

INVESTIGATION ON THE POSSIBILITY OF USING NATURAL RUBBER SEED OIL AS BRAKE FLUID

Abstract

This paper studies the possibility of using natural rubber seed oil as a brake fluid. The laboratory properties of both standard brake fluid and rubber seed oil were determined. The actual test of the braking efficiencies of the brake fluids were carried out with a Mercedes 190 model within the speed range of 20km/hr to 90km/hr at the permanent campus of University of Uyo and the braking efficiency of 93.45% for the standard brake fluid and 90.24% for the natural rubber oil seed were obtained. This result shows that natural rubber seed oil is suitable for use as a brake fluid.

Keywords: Brake fluid, natural rubber, brake properties,braking efficiency

INTRODUCTION

In fluids deformation takes place and the particles continuously change their positions relative to one another Bernard (2001), Hannah et al (1985}. It offers no lasting resistance to displacement. Deformation of the fluid takes place continuously so long as a shear force is applied .But if this force is removed the shearing movement subsides and as there are then no forces tending to return the particles of fluid to their original relative positions, the fluid keeps its new shape (Bernard 2001)Fluids may be divided into liquid and gases. Under ordinary conditions liquids are so difficult to compress and for most purposes may be regarded as incompressible, however gases may be much more easily compressed Douglas et al (1985) Fluids have unique and distinct properties that enable its application in Engineering .The brake fluid is a very important component of the braking system. It assists the braking system to bring a moving mass to rest. Most of the brake fluids that are in use are glycol-ether based though

25 mineral oil and silicone- based fluids also exist. These brake fluid must meet the standard spelt
 26 out by various organizations. Brake fluids are classified according to their physical properties.
 27 The standards in the US come from the Department of Transportation (DOT)(1971).Thus we
 28 have DOT 3, DOT 5 and DOT 5.1. The society of Automotive Engineers SAE has similar
 29 standards of SAE J1703, J1704 and J1705. The international organization for standardization
 30 (ISO) 4925 SPECIFICATIONS exist for non-petroleum based brake fluids for hydraulic system.
 31 The two commonly available types of brake fluids are- Glycol-ester blends. These glycol-based
 32 fluids normally have low compressibility but are hygroscopic in nature. The dry boiling point of
 33 glycol based fluid seldom exceeds 304°C . The second classification which is ester-based has
 34 higher dry and wet boiling points. It is not hygroscopic but it is more expensive than the glycol-
 35 based fluids.
 36 There are numerous properties which a fluid must possess for it to be considered as a brake fluid.
 37 These properties are: Dry and wet equilibrium boiling point, viscosity, pH value, fluid stability.
 38 Corrosion resistant, fluidity and appearance at low temperature, water tolerance, resistant to
 39 oxidation, swell test, compressibility test, chemical stability, compatibility. The brake fluid must
 40 possess a high boiling point to avoid it vapourising and becoming spongy. It must not boil after
 41 accepting a certain amount of moisture. The brake fluid must also possess high viscosity and
 42 should not change under a wide range of temperatures. The pH value should not be less than 7.0
 43 or more than 11.5 Brake fluid should not be corrosive. Brake fluid must maintain low
 44 compression despite variance operating temperature. The braking efficiency is said to be 100%
 45 when the braking force is equal to the weight of the vehicle, or when deceleration is 9.81m/s^2
 46 (Dolan, 1991). An efficiency of 100% is not desirable because of the rapid wear of the brake

linings and tyres, discomfort to passengers and the risk of losing control of the vehicle. It is generally accepted that brake efficiency of 80% to 85% should be aimed at (Dolan 1991).

The main objective of this paper is to determine the possibility of using natural rubber seed oil as a brake fluid.

MODELS AND THEORIES

The braking force is derived from the applied pressure in a confined fluid and if the fluid is incompressible that pressure is transmitted equally in all directions throughout the fluid. Work is done by the applied force which pushes a friction plate onto the rotating brake drum .When rotating members of a machine are caused to stop by means of a brake, the kinetic energy is absorbed Shigley (1977) .The energy absorbed by the brake depends on the type of motion, such motion could be translational , pure rotational or both (Khurmi, 2005 et al).

For pure translation motion, the energy absorbed is:

$$E_1 = \frac{1}{2} m(v_1^2 - v_2^2) \quad 1$$

Where E is the energy absorbed, m the mass and v_1 and v_2 are the initial and final velocities respectively, If the moving mass is brought to rest after the braking, then v_2 is zero

Thus,

$$E_1 = \frac{1}{2} m(v_1^2) \quad 2$$

In pure rotational motion the kinetic energy of the rotation is expressed as:

$$E_2 = \frac{1}{2} m(\omega_1^2 - \omega_2^2) \quad 3$$

Where ω_1 and ω_2 are the initial and final angular velocities.

If the moving body is stopped after applying the brake , ω_2 is equal to zero.

$$E_2 = \frac{1}{2} m (\omega_1^2) \quad 4$$

For both translational and rotational motion , the total kinetic energy involved is:

$$E_T = E_1 + E_2 \quad 5$$

Work done by the braking force in time t seconds is :

$$W = F_t x \prod dNxt \quad 6$$

Where F_t is the braking or frictional force, d the diameter of the brake drum, N, mean speed of the brake drum and $\prod$ a constant.

The total energy to be absorbed by the brake must be equal to the work done by the frictional force, thus:

$$E_T = W \quad 7$$

The heat dissipated during braking is transformed into heat and lost into the surrounding air in order to avoid excessive temperature of the brake lining, wheel and tyres, this heat generated is given as :

$$H_g = \mu R_N v = \mu \rho A v \quad 8$$

Where H_g is the heat generated, R_N normal force acting act the contact surface (N), ρ normal pressures between the braking surfaces ($\frac{N}{m^2}$) A, the area m^2 and v the peripheral velocity m/s

The heat dissipated is estimated from:

$$H_d = C(t_1 - t_2) A_t \quad 9$$

Where H_d is the heat dissipated, C is the dissipation coefficient of heat transfer ($W/m^2/^\circ C$

t_1, t_2 are the temperature differences between the exposed radiating surface and the surrounding

88 air and A_r area of radiating surface (m^2).

89 The rise in the temperature of the brake drum is given as :

$$90 \quad \Delta t = \frac{H_g}{mc} \quad 10$$

91 C is the specific heat capacity of the material of the brake drum ($J/Kg^\circ C$)

92 **METHODOLOGY**

93 Natural rubber seed oil was extracted using n-hexane, The viscosity, the dry boiling ,wet boiling
94 points, ph value , fluid stability, corrosion test of the of the oil were all determined and the
95 values compared with the standard commercial DOT 3 brake fluid.

96 The brake fluid line was emptied and flushed before the inclusion of the natural rubber seed oil
97 fluid in the system. The fluid line was bled to remove any entrapped air. The test live was
98 conducted using a Mercedes 190 model car of about 3000kg Before conducting the test the
99 brake system and the tyres were checked to be in good conditions .A point was and marked on a
100 tarred road for an experienced driver to start to apply his brake. When the car finally comes to
101 rest that point was also noted . The distance between when the brake was applied and when the
102 car stops was measured. The time interval of each activity was measured. For each speed limit
103 six values were obtained and the mean data recorded. The speed range used was between
104 20km/hr to 90km/hr.

105 **RESULTS AND DISCUSSION**

106 The measured physical properties of the DOT 3 standard brake fluid and cotton seed oil brake
107 fluid are presented in table 1. The physical properties of natural rubber seed oil match closely
108 with the DOT 3 brake fluid .The boiling point natural rubber seed oil brake fluid is within the
109 range stipulated and is close to that of the commercial DOT 3 brake fluid used for the study.

110 Natural rubber seed oil has a higher wet equilibrium boiling point of 172.5°C compared to
 111 162.5°C of the DOT 3 brake fluid which shows that it is less hygroscopic. The natural rubber
 112 seed oil also possesses a higher viscosity than the DOT 3 and thus can withstand a higher shear
 113 stress. The natural rubber seed oil is also chemically stable as shown in table 1.

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115 **Table 1: Physical properties of a standard brake fluid and natural rubber seed oil**

S/N	FLUID PROPERTIES	STANDARD DOT 3 BRAKE FLUID	NATURAL RUBBER SEED OIL
1.	Equilibrium reflux boiling point ERP	245°C	235°C
2.	Wet ERBP	162.5°C	158°C
3.	pH value	9.5 at 32°C	6.5 at 32°C
4.	Dynamic viscosity	402.39×10^{-10} Ns/m ²	455.5×10^{-10} Ns/m ²
5.	Kinematic viscosity	$43.90 \times 10^{-6} \text{ m}^2/\text{s}$	$48.0 \times 10^{-6} \text{ m}^2/\text{s}$
6.	High temperature stability	Stable (243.75°C)	Stable (234°C)
7.	Chemical stability	Stable (181.25°C)	Stable (185°C)
8.	Fluidity and appearance (colour)	Amber	Dark brown
9.	Water tolerance	Tolerant	Tolerant
10.	Compatibility	Compatible	compatible

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121 The performance data of the standard and the natural rubber seed oil brake fluids are presented in
 122 table 2.

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124 **Table 2: Performance Test of Standard Brake Fluid**

S/NO.	Speed (m/s)	Braking Distance (m)	Braking time(s) (SBF)	Deceleration (m/s^2) (SBF)	Braking time(s) (NRF)	Deceleration (m/s^2) (NRF)	Applied force (N) (SBF)	Applied force (N) (NRF)	Energy Absorbed (J)
1	5.56	3.50	2,4	4.42	3.01	3.82	13,260	11,460	46,370.40
2	11.11	8.00	4,01	7.71	3.48	7.71	23,130	23,130	185,148.15
3	16.67	14.00	4.25	9.92	4.13	8.66	29,760	25,980	416,833.35
4	22.22	25.50	5.00	9.87	5.12	9.83	29,610	29,490	740,593.60

125 *SBF – Standard brake fluid * NRF -Natural rubber oil brake fluid

126 Table 3 shows the corrosive test results for the two brake fluids. The lack of change in mass of
 127 the specimen for closed and opened system study show that the natural seed oil is not corrosive.

128 **Table 3: Corrosive effect of Standard Brake and Natural rubber seed oil Fluid on**
 129 **Metal Strips**

S/N	Material	Original Mass (g) in SBF	Mass after 4 days in a closed system (g) in SBF	Mass after another 6 days in an open system (g) in SBF	Original Mass (g) in NRF	Mass after 4 days in a closed system (g) in NRF	Mass after another 6 days in an open system (g) in NRF
1	Brass	10.12	10.12	10.12	10.14	10.14	10.14
2	Copper	10.18	10.18	10.18	10.18	10.18	10.18
3	Aluminum	15.47	15.47	15.47	16.26	16.26	16.26
4	Steel	25.38	25.38	25.38	46.78	46.78	46.78
5	Cast iron	50.05	50.05	54.05	78.87	78.87	78.87

130 Table 4 shows the braking efficiency of the two fluids .The natural rubber seed oil brake
 131 fluid gives an average braking efficiency of 90.24% which is more than the minimum required

(Doland, 1991) and close to 93.45% obtained from DOT 3 used in this case study.

Table 4: Braking efficiency of the two brake fluids

Speed (m/s)	Deceleration (m/s ²)	Deceleration (m/s ²)	Braking efficiency Of a standard DOT 3 brake fluid %	Braking efficiency Of natural rubber seed oil brake fluid %
5.56	4.42	3.82	70.20	60.9
11.11	7.71	7.71	78.9	78.9
16.67	9.92	8.66	99.8	90.8
22.22	9.87	9.83	99.2	99.8
Average braking efficiency			93.45	90.24

CONCLUSIONS /RECOMMENDATIONS

From the laboratory and test results presented, natural rubber seed oil is effective for use as a brake fluid. The natural rubber seed oil possesses good hydraulic properties which can be used in other areas of hydraulics and fluid machinery. The natural seed oil brake fluid is not corrosive and other desired fluid properties can be enhanced by the addition of additives. A further research in this area is recommended.

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