THE PERFORMANCE ANALYSIS OF HIGH SPEED STEEL TOOL IN HIGH SPEED DRILLING.

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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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Author's Name	:	Razif Bin Mudzlan
Date	:	29 June 2012

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The members of the supervisory committee are as follow:

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ABSTRAK

Pada masa kini, banyak industri mengamalkan penggerudian kelajuan tinggi dalam proses pembuatan mereka. Permintaan ke atas masa penghantaran dan peningkatan produktiviti pembuatan juga telah menyebabkan pengiktirafan proses penggerudian kelajuan tinggi. Keluli Berkelajuan Tinggi (HSS) adalah sejenis alat yang biasa digunakan dalam industri pembuatan. Ciri-ciri yang terdapat pada mata alat keluli halaju tinggi membolehkannya dirinya untuk menjadi salah satu alat yang terbaik disebabkan oleh ketahanan, kekuatan kepada hentaman, rintangan kepada kejutan haba dan juga tahan kepada retak adalah lebih baik daripada jenis matalat yang lain. Walau bagaimanapun, penggunaan mereka dalam penggerudian kelajuan tinggi masih boleh dipersoalkan. Objektif utama projek ini adalah untuk menyiasat pengaruh parameter pemotongan seperti kelajuan pemotongan dan kadar suapan pada kekasaran permukaan dan kehausan matalat dalam proses penggerudian kelajuan tinggi. Gerudi keluli kelajuan tinggi jenis putar berdiameter 7 mm yang boleh didapati dalam pasaran digunakan untuk menggerudi lubang pada bongkah Aluminium pada pelbagai kelajuan pengumpar di antara 10,000 rpm dan 18,000 rpm. Daripada keputusan didapati bahawa kelajuan pengumpar yang lebih tinggi dan kadar suapan yang rendah menghasilkan permukaan yang paling licin. Di samping itu, kelajuan pemotongan yang tinggi dan kadar suapan yang tinggi memberikan kadar kehausan matalat yang lebih tinggi. Didapati juga matalat keluli halaju tinggi tidak sesuai digunakan pada kelajuan pengumpar 18,000 rpm.

ABSTRACT

Nowadays, many of industry applied high speed drilling in their manufacturing process. The demand on time delivery and also increased manufacturing productivity has resulted in the recognition of high speed drilling process. High Speed Steel (HSS) is a common type of tool that use in manufacturing industries. The characteristic of HSS allowed itself to be one of the best tools because the toughness, impact strength, thermal shock resistance and also resist to fracture is better than the other type of tools. However, their implementation in high speed drilling is still questionable. The main objective of this project is to investigate the influence of cutting parameter such as cutting speed and feed rate on the surface roughness and tool wear in high speed drilling process. Commercially available High speed Steel twist drill bit of 7 mm diameter was used to drill holes on Aluminium block at the spindle speed range between 10,000 rpm to 18,000 rpm. From the results it was observed that higher spindle speed and low feed rate produced smoother surface. In addition high cutting speed and high feed rate gave higher tool wear rate. It is also found that HSS was not suitable to be used at spindle speed of 18,000 rpm.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND NOMENCLATURE

C	-	Carbon
CNC	-	Computer Numerical Control
CMM	-	Coordinate Measuring Machine
Co	-	Cobalt
Cr	-	Chromium
Fe	-	Iron
FYP	-	Final Year Project
HSM	-	High Speed Machining
HSS	-	High Speed Steel
M	-	Molybdenum
SEM	-	Scanning Electron Microscope
Ra	-	Mean Roughness
Ry	-	Maximum Peak of Roughness
Rz	-	Ten Point of Mean Roughness
RPM	-	Revolution per Minute
T	-	Tungsten
UTeM	-	Universiti Teknikal Malaysia Melaka
V	-	Vanadium

CHAPTER 1
INTRODUCTION

1.1 Background of Project

High speed drilling is one type of manufacturing process that needs a high speed to make a hole. The speed of the drilling process depends on the type of the material, hole size, tool size and much more. High speed drilling is a process that required a high speed of spindle that different from the common drilling process. High speed drilling is one type of high speed machining. High Speeds Machining (HSM) is one of the modern technologies, which in comparison with conventional cutting enables to increase efficiency, accuracy and quality of workpieces and at the same time to decrease costs and machining time (Pasko et al, 2011). This high speed drilling is usually used in manufacturing plants that require on time delivery and also industry with high manufacturing productivity. The use of HSM allows to shorten the production time and to increase the accuracy of machined parts (Pasko et al, 2011). This is because of the high speed drilling can produce hole of the workpiece faster than the common drilling process. The usage of high speed drilling can support demand for the product because the time of drilling process may reduce. The speed of drilling process is variable with the type of material. The high speed drilling is usually applied in the automotive industry. The usage of high speed steel in high speed drilling will give other result of wear and also tool life than the usage of ceramics and carbide tool. American machinist (2011) said that toolmakers need to design tools that prevent chips from coming into contact with the tool's cutting edges and flutes. This is because of the high speed drilling will produce a lot of chips that very hot because of the friction between tool and workpiece.

The chip that produced is very hot can soften and smear against the tool, filling in microscopic crevices in its edge surface and the usage of sufficient coolant can flush away the chips while if the coolant is not used, it can cause the tool wear and shorten tool life. The common tool that used in high speed drilling is carbide because of the smaller grains resist wear with less of a sacrifice in toughness (American Machinist,2011). The usage of high speed steel in high speed drilling is very rare due to the properties. The results of tool wear and tool life of HSS by using high speed drilling is very different from carbides, ceramics, and also the other coated tool that can cause a very high cost.

Tool wear is one of the characterizations that most studied to ensure that that the process become more efficient. Nowadays, there are many types of tools that used in manufacturing plants. One of the process that used tools to machine the material is drilling. Drilling is a type of process to make holes and it is among the most important operations in manufacturing (Kalpakjian and Schmid, 2010). The most common tool that used in manufacturing is High Speed Steel (HSS) tools. Tool wear is the important knowledge that must know by every manufacturer in order to make the usage of the tool can be maximized. During drilling, the tools remove material from the material to achieve the required design, shape of the hole and also the surface roughness of the hole. However, wear occurs during the drilling process and this will ultimately result in the failure of the drilling tool. The tool wear can affect the result of the surface roughness of the drilling hole. The main objective of this project is to verify how all of these parameters will influence the tool wear and also the hole quality such as the surface roughness. In this project, the drill speed will used the high speed and the material that used in this project is aluminium. Aluminium is widely used to make product.

1.2 Problem Statement

High speed drilling is a process that needs the spindle rotate very fast. Nowadays, many of industry applied high speed drilling in their manufacturing process. High speed drilling and also tooling has the relationship. The most common tools that used in high speed drilling are carbides and ceramics which can cause a rapid tool wear. High speed drilling will produce higher tool wear than the conventional method. The suitable speed and also the other parameter such as feed rate will make the tool life become longer and also the tool did not easily to wear. The rapid tool wear will make the tool life become shorter. The shorter tool life will increase the production cost because the tool is changed frequently to ensure that the part that produce is in quality. The focus tool that used in this project is HSS tool. HSS has now used for many years because the characteristic itself that resist to fracture, high toughness, wide range of roughing and also good for interrupted cuts (Kalpakjian and Schmid, 2010). Based on the characteristic of HSS that stated by Kalpakjian and Schmid, HSS can be used in high speed drilling process, but need to study the tool wear and also the hole quality including the surface roughness.

1.3 Objectives

The objectives for analysis high speed drilling with HSS tools are:

(a) To study the effect of high speed drilling process on tool wear.
(b) To investigate the influence of cutting speed on surface roughness in high speed drilling.
(c) To study the influence of feed rate on surface roughness in high speed drilling.

1.4 Scope of Project

The research was conducted within the following limits:

(a) Commercially available High speed Steel twist drill bit of 7 mm diameter.
(b) Work material used was Aluminium 6000 series.
(c) High speed range used are between 10,000 rpm to 18,000 rpm.
(d) The drilling process is not used any lubricant.
(e) The effect of high speed drilling will be based only on surface roughness and tool wear.

1.5 Report Outline

This report writing consists of five chapters for the whole FYP. The chapter one is explaining about the introduction which is includes the project background, problem statement, objectives of the project, scope of the project and the significant of this study. Then the chapter two was stressed on the literature review of the related issue in this project. Meanwhile, chapter three is more about the project methodology which has included the process planning for this project, flowchart, data gathering method and data analysis technique in this report. Chapter four explains about the result and discussion while in the last chapter explained about the conclusion and recommendations.

CHAPTER 2
LITERATURE REVIEW

2.1 Manufacturing Process

The manufacturing process that is used in this project is high speed drilling where the speed of this process is different from the conventional drilling.

2.1.1 High Speed Drilling

The meaning of high speed drilling is the drilling process is at high speed. The high speed of the drilling process is changing from time to time. Some manufacturer defines high speed drilling as drilling at spindle speeds fast enough for penetration rates that are three to ten times greater than those considered conventional (American Machinist, 2011). It is faster than usual drilling process. Because of the usage of high speed drilling, there are many problems that occur in the process like the coolant is not sufficient to remove the chip that produced, that can cause sticking to the tool and also make the tool life short. In this high speed drilling process, the tool that suitable for this process is carbide and ceramics, this material is the trade of high speed steel which has greater wear resistance and also heat resistance. The demand on time delivery and also increased manufacturing productivity has resulted in the recognition of high speed drilling process (Farid et al, 2011). This shows that high speed drilling process is really helping to improve productivity of the industry. This also helps to achieve on time delivery which need to produce parts quickly. For the

speed of spindle that exceeds 10,000 rpm, the drill and also the tool holder can be critical (American Machinist,2011).

Table 2.1: Differentiation between type of speed (Kalpakjian and Schmid, 2010).

Type of speed	Speed (m/min)
High Speed	600 – 1,800
Very High Speed	1,800 – 18,000
Ultra high Speed	18,000

Based on the table above, there is differentiation between the types of speed. For this project, we used high speed drilling which is 600 to 1800 m/min. Now, spindle rotational speeds in machine tools can range up to 50,000 rpm (Kalpakjian and Schmid, 2010). Sharma (2011) stated that the high speed machining starts from 700 to 1500 m/min. However, the spindle speed depends on the workpiece material that used. (Sharma, 2011).

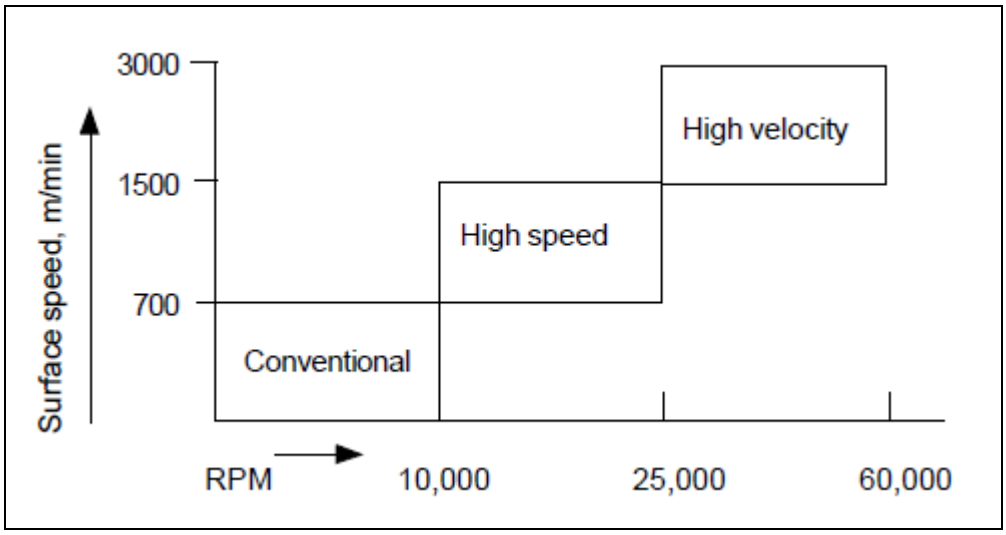

Figure 2.1: Conventional, High speed, and High velocity machining (Sharma, 2011).

2.1.2 Twist Drills

The most common type of drill used today is a twist drill. This type of drill is made with two or more flutes that used for removal of chips and also allow lubricant or coolant to get down to the cutting edge. It's also made from two or more cutting lips and also has many varieties of design.

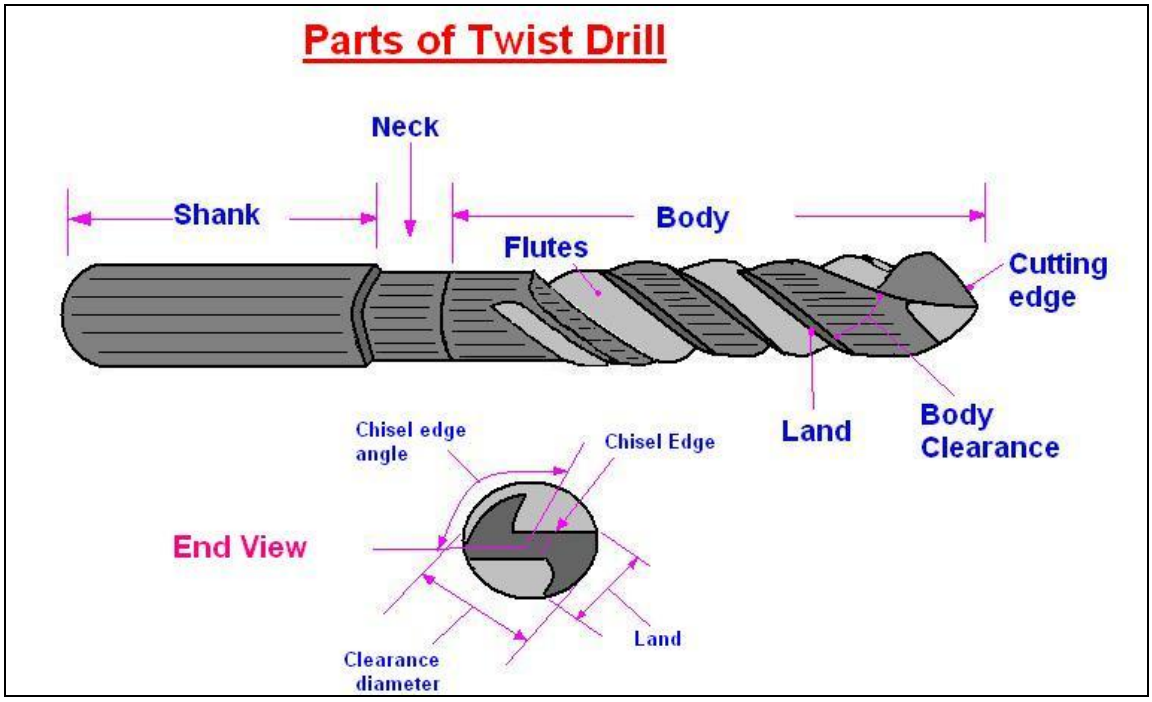

Figure 2.2: Parts of twist drill.

There are several features of the twist drills. The function of flutes is to remove the chip that produced while drilling process and also it allow the coolant to pass the tool and get down to the cutting edge. The function of body clearance is to cut down friction between the drill and the wall of workpiece. The shank part will clamp in the spindle that the shank may be either straight or tapered. There are different of straight and tapered shank. The straight shank is used with a chuck while the tapered shank has self-holding tapes that fit directly into the drill press spindle (Kibbe et al, 2010).

2.1.3 High and Low Helix Drills

High or low helix drill is based on the rake angle of the drills either it is small or large. High helix drills also known as fast spiral drills are designed to remove chips from the deep hole of the workpiece. High helix drill means the rake angle of the drill is large that will make this drill suitable for soft metals such as aluminium and also mild steel (Kibbe et al, 2010). This type of helix also suitable for thin material. Low helix drills also known as slow spiral drills can stand more torque because of it is more rigid than standard helix drills. The flutes of this low helix drills do not remove chips well from deep holes, but large chip space allows maximum drilling efficiency in shallow holes (Kibbe et al, 2010). Below is the figure that shows the high and low helix drill.

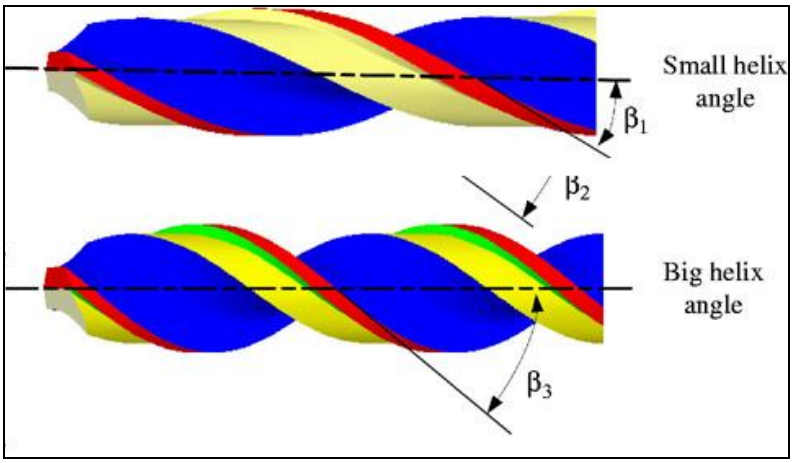

Figure 2.3: Small (low) and big (high) helix angle (Fu et al, 2010).

2.1.4 Drill Design

Drill design of high speed drilling to drill aluminium workpiece is different from the conventional method and also to drill other workpiece material. One drill design for drilling aluminium at high speed has a rolled-heel flute form with 4 facets overlapping radius split point (Sharma, 2011).

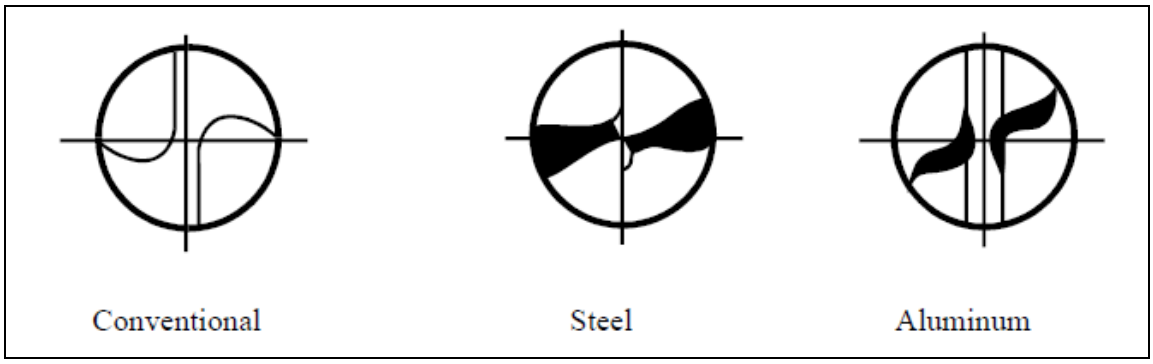

Figure 2.4: Differentiation of tool design (Sharma, 2011).

The reason of the design is to optimize chip formation and evacuation to prevent welding of the aluminium to the chisel, which due to excessive heat produced (Sharma, 2011). The spiral angle also different to remove the chips quickly. The most effective design for drilling aluminium is a slower spiral of 12 degrees at speed about 10,000 rpm (Sharma, 2011). This result is got after conduct some test.

2.1.5 Differentiation between conventional and high speed

There is some differentiation between these conventional methods and high speed machining (drilling). The speed, workpiece change time, and also tool change time is different. The difference between them as shown in the table below:

Table 2.2: Differentiation between conventional and high speed (Sharma, 2011)

Features	Conventional	High speed
Workpiece change time, sec	5-10	3
Axes travel and positioning time -rapid traverse speed m/min.(degrees/sec)	20(130)	40(330)
axes acceleration m/s^2	1 to 1.5	6.5
Tool change time, sec	4	0.8
Workspindle acceleration time, sec - 0 to 10,000 rpm - 0 to 15,000 rpm	3 -	0.6 1.0
Speed behavior of CNC -block change time millisec -cycle time of PLC per 1000 instructions, millisec	50 16	10 1
Machining time influencing factors - spindle speed, rpm - internal coolant feeding pressure, bar	10,000 20	15,000 70

2.2 Tool Material – High Speed Steels (HSS)

This project is to study the tool wear and also tool life of HSS by using high speed drilling process. HSS is the common tool that used in the drilling process.

2.2.1 Definition

HSS is a common type of tool that use in manufacturing. It has been developed in 1900's and HSS was developed to machine at higher speed than was previously possible (Kalpakjian and Schmid, 2010). HSS contain significant amounts of Co, V and Cr besides Fe and C (Black and Kohser, 2008). HSS nowadays is used as cutting tools and also drilling tool.