

I have read this thesis and in my opinion this thesis coincides with the scope and the quality to be awarded Bachelors Degree in Mechanical Engineering (Automotive).

Signature: *Azli*
Supervisor: En, Mohd Azli bin Salim
Date: 10/5/2010
.....

**A STUDY OF WINDSHIELD AUTOMOTIVE WIPER NOISE AND VIBRATION
USING FINITE ELEMENT (FE) METHOD**

KUMARESAN S/O MAGASWARAN

**This report is submitted in partial fulfillment of the requirement for the Bachelor of
Mechanical Engineering (Automotive)**

**Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka**

APR 2010

DECLARATION

I hereby, declare this thesis entitled “A STUDY OF WINDSHIELD AUTOMOTIVE WIPER NOISE AND VIBRATION USING FINITE ELEMENT (FE) METHOD” is the results of my own research except as cited in references.

Signature : *Kumaresan*
Author's Name : KUMARESAN M. MAGASWARAN
Date : MAY 2010

DEDICATIONS

For my beloved Nithiyaa, family and friends

ACKNOWLEDGEMENTS

It gives me utmost pleasure to express my gratitude to who have directly or indirectly contributed to the fruition of the compilation. They include;

My supervising lecturer, Mr. Mohd. Azli b. Salim of which we had a excellent working relationship, and who offered tremendous help and encouragement,

My family, who inspired me, weather through the storm and carry on, and last but not least lecturers, friends and relevant personnel who helped in one way or another.

Thank you.

ABSTRACT

This paper presents the analysis of automotive windscreen wiper vibration by experimentation and finite element method. In this study, a wiper blade is tested for noise and vibration then a finite element model of that wiper blade is developed and then validated. ABAQUS analysis software is used to analyze the finite element model. The simulation is validated with the experiment. After validation, various modifications are proposed in order to reduce noise and vibration.

ABSTRAK

Kertas kerja ini menunjukkan analisis getaran pengelap cermin hadapan kereta melalui eksperimen dan kaedah unsur terhingga. Dalam kajian ini, pangelap kereta diuji untuk bunyi dan getaran, selepas itu modal unsur terhingga dibangunkan dan disahkan. Perisian computer analisa ABAQUS digunakan untuk menganalisa model unsur terhingga. Simulasi tersebut disahkan dengan eksperimen. Selepas pengesahan, beberapa pengubahsuain dicadangkan untuk tujuan pengurangan bunyi dan getaran.

CONTENTS

CHAPTER	TOPIC	PAGE
	Déclaration	ii
	Dedication	iii
	Acknowledgement	iv
	Abstract	v
	Abstrak	vi
	Table of contents	vii
	List of tables	ix
	List of figures	x
1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Problem statement	2
	1.3 Objective	2
	1.4 Scope of the project	2
	1.5 Research outcome	2
	1.6 Outline of the thesis	3
2	LITERATURE REVIEW	4
	2.1 Introduction	4
	2.2 Wiper System	4
	2.2.1 Types of wipers	5
	2.2.2 Wiping Styles	
	2.2.3 Wiper system basic functional requirements	7
	2.3 Vibrations	8

	2.3.1 Frequency	8
	2.3.2 Natural Frequency	16
	2.3.3 Eigenvalue	16
3	METHODOLOGY	10
	3.1 Introduction	10
	3.2 Flow chart	10
	3.3 Literature review	12
	3.4 Experimentation	12
	3.5 Software Description	13
	3.6 Simulation	14
	3.7 Validation	14
	3.8 Modification	15
	3.9 Conclusion	15
4	RESULT	15
	4.1 Introduction	15
	4.2 Measurement criteria	16
	4.3 Results (first experiment)	51
	4.3.1 Test results	17
	4.3.2 Findings from the graphs	19
	4.4 Results (second experiment)	20
5	NUMERICAL METHOD RESULTS	23
	5.1 Introduction	23
	5.2 Development of finite element model	23
	5.3 Analysis Results	27
6	CONCLUSION RECOMENDATIONS	34

6.1	Introduction	34
6.2	Conclusion	34
6.3	Recommendations	35
	REFERENCE	36

LIST OF TABLES

NO.	TITLE	PAGE
1.	Table 4.1: Experiment Data	21
2.	Table 5.1: Wiper CAD	23
3.	Table 5.2: Material Properties	25
4.	Table 5.3: Comparison between experimental results and simulation results	27
5.	Table 5.4: Wiper Rubber Modifications	28
6.	Table 5.5: Simulation results	31

LIST OF FIGURES

NO.	TITLE	PAGE
2.1	Wiper System	4
2.2	This is type of wiper is found on a few new models and widely available on the market	5
2.3	This is the common type of wiper found in most vehicles	5
2.4	Wiper blade types	5
2.5	Whippletree structure	6
2.6	Wiping style	6
2.7	Wiper system basic functional requirements	7
2.8	Vibration Types	8
3.1	Methodology flowchart	11
3.2	Experimentation diagram	13
3.3	Simulation Flow Chart	14
4.1	Measurement criteria	16
4.2	FFT graph for 2 sensors in dry condition speed 1	17
4.3	FFT graph for 2 sensors in dry condition speed 2	18
4.4	FFT graph for 2 sensors in dry condition speed 3	18
4.5	FFT graph for 2 sensors in wet condition speed 1	19
4.6	FFT graph for 2 sensors in wet condition speed 2	19
4.7	FFT graph for 2 sensors in wet condition speed 3	20
4.8	FFT graph sensor at position 3 in wet condition speed 2	21
5.1	Wiper System Assemblies in Abaqus	26

5.2	Wiper System Meshed Model	27
5.3	Graph Comparing Vibrational Frequencies of Base Wiper Rubber and Modified Wiper Rubber	32

CHAPTER I

Introduction

1.1 Introduction

Noise and vibration reduction is an important part in improving the comfort level in a car. As technological advancement and innovation happens, engine noise and environment noise that can be heard in the passengers' compartment had been reduced quite a lot. The noise had been reduced to such a level that other noise that had been over looked in the automotive industry has been more revealing. The noise from the wiper system can be quite disruptive to the comfort level in the vehicle. When the comfort level drops the driving performance can be affected as well. (S.Goto et al, 2001) Many car manufactures are currently looking in to various directions to curb this phenomenon. A lot of resources are poured into this matter as comfort is what sells a car. Due to this, we are seeing in the market a set of new generation wiper system emerging, rimless wiper is an example. Wiper blade generates many types of unwanted noise. Thus a study needs to been done to find out the types of noise generated by referring to the vibration produced by the wiper blades during operation so that design changes can be done accordingly.

1.2 Problem Statement

The problem is wiper blades generates unwanted noise that disrupts comfort levels in a vehicle, thus without proper study of the wipers vibration and its characteristics it's impossible to know the design changes that must be implemented. The second, without a simulation model which is validated with experimental results, a design change can't be tested unless a prototype is produced. A prototype involves high cost, thus simulation can cut down on development cost.

1.3 Objective

In this study there are three objectives which are needed to be completed. Firstly is to study the wiper system characteristics based on noise and vibration. Next is to analyze noise and vibration created by wiper system using finite element method. Lastly is to investigate the level of reversal noise that happens in wiper system

1.4 Scope of the project

The scope of this project does not involve the wiper arm and the wiper motor of the wiper system. The experimental measurements are done using fast Fourier transformation (FFT).The wiper system is needed to be modeled using computer aided design (CAD) software. Then the results for both experimental and simulation iscompared.

1.5 Research Contribution

The created system is able to fulfill the task required. Firstly proper experiment is done which means the experiment followed the actual conditions without any errors. Then it is proven that the simulation produced the same results as the experiment. After analyzing the experiment and simulation a few designs are tested with the simulation. A new design with lesser noise and vibration is proposed

1.6 Outline of the Thesis

Chapter Two, there is a complete literature study on wiper systems, noise, vibration and measurement techniques. The study focuses on previous research done so that assumptions can be made correctly. Besides that the simulation model also can be simplified so that its easier to run the simulation in the sense of reducing simulation time and save memory usage.

Chapter Three explains thoroughly about the method used to achieve the project objective. The methods mainly consist of experimentation and simulation. Another part is the validation; the validation is the part where the connection between simulation and experiment can be seen

Chapter Four presents the experimental results and the results analysis. In this chapter it can be seen the behavior of the wiper blade in the aspect of vibration. Different behavior at different conditions can be seen clearly.

Chapter Five is the numerical method result and the modifications proposed to reduce noise and vibration. This is where the validation happens. When the simulation model is found valid then it can be used for modifications and improvement

Chapter Six provides conclusion and recommendation for future works based on the outcome of this research

CHAPTER II

Literature Review

2.1 Introduction

In this section a complete literal study on the wiper system is done. The wiper system and its components are described and the types of wipers which are available are discussed. Then the noise and vibration is added to the study emphasizing on natural frequency.

2.2 Wiper systems

Wiper System is must on all vehicles and is an important system. Wiper system is considered one of the safety gadgets on a vehicle thus it is very important.

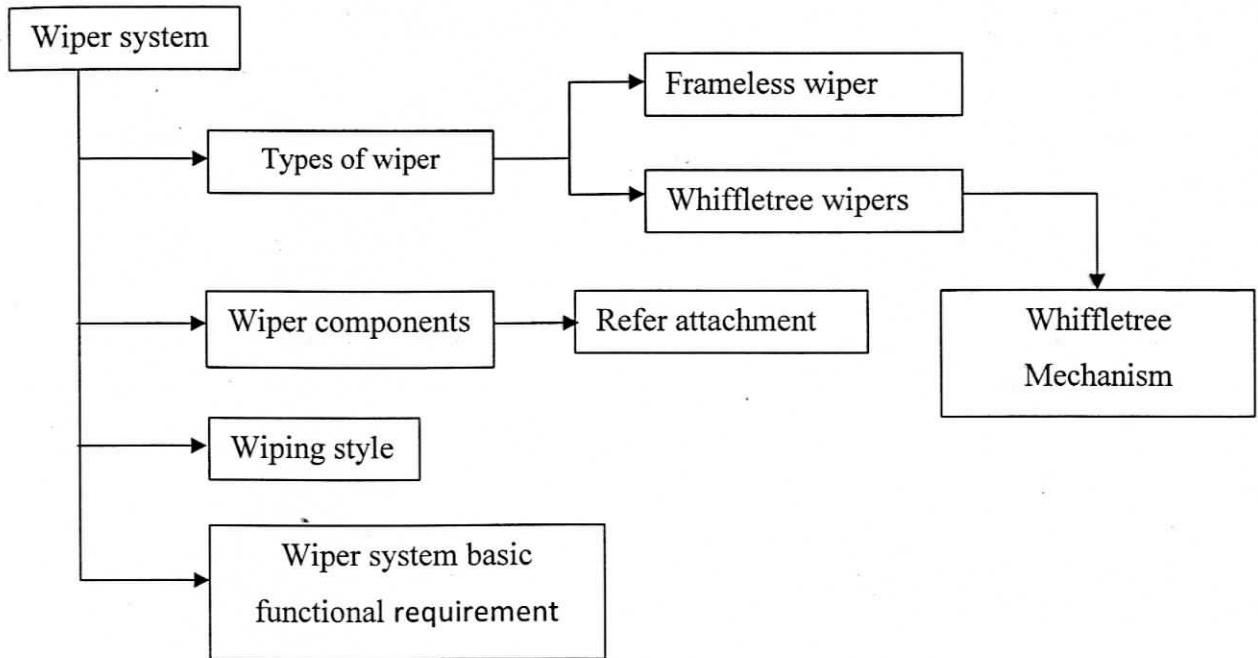


Figure 2.1: Wiper System

2.2.1 Types of wiper

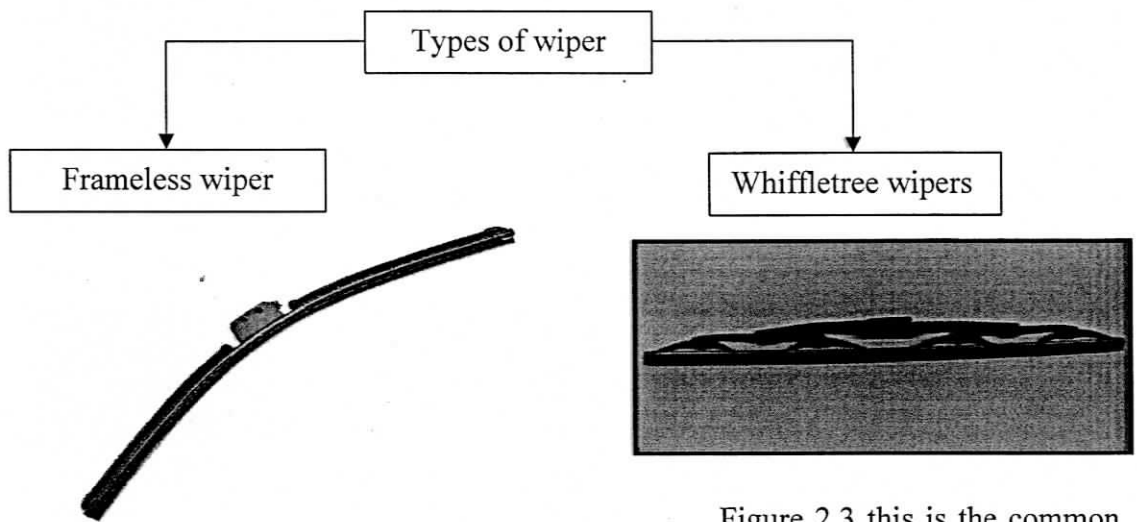


Figure 2.2 this is type of wiper is found on a few new models and widely available on the aftermarket

Figure 2.3 this is the common type of wiper found in most vehicles

Figure 2.4: Wiper blade types

The whiffletree mechanism is a mechanism to distribute force evenly through linkages. It consists of a bar pivoted at or near the centre, with force applied from one direction to the pivot, and from the other direction to the tips. Several whiffletrees may be used in series to distribute the force further. Whiffletrees may be used either in compression or tension

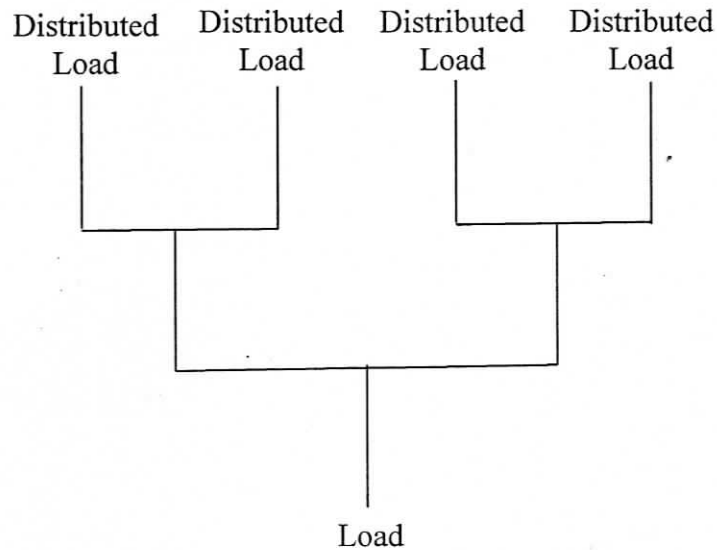
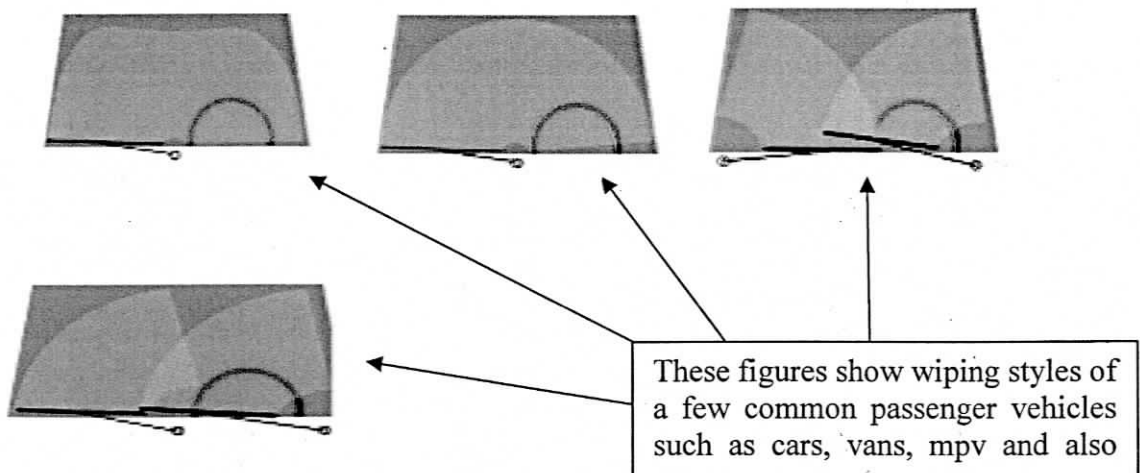


Figure 2.5: Whiffletree structure

2.2.2 Wiping style



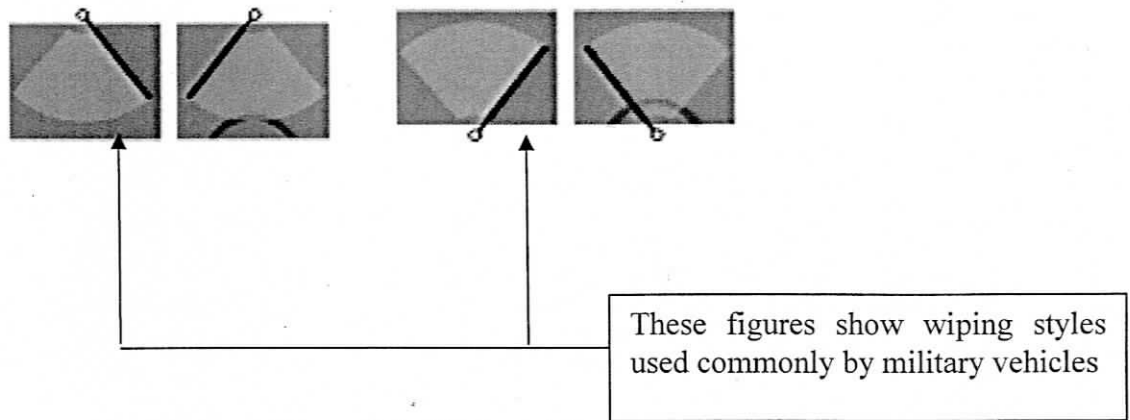
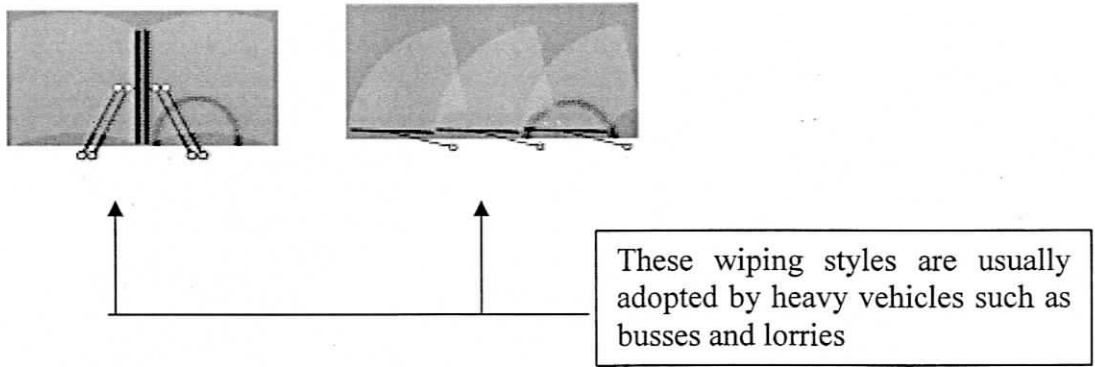


Figure 2.6: Wiping styles
(www.wikipedia.org , 5th august 2009)

2.2.3 Wiper system basic functional requirements

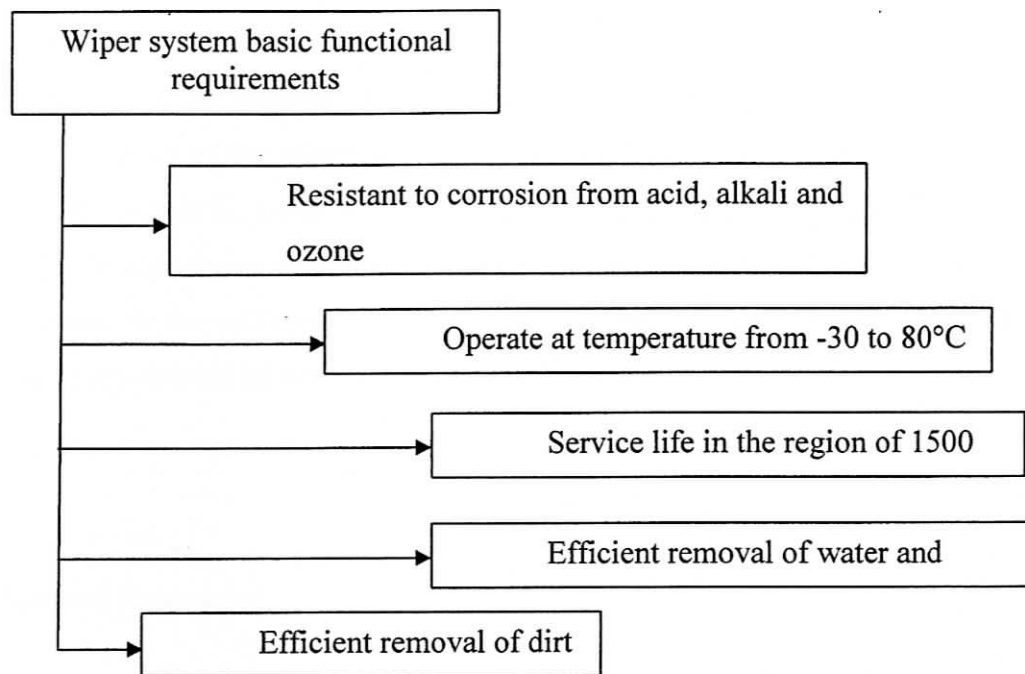


Figure 2.7: Wiper system basic functional requirements adapted from SAE standard SAE J903 (R)

2.3 Vibrations.

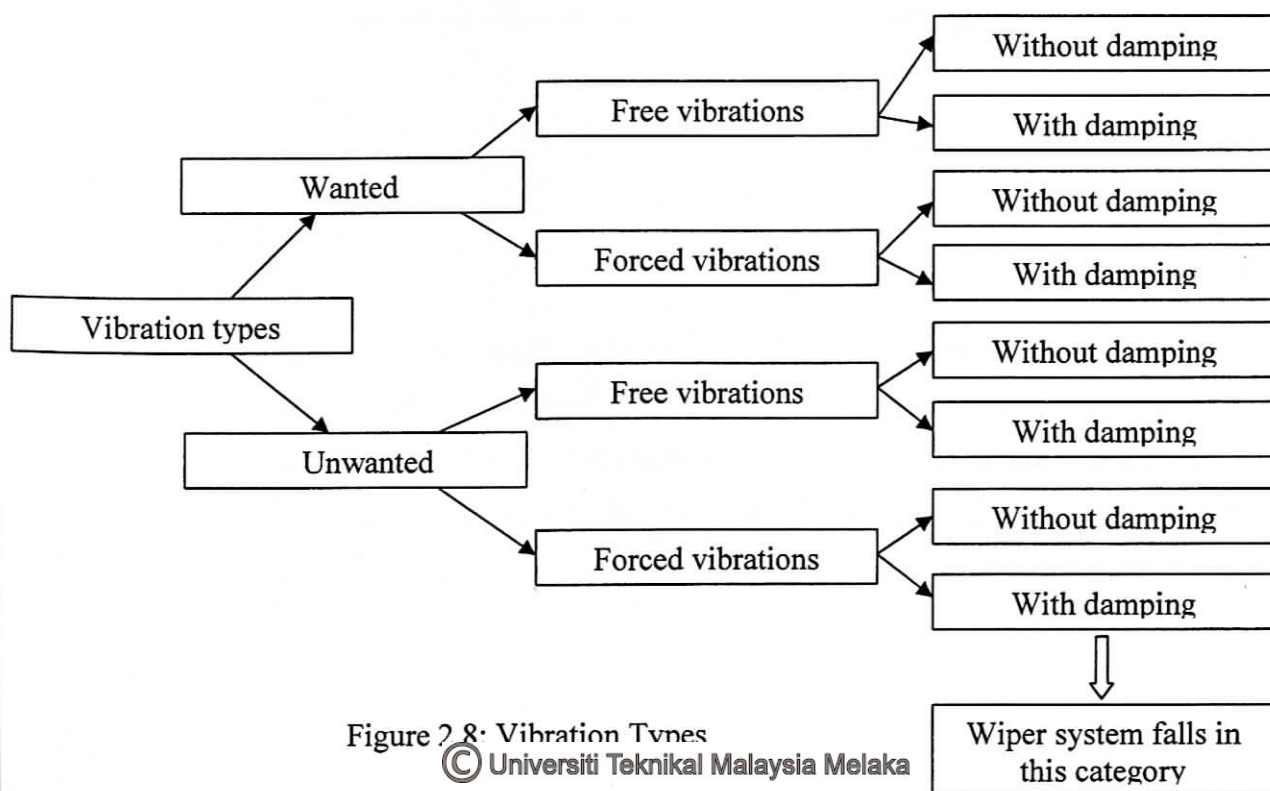


Figure 2.8: Vibration Types
 © Universiti Teknikal Malaysia Melaka

2.3.1 Frequency

Frequency is the number of occurrences of a repeating event per unit time. During the operation of the wiper, the wiper blades are designed to move along the windshield, this would be a single degree of freedom operation but during operation the wiper blade experience motion normal to desired motion. The motion normal to desired motion is an unwanted motion which called vibration. The repeating occurrence of this unwanted motion is measured as the frequency.

2.3.2 Natural Frequency

Natural frequency refers to one of frequencies which tend an object or system to vibrate when subjected to an impact or mechanical displacement. A certain object or system may have a few natural frequencies.

$$F_n = (1 / 2\pi) * \sqrt{(k / m)}$$

Above is the general equation of natural frequency, where k is the stiffness value.

2.3.3 Eigenvalue

Eigenvalue is much related to vibration studies. Eigenvalue is a representation of a vibrational frequency in mass and stiffness matrix. These methods have been used to study various noise and vibration problem such as disc brake sequel noise (P.liu et al, 2007). Since the wiper system is complex thus the Abaqus is used to do the analysis.

CHAPTER III

Research Methodology

3.1 Introduction

In this chapter is a detailed description about how the project can be implemented to fulfill the task required is explained. Each aspect of project implementation is discussed. The chapter begins with a description of overall implementation process. This is followed by a description of the process along the project. The software component used is Abaqus to analyze. The model is modified to improve its performance.

3.2 Flow Chart

The methodology describes about the methods or steps that is going to proceed to complete the project. Each category has own activities and procedures. The descriptions of each activity or procedure are given below.

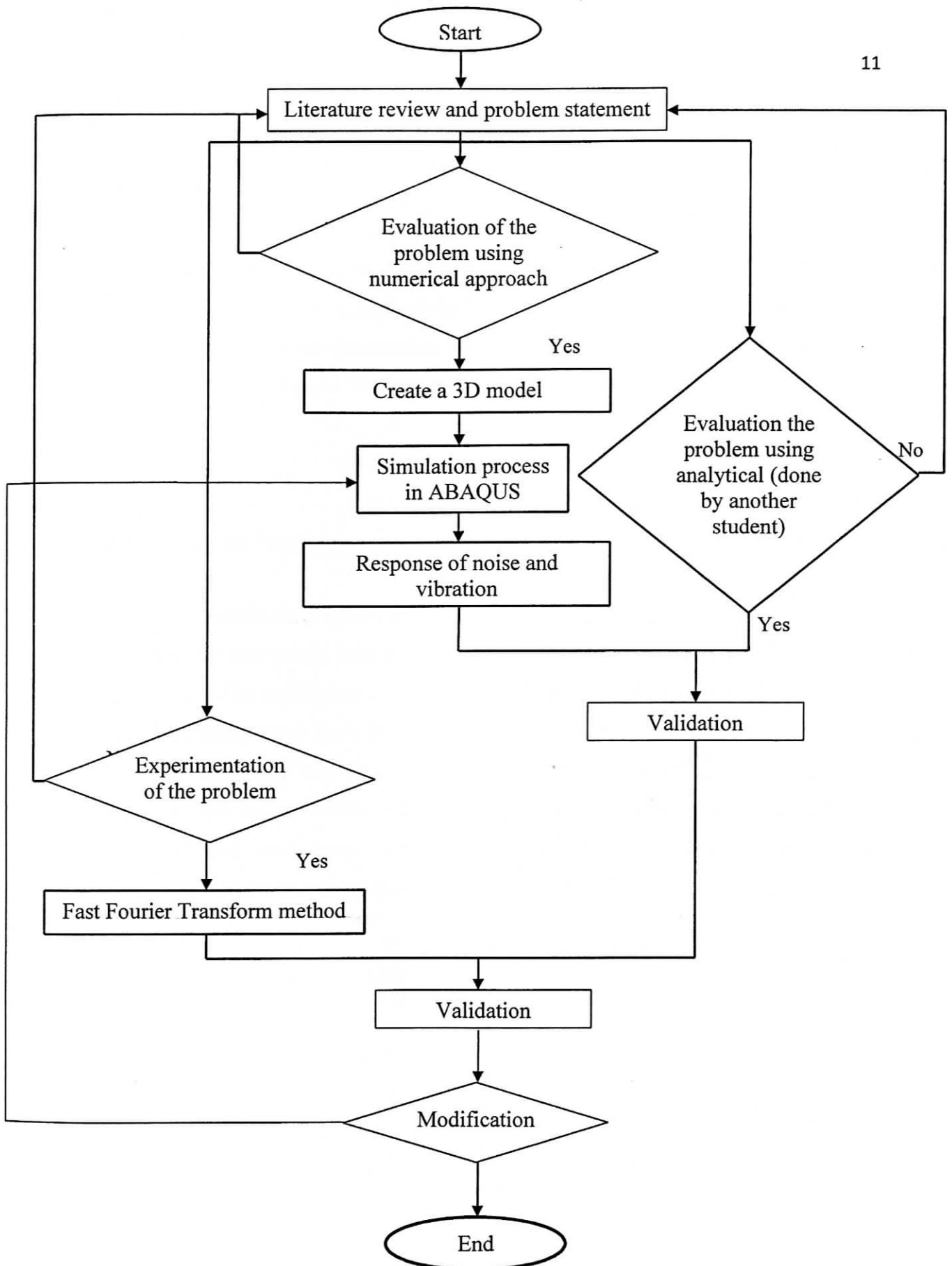


Figure 3.1 Methodology flowchart