Analysis of Braking Distance for Four Wheel Drive

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***Abstract* - Hydraulic brakes are widely used in automobile today. Hydraulic brakes are better than the mechanical brakes and air brakes because it is safe to use for the driver. Hydraulic brake system is economical to the user, it is easy to operate, maintain and repair. Now local automobile companies and manufacturers use hydraulic brakes in their automobiles. In this research paper, in accordance with the braking force, the length of the brake pedal and the size of master cylinder, the force acting on the brake shoe vary. Calculation of braking force, wheel cylinder forces, coefficient of friction, stopping distance, brake average torque and brake efficiency are mentioned. According to the design calculation, the master cylinder diameter for front wheel is 25mm and the master cylinder diameter for rear wheel is 31mm respectively. The master cylinder diameter is chosen as the greater master cylinder diameter, the greater the force on the braking system.**

***Keywords*— Brake Force, Stopping Distance, Brake Efficiency, MATLAB Codes**

I. INTRODUCTION

The hydraulic braking system is one of the most important systems of the car. The brake system is designed to slow and stop the automobile moving at high rate of speed. If this system does not operate properly, the driver and passengers in the car could be killed in an accident. Technicians who service the components of the brake system must be highly skilled experts since the work who they can do save lives.

In present day, vehicles the wheel brakes are usually operated by a foot pedal and are the ones used on the most occasions: they are sometimes referred to as the service brakes. The brakes on the rear wheels can generally be operated also by a hand lever and are used chiefly for holding the vehicles when it is parked and are consequently called parking brakes but as they can, of course, be used in emergencies they are sometimes called emergency brakes.

Table1. Specifications of Four Wheel Drive

Descriptions	Values	Units
Gross Vehicle Weight	1080	kg
Payload	500	kg
Diameter of Wheel	673	mm
Maximum Speed	130	km/hr
Overall Length	5080	mm
Overall Width	1750	mm
Overall Height	1775	mm
Wheel Base	2900	mm
Tire Width	140	mm
Tire Diameter	673	mm

II. BRAKE ENERGY AND POWER

Energy is ability to do work. Energy can be converted from one form to another but can be never be destroyed. Moving vehicles requires the use of energy. Energy is never lost, it just changes forms. The engine converts heat energy into motion, and then, using different components of the vehicle, transfers motion to the wheels. The wheels rotate, using this motion to move the vehicle.

Automotive engines changes the potential energy of gasoline or diesel fuel into heat energy. The rate at which an engine can perform this change can be considered the power of the engine. Thus an engine that causes energy to change the state of energy, then the brakes must be capable of delivering much more power than the engine.

III. COEFFICIENT OF FRICTION

The coefficient of friction is a measurement of the friction between the two objects in contact with each other. Force is the effort required to slide one surface across the other. It is determined by dividing the force required to move an object by the weight of an object.

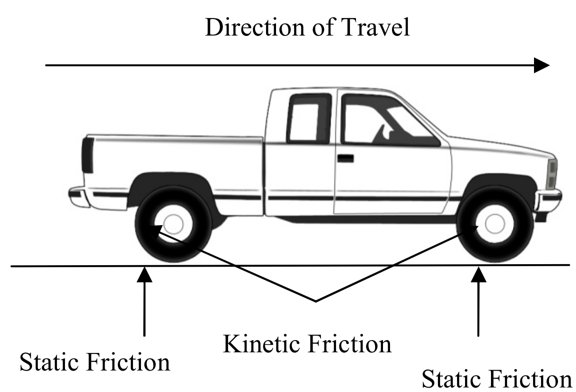

Fig1. Friction During Braking Action

The coefficient of friction varies with the type of lining used and condition of the drum or rotor surface. If the coefficient of friction is too low, excessive pressure on the brake pedal would be required to stop the automobile. Different materials have different fractional characteristics. The coefficient of friction can be calculated by measuring the force required to slide an object over a surface and then dividing it by the weight of the object.

IV. ENERGY ABSORBED BY A BRAKE

The energy absorbed by a brake depends upon the type of motion of the moving body. Kinetic energy of the vehicle is,

$$E_k = \frac{mv^2}{2} \quad (1)$$

Where, E_k – Kinetic energy (Nm)

m – mass of vehicle (kg)

v – velocity (m/sec)

The potential energy of the vehicle is

$$E_p = mgh \times slope \quad (2)$$

Total energy of the vehicle,

$$E = E_k + E_p \quad (3)$$

Since the vehicle is to be stopped in a distance, the tangential braking force is,

$$F_t = \frac{E}{S} \quad (4)$$

Where, S - Stopping distance (m)

Average braking torque is,

$$T_b = F_t \times r_b \quad (5)$$

Where, r_b – Radius of Brake Drum (m)

Normal force between the contact surfaces, this is equal to weight of the vehicle,

$$R_N = mg \quad (6)$$

The tangential braking force,

$$F_t = \mu R_N \quad (7)$$

Retarding force produced from the ground is,

$$F = \frac{F_t r_b}{R_w} \quad (8)$$

Where, F – Retarding force produced on ground (N)

R_b – Radius of the brake drum (m)

R_w – Radius of the vehicle (m)

V. BRAKE EFFICIENCY

The rate at which brake system will bring the vehicle to a stationary position from a given speed is known as brake efficiency. It is the ratio of its rate of deceleration to the acceleration due to property.

$$\eta = \frac{\alpha}{g} \times 100\% \quad (9)$$

Although theoretical limit for brake efficiency is 100%, in actual practice, efficiency of 100% is rarely used for ordinary vehicle. Requirements like safety of passengers in public vehicles and safety of the body in case of heavy good vehicles reduce the brake efficiency to be used.

Highly efficient brakes given large deceleration might inquire the passengers due to sudden stopping of the vehicle. The minimum brake efficiency is 30% and the highest should be 80%, which enable the vehicle to stop within reasonable distance.

VI. STOPPING DISTANCE

During emergency braking, the reaction of the driver and response times of the brakes also play an important part. The total stopping distance in case of emergency braking may be divided into three parts;

- ✓ Distance transverse during the reaction time of the driver,
- ✓ Distance transverse during the time elapsed between the driver pressing the brake pedal and being actually applied at the wheels, and
- ✓ Net stopping distance, depending upon the deceleration.

Stopping distance is,

$$S = \frac{v^2}{2\alpha} \quad (10)$$

VII. RESULTS AND DISCUSSION

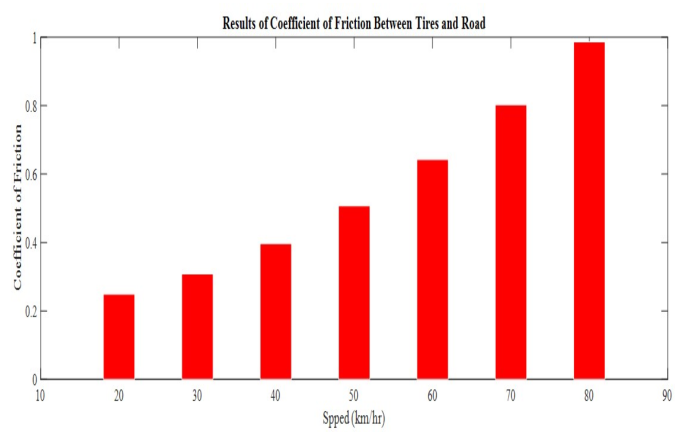

Fig2. Results of Coefficient of Friction

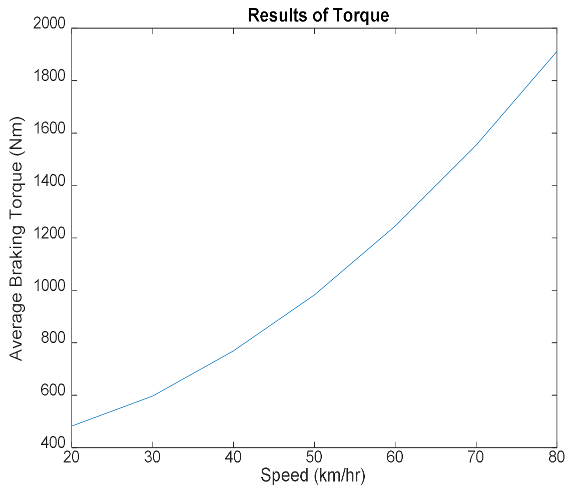

Fig3. Results of Average Braking Torque

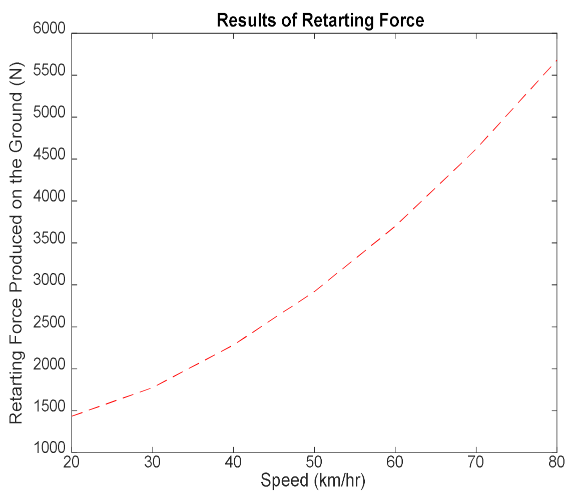

Fig4. Results of Retarding Forces

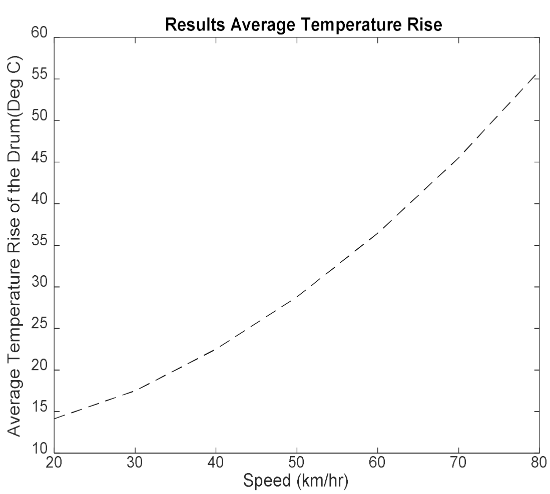

Fig5. Results of Average Temperature Rise

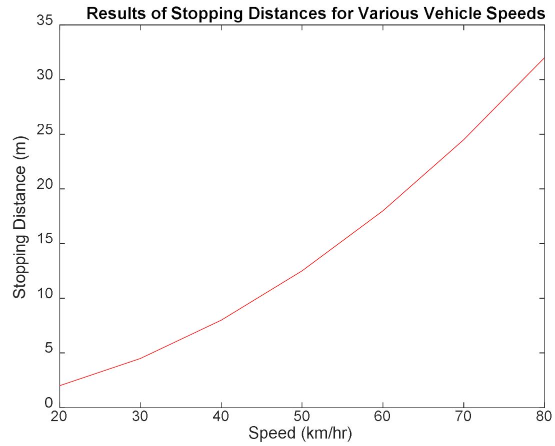

Fig5. Results of Stopping Distance

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