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The Friction of Vehicle Brake Tandem Master Cylinder

M J Kao¹, H Chang¹, T T Tsung¹ and H M Lin²

¹ Graduate Institute of Mechanical and Electrical Engineering
National Taipei University of Technology, 1 Sec.3, Chung Hsiao E. Rd. 10608, Taipei,
Taiwan, China

² Department of Materials Engineering, Tatung University, Taipei, Taiwan, China

E-mail: mjkao@ntut.edu.tw

Abstract. The behaviour of an elastomeric seal for vehicle brake Tandem master cylinder is measured and analyzed in temperature and brake fluids changed. Working conditions are simulated for different piston rod velocity and cylinder supply pressure, in temperature rising, brakefluid boundary and Nanoaluminum oxide brakefluid oxide brakefluid lubrication. The result shows that Nanoaluminum oxide brakefluid with its ball shape can highly reduce friction coefficient to avoid seal excessive wear and reduce slick slip in brake applications.

1. Introduction

Hydraulic braking systems are used wide due to stand high temperatures during operation in extreme environments such as when descending steep grades. Hydraulic systems are also relatively smaller and less expensive. The tandem master Cylinder is designed to provide two separate hydraulic cylinder pressure chambers operated by a single input push rod, each of which pressurizes a separate hydraulic line. The tandem master cylinder units consist of a hollow housing with a rubber diaphragm (seal) across the center in order to maintain brake fluid pressure during force transfer. Each cylinder chamber is able to generate its own fluid brake pipe line circuits. When the brake is applied, the push rod and the primary return spring pushes both pistons towards the cylinder's blank end. Immediately both recuperating poppet valves are able to snap closed. The fluid trapped in both primary and secondary chambers is then squeezed, causing the pressure in pipe line circuits to rise and operate the brake cylinders to stop the wheels [1, 2]. The elastomeric seal for vehicle brake tandem master cylinder is between outside aluminum wall and inside piston [3]. The friction force of seal between outside aluminum wall and inside piston is typically a combination of several friction forces and is at the point of contact with the surface such as static friction and molecular friction slow down the rolling due to the materials of seal is soft and deform as it rolls. Its distortion caused the plowing effect is a major force in slowing the motion (stick slip) and the malfunction of vehicle braking. Nanoaluminum oxide brakefluid (NOB) by plasma charging system prepared by our laboratory was used in brake tandem master cylinder, nanofluid (solid-liquid mixture) has been characterized the excellent suspension, anti-oxidation and incondensability in a presence of geometrically round particles [4, 5]. With its ball shape nanoaluminum oxide brakefluid can highly reduce seal friction coefficient and reduce slick slip in brake applications even the seal deform as it rolls.

2. Theory and Experimental Design

The design tester comprises of adjusted pneumatic supplier and mounting frames which are connected to a test master cylinder assembly temperature sensors and pneumatic pressure sensor with computer data acquisition and control as shown in figure 1. PC based control and data acquisition software is integral part of supply. Friction force is shown in equation 1.

$$F_R = P_A \cdot A_A - \ddot{m} \quad (1)$$

The recorded parameters are pneumatic pressure, temperature and test duration. This frictional force is typically a combination of several friction forces and is at the point of contact with the surface. When one of the materials is soft, it will deform as it rolls, adding a component to the rolling friction. Its distortion caused the plowing effect is a major force in slowing the motion. Molecular friction is caused by the molecular attraction or adhesion of the materials when temperature rising. It is like a "stickiness" factor. When materials are pushed together, molecular forces try to prevent them from being pulled apart so called stick slip motion. Consider a one-dimensional model which includes one plates, aluminum wall and seal on inside piston, a single nanoparticle of mass m embedded between them. The interaction between the particle and each of the plates is described by the periodic potential caused rolling and friction lower. Supposing the top rubber of mass M is pulled by a spring with force constant K connected to a stage moving with a velocity v as shown in Figure 2 [6, 7]. The coupled equations of motion for the plate and the particle can written in a dimensionless form as

$$\ddot{Y} + \varepsilon f(\dot{Y} - \dot{y}) + \alpha^2(Y - v\tau) - \frac{\varepsilon}{2\pi} \sin[2\pi(y - Y)] = 0 \quad (2)$$

$$\ddot{y} + f(2\dot{y} - \dot{Y}) + \frac{1}{2\pi} \sin(2\pi y) + \frac{1}{2\pi} \sin[2\pi(y - Y)] = 0 \quad (3)$$

Where y and Y are the coordinates of the particle and plate, respectively, in units of the dimensionless time, f is a dimensionless friction constant which accounts for dissipation due to phonons or other excitations, $\varepsilon = m/M$ is the ratio of particle and plate masses, and $\alpha = \Omega/\omega$ is the ratio of frequencies of the free oscillations of top plate and the particle, $\Omega = \sqrt{K/M}$ [6, 7].

3. Results & Discussion

Figure 5, a Transmission Electron Microscope (TEM, JEOL JSM-1200EX2 and Hitachi-H7100) was applied to examine and measure home-made nanoparticles' appearance and size, ball type Al_2O_3 nanoparticles with mean sizes (50nm) were used in experiment. As can be seen from figure 3, ball type nanoparticles provide good rolling basic to reduce friction force between aluminum wall and piston rubber seal. Comparing the friction force at temperature 25°C and 60°C, as shown in figure 4, both friction forces at 25°C have the peak valve at five seconds interval. It means that lower temperature friction needs more times to become stable in brake system. Round particles are suitable for tribological application and effective as the suspending fluid (solid-liquid mixture) in lubricants used. As well as being powerfully lubricating, a nanofluid can "mend" or "fill up" cracks and flaws in a metal wall surface by the uniform dispersal. The tiny spherical nanoparticles are uniformly dispersed in a carrier for rolling, so the nanofluid exhibits powerful rolling-sliding ability and a lower the coefficient of friction. The outstanding physical properties to the operation of vehicle brake master cylinder will lead to a reduction of seal excessive wear and reduce slick slip in brake applications.

4. Conclusion

The friction force for two parts (aluminum wall and piston rubber seal) is lower during the nanoaluminum oxide is added, the round nanoparticles can fill up the cracks and rough surface on the wall surface of metal and reduce the friction force largely. The applications of these outstanding physical properties to the operation of vehicle brake master cylinder will lead to a reduction of seal excessive wear and reduce slick slip in brake applications

Figure/Table captions

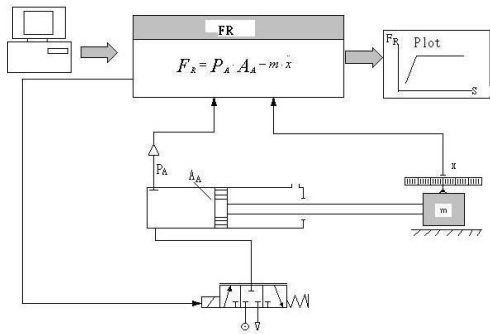


Figure 1. Schematic sketch of friction tester.

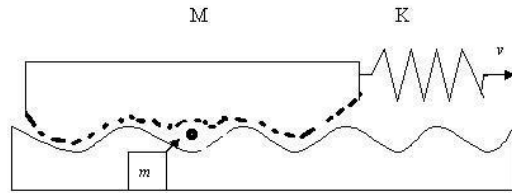


Figure 2. Schematic sketch of the nanoparticle Stick-slip model geometry.

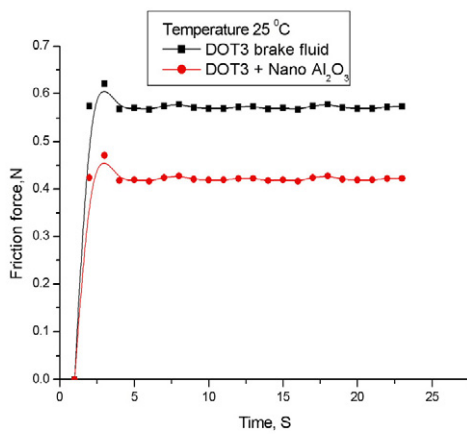


Figure 3. Friction force DOT3 brakefluid and NOB at 25 °C.

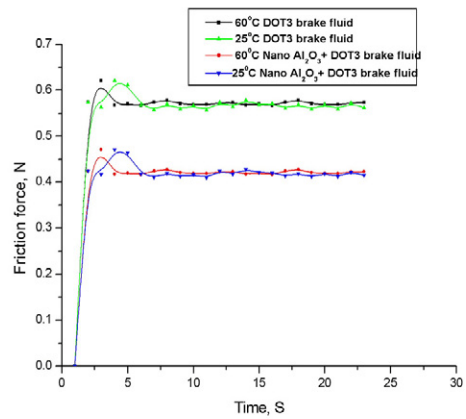


Figure 4. Friction force DOT3 brakefluid and NOB at 25 °C, 60 °C.

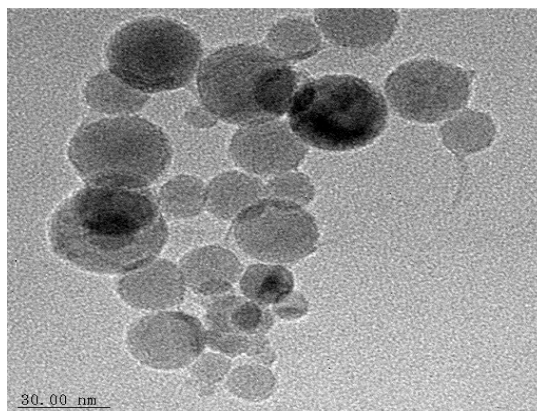


Figure 5. TEM diagram of nanoaluminum oxide in DOT3.

References

- [1] Rudolf I 1992 *Brake Design and Safety* (Society of Automotive Engineers Inc)
- [2] Bosch 1996 *Automotive Handbook*(4th Edition) (Society of Automotive Engineers)
- [3] Thomas W. Birch 1995 *Automotive Braking Systems* (Delmar Publishers)

- [4] Chang H, Tsung T T, Chen L C, Yang Y C, Lin H M, L L Han and Lin C K 2004 *Mate. Trans. The Japan Institute of Metals* **45** 806-811
- [5] Tsung T T, Chang H, Chen L C, Liu M K, Lin H M and Lin C K 2004 *International J. Adv. Manu. Tech.* Published Online **24** 879-885
- [6] Rozman M G., Urbakh M and Klafter J 1996 *Phys. Rev* **77** **4** 683-686
- [7] Field S, Venturi N. and Nori F. 1995 *Phys. Rev* **74** **1** 74-77