ANALYSIS FOR CAST ALUMINIUM ALLOY TITANIUM CARBIDE

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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 Design) (Hons.)

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Analysis for Cast Aluminium Alloy Titanium Carbide**

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

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I hereby, declared this report entitled "Analysis for Cast Aluminium Alloy Titanium Carbide" is the results of my own research except as cited in references.

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Author's Name : NUR AZARENA BINTI ALI

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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 Design) (Hons.). The member of the supervisory is as follow:

……………………………………

(Dr. Taufik)

ABSTRAK

Bahan-bahan yang biasa digunakan untuk membuat gegancu motosikal adalah keras, kukuh dan kekuatan mulur tinggi dari segi fizikal. *Aluminium alloy titanium carbide* adalah campuran baru yang mungkin mempunyai prestasi yang lebih baik daripada bahan-bahan yang biasa digunakan dan masalah ini mendorong penulis untuk mengkaji *cast aluminium alloy titanium carbide*. Projek ini bertujuan untuk membuat kajian terhadap gegancu bahagian depan Yamaha LC135 melalui analisis terma fana, analisis struktur statik dan pemilihan bahan. Tiga bahan dibandingkan dalam analisis ini; *aluminium alloy titanium carbide*, *aluminium* dan *cast iron*. Hasil kajian untuk analisis terma fana ialah suhu global manakala analisis struktur statik menunjukkan hasil kajian tekanan, perubahan bentuk dan faktor keselamatan. Bahan yang memenuhi kriteria dan terbaik dipilih dalam pemilihan bahan. Analisis-analisis tersebut telah membuktikan bahawa *aluminium alloy titanium carbide* adalah bahan yang terbaik. Tiga objektif telah berjaya dicapai dan beberapa cadangan telah dicadangkan untuk masa depan.

ABSTRACT

The most common used materials for motorcycle sprocket are hard, strong and high ductile strength in term of physical properties. Aluminium alloy titanium carbide is a new mixture which might be has better performance than the common used materials which this problem motivate the author to study the cast aluminium alloy titanium carbide. This project aim is to do a research on Yamaha LC135 front sprocket through transient thermal analysis, static structural analysis and material selection. Three materials are compared in these analyses; aluminium alloy titanium carbide, aluminium and cast iron. The results obtained for transient thermal analysis is global temperature while static structural analysis show stress, deformation and factor of safety (FOS). The best material due to its material properties is selected in material selection. It is proved that aluminium alloy titanium carbide is the best material through these analyses. Three objectives are successfully achieved and few recommendations are suggested for future work.

DEDICATION

I sincerely dedicate this project to my father (Ali bin Yuner) and mother (Nor Aliza Abdullah) who are my best teachers of love and maturity.

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

I take this opportunity to express my profound gratitude and deep regards to my guide, Dr. Taufik, for his exemplary guidance, monitoring and constant encouragement throughout the course of this project.

Secondly, my thanks and appreciation go to my colleague in developing the project and people who have willingly helped me out with their abilities. A big contribution and hard worked from them during the Final Year Project (FYP) is very great indeed.

Last but not least, I would like to thanks to my parents for their continue supports and being understanding to me.

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%	Percent
°	Degree
2D	Two Dimensional
3D	Three Dimensional
Al	Aluminium
C	Celsius
CAD	Computer Aided Design
CDI	Capacitor Discharge Ignition
CES	Cambridge Engineering Selector
cm^3	Centimeter cube
Cu	Copper
DC	Direct Current
e.g.	example given
et al.	and others
etc.	Etcetera/and other things
F	Fahrenheit
Fe	Iron
FEA	Finite Element Analysis
FEM	Finite Element Method
FOS	Factor of Safety
FYP	Final Year Project
g	Gram
GDP	Gross Domestic Product
in	Inch
K	Kelvin
kg	Kilogram
kW	Kilowatt

lb	Pound
m	Meter
Mg	Magnesium
mm	Millimeter
MMC	Metal Matrix Composites
Mn	Manganese
N/m^2	Newton per meter cube
Ni	Nickel
Nm	Newton meter
Pb	Lead
POM	Polyoxythylene
RMS	Root Mean Square
rpm	Revolution per minute
Si	Silicon
SiC	Silicon Carbide
Sn	Tin
SOHC	Single Overhead Camshaft
Ti	Titanium
TiC	Titanium Carbide
TPC	Thermoplastic elastomer
UNS	Unified Numbering System
W	Watt
Zn	Zinc
µin	Micro inch
µm	Micrometer

CHAPTER 1

INTRODUCTION

This section basically the introductory chapter which explain about the introduction of the material namely aluminium alloy titanium carbide and the propose product. Aside from the introduction, problem statements, objectives, scope of the project and project planning are also stated in this chapter.

1.1 Background of Study

Asgari *et al.* (2010) stated that Malaysia has grown at an average rate of 7.8% in the 1970s and 8.8% during 1987 to 1996, whereby the previous economic focus structure is based on agriculture, industry and services have shifted to manufacturing which gives an increase in the percentage shares of Gross Domestic Product (GDP) growth of 16.4% in 1975 to 34.5% by 1996. It is important for Malaysian companies to stay ahead of the competition in which products demand is increasing from time to time and they need to improve the level of their production.

According to Frankel *et al.* (2006), casting appears in more than 90% of all manufactured goods and in 100% of all manufacturing machinery. For example, the multibillion-dollar metal casting industry serves the motor vehicle industry, industrial machinery manufacturers and electrical-power equipment industry. Miyake *et al.* (2009) stated that casting is one of the principal techniques in the field of industry metal production.

A Metal Matrix Composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound (Callister *et al.*, 2009). The reinforcement material is embedded into the matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity.

The eutectic aluminium silicon alloy or refer as aluminium alloy is the near-eutectic group of aluminium silicon alloys has characteristics of low thermal expansion, excellent castability, high corrosion resistance, high abrasive wear resistance, good weldability, good thermal conductivity and high strength at elevated temperatures (Hajjaj, 2007). In addition, according to Sulaiman *et al.* (2008), aluminium silicon alloy is a eutectic alloy having the lowest melting and the main composition is about 85.95% of aluminium and 11% to 13% of silicon.

The characteristic of titanium carbide (TiC) which are wear-resistant, high temperature strength and refractory properties, useful in some applications, for examples, skins of space rockets, jet engine nozzles, combustion engines, radiation resistant first walls of nuclear reactors, armouring jackets and machine armors. Due to its light weight, TiC hard metals will be successfully used for the constructions of armor jackets for airspace machines if compared with hard metals based on tungsten carbide (Jalabadze *et al.*, 2012).

The material namely aluminium alloy titanium carbide is tested on proposed product which is motorcycle sprocket to observe the higher performance that can be achieved. Aluminium alloy titanium carbide is a new mixture of metal matrix composite (MMC); aluminium alloy with reinforcement material; titanium carbide (TiC) which the aluminium alloy also known as aluminium silicon alloy or LM6 alloy. According to Fatchurrohman *et al.* (2012), MMC specimen with volume fractions of 5 and 15% of TiC are reinforced to the aluminium alloy-11.8%. Suraya *et al.* (2014) have done experiment on this composition in their journal.

The existing product chosen is Yamaha 135LC front sprocket. This is because when the motorcycle is used, the sprocket can heat up during operation of the motorcycle. This project aim is to do a research on motorcycle sprocket through transient thermal analysis, static structural analysis and material selection.

Sprocket is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain, track or other perforated or indented material (Merriam, 2011). Sprockets are widely used in bicycles, motorcycles, cars and other machinery to transmit rotary motion between two shafts. The most common used materials for motorcycle sprocket are aluminium, cast iron, various kinds of cast steel, stainless steel and etc.

The process involved to produce aluminium alloy titanium carbide is gravity casting process according to Fatchurrohman *et al.* (2012). The gravity casting process is a sub-type of permanent mold casting. Through this report, this research is known as analyzing the cast aluminium alloy titanium carbide on Yamaha 135LC front sprocket.

1.2 Problem Statement

The most common used materials for motorcycle sprocket are hard, strong and high ductile strength in term of physical properties. Aluminium alloy titanium carbide is a new mixture which might be has better performance than the common used materials for motorcycle sprocket. However, there is a lack of study of motorcycle sprocket using cast aluminium alloy titanium carbide. This study motivates the author to do research of cast aluminium alloy titanium carbide on Yamaha 135LC front sprocket.

1.3 Objectives

The objectives of this project are as follows:

a) To investigate the cast aluminium alloy titanium carbide on Yamaha 135LC front sprocket.
b) To analyze the transient thermal analysis, static structural analysis and material selection on Yamaha 135LC front sprocket.
c) To select the best material among three candidates of materials which are aluminium alloy titanium carbide, aluminium and cast iron for Yamaha 135LC front sprocket.

1.4 Scope of Project

The scope of this project is to prove that cast aluminium alloy titanium carbide is the most suitable material to replace the common material used for motorcycle sprocket. Transient thermal analysis and static structural analysis will be done on motorcycle sprocket using new material; cast aluminium alloy titanium carbide. The factor of safety (FOS) for cast aluminium alloy titanium carbide also will be determined. Two candidate materials (common material used) are compared with aluminium alloy titanium carbide. There are aluminium and cast iron. The comparison of these materials will be discussed in material selection. The material compositions of aluminium alloy and titanium carbide (TiC) are 90% of aluminium alloy and 10% of titanium carbide (TiC). The design of motorcycle sprocket selected is the existing product which is Yamaha 135LC front sprocket. The process involved to produce aluminium alloy titanium carbide is gravity casting (sub-type of permanent mold casting) referring to Fatchurrohman *et al.* (2012) and Suraya *et al.* (2014). This report only focused on Yamaha 135LC front sprocket model.

1.5 Project Planning

Table 1.1 shows the project planning table which content detailed date for both FYP 1 and FYP 2. Figure 1.1 shows the project planning through one year which functions as guidelines to ensure the project complete at the right time.

Table 1.1: Project Planning Table

	FYP 1	FYP 2
Week 1	9th Sept – 15th Sept 2013	17th Feb – 23rd Feb 2014
Week 2	16th Sept – 22nd Sept 2013	24th Feb – 2nd Mac 2014
Week 3	23rd Sept – 29th Sept 2013	3rd Mac – 9th Mac 2014
Week 4	30th Sept – 6th Oct 2013	10th Mac – 16th Mac 2014
Week 5	7th Oct – 13th Oct 2013	17th Mac – 23rd Mac 2014
Week 6	14th Oct – 16th Oct 2013	24th Mac – 30th Mac 2014
Week 7	21st Oct – 27th Oct 2013	31st Mac – 6th Apr 2014
Week 8	28th Oct – 3rd Nov 2013	7th Apr – 13th Apr 2014
Week 9	4th Nov – 10th Nov 2013	14th Apr – 20th Apr 2014
Week 10	11th Nov – 17th Nov 2013	21st Apr – 27th Apr 2014
Week 11	18th Nov – 24th Nov 2013	28th Apr – 4th May 2014
Week 12	25th Nov – 1st Dec 2013	5th May – 11th May 2014
Week 13	2nd Dec – 8th Dec 2013	12th May – 18th May 2014
Week 14	9th Dec – 15th Dec 2013	19th May – 25th May 2014
Week 15	16th Dec – 22nd Dec 2013	26th May – 1st June 2014

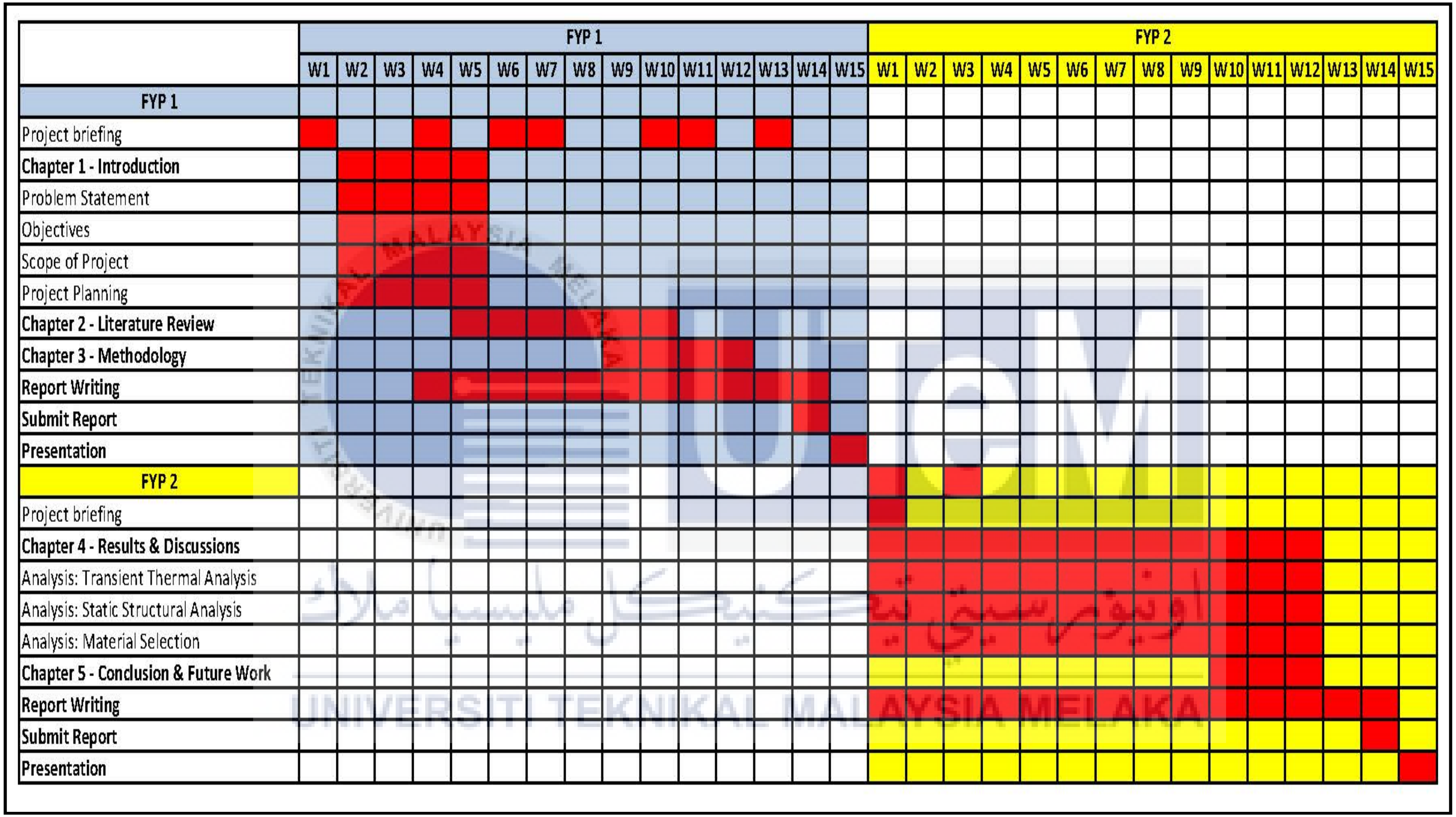

Figure 1.1: Project Planning (Gannt Chart)

CHAPTER 2

LITERATURE REVIEW

This section is review about the gravity casting, aluminium alloy titanium carbide, Yamaha 135LC, analysis software and material selection.

2.1 Gravity Casting

The gravity casting is a sub-type of permanent mold casting as in the Figure 2.1. The gravity casting process begins by preheating the mold to 150-200°C (300-400°F) to ease the flow and reduce thermal damage to the casting. The mold cavity is then coated with a refractory material or a mold wash, which prevents the casting from sticking to the mold and prolongs the mold life. Any sand or metal cores are then installed and the mold is clamped shut.

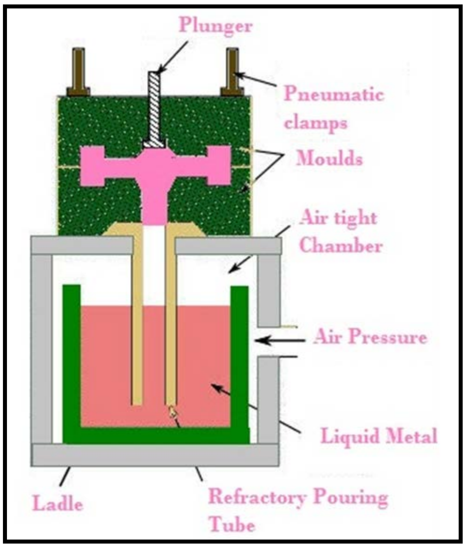

Figure 2.1: Gravity Casting (Degarmo *et al.*, 2003)

Molten metal is then poured into the mold. Soon after solidification the mold is opened and the casting removed to reduce chances of hot tears. The process is then started all over again, but preheating is not required because the heat from the previous casting is adequate and the refractory coating should last several castings. Because this process is usually carried out on large production run workpieces automated equipment is used to coat the mold, pour the metal, and remove the casting (Degarmo *et al.*, 2003).

The metal is poured at the lowest practical temperature in order to minimize cracks and porosity (Kalpakjian *et al.*, 2006). The pouring temperature can range greatly depending on the casting material; for instance zinc alloys are poured at approximately 700°F (371°C), while gray iron is poured at approximately 2500°F (1370°C) (Todd *et al.*, 1994).

2.2 Aluminium Alloy Titanium Carbide

In 2008, up to 4.4 million kg of Metal Matrix Composites (MMC) were used globally and the number is increasing with annual growth rate at 5.9% (Swift, C., 2009). MMC are nearly always more expensive than the most conventional materials they are replacing. Thus, MMC are applied where improved properties and performance can justify the added cost (Chawla, 2006).

Further study of MMC, Asthana (1998), indicates that various solidification parameters have an effect on the microstructure and the mechanical properties of the cast MMC. In MMC, like the monolithic metals and alloys, the properties of the cast MMC are largely dependent on the solidification behaviour which is dictated by the thermo-physical properties of the reinforcement, matrix materials and the mould (Rajan *et al.*, 2007). Contemporary research on solidification of MMC were done by Wu *et al.* (2002), where they had found that the solidification time of primary dendrites is shortened because of the presence of the ceramic particulate.