EXPERIMENTAL INVESTIGATION OF DRUM BRAKE PERFORMANCE FOR PASSENGER CAR

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Abstract- Brake system is the most significant safety aspect of an automobile. It must be slow the vehicle quickly and reliably under varying conditions. This paper aims to establish a brake test rig capable of measuring the performance of a drum brake at different operational and environmental conditions. The effects of dry and humid environment are considered under different applied forces and vehicle sliding speed. The experimental results showed a slight increase in the friction coefficients between drum and brake lining with increasing pressure or speed at dry and wet conditions.

Keywords- Drum Brake, Friction Coefficient, Applied Load, Vehicle Speed, Dry and Wet Conditions.

I. INTRODUCTION

The main function of brake system is to retard the vehicle by transforming the kinetic energy of the vehicle into heat by the process of friction, and this heat must be effectively and efficiently dissipating to the surroundings by the brake components. There are many types of brake systems that have been used since the inception of the motor car, but in principle they are all similar. A drum brake is a brake in which brake shoes with lining (friction material) attached to them are pushed by hydraulic pistons against the inner surface of a drum rotating together with the axle. This generates friction, which converts kinetic energy into heat and slows or stops the drum and the attached wheel. There are three types of drum brakes namely: Leading/Trailing Shoe, Twin Leading Shoe and Duo-Servo, as shown in Fig. 1.

leading shoe *twin leading shoe* *duo-servo*

Fig. 1 Types of drum brakes

It is fact that owing to recent improvement in the braking mechanism may be chiefly attributed the increased speeds of the modern cars on the road. There are many studies investigated experimentally the performance of the brake systems, as well as studying the braking process behavior. Blau in 2001, presented a survey of commercial brake materials and additives. Brake material test methods were also briefly described. History records the use of many kinds of materials for brakes. Chowdhury et al. 2012, investigated the effect of sliding speed on friction coefficient. Their results showed that the friction coefficient decreases with the increase of sliding speed for aluminum. They reported that the decrease of friction coefficient of aluminum with the increase of sliding speed may be due to the change in the shear rate which can influence the mechanical properties of the mating materials. In addition, the strength of these materials is greater at higher shear strain rates, which results in a lower real area of contact and a lower coefficient of friction in dry contact condition.

Dewan et al. 2012, studied the effect of normal load and sliding velocity on friction coefficient of aluminum sliding against different materials. The results indicate that the magnitudes of friction coefficient are different for different material pairs depending on normal load and sliding velocity. Sliding contact of two materials results in heat generation at the asperities and hence increases in temperature at the frictional surfaces of the two materials. They reported that the increase in friction coefficient with sliding velocity is due to more adhesion of counter face material on disc. From the obtained results, it can also be seen that the highest values of the friction coefficient are obtained for aluminum-brass pair and the lowest values of friction coefficient are obtained for aluminum-aluminum pair. An investigation which studied the effect of braking speeds on the Tribological properties of Carbon/Carbon Composites was carried by Yu Shu, et al 2010. This study described the Tribological properties of carbon/carbon composites used as braking materials under various braking speeds, in which the materials with three kinds of microstructures were used: rough lamina, smooth lamina, and the mixture of rough lamina and smooth lamina respectively. It was observed that temperatures of friction surface increase with the increasing braking speed.

Recently, Dewan et al. 2013, Carried out a study to investigate the friction coefficient of copper and aluminum with sliding velocity. In the experiments it was found that as the sliding velocity increases from 1 to 2 m/s, friction coefficient of copper increases from 0.25 to 0.36. On the other hand, friction coefficient of aluminum increases from 0.46 to 0.60 as the sliding velocity increases from 1 to 2 m/s. Due to the interaction of the asperities of two contact surfaces, frictional heat generation occurs and hence temperature increases at the contact surfaces. Due to more adhesion of pin material on the disc with the increase in sliding velocity, friction increases. These findings are supported by the previous findings of Nuruzzaman and Chowdhury. Greselle et al. 2010, investigated the influence of temperature on the friction coefficient of friction materials. The experiments were performed in three distinct stages: bedding-in, characterization and fade.

The bedding-in stage was the first to be performed, with the aim of increasing the friction pair contact. Then, three sets of twelve braking were performed for friction characterization, where each braking was interspersed with a stage of fade. The fade stages degrade the phenolic resins of the materials and affect the performance of the friction material. The test results showed that brake pads with different with braking at high temperatures, which is in accordance with specialized literature.

Experimental approaches using brake dynamometers (test rigs) have been widely used to examine the brake performance, to investigate the effects of different parameters and operating conditions, to understand the characteristics of the brake system. There are two designs for the brake dynamometer. The first design is an inertia-type brake dynamometer that has flywheel attached to it. The second design is a drag-type brake dynamometer that can only test brake at a constant speed. The advantage of brake dynamometer is that it provided a means of tight experimental control.

In this research, a drum brake of a passenger car is used. Firstly, the description of brake dynamometer that is developed to measure the brake performance at different applied pressure and vehicle sliding speed is explained. Next, measurements methodology of friction coefficient at dry and wet conditions is discussed. Finally the measured values of these conditions are plotted and discussed.

II. DESIGN AND DEVELOPMENT OF BRAKE TEST RIG

Drum brake test rig is designed to provide the necessary rotation speed and applied pressure to the braking applications. Fig. 2, shows the brake test rig that has currently been developed. Drum brake system of passenger car is used.

The backing plate provides a base for the other components. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes, and assorted hardware. Since all braking operations exert pressure on the backing plate, it must be strong and wear-resistant. It is positioned close to the brake shoe without actually touching it, and rotates with the wheel and axle, as shown in Fig. 3. When a driver applies the brakes, the lining pushes against the inner surface of the drum, generating friction heat.

Actual dimensions of drum brake as following; outer diameter =184mm, inner diameter=156mm, width=57mm and thickness=8mm. A 4.47 kw AC motor at 1450 rpm is used as the power supply. A series of pulleys and belts are used for initial reduction of motor speed and five reduction gear box which has different gear ratios is used.

Applied force generation with the use of hydraulic jack that has maximum load up to 3 tons is used, as shown in Fig. 4. The brake line pressure can be applied by hydraulic jack that has maximum load up to 3 tons and controlled by hydraulic valve to a certain value, which can be displayed in pressure gauge.

The braking force is measured using a S-type load cell during the braking process. The output of load cell is delivered to an amplifier. The amplifier connected to data acquisition system which display on the monitor and coefficient of friction can be calculated. Fig. 5 shows the load cell. Tachometer is used to measure the rotation speed.

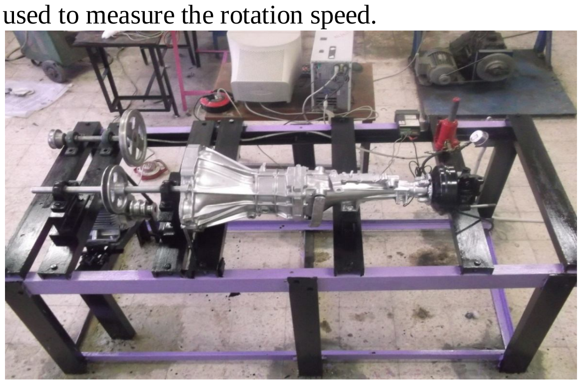

Fig. 2 Brake test rig

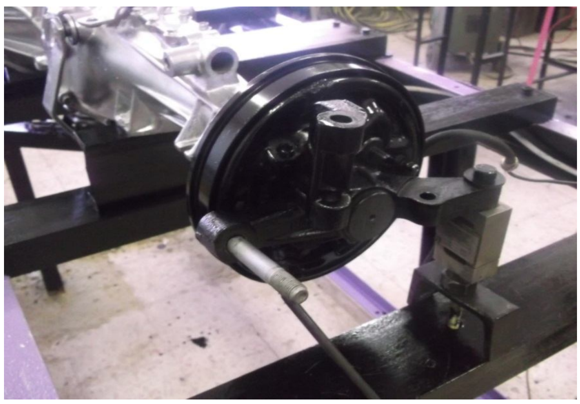

Fig. 3 Drum brake

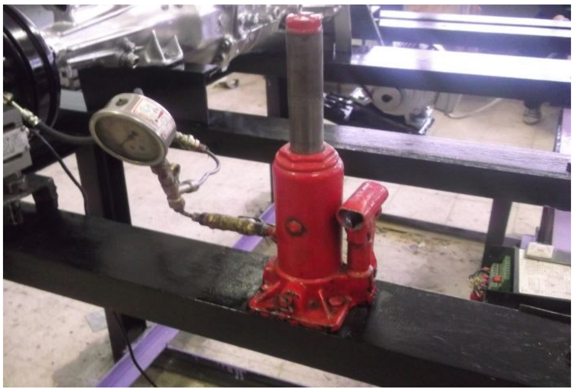

Fig. 4 Hydraulic jack

Fig. 5 Load cell

III. EXPERIMENTAL RESULTS AND DISCUSSION

In this section, the experimental results of many tests at various operating conditions namely: different pressures and sliding speeds are listed. The experiments are carried out using drum brake system of a passenger car is used in the current work. The brake test rig is capable of measuring performance at various operating conditions. The effect of applied pressure and sliding speed will be discussed in the following sub-sections.

A. The Effect of Applied Force

A series of experimental tests for different applied forces from77 to 462 N, are carried out to investigate the effect of applied force towards performance of drum brake at four different sliding speeds 15, 24, 38 and 63 km/h. respectively, at dry and wet conditions. From the results shown in Fig.s 6 to 9, it can be seen that in general the friction coefficient increases with increasing applied load. In addition, in the case of wet braking tests, there is a significant reduction in the friction coefficient to unacceptable levels for frictional brake applications which in a rainy and humid environment is considered as a serious problem as it influences the safety of the vehicle.

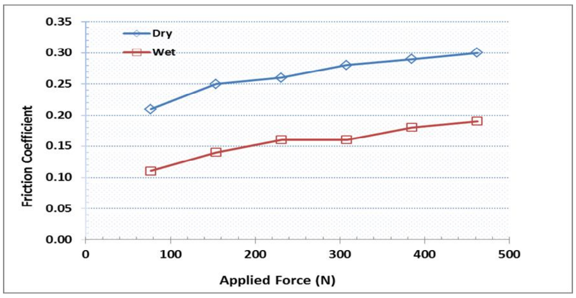

Fig. 6 Applied forces versus friction coefficient at 15km/h.

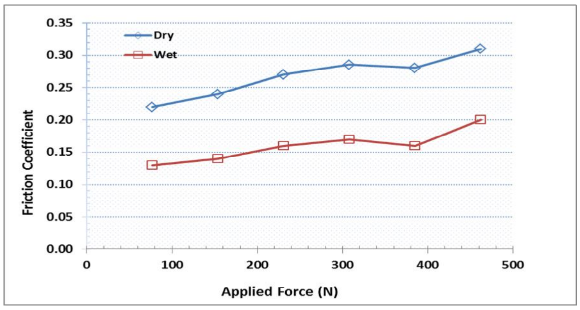

Fig. 7 Applied forces versus friction coefficient at 24km/h.

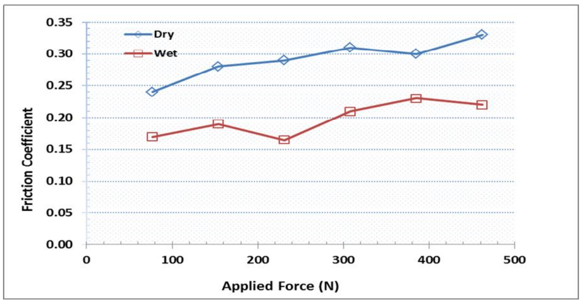

Fig. 8 Applied forces versus friction coefficient at 38km/h.

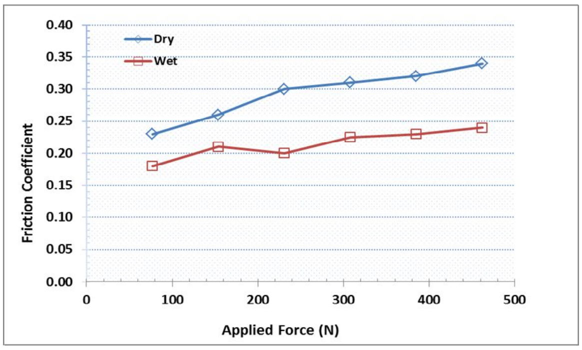

Fig. 9 Applied forces versus friction coefficient at 63km/h.

B. Effect of Vehicle Speed

To investigate the influence of the vehicle sliding speed on brake force for four different sliding speeds 15, 24, 38 and 63 km/h. for dry and wet conditions, a series of experimental tests are conducted at different applied forces. From the results shown in Fig.s 10 to 13, it can be seen that the increase of the sliding speed increase the friction coefficient at different values of applied forces. In addition, the friction coefficient for wet conditions is less than the friction conditions for dry conditions.

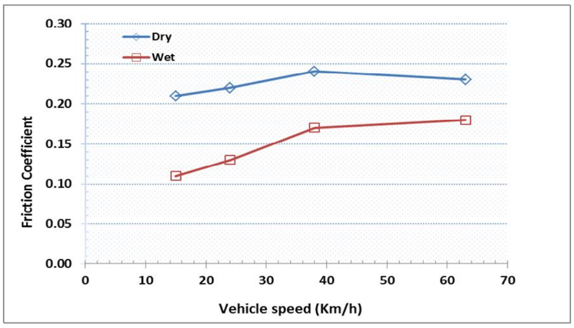

Fig. 10 Vehicle speeds versus friction coefficient at 77 N.

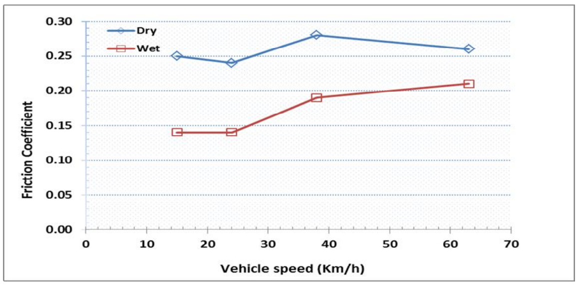

Fig. 11 Vehicle speeds versus friction coefficient at 154 N.

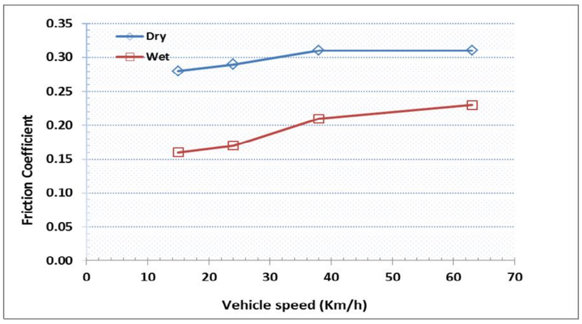

Fig. 12 Vehicle speeds versus friction coefficient at 308 N.

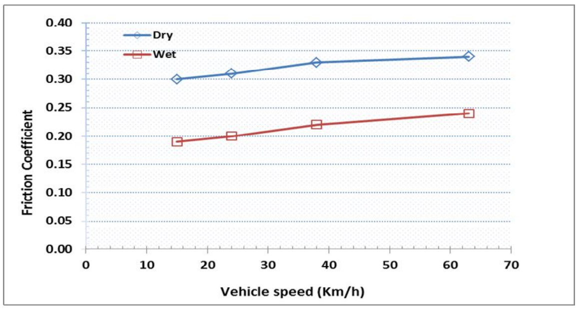

Fig. 13 Vehicle speeds versus friction coefficient at 462 N.

CONCLUSIONS

The experimental study of the friction coefficient is carried out for automotive drum brake assembly of a passenger car using brake test rig. The test rig is designed for the purpose of measurements of brake performance generated by friction coefficient. Various operating conditions are applied to the drum brake assembly. The important conclusions that are arrived at this research work are described below:

1. The sliding speeds increase the braking friction coefficient at different values of applied forces at dry and wet conditions.
2. Generally, the friction brakes coefficient increase with the increase in applied forces.
3. A dramatic reduction in the friction coefficient for wet conditions than the dry friction.

REFERENCES

[1]. J. Peter Blau: Compositions, Functions, and Testing of Friction Brake Materials and Their Additives, August 2001.

[2]. M. A. Chowdhury, M. K. Khalil, D. M. Nuruzzaman, M. L. Rahaman : The Effect of Sliding Speed and Normal Load on Friction and Wear Property of Aluminum :Dhaka University of Engineering & Technology ,2011.

[3]. Yu Shu, Chen Jie, Huang Qizhong, Xiong Xiang, Chang Tong and Li Yunping: Effect of Braking Speeds on the Tribological Properties of Carbon/Carbon Composites:, Central South University, (2010) .

[4]. D. Muhammad Nuruzzaman, M. Asaduzzaman Chowdhury: Effect of Normal Load and Sliding Velocity on Friction Coefficient of Aluminum Sliding Against Different Pin Materials:, Dhaka University of Engineering and Technology, 2012 .

[5]. J. Greselle Balotin, Patric Daniel Neis, Ney Francisco Ferreira: analysis of the influence of temperatures on the friction coefficient of friction materials: Universidade Federal do Rio Grande do Sul, 2010.

[6]. D. M. Nuruzzaman and M. A. Chowdhury: Friction Coefficient and Wear Rate of Copper and Aluminum Sliding against Mild Steel: a Faculty of Manufacturing Engineering, University Malaysia Pahang, MALAYSIA, b, Dhaka University of Engineering and Technologies, 2013.

[7]. M.A. Chowdhurya, D.M. Nuruzzamana, A.H. Miaa, M.L. Rahaman: Friction Coefficient of Different Material Pairs Under Different Normal Loads and Sliding Velocities: Dhaka University of Engineering and Technology,2012.

[8]. T. F., Chen "Relationship between Formulation and Noise of Phenolic Resin Matrix Friction Lining Tested In Acoustic Chamber on Automotive Brake Dynamometer," Master of Science Thesis, Southern Illinois University, 2005.

[9]. M. M. Amr Rabia, Nouby M. Ghazaly, M. M. M. Salem, Ali M. Abd-El-Tawwab "An Experimental Study of Automotive Disc Brake Vibrations" The International Journal of Engineering and Science (IJES), Vol.2, Issue 01, PP. 194-200, 2013.

[10]. S. James, "An experimental study of disc brake squeal", PhD Thesis, Department of Engineering, University of Liverpool, May 2003.

[11]. M. Nouby Ghazaly "Study on Automotive Disc Brake Squeal Using Finite Element Analysis and Design of Experiments" PhD. Thesis, Department of Mechanical Engineering, Anna University, India, 2011.

[12]. M. M., Mostafa, M. G., Nouby, Abd El-Gwwad K. A., Mahmoud K. R. and Abd-El-Tawwab A. M., A Preliminary Experimental Investigation of a New Wedge Disc Brake, Int. Journal of Engineering Research and Applications, Vol. 3, Issue 6, pp.735-744, Nov-Dec 2013.

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