemunculan penyejuk. Tujuan projek ini adalah untuk mendapati keadaan optimum dalam menghasilkan kemasan permukaan yang baik dalam proses penggerudian dengan kaedah Taguchi. Kelajuan pemotongan dipilih untuk proses penggerudian adalah 955m/min, 1273m/min and 1591m/min. Untuk kadar suapan, parameter adalah 191mm/min, 381mm/min dan 636mm/min. Parameter ketiga yang akan dipertimbangkan dalam projek ini adalah jenis alat penggerudian yang Steel Berkelajuan Tinggi (HSS) bersalut dengan Titanium nitrida (TiN), Speed Steel tinggi (HSS) bersalut dengan Titanium nitrida Karbon (TiCN) dan tinggi Spped Steel (HSS) tidak bersalut. Proses pemesinan telah dijalankan pada mesin pengilangan CNC. Kekasaran permukaan akan menjadi ujian dengan menggunakan Permukaan Kekasaran Penguji Mitutoyo SJ-410. Nilai nisbah bagi S/N nilai purata bagi kekasaran permukaan akan dapat diperolehi dari kaedah Taguchi dalam perisian Minitab. Analisis ANNOVA juga dijalankan untuk menyiasat parameter penggerudian yang sangat ketara menjejaskan ciri-ciri prestasi penggerudian. Akhir sekali, ujian pengesahan yang dijalankan adalah untuk memastikan kesahihan ujian tersebut.

DEDICATIONS

To my beloved parents En Masiron Bin Kibok and Pn Aesah Binti Masdar, this is for you. Thank you for all your sacrifice. I love u so much mom,dad, angah, kak de and adik.

ACKNOWLEDGMENTS

First of all, I would like to express my gratitude to all those who gave me the possibility to complete this project. I am deeply indebted whose help, stimulating suggestions and encouragement helped us in all the time of this project among this report in progress until done.

Big thanks to my academic supervisor, Mr Mohd Hairizal Bin Osman. He has been helping me out in the academic field including finishing this technical report. And not to forget to the Department of Process Engineering staff and lecturers and other UTeM staffs and lecturer and who had been involving directly or indirectly though out this process. Without their help and support, it would have been tougher for me to finish my project.

And last but not least, I would like to express thousands thanks to my family and friends which always give their support and advice for me. They have contributed for ideas, critics, opinions, and advices during the training period and finalizing my report.

Besides that, we want to thank thanks again for all their help, support, interest and valuable hints. They were very nice and helpful to me. Finally, I want to thanks again to all who has been involved in this process.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will discuss briefly the project flow from introduction, project background, problems statement of project, project objective, project scope and the flow chart of the project. This project title is a Cutting Parameter Optimization for Surface Finish in Drilling Process of AISI D2 Tool Steel using Taguchi method. The existing method that is currently used is Taguchi method. This project will focuses on all effects of parameters on surface finish in drilling operation with coolant. The parameter that will be use are spindle speed, feed rate and type of drill bit. This part of the report will explain further about the purpose of the project.

1.1 Background

This project is focuses on optimizing drilling parameters with coolant based on Taguchi method for minimizing surface finish. Drilling is the one of the most basic machining technologies and move towards high precision or high speed applications to improve productivity. Drilling is one of the most important metal cutting operations, comprising approximately 33% of all metal cutting operations (Nalawade and Shinde, 2015). This project is conducting on a CNC milling machine that produces holes at a specified rate of parameters in presence of coolant. The parameter that have selected are spindle speed, feed rate and type of the drill bit. Coolant is used to lubricate the machined surface and too reduce heat from the tool and the work-piece (Siddiquee et al, 2014).

Coolant lubricants can improve the machinability of the work piece, increase productivity and extend tool life by reducing tool wear. Besides, coolant is very important in machining processes to reduce the effects of friction and also make the surface roughness become smooth. The type of coolant that will use in CNC Milling machine is lubricant with a grade of ECOCOOL 6210 IT. The size of the block AISI D2 Tool Steel 100mm x 100mm with thickness of 40mm is used as a base of the drilling process. AISI D2 Tool Steel is hardened in air with a low order of movement, high corrosion resistance when polished, very high wear resistance and toughness. AISI D2 Tool Steel with a hardness of 45-68 HRC was hard machined (Takacs and Farkas, 2014).

In this project, there are 3 types of drilling tool that had be selected to use which is High Speed Steel (HSS) coated with Titanium Nitride (TiN), HSS coated with Titanium Carbon Nitride (TiCN) and HSS uncoated. The diameter of all these drilling tool was selected as 10mm. High Speed Steel is a cutting tool material that had been used in drilling, milling, turning, threading, boring, broaching, gear cutting and other types of machining process. High-speed tool steels are used for most of the common types of cutting tools including single-point lathe tools, drills, reamers, taps, milling cutters, end mills, hobs, saws and broaches (Bayer et al, 1989).

The parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for the cutting parameters. Taguchi defines the quality of a product, in terms of the loss imparted by the product to the society from the time the product is shipped to the customer (Ghani et al, 2004). A series of experiment based on L9 orthogonal array are conducted and the collected of the experimental result was analyzed by Taguchi method. To perform the Taguchi method, the Minitab software was used for the design and analysis of the experiments. Minitab is software packages that help to analyze data. From the Minitab, the signal to noise ratios can be obtain from there.

1.2 Problem Statement

The problem for this project is the material of AISI D2 Tool Steel is hard to machine because the hardness ranging is about 54-61 HRC. HRC is stand for Rockwell C hardness which is one of the metallurgy testing. A popular grade for toolmakers, D2 is used in a wide variety of tool making applications (Rob and Duncan, 2015). The blanking dies and punches for sheet in stainless steel, brass, copper, zinc and hard abrasive materials are the typical applications for AISI D2 Tool Steel.

1.3 Project Objective

The following are the objective of this project;

1) To study the effects of various cutting parameters to the surface finish of AISI D2 Tool Steel in drilling process.
2) To analyze the optimum parameter for drilling process for the better surface finish.

1.4 Project Contributions

The contributions in this project are mainly to increase the quality of the surface finish in drilling process in order to optimize the cutting parameter.

1.5 Project scope

This project will focuses on all effects of parameters on surface finish in drilling process in using a coolant. The purpose of coolant is to carry away heat in machining operation. The type of coolant that use in this process is a lubricant with a grade of ECOCOOL 6210 IT. AISI D2 Tool Steel was chosen as the work piece material. Only one piece of AISI D2 Tool Steel is use and the dimension of the work pieces is 100mm × 100mm with thickness 10mm. The parameter use for this project is spindle speed, feed rate, and type of drill bit. Besides, the result will be analyzed with the Surface Finish Tester Instrument and compare the surface finish with different type of drilling tools. The types of drilling tool that be selected is High Speed Steel (HSS) coated with Titanium Nitride (TiN), HSS coated with Titanium Carbon Nitride (TiCN) and HSS uncoated with the diameter of 10mm. Coating is functional to make the life time of the tool more longer than uncoated. Each type of drilling tools will make three holes, so 9 holes will produce. The project will be done after get the better surface finish from comparing the result by different drilling tools.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This literature review is presented thoroughly on the issue that is related with the Cutting Parameter Optimization for surface Finish in Drilling Process of AISI D2 Tool Steel using Taguchi method. The literature review provides background information and thus to determine the objectives of the present project. It will give part in order to get that information.

2.1 Drilling Process

Hole making or usually known as drilling is a major and common hole making that make it among the most important operations in manufacturing. The purpose of drilling is to remove the unwanted materials to produce hole. Drilling is the most economical and efficient way to produce hole on a solid metal. The function of drilling process that involved in an aircraft and aerospace industry is the fabrication of aircraft engine by using robotics. In an automotive industry, the drilling process is an engaged at the nozzle holes by using laser drilling. Drilling processes are widely used in the aerospace, aircraft and automotive industries (Nalawade and Shinde, 2015).

The Drilling process that involves the creation of holes that are right circular cylinders and it is reaching a most typically by using a twist drill. The Figure 1 below shows an illustration about how the common twist drill cut and produces a cross section of a hole. Based on the Figure 1, the drilling tool is embedded inside the work piece and the chips must exit by the flutes to the outside of the drilling tool. Therefore, it making the cooling is more difficult. The drill cutting area can be flooded, coolant or cutting fluid can be applied and can be delivered through the drill bit shaft.

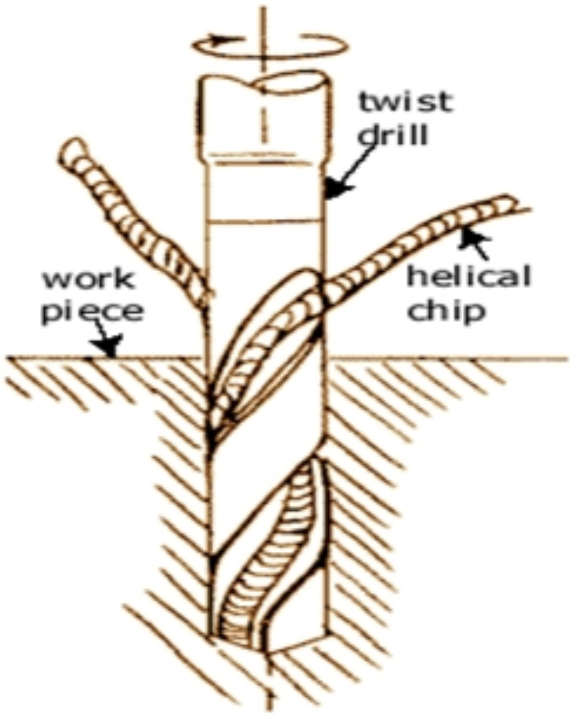

Figure 2.1: Illustrates about the common twist drill
(Drilling : Introduction,2015)

2.1.1 Characteristics and Design Consideration for Drilling

Below are the characteristics of drilling operation that set it apart from other metal cutting operations (Drilling Characteristics, 2015).

i. The chips must exit from the hole to the outside of the drilling tool that created by the cutting.

ii. If the chips are large or continuous, the problem can cause when the chip exit.

iii. The drill can wander when enter the work piece and for deep holes.

iv. Coolant or cutting fluid has to be delivered through the drill shaft to the cutting front for deep holes in a large work pieces.

v. The drilling on a drill press is the most likely to be performed by someone who is not a machinist.

2.2 CNC Milling Machine for Drilling Machine

The meaning of CNC is a Computer Numerical Control where is a computer converts the design that produced by Computer Aided Design software into numbers. The drilling process is performing on a CNC milling machine of DMC 635 Veroline with a controller by a Siemens 840. The earliest precedent to CNC machines may be the Jacquard loom, a mechanical process invented in 1801 by Joseph Marie Jacquard to simplify the process of manufacturing complex textile patterns. (Sammarco, 2011).

The machining tools that includes in the CNC Technology are lathes, multi-axis spindles, wire electrical discharge machines and milling machines. The function for all that machining tools was performed by the computer-control module. To form a finished part the cutting process can be started from a solid block, pre machined parts or castings (Technical Description CNC Milling, 2011).

2.2.1 Related Cutting Parameter

To obtain the maximum machining rate as well as minimum machining cost, the cutting parameter is very important factor. The high productivity and high material removal rate for drilling process can be achieve by changing the process parameters such as drilling diameters, cutting speed, feed rate and many more. The drilling performance like tool life and material rate removal also can improve. Study on the influence of cutting parameters such as cutting velocity, feed rate, cutting time on drilling metal – matrix composites and concluded that interaction of cutting speed/feed is the most important factor contributing towards surface roughness of drilled holes (J Paulo davim, 2003).

According to Nalawade and Shinde (2015), the 3 parameters of Cutting Speed, Feed rate and type of tool with 3 levels as shown in the table below is selected as 3 parameters for optimization of surface finish and using the set smaller is better for optimization of setting of parameters for achieving higher surface finish.

Table 2.1: Recommendation parameter (Nalawade and Shinde,2015)

Parameter	Level 1	Level 2	Level 3
Cutting Speed (m/min)	30	40	50
Feed Rate (mm/min)	0.2	0.3	0.4
Type of tool	HSS+TiN	HSS+TiAN	HSS (uncoated)

2.2.2 Application of Coolant

Cutting fluids are widely be use to optimize the process of machining operations such as turning, drilling, boring, grinding, milling, drawing, stamping, and sawing. The benefits of cutting fluid such as extended tool life, increased speeds and feeds, tighter tolerance capability, and improved finish will provide by the proper selection of cutting fluid. It has seen extensive use and has commonly been viewed as a required addition to high productivity and high quality machining operations. (Adler et al, 2006).

Coolant and lubricants will make the surface finish become smoother and widely used in industries for metal cutting operations. There also can improve the machinability of the work piece, increase productivity, make the tool life is longer by reducing tool wear and flush away the chips that are produced during the machining. Depending on the type of machining operation, the cutting fluid needed may a coolant, a lubricant or both (Kalpakjian 2010).

2.2.3 Various Types of Drilling Tool

The most important factors in machining operations are the selection of the cutting tool materials for a particular application. High speed steels (HSS) are the most highly alloyed tool and die steels that generally used for machining operations in drilling, milling, turning, threading, boring, broaching, gear cutting and others at high speeds of cutting tool material. The application of high speed steels is to form tools, slitter knives, guillotine knives, parting tools and other types of cutting tools. The molybdenum type (M-series) and the tungsten type (T-series) are the two basic types of high speed steel. First developed in the early 1990s, they maintain their hardness and strength at elevated operating temperatures (Kalpakjian 2010).

There are the general characteristic of all high speed steel:

i. Excellent toughness

ii. Resistance to fracture

iii. Wide range of roughing and finishing cuts

iv. High working hardness

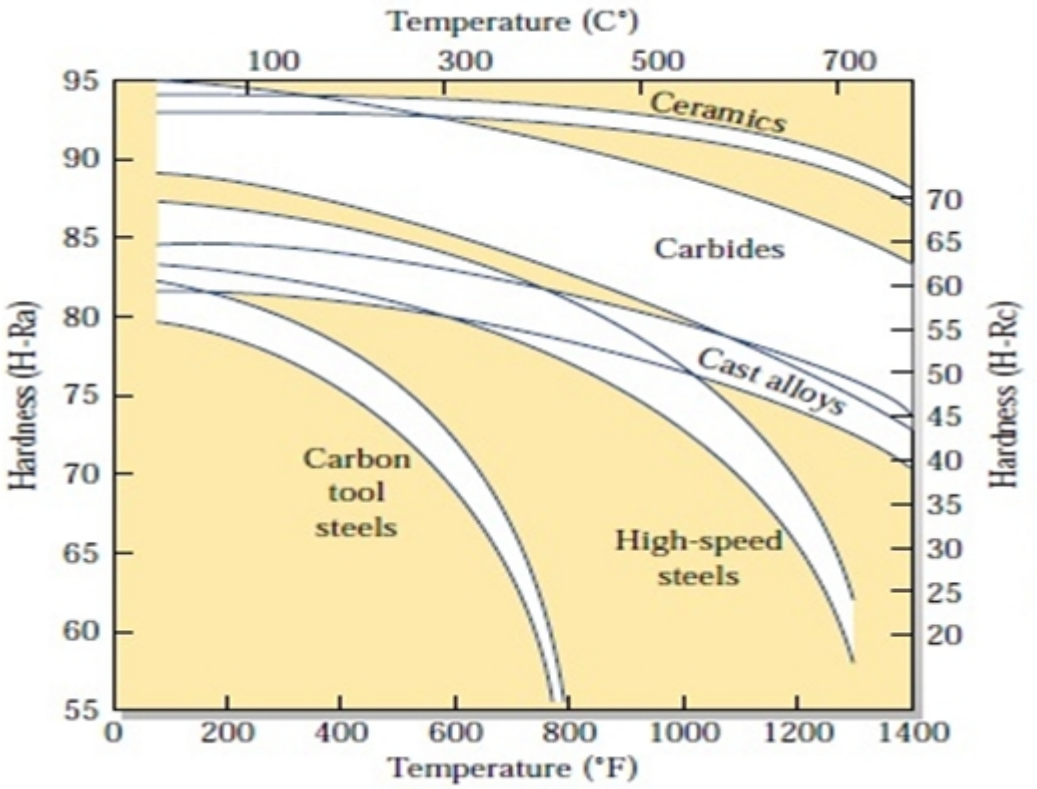

Figure 2.2 : Hardness of various cutting tool materials (2012)

2.2.4 Coating of Drilling Tool

Coating is a layer of material deposited onto a substrate to increase the surface properties for corrosion and wear protection. The coating of tool is very helpful to extend the lifetime of tools. The effectiveness of coatings is be improved by the hardness, toughness and high thermal conductivity of the substrate. There are several factors that affecting the choice of a coating which is service of environment, life expectancy, substrate material compatibility, component of shape and size also the cost. Coated tools can have lives 10 times longer than those of uncoated tools, allowing for high cutting speeds and thus reducing both the time required for machining operations and production costs (Kalpakjian and Schmid, 2010).

There are several type of properties for coated tools:

i. Lower friction

ii. Higher adhesion

iii. Higher resistance to wear and cracking

iv. Acting as a diffusion barrier

v. Higher hot hardness and impact resistance

2.2.4.1 Coated of Titanium Nitride (TiN)

Based on the book of Manufacturing Engineering and Technology (Kalpakjian and Schmid, 2010), The Titanium Nitride (TiN) coating are gold in color can perform very well at higher cutting speeds and feeds because it have a low friction coefficient, high hardness, resistance to high temperature and good adhesion to the substrate. The TiN are really helpful to improve the life tools of high speed steel, lives of carbide tools, drill bits and the cutters. Figure 2.3 below shows a diagram of the High Speed Steel drill bit coated with Titanium Nitride (TiN).