**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**BORANG PENGESAHAN STATUS TESIS***

JUDUL: **DESIGN AND ANALYSIS OF TURBOCHARGER BY CASTING TECHNOLOGY**

SESI PENGAJIAN: 2009-2010

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## DESIGN AND ANALYSIS OF TURBOCHARGER BY CASTING TECHNOLOGY

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

by

**SALMIE SUHANA BINTI SAAD**

FACULTY OF MANUFACTURING ENGINEERING

2010

# DECLARATION

I hereby, declared this report entitled "Design and Analysis of Turbocharger by Casting Technology" is the result of my own research except as cited in references

| | | |
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| Signature | : | ………………………………………. |
| Author's Name | : | SALMIE SUHANA BINTI SAAD |
| Date | : | 11 MAY 2010 |

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

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Supervisor: MR. TAUFIK

Date: ................................................

Stamp: ..............................................

# ABSTRACT

This project presents the design and analysis of turbocharger by using casting technology. The objectives of this project are investigating the design parameters of turbocharger in turbine-compressor assembly by casting technology and to propose a design of compressor in turbine-compressor assembly. This project was used the Metal Matrix Composite (MMC) material. The main material was used in this project is Aluminium Silicon Carbide. Aluminium alloy as a matrix material and $SiO_2$ quartz as a particulate reinforce added in different percentage. The analysis of the parameters of temperature, pressure, and static structural were presented by using simulation tools. Based on the simulation result, the composition of 85.95% Aluminium and 11%of Silicon Carbide was proposed to improve the turbocharger design in turbine-compressor assembly. An investment casting technique is recommended for producing the turbocharger due to the high complexity with tight tolerances to meet the highest performance standard. In addition, design parameters and technical specification in designing of new compressor assembly were proposed. As a result, a new compressor design in turbine – compressor assembly was developed.

# ABSTRAK

Projek ini membentangkan Rekabentuk dan Analisis Turbocharger menggunakan Teknologi Tuangan. Objectives projek ini adalah untuk mengenal pasti parameter pada Turbocharger yang ada di dalam pemampat turbin menggunakan teknologi tuangan dan mencadangkan satu rekabentuk turbocharger dalam pemampat turbin. Projek ini menggunakan campuran antara logam dan komposit sebagai bahan. Bahan utama yang telah digunakan dalam projek ini ialah Aluminium Silicon Carbide.Aluminium aloi sebagai satu bahan matriks dan $SiO_2$ sebagai satu bahan campuran yang ditambah mengikut komposisi yang berbeza. Analisis berkaitan suhu, tekanan dan struktur statik telah dilakukan dengan menggunakan perisian. Hasil daripada proses simulasi menunjukkan komposisi Aluminium adalah sebanyak 85.95% dan 11% untuk Silicon Carbide adalah dicadangkan untuk meningkatkan rekabentuk turbocharger dalam pemampat turbin. Teknik penuangan lilin adalah dicadangkan untuk menghasilkan Turbocharger disebabkan mengalami kerumitan yang tinggi dan toleransi yang ketat untuk mencapai spesifikasi yang telah ditetapkan. Sebagai tambahan, parameter rekabentuk dan spesifikasi teknikal dalam penghasilan baru bagi pemampat telah dicadangkan. Hasilnya, rekabentuk baru bagi pemampat telah dilaksanakan.

# DEDICATION

In the name of ALLAH S.W.T and the help of ALLAH, goods ascription's devotions, good expressions, prayers are for ALLAH. I bear witness that there is no god save ALLAH alone, no partners unto Him, and I bear witness that Muhammad is His servant His Messenger, sent him along with the truth, as giver of glad tidings and as Warner, and to tell that the hour is fast approaching, no doubt in it. Peace is on You, the Prophet, and ALLAH's Mercy and His Blessings. Peace is on us and on ALLAH's upright servants. ALLAH, forgive me and straighten me.

Therefore, I would like to dedicate this project especially to my supervisor Mr.Taufik for the valuable comments and to my parents who gave me full support during the course of this work.

# ACKNOWLEDGEMENT

In the name of ALLAH, The Most Beneficent, The Most Merciful, who gives me the strength and ability to complete this project as it is today. Praised to Him alone for His endowment, that let me to complete this final year project. Alhamdulillah, finally the project has been completed within the specified period. I have gained a valuable experience and new knowledge, especially in casting technology. The completion of this project marks the end of an invaluable learning experience for me. I would like to extend my gratitude to all those who helped make throughout the journey.

I would like to express my gratitude and appreciation to my supervisor Mr. Taufik, lecturer in Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, for her invaluable suggestions, guidance and constant encouragement.

Finally yet importantly, I am grateful to my family, especially to my parents for their caring, encouragement, invaluable advice and support. Sincerely no words could be said for the things that you all have done for me. I am grateful indebted for all the favors and supports. Thank you and May Allah Bless you.

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| | |
|---|---|
| CAD | :Computer Aid Design |
| CFX | : Advanced Computational Dynamics |
| MMC | :Metal Matrix Composite |
| CMC | :Ceramic Matrix Composite |
| PMC | :Polymer Matrix Composite |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

There is various manufacturing process to produce parts which is including machining, casting, joining, forming and shaping. Among these manufacturing processes, metal casting is the most effective to produce metal parts. Metal casting processes include sand casting, plaster casting, investment casting and others. Each of the process has its own characteristics and application to meet specific engineering and services requirement.

According to Kalpakjian and Schmid (2006), metal casting technology was started before 4000 B. C. by using materials such as gold, copper and meteoric iron. Lost wax process which is known as investment casting was started around 4000 B.C to 3000 B.C. The technique of metal casting is keeping improved until nowadays to produce the best quality of metal product and to achieve public need and requirement.

The process of casting metal to shape is the oldest and still one of the most widely used metal-forming processes. A casting is produced by pouring molten metal into a mould cavity and allowing it to solidify. The mould cavity is the shape of the required component.

In all casting processes the pattern has to be made oversize to allow for any contraction of the metal that may occur during the change of state from liquid to solid and also allow for the continued contraction as the solid metal cools to room temperature. Note that cast iron is exceptional in that it expands as it solidifies and this helps it to take a sharp impression from the mould. However, after solidification, it contracts like any other metal. In addition to shrinkage allowance, a machining allowance also has to be provided when a surface is to be machined. Not only must sufficient additional metal be provided to ensure that the surface ‘ cleans up’ during machining, but also that there is sufficient depth of metal for the nose of the cutting tool to operate below the hard and abrasive skin of the casting.

This study will carry out a design turbocharger by using a Solidworks which metal matrix composites is choosing as a material. Analysis the parameters of temperature and pressure will be presented by using ANSYS. This study also includes the prototype of turbocharger. Rapid Prototyping and Investment Casting process will be used for fabricated the parts.

## 1.2 Problem Statement

Turbocharger is a very unique product. One of the main problems with turbocharger is the angle of curvature at the inlet of curve inducer blades is hard to produce using advanced machining technique. It needs sharp edge and strength to sustain it life. To sustain turbocharger life, material selection is very important. Different material provides different characteristic of turbocharger. Before this, turbocharger was produced using titanium but the disadvantage of titanium is considerably more expensive than other metals. However, the disadvantages of titanium is that it work hardens rather easily. This means that, if a piece of titanium wire is worked often enough, it will snap like bending a paper clip repeatedly until it breaks. Therefore, new material for turbocharger is needed to overcome this problem.

## 1.3 Objectives

The aims of this project are:

- To investigate the design parameters of turbocharger in turbine- compressor assembly by casting technology.
- To analyze the parameters of temperature and pressure in the compressor of turbocharger.
- To propose a design of compressor in turbine – compressor assembly.

## 1.4 Scope and Key Assumption

This project presents the design of turbocharger by casting technology or investment casting. Solidworks will be used to perform the design. The analysis of temperature & pressure will be presented by using ANSYS. A new compressor design in turbine – compressor assembly will be develop.

## 1.5 Organization of the Project

The whole report is divided into six major parts, which is known as Introduction, Literature Review, Methodology, Results, Discussion, and Conclusion. Basically, each chapter is briefly such as below:

### a) Chapter 1: Introduction

This chapter contains the background of the problem statement generally and includes the objectives and the scope of the study. Overall in this chapter, it summarized the progress of the whole project describing the how the whole project is been done.

**b) Chapter 2: Literature Review**

In this chapter, any information which is related to the project is studied and summarized it; descriptions on turbocharger, types of materials, method of designing turbocharger and etc. The source of the information can be from journals, books, internet, articles and etc. Base on the information from past studies and research, it will guide a correct path for the continuous project.

**c) Chapter 3: Methodology**

Methodology shows the flow of designing of the project. It starts from the problem analysis to the concept selection, concept testing and design decision.

**d) Chapter 4 : Results and Discussion**

It states all the results such as tables, figures and graphs when research carrying out. All the important findings will be presented in a comprehensive way. It also analyzes the results statistically and provides a general discussion on the design, the result of the study, stressing the significance and implications of the findings of the study.

**e) Chapter 5 : Conclusion**

It summarizes the main findings and how the scope is covered fully and brief recommendation for further study. Hence, alternative ways or suggestions can be recommends for improving the project in further studies.

## 1.6 Summary

Basically in this chapter, summarized of the whole idea of the project is all about. It begins with the objective of the project, scope of study and research. On going to the project, problems which encounter should be determined and this will lead to solving problems by studying research and information from various types of resources.

# CHAPTER 2

## LITERATURE REVIEW

In this chapter, related information of the project is summarized. The literature reviews includes the introduction to turbocharger, technology of casting, material selection for turbocharger and tool selection for design the turbocharger and to analysis it. The sources which are from journals, books, internet, articles and others are the guide to completing this project.

### 2.1 Turbocharger and Turbocharging Techniques

Turbochargers are a type of forced induction system that compresses the air flowing into the engine. Compressing the air introduces more air into the engine, and more air means that more fuel can be added. Thus, more power can be provided by the combustion process and in other word, the efficiency or power- to-weight ratio for the engine is improved. The flow of gas through a turbocharger is shown in Figure 2.1.

The turbocharger itself is rather a simple device; the typical turbocharger consisting a single turbine attached by a shaft to a single compressor. The operation of turbocharger is explained in detail by T. C. Kuah (2008) in his research. The turbine is driven by the exhaust gas at high temperature and pressure from the exhaust manifold. The work of the turbine drives the compressor, and the air entering the intake manifold is compressed. Although this arrangement seems simple, due to its inherently unsteady operating environment, turbocharger design process is still quite complex. Despite the complications of transient operation of an engine, the advantages associated with the implementation of a turbocharger are universally accepted when applied to high efficiency diesel engines. Significant effort has been aimed at improving the efficiency and power to weight advantages of turbocharged engines.

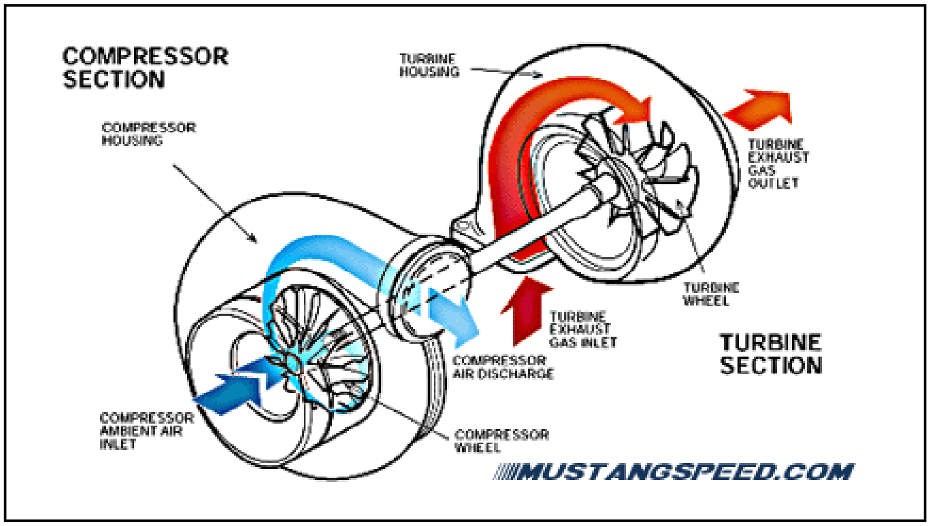


**Figure 2.1:** Inlet and Exhaust Gas Flow Through a Turbocharger (source: Nunney 2006)

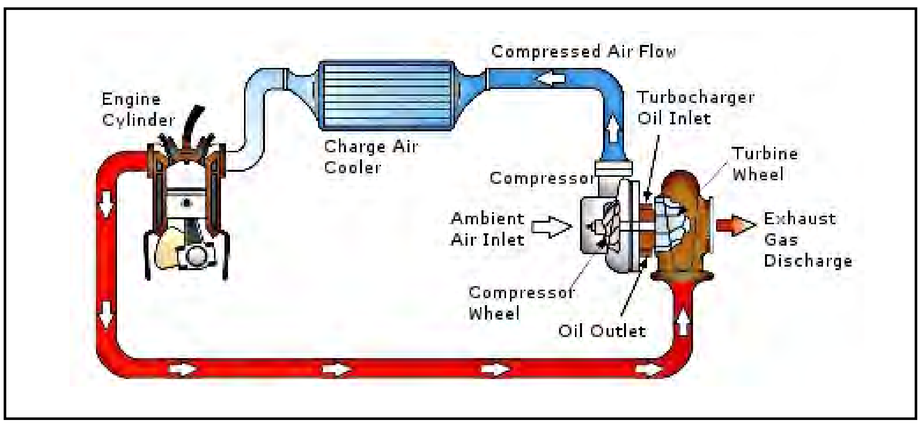


**Figure 2.2:** Schematic of an engine turbocharger system (source: Garret)

Early turbocharcing systems isolate the turbine from the inherently unsteady exhaust flow by connecting a large exhaust plenum between the exhaust valves and turbine. The plenum served to dampen the transient exhaust pulsations, allowing the turbocharger to operate in an essentially steady pressure environment. This technique is called constant pressure turbocharging. Due to the isenthalpic expansion process, constant pressure turbocharging decreases available energy to the turbocharger. It