FINITE ELEMENT ANALYSIS OF AUTOMOTIVE INTAKE MANIFOLD USING CAE SOFTWARE

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for the award of the degree of
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive/Manufacturing*

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

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This project is dedicated to

both my beloved parents,

Haron Mohamed and Aishah Abd Rahman

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ABSTRACT

This project focused on simulation testing of automotive intake manifold design using Computer Aided Engineering software. Finite element Random Vibration analysis is conducted on Proton WAJA 1.6 intake manifolds designs for material cast aluminium alloy AlSi12 and glass-fibred polyamide PA6 GF30. The purpose of this project is to study the computational maximum stress on the model due to the effect of engine vibrations and pressure pulsation loads. The input data of vibrations and pressure pulsation loads are taken from previous studies. The softwares used are SOLIDWORK 2005 and ALGOR V16. Base on the simulation results obtained, the maximum stress of both materials are compared to distinguish which is better in resisting the vibration loads applied.

ABSTRAK

Projek ini memfokuskan kepada ujian simulasi terhadap rekabentuk manifol pengambilan automotif dengan menggunakan perisian kejuruteraan-bantuan-komputer. Analisis Getaran Rawak finite elemen dijalankan terhadap rekabentuk manifol pengambilan untuk kereta jenis Proton WAJA 1.6 yang diperbuat daripada bahan argentum aloi AlSi12 dan poliamid gentian kaca PA6 GF30. Tujuan projek ini adalah untuk mengkaji regangan maksimum pada model manifol akibat daripada getaran enjin dan denyutan tekanan yang berada dalam manifol itu. Data input getaran dan denyutan tekanan itu diperolehi daripada kajian-kajian lepas yang telah dijalankan oleh beberape penyelidik. Perisian yang digunakan dalam projek ini ialah SolidWorks 2005 dan ALGOR V16. daripada keputusan analisis yang diperolehi, regangan maksimum bagi kedua-dua bahan tersebut dibandingkan untuk mengenal pasti bahan mana yang terbaik menahan getaran yang dikenakan.

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P	Instantaneous power of vibration signal
$s(t)$	Vibration signal in time domain
$S(f)$	Vibration signal in frequency domain
$R(\tau)$,	Autocorrelation function
f	Frequency
$G(f)$	Power spectrum
π	Constant = 3.141592654

LIST OF ABBREVIATIONS

AlSi12	Cast aluminium alloy with 12% Si
PA6 GF30	Polyamide composite with 30% glass fibre
CAD	Computer-aided drafting
CAE	Computer-aided engineering
FE	Finite element
PSD	Power spectral density
SAE	Society of Automotive Engineers

CHAPTER 1

INTRODUCTION

1.1 Background

A properly designed intake manifold is essential for optimal functioning of an internal combustion engine. Traditional intake manifold optimization has been based on the direct testing of prototypes. This trial and error method can be effective, but expensive and time consuming. Moreover this method cannot provide any information about the actual structure properties of the intake manifold. One of the possible ways to obtain this information within a reasonable amount of time and cost is to conduct computational analysis.

Recently many studies have been carried out on flow through intake manifold in the past using Computer Aided Engineering (CAE) software. However there are only few studies of failure analysis for this automotive component using simulation. Hence this project is focused on determination of computational maximum stresses resulting from vibrations of operating engine and pressure pulsation load that occurs inside the intake manifolds. Stresses that are involved due to above loads are analyzed using CAE software.

Comparison of maximum stress on intake manifolds of different materials also is done. The materials chosen for analysis are cast aluminium alloy AlSi12 and polyamide PA6 GF30. The reason why these materials are chosen is because aluminium alloy is a common material for intake manifolds while polyamide is a new trend in automotive

industry to develop intake manifold by it. This comparison is done to determine which material is better in term of maximum stress in withstanding the loads applied.

For the determination of the failure and wear causes, hands-on reverse engineering approach is used. All the three type of intake manifolds are measured and the parameters are transferred to CAD software. Later the CAD designs are analyzed using CAE software. The two types of software that used in this project are SolidWorks (CAD) and ALGOR V16 (CAE). The analysis types that are use with the CAE software are Static Stress with Linear Material Model, Natural Frequency (Modal) analysis and Random Vibration analysis.

From the simulation results of the intake manifold, locations of weak-spots are located and the maximum stress at each location are analyzed and compared.

1.2 Problem statement

This project will focus on the study of maximum stresses on an automotive intake manifold design resulting from engine vibration and pressure pulsation loads.

1.3 Objectives

1. To carry out finite element stress analysis on an intake manifold design for maximum stress using Computer Aided Engineering software.
2. To compare the maximum stress between two different materials for the intake manifold.

1.4 Project Scope

The computational stress from finite element analysis will be carried out on a Proton WAJA 1.6 intake manifolds design. It is decided that intake manifolds of a multi-cylinder 1600cc internal combustion engine will be analyzed. The two different materials that are chosen for analysis is cast aluminium alloy, AlSi12 which is common material for intake manifold and polyamide PA6 GF30.

1.5 Flow Chart

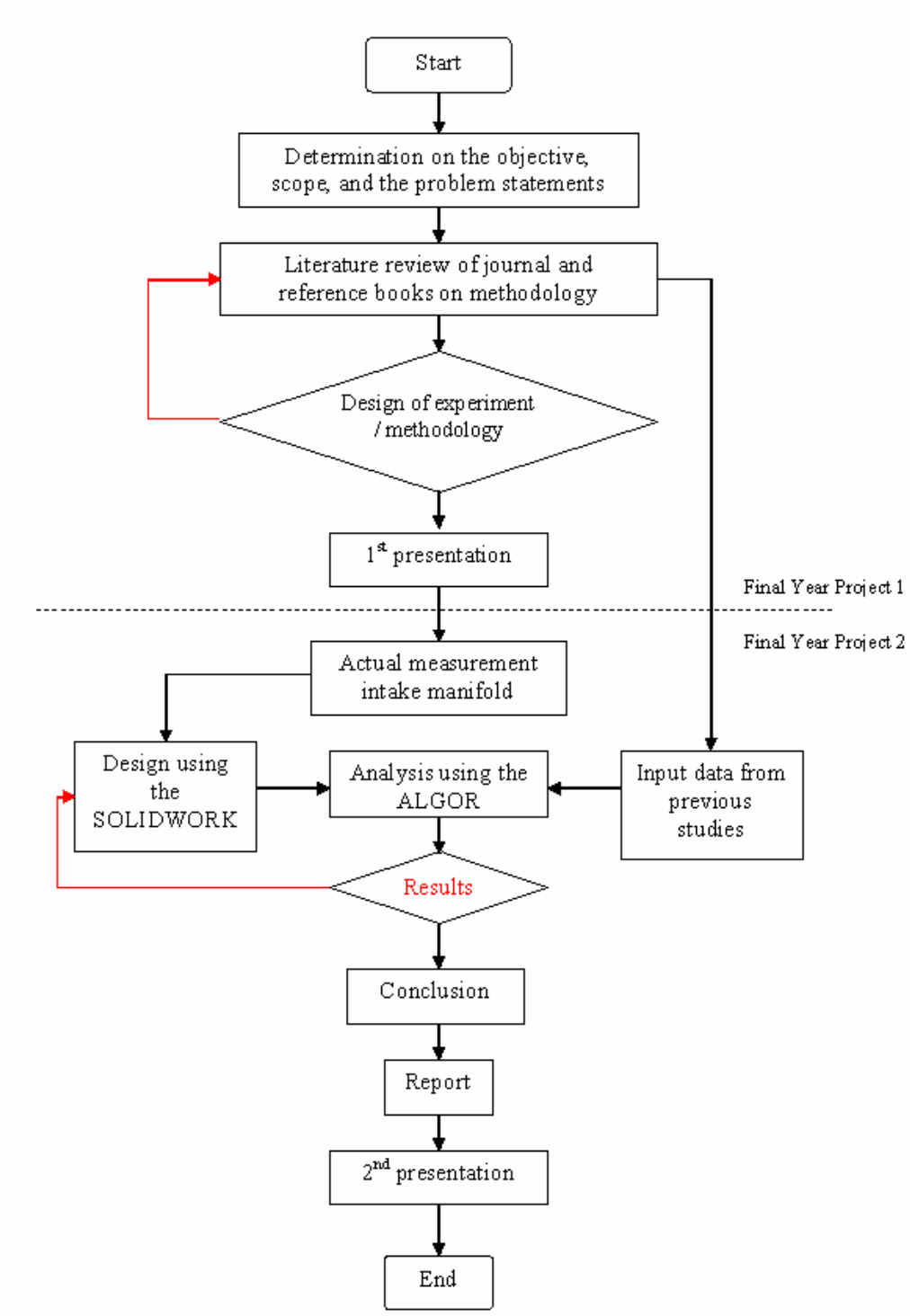

Figure 1.1 Flow chart of project.

1.6 Gantt Charts

PROJECT ACTIVITIES		WEEKS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Discuss title and objectives														
2	Discuss scope and problem statement														
3	Chapter 1														
4	Discuss the format of project														
5	Literature - journals and ref. books														
6	Discuss literature on the manifold														
7	Discuss literature on CAD and CAE														
8	Discuss literature on types of analysis														
9	Chapter 2 - literature review														
10	Discuss the analysis and methodology														
11	Chapter 3 methodology														
12	Preparation for presentation 1														

Figure 1.2: Gantt chart / Project Schedule for Final Year Project 1

PROJECT ACTIVITIES		WEEKS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Literature review														
2	Measure the dimension of intake manifolds														
3	Design using SOLIDWORKS														
4	Assemble the parts in SOLIDWORKS														
5	Discuss on analysis, constraints and loads														
6	Analyze manifold design using ALGOR														
7	Analyze and discuss the simulation results														
8	Conclude the project														
9	Complete chapter 4 and 5														
10	Prepare final report														
11	Preparation for presentation 2														

Figure 1.3: Gantt chart / Project Schedule for Final Year Project 2

CHAPTER 2

LITERATURE REVIEW

2.1 Intake Manifold – an overview

An intake manifold is one of the primary components regarding the performance of an internal combustion engine. An intake manifold is usually made up of a plenum, throttle body connected to the plenum and runners depending on the number of cylinders, which leads to the engine cylinder. A typical intake manifold is shown in Fig.1.4

.

Figure 2.1: Typical intake manifold

2.2 Air Intake System

The main function of air intake system is to filter; meter and measure the air flow into the engine cylinders. The air intake system consists of air filter and throttle body assembly, which includes throttle valve, intake manifold and either fuel injectors or a carburettor to inject fuel. The manifold consists of plenum chamber and manifold runners. Cylinder head intake path and intake valves also form part of air intake system. Figure 1.5 shows different parts of a general air intake system.

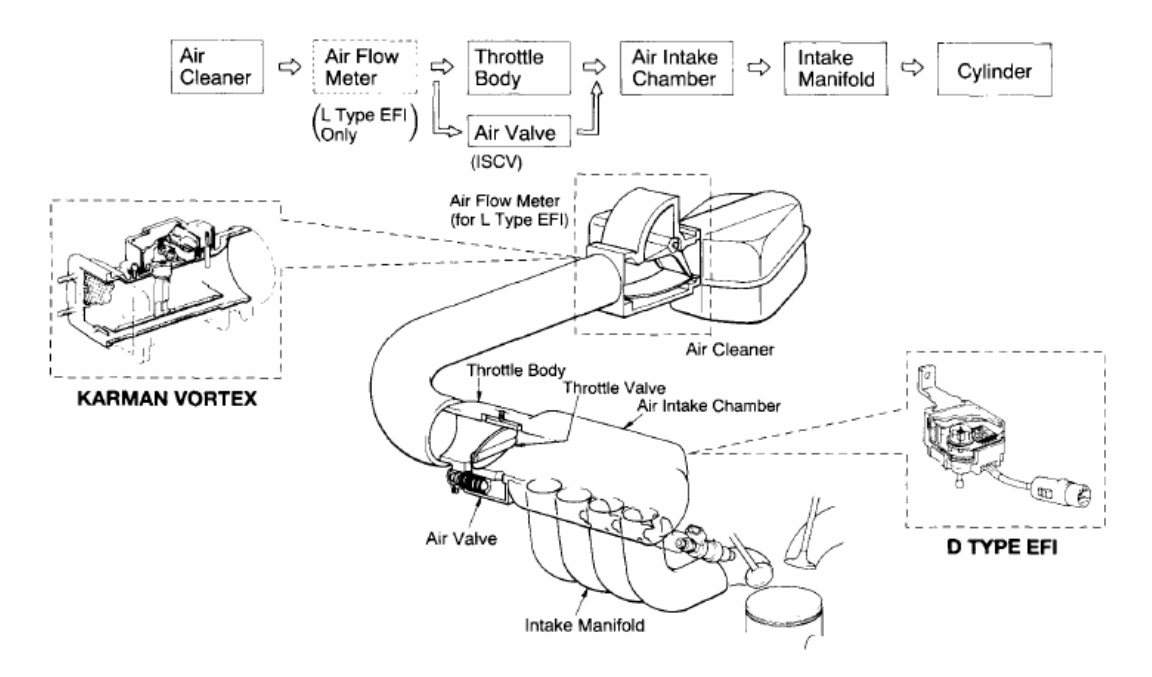

Figure 2.2: Air induction system [10]

2.3 Materials

There are several types of material used to make intake manifolds. The materials are cast aluminium alloy (AlSi12), magnesium alloy and polyamide composite (PA6 GF30) [14]. Locally, common intake manifolds are usually made of aluminium alloy. The materials that used in this project for analysis are AlSi12 and PA6 GF30.

2.3.1 Cast Aluminium Alloy AlSi12

AlSi12 alloy is a common material widely used in automotive and general engineering applications. It is also a material that most frequently encountered with in automotive intake manifolds. It consist of about 87% Al, 12% Si, and the rest are Fe, Mn, Zn, Mg, and Cu. [12]

The typical applications of this material are usually in casting intricate, thin-walled components and pressure tight items which require very good corrosion resistance, medium strength and high ductility. The mechanical properties are strongly dependent on the casting method applied such as sand casting and gravity die casting. Besides that, it also has excellent casting properties and can be produced by Hydro with a low Fe-content. [11]