UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TOOL LIFE OF HIGH SPEED STEEL HARDFACED WITH TOOL STEEL DEPOSITED BY GMAW

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

by

MUHAMMAD IZZUDDIN BIN MOHD NOH

B051210184

910923-01-6071

FACULTY OF MANUFACTURING ENGINEERING

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **TOOL LIFE OF HIGH SPEED STEEL HARDFACED WITH TOOL STEEL DEPOSITED BY GMAW**

SESI PENGAJIAN: **2014/15 Semester 2**

Saya **MUHAMMAD IZZUDDIN BIN MOHD NOH**

mengaku membenarkan Laporan 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:

_____ _____

Alamat Tetap:

593, Jalan Azam,
Taman Sri Lambak
86000 Kluang, Johor Darul Takzim

Cop Rasmi:

Tarikh: _____

Tarikh: _____

** 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 "Tool Life of High Speed Steel Hardfaced with Tool Steel Deposited by GMAW" is the results of my own research except as cited in references.

Signature : ……

Author's Name : Muhammad Izzuddin Bin Mohd Noh

Date : 1 June 2015

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) with Honours. The member of the supervisory committee is as follow:

…….

(Dr. Nur Izan Syahriah Binti Hussein)

…….

(Mohamad Nizam Bin Ayof)

ABSTRACT

The main goal of this project is to 'Study the Tool Life on Hardfaced High Speed Steel cutting tool' and also the parameters optimization in producing a better tool life using cutting speed and feed rate as manipulated variables and depth of cut, material of cutting tool, type of coolant and coolant direction as constant variables. Aiming to achieve this goal, several turning experiments were carried out with different cutting speed and feed rate. When the tool reaches its wear in between 0.3 to 0.35mm, the experiment was stopped. The wear was determined by using microscope. The present study tested the hypothesis that tool wear of hardfaced cutting tool are better when compare with as received cutting tool. The proposed method uses an Optical Microscope to measure the wear of the high speed steel cutting tool employed in single-point turning operation. The results of this project was the hardfaced cutting tool did gives better tool life compared with as received cutting tool.

ABSTRAK

Matlamat utama projek ini adalah untuk 'Kaji Hayat Alat pada Pelapisan Pemotong Alat Keluli Kelajuan Tinggi' dan juga pengoptimuman parameter dalam menghasilkan jangka hayat yang lebih baik menggunakan kelajuan pemotongan dan kadar suapan sebagai pembolehubah dimanipulasi dan kedalaman pemotongan, bahan alat memotong, jenis penyejuk dan arah penyejuk sebagai pembolehubah malar. Bertujuan untuk mencapai matlamat ini, beberapa eksperimen beralih dijalankan dengan kelajuan pemotongan yang berbeza dan kadar suapan. Apabila alat mencapai haus di antara 0.3 hingga 0.35mm, eksperimen dihentikan. Kadar kehausan ditentukan dengan menggunakan mikroskop. Kajian ini menguji hipotesis bahawa penggunaan alat-alat pemotong pelapisan adalah lebih baik apabila dibandingkan dengan yang alat memoton yang diterima seadanyag. Kaedah yang digunakan Mikroskop Optik untuk mengukur haus alat pemotong keluli kelajuan tinggi yang digunakan dalam titik tunggal operasi larikan. Keputusan projek ini adalah pelapisan alat pemotong memberikan hasil yang lebih baik berbanding dengan alat memotong yang diterima seadanya.

DEDICATION

To my beloved family…

ACKNOWLEDGEMENT

Alhamdulillah, praised to Allah for His blessings in giving me the opportunity to completing this report. To my parents, my mother and father, for continuous support. Without their prayers, I will never make it in completing this report. To my supervisor, Dr. Nur Izan Syahriah Bt Hussein, for guiding and motivate me in most of the step in completing this report. Without whom, this report may not be succeed. To my friends who always supporting me in my up and down and always helping when I ever in need of help.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

This section outlines the backgrounds of problems, problems statements, objectives, scopes, project organization and planning. In order to shows the problem existing in studying the tool life of hardfacing of cutting tools using gas metal arc welding method, the background of problem is stated and the problem statement are based on problem background. Due to the problem, this project is carried out to determine the results of the current situation. Objectives and scope of project is clearly stated in this section to ensure the project run together with the objectives and prevent the project from stray from its scope. Gantt chart provided for "Projek Sarjana Muda 1" (PSM 1) and "Projek Sarjana Muda 2" (PSM 2) to plan for the project activities and flow in two semesters.

1.1 Background

According to Erasteel Company (2010), High Speed Steels (HSS) are special steels that can perform at high rate performance and also having a high hardness at temperature near 500^{o}C. HSS are also high in wear resistant due to having alloying elements like molybdenum, tungsten, chromium and vanadium. All of those alloying elements are made from carbides. In certain special conditions where the hot hardness needs to be increase, cobalt may also be added. HSS usually used as cutting tools mainly due to its properties as stated before. Hardfacing method is methods that commonly used when we talk about cutting tools. It is a method of creating layers of material that has better mechanical properties on the cutting tool surface rather than make the whole cutting tool out of the same material. This is to reduce cost as material with better mechanical

properties usually is very high in cost. Hardfacing method also used to extent the tool life of the cutting tools and usually limited to either one, two or three layers. Various welding methods can be used in hardfacing methods and it is proven that hardfacing method especially by shielded metal arc welding and gas metal arc welding can increase the tool life by approximately two times compare to the original tool life. The HSS used for cutting tool are usually mediocre grade of HSS in term of mechanical properties. This is to not only reduce the cost but these types of HSS are easy to be grind.

In this project, the tool life of a cutting tool will be studied when it is hardfaced with tool steel wire by using a gas metal arc welding process. The hardfaced cutting tool will be compared with the usual high speed steel in term of tool life. A cutting tool, according to Anuar (2006), is a tool that subjected to an extreme rubbing process with a contact of metal-to-metal between workpiece and chip under a very high stress and temperature. A constant process of this will eventually lead to wear and thus lead to failure of the cutting tool. To prevent replacement for the cutting tool, hardfacing method is selected. This method can extent the tool life services and gives a wear resistant surface (Lincoln Co., 2014).

Hardfacing method has been used for many industrial components for extending tool life and improving its properties and there are many methods to do a hardfacing on a tool especially cutting tool. But, in order to do a hardfacing method, few considerations need to be looked and analyzed. Among most used method in hardfacing is the gas metal arc welding. This method is preferred because of its versatility, speed and lastly because of its relative ease of adapting the process to robotic automation (Yazici, 2011).

The aim of this project is to study and compare the tool life of the hardfacing method of tool steel wire using gas metal arc welding with the usual high speed steel cutting tool according to the proper methodology.

1.2 Problem Statement

According to Uddeholm Company Handbook (2014), high speed tool steel is the mostly used type of steel when it comes of welding because of its alloying elements. It consist of several alloying elements makes it more in term of hardness. High speed steel is the type of material used for a cutting tool because of its ability to perform a material removal at a high speed. It has an alloying element that creates properties against wear resistance. It also has good hardness, hot hardness and also toughness.

When using the HSS as the cutting tool, the problem that usually occurs is the tool life compare to other cutting tool (Faizal, 2010.)

This is mainly because due to the material composition of both material since the as received tool steel specifically the high speed steel for turning machine are manufactured using machining which involve material removal. Since welding is the process of hot working, the composition is rather different compare to the as received high speed tool steel. The welding process including the melting and cooling of the material make it change from ferrite to austenitic phase make it increase in mechanical properties (Kuo, 2003).

According to Yazici (2011), the consequence that could happen if this is continue is that the HSS cutting tool need to be sharpen each time it is wear and the cutting tool will become shorter each time it undergoes sharpen process. This will be costly since the HSS need to be replaced each time it is too short to be used. The solution of this problem would be hardfacing method. When the HSS cutting tool undergoes hardfacing method, it is improved in term of performance and tool life.

1.3 Objectives

The objectives of this project are:

i. To deposit tool steel wire on to the high speed steel cutting tool.
ii. To study the effect of machining parameters on the tool life of the high speed steel tool hardfaced with tool steel wire.
iii. To compare the tool life of as received high speed steel to those haardfaced with tool steel.

1.4 Scope of Project

This project is focused on the tool life comparison of as received high speed steel tool with hardfaced one. The material used to hardfaced the high speed steel tool is tool steel. The tool steel will be deposited on the high speed steel tool by using gas metal arc welding. To study the tool life of the hardfaced tool, the changing parameter used are cutting speed and feed rate while the constant parameter will be depth of cut other than cutting tool material which is high speed steel, coolant type and coolant direction. The tool life experiment will be stopped when the wear reach 0.3 to 0.35mm. The tool life experiment will be conducted at the machining lab.

1.5 Project Organization

This report is split into three different chapters. The chapters are as follow:

(a) Chapter 1: Introduction

This chapter describes about the entire project is all about and the reason why this project is being conducted. It covers the background of the project, problem statement, objectives, scope of project, project organization and project planning schedule.

(b) Chapter 2: Literature Review

Chapter two explains about the flow of the project and the details about the research boundary. It covers all the important details about the tool life of the high speed steel that has been hardfaced with tool steel when deposited by gas metal arc welding.

(c) Chapter 3: Methodology

Chapter three describes the method used in executing the analysis on the tool life for the hardfaced tool steel that deposited by using gas metal arc welding. The design of experiment is also being discussed in this chapter. Everything related to the experiment and analysis of the tool life of the hardfaced tool life is stated in this chapter.

(d) Chapter 4: Results and Discussion

Chapter four shows the results obtained from conducting the experiments regarding the tool life of the tool steel hardfaced cutting tool. The optimum cutting parameter was obtained during the experiment from four hardfaced cutting tool sample with different set of parameters. The parameters was set

using a design matrix obtained in Minitab software according to the specified cutting parameters range obtained from the journal. The optimum cutting parameter was then being compared with the as received cutting tool to be tested in term of tool wear.

(e) Chapter 5: Conclusion and Recommendation

Chapter five is the summarized of the whole report regarding the results obtained from the previous chapter. The conclusions were made after the whole project was finished and the recommendations are given to improve the experiment for future references.

1.6 Significance of Research

From this research, we can see that many manufacturer that involve in machining whether directly or not will be benefited by this research. The extending of tool life of high speed tool steel when it is hardfaced and deposited by GMAW will lead to many advantages such as gives tool lives services and tool wear services other than reducing cost effectively. When compared with the as received high speed tool steel with the hardfaced high speed tool steel, the difference in tool life will changes the rate of services. The improved tool life and tool wear services are last longer and hence reduce the rate of service of the cutting tool. The hardfaced cutting tool are also east to be repaired since the wear of the cutting tool only need to be hardfaced again instead of changes to another cutting tool which is costly. This also reduces the breakdown time in manufacturing hence increasing working efficiency.

1.7 Project Planning

The project planning can be referred at Appendix A and Appendix B.

CHAPTER 2
LITERATURE REVIEW

This chapter contains all data and information obtained through details research from past researches by various sources such as handbook, books, journals and articles regarding the tool life studies of hardfacing method using gas metal arc welding on cutting tools.

2.1 Hardfacing Method for Cutting Tools

Hardfacing method is the method where the higher mechanical properties metal is applied to the lower mechanical properties base metal. The hardfacing method uses weld techniques to the base material and the higher mechanical properties metal take the form of electrodes to perform the welding for hardfacing method on the base metal. According to Sexton (2014), there are various methods that can deposit hardfacing method:

Table 2.1: Various methods of hardfacing deposition (Sexton, 2014).

Category	Process
Arc Welding	Flux core arc welding (FCAW) Gas metal arc welding (GMAW) Gas tungsten arc welding (GTAW) Plasma arc welding (PAW) Shielded metal arc welding (SMAW) Submerged arc welding (SAW)
Torch Welding	Oxyfuel gas welding (OFW)
Other Welding	Electron beam welding (EBW) Electroslag welding (ESW) Furnace braze (FB) Laser beam welding (LBW)

According to Ulmanu, Draghici, Zecheru and Minescu (2000), the material selected for hardfacing must be primarily wear conditions met and cost considered. This is because in manufacturing, these two factor are always to be considered first in any decision making process. The base material parts or in this case, the cutting tool need to be wear at certain level before it is to be services using the hardfacing method because we not only consider the conditions of the cutting tool to be wear but also the cost factor. The cutting tool needs to be services at optimum wear conditions and the rate of services can be calculated after that.

Surface hardness was the one that usually linked with wear resistivity even tough increase in hardness only lead to material become brittle and finally interfere with wear behavior. That is why the material used to be deposited need to take few considerations first for example the type of work it undergoes, the mechanical properties after the material undergoes the working and also the microstructure that finally lead to the tool wear or tool life services of the cutting tool (Yazici, 2011).

In case of hardfacing HSS cutting tool, weld technique that commonly used would be gas metal arc welding. Gas metal arc welding is the most industrial common use welding because of its preferred versatility, speed and adaptability to robotic automation. According to Lincoln Electric Company (2014), hardfacing method has few benefits that common in industrial environment:

- Need only few replacement parts.
- Increase efficiency in operating by downtime reducing.
- Can use less expensive base material.
- Able to reduce overall cost.

According to Ulmanu *et al.* (2000), there are several considerations need to be taken when using the hardfacing method:

- The requirements of impact, corrosion, oxidation and thermal requirements.
- The ability to be welded.
- Deposition process.

Ulmanu *et al.* (2000) also stated that hardfacing method has to meet certain requirements or objectives:

- The hardfacing band and the base metal must be perfectly bond.
- Deleterious martensitic reaction in the heat affected zone must be minimized by pre and post heat.
- Dissolution of carbides needs to be controlled due to high temperature and oxidation.
- The microstructure and mechanical properties of hardfacing need to be controlled by solidification kinetics.
- Cost reductions.

2.1.1 Hardfacing Method Using GMAW

Hardfacing can be deposited with many types of welding. One of the most used welding in industry for depositing a hardfacing is the gas metal arc welding (GMAW). It can improve the productivity by keeping wear parts from wear in terms of physical dimension tolerances with continuous hardfacing each time its starts to wear.

Process of hardfacing by using GMAW can be explained by the process of overlaying the wear base material parts by using the GMAW method whether by using manual, skilled labor welder or automated robot arm welding depending to the situation with the aim to improves the material mechanical properties (Sexton, 2014).

Before the hardfacing process is being done, the base material parts need to be cleaned from any dust particles rust, grease oil or any containment on the surface to be weld. The surface crack, deformedany work hardened needed to be removes first by using any removeing method such as grinding or machining as a surface preparation procedure (Lincoln Co., 2014).

The benefits of using GMAW when deposit the hardfacing method on the base material parts are GMAW can offers higher efficiencies of electrode hence, the cost of the electrode can be lowered drastically and also higher rate of deposition when compare to others type of welding deposition especially shielded metal arc welding (SMAW) processes. GMAW are also good and suitable if used with automated robotic arm because of its easily adapted for their high-speed robotic application movement. Other advantages of using GMAW as hardfacing deposited method are it requires minimal labor skill, low postweld cleaning and also less welding fumes when compared with SMAW (Yazici, 2011).

2.2 High Speed Steel

According to Erasteel Company (2010), high speed steel (HSS) are a metal alloy that obtained their properties from between tungsten or molybdenum. It can perform at a high rate performance and having a high hardness at temperature near 500^{o}C or 932^{o}F. HSS are also high in wear resistant due to having alloying elements like molybdenum, tungsten, chromium and vanadium. All of those alloying elements are made from carbides. In certain special conditions where the hot hardness needs to be increase, cobalt may also be added. HSS usually used as cutting tools mainly due to its properties of high hardness and high performance rate. There are 15 known HSS in industry and two has been trademarked by Erasteel Company as their unique HSS. There are T1, M1, M50, M2, ABC III, M7, M3:1, M3:2, GRINDAMAX^{TM} V3, M4, Actium^{TM} 74, M35, C8, MAT II, M42, WKE 42 and WKE 45.

High speed tool steel is the most usually used in schools for lathe operations. This typical type of steels contains the combinations of tungsten, chromium, vanadium, molybdenum and cobalt. They are capable of taking heavy cuts, withstand shock and still maintain a sharp edge under red heat (Krar and Check, 1997).

2.3 Tool Life

According to International Standard handbook (1993), the definition of tool life can be paraphrase to the time of cutting needed to reach the criterion of the tool-life itself. It means that the time needed for the cutting to reach the specific optimum criteria as stated in the standard. There are also few criteria need to be considered first before the tool life are being calculated. For example, the grade of the material used to deposited during hardfacing process, chemical composition of the hardfaced material, hardfing physical properties, microstructure and composition of the hardfaced cutting tool, tested hardness, detailed of complete process route of the work material which is the hot work