UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Tools Performance of 22MnB5 Boron Steel Cutting Tools during Turning Machining with Aluminium Alloy (AA 6061)

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

by

AINA NADIA BINTI MOHAMAD SAUFI

B051610252

951223-11-5328

FACULTY OF MANUFACTURING ENGINEERING

2020

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **Tools Performance of 22MnB5 Boron Steel Cutting Tools during Turning Machining with Aluminium Alloy (AA 6061)**

Sesi Pengajian: **2019/2020 Semester 2**

Saya **AINA NADIA BINTI MOHAMAD SAUFI (951223-11-5328)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh:

PROF. MADYA IR. DR. MOHD HADZLEY BIN ABU BAKAR
Ketua Jabatan
Jabatan Teknologi Industri
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Alamat Tetap:
B9/1/3 Flat Polis Padang Hiliran,
Jalan Sultan Mohd,
21100 K. Trg, Terengganu.

Tarikh: 8 SEPTEMBER 2020

Cop Rasmi:

Tarikh: 8 SEPTEMBER 2020

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Tools Performance of 22MnB5 Boron Steel Cutting Tools during Turning Machining with Aluminium Alloy (AA 6061)" is the result of my own research except as cited in references.

Signature : ....

Author's Name : AINA NADIA BINTI MOHAMAD SAUFI

Date : 8 SEPTEMBER 2020

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

....

(PM Ir. Dr. Mohd Hadzley Bin Abu Bakar)

ABSTRACT

22MnB5 boron steel is a new material that possess high hardness and categorized as Ultra High Strength Steel. This project focused on the assessment of the tool life and tool wear mechanism during machining aluminum alloy (AA 6061) with 22MnB5 boron steel cutting tools under dry and wet conditions. 22MnB5 boron steel that prepared in the form of metal sheet tool was cut into round shape using laser cutting machine. The thickness of the 22MnB5 boron steel was set at 2.6 mm with diameter 12 mm according to the RNGN 120300 cutting tool designation. Machining test were held at constant 40 seconds machining period with the 100-500 m/min cutting speed, 0.1 mm/rev feed rate and 0.5 mm depth of cut. The results show that 22MnB5 boron steel capable to machine AA 6061 with at the cutting speed of 100-500 m/min with the tool wear demonstrated stabilized value between 200-350 m/min. For dry cutting, the tool wear varied from 0.15 to 0.27 mm while for wet cutting, the tool wear reduced to the range of 0.08-0.18 mm. Wear formation dominated with the formation of built up edge for dry cutting. Whereas, for wet cutting, wear formation appeared to be adhesive wear with minimum effect of built-up edge formation. This study presents the feasible application of 22MnB5 boron steel as cutting tool for machining low strength materials.

ABSTRAK

Keluli boron 22MnB5 adalah bahan baru yang mempunyai kekerasan tinggi dan dikategorikan sebagai Keluli Kekuatan Ultra Tinggi. Projek ini memfokuskan pada penilaian kehidupan alat dan mekanisme haus alat semasa pemesinan aloi aluminium (AA 6061) dengan alat pemotong keluli boron 22MnB5 dalam keadaan kering dan basah. Keluli boron 22MnB5 yang disiapkan dalam bentuk alat kepingan logam dipotong menjadi bentuk bulat menggunakan mesin pemotong laser. Ketebalan keluli boron 22MnB5 ditetapkan pada 2.6 mm dengan diameter 12 mm sesuai dengan sebutan alat pemotong RNGN 120300. Ujian pemesinan diadakan pada masa pemesinan 40 saat yang berterusan dengan kelajuan pemotongan 100-500 m / min, kadar suapan 0.1 mm / rev dan pemotongan kedalaman 0.5 mm. Hasil kajian menunjukkan bahawa keluli boron 22MnB5 mampu memesin AA 6061 dengan kelajuan pemotongan 100-500 m / min dengan kehausan alat menunjukkan nilai stabil antara 200-350 m / min. Untuk pemotongan kering, kehausan alat bervariasi dari 0.15 hingga 0.27 mm sementara untuk pemotongan basah, keausan alat dikurangkan hingga kisaran 0.08-0.18 mm. Pembentukan pakaian didominasi dengan pembentukan tepi yang dibina untuk pemotongan kering. Manakala, untuk pemotongan basah, pembentukan haus nampaknya memakai pelekat dengan kesan minimum pembentukan pinggir binaan. Kajian ini mengemukakan aplikasi keluli boron 22MnB5 yang layak sebagai alat pemotong untuk pemesinan bahan berkekuatan rendah.

DEDICATION

Only

my dear father, Mohamad Saufi Bin Abd. Halim

my beloved mother, Rosalina Bt Jamin

my lovers sister and brother, Nur Izzatie, Izzuwan and Nur Kamilia

Thank You So Much & Love You All Forever for providing me emotional and financially support, help, reinforcement and compassion

Love You All Everlasting & Thank You Very Much

ACKNOWLEDGEMENT

Alhamdulillah, praise to Allah, the Lord of the universe for giving me an ultimate strength to complete my studies as well as final year report despite all the challenges that I have to overcome throughout my Bachelor Degree studies. My utmost gratitude to my beloved parents (my mother, Puan Rosalina binti Jamin and my father, Encik Mohamad Saufi bin Abd. Halim) for their never ending supports, love, dream and sacrifice throughout my life. There are no words that can describe my commitment to all of them and my belief in my ability to reach my ambitions. My supervisor, Pm Ir. Dr. Mohd Hadzley Bin Abu Bakar for his invaluable guidance, continuous assist and constant encouragement in making this project become possible. His motivation always gives me strength. My sincere thanks go to all my colleagues and others lecture of Faculty of Engineering Manufacturing, who always had helped me in many ways and made my stay there pleasant and unforgettable. I also want to thank my dear siblings for their endless affection, enthusiasm and motivation. Last but not least, thank you for all the uncountable support together with encouragement in finishing this project.

TABLE OF CONTENT

TABLE OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATIONS

GDP	-	Gross domestic product
CNC	-	Computer numerical control
HSS	-	High Speed Steel
AlTiN	-	Aluminum Titanium Nitride
ANSI	-	American national standard institute
ISO	-	International organization of standard
CVD	-	Chemical vapor deposition
PVD	-	Physical vapor deposition
MAO	-	Micro-arc oxidation
Ra	-	Roughness mean
Rz	-	Roughness depth
SEM	-	Scanning electron microscope
Mn	-	Manganese
B	-	Boron
BUE	-	Built up edge
BUL	-	Built up lenght

LIST OF SYMBOL

cm	-	Centimeter
m	-	Meter
%	-	Percent
g/cm^3	-	Grams per centimeter cube
mm	-	Millimeter
kg	-	Kilograms
mm/min.	-	Millimeter per minute
s	-	Second
RPM	-	Rotation per minute
mm/rev	-	Milimeter per revolution

CHAPTER 1

INTRODUCTION

Introduction

This chapter describes the study's context, objective, problem statement and scope for this project. The type of material being used, type of machine uses and the machining performance that needs to be analysed will be delivered in background project. While the purpose addresses the mission required for this project and task to be completed, it includes all that this project is intended to do.

1.1 Background Project

Automotive industry is one of the biggest manufacturing companies in Malaysia. The example of it is Proton Holdings. Proton manufacture are able to design, assemble and manufacture car. According to the Local News by Anthony Lim (2019), last year the Malaysian automotive sector continued to contribute significantly to the economy, contributing 4.2% to the gross domestic product (GDP) of the country. In the automotive manufacture they are using machining operations. Machining operation is a method or way to cutting the material into the desired form to produce a specific component parts.

Turning, milling and drilling are the most common types of cutting activities (Patel et al, 2014). In major industrial activities such as automobile, aviation, medical, oil and gas, and nuclear, this method was implemented. Metal machining is taking a lead in today's manufacturing sector as there are numerous developments in new alloys and engineered metal that eventually lead to high strength, durability, and other material properties. Computer numerical control (CNC) machine is one of the types that are widely used in the industry. This CNC machine is controlled by computer programming and operate automatically. CNC machine can be separated into two variations, first CNC lathe machine and CNC milling machine. In this study, CNC lathe machines are used to run cutting process for aluminium alloy.

The car frame are made from 22MnB5 (boron steel) material. Boron steel is a material that can be classified under ultra-high strength steel that normally used as high performance car chassis. These materials possess high hardness that almost equivalent to high speed steel (HSS) enables this material could be promising in the machining application.

1.2 Problem Statement

Boron steel normally applied as car chassis. This material is three times stronger than the others galvanised steel that was used as a car chassis. The strength of 22MnB5 is almost similar like high speed steel (HSS). High speed steel is a common material that use as a cutting tools in machining operations. It is a good candidate for parts production with an ideal combination of high strength, wear resistance, durability and hardness due to their special physical and mechanical characteristics (Herranz, 2012).

Therefore, the innovation of 22MnB5 as cutting tools could be useful for machining operations. Besides, it also can protect the environment by reusing the car framework from the unused car at the scrap metal place. The car from the place usually will be split into small parts. By reusing the car framework it also could reduce waste of time, cost and human power.

1.3 Objective

Since boron steel is a hard steel. The use of boron steel can be improve to be applied in other processes such as machining process as cutting tools therefore the objective of this study is:-

1) To evaluate the tool life of 22MnB5 boron steel cutting tools under wet conditions.

2) To compare the surface profile of the cutting tools that undergoes dry and wet turning machining.

3) To assess the wear mechanism of 22MnB5 boron steel cutting tools under dry and wet conditions.

1.4 Scope

1) This study included the wear performance (tool life and wear mechanism) of 22MnB5 boron steel cutting tools that comes from car chassis scratch during machining with aluminium alloy.

2) The boron steel cutting tools will apply on CNC turning machine under dry and wet conditions.

3) This data from cutting tools wear performance with aluminium alloy will be examined and compared among both conditions.

CHAPTER 2
LITERATURE REVIEW

Introduction

The literature review was made to obtain the information related to the project developed. In this study, less based on projects done either directly or simply through insight. In the context of this research, the focus point on the material of cutting tools, the process to make the cutting tools and the outcomes of this study such as surface roughness and tool wear.

2.1 Boron Steel (22MnB5)

22MnB5 is typically used in the automotive sector. Due to its mechanical properties of the materials, it is apply as car framework. Rather than high strength, the materials need to be lightweight (Mohammad and Salwani, 2017). 22MnB5 is significantly used for endure car's body parts and safety-relevant parts such as impact protection, side, centre pillars, and bumpers or chassis parts. These materials contain high manganese and low carbon. Carbon steel hardened and strength will be increased by the presence of these alloy elements such as chromium, nickel, manganese, molybdenum, tungsten, boron and vanadium.

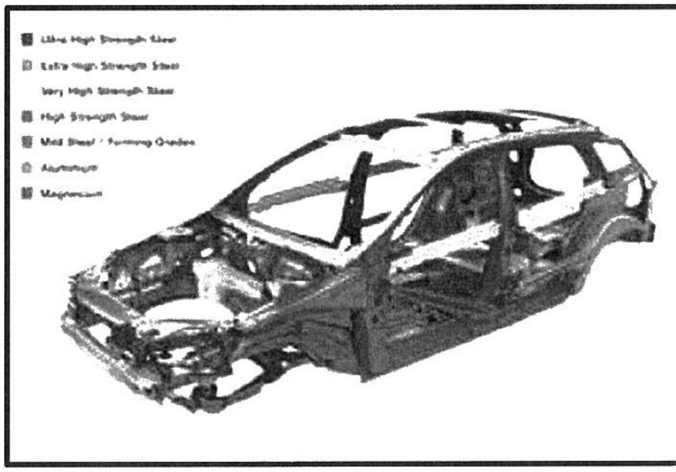

Figure 2.1: Boron Steel in Vehicle (http://rescue-org-ireland.com/resources/files/)

The purpose for appearance of manganese in all of carbon steel is to neutralize the action and it is very negative of the existence of sulfur and oxygen. Manganese disperses in the ferrite hardening it. These steels could be reaching until 45 and 50 HRC hardness, and the strength is between 1200 and 1500 MPa for tempered and quenching state. The elongation could achieve from 8 to 10% while the tempering state can goes generally between 1200 to 1500 MPa (Garcia and Criado Portal, 2015). Table 2.1 shows the properties of mechanical for boron steel.

Table 2.1: Mechanical Properties for boron steel (http://rescue-org-ireland.com/resources/files/)

Melting point	3,767 degrees Fahrenheit
Boiling point	7,232 degrees Fahrenheit
Yield point	1,300 – 1,400 N/mm2 (195,000 – 203,000 psi)

Chemical Element	Percentage (%)
Carbon, C	0.250
Silicon, Si	0.400
Manganese, Mn	1.350
Phosphorus, P	0.023
Sulphur, S	0.010
Aluminium, Al	0.080
Nitrogen, N	0.010
Chromium, Cr	0.250
Boron, B	0.004

Figure 2.2: Formation of 22MnB5 (Mohammad and Salwani, 2017)

The shortened of 22MnB5 ferrite transformation incubation duration significantly affected by isothermal deformation (Min et al, 2012). Moreover, (Li, Fu and Lin, 2014) state that the cooling process needed to be controlled strictly during the large hot deformation in hot stamping process so that the component become fully martensite.

2.2 Hot Stamping

Hot stamping or instead recognized as hot press process as shown in figure 2.3 is one of existing technology that make ultra-high strength steel that usually use in automotive manufacturing such as door beams, beams of effect, beams of reinforcement, supports, rails of the roof and tunnels. Hot stamping is the forming process that is working above the recrystallization temperature.

The tensile strength for hot stamping steels could achieved until 1500 MPa that give ultrahigh strength with light weight products and it was the reason behind the evolution of hot stamping techniques used throughout the automobile industry. Besides, the uniform elongation also has been reduced from 20% to 6%. In long production runs, hot stamping process could reach a good repetition without springback by (Muvunzia et al, 2017)

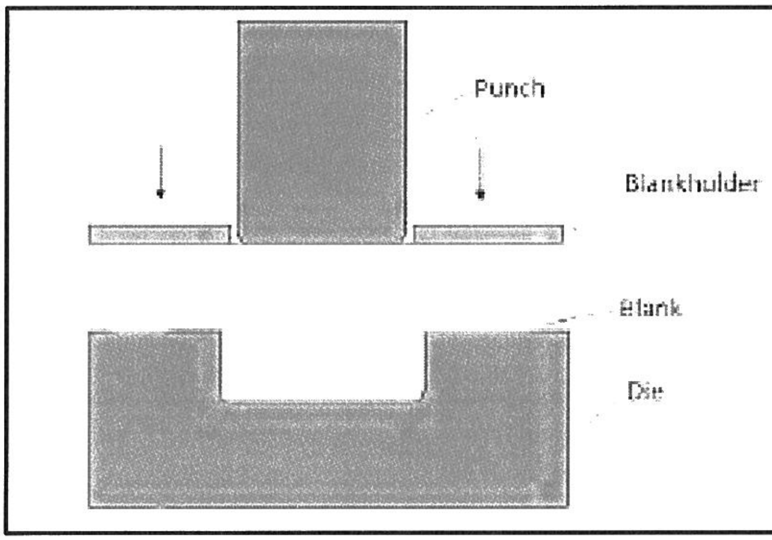

Figure 2.3: Hot stamping (Muvunzia et al, 2017)

2.2.1 Hot Stamping Process

Ganapathy et al, (2017) showed that the hot stamping process is started with the blanks or pre-formed components that are loading continuously through the furnace and then heating between 900°C - 950°C to reach austenite condition between three to five minutes. By (Aziz and Aqida, 2013), the microstructure for boron steel at the beginning before being processed by hot stamping process were ferrite-pearlite microstructure. The blanks are putting into the hydraulic press and disfigure into wanted shape. The cooled water has been used as an agent to minimize the time of cooling rate until the temperature gain totally martensitic transformation at the end of this process as being shown by figure 2.3 below. (Schemmel et al, 2015) write that the required range for cooling rate are 40-100°C/s to prevent surface oxidation from occurs.

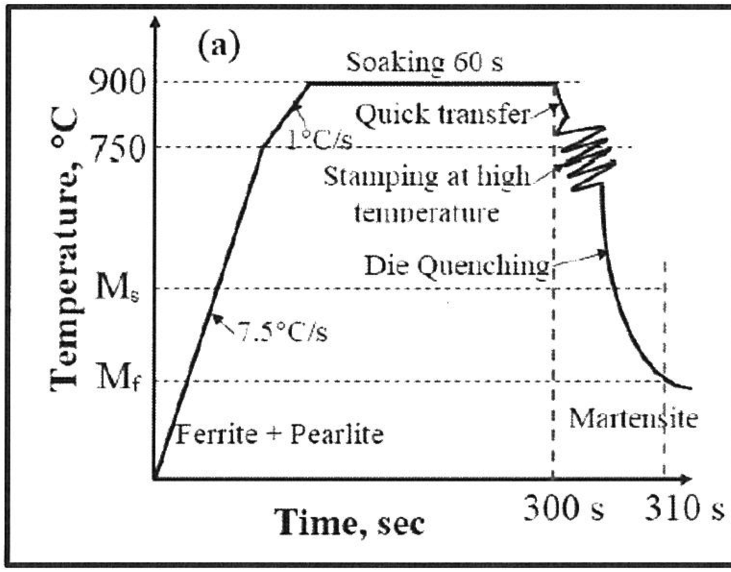

Figure 2.4: The typical stamping process (Ganapathy et al., 2017)

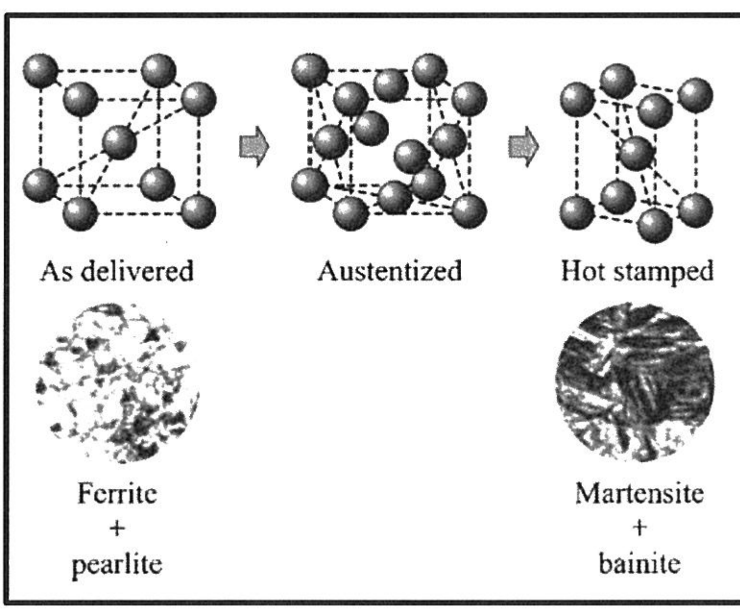

Figure 2.5: The schematics before hot stamping with ferrite and pearlite microstructures and the full martensitic microstructure after hot stamping (Karbasian and Tekkaya, 2010).

In the production lines, it can be divided into two variety of hot stamping process. The first one is direct hot stamping and the second one is indirect hot stamping line are commonly used (Shi, 2018).