A STUDY ON WEAR EFFECTS FROM METHYL-ESTER IN OIL MIXTURES

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ABSTRACT

The authors conducted previous research in oil dilution by biodiesels because unburned biofuels, with their lower volatility and early aging, can enhance degradation of oil lubricity. Research is presented here on the dilution effects on wear for the most typical methyl-esters in biodiesels when added in known percentages to SAE 15W40 mineral oil in binary-mixtures. Tribometer studies are carried out for such mixtures to explain the observed differences between different feed-stock biodiesels when they are mixed in oil.

Introduction

Engine oil dilution by diesel engine is accepted and it happens because unburned biodiesel reaches the engine oil pan in all diesel engines. But when the engine is fueled by biodiesels and their blends, engine oil dilution rates and their effects can be different (because of lower distillation temperature) than those from regular diesel fuel. This study is concerned with possible wear effects (e.g., viscosity and lubricity) when biodiesel mixes with mineral oil; while higher viscosity of biodiesels generally could help lubricity, the overall effect on wear is not clear [1]. Each biodiesel feedstock has a different breakdown of methyl esters (from its feedstock fatty acid composition. Shanta and Molina [1] carried out the first tribometry studies of mineral oil diluted with biofuels; they suggested that a larger fraction of methyl oleate and/or lower fraction of methyl linoleate in biodiesels may lead to reduction of wear when diluting engine oil, while other methyl components of biodiesels may increase tribometer wear. Wadumesthrige et al [3] and Lapuerta [4] previously investigated the effects of other minor components of biodiesels, the former studied glycerol, free fatty acids, antioxidants and phospholipids as components; their works indicate that lubricity of biodiesel in mineral-oil mixtures can be different than those for conventional fossil-diesel in same oil. But there is no data the tribological effects of the main components of biodiesels, the methyl esters typical of biodiesels, when mixed in engine oil.

The purpose of this study was to assess the effects on wear and on other tribological parameters of mixtures of methyl esters (typical of biodiesels) in mineral oil. Different dilutions (for 5%, 10%, 20%, 30% 50% and 100% of dilution in 15W40 oil) of each six methyl esters (methyl-palmitate, -oleate, -linoleate, -laurate, -stearate, -myristate) and also two biodiesels (soybean oil and peanut oil biodiesels) in the mineral oil (and the reference 15W40 mineral oil) were tested in a T-11 pin on disk tribometer (with 1/8inch-AISI 316 stainless steel ball-on-1inch-AISI 1018 disk, load of 2kg, linear velocity of 0.15m/s, and run time of 5,000sec) and a FLC lubricity tester (4719 steel test roller, dead weight of 2kg, and run time of 30min); wear, friction force, roughness, and viscosity data, and microscope images for such mixtures were obtained for comparison purposes

Selected Experimental Results and Discussion

Figure 1 presents specific wear measurements by the T-11 tribometer and FLC lubricity tester for the six mixtures of peanut oil biodiesel diluted in engine oil. The 100% engine oil as reference yielded the minimum measured specific wear (for both tribometer and lubricity tester), while all biodiesel mixtures led to increased wear, with the 10% mixture showing the minimum among such mixtures. Similar results (data not shown here) were obtained for engine oil diluted with soybean oil biodiesel at same percentages.

Figure 2 presents specific wear for methyl oleate diluting SAE 15W40 oil by the T-11 tribometer and FLC lubricity tester for the six mixtures and for 100% engine oil as reference. The plot shows that for the 20% dilution yielded the lowest measured specific wear (for both tribometers), and even slightly lower than that for the 100% oil reference. Figure 3 presents specific wear for methyl linoleate diluting SAE 15W40 oil by the T-11 tribometer and FLC lubricity tester for the six mixtures and for 100% engine oil as reference. The figure shows that for the 5% dilution the specific wear is the lowest and not significantly different than that for 100% oil reference, but wear increases for levels of dilution higher than 10%. Figure presents specific wear for methyl palmitate diluting SAE 15W40 oil by the tribometers for the six mixtures and for 100% engine oil reference, and that for the 5% dilution the specific wear is slightly lower than that for 100% oil reference, but wear monotonically increases for levels of dilution higher than 20% in the tested dilution interval. Measurements of viscosity (which show that viscosity of methyl-esters-in-oil mixtures decreases for increasing percentages of added methyl esters, not presented here) seem to match the wear trends of figures 1 to 4, but there is no consistent matching of friction measurements (not presented here) and wear ones for same methyl-ester dilution sequences. Wear, viscosity and friction force for other minor methyl-ester components of biodiesels (not presented here) yielded similar trends. Good repeatability of performed tribometer tests was found.

Conclusions

This research work shows that the employed methodologies and instruments are suitable to study how each typical methyl ester, when diluting mineral oil, may affect the mixture lubricity, and to evaluate if the breakdown of a biodiesel may explain its tribological behavior when mixtured with oil. This research work also showed that engine oil dilution by methyl esters in all of the tested percentages may negatively affects the lubricity performance of engine oil. In general, methyl esters and biodiesels dilutions in the interval of 5% to 20% yielded the lowest wear, but they were generally higher than that of the 100% mineral 15W40 oil (with a few mixtures yielding wear in the same range as pure oil). For the peanut oil biodiesel and soybean oil biodiesel used for this thesis work, it was found that the former yields relatively lower specific wear than the later at all dilution percentages. This result, as well as of previous research work of Shanta and Molina [1] may be explained by the lower methyl linoleate and higher methyl oleate contents (for instance, of peanut oil biodiesel as compared to those of soybean oil biodiesel). The authors recognize that may be unknown interactions of these methyl ester components between themselves and also with oil additives. Current research is focused on elucidating tribometer wear effects of ternary mixtures (i.e., of two typical methyl esters in oil), and on evaluating if prediction of tribometer wear can be carried out by such results for a given methyl-ester-oil mixture.

References [1] Shanta, S. M., Molina, G. J., and Soloiu, V. (2011), "Tribological effects of mineral-oil lubricant contamination with biofuels: a pin-on-disk tribometry and wear study", Advances in Tribology, Article ID 820795, 2011 [2] Gili, F., Igartua, A., Luther, R., and Woydt, M. (January 2010). "The Impact of Biofuels on Engine oil performance". Proc. of TAE Esslingen, 17th Int. Colloquium Tribology. Germany. [3] K. Wadumesthrige, M. Ara, S. O. Salley, and K. S. Ng, "Investigation of lubricity characteristics of biodiesel in petroleum and synthetic fuel," Energy and Fuels, vol. 23, pp. 2229-2234, 2009. [4] M. Lapuerta, J. Sánchez-Valdepeñas, D. Bolonio, and E. Sukjit, "Effect of fatty acid composition of methyl and ethyl esters on the lubricity at different humidities," Fuel, vol. 184, pp. 202-210, 2016.

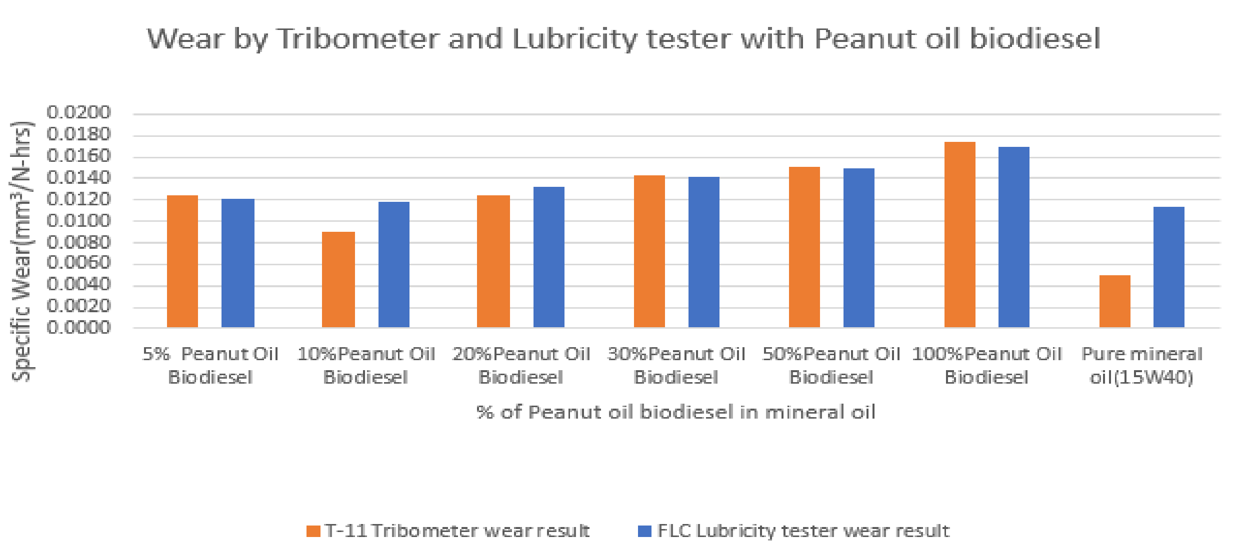

Figure 1: Wear by Tribometer and Lubricity Tester with mixtures of Soybean oil biodiesel in 15W40.

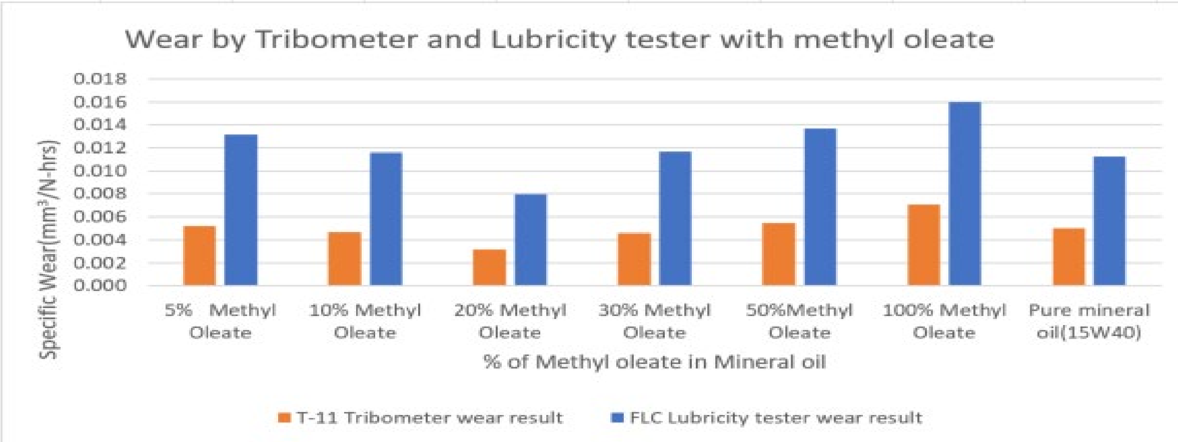

Figure 2: Wear by Tribometer and Lubricity Tester with mixtures of Methyl Oleate in 15W40.

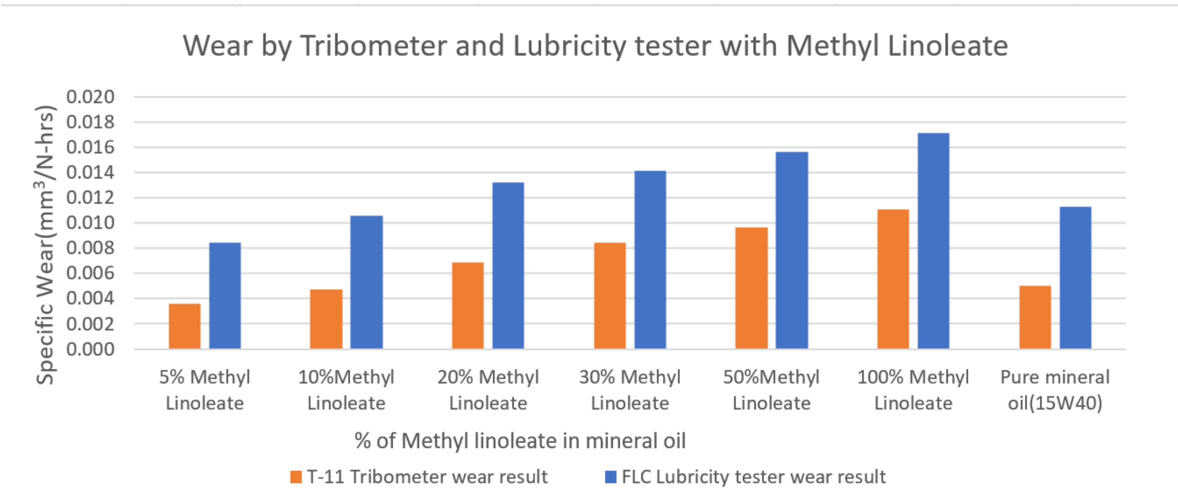

Figure 3: Wear by Tribometer and Lubricity Tester with mixtures of Methyl Linoleate in 15W40.

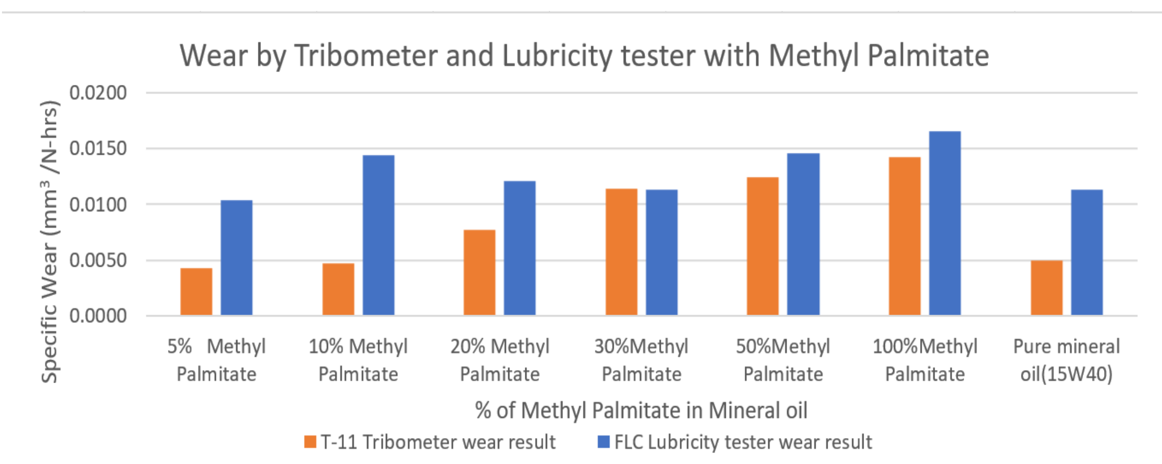

Figure 4: Wear by Tribometer and Lubricity Tester with mixtures of Methyl Palmitate in 15W40.