Faculty of Manufacturing Engineering

TRIBOLOGY CHARACTERISTICS OF 22MNB5 BORON STEEL COATED WITH TITANIUM ALUMINUM NITRADE

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DECLARATION

I declare that this thesis entitled “Tribology Characteristics of 22MnB5 Boron Steel Coated with Titanium Aluminium Nitrade” is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :……...

Name :Muhammad Faizal Bin Abu Bakar……...

Date :……...

APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature :……...

Supervisor Name : PM Ir. Dr. Mohd Hadzley Bin Abu Bakar

Date :……..

DEDICATION

To my beloved father Abu Bakar Bin Ali, my beautiful mother Fauziah Binti Ganyu and my siblings for giving me moral support, money, cooperation, encouragement and also understandings thank you so much and love you all forever.

ABSTRACT

Boron steels are used in hot stamping process due to their good mechanical properties. During the stamping process, the dies are exposed to aggressive conditions including adhesive wear, thermal stresses, fatigue, and abrasion. In the present work, there are four samples with different HRC. The name for the four sample are first blank sample, blank sample with self-hardening, factory sample with 60 HRC and factory sample with 70 HRC. Blank sample is without doing anything. One sample will use different procedure of preparation which is using quenching that self-hardening while other two used hot stamping. Then all samples are coated with Titanium Alumiunm Nitrade (TiAlN) using Physical Vapor Deposition. After that, the samples coating were characterized and tested using Scanning Electron Microscopy (SEM), density, hardness test and wear test. By using SEM, the width of the stroke becomes smaller when using hot stamping process. For the hardness test, the sample form Proton Factory 70HRC stronger than others because using hot stamping process. Wear resistance of coatings increase due to the decreasing of coefficient of friction obtained. While others suggest that the transformation of the layer into produce martensite phase and more harder is the ultimate responsible for such changes. These four samples will make a comparison and find the best. Sample Proton Factory 70HRC it has lowest presence of porosity inside the sample so, the sample has highest hardness. The best will go further to machining process. The results in term of hardness and wear which are using hot stamping with higher HRC of sample will be better than others.

ABSTRAK

Keluli boron digunakan dalam proses stamping panas kerana sifat mekanik yang baik. Semasa proses stamping, acuan terdedah kepada keadaan agresif termasuk memakai pelekat, tekanan haba, kelemahan, dan lelasan. Dalam kerja ini, terdapat empat sampel dengan HRC yang berbeza. Nama untuk sampel empat adalah sampel kosong pertama, sampel kosong dengan pengerasan diri, sampel kilang dengan 60 HRC dan sampel kilang dengan 70 HRC. Sampel kosong tanpa melakukan apa-apa. Satu sampel akan menggunakan prosedur penyediaan yang berbeza yang menggunakan pelindapkejutan yang mengeraskan diri manakala dua lagi menggunakan stamping panas. Kemudian semua sampel disalut dengan Titanium Alumiunm Nitrade (TiAlN) menggunakan Deposisi Wap Fizikal. Selepas itu, salutan sampel dicirikan dan diuji dengan menggunakan Mikroskopi Pengimbasan Elektron (SEM), ketumpatan, ujian kekerasan dan ujian memakai. Dengan menggunakan SEM, lebar strok menjadi lebih kecil apabila menggunakan proses stamping panas. Untuk ujian kekerasan, sampel Proton Factory 70HRC lebih kuat daripada yang lain kerana menggunakan proses stamping panas. Pakai rintangan salutan yang bertambah kerana penurunan pekali geseran yang diperolehi. Sedangkan yang lain menunjukkan bahawa transformasi lapisan menjadi fasa martensit menghasilkan dan lebih keras adalah yang paling bertanggung jawab untuk perubahan tersebut. Empat sampel ini akan membuat perbandingan dan mencari yang terbaik. Sampel Proton Kilang 70HRC mempunyai kehadiran terendah dalam porositas di dalam sampel jadi, sampel mempunyai kekerasan tertinggi. Yang terbaik akan pergi ke proses pemesinan. Hasil keputusan dari segi kekerasan dan pakai yang menggunakan stamping panas dengan sampel HRC yang lebih tinggi akan lebih baik daripada yang lain.

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LIST OF ABBREVIATIONS

22MnB5	-	Boron Nitrade
TiAlN	-	Titanium Aluminium Nitrade
SEM	-	Scanning Electron Microscopy
XRD	-	X-Ray Diffraction
XRF	-	X-Ray Florescence

LIST OF SYMBOLS

CoF	-	Coefficient of Friction
g	-	Gram
g/l	-	Gram/Litre
h	-	Hour
kg	-	Kilogram
^{o}C	-	Degree Celcius
HV	-	Hardness Value
Mpa	-	Mega Pascal
%	-	Percent
µm	-	Micro meter
cm	-	Centimeter
mm	-	Milimeter
wt %	-	Weight percent
A/dm^2	-	Current density
Rpm	-	Revolution per minute
s	-	Second

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Today, in recent manufacturing, the manufacturing and process industry now get to faces a great deal of challenge. Then, the quality of the final product and the increase in productivity are the example of the challenge of this modern manufacturing sector. This is why many people understand that the manufacturing industry is so valuable for the global. Processing method is some of the key parts of the manufacturing business (Blokland *et al.*, 2017). Furthermore, during the time spent cutting process, it has different angles that we have to think about which is stated below. This remains on the grounds that the manufacturing procedure envelops entirely perspectives of the material as well as of different structures in the cutting procedure (Khakzad *et al.*, 2017).

1) Hardness - Happening the cutting procedure, hardness be present significant meant for great hotness in any circumstance.

2) Toughness - This one is additionally significant in place of non-broken cutting apparatuses while undertaking the procedure.

3) Wear safe - The situation should most likely get by until we change it once more.

These viewpoints are significant in creating an item through extraordinary dimensional precision and excellence completions. Not just that, now the determination of decent cutting devices, it necessity probably give extraordinary thermal conductivity (Curtze *et al.*, 2009). 22MnB5 are planned for use in car basic and safety segments. These steels are intended to be

heat treated and afterward die-quenched amid the hot stepping process. This stays on the grounds that the high temperature created beginning the profound machining procedure is quickly discharged. 22MnB5 Boron steel, which has high mechanical quality after hot stepping, is steel in the scope of items created to meet vehicle weight decrease necessities (Yoon *et al.*, 2017). The mechanical properties of the last part make noteworthy weight investment funds conceivable which is up to 50 percent contrasted with standard high yield quality steel. The very high yield strength of these steels after heat treatment and hot stepping make them reasonable for anti-intrusion and safety cage parts, including A-pillars, B-pillars, door beams, bumper beams and roof rails. The manufacturing procedure of these steels, and the thermo mechanical treatment they experience amid hot rolling, result in great basic consistency and quenchability, guaranteeing great reaction to heat treatment and hot stepping (Shugurov & Kazachenok, 2018). The fundamental points of interest to 22MnB5 are division of framing and administration properties, high hot formability permitting generally complex geometries and absence of part spring back (Mori *et al*., 2018). In this study we have 4 samples of 22MnB5 with various HRC and different method of preparation of the samples. The 4 different samples of 22MnB5 are called blank sample, blank sample with self-hardening, sample from Proton factory 60 HRC and sample Proton factory 70 HRC. This entire sample will be coated by titanium aluminium nitrade, TiAlN using physical vapor deposition, PVD and will further tested by hardness, wear, microstructure and density.

1.2 Problem Statement

Manufacturing and machinery industries need innovative materials in the direction of diminish petrol reserve funds and part heaviness, just by means of security requests. Boron steels usually for steel grade most part the 22MnB5 (Yao *et al*., 2018). Cutting tool made from

steel prone to fail due to low hot hardness. Coolant required to try this material in machining. The steel need to be coated to improve friction resistance and lubrication properties. The steel can be obtain from the excessive chasis that already processed during hot stamping. In this manner, investigation of tribology normal for 22MnB5 Boron steel is basic to assess their ability in tear and wear application.

1.3 Objectives

In the present, 22MnB5 Boron Steel will fundamental material for the study. The target of the examinations will concentrated on following criteria:

1. To fabricate a coated boron steel with Titanium Aluminium Nitrate (TiAlN) using PVD in the form of cutting tool.
2. To evaluate the mechanical properties of 22MnB5 Boron Steel, between uncoated and coated with TiAlN in terms of density, hardness and surface appearance.
3. To compare the coefficient of friction between uncoated and coated with TiAlN using PVD 22MnB5 Boron Steel by pin on disk.

1.4 Scope

The primary reason for this investigation is to think about an impact of boron steel, 22MnB5 coated with titanium aluminium nitrade, TiAlN. There are four samples will be study in this research. Four samples which is blank sample, blank sample with self-hardening, sample from Proton factory 60 HRC and sample Proton factory 70 HRC will be studied in this work. This will be more specific on to find the alternative to replace or improve the current product or cutting tool to make the life of the product longer. The example of that we want to replace or improve is cutting tool for turning, product that cut the tree and other.

1.5 Important of Study

When finish this study, there are some conceivable benefits that can be picked up by the aerospace, automotive and marine industry after the achievement of this study. Coating the samples then heat treat it will improve the properties or not. So, this study will prove with four samples which one is better in term of main factor to build the hardness, wear and microstructure of boron steel coated with titanium aluminium nitrade.

1.6 Organization of the Report

Before conducting any experiments, the libraries review has been deepened for the acquisition of information or further understanding of the project. The readings include all aspects including materials, manufacturing and machining. Therefore, the organization of the report has been organized to facilitate structure facilitates and coordinates.

This report comprises of five sections. Chapter 1 covers the introduction of the exploration. This part examines the background of study, problem statement, objectives, scope

and important of study. Issues are recognized through the environmental and current situation in worldwide.

Chapter 2 comprises of literature review part. Some reading has been done to learn more about this project for example properties of the material, including the Physical Vapor Deposition coating process with respect to the research topic and the past investigations from journals, books, article and the web.

Chapter 3 contains the methodology part. This section clarifies the flow of the entire undertaking that has been done. Starting from beginning until end of this project.

Chapter 4 contains of result and discussion part. Discussion has been made and includes all the required sessions in this project. Finding of the task is the most vital in this chapter.

Chapter 5 contains the conclusion and some suggestions will be forwarded for further in the future. The conclusion made depends on the targets.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

2.1.1 Boron Steel

Nowadays, Boron has widely used in variety of sector of manufacturing and automotive industry. In manufacturing industry, Boron is added to unalloyed and low alloyed steel to increase the hardness of steel. The small amount of Boron to steel, the hardenability should be increase. The advantage of Boron was excellent heat resistant and very hard of surface.

Boron steel comprises of little measures of boron being added to the steel. The additional boron essentially influences the hardness of the alloy, which improves its suitability for certain mechanical applications, which are ordinarily identified with development (Yoon *et al.*, 2017). Steel is a typical alloy made of copper and iron. The best widely recognized expansion to steel is chromium. Different components are additional to steel to modify its possessions, as well as boron. The chromium frames a thin layer all over the place the steel as soon as it shapes a chromium oxide compound. This film shields the material as of rust and extra recoloring reason the fresh material is named stainless steel.

Boron steel has very high strength compare to steel after heat treatment process whereby the yield point is about 1350-1400N/mm^2. The strength of this steel is come from boron and manganese content. Boron Steel are tempered boron-alloy steel is one of the steel

that have highly demand among automotive industry. From the survey, one of the national brand car was Proton Iriz that adopted boron steel in automotive part at the chassis. The material undergoes hot stamping process also known as press hardening process.

22MnB5 is a standout amongst the most commonplace hot stamping boron steels. So on the mechanical properties of hot stamping boron steel 22MnB5 as toward examine the impact of austenitizing holding time and temperature, a progression of quenching progression be there applied to improve properties of boron steel. The outcomes demonstrate that 22MnB5 consumes a decent quenching performance, the hardness and tensile strength of tests quenched in a water-cooled steel pass on remain like those of water quenching.

2.1.2 Boron Steel Properties

Boron steel 22MnB5 is a high-quality steel item with great formability after hot stamping process. It appropriate for items requiring formability in conveyance condition and high quality as a last item. The use of micro-scale alloyed boron steel (22MnB5) which takes a tensile strength in the variety between 1200-1400MPa be present reliably expanded towards decrease the heaviness of BIW arrangement in automotive manufacturing, the steel's quality and hardness are accomplished by quench solidifying subsequent to shaping. Table 2.1 beneath showcases the chemical composition of boron steel and Table 2.2 shows the properties of boron steel.

Table 2.1: Chemical composition of Boron Steel (Shugurov & Kazachenok, 2018)

Elements	**Contents**
Boron, B	22%
Manganese, Mn	5%
Steel	73%

Table 2.2: Properties of Boron steel

Properties	
Element Category	Metalloid
Hardness (before hot stamp)	
Hardness (after hot stamp)	
Melting Point	3769F (2076°C)
Density	

Investigation from (Yao *et al.*, 2018) state sheets of steel 22MnB5 in the press-hardened condition and hot-dipped be there utilized. 22MnB5 steel coated AlSi10Fe3 of using a thickness of 1.4 mm remained fabricated via Thyssen Krupp Steel in Duisburg in Germany. The chemical compound piece of the 22MnB5 steel and the AlSi10Fe3 coating is shown Table 2.3. The AlSi10Fe3 coating which is thickness: 20 - 30 μm remained set down taking place the 22MnB5 steel through hot-dipping at a temperature of approx. 675°C. Hot-dipped 22MnB5 sheets were austenized on behalf of tAUS = 7 min at various temperatures (TAUS = 930 - 1100°C) now an inactive gas heating system lower than an argon environment just before change the composition of coating's stage, particularly the periods of sort Al5Fe2 and AlFe.

Table 2.3: Chemical composition of the materials used [mass-%] (Yao *et al*., 2018)

	22MnB5	**X38CrMoV5**	**AlSi10Fe3**
C	0.23	0.39	
Si	0.29	0.34	10.23
Al	0.03		Bal
Mn	1.26		
Cr	0.12	4.81	
B	0.02		
Mo		2.77	
V		0.55	
Fe	Bal	Bal	2.16

2.1.3 Boron Steel in Vehicle

This type of Boron Steel has extremely high strength and used for automobile part nowadays. This material can be about three to multiple times more grounded than the normal high-strength steel. In any case, the procedure used to make it so solid that it expels a portion of the functionality properties of the steel. In the automotive industry have responded to this Boron Steel due to the greater car chassis and lower the weight for safety and fuel efficiency. This technology nowadays, this new advance steel with new concept have been adopt to achieve the weight reduction with improves the crash impact. The Figure 2.1 shows from the forum that the Boron Steel has a high strength and ultra-strength steel and the Figures 2.2 shows the 2010 Ford Taurus Body Structure. All the below show that not a National car only using this kind of Boron Steel but International Brand car also using this material because this material already proved the high strength.