



BORANG PENGESAHAN STATUS TESIS*

JUDUL: DESIGN AND ANALYSIS OF TURBOCHARGER BY
CASTING TECHNOLOGY

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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
(Manufacturing Design) with Honours

by

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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

Signature :

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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:

.....

Supervisor: MR. TAUFIK

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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 SiO₂ 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.

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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.

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TABLE OF CONTENT

Declaration	i
Approval	ii
Abstract	iii
Abstrak	iv
Dedication	v
Acknowledgement	vi
Table of Content	vii
List of Tables	xi
List of Figures	xii
List Abbreviations	vi
CHAPTER 1 INTRODUCTION	1
1.1 Background	2
1.2 Problem Statement	3
1.3 Objectives	3
1.4 Scope and Key Assumption	3
1.5 Organization of the Report	4
1.6 Summary	4
CHAPTER 2 LITERATURE REVIEW	5
2.1 Turbocharger and Turbocharging Techniques	5
2.2 Technology of Casting	8
2.3 Investment Casting	8
2.4 Defect of Casting	12
2.5 Advantages and Disadvantages of Investment casting	13
2.5.1 Advantages of Investment casting	13
2.5.2 Disadvantages of Investment Casting	13
2.6 Material Selection	14
2.6.1 Composite	14
2.6.2 Metal Matrix Composite (MMC)	14

2.6.3	Ceramic Matrix Composites (CMC)	16
2.6.4	Polymer Matrix Composite (PMC)	17
2.6.5	Non –ferrous Alloy	18
2.6.6	Aluminium	18
2.6.7	Composite Material Based on Aluminium Alloy	20
2.6.8	Aluminium Silicon Carbide	21
2.6.9	Titanium	22
2.6.9.1	Composite Material based on Titanium Alloy	22
2.6.9.2	Titanium Carbide	24
2.6.10	Copper	25
2.6.10.1	Composite Material based on Copper	26
2.6.10.2	Copper Alloy Carbide	27
2.7	Heat Transfer	28
2.7.1	Heat Transfer Mechanism	28
2.7.2	Internal Energy	28
2.8	Solidwork	29
2.9	Analysis Tool ANSYS	31
 CHAPTER 3 METHODOLOGY		 33
3.1	Introduction	33
3.2	Methodology	34
3.3	Methodology Flow Chart	34
3.4	Problem Analysis	35
3.5	Preliminary Design & Decision Making	35
3.6	Design Concept for Turbocharger	36
3.7	Material Selection	40
3.7.1	Comparison between Aluminium Silicon Carbide, Titanium Carbide andCopper Alloy	40
3.8	Investment Casting Process	41
3.9	Method to Conduct an ANSYS Simulation	42
3.9.1	Create Geometry of Turbocharger	42
3.9.2	Create CFX Mesh File	43
3.9.3	Setup the Solver and Physical model in ANSYS FLUENT	44

3.9.4	Simulate and Viewing the Result in ANSYS FLUENT	44
3.10	Gantt Chart	45
CHAPTER 4 RESULT AND DISSCUSSION		49
4.1	Introduction	49
4.2	Solidwork Software	49
4.3	Setup the Turbocharger Geometry and Analyze by ANSYS FLUENT	51
4.4	Evaluate the Result of Turbocharger	72
4.4.1	Analysis Result for Fluid Flow	72
4.4.1.1	Temperature at 300 K	72
4.4.1.2	Temperature at 350K	76
4.4.1.3	Temperature at 400K	80
4.4.2	Analysis Result for Static Structural	84
4.4.2.1	Loads on 100 N	85
4.4.2.2	Loads on 50 N	89
4.4.2.3	Loads on 150 N	93
4.5	Discussion	99
4.5.1	Material Selection	99
4.5.2	Advantages and Disadvantages of ANSYS CFX Simulation	100
4.5.3	Air Flow Path and Changes in Temperature	101
4.5.4	Discussion on the Design	102
CHAPTER 5 CONCLUSION		104
5.1	Conclusion	104
5.2	Recommendation	105
REFERENCES		107
Appendices		109
Appendix A	Investment Casting Process	109
Appendix B	CFD Flow Design	110
Appendix C	Turbocharger	110

Appendix D	The flow of gas through a turbocharger and schematic of an Engine turbocharger system	111
Appendix E	Data Analysis for Fluid Flow 400K	112
Appendix F	Data Analysis for Static Structural	131

LIST OF TABLES

Table 2.1: Characteristic of Casting Process	11
Table 2.2: Typical compositions and applications for MMC	16
Table 2.3: Properties of Aluminium	19
Table 2.4: Matrices of aluminium alloy based composite materials	20
Table 2.5: Mechanical properties of aluminium alloy based composite materials	20
Table 2.6: Mechanical Properties of Aluminium Silicon Carbide	21
Table 2.7: Physical Properties of Aluminium Silicon Carbide	21
Table 2.8: Thermal Properties of Aluminium Silicon Carbide	21
Table 2.9: Properties of Titanium Carbide	24
Table 2.10: Applications of copper base composite materials	26
Table 2.11: Properties of Copper Alloy Graphite	27
Table 3.1: Comparison between MMC materials	40
Table 3.2: Gantt Chart for PSM 1	46
Table 3.3: Gantt Chart for PSM 2	47
Table 4.1: Problem Description of the Turbocharger	64
Table 4.2: Structural Strain Life Parameter	89
Table 4.3: Structural Strain Life Parameter	93
Table 4.4: Structural Strain Life Parameter	97
Table 4.5: Parameter and physical Requirement for new design compressor Assembly	98

LIST OF FIGURES

Figure 2.1: Inlet and Exhaust Gas Flow Through a Turbocharger	6
Figure 2.2: Schematic of an engine turbocharger system	6
Figure 2.3: Schematic illustration of the investment casting (lost-wax) process.	10
Figure 2.4: Example of common defects can be minimized or eliminated by proper design and preparation of mold and control of pouring procedures	12
Figure 2.5: Simple classification of polymers used for matrix composites.	18
Figure 2.6: High temperature yield strength at 8108C of Titanium based Composite materials containing 10vol.% TIB in comparison with wrought materials.	23
Figure 2.7: Effect of the TIB dispersion particle content on changes in the Young's modulus of different titanium alloy based composite materials	23
Figure 2.9: Example design using SolidWork software	30
Figure 2.10: CFD design iteration	32
Figure 3.1: Methodology Flow Chart	34
Figure 3.2: Isometric View (a)	36
Figure 3.3: Isometric View (b)	36
Figure 3.4: Isometric View (c)	37
Figure 3.5: Isometric View (d)	37
Figure 3.6: Top View	38
Figure 3.7: Bottom View	38
Figure 3.8: Side View (a)	39
Figure 3.9: Side View (b)	39

Figure 4.1: Model in Solidwork software (Turbocharger)	50
Figure 4.2: Model in Solidwork software (Turbocharger with the casing)	50
Figure 4.3: Turbocharger (Isometric View)	51
Figure 4.4: Casing Turbocharger	51
Figure 4.5: Turbocharger with the casing	52
Figure 4.6: ANSYS Workbench Working Place	53
Figure 4.7: Import Geometry into the Meshing System	54
Figure 4.8: Browse and Select Suitable Geometry Which Needed to Convert	54
Figure 4.9: Begin to Edit the Mesh of Redesign Dryer System	55
Figure 4.10: Meshing Working Place	55
Figure 4.11: Develop Boundaries Condition of the Drying System	56
Figure 4.12: Named the Boundaries Conditions	56
Figure 4.13: Select the Source Surface and Apply It	57
Figure 4.14: Open CFX Mesh to Refine the Mesh System in Current Geometry	58
Figure 4.15: CFX Mesh Working Place	58
Figure 4.16: Create 2D region on the Drying System Geometry	59
Figure 4.17: Select the Air Source Surface and apply it as Main Inlet for 2D Region	59
Figure 4.18: Reset the Body Spacing Value	60
Figure 4.19: Complex Surface Area of the Drying System Region	61
Figure 4.20: Set the Face Spacing Value for Selected Surface Area Region	62
Figure 4.21: Generate the Surface Meshes on the Drying System Geometry	63
Figure 4.22: To Preview the Mesh Range of Turbocharger Geometry	63
Figure 4.23: After Mesh Refinement of Turbocharger Geometry	64
Figure 4.24: Open ANSYS FLUENT Launcher	65
Figure 4.25: Set and Launch the ANSYS FLUENT	65
Figure 4.26: ANSYS FLUENT Working Place	66
Figure 4.27: Import the turbocharger mesh file into ANSYS FLUENT Working Place	66
Figure 4.28: Search and Open the Drying System Mesh File	67
Figure 4.29: Search and open the turbocharger mesh file	68
Figure 4.30: Select General Setting in the Navigation Pane	69
Figure 4.31: Energy Dialog Box	68

Figure 4.32: Viscous Model Dialog Box Expanded	69
Figure 4.33: Create and Edit Velocity Inlet Setting Dialog Box	69
Figure 4.34: Create and Edit Velocity Inlet Setting Dialog Box	70
Figure 4.35: Enter Velocity Magnitude Value into the Momentum Properties	70
Figure 4.36: Enter the temperature Value into the Thermal Properties	71
Figure 4.37: Set the Number of Iteration and Run the Analysis and Simulation of the Turbocharger	71
Figure 4.38: Beginning Air Flow Rate in the Turbocharger at temperature 300 K	72
Figure 4.39: Static Pressure in the Turbocharger at temperature 300 K	73
Figure 4.40: Static Temperature in the Turbocharger at temperature 300 K	73
Figure 4.41: Turbulent Kinetic Energy in the Turbocharger at temperature 300 K	74
Figure 4.42: Specific heat in the Turbocharger at temperature 300 K	74
Figure 4.43: Vector of Static Pressure in the Turbocharger at temperature 300 K	75
Figure 4.44: Vector of Static Temperature in the Turbocharger at temperature 300 K	75
Figure 4.45: Vector of Turbulent Kinetic Energy in the Turbocharger at temperature 300 K	76
Figure 4.46: Beginning Air Flow Rate in the Turbocharger at temperature 350 K	76
Figure 4.47: Static Pressure in the Turbocharger at temperature 350 K	77
Figure 4.48: Static Temperature in the Turbocharger at temperature 350 K	77
Figure 4.49: Turbulent Kinetic Energy in the Turbocharger at temperature 350 K	78
Figure 4.50: Vector Static Pressure in the Turbocharger at temperature 350 K	78
Figure 4.51: Static Temperature in the Turbocharger at temperature 350 K	79
Figure 4.52: Vector Turbulent Kinetic Energy in the Turbocharger at temperature 350 K	79
Figure 4.53: Beginning Air Flow Rate in the Turbocharger at temperature 400 K	80
Figure 4.54: Static Pressure in the Turbocharger at temperature 400 K	81
Figure 4.55: Static Temperature in the Turbocharger at temperature 400 K	81

Figure 4.56: Turbulent Kinetic Energy in the Turbocharger at temperature 400 K	82
Figure 4.57: Vectors Static Pressure in the Turbocharger at temperature 400 K	83
Figure 4.58: Vectors Static Temperature in the Turbocharger at temperature 400 K	83
Figure 4.59: Vectors Turbulent Kinetic Energy in the Turbocharger at temperature 400 K	84
Figure 4.60: Setting the loads and force on the Turbocharger	85
Figure 4.61: After applied the loads and force on the Turbocharger	86
Figure 4.62: Graph Force versus Time	86
Figure 4.63: Graph Force 2 versus Time	87
Figure 4.64: Graph static structural for Standard Earth Gravity on the Turbocharger	88
Figure 4.65: Graph static structural for Rotational Velocity on the Turbocharger	88
Figure 4.66: Setting the loads and force on the Turbocharger	90
Figure 4.67: After applied loads and force on the Turbocharger	90
Figure 4.68: Graph Force versus Time	91
Figure 4.69: Graph Force 2 versus Time	91
Figure 4.70: Graph static structural for Standard Earth Gravity on the Turbocharger	92
Figure 4.71: Graph static structural for Rotational Velocity on the Turbocharger	92
Figure 4.72: Setting the loads and force on the Turbocharger	94
Figure 4.73: After applied loads and force on the Turbocharger	94
Figure 4.74: Graph Force versus Time	95
Figure 4.75: Graph Force 2 versus Time	95
Figure 4.76: Graph static structural for Standard Earth Gravity on the Turbocharger	96
Figure 4.77: Graph static structural for Rotational Velocity on the Turbocharger	97
Figure 4.78: Static Pressure in the Turbocharger	101
Figure 4.79: Current design of Bottom compressor	102
Figure 4.80: New design of Bottom compressor	103

LIST OF ABBREVIATIONS

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 its life. To sustain turbocharger life, material selection is very important. Different materials provide different characteristics 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 works 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.

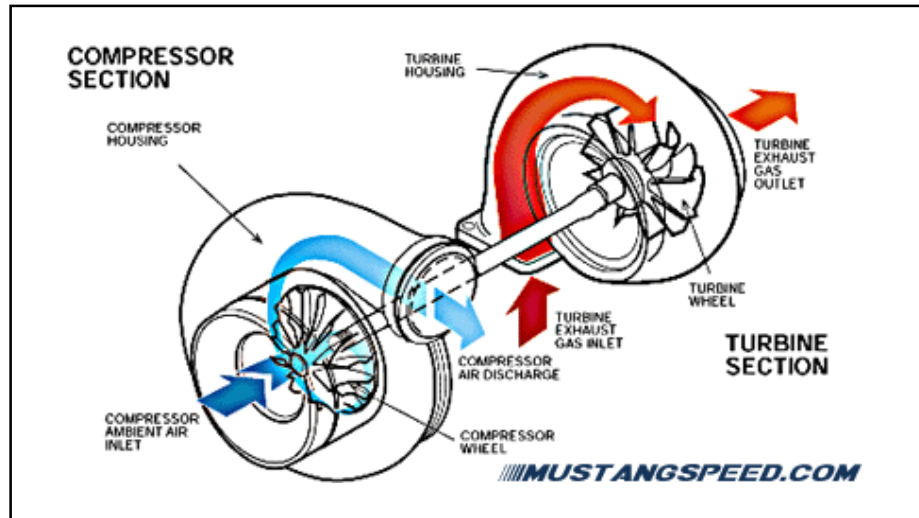


Figure 2.1: Inlet and Exhaust Gas Flow Through a Turbocharger (source: Nunney 2006)

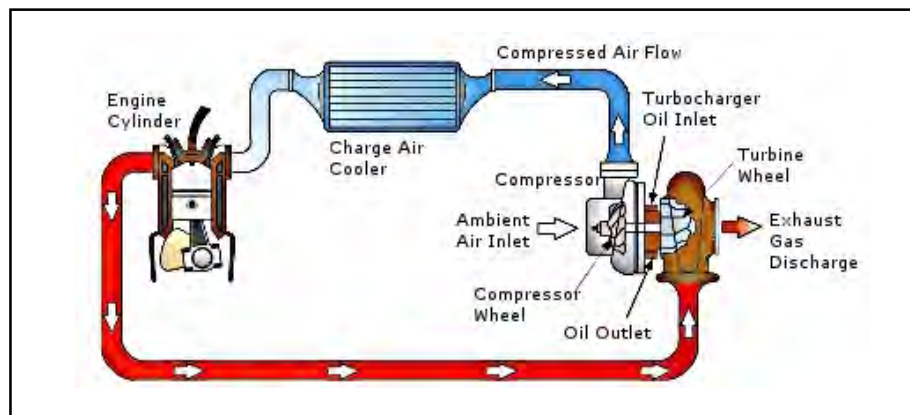


Figure 2.2: Schematic of an engine turbocharger system (source: Garret)

Early turbocharging 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