UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF DRILLING PROCESS USING NANOFLUID

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process)(Hons.)

by

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ABSTRAK

Cecair nano merupakan satu formula baru bagi cecair pemotong yang digunakan dalam pemesinan bertujuan untuk mendapatkan hasil kemasan permukaan produk yang lebih baik. Ia juga mempunyai daya tahan haba yang tinggi berbanding cecair pemotong konvensional. Oleh itu, penyelidikan kesan cecair nano terhadap proses penggerudian telah dilakukan. Objektif kajian ini adalah untuk menyiasat prestasi lubang digerudi (kekasaran permukaan, ketepatan dimensi dan pembentukan gerigi) menggunakan (karbon nanofiber dicampur dengan air ternyah ion) cecair sebagai cecair pemotongan semasa proses penggerudian dan akhir sekali untuk membandingkan kesan cecair karbon nanofiber dan air ternyah ion terhadap kualiti pemesinan. Lima kepekatan karbon nanofiber yang berbeza iaitu 0%, 0.25%, 0.50%, 0.75% dan 1% telah digunakan dalam kajian ini. AISI 304 keluli tahan karat digunakan sebagai bahan kerja. Kelajuan pemotongan dan jumlah cecair karbon nanofiber adalah kekal malar yang masing-masing 120 rpm dan 3.8 ml. Beberapa peralatan yang sesuai telah digunakan untuk mengukur kekasaran permukaan dalam lubang digerudi, ketepatan dimensi dan pembentukan gerigi. Hasil kajian menunjukkan bahawa dengan menambah karbon nanofiber ke dalam cecair asas boleh membantu untuk meningkatkan prestasi lubang yang digerudi. Berdasarkan hasil keputusan kekasaran permukaan, peningkatan kepekatan cecair karbon nanofiber memberikan kadar kekasaran permukaan paling rendah iaitu 2.54 µm. Apabila menggunakan cecair nano CNF, ketepatan dimensi lubang yang digerudi memberikan perbezaan nilai purata yang paling sedikit antara lubang masuk dan lubang keluar berbanding tidak menggunakan cecair nano CNF. Perbezaan saiz

purata apabila menggunakan 0.25% CNF adalah 0.0624 mm. Selain itu, sedikit ketebalan gerigi dilihat iaitu 0.01 mm apabila 0.75% cecair nano CNF digunakan.

ABSTRACT

Nanofluid is one of the new formulation of cutting fluid used in machining in order to obtain better surface finish of products. It also has high thermal conductivity compared to conventional cutting fluid. Hence, in this study, the effect of nanofluid to the performances of drilling process were investigated. The objectives of this study is to investigate the performances of drilled hole (surface roughness, dimensional accuracy and burr formation) using nanofluid (carbon nanofiber mixed with deionized water) as cutting fluid during the drilling process and lastly to compare the machining performance using carbon nanofiber nanofluid and deionized water. Five different concentrations of carbon nanofiber which is 0%, 0.25%, 0.50%, 0.75% and 1% were used in this investigation. AISI 304 stainless steel was used as the workpiece. The cutting speed and volume of carbon nanofiber nanofluid were remained constant which is 120 rpm and 3.8 ml respectively. The appropriate equipments were used to measure the surface roughness inside drilled holes, dimensional accuracy and burr formation. The result shows that by adding carbon nanofiber to base fluid can help to improve the performances of driled holes. Based on surface roughness result obtained, when the presence of CNF concentration increased up to 0.75% the lowest surface roughness which is 2.54 µm was obtained. The dimensional accuracy of drilled hole in term of total different diameter of entry and exit hole with the presence of CNF nanofluid gives smaller value of diameter deviation compared to without presence of CNF particles. With the presence of CNF 0.25% give least average of different size 0.0624 mm. Besides, less of entrance burr width was observed with the thickness of 0.01 mm by applying 0.75% of CNF nanofluid.

DEDICATION

To my beloved late father, mom and siblings.

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First and foremost, I would like to express my greatest gratitude to Almighty God for giving me strength and courage to finally complete my bachelor degree project with the best I could. Indeed, without His Help and Well, nothing will be accomplished.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AISI	-	American Iron and Steel Institute
Amp	-	Amplitude
CNC	-	Computer Numerical Control
CNF	-	Carbon nanofiber
CNT	-	Carbon nanotube
Cr	-	Chromium
DIW	-	Deionized water
MQL	-	Minimum Quantity Lubrication
MWF	-	Metalworking fluid
NC	-	Numerical Control
ND	-	Nano Diamond
O/W	-	oil-in-water
PVP	-	Poly vinyl pyrrolidone
Ra	-	Surface Roughness
RPM	-	Revolutions per Minutes
SiO_2	-	Silicon oxide
W	-	Weight
ø	-	Concentration

ρ	-	Density
x	-	Mass

CHAPTER 1

INTRODUCTION

This section basically describes the introduction of the project. It includes backgrounds, problem statement, objectives and the scope of this project. The investigation of drilling process using nanofluid is involved in this project.

1.1 Background

Drilling is known as the most common machining process where the process is involved in making of cylindrical holes in metallic and non-metallic materials. The main function of holes is for assembly such as screws and bolts part. This process mainly described as a process where a multi-point tool is used to remove unwanted materials. It is broadly used in the aircraft, aerospace and also automotive industries. However, the cost of making a hole is among the highest machining process. During the operation, chips that are produced within the workpiece must exit through the flutes to the outside of the tool. During the operation, friction will generate when the chip is formed and extracted towards the surface (Aaron et al, 1989).

Generally heat is produced when the drill tool touches the workpiece during the operation. Thus, cutting fluids is the most important elements to be considered during this operation. The main purpose of cutting fluids is cooling the workpiece, reduce friction and prevent the chips produced during the process. Besides, cutting fluids also help to avoid the machined surface from corrosion and reduce the cutting forces during the process consequently can save the source of energy. However, the using of cutting fluids in machining come with a number of disadvantages. The cutting fluid expenses are more expensive compared to the tool-related costs (Astakhov, 2008). Usually, most of the cutting fluids will possess the health hazard to the operator. Dispose of the used for cutting fluid is also a major challenge. In the recent past, there has been a general liking for dry machining (Sreejith and Ngoi, 2000). Besides, several researchers started exploring the application of minimal cutting fluid during machining operation.

In this investigation, carbon nanofiber nanofluids is used as a cutting fluid during the drilling operation of AISI 304 stainless steel.

1.2 Problem Statement

Machining is one of the most capable methods used in manufacturing to produce workpiece with good surface finish and quality. Drilling process is the most widely used manufacturing processes for the production of making cylindrical holes in any type of materials. However, the high temperatures produced due to friction during drilling operation badly affect the quality of workpiece in spite of the use of cutting fluids. Surface roughness, dimensional accuracy and burr are generally classified as hole quality. According to Haron et al. (2009), bad quality of surface finished are formed due to the extensive tool failure and chipping at the cutting edge of cutting tool. Furthermore, the rejection of part is due to the poor hole quality as the holes are drilled in the finished product, thus give impact results in manufacturing loss. This will finally increases the manufacturing costs and decreases the production rate of products (Hocheng, 2005). There is some ways to avoid the negative effects of conventional cutting fluids which is approach modern cutting fluids gifted with user and eco friendly properties.

In this day and age, the formulation and performance of modern cutting fluid such as nanofluids are one of the alternatives to conventional cutting fluids in drilling process. In this study, carbon nanofiber mixed with deionized water has been used as a cutting fluid during the operation of drilling. On the other hand, there is the consideration of output responses for drilling process such as quality of drilled hole. The output responses are important to determine the performance of the final product after the drilling operation is done.

1.3 Objective

The main purpose of this study is to do an investigation of drilling process using nanofluid.

The objectives of this study is :

1. To investigate the performance of drilled holes (surface roughness, dimensional accuracy and burr formation) using nanofluid (carbon nanofibers mixed with deionized water) as cutting fluid during the drilling process.

2. To compare the machining performance using carbon nanofiber (CNF) nanofluid and deionized water.

1.4 Scope of Study

In this study, the main focused is on investigation of drilling process using nanofluid. Nanofluid is the billions of fine nanoparticles in a base fluid. Carbon nanofibers mixed with deionized water has been uses as a cutting fluid during the process of drilling. The type of material for workpiece and drill bit are AISI 304 stainless steel and 7.5 mm HSS twist drill, respectively. All of the findings are depend on the performance of drilled holes achieve after the drilling operation is done.

CHAPTER 2

LITERATURE REVIEW

This chapter contains the literature review of the project which is related to the objectives and scope of the project. This chapter also explains about the literature review that will be used in this entire investigation. The literature is depends on the journal that summarized all the information for every important element that has referred for this investigation. All of them are described in this chapter.

2.1 Drilling

Drilling machine comes in various shapes and sizes, from small hand-held power drills to bench mounted and finally floor-mounted models. Drilling machines also can perform other operation such as countersinking, counter boring, reaming, and tapping large or small holes. Drilling machine which known as a drill press is used to cut holes into or through metal, wood, or some other materials. Drilling machines use a drilling tool that has cutting edges at its point which is held in the drill press by a chuck or Morse taper and is rotated and fed into the work at variable speeds. Other operation such as countersinking, boring, and counter boring, spot facing, reaming, and tapping can be performed by using drilling machine (Kalpakjian, 2008).

2.1.1 Tooling for drill bit

The most common cutting tools used during drilling operation are twist drills. Twist drills used for the making of hole probably have one of the most complex shapes in machine tooling (Kadam et al., 2011). Twist drills can produce round holes rapidly and precisely in all materials during the drilling process. Twist drills equipped with the helical flutes or grooves that wind around the body from the point of the neck of the drill and appear to be twisted (Figure 2.1). Twist drills are simply constructed, but they are very strong designed to withstand the high torque of turning, the downward pressure of the drill and the high heat produced by friction.

Basically, two types of twist drills used in manufacturing which are high speed steel drills and carbide tipped drills. However, the most common type used is high speed steel drills due to lower cost. Usually, carbide tipped drills are used in production work where the drill must remain sharp for some periods. Twist drills are classified into two which are straight shank or tapered. Usually, straight shank twist drills are ½ inch or smaller and tit into the geared drill chucks. Tapered shank drills are used for the larger drills that need more strength which is provided by the taper socket chucks. Figure 2.1 shows the nomenclature of twist drill (Kalpakjian, 2008).

Kalpakjian (2008) has pointed out the standard point twist drill is the most common drill used . The main characteristics of the drill point are a point angle, a lip-relief angle, a chisel-edge angle, and lastly a helix angle. The geometry of the drill tip is such that the normal rake angle and velocity of the cutting edge vary with the distance from the center of the drill. Furthermore, the step drill, core drill, counterboring and countersinking drills, center drill, and spade drill are the other types of drills classifications. Figure 2.2 shows the various types of drills and drilling operations.

According to Boothroyd and Knoght (2006), twist drill is the most commonly used tools in drilling operation. It is available from 0.25 mm to 80 mm in diameters. The main feature is the combination of both cutting and extrusion of metal at the chisel edge located at center of the cutting tool. The high thrust caused by the feeding motion cause the metal under the chisel edge was extruded. After that, it shears under the action of the negative rake angle of tools. The cutting action on the chisel edge has been found to be closer to that of orthogonal cutting at relatively high negative rake angles and very low cutting speeds thus, discontinuous chip formation is produced during machining (Bilalis et al., 2011).

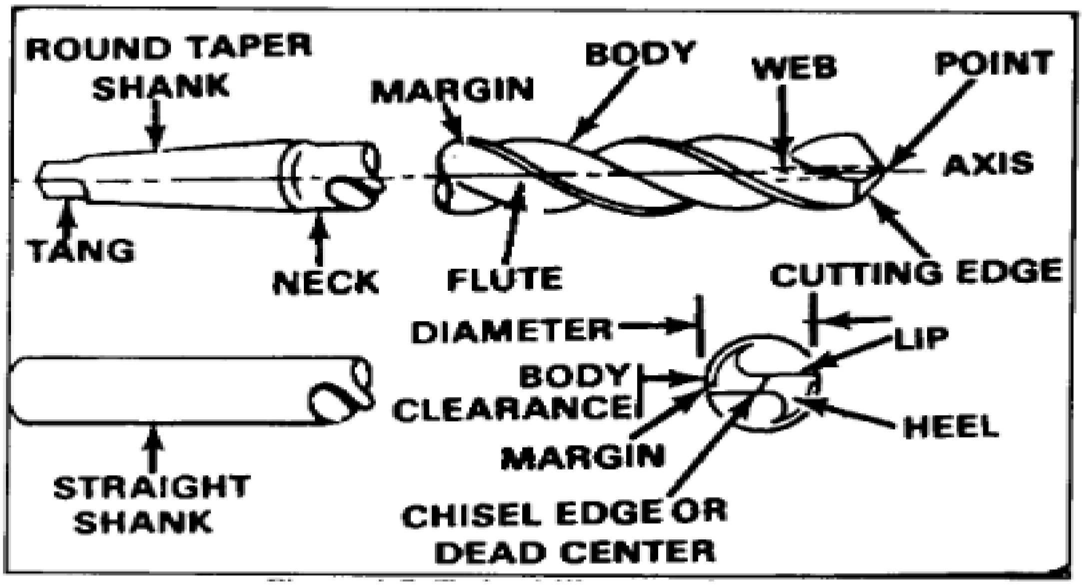

Figure 2.1: Nomenclature of twist drill (Kalpakjian, 2008).

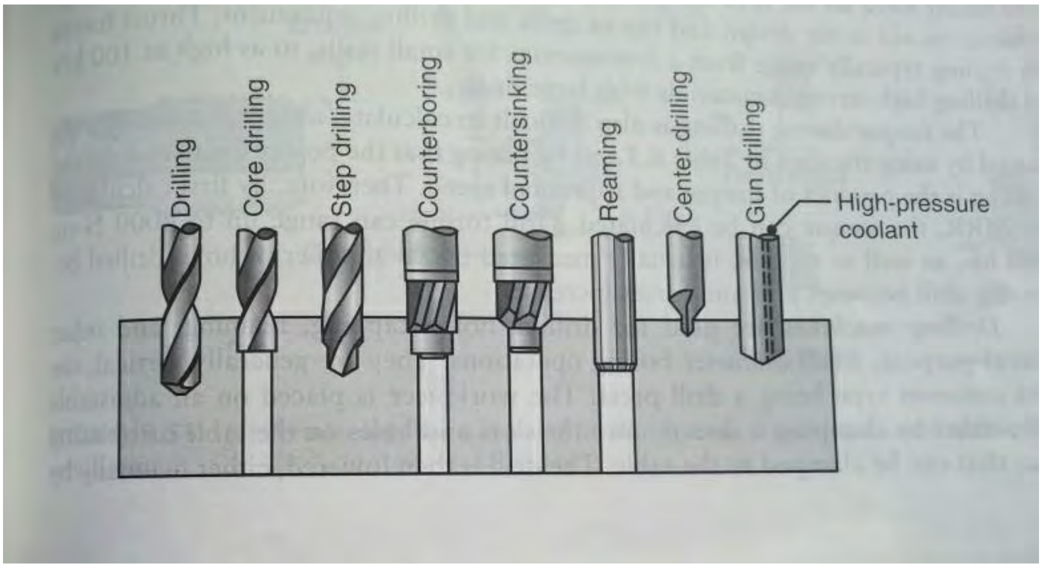

Figure 2.2: Various types of drills and drilling operations (Kalpakjian, 2008).

2.2 Parameter

The performance of the drilled hole is influenced by drilling parameter such as cutting speed and type of coolant.

2.2.1 Cutting Speed

High cutting speed can effect in the performance of the drilled hole. When cutting speed increase, the workpiece materials may be lacerating due to high temperature. Besides, increasing in cutting speed will effect the roughness of drilled surface which resulting in bad shape of hole. The important factor to produce best quality of drill hole are drilling vibrations and the chatter (Kurt et al., 2007).

Kaware (2003) outlines that most metals are drilled at slow speeds around 300-900 rpm. But soft metals such as pure aluminium are an exception to the slow speed rule. These build up small particle deposites that stick to the drill bit's cutting edge. To reduce this problem a fast rotation speed can be apply together with a slow feed rate.

The height and the width of the burr were reduced at both entry and exit sides when apply a higher cutting speed during machining (Pilny, 2011). Besides, the burr height and width increase on both sides with a more moderate trend up to a certain value where it stabilizes when higher feed rates was used. However, variation in burr formation was decreased when higher speed of cutting was used which leading to process stabilization.

Salomon (1931) as cited in (Kazban, 2005) claims that at a certain cutting speed the temperature of cutting was reached the peak. The temperature was decreased as well as the cutting speed increased. Thus, at high speed better cutting conditions are possible to be obtained.

2.3 Cutting Fluids

Main function of cutting fluid is to remove the formation of chips at cutting zone. Hence, the chips will not interfere with further processing. The cutting fluid act as lubricant to avoid chip tool interactions within the flutes. It also help to remove heat from the chips and tool and supporting in the evacuation of chips (Haan et al., 1996). Besides, according to Shaw (1958), heat removal of the cutting fluid influence the curl of the chip formed during machining operation. The cutting fluid is effective in cooling and lubricating workpiece (Liu et al., 2009). Its function as reducing friction among the cutting tools, chips and workpiece. Furthermore, its function to cooling the tools, chips and workpiece. Based on Cakir et al. (2007), generally the cutting fluids have three characteristics which included cooling effect, lubrication effect and wash away chip from adhered at the cutting zone.

Cutting fluids are important in machining due to their help to diminish the generated friction, cooling the workpiece and remove the chips that formed during machining. By applying cutting fluids, the tool wear decreases and improves surface performance of the workpiece. Besides, machined surface can be avoided from corrosion when cutting fluids is applied. The cutting forces can be minimize, thus saving the source of energy. According to Astakhov (2008), the cutting fluid costs are more expensive compared to cost of tool related.

In drilling process, friction between the drill and the workpiece will generates heat. This condition can affect the dimensional accuracy, surface finish, chip flow and quality of the part produced. Cutting fluid is used in the drilling operation as lubrication at the chip-tool interface and cooling. Table 2.1 shows the general properties for cutting fluids.

Table 2.1: General properties of cutting fluids (Boston, 1952)

No	Properties of cutting fluids
1	High thermal conductivity for cooling
2	Good lubricating qualities
3	High flash point, should not entail a fire hazard
4	Must not produce a gummy or a solid precipitate at ordinary working temperatures
5	To be stable against oxidation
6	Must not promote corrosion or discoloration of the work material
7	Must afford some corrosion protection to newly formed surfaces
8	The components of the lubricant must not become rancid easily
9	No unpleasant odor must develop from continued use
10	Must not cause skin irritation or contamination
11	A viscosity that will permit free flow from the work and dripping from the chips

2.3.1 Types of Cutting Fluids

There are two types of cutting fluids used in machining which are neat oils or straight cutting oils and water-mixed fluids. Water-mixed fluids are made up of three types which are emulsifiable oils, pure synthetic fluids and semisynthetic fluids.

2.3.1.1 Neat Oils

Neat oils are based on mineral oils. There are mixtures of mineral oil and animal, vegetable, or marine oils to improve the wetting and lubricating properties. Neat oils are generally blends of mineral oils and other additives. The most common additives used are fatty materials, chlorinated paraffin, sulfurized oils, and free sulphur. Sometimes organic phosphorous compounds are also used as additives. According to Trent (1984), extreme pressure additives containing chlorine, sulphur, or phosphorous react in the tool-chip interface producing metallic chlorides, phosphates, and sulphides, thus protecting the cutting edge.

According to Chiffre and Belluco (2002) vegetable cutting fluids gave superior or equal performance to that of mineral oil based cutting fluid. The comparison performance of cutting fluids for turning, drilling, reaming and tapping operation for austenitic stainless steel and other four materials is investigated in terms of cutiing forces, tool life and dimensional quality. Austenitic stainless steel used as a workpiece material for the different machining process under the different cutting conditions proved that vegetable cutting fluid is the best fluid for machining.

The tool life and tool wear mechanism of workpiece during milling operation were affected by the cooling and lubrication conditions which are flood of vegetable oil based emulsion, low flow of neat vegetable oil, neat vegetable oil in a flow of compressed air and dry cutting. By using low flood of neat vegetable oil, the tool life is more longer (Junior et al., 2009).

Rahim and Sasahara (2011) investigated the lubrication behaviour of palm oil using Minimum Quantity Lubrication (MQL) for a high speed drilling of Ti-6Al-4V and synthetic enter using MQL, air blow and flood conditions is used. The result proved that the performance on the cutting forces, temperature, power and specific cutting energy is better by using palm oil with the flood conditions compared to synthetic ester.

Khan and Dhar (2006) found that vegetable cutting fluids with Minimum Quantity Lubrication (MQL) depended on cutting speed and feed rate reduced with tool wear in the range of 5% to 12% with respect to dry cutting. MQL increase tool life and can give a better surface finish compared to dry cutting.

2.3.1.2 Water-Mixed Fluids

For water-mixed fluids, water quality have a large effect of coolant. High mineral content can cause stains and corrosion of machines and workpieces. Basically, water can be deionized to remove the impurities of minerals. The best fluid for cooling is water. Water has the best ability to carry heat away. Unfortunately, water is a very poor lubricant and may cause corrosion. Oil is excellent for lubrication, but very poor for cooling. Besides, it is also flammable. If water and oil are combined and an attempt is made to minimize the weakness and the best properties of both may be balanced to obtain the best end properties of cutting fluid. Table 2.2 shows the types of water-mixed fluids.