DEVELOPMENT OF SUPPRESSION SYSTEM FOR NOISE AND VIBRATION IN AUTOMOTIVE FLEXIBLE WIPER

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ABSTRACT

(Keywords: Wiper System, Vibration and Noise, Newtonian Method)

This report presents the analysis of automotive windscreen wiper vibration by experimentation and analytical method. In this study, Newtonian approach was used as a technique to solve the modeling problem. The mathematical model is used to develop a simulation model using SIMULINK block diagrams in MATLAB. Based on the simulation, the results are shown in time and frequency domain to demonstrate the level of noise and vibration of wiper system. The simulation is validated with the experiment data analyzed by Fast Fourier Transform method. Based on the result, unwanted noise and vibration was identified as one of the disturbances to wiper system and this was verified with other researchers work.

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List of Publications

1. Preliminary study – Analytical approach in experimental rig of automotive flexible wiper system.
   International Journal of Physical and Mathematical Sciences - Published

2. Validation of vibration level in automotive flexible wiper system.
   Malaysian Technical Universities Network International Conference on Engineering and Technology - Published

3. Experimental study on vibration level of automotive flexible wiper system.
   Journal of Engineering and Technology - In-press.

4. Modeling, simulation and verification of parameters study on wiper system mathematical expression.
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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the background about the core of project title. Next is followed by the problem statement that faced in windscreen wiper during it maneuver. After that, objective of project being explained and the scope of the project being covered. This chapter will end with research contribution and outline of the Thesis.

1.2 Background

Wiper is an important element in a vehicle that functions to wipe rain drop and dirt from windscreen. Wipers are used in almost every vehicle, such as cars, buses, trams, locomotives, aircraft and ships. In automotive industry, majority of car manufacturer spend quite an amount of resources, efforts and researches to reduce unwanted noise produced in car wiper. Car engineers optimize engine design with an intention to reduce noise and vibration. However, when the engine had been successfully optimized, different types of sources will occur and one of the sources is produced from car wiper system. The main purpose of this report is to study of noise and vibration in flexible wiper system using analytical approach.

1.3 Problem Statement

Vibration and noise are two major problems in many moving components, such as engine system, transmission, suspension, etc. The vibration that takes place under the excitation of external forces is called forced vibration. If excitation is harmonic, the system is forced to vibrate at excitation frequency. This vibration is occurring in wiper system rottenly. Noise can explain as unwanted sound or noise pollution. The noise in wiper system directly influence by the vibration. With a simulation model of windscreen wiper system which is validated with experimental results, may lead to ideas and recommendation for reducing or minimizing noise and vibration in wiper system. Thus, the study of noise and vibration occupied in windscreen wiper system was carried out and evaluated with approaching an analytical method in this project.

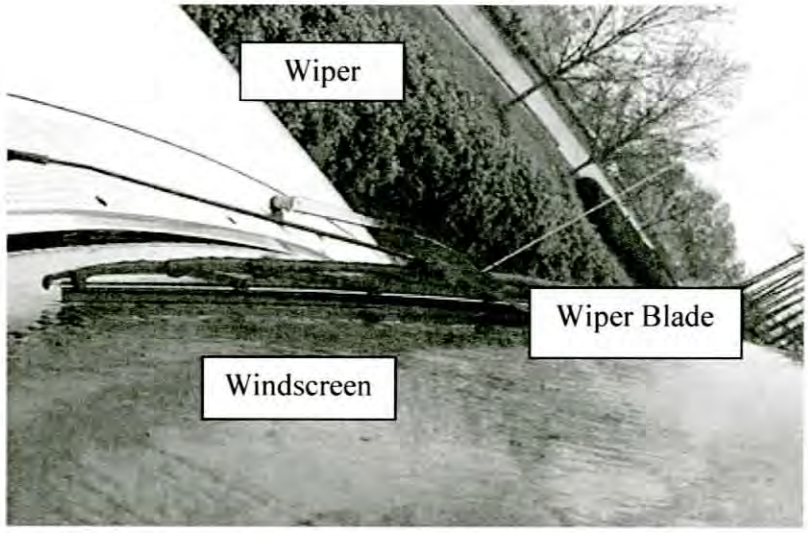

Figure 1.1: Windscreen wiper

(Source: www.wipeautomotive.com/images (05 July 2009))

1.4 Objective

The study of noise and vibration in windscreen wiper system was developed with a few objectives in this project. Those objectives are:

i. To study the wiper system characteristic-noise and vibration during operation.
ii. To analyze noise and vibration created by wiper system using analytical approach.

1.5 Scope

Following statements are the scopes of project:

1. The study do not involved the arm and motor of wiper system.
2. Experimental measurement using Fast Fourier Transform (FFT).
3. Needs to model wiper system using MATLAB.
4. The result for both experimental and simulation is needed to compare.

1.6 Research Contribution

It is expected that, the evaluation of noise and vibration of wiper system through the experiment and simulation on MATLAB will be able to fulfill the task required. Firstly the experiment using Fast Fourier Transform will be held. Then the wiper modal system developed in MATLAB. Hence, the comparison studies between experimental and MATLAB simulation results lead to further studies.

1.7 Outline of the Report

Chapter 2, there is a complete literature study on windscreen wiper system. It's also reviewed the vibration and analytical method.

Chapter 3 explains thoroughly about the method used to achieve the project objective.

Chapter 4 is the result obtained from the method used especially the experimental result. The result measured was analyzed through Fast Fourier Transform and detailed in this chapter.

The result validation and discussion of the product are explained in Chapter 5. The simulation result was validated with experimental result and clarified in this chapter.

Conclusion and recommendation for future works are explained in the final chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covered about windscreen wiper system in detail. Chapter begins with a literature search of windscreen wiper system and followed with the description of analytical method. It also includes explanations of noise and vibration.

2.2 Windscreen wiper system

Windscreen wiper is mechanical device that cleans the windshield. The first windscreen wipers were operated manually by moving a lever inside the car back and forth. Today, most of vehicles use electric windscreen wipers. The wipers faithfully keep the window clear, moving back and forth across the windscreen countless times as they sweep the water away.

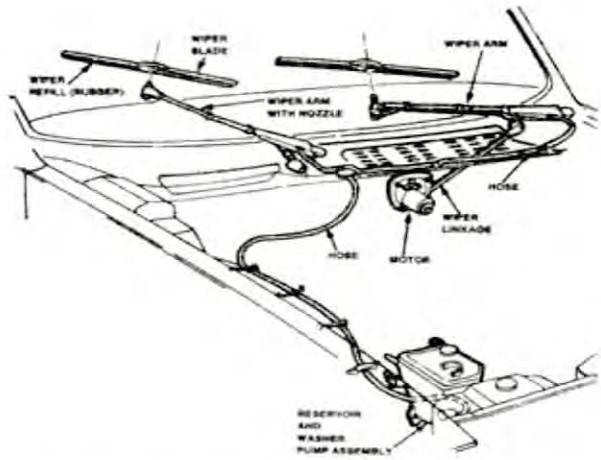

Figure 2.1: Windscreen wiper model

(Source: www.procarcare.com (05 July 2009))

2.2.1 Wiper Blades

The wiper blades are important part in wiper system. They are made of a rubber compound and are held on to the windshield wiper glass by a spring in the wiper arm. The wiper blade and its parts showed in Figure 2.2.

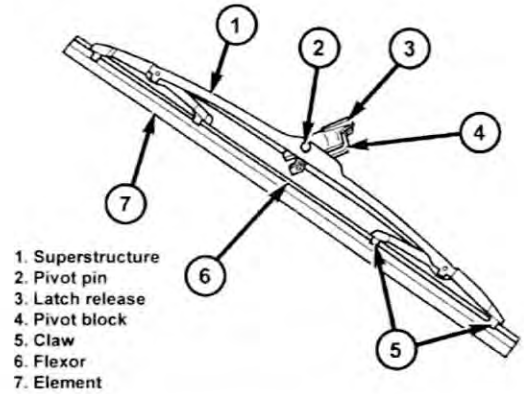

Figure 2.2 Wiper blade and its parts

(Source: www.wjjeeps.com (02 July 2009))

The aerodynamic properties of the wiper blades have become increasingly important due to the design of the vehicle as different air currents flow on and around the screen area. The strip on top of the rubber element is often perforated to reduce air drag. A good quality blade will have a contact width of about 0.1mm. The lip wipes the surface of the screen at an angle of about 45°. The pressure of the blade on the screen is also important as the coefficient of friction between the rubber and glass can vary from 0.8 to 2.5 when dry and 0.1 to 0.6 when wet (Anthony et al, 2010).

There are two type of wiper blade which is rubber and silicone. Wiper blades are like squeegees. The arms of the wiper drag a thin rubber strip across the windscreen to clear away the water. When the blade is new, the rubber is clean and has no nicks or cracks. It wipes the water away without leaving streaks. When the wiper blades are old, nicks or cracks form, road grime builds up on the edge and it does not make as tight a seal against the window, so it leaves streaks. A little extra life can be obtained out of the wiper blade by wiping the edge with a cloth soaked in window cleaner until no more dirt comes off the blade (Anthony et al, 2010).

2.2.2 Types

The basic blade is a single edged rubber strip, but other versions are available. There are multi-edged blades that claim to clear the windshield more thoroughly, a claim made by the double blade as well. The frame of this blade holds two wiping surfaces.

A winter wiper blade is usually made of heavier plastic or can be a blade which has the superstructure covered by fabric to prevent snow and ice from accumulating and freezing it to the windshield. A consumer has the option of replacing just the rubber, which is called a refill. The blade and frame can also be replaced.

2.2.3 Size

Wiper blades are sold by application, location and size. Blades are measured along the length of the rubber. It is not unusual for a vehicle to have two sizes of wiper blade depending on its location on the car. Wiper blades for the rear of SUV's, hatchbacks and wagons are generally shorter.

2.2.4 Raw Materials

The manufacturer purchases all of the parts from companies that specialize in fabricating parts from aluminum and steel, rubber blades, plastic bushings for the linkages, and the motors. Windshield wipers and windshield wiper systems (with motors) are different assemblies; some manufacturers make both, and others produce wipers only.

The connecting and drive links and the pivots that move the wipers are made of galvanized steel. Galvanization is the process of applying zinc coating to steel to protect it from corrosion. Drive arms for boats and vehicles used in the marine industry are made of stainless steel that resists damage from salt water. The wiper suspension and claws are also galvanized steel. The galvanizing zinc coating is easier to paint than uncoated steel. Steel is also the material in the small parts of wipers, such as washers, screws, nuts, springs, and brackets.

The blade frame is made from aluminum. The blades are made of natural rubber or synthetic compounds. Some rubber blades are composites of soft rubber on the wiping edge (the squeegee surface) and firm rubber that support the wiping edge in the rest of the blade.

Other materials that comprise parts of windshield wipers are rubber for washers in the pivots and plastic bushings that line holes for connecting parts of the linkage. The wiper suspension is typically painted black. If the wiper manufacturer also builds wiper systems, motors are purchased from subcontractors. The motors are contained in steel housings and include permanent magnet motors wound with copper wire. Each of housing has connections for the electrical wires those are part of the vehicle and wiring harnesses are furnished specific to operating the wipers. Each motor also contains one or more electronic circuits depending on the sophistication of the system that the motor controls.

2.2.5 Function of Wiper System

Windscreen wipers make it possible to drive in the rain and snow, and also clean the windshield when it is dirty, so that the driver can drive safely. The windscreen wiper system is comprised of the wiper switch, the wiper motor, the washer switch, the washer motor, the delay box and wiring from the ignition and the fuse panel.

The wipers themselves are metal or plastic arms, which carry rubber blades. The wiper arms are connected to the wiper motor via a series of arms and bushings. When the windshield wiper motor turns, it moves the arms those are hooked to the motor and the windshield wiper arms, therefore moving the arms holding the blades back and forth across the windshield. The rubber on the windshield wiper arms works like a squeegee, wiping water, ice and snow from the windshield.

Moreover, wiper system is a device that operates to wipe windscreen from rain and dust. A clear vision during these bad weathers is important to the safety of driver and passengers. The back and forth movement of wiper at the same times will produces an unwanted noise and vibration level. Figure 2.3 shows a schematic diagram of a

simple wiper system. A study such as in analytical and visualization approaches is implemented to found out the level of noise and vibration in this system.

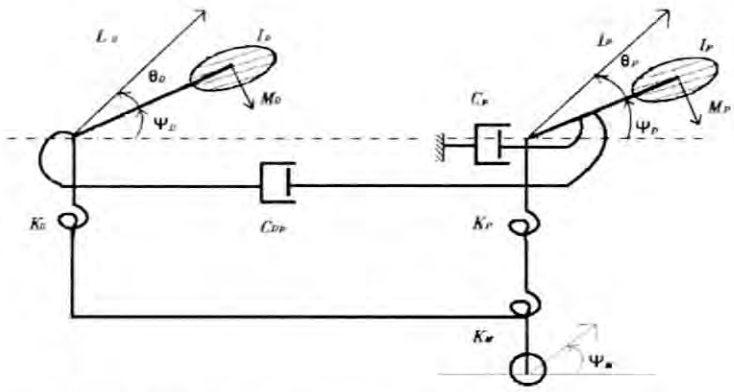

Figure 2.3: Schematic Diagram of Wiper System
(Sources: Chang S. C. & Lin H. P. (2004))

2.3 Noise and Vibration

Noise means unwanted sound or sound pollution. Vibration refers to mechanical oscillations about an equilibrium point. A body is said to vibrate if it has periodic motion. Vibrations are harmful for engineering systems. Sometimes vibrations can be useful. For example, vibratory compactors are used for compacting concrete during construction work. Excessive vibration causes discomfort to human beings, damage to machines and buildings and wear of machine parts such as bearings and gears.

The study of vibrations is important to aeronautical, mechanical and civil engineers. It is necessary for a design engineer to have a sound knowledge of vibrations. The vibration that takes place under the excitation of external forces is called forced vibration. If excitation is harmonic, the system is forced to vibrate at excitation frequency. More often, vibration is undesirable, wasting energy and creating unwanted

sound. For example, the vibration motions of engines, electric motors, or any mechanical device in operation are typically unwanted.

2.4 Natural Frequency

Natural frequency is the frequency at which a system naturally vibrates once it has been set into motion. In other words, natural frequency is the number of times a system will oscillate (move back and forth) between its original position and its displaced position, if there is no outside interference. For example, consider a simple beam fixed at one end and having a mass attached to its free end, as shown in Figure 2.4. If the beam tip is pulled downward, then released, the beam will oscillate at its natural frequency.

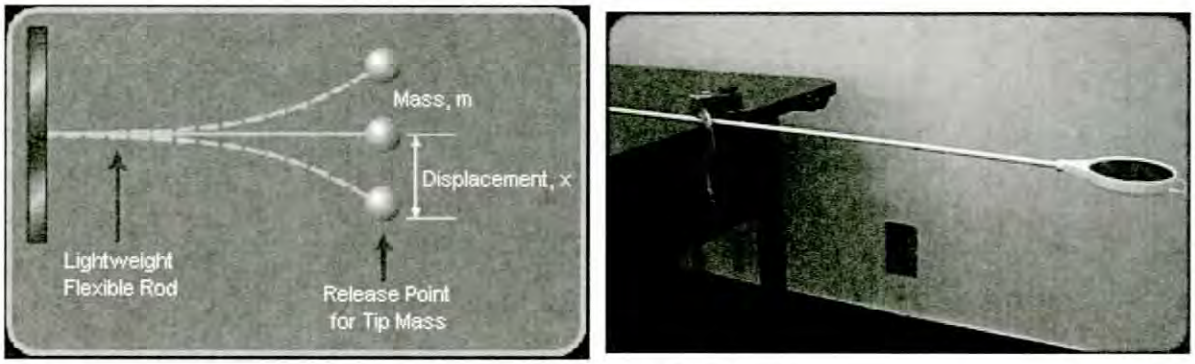

Figure 2.4: Frequency of beam

(Source: www.cs.wrigth.edu (10 July 2009))

In simple terms, damping is the conversion of mechanical energy of a vibrating structure into thermal energy, which is then lost to the structure's environment.

2.5 Analytical Method

Analytical means to proceed by way of analysis. An analytical way of doing something involves the use of logical reasoning. The analytical approach in mechanical is a highly mathematical form of classical mechanics, constructed from the eighteenth century onwards as a formulation of the subject as founded by Isaac Newton. The correctness of the simulation when using an analytical method is easily provable because analytical solutions are based directly on the laws of Newtonian dynamics. Analytical methods however are much more complex to derive and implement.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter is a detailed description about how the project can be implemented and carried out to fulfill the task required. Each aspect of project implementation is discussed. The chapter begins with a description of overall implementation process. This is followed by a detailed explanation of every aspect.

3.2 Methodology Flow Chart

The methodology flow chart describes about the methods sequence or steps that is going to be implemented to complete the project. The process will be started with reviewing the core element of the project; windscreen wiper system and analytical method. Each category has its own activities, procedures and tools.

The evaluation of noise and vibration in wiper system was developed using analytical method, while an experiment was conducted to find the noise and vibration response in wiper. A comparison will be made between the experimental result and the analytical (simulation) result. Figure 3.1 shows the flow chart for the methodology.

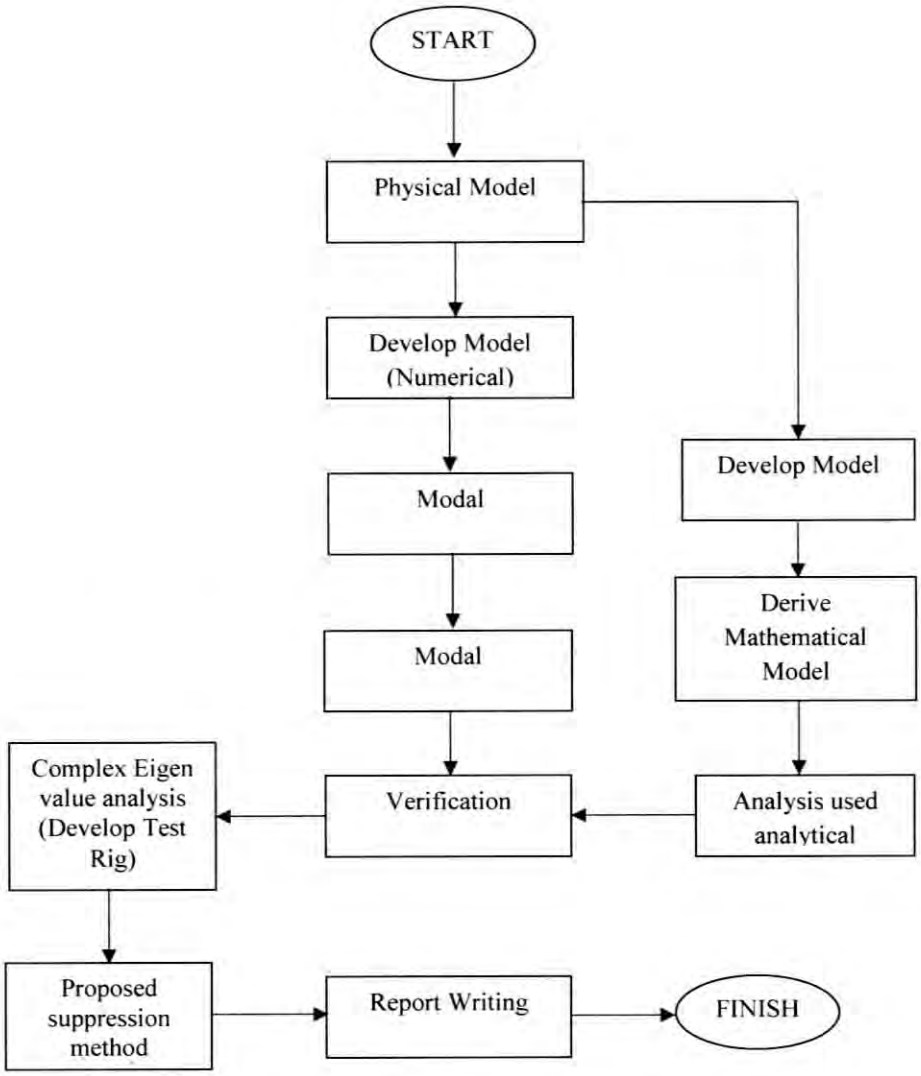

Figure 3.1: Methodology flowchart

3.2.1 Detail Description of Flow Chart

a) Literature Review

The previous chapter briefly described the literature of windscreen wiper system, noise, vibration and analytical method. Much information was collected and analyzed from literature review for implementation process. The literature review briefly describes about windscreen wiper.

b) Analytical approach

i) Mathematical model

The wiper system should derive in mathematical equation to do the simulation using MATLAB software. Figure 1 is the actual mechanical model of wiper system contains applied dynamic and static forces.

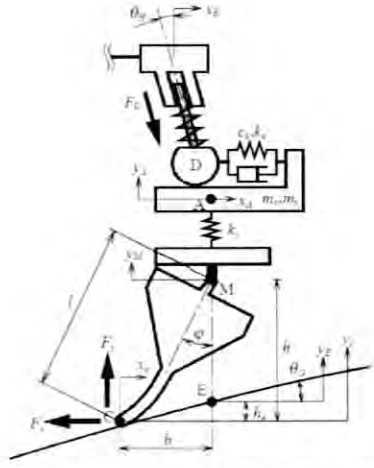

Figure 3.2: Actual model of wiper system

(Source: Okura S. et al (2000))