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THE EFFECT OF CUTTING PARAMETER TO THE HOLE DIAMETER ACCURACY OF AISI D2 TOOL STEEL IN DRY DRILLING PROCESS

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

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Effect of Cutting Parameter to the Hole Diameter Accuracy of AISI D2 Tool Steel in Dry Drilling Process**

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APPROVAL

This report is submitted to the Faculty of 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:

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(Mohd Hairizal Bin Osman)

ABSTRACT

This project focuses on measure the effect of cutting parameter on the holes diameter accuracy and to identify the optimum parameter for the dry drilling process of AISI D2 tool steel. CNC Milling Machine DMC 635 V Ecoline will be utilized in this project to produce a hole by undergoing the drilling process. The parameters selected to be focused are spindle speed, feed rate and types of drill bit. During conduct the drilling process, the coolant will be eliminated and the process will undergo in dry drilling. Different cutting tools which have been selected are High Speed Steel uncoated, coated with Titanium Nitride and Titanium Carbon Nitride. The diameter of the cutting tools is 10mm. AISI D2 tool steel was selected as the work piece material. The size of the material is 100mm x 100mm with 10mm thickness. The design of experiments in this project will be used Taguchi method with L9 of orthogonal array. Mean there are 3 factors at 3 levels of parameter. This method provides a simple, systematic, and efficient methodology for the cutting parameter. Then by using the Coordinate Measuring Machine (CMM) with four point circle micro method, the accuracy of hole diameter will measure. Then to determine which machining parameter is optimum, Taguchi method will be used by using Minitab software. This analysis will be investigated which drilling parameter significantly affected the diameter hole accuracy. Confirmation test with the optimal level of machining parameters are carried out in order to illustrate the effectiveness of the Taguchi optimization method.

ABSTRAK

Projek ini memberi tumpuan kepada langkah kesan memotong parameter kepada ketepatan diameter lubang dan untuk mengenal pasti parameter yang optimum untuk proses penggerudian kering keluli AISI D2. Mesin CNC Pengisar DMC 635 V Ecoline akan digunakan dalam projek ini untuk menghasilkan lubang dengan menjalani proses penggerudian. Parameter yang telah dipilih untuk difokuskan adalah kelajuan spindal, kadar suapan dan jenis mata gerudi. Semasa menjalankan proses penggerudian, penyejuk akan dihapuskan dan proses ini akan berlaku dalam penggerudian kering. Alat pemotong yang berbeza yang telah dipilih adalah Keluli Tahan Lasak tidak bersalut, disalut dengan Titanium Nitrida dan Titanium Karbon Nitrida. Diameter alat pemotong adalah 10mm. Keluli AISI D2 telah dipilih sebagai bahan benda kerja. Saiz bahan adalah 100mm x 100mm dengan ketebalan 10mm. Reka bentuk eksperimen dalam projek ini akan menggunakan kaedah Taguchi dengan L9 array ortogon. Bermakna terdapat 3 faktor pada 3 tahap parameter. Kaedah ini menyediakan kaedah mudah, sistematik, dan cekap untuk parameter pemotongan. Kemudian dengan menggunakan Mesin Menyelaras Mengukur (CMM) dengan bulatan empat titik kaedah mikro, ketepatan diameter lubang akan diukur. Kemudian untuk menentukan optimum parameter pemesinan, kaedah Taguchi akan digunakan dengan menggunakan perisian Minitab 17. Analisis ini akan menyiasat penggerudian parameter yang mana akan menjejaskan ketepatan lubang diameter. Ujian pengesahan dengan tahap optimum parameter pemesinan dijalankan untuk menggambarkan keberkesanan kaedah pengoptimuman Taguchi.

DEDICATIONS

To my beloved parents, family and friends.

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In the name of Allah, the Compassionate, the Merciful, Praise be to Allah, Lord of the Universe, and Peace and Prayers be upon His Prophet and Messenger. With Grace and Blessing from Allah, I am Mohamad Ammar Faiz Bin Latif from Faculty of Engineering Technology have succeeded in completing my final year project together with this thesis. First and foremost, I would like thank to Allah, because of His willing and Blessing, I have succeeded in completing this project. High appreciate to my supportive project supervisor, Mr. Mohd Hairizal Bin Osman for his guidance during performing this project.

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CHAPTER 1
INTRODUCTION

1.0 Introduction

This project title is optimization of holes diameter accuracy in dry drilling on AISI D2 tool steel by Taguchi method. Several test will be conduct with different parameters, different types of drill bit and the material use to drill on is AISI D2 tool steel. Taguchi analysis will be used to analyze this project. By doing the analysis using Taguchi analysis, the optimize parameter for the drilling process that produce the best holes diameter accuracy can be determine.

1.1 Background

This project focuses on optimizing drilling parameter in dry machining based on the Taguchi method for finding optimal hole diameter accuracy. CNC Milling Machine DMC 635 V Ecoline will be utilized in this project to produce a hole by undergoing the drilling process. The parameters that have selected are spindle speed, feed rate and types of drill bit. During conduct the drilling process, the lubricant will be eliminated and the process will undergo in dry drilling.

Different cutting tools which have been selected are High Speed Steel uncoated, coated with Titanium Nitride and Titanium Carbon Nitride. The diameter of the cutting tools is 10mm. AISI D2 tool steel was selected as the work piece material. The size of the material is 100mm x 100mm with 10mm thickness.

The design of experiments in this project will be used Taguchi method with L9 of orthogonal array. Mean there are 3 factors at 3 levels of parameter. This method provides a simple, systematic, and efficient methodology for the cutting parameter. Then by using the Coordinate Measuring Machine (CMM) with four point circle micro method, the accuracy of hole diameter will measure. Then to determine which machining parameter is optimum, Taguchi method will be used by using Minitab software. This analysis will be investigated which drilling parameter significantly affected the diameter hole accuracy.

1.2 Problem Statement

D2 tool steel is steel is an ideal steel to use for punch and dies or injection mold tools. It is a difficult material to machine and requires a special tool to cut this material. D2 tool steel is steel is an ideal steel to use for punch and dies or injection mold tools. There are uses for applications like injection molding due to their resistance to abrasion is an important criterion for a mold that will be used to produce hundreds of thousands of parts is essential. It is a difficult material to machine and requires a special tool to cut this material.

In drilling process, drill performance and hole quality are basically subject to the cutting parameters and drilling tools. Because of this, many researchers have been focused on determining the best drilling process. Therefore, many experimental techniques have been developed and used by researchers in the past decade in order to predict and determine significant parameters which affect the drilling process and hole accuracy. Other researchers have also investigated the effect of machining parameters and different coatings on hole quality in the drilling process.

Cutting fluids may undergo chemical changes as they are used repeatedly and again after some time. These changes may be due to environmental effects or to contamination from different sources, including metal chips, fine particles produced during machining and tramp oil. The changes involve the development of organisms, particularly in the presence of water, becoming an environmental hazard and also adversely affecting the characteristics and effectiveness of the cutting fluids. So dry machining is one of the viable alternatives. With significant advances in cutting tool, dry machining has been shown to be effective in different machining operations.

1.3 Objectives of Research

The objectives of this project are:

a) To measure the effect of cutting parameter on the holes diameter accuracy by using dry drilling.
b) To identify the optimum parameter for the drilling process of AISI D2 tool steel.

1.4 Scope of Research

The scopes of this project are:

a) The drilling tools use is HSS+TiN, HSS+TiCN and HSS uncoated.
b) The diameter of drilling tool is 10 mm.
c) The work piece for this investigation is AISI D2 tool steel of size 100mm X 100mm X 10mm.
d) The measurement of holes accuracy is made by using Coordinate Measuring Machine (CMM).
e) The research is focusing on CNC milling machine under dry condition.
f) Machine parameter; spindle speed at 680rpm, 825rpm, and 970rpm, feed rate at 136mm/min, 206.25mm/min, 291mm/min, type of drill bit is HSS+TiN, HSS+TiCN and HSS uncoated.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter discusses about the literature review of this project. The purpose of this literature review is to review the critical knowledge and provide information that substantive findings as well as theoretical and methodological contributions to this project. This literature review will include findings the general knowledge regarding machining by the drilling process, cutting tools and coating of the drill bit based on the pass and recent related studies.

2.1 D2 Tool Steel

D2 tool steel is steel is an ideal steel to use for punch and dies or injection mold tools. It is a difficult material to machine and requires a special tool to cut this material. D2 tool steel is steel is an ideal steel to use for punch and dies or injection mold tools. There are uses for applications like injection molding due to their resistance to abrasion is an important criterion for a mold that will be used to produce hundreds of thousands of parts is essential. It is a difficult material to machine and requires a special tool to cut this material.

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion and deformation and the ability to hold a cutting edge at elevated temperatures. As a result tool steels are suited for their use in the shaping of other materials. With carbon content between 0.5% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality. The presence of carbides in their matrix plays the dominant role in the qualities of tool steel. The four major alloying elements in tool steel that form carbides are tungsten, chromium, vanadium and molybdenum (Kalpakjian and Schmid, 2006).

2.2 Drilling Process

CNC machine is used to produce accurate work pieces. Location, size and surface finish of holes can be controlled precisely. Drilling is the common machining operation and any improvement in this process offers gains in productivity. A selection tool to make holes become critical. Choices of tools that will do the job become more varied all the time. A hole may require spot drilling, drilling, boring and reaming. If any of this operation can be eliminated, machining time may be reduced.

In the aerospace industry, hole quality is very important by depending on the application (Basile, 1993). The response variables of interest are the important quality characteristics of holes. These include the hole diameter accuracy and the surface roughness inside the hole (Sauter and Lenth, 2015). In this process, drill performance and hole quality are basically subject to the cutting parameters and drilling tools. Due to this, many researchers have been focused on determining the best drilling process. Therefore, many experimental techniques have been developed and used by researchers in the past decade in order to predict and determine significant parameters which affect the drilling process and hole accuracy. Other researchers have also investigated the effect of machining parameters and different coatings on hole quality in the drilling process.

Developed a new mathematical model based on the mechanics and dynamics of the drilling process was developed for the prediction of cutting forces and hole quality (Pirtini and Lazoglu, 2005). According to Kalidas et al. 2001, performance an experimental investigation of the role of the three types of coating in the hole quality of the hole produced in the drilling of cast aluminum 356 alloy in dry and wet conditions. Additionally, the influence of the machining parameters on the hole surface roughness and hole dimensions for different coated drills has been examined by Nouari et al. 2005.

2.2.1 Dry Drilling

Dry drilling also is a viable alternative. With major advances in cutting tools, dry drilling has been shown to be effective in various machining operations, especially turning, milling, and gear cutting operation on steels, steel alloys, and cast irons but generally not for aluminum alloys (Nalawade and Shinde, 2015).

One of the functions of a metal-cutting fluid is to flush chips from the cutting zone. This function seems to be problematic with dry drilling. However, tool designs have been developed that allow the application of pressurized air, often through the tool shank. The compressed air doesn't serve a lubrication purpose and provides only limited cooling, but is very effective at clearing chips from the cutting interface (Nalawade and Shinde, 2015).

2.2.2 Drilling with Coolant

There are many benefits to drilling with coolant. Directing the coolant through the tool to the cutting edge improves lubricity and reduces the temperature at the point of contact. Reduced heat build-up and improved lubricity lead to lower wear and tear on the drill that improves the tool life and reduces the cost per hole. Depending on the application, the introduction of through the tool coolant may enable the operator to increase feeds and speeds as well as reducing or eliminating the retract cycle which contributes to a lower cost per hole. Hole finishes are improved due to the flushing of the chips away from the drill or workpiece interface which reduces the scarring of the workpiece by previously cut chips (Williams, 1974).

2.3 Related Process Parameter in Drilling Process

There are a lot of previous investigations which diversify the machining parameter. Between the parameters are cutting speed, feed rate, and depth of cut, tool material, hot or cold worked and much more. The main objectives of the research are to establish optimum parameter and to measure the effect of cutting parameter on the hole diameter accuracy by using dry drilling.

Nalawade and Shinde (2015) has investigated the cutting parameter optimization for surface finish and hole accuracy in drilling. Feed rate is the most significant factor effected to hole diameter error with contribute 73.53% in the dry drilling process. According to Navanth and Karthikeya (2013), the most significant factor effected hole diameter for the dry drilling of Al 2014 were point and helix angle with contribute 99.11%.

2.4 Cutting Tool

Drills typically have high length-to-diameter ratios as shown in Figure 2.1. Hence, they are capable of producing relatively deep holes. However, drills are somewhat flexible and should be used with care in order to drill holes accurately and to prevent breakage. Furthermore, the chips that are produced within the hole move in in a direction opposite to the forward movement of the drill. Thus, chip disposal and ensuring cutting-fluid effectiveness can present significant difficulties in drilling (Nalawade and Shindle, 2015).

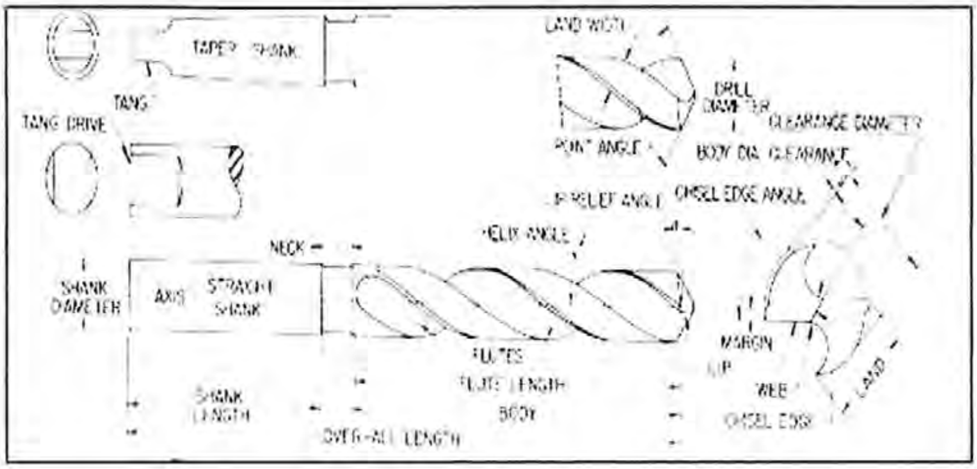

Figure 2.1: Two Common Types of Drills (Nalawade and Shindle, 2015)

The geometry of a drill bit very much affects the way it behaves during drilling as shown in Figure 2.2 for drill bit geometry. The land is the area remaining after fluting. In order to reduce the amount of land that creates friction with the hole wall (thus generating heat), drill bits are marginally relieved. The amount of land remaining in contact with the hole wall during drilling is referred to as the margin. The wider the margin, the greater the friction area (Kalpakjian and Schmid, 2006) and the higher the drilling temperature, results in higher extent of heat related (Navanth and Karthikeya, 2013).

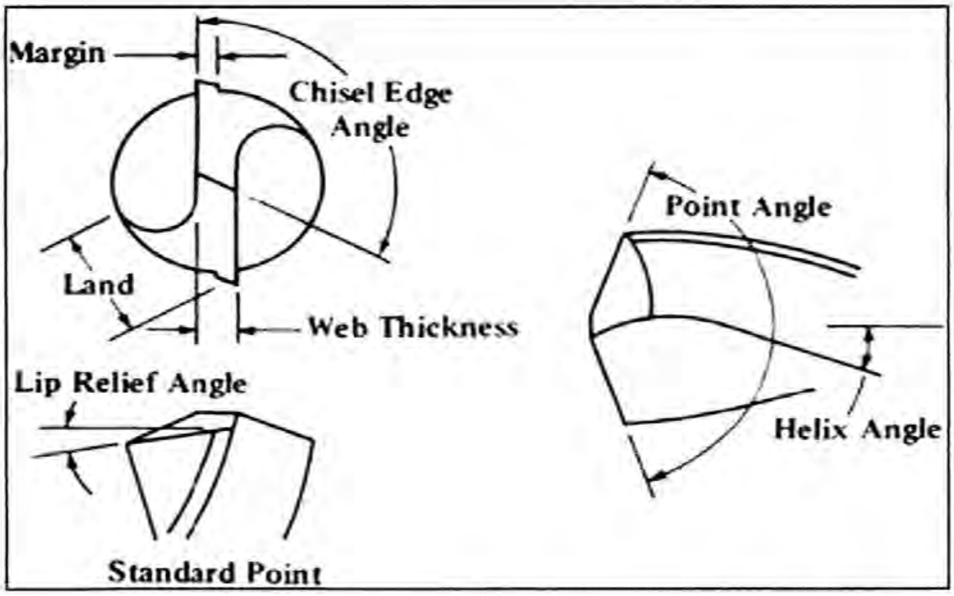

Figure 2.2: Drill Bit Geometry (Navanth and Karthikeya , 2013)

The most common drill is the conventional standard point twist drill. The geometry of the drill point is such that the normal rake angle and velocity of the cutting edge vary with the distance from the center of the drill. The main features of this drill are as follows:

- Point angle (118° to 135°)
- Lip-relief angle (7° to 15°)
- Chisel-edge angle (125° to 135°)
- Helix angle (15° to 30°)

Two spiral grooves (flutes) run the length of the drill, and the chips produced are guided upward through these grooves. The grooves also serve as passageways to enable the cutting fluid to reach the cutting edges. Some drills have internal longitudinal holes through which cutting fluids are forced, thus improving lubrication and cooling as well as washing away the chips. Drills are available with a chip-breaker feature ground along the cutting edges. This feature is important in drilling with automated machinery, where a continuous removal of long chips without operator assistance is essential.

The various angles on a drill have been developed through experience and are designed to produce accurate holes, minimize drilling forces and torque, and optimize drills life. Small changes in drill geometry can have a significant effect on drill's performance, particularly in the chisel-edge region, which accounts for about 50% of the thrust force in drilling.

2.5 Cutting Tool Material

High-speed steel (HSS) tools are so named because they were developed to machine at higher speeds than was previously possible. First produced in the early 1900s, high-speed steels are the most highly alloyed of the tool steels. They can be hardened to various depths, have good wear resistance, and are relatively inexpensive. Their most important limitation (due to their lower hot hardness) is that their cutting speeds are low compared with those of carbide tools. Because of their toughness (hence high resistance to fracture), high-speed steels are suitable especially for:

- High positive rake-angle tool.
- Interrupted cuts.
- Machine tools with low stiffness are subject to vibration and chatter.
- Complex and single-piece tools, such as drills, reamers, taps, and rear cutters.

General purpose drills, other than those made from low-alloy steels for low production of wood or soft materials, are made from high-speed tool steels, typically Ml, M2, M7, and M10. For lower cost hardware quality drills, intermediate high-speed tool steels M50 and M52 are sometimes used, although they cannot be expected to perform as well as standard high-speed tool steels in production work. For high hot hardness required in the drilling of the more difficult-to-machine alloys such as nickel-base or titanium product, M42, M33, or T15 are used. High-speed tool steel twist drills are not currently being coated as extensively as gear cutting tools because many drills are not used for production applications. Also, the cost of coating (especially for titanium nitride) is prohibitive because it represents a higher percentage of the total tool cost. Drills coated with titanium nitride reduce cutting forces and improve the surface finishes to the point that they eliminate the need for prior core drilling or subsequent reaming. Coated drills have been found especially suitable for cutting highly abrasive materials, hard nonferrous alloys, and difficult to machine materials such as heat-resistant alloys. These tools are not recommended for drilling titanium alloys because of possible chemical bonding of the coating to the work piece material (Kalpakjian and Schmid, 2009). The table 2.1 below shows the chemical composition of high speed steel and grades.

Table 2.1: Chemical Composition of High Speed Steel and Grades

Chemical composition					
	T1	M2	M7	M36	M42
Carbon (C)	0.65 – 0.80	0.95	1.00	0.94	1.10
Chromium (Cr)	4.00	4	4	4	3.75
Molybdenum (Mo)	-	5	8.75	5	9.5
Tungsten (W)	18	6.0	1.75	6.0	1.5
Vanadium (V)	1	2.0	2.0	2.0	1.15
Cobalt (Co)	-	-	-	8.0	8.0
Manganese (Mn)	0.1 – 0.4	-	-	-	-
Silicon (Si)	0.2–0.4	-	-	-	-