AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
AUTOMOTIVE ENGINEERING DEPARTMENT

COMPARATIVE STUDY OF PERFORMANCE OF CONVENTIONAL AND REGENERATIVE BRAKING SYSTEMS IN HYBRID VEHICLES

A thesis presented in partial fulfilment of the requirements for the Masters of Science Degree in Mechanical Engineering (Automotive)

By

Eng. Fadi Samir Saadallah

Under the supervision of

Dr. Mohamed Abdelmawgood Saleh
Dr. Nabila Shawky El Nahas
Dr. Ibrahim Mohamed Omran

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ABREVIATIONS

ABS	Anti-Locking Brake System
AMC	American Motors Corporation
AMT	Automatic Manual Transmission
CAD	Computer Aided Design
CG	Centre of Gravity
CNG	Compressed Natural Gas
CVT	Continuously Variable Transmission
DC	Direct Current
EMD	Electro-Motive Diesel
EV	Electrical Vehicle
HCM	Half Car Model
HEV	Hybrid Electrical Vehicle
ICE	Internal Combustion Engine
IGBT	Isolated Gate Bipolar Transistor
ISG	Integrator Starter Generator
PHEV	Parallel Hybrid Electric Vehicle
PLC	Programmed Logical Control
PM	Permanent Magnet
PM	Particulate Matter
PWM	Pulse Width Modulator
QCM	Quarter Car Model
RBS	Regenerative Braking System
RHS	Rectangular Hollow Section
SOC	State Of Charge

LIST OF SYMBOLS

W	Load in [N]
B	Brake Severity in [N.m]
δ	road slope in [%]
μ	coefficient of adhesion
P	inflation pressure in [bar]
t	stopping time in [Sec]
D	stopping distance in [m]
T	temperature in [°c]

SUMMARY

The purpose of this study is to examine and analyze the braking performance of both ‘Regenerative Braking’ and ’Conventional Braking’ systems in a comparative study conducted on a specially designed test bench.

The main research question engendering this thesis focuses primarily on the main aspects of the braking performance, which are the stopping distance and stopping time. Secondly, on the derivative symptoms such as the heat generated in the conventional system compared to the generated electricity from the regenerative system, the emission generated, the heat generated, etc…

The test rig consists of the following three main components: vehicle chassis, brake tester, and measurements tools to allow for the following test conditions: change in vehicle speed, road slope, steering angle, weight transfer and loads.

The experiments showed that the stopping distance was minimum for the cases of full load on either wet or dry ascending roads with the strong braking and during the use of a flat tyre.

The results of the temperature’s increase in tests of 20-30 seconds showed a rise of around 6-8°C, nevertheless, the resulted amount of debris was quite insignificant due to the same short period tests.

It was also found that the regenerative braking is behaving with similarity with respect to the rate of stopping under almost all the different conditions.

The performance of the regenerative braking under those 2 severities of braking of 120[N.m] and 250[N.m] showed between 0.1% and 0.25% increase in the SOC for single cycles.

It was also observed that there is a strong correlation between the regenerative electricity in terms of power in [Watt] from one side and the heat generated in the form of temperature increase in [°c] on the other side.

In general, the stopping time and stopping distance in the regenerative braking is found to be between 5% and 10% more than it takes in the conventional braking, taking into consideration the pre-set braking torque.

CHAPTER (1)

INTRODUCTION

1.1 CONVENTIONAL BRAKING SYSTEM

A brake is a device that decelerates a moving object such as a machine or vehicle by converting its kinetic energy into another form of energy. Most commonly, brakes use friction to convert kinetic energy into heat; brakes are often applied to rotating axles or wheels.

Frictional brakes are most common and can be divided broadly into ‘shoe’ or ‘pad’ brakes, using an explicit wear surface. Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface.

Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called a ‘drum brake’. As illustrated in Figure (1.1) Other configurations are possible such as pads that pinch a rotating disc, commonly called a ‘disc brake’ as shown in Figure (1.2) This type of braking is the one used in the experimental work.

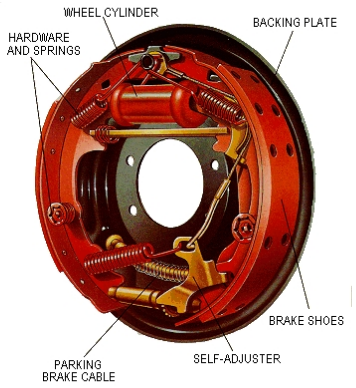

Figure (1.1) Drum Brake

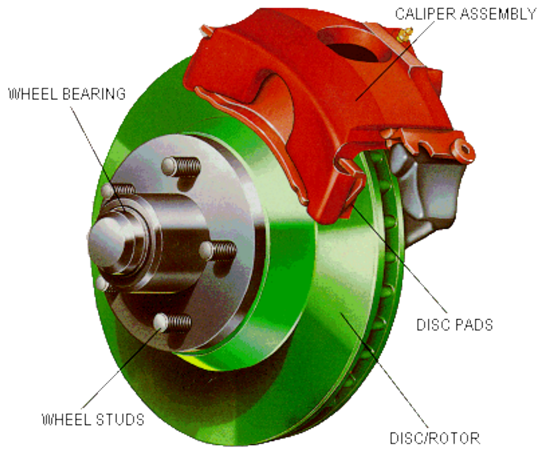

Figure (1.2) Disc Brake