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

MAGNETORHEOLOGICAL BRAKE SYSTEM CHARACTERIZATION USING NON PARAMETRIC TECHNIQUE

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Faculty of Mechanical Engineering
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APRIL 2009

CONFESSION

"I admit that this report is from my own work and idea except for the summary and a few sections which were extracted from other resources as being mention".

Signature : ....

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Date : 13/05/2009

DEDICATION

FOR MY LOVELY FAMILY…
YOU ARE THE BEST IN MY LIFE…

FOR MY LECTURER AND MY FRIEND…
THANKS FOR YOUR SUPPORT…

ACKNOWLEDGEMENT

Firstly I want to give high appreciation to my supervisor, Dr. Khisbullah Hudha cause guidance and instigation me to finish my PSM (Projek Sarjana Muda). Special thanks to En. Ubaidillah as master student also guidance me gave many information to help me do my project.

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ABSTRAK

Industri Automotif berubah setiap hari. Berbilion wang dilaburkan untuk mengkaji dan membangunkan keselamatan, berharga rendah dan pretasi yang baik untuk kenderaan. Salah satu pelaburan ialah judul "x dengan wayar" yang telah diperkenalkan untuk meningkatkan mekanikal sistem pada automobil yang sedia ada. "x dengan wayar" bermaksud menukarkan sistem mekanikal kenderaan kepada sistem elektromekanikal di mana ia dapat melakukan sesuatu pekara dengan cepat, boleh dipercayai dan cara yang betul daripada sistem mekanikal yang sedia ada.

Dalam laporan ini juga menunjukkan sifat 'magnetorheological' brek dibuat berdasarkan sifat fizikal cairan MR, arus elektrik dan sifat rekabentuk brek.

ABSTRACT

Automotive industry is changing everyday. Billions of dollars are invested in research and development for building safer, cheaper and better performing vehicles. One such investment is the "x by wire" topic which has been introduced to improve the existing mechanical systems on automobiles. This "x by wire" means that the mechanical systems in the vehicles can be replaced by electromechanical systems that are able to do the same task in a faster, more reliable and accurate way than the pure mechanical systems.

This paper shows the characterization of a Magnetorheological brake can be made through the physical characteristics of the MR fluids, current and brake model characteristics.

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INTRODUCTION

1.1 BACKGROUND

The MRB is a pure electronically controlled actuator and it has the potential to further reduce braking time as well as easier integration of existing and new advanced control features such as anti-lock braking system (ABS), vehicle stability control (VSC), electronic parking brake (EPB), adaptive cruise control (ACC), as well as on-board diagnostic features. Furthermore, it will reduce number of components with simplified wiring and better layout is all additional benefits. In the automotive industry, companies such as Delphi Corp. and Continental Automotive Systems have been actively involved in the development of commercially available EMB as next generation 'brake by-wire' technology.

These are aimed at passenger vehicles with conventional power trains, as well as vehicles with advanced power sources, like hybrid electric. For example, Delphi has recently proposed a switched reluctance (SR) motor as one possible actuation technology for EMB applications. Another type of passenger vehicle EMB that a number research groups and companies have been developing is Eddy Current Brakes (ECB). While an ECB is a completely contact less brake that is perfectly suited for braking at high vehicle speeds. However, it cannot generate enough braking torque at low vehicle speeds.

In this chapter, will be discussed the objective of the project, scope of the project and the problem statement. The title of this project is to develop the magnetically activated brake system. This brake system is different with the conversional brake system where it use magnetic device to activate the brake function. This brake system also use a smart material called Magnetorheological fluid (MR fluid) that is the latest technology used in automotive industries.

1.2 OBJECTIVE

1. To characterize the behavior of the existing MR Brake.
2. To validate the MR brake model with the experimental result.
3. To compare the parametric technique with non parametric technique.

1.3 SCOPE

The scopes of this project are the completion of the existing MR Brake Test Rig. Then, the MR Brake will be characterized experimentally to involve the behavior in the form of torque versus current, current stopping versus time characteristic. The result of the MR Brake characterization then used to validate the simulation model which has been carried out using MATLAB simulink.

1.4 PROBLEM STATEMENT

The problem related to the Conventional Hydraulic Braking System is the conversion of kinetic energy to thermal energy to provide the required braking torque to stop a vehicle. It has several limitations and disadvantages such as response delay, wear of braking pad, high power consumption and requirement for auxiliary component. The auxiliary component such as hydraulic pump, transfer pipes and brake fluid reservoir can increased overall vehicle weight. When the driver presses on the brake pedal, the hydraulic brake fluid provides the pressure in the brake actuators that squeezes the brake pads onto disk. The heat produced cause from the interface of the pad brake with the disk where it can decrease the friction capability of brake pads compound. Other factor is possibility of leakage of the brake fluid that can cause fatal accident.

1.5 OUTLINE PROJECT

CHAPTER 1

In this chapter, the description about a background of braking system, an objective of the project, scope and the problem statement that comes from the braking system.

CHAPTER 2

In this chapter are literature review where the information about history of automotive braking system, the Magnetorheological Fluid (MR fluids) and Magnetorheological Brake.

CHAPTER 3

This chapter are methodology that the method that used to complete the project. It's included the flow chart, results variable, equipment, experiment procedures and also instrument setting. The experimental is for parametric and non parametric method.

CHAPTER 4

This chapter is result and discussion about the result that obtained from the simulation and experiment. The mathematical model for MR braking system of parametric equation, the MR fluid behavior and brake torque calculation are explained in this chapter. Then, the experimental result that will be compared wit parametric and non parametric. The non parametric is determined from the experimental data. After that, the validation of each graph will be discussed.

CHAPTER 5

The conclusion of the entire project is explained in this chapter. Then, the recommendation for reformation of the MR brake system for future works.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter presents a review of the technical literature review to the issue that related in design and develops the magnetic brake system. The chapter review about history of the brake system, the conventional brake system that used in automotive industries, review about the Magnetorheological fluids, and review about the 'Magnetorheological Braking System' with the equation related to the 'Magnetorheological Braking System'.

2.1 HISTORY OF AUTOMOTIVE BRAKE SYSTEM

The disk brake was design by Dr. F.W. Lanchester in 1902 in England. It was incorporated into the Lanchester car produced between 1906 through 1914. These early disk brakes were not as effective at stopping as the contemporary drum brakes of that time. Another important development occurred in the 1920 when drum brakes were used at all four wheels instead of a single brake to halt only the back axle and wheels. The disk brake was again utilized during World War II in the landing gear of aircraft.

In the technology of system brakes, drum brakes and disk brakes have advantages and disadvantages. Drum brakes still have the edge in cheaper cost and lower complexity. Most cars were built today using disk brakes in front and drum brakes in the back wheels. Drum brakes had another advantage compared to disk brake systems. The geometry of the brake shoes inside the drums can be designed for a mechanical self-boosting action. The rotation of the brake drum will push a leading shoe brake pad into pressing harder against the drum. Early disk brake systems required an outside mechanical brake booster such as a vacuum assist or hydraulic pump to generate the pressure for primitive friction materials to apply the necessary braking force. All friction braking technology uses the process of converting the kinetic energy of a vehicle's forward motion into thermal energy.

According to a research study by Frost & Sullivan, there is probability that after 2010, the global automotive industry will start using brake-by-wire systems instead of hydraulic braking systems. The various technologies such as electro mechanical braking system and the electronic wedges brake are soon going to replace the older braking systems. With the help of these brake-by-wire systems, automobile drivers will be having more control on their vehicles particularly in case of sheer emergency.

2.1.1 Hydraulic Brake

The hydraulic brake is an arrangement of braking mechanism which uses brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling unit, which is usually near the operator of the vehicle, to the actual brake mechanism, which is usually at or near the wheel of the vehicle. The most common arrangement of hydraulic brakes for passenger vehicles consists of a brake pedal, a vacuum assist module, a master cylinder, hydraulic lines, a "slave cylinder", and a brake rotor or brake drum. Typical passenger vehicles employ disc brakes on the front wheels and drum brakes on the rear wheels. However, four wheel disc brakes are becoming more popular.

When the force is applied to this piston will increase the pressure in hydraulic system and forcing fluid through the lines to the slave cylinders. The two most common arrangements of slave cylinders are a pair of opposed pistons which are forced apart by the fluid pressure (drum brake), and a single piston which is forced out of its housing (disc brake). The friction between the linings and drum or rotor causes a braking torque to be generated and it will slow the vehicle movement or stop the vehicle.

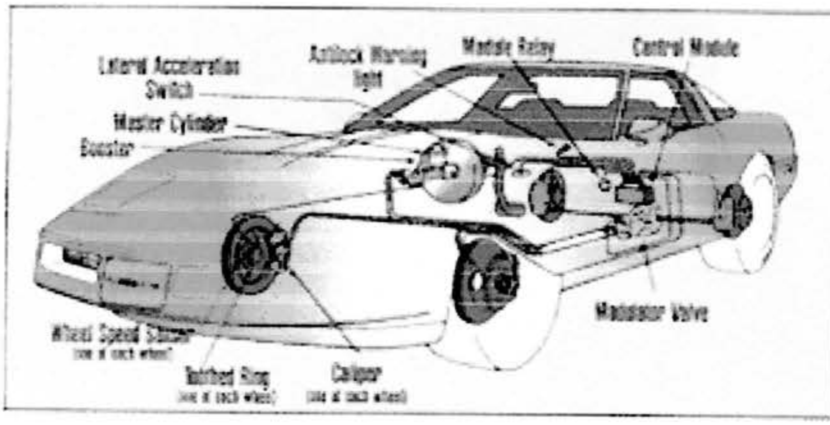

Figure 2.1: Hydraulic Pipe Linkage

2.1.2 Disk Brake

The disc brake or disk brake is a device for slowing or stopping the rotation of a wheel. A brake disc usually made of cast iron or ceramic composites such as carbon, Kevlar and silica. The disk brake is connected to the wheel and the axle. To stop the wheel, friction material in the form of brake pads is mounted on a device called a brake caliper that is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. The friction will cause the disc and attached wheel to slow or stop.

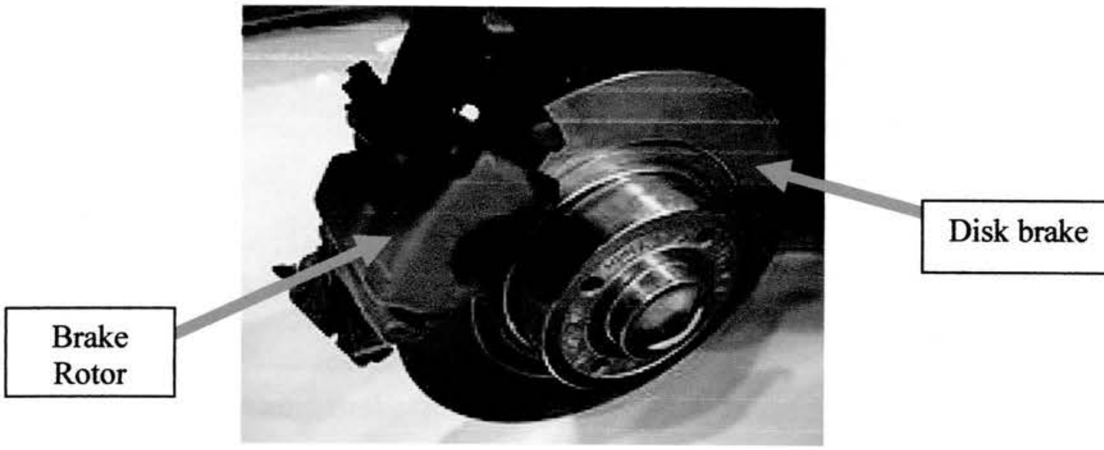

Figure 2.2: Disk Brake Component

2.1.3 Drum Brake

A drum brake is a brake in which the friction is caused by a set of shoes or pads that press against the inner surface of a rotating drum. The drum is connected to a rotating wheel. Drum brakes have a natural 'self-applying' characteristic. The rotation of the drum can drag either or both of the shoes into the friction surface, causing the brakes to bite harder, which increases the force holding them together. This increases the stopping power without any additional effort being expended by the driver, but it does make it harder for the driver to modulate the brakes sensitivity.

Disc brakes exhibit no self-applying effect because the hydraulic pressure acting on the pads is perpendicular to the direction of rotation of the disc. Disc brake systems usually have servo assistance (Brake Booster) to decrease the driver's pedal effort.

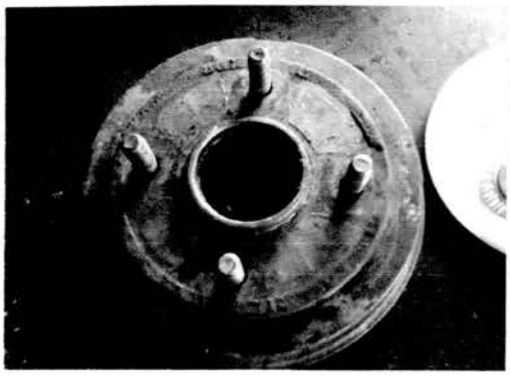

Figure 2.3: Drum Brake

Figure 2.4: Brake Shoe (red arrow)

2.1.4 Air Brake System

An air brake system uses compressed air to apply the brakes. Air under pressure can be conveniently stored and carried through lines or tubes. An air pump or compressor driven by the engine is used to compress air and force it into a reservoir where it is forced under pressure and made available for operating the brakes. Air under pressure in the reservoir is released to the brake lines by an air valve operated by the brake pedal. The force of the compressed air admitted to the brake chamber causes the diaphragm to move the plate and operate the brake shoes through the linkage. Considerable force is available for braking because the operating pressure may be as high as 110 psi. All brakes on a vehicle, and on a trailer when one is used, are operated together by means of special regulating valves.

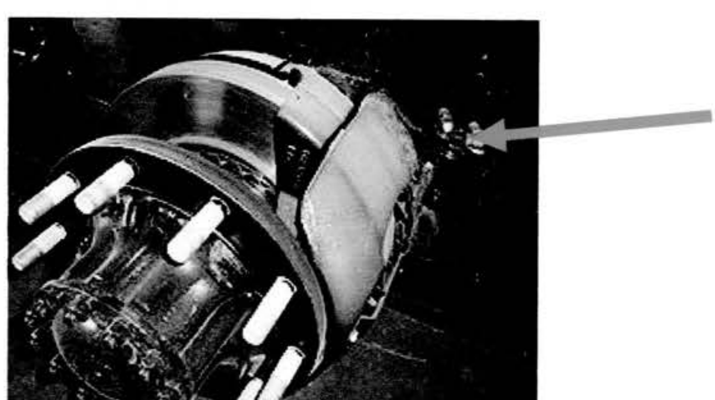

Figure 2.5: Truck Air Actuated Disc Brake

2.1.5 Vacuum Brake System

The vacuum brake is a braking system used on trains. It was first introduced in the mid 1860s and a variant, the automatic vacuum brake system became almost universal in British train equipment, and in those countries influenced by British practice. It enjoyed a brief period of adoption in the USA, primarily on narrow gauge railroads. Its limitations caused it to be progressively superseded by compressed air systems, in the United Kingdom from the 1970's. The vacuum brake system is now obsolescent where it is not in large-scale use anywhere in the world. In its simplest form, the automatic vacuum brake consists of a continuous pipe, running throughout the length of the train. In normal running a partial vacuum is maintained in the train pipe, and the brakes are released. A vacuum is sustained on the other face of the pistons, so that a net force is applied. A mechanical linkage transmits this force to brake shoes which act by friction on the treads of the wheels.

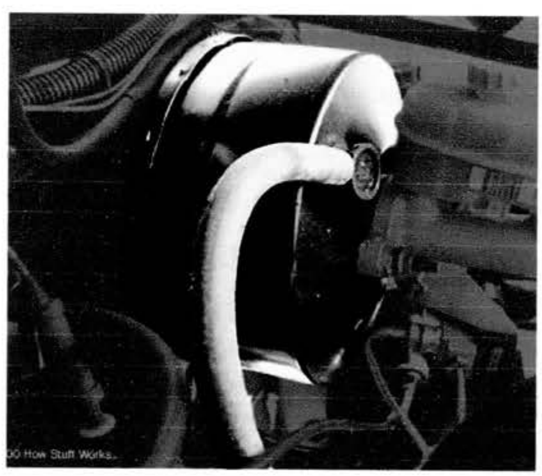

Figure 2.6: Brake Booster

2.1.6 Antilock Braking System

An anti-lock braking system or **ABS** is a safety system which prevents the wheels on a vehicle from locking while braking. A rotating road wheel allows the driver to maintain steering control under heavy braking by preventing a skid and allowing the wheel to continue interacting tractively with the road surface as directed