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WEAR FROM OIL-DILUTION BY BIODIESELS: A TRIBOMETER STUDY ON EFFECTS OF BIODIESEL METHYL-ESTER COMPONENTS

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ABSTRACT

Use of biodiesels in internal combustion engines leads to oil dilution because unburned biodiesel reaches the engine oil pan, and its lower volatility and early aging can enhance degradation of oil lubricity. The authors conducted previous research in a pin-on-disk tribometer showing that oil dilution (of SAE 15W40 mineral oil contaminated by known percentages of the biodiesels from canola-, peanut-, soybean-, chicken-fat-, and cotton-seed-oil) can significantly reduce wear-protection. But wear-outcomes consistently varied between different feed-stock-biodiesels under same testing conditions. New research is presented on the dilution effects for the most typical methyl-esters in biodiesels: tribometer studies are carried out for mixtures of known percentages of such methyl-esters in SAE 15W40 mineral engine-oil. The possible interactions of methyl-esters with oil components are discussed, as they may explain some of the observed differences between biodiesels and their components.

Introduction

Engine oil dilution by diesel engine is accepted and it happens in all diesel engines. But when the engine is fueled by biodiesels or biodiesel blends, engine oil dilution rates and their effects can be different than those from regular diesel fuel. This study is concerned with possible wear effects because of such oil dilutions by unburned biodiesel which reaches the engine oil pan. When biodiesel mixes with mineral oil, viscosity and lubricity are the most relevant properties of biodiesel to this tribological study. The lubricity of biodiesel is highly dependent on the transesterification process and fatty acid composition. Also, higher viscosity of biodiesel generally leads to good lubricity performance and to low specific wear [1]. Each biodiesel feedstock has a different breakdown of methyl esters, and these major components (methyl esters) affects the performance of biodiesel. Different biodiesel dilutions in engine oil occur due to lower distillation temperature of biodiesel leading to more unburned biodiesel dilution in the engine oil [2].

Shanta et al [1] carried out a study on the tribological effects of mineral oil lubricant contamination with biofuels. They found that the larger fraction of oleic acid and the lower fraction of linoleic acid that are typical in chicken fat biodiesel may play an important role in reducing the measured wear when engine oil is diluted by biodiesels. Wadumesthrige et al [3] and Lapuerta [4] investigated the effects of minor components of biodiesels, the former studied glycerol, free fatty acids, antioxidants and phospholipids as components. They used ultra-low sulfur diesel as base oil and employed the High Frequency Reciprocating Rig method for lubricity testing. They found that a 2% blend of soybean oil biodiesel in ultra-low sulfur diesel resulted in increased wear as the temperature increased up to 70ºC. These previous works on the tribology of biodiesel mixtures with mineral-oil and fossil diesels indicate that tribological properties of such mixtures can be different than those for conventional fossil mineral oil, and they suggest that contamination by biodiesel in fossil oils can affect the lubricity of such mixtures. But no previous research work attempted to investigate the tribological effects of methyl esters typical of biodiesels when mixed in engine oil.

Purpose of this study

The purpose of the present work was to assess the effects on wear and on other tribological parameters of methyl esters typical of biodiesels when mixed in mineral oil. Different dilutions (each tested for 5%, 10%, 20%, 30% 50% and 100% of dilution in 15W40 oil) of each of those methyl esters and of two typical biodiesels (soybean oil biodiesel and peanut oil biodiesel) in engine mineral oil were tested, and extensive experimental results were obtained for wear, friction force, roughness, viscosity, and microscope images for such mixtures, and compared to the results for reference fluid (15W40 mineral oil) tests.

Experimental methods

Studies were carried out employing a T-11 pin on disk tribometer and a FLC lubricity tester. The methyl esters used were methyl palmitate, methyl oleate, methyl linoleate, methyl laurate, methyl stearate, methyl myristate and also two biodiesels (soybean oil and peanut oil biodiesel) are also mixed in mineral oil and tested. Lubricity performance in terms of wear of the diluted engine oil are being measured. After-tests roughness and, viscosity of all tested mixtures also were measured, and friction force vs. time data was acquired (not shown here).

Selected Experimental Results and Discussion

- **Results for mixtures of peanut oil biodiesel diluted in engine oil**

The employed engine oil is diluted with peanut oil biodiesel at 5%, 10%, 20%, 30%, 50% and 100% volume ratios. Figure 1 presents specific wear measurements by the T-11 tribometer and FLC lubricity tester for this six mixtures of peanut oil biodiesel diluted in engine oil and for engine oil as reference. The plot indicates that the 10% mixture yielded the minimum measured specific wear. Matching patterns were observed for the FLC lubricity tester and T-11 tribometer specific wear plots. Similar tests were carried out for engine oil diluted with soybean oil biodiesel at 5%, 10%, 20%, 30%, 50% and 100% volume ratios; results show that the 10% mixture yielded the minimum measured specific wear and that similar wear vs. biodiesel percentage evolution was obtained for the two tribometers, and those patterns matched those of the peanut-oil biodiesel dilutions.

- **Results for mixtures of methyl oleate diluted in engine oil**

The employed engine oil is diluted with methyl oleate at 5%, 10%, 20%, 30%, 50% and 100% volume ratios. Figure 2 presents specific wear measurements by the T-11 tribometer and FLC lubricity tester for these six mixtures and for engine oil as reference. The plot shows that for 20% dilution, the measured specific wear was the lowest. Similar trends and a minimum specific wear at 20% dilution were observed for the two tribometers wear plot. The 20% Methyl Oleate dilution in engine oil yielded lower measured specific wear as compared to that of pure engine oil.

- **Results for mixtures of methyl linoleate diluted in engine oil**

The employed engine oil is diluted with methyl linoleate at 5%, 10%, 20%, 30%, 50% and 100% volume ratios. Specific wear measurements were performed by the T-11 tribometer and FLC lubricity tester for this six mixtures and engine oil as reference. The plot indicates that at a 5% dilution of engine oil the measured specific wear amount is the lowest for the tested interval. Similar trends and minima of specific wear at 20% dilution were observed for the measurements by the two employed tribometers.

Wear measurements for other minor methyl-ester components of biodiesels yielded similar trends.. Viscosity of biodiesel-in-oil and methyl-esters-in-oil mixtures showed decreasing viscosity for increasing percentages of added biodiesels and methyl esters; these results and those of after-tests roughness of specimens and of average friction force during tests were consistent with the wear measurements.

Conclusions

This research work shows that the employed methodologies and instruments are suitable to study this relevant research problem and those of evaluating how the breakdown of biodiesel may explain the tribological behavior of their mixtures with oil. Repeatability of performed tribometer test was also proved This research work also showed that engine oil dilution by methyl esters in all of the tested percentages negatively affects the lubricity performance of engine oil. For all tests, methyl esters and biodiesels dilutions in the interval of 5% to 20%

yielded the lowest wear, but higher than that of the 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 peanut oil biodiesel yields lower specific wear results at all dilution percentages, as compared to those of soybean-oil biodiesel ones. This result may be explained by the lower methyl linoleate and higher methyl oleate contents of peanut oil biodiesel as compared to those of soybean oil biodiesel, and that may be unknown interactions of these components with oil additives. Future research will focus on elucidating such possible interactions, and on predicting tribometer wear of a biodiesel-in-oil mixture from its methyl ester breakdown.

References

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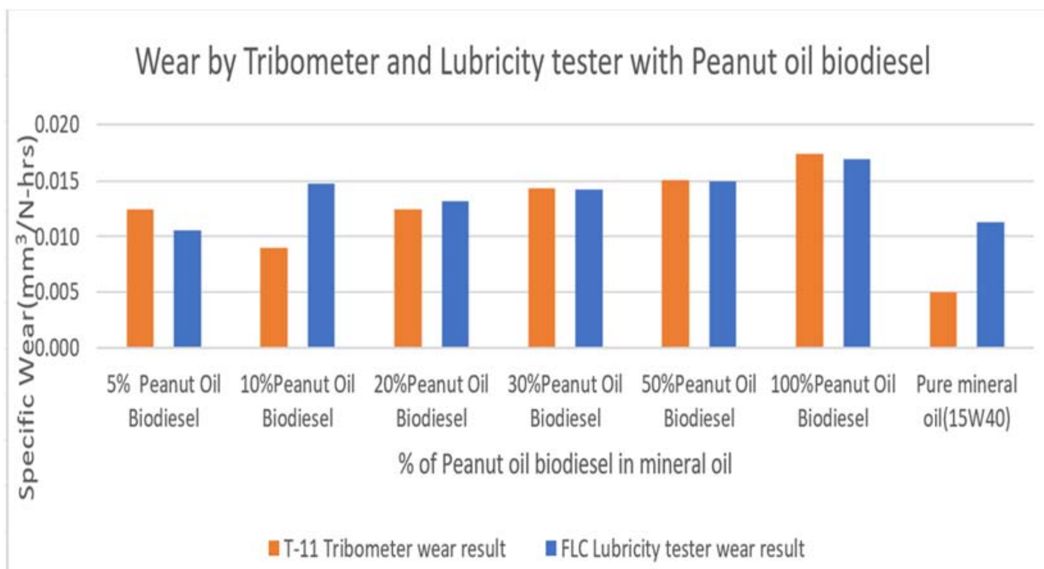

Figure 1: Wear by Tribometer and Lubricity Tester with mixtures of Peanut oil biodiesel in 15W40.

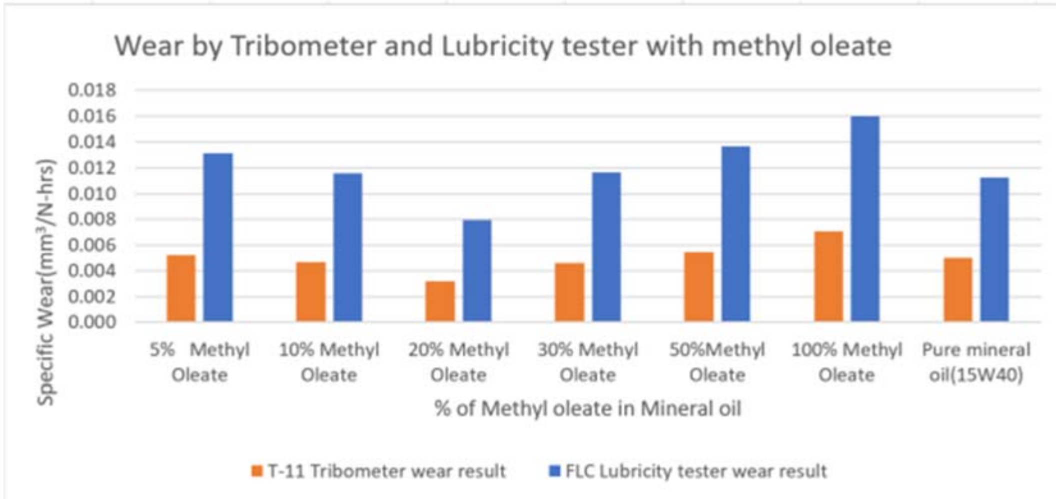

Figure 2: Wear by Tribometer and Lubricity Tester with mixtures of Methyl Oleate in 15W40.