UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF DRILLING PARAMETERS ON DIAMETER ACCURACY IN DRY DRILLING PROCESS OF AISI D2 TOOL STEEL

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

by

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APPROVAL

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……

(Project Supervisor)

ABSTRAK

Kajian ini dijalankan untuk menentukan parameter optimum untuk ketepatan garis pusat lubang pada bahan AISI D2 dalam proses penggerudian kering dengan menggunakan kaedah Taguchi. Objektif projek ini adalah untuk mencari keadaan optimum dalam menghasilkan ketepatan yang tinggi pada garis pusat lubang. Kelajuan pengumpar yang terlibat semasa proses penggerudian ini adalah 482 RPM, 550 RPM and 627 RPM. Parameter kadar suapan adalah 68 mm/min, 103 mm/min and 146 mm/min. Parameter seterusnya ialah jenis salutan pada mata gerudi yang terdiri daripada keluli laju tinggi bersalut Nitrida Titanium(TiN), Karbon Nitrida Titanium(TiCN) dan Aluminium Nitrida Titanium(TiAlN). Proses pemesinan dijalankan dengan menggunakan mesin kawalan berangka terkomputer. Ketepatan garis pusat lubang diuji dengan menggunakan mesin mengukur koordinat.

ABSTRACT

This research was carried out to determine the optimization parameter for hole diameter accuracy in dry drilling process of AISI D2 Tool Steel using Taguchi method. The objectives of this project is to find the optimum condition in producing high accuracy of hole diameter. The selected spindle speeds for drilling process are 482 RPM, 550 RPM and 627 RPM. The feed rate parameters are 68 mm/min, 103 mm/min and 146 mm/min. Next parameter is the types of drill bit which consist of High Speed Steel (HSS) coated with Titanium Nitride (TiN), High Speed Steel (HSS) coated with Titanium Carbon Nitride (TiCN) and High Speed Steel (HSS) coated with Titanium Aluminium Nitride (TiAlN). The machining process will be performed on the CNC Milling machine. The diameter accuracy of holes will be tested by using Coordinate Measuring Machine (CMM).

DEDICATION

A special appreciation, I dedicate this thesis to my mother Aminah Binti Ahamat, my father Saadon Bin Mohd Saleh and all.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CNC	-	Computerized Numerical Control
CMM	-	Coordinate Measuring Machine
AISI	-	American Iron and Steel Institute
C	-	Carbon
Mg	-	Magnesium
Co	-	Cobalt
Mo	-	Molybdenum
Cr	-	Chromium
V	-	Vanadium
Fe	-	Ferum
Si	-	Silicon
HSS	-	High Speed Steel
TiN	-	Titanium Nitride
TiCN	-	Titanium Carbon Nitride
TiAlN	-	Titanium Aluminium Nitride
DOE	-	Design of Experiment
JTKP	-	Jabatan Teknologi Kejuruteraan Pembuatan
PVD	-	Physical Vapor Deposition
RPM	-	Revolution per Minutes
ANOVA	-	Analysis of Variance
S/N Ratio	-	Signal Noise to Ratio
DF	-	Degree of Freedom
Adj SS	-	Adjusted Sum of Square
Adj MS	-	Adjusted Mean Square

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter will discussed about the flow of the project consist of introduction, objectives, problem statement and project scope. The sub-topic are relates each other to ease the readers to understand the project flow better. This project will describe about the optimization parameter of dry drilling process on diameter accuracy. There are several tests to be conduct by using different parameters and different types of material of drill bit in order to drill AISI D2 Tool Steel. Taguchi method will be used to analyse the best parameter to drill AISI D2 Tool Steel which possess the best diameter accuracy.

1.1 Project Background

In modern manufacturing technology, there are many challenges faced by the industry in terms of dimensional accuracy and precision especially for hardened materials. Hard material such as AISI D2 Tool Steel with hardness in the range of 54-62 HRC has a high strength, very high resistance to cracking and high resistance to softening and wear[1]. This project will be focused on the optimization parameter on the diameter accuracy for dry drilling process using the Taguchi method. Drilling is a process to cut or enlarge a hole of circular cross-section in solid materials using a drill bit. Drilling may affect the mechanical properties of work piece due to the formation of low residual stresses around the hole opening.

This causes the work piece to become more susceptible to corrosion and crack propagation at the stressed surface. Several factors that can affect the quality of the drilled holes are the cutting parameters used. For instance, cutting speed, feed rate and cutting configurations which consists of tool diameter, material and geometry[2]. The chosen parameters for this project are spindle speed, feed rate and types of drill bit. There are two types of machining which are conventional and non-conventional. In this case, we are using non-conventional machining which is CNC milling machine.

Conventional machining is a machine that are operated or driven with the help of human resources. This machining method requires direct or physical contact of tool and work piece. On the other hand, non-conventional machining involves machine which are fully automated with no need of human resource to control the functions of the machine. These may be controlled by a pre-programmed computer or a robot[20]. Normally, CNC machining is more prefer in the industry because of its advantages over conventional machining. For example, non-conventional machining offers high accuracy and surface finish better than the conventional. Next, they are programmed with a design that can be reproduced exactly. This plays an important role in modern industry where a faulty cut on one component can render the whole machine unusable. The velocity and positioning can be controlled exactly with usually an accuracy rate of 100 per cent.

The advanced software allows CNC machines to make products that cannot be made by hand even by the most skilled machinists available. Besides that, this machine does the skilled work and because of that the operator does not need to have advanced training. This makes it easier for students to operate the machine with the help of technician. Once the machine is programmed, only one person requires supervising because the machine can work by itself. It will reduce workload as well as the human error incident. Others advantages that non-conventional possess which becomes favourable by industries are they can produce thousands of identical parts in a relatively short amount of time, much faster than conventional machining. The machines can operates continuously 24 hours a day and will require a short down time for maintenance. Besides that, the software can be changing for updating

process and can be reprogrammed in a short span of time. The past program also can be store to use at any time[21].

There are three types of drill bit with diameter of 11mm to be used such as High Speed Steel coated with Titanium Nitride(TiN), High Speed Steel coated with Titanium Carbon Nitride(TiCN) and High Speed Steel coated with Titanium Aluminium Nitride(TiAlN). The selections of coating materials is an important task because an improper selection can lead to less tool life than an uncoated tool and sometimes it may result in more problems than solutions. There are some characteristics to be considered during the selections of coating materials such as hardness. A high surface hardness is the best way to increase tool life which means the harder the material or surface, the longer the tool will last. For example, Titanium Carbon Nitride(TiCN) has a higher surface hardness compared to Titanium Nitride(TiN) according to the previous research. This is due the addition of carbon that gives TiCN 33 per cent higher hardness than TiN and changes the range from about 3000 to 4000 Vickers.

Next, wear resistance property which is the ability of coating to protect against abrasion. It is important because although a material may not be hard, the process and elements added during production may aid in the breakdown of cutting edges or forming lobes. Besides that, surface lubricity also plays an important role. A decrease of coating life or coating failure is influenced by the coefficient of friction. The higher the coefficient of friction caused the higher heat producing which leads to the problem. However, a lower coefficient of friction can greatly increase tool life. The amount of heat can be reduced by a surface that lacks coarseness or irregularities. This is because the slick surface lets the chips to slide off the tool face results in less heat produced. A higher surface lubricity will increase speeds when compared to non-coated versions. This will also help to fend off the work material. Oxidation temperature is the point at which the treatment starts to break down. A higher oxidation temperature shows improves success in high heat applications. There are some coating materials that not as hard as TiCN at room temperature but it is more effective where the heat is generated. For example TiAlN holds its hardness at higher temperature with the help of layer of aluminium oxide that forms between

the cutting chip and tool. The formation of this layer helps to transfer heat away from the tool and into the chip or part.

On the other hand, anti-seizure is a property to keep material from depositing onto the tool by reducing the chemical reactivity between the tool and cutting material. Non-ferrous materials like brass or aluminium has a common problem with the BUE or Built Up Edge whereby it can lead to chipping of the tool or part oversizing. Once the material starts adhering to the tool, it continues to attract. For instance, during machining aluminium with a forming tap, the aluminium deposits grow larger after every hole. It caused the enlargement of pitch diameter which is the part becomes oversized and needs to be scrapped. Thus, a coating with increased anti-seizure properties may be some helps where poor coolant quality or concentration is a problem[19].

Cutting fluids or lubricants play an important role in material removal process and machining operation such as turning, milling and drilling. It has been used since past machining process because according it achieved 40 per cent increase in cutting speed while machining steel with high speed steel tool and water as a coolant[22]. In this project, the process does not involve of cutting fluid. Drilling is one of the machining processes most used by manufacturing companies which is very complex from the perspective of scientific study. The geometry and the surface are generated in a single operation with many influential parameters. The reduction or elimination of the cutting fluids caused geometric and dimensional controls are more critical because the temperatures in the process may influence the shape and dimensional accuracy of the holes[18]. In manufacturing industry, the effect of cutting fluid has been a consideration because of the negative impacts. The chemical contain in the cutting fluids caused harm for instance dermatitis when in contact with hands or bodies. As for the environment, the use of chlorine in cutting fluid makes it toxic and become harmful such as water pollution and soil contamination if the waste is thrown in the river[22].

Although there are some important operations that are not possible without lubricants, the recent approach using tools with hard coating layers makes it enable for dry drilling and tapping of steels process. The hard coating layers allows the improvement of chip flow with a lowered coefficient of friction and reduced cutting force[23]. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA), and regression analyses are employed to find the optimal levels and to analyse the effect of the drilling parameters on hole diameter accuracy values. Taguchi method is desirable in this project due to its practicality in designing high quality systems that provide much-reduced variance for experiments with an optimum setting of process parameters[3].

1.2 Problem Statement

Nowadays, the industry is facing a problem to machine hard materials such as AISI D2 Tool Steel. D2 tool steel with hardness in the range of 54-62 HRC has a high strength, very high resistance to cracking and high resistance to softening and wear. This is due to its typical composition which consist of 1.55% Carbon(C), 0.3% Silicon(Si), 0.4% Manganese(Mg), 11.8% Chromium(Cr), 0.8% Molybdenum(Mo) and 0.8% Vanadium(V). However, it is favourable by industry due to several applications such as stamping or forming dies, punches, molds, forming rolls, tools and etc[1]. Besides that, the usage of cutting fluid also has been considerate. Metal working fluids has been found causing very much damage to employee health and environmental pollution. High production volume, the large number of occupationally-exposed workers, and the lack of carcinogenicity and chronic toxicology data of metal working fluids demands a careful scrutiny. The cleaning process is difficult and requiring the use of cleaning solvent. The growth of bacteria and yeast becomes environmentally hazard and waste disposal of cutting fluids are quite expensive[4,5]. Thus, there is no application of cutting fluid during the hole drilling process.

1.3 Objective

The objectives of this project are:

1. To study the significant factor affecting diameter accuracy in dry drilling

2. To optimize the parameters of Computer Numeric Control (CNC) machine for dry drilling process.

1.4 Project Scope

In this project, there are several scopes to be considered in order to achieve the objectives. The material block to be machine is AISI D2 Tool Steel with size of 200mm × 200mm × 13mm by using Computer Numeric Control (CNC) milling machine. The numbers of holes to be drilled are 54 holes and each parameter will be drilling for 6 holes using the same cutting tool. There are 3 types of drill bit to be used which are High Speed Steel coated with Titanium Nitride (TiN), High Speed Steel coated with Titanium Carbon Nitride (TiCN) and High Speed Steel coated with Titanium Aluminium Nitride (TiAlN). The thickness of coating is in a range of 3-6µm. The coating process to be used is Physical Vapor Deposition (PVD). It is a vaporization coating technique involving transfer of material on an atomic level. This process is carried out under vacuum conditions that involving four steps which are evaporation, transportation, reaction and deposition[9]. The diameter of each drilling bit is the same which is 11mm. Coordinates Measuring Machine (CMM) will be used to measure the accuracy of hole diameter and Minitab software for the analysis process. There is no application of cutting fluid during the drilling process.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, there will be some discussion of the research background which is related to the project. The literature review is a text of a scholarly paper which consists of the current knowledge including substantive findings as well as theoretical contributions.

2.1 Drilling Process

Hole making is one of the most important operations in manufacturing industry whereby drilling is the major and common process. It is used to cut a hole into a work piece. The machining process which called as material removal process is done by creating features on desired part by cutting away the unnecessary material. It requires a machine, work piece, cutting toll and fixture to hole the work piece tightly. Various types of machines can be used to perform a hole making process for instance, CNC milling machine and CNC turning machines.

There are also an equipment which is specialized for hole making such as drill presses and tapping machines. Hole making operations are typically performed amongst many other operations in the machining of a part. However, it can be performed as a secondary machining process for an existing part like forging or casting. It can be done in order to add features which were too costly to form during

primary process or to improve the surface finish as well as the tolerance of the holes. Hole is a cylindrical feature that is machine onto the work piece by a rotating cutting tool which enters the work piece axially during machining. It has the same diameter as cutting tool and match geometry.

A non-cylindrical features or pockets can also be machined, but they require end milling operations instead of hole making operations. Though all machined holes possess the same basic form but they are differ in many ways according to the application given. It can be characterized by different features or parameters to determine the type of hole making process and tool required such as diameter, tolerance, depth, thread and recessed top. There are several hole making operations available which used a different type of cutting hole to form a different type of hole for example, drilling, reaming, tapping, boring, counter-boring and counter-sinking[26].

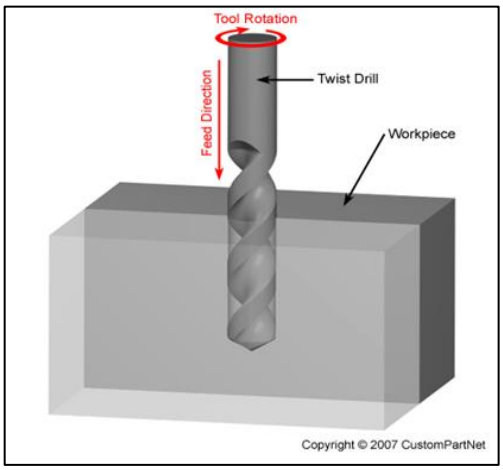
Drilling operation involved cutting process of using a drill bit in a drill to cut or enlarge holes in solid materials like metal or wood. The methods and tools selected to be used for drilling is depend on the type of material, the size of the hole, the number of holes, and the time to complete the operation. This operation most frequently performed in material removal and usually used as a preliminary step for many operations such as tapping, reaming and boring. The cutting process in which a hole is originated or enlarged by means of a multipoint, fluted, end cutting tool. A drill bit enters the work piece axially and cuts a blind hole or a through hole with the equal diameter as the tool.

The material removal is in form of chips which move along the fluted shank of the drill and its happened during the drill is rotated and advanced into the work piece. Figure 1 shows the drilling operation on to the work piece. The adjustment of feed rate may result in a range of different size and shape of chips although long spiral chips are the usual result. Besides that, work piece material also influence the sizes and shapes of chips generally, the hole diameter produced are oversize or

slightly larger than the drill diameter. The amount of oversize is depend on the drill quality and the equipment used as well as machinist skill[25].

The mechanical properties of the work piece may be affected by the existence of low residual stresses around the hole opening and a formation very thin layer of highly stressed and disturbed material on the newly formed surface in drilling operation. It causes crack propagation at the stressed surface and makes the work piece to become more susceptible to corrosion. However, the detrimental conditions can be avoided by performing a finish operation.

Figure 2.0: Drilling Operation



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