TRIBOLOGICAL CHARACTERISTICS STUDY OF CONTINUOUS VARIABLE TRANSMISSION OIL AND STANDARD AUTOMATIC TRANSMISSION OIL

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ABSTRACT

Reduction of friction and wear is very important to get the best fuel efficiency and reduce loss of engine power. In this study, the anti-friction and anti-wear characteristics of transmission oils, namely the D Service Part ATF3, Runs Forever ATF3 and Proton CVTF, were investigated and their friction and wear response at different operating condition with varying speeds and temperatures were measured. Wear scar diameter was viewed on computer by using specific wear scar measurement software. The results obtained show that the frictional torque, and coefficient of friction of Runs Forever ATF3 are lower than D Service Part ATF3 at low speed of 1000rpm, but they became higher when the speed increased up to 2000rpm. Frictional torque and coefficient of friction of Proton CVTF are lower than both of the ATFs. The wear scar diameter of Runs Forever ATF3 is lower than those of D Service Part ATF3 at 1000 and 1500 rpm.

KEYWORDS

Friction coefficient; transmission oil; fluid film

INTRODUCTION

Existing of fluid film between two moving surfaces is critical and strongly dependent on the characteristic of its viscosity [1]. Without enough viscosity, friction will increase due to more sliding, especially metal to metal contact between two surfaces. Transmission oils are used widely for a long time since the car was first made. This is because during transmission's operation, there are sliding surfaces that make contact between each other. It needs a lubricant to avoid metal to metal contact, reduce friction and prevent from corrosion [2]. It also helps to transfer the heat and provide cooling for the transmission, which assists in reducing power loss and serves for better fuel consumption.

There are two types of transmission, which are manual and automatic transmission. Each type of transmission has their own lubricant requirements that are suitable with their operating condition. Both transmission oils are graded according to their viscosity characteristics that have been made by The Society of Automotive Engineers (SAE). Viscosity is the single most critical physical property of oil, as it affects the wear rate and fuel efficiency.

Automatic transmission fluid (ATF) is the fluid used in vehicles with self-shifting or automatic transmission. There are some specifications for ATF such as DEXRON and MERCON series that are identified by vehicles manufacturer on which ATF is appropriate with the vehicle being used. Most ATFs contain some combination of additives that improve their characteristics qualities such as anti-wear additives, corrosion inhibitors, extreme pressure additives, detergents and dispersants, anti-foam additives, seal well inhibitors, gasket conditioners and pour point dispersant [3,4].

Each transmission oil has its own viscosity index value. Lubricating oil that has high value of viscosity index is classified as good lubricating oil compared to another one that has lower value of viscosity index. Lubricating oils are derived from mineral oil which comes from under the ground. Then, in late 1930, it was replaced to synthetic oil by German scientist because there was lack of sufficient quantities of crude oil used in their military needs. Synthetic based lubricants have become more popular compared to mineral based lubricants due to their capability to maintain fluidity in low temperature during winter, compared to mineral oils which tend to solidify during cold weather [5].

EXPERIMENT

The experiment was conducted by using Fourballtester machine according to standard of ASTM 4172. The average duration for each test in the experiment was 60 minutes. The variable parameters for the experiment were speed and temperature and the load was considered constant at 392 N (40kg). Wear scar diameter was measured after the experiment. The main function of the measuring wear scar diameter was to compare the effectiveness of the lubricant. Wear scar diameter was viewed on computer by using specific wear scar measurement software.

RESULTS AND DISCUSSION

Table 1 shows the oil viscosity for the Automatic Transmission Fluids (ATF) that was obtained by using a viscometer.

Table 1: Oil Properties of ATFs

Properties	D Service Part ATF3	Runs Forever ATF3
Viscosity @ 60°C, cSt	13.3	12.5
Viscosity @ 70°C, cSt	10.3	9.4
Viscosity @ 80°C, cSt	7.3	6.9

Figure 1 shows the value of frictional torque against variable speed for the Automatic Transmission Fluids of Runs Forever ATF3 and D Service Part ATF3, together with the Proton Continuous Variable Transmission Fluid. The graph in Figure 1 shows that the value of friction torque of D Service Part ATF3 was higher than Runs Forever ATF3 at 1000rpm. However, at 2000rpm, the D Service Part's friction torque became lower than that of Runs Forever ATF3. It was assumed that the concentration of Runs Forever's friction modifier additive was higher than that of D Service Part. The surface films generated were effective only at low temperature and load. Based on Table 1, the viscosity of Runs Forever was lower than that of D Service Part's viscosity at 60°C, 70°C and 80°C. That was why Runs Forever showed higher friction torque compared to D Service Part at running temperature.

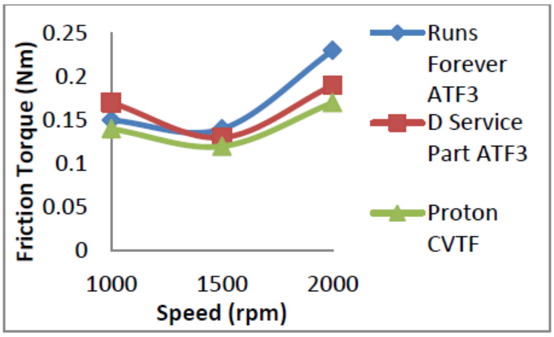

Figure 1: Graph of Friction Torque against Speed

It was also assumed that D Service Part's anti-wear additive was higher than that of Runs Forever. By reducing viscosity across the high-to-low temperature range, fuel economy could be improved [2].

It can be said that the friction torque value for all types of oil were obviously varying against speed. Also, Proton CVTF oil had less experience of friction torque compared to automatic transmission oil from 1000rpm until 2000rpm. The friction torque of CVTF exert to ball bearings was low due to sufficient lubrication at low speed. It was assumed that Proton CVTF had high viscosity compared to D Service Part ATF3 and Runs Forever ATF3. Instead, the oil that had low viscosity experienced thin fluid film due to high speed, which could cause fluid film breakdown due to its increasing speed.

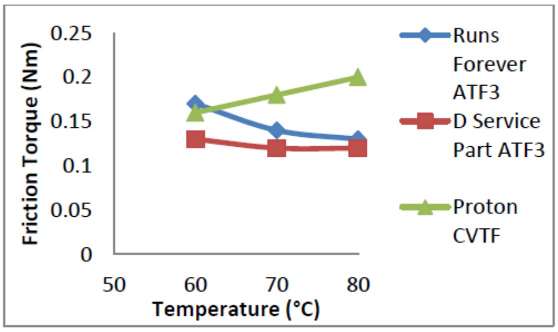

Figure 2: Graph of Friction Torque against Temperature

Figure 2 shows that the friction torque of D Service Part ATF3 was lower than that of Runs Forever ATF3 at temperature of 60°C. It was assumed that anti-wear additive concentration of D Service Part ATF3 was higher than Runs Forever ATF3. Then, the values of friction torque of both ATFs decreased after temperature of 60°C up until temperature of 80°C. In addition, both ATFs were run at normal range of automatic transmission temperature which was between 60°C - 140°C. Due to this condition, both ATF's fluid films were at their best efficiency to maintain their lubricity capability.

Meanwhile, the friction torque of Proton CVTF was slightly lower than that of D Service Part's at 60°C. It was assumed that anti-wear additive concentration of Proton CVTF was higher than that of D Service Part's. However, the friction torque of Proton CVTF increased up until temperature of 80°C compared to both ATFs which decreased. The reason was the normal range of CVT temperature between 50°C - 80°C. Then, when it reached the maximum temperature, the oils might have been dried out because of the high evaporation. Liquid lubricants may lose load carrying capacity at high temperature. Thus, at maximum temperature, the CVTF's fluid film would gradually break down, which would increase the friction torque.

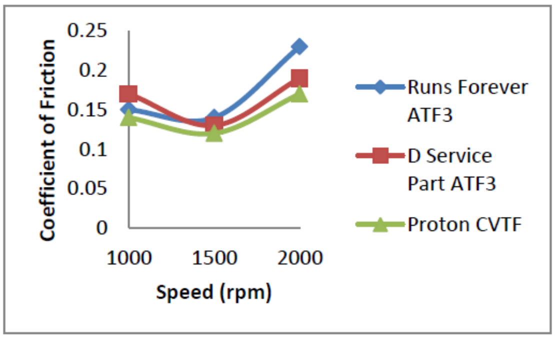

Figure 3: Graph of Coefficient of Friction against Speed

The graph in Figure 3 shows that the coefficient of friction of D Service Part ATF3 was higher than that of Runs Forever ATF3 at 1000rpm. However, at 2000rpm, D Service Part ATF3's coefficient of friction became lower than that of Runs Forever ATF3. Based on Table 1, viscosity of Runs Forever ATF3 was lower than that of D Service Part at 60°C, 70°C and 80°C. D Service Part ATF3 should have low coefficient of friction compared to Runs Forever ATF3 due to its higher viscosity. However, it was assumed that the concentration of Runs Forever's friction modifier additives was higher than that of D Service Part. The surface films generated by friction modifier were effective only at low temperature and load. Instead, D Service Part ATF3 showed less coefficient of friction compared to Runs Forever ATF3 at running temperature. Also, it was assumed that D Service Part's anti-wear additive was higher than that of Runs Forever due to increase of speed.

Meanwhile, the Proton CVTF experienced the least value of coefficient of friction compared to both automatic transmission oils. The coefficient of friction of CVTF was low due to sufficient lubrication at low speed. It was assumed that Proton CVTF had high viscosity compared to D Service Part ATF3 and Runs Forever ATF3. Instead, the oil that had low viscosity experienced thin fluid film due to high speed, which caused fluid film break down due to its increasing speed. Also, it caused the increase of coefficient of friction in this condition.

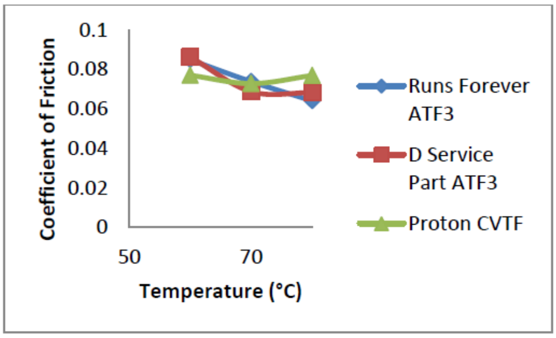

Figure 4: Graph of Coefficient of Friction against Temperature

Figure 4 shows that at 60°C, both ATFs suffered higher coefficient of friction. However, at 70°C, Runs Forever ATF3 experienced higher coefficient of friction than D Service Part ATF3. It was assumed that anti-wear additives concentration of D Service Part ATF3 was higher than Runs Forever ATF3. However, at 80°C, the coefficient of friction increased and became higher than that of Runs Forever ATF3. It was because at high temperature, D Service Part ATF3 oil might have dried out because of high evaporation. Liquid lubricants may lose load carrying capacity at high temperature. Therefore, D Service Part's fluid film would gradually break down compared to Runs Forever, thus there was high coefficient of friction exerted on ball bearing for D Service Part ATF3. Also, it was observed that coefficient of friction of Proton CVTF was lower than both ATFs at 60°C. It was assumed that Proton CVTF had higher viscosity at low temperature. Both ATF's coefficient of friction decreased with increasing temperature from 60°C until 80°C. Meanwhile, coefficient of friction for CVTF increased from 70°C until 80°C. It was because when Proton CVTF reached its maximum temperature condition, the oil might have dried due to evaporation process.

Figure 5 shows that the wear scar diameter of Runs Forever ATF3 was lower than that of D

Service Part ATF3 at 1000rpm. It was assumed that concentration of Runs Forever's friction modifier additive was higher than that of D Service Part. The molecules were attached to the surface, and formed a carpet of molecules which reduced friction and wear. The friction modifier was effective only at low temperature. However, at higher speed of 2000rpm, the wear scar diameter of D Service Part ATF3 was lower than that of Runs Forever ATF3. It was assumed that concentration of anti-wear additives protected the contacting surfaces at higher speed and temperature above the range of effectiveness by friction modifier. The protective surface layer was more durable than the friction modifier.

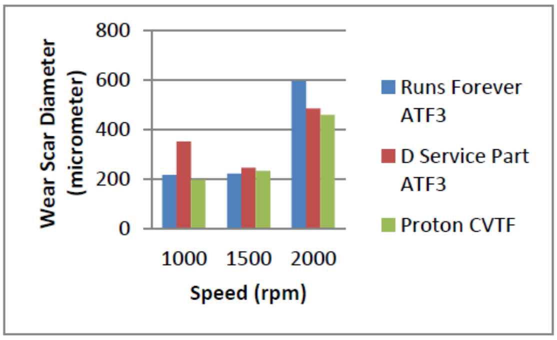

Figure 5: Graph of WSD against Speed

Moreover, it was observed that Proton CVTF experienced lesser wear scar diameter compared to ATFs. It was assumed that concentration of Proton CVTF's anti-wear additive was more than both of ATF's anti-wear additive. That is why when the speed increased, the wear scar diameter of Proton CVTF became lower than both of the ATFs due to its anti-wear additive effective at that temperature. In addition, high viscosity would give appropriate amount of fluid film at running temperature.

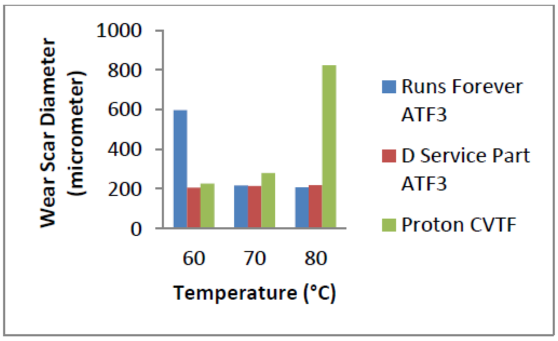

Figure 6: Graph of WSD against Temperature

Figure 6 shows that the wear scar diameter of D Service Part ATF3 was lower than that of Runs Forever ATF3 at 60°C. Higher viscosity grade would give low wear rate at low temperature. According to its low wear scar from 60°C until 70°C, it was assumed that concentration of D Service Part's anti-wear additive was higher than that of Runs Forever. However, at 80°C, the wear scar diameter of D Service Part ATF3 increased slightly higher than Runs Forever ATF3. The reason could be that the D Service Part's oil evaporation was slightly quicker, thus the fluid film became thin due to the evaporation. Meanwhile, it was observed that at the temperature 60°C, the wear scar exerted on ball bearing by Proton CVTF was slightly higher than that of D Service Part ATF3. However, for the increment of temperature, the Proton CVTF experienced high wear scar diameter compared to both ATFs. It was assumed that concentration of extreme-pressure additives of CVTF was lesser than that of ATF.

Conclusion

1. The frictional torque and coefficient of friction values of Runs Forever ATF3 were lower than D Service ATF3 at low speed of 1000rpm. However the values increased at 1500 and 2000rpm.
2. The wear scar diameter of Runs Forever ATF3 was lower than D Service Part ATF3's WSD at low speed of 1000rpm, but it became rougher when the speed increased up to 2000rpm.
3. The wear scar diameter of the ball specimens of Proton CVTF increased with the increase of temperature from 60°C to 80°C.
4. The D Service Part ATF3 gives good transmission oil lubrication performance based on the lower value of frictional torque and wear scar diameter as compared with Runs Forever ATF3 at normal operating condition.

References

[1] Gohar, R. and Rahjenat, H., 2008. Fundamentals of Tribology (pp 77-86) Imperial College Press.

[2] Johson, M., 2008. Selecting the Correct Lubricant, Tribology & Lubrication Technology, pp 28-36.

[3] Muhammad, S.D., 2012. The Influence of the Speed in Wear Resistance Characteristic of Palm Fatty Acid Distillate (PFAD) UTM Thesis.

[4] Kalam, M.A., Masjuki, H.H., Varman and Liaquat, A.M., 2011. Friction and Wear Characteristics of Waste Vegetable Oil Contaminated, Lubricants International.

[5] Ajay, K., Simon, C.T., Martin, P. and Shirley, 2001. Automotive Tribology, CRC Press LLC.