AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

DEPT. OF ENERGY & AUTOMOTIVE ENGINEERING

PERFORMANCE OF A HEAVY DUTY BRAKE

A Thesis Submitted In Partial Fulfilment Of

The Requirements For The Degree Of

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BY

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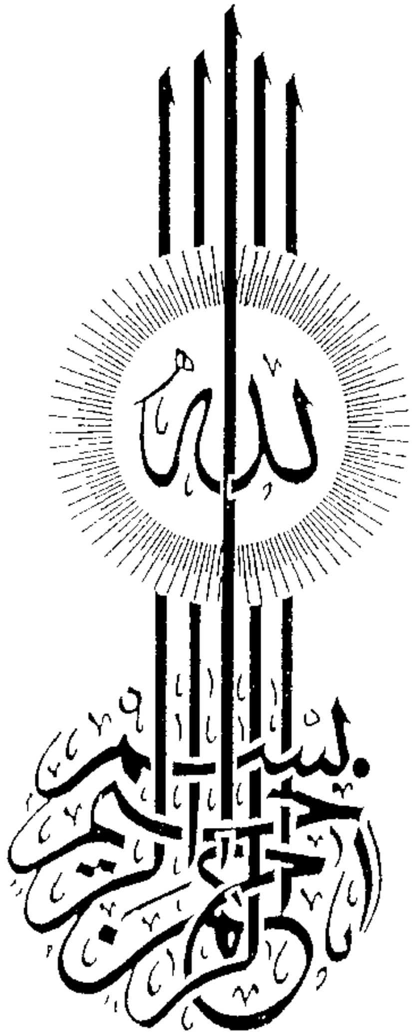
FOR MY BELOVED PARENTS

WHO ALWAYS OVERSHADOWS ME

WITH THEIR NEVER-ENDING LOVE AND CARE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CONTENTS

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SUMMARY

This research was carried out aiming to evaluate the brake performance of one of the heavy duty brakes under variable operating conditions.

For this purpose a test rig was constructed, and equipped with a Duo-Servo drum brake unit of the type fitted to the rear axle of bus type Saturn I-HD Deutz, (Nasr/Cairo bus). Proper instrumentations were made for measuring the applied brake pressure, braking torque developed, drum and lining temperature as well as the drum rotating speed. The results were recorded throughout a single and drag brake applications.

The study concluded that the braking torque varies throughout the stop. The average braking torque increases as the actuating brake pressure increases in a non-linear form, and depends on the initial drum speed during the stop (for the same actuating pressure and initial lining temperature). The torque developed reaches an initial maximum value before the lining temperature reaches its maximum during the stop.

The coefficient of friction between drum and lining varies during the stop. It is influenced by both the lining temperature and the initial drum speed. The coefficient of friction decreases as the lining temperature and initial drum speed increase.

The lining temperature distribution follows approximately a sin form along the lining arc. For the primary shoe (floating shoe), the position

of the instantanious maximum lining temperature varies with drag time duration. It moves slightly towards the shoe toe during the drag brake applications. For the secondary shoe (fixed shoe) the position of the instantanious maximum lining temperature is independent of the variable operating conditions. It always occures at an angle 90^{o} approximately measured from the shoe pivot.

Drum eccentricity affects both the actuating pressure, braking torque and lining temperature during brake applications. This effect is recognized as a periodic function supperimposed on all recorded signals. The periodicity was found to be equal to the time of one complete drum revolution. The phenomenon is influenced by the variable operating conditions.

NOTATIONS

μ	:	Coefficient of friction, lining to drum.	
O	:	Drum centre.	
N	:	Anchor point, attached to brake backing plate.	
P	:	Actuating braking force.	(N)
F	:	Radial force of lining on drum.	(N)
R	:	Drum and shoe radius.	(M)
θ_1	:	Angle, Anchor diameter to toe end of shoe lining.	(o)
θ_2	:	Angle, Anchor diameter to heal end of shoe lining.	(o)
θ	:	Angle, Anchor diameter to infinitesimal segment at Z,Z'	(o)
a	:	Distance, line of actuation force to drum centre.	(m)
a'	:	Distance, Anchor point to drum centre.	(m)
b	:	Lining width.	(m)
d	:	Distance, centre line of brake adjuster to drum centre.	(n)
μ F	:	Tangential force of lining on drum.	(N)
R'	:	Friction radius	(m)
L'	:	Distance, line of actuation force to adjuster centre line.	(m)
v	:	Drum sliding speed.	(m/s)
ω	:	Drum rotating speed.	(r.p.m)
S	:	Primary shoe factor.	
S'	:	Secondary shoe factor.	
K	:	Radius of giration.	(m)
I	:	Moment of inertia	(kg.m^2)
η_b	:	Brake efficiency.	
ϕ	:	Half the angle of lining	(o)
γ	:	Temperature	(^{o}c)
t	:	Time	(sec)

CHAPTER ONE

1.1 INTRODUCTION

The brakes not only must develop the force required to slow, stop, or hold the vehicle on the slopes and convert to heat and dissipate the kinetic energy of the vehicle, but they are required to accomplish this by means readily controllable by the driver, to have a long and economical life, and to promote the highest degree of safety upon the road.

The vehicle weight and braking requirements of the vehicle largely influence what type of brakes should be fitted. Shoe-drum brake type is commonly used in the heavy duty vehicles for its high braking power capacity. This brake type has self-energizing effect, which produces a higher brake effectiveness for the same force applied to the brake shoes.

Duo-Servo drum brakes are used to increase the self-energizing effect (self-servo action). This leads to the increase of the contact pressure of drum and lining to higher value than result from input force alone, and thereby increases the ratio of the output to input brake force. The degree of self-energizing effect in the drum brake is expense of reducing the service life of the brake lining. Also when the brakes get hot, the drum expand away from the lining, increasing pedal travel. This makes the brake less stable, and not consistent in performance.

Nowadays several intensive investigations, and developments are carried out by the brake-specialized authorities to achieve less complicated design, and to avoid accumulation of heat generating in the braking device.

1.2 REVIEW OF PREVIOUS WORK

1.2.1 BRAKING TORQUE

Johnson [1] * studied the braking torque developed as a function of actuating pressure, initial velocity and interface temperature during single braking applications. He used three different but comparable brake assemblies. The tests were carried out on an inertia dynamometer under variable operating conditions. The results showed that the brake torque varies during the stop, Fig (1.1). Furthermore the rate of increase of average brake torque decreases as the actuating pressure increases.Moreover, at the same actuating pressure the average torque increases as the initial drum speed decreases, Fig (1.2). He concluded that both the speed and temperature affect the brake performance during the stop.

Super[2] investigated the effect of initial drum speed on the braking torque developed. He carried out five single stop tests, and recorded only the torque-time history for the first and fifth single stops. The results were repeted for different initial drum speeds. The results showed that the peak level of the initial build-up torque of the fifth test decreases compared with the peak level of the first test, while the torque shape does not change appreciably in the mid and end of stop regions.

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* Numbers in parenthesis designate references given in pages (55),(56).

On the whole the torque stability for the fifth stop improved than for the first stop.

The results also demonestrated that the average torque increases as the initial drum speed decreases. His conclusion was that the rate of heat generation increases as the initial drum speed increases. Consequently a higher interface temperature is attained, results in decreasing the coefficient of friction. Hence decreasing the friction force, and braking torque. The obtained results are given in Fig (1.3).

1.2.2 BRAKE FACTOR

Brake factor is defined as the ratio of drum drag to the force applied to the brake shoes. The brake factor is equal to the sum of the two shoe factors.

Newcomb and Spürr [3] studied the variation of shoe and brake factor with the coefficient of friction for a typical fixed pivoted brake and a duo-servo one. The results are given in Fig (1.4). It was found that the shoe factor of the leading shoe is very sensitive to the coefficient of friction, while that for the trailing shoe is less sensitive. The torque output of a leading shoe is about three times that for a trailing shoe (for a coefficient of friction of 0.4). The duo-servo brake type found to have the highest braking torque. They concluded that the reaction of the primary shoe is transfered as an actuating force on the secondary shoe, and both shoes in this case are considered two leading shoes. They stated that the torque developed by a duo-servo brake is higher than that of a two leading shoe brake having the same dimensions.

1.2.3 TEMPERATURE RISE DURING BRAKE APPLICATIONS

1.2.3.1 SINGLE BRAKE APPLICATION

Newcomb [4] studied theoreticaly the temperature rise of the drum during the brake applications. He considered the case of emergency brake. His analysis was based on the assumption of knowing the physical properties and dimensions of the drum, and the rate at which heat enters the drum. While the heat loss from the interface by cooling was neglected.

Newcomb [5] described the temperature rise of the drum and lining during the stop. A finite element model was used. He reported that the drum outside surface temperature increases very little. While, at first, the interface temperature increase rapidly during the beginning of the stop. While it decreases as the drum speed slows down. His conclusion was that as the drum speed slows down allowing heat to flow away from the interface faster than it is flowing into the interface. He mentioned that the lining surface next to the drum surface is at the interface temperature, but heat does not flow rapidly into an organic lining because of its low conductivity. Therefore, the temperature of the inside of the lining does not rise much during a single stop. The results are given in Fig (1.5).

1.2.3.2 DRAG BRAKE APPLICATION

Newcomb [6] investigated the temperature rise of the drum during drag brake application. The tests were carried out using a test vehicle climbing a slope at constant speed. The actuating pressure was kept constant. He mentioned that the drum attained the equilibrium temperature after a certain time duration depending on the heat imparted to the drum, the thermal capacity of the drum, and the ambient temperature. The results are shown in Fig (1.6).

Newcomb [7] studied the cooling rates of brake drum and lining. He measured the initial and final drum temperature at appropriate intervals of time while the vehicle was traveling at constant speed. He stated that the results approximately obey Newton's Low for cooling. The results are given in Fig (1. 7).

1.2.4 LINING WEAR

Kobayashi [8] described the wear distribution along the lining length. The experiments carried out on a fixed pivoted brake. He stated that the lining wear is related to angle of lining arc. Also the wear is higher toward the toe than at the heel of shoe. He found that the wear distribution along the lining length follows a sin curve. It was proved that the lining wear is proportion to the lining plane pressure. The experimental test results were found to be in agreement with the theoretical analysis, Figs. (1.8) to (1.11).