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Effect of the Use of Biodiesel on the Materials of the Engine Components

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Biodiesel is regarded as a viable substitute to diesel fuel owing to its green and biodegradable origin. Among the main advantages are reducing CO_2 demand and the absence of SO_2 emissions since it does not produce sulphur. This work aims to investigate the effect of biodiesel usage on the properties of specific engine components, such as polymeric sections, ceramic materials used as thermal barriers, and lubricating oil. Mechanical tests were performed on samples of various polymers used in parts of the fuel system of current diesel engines subjected to varying biodiesel interaction periods. Specifically, measures of fuel absorption in acrylonitrile "o" rings and hoses and their effect on final mechanical properties. The results show that more significant biodiesel cuts result in greater absorption and degradation of mechanical properties. The chemical analyses were performed on the engine oil at various levels of a long-term evaluation conducted on the test bench. The objective was to determine the possible contamination of the same and variation of its lubricating properties. The conclusions were made about the actions of materials that remain in touch with biodiesel analysis of data collected during the various trials.

Keyword: Biodiesel, Degradation, Diesel engines, Lubrication, Materials

Introduction

The greenhouse effect is responsible for most of our planet's environmental issues. That would be the mechanism in which some molecules in the atmosphere absorb a considerable portion of the radiation released by the planet and return it to the earth's surface to heat it. The CO_2 levels in the environment are now increasing rapidly due to various human actions.[1] The most significant of which is the burning of coal, oil, and natural gas, which emits emissions from these fossil fuels. For the past three decades there has been a strong desire to reduce excessive fossil fuel emissions and improve energy efficiency. A good example is an increase in the performance of internal combustion engines and the reduction in the size and weight of cars.[2] The governments and scientists in the more industrialised nations are now trying to prevent these annoyances. One illustration is creating alternative energy sources that increase the greenhouse effect while also reducing or maintaining unsustainable non-renewable energy use. The usage of biofuels which are oils made from wood that are 100% organic is one of the most significant developments. It can be used as pure (B100) or in various concentrations of gasoline. A mixture of 20% biodiesel and 80% diesel is referred to as B20. While the low levels of output of these fuels render complete substitution of petroleum derivatives impractical they do help to reduce emissions of the latter and help to prevent the production of toxic gases to the atmosphere.[3] In our nation current law mandated using 5% biodiesel in diesel and 5% bioethanol in gasoline starting in the year 2010. Previous experiments on a diesel cycle engine have been conducted. This work entailed conducting engine efficiency experiments with diesel and various diesel-biodiesel blends. As the amount of biodiesel in the mixture rises the strength and engine torque values decrease slightly.

On the other hand the real intake increases as the percentage of biodiesel in the mixture increases. They also demonstrate that the temperature of the exhaust drops which is explained by the fuel's lower calorific value. Another latest study theme is in the area of chemicals. Since there are no heat leaks through the walls in this ideal engine it achieves a more effective energy transfer.[4] The issue is that the extreme temperatures achieved during service are too high for modern metallic products to withstand. It has been

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focusing on producing and applying materials with a higher point of fusion such as ceramics properties are much too sensitive to the strong stresses encountered during engine action. It appears as a modern option to use a thermal barrier made of ceramic content to protect the metal pieces visible to the front of the name. Thermal Barrier Coatings (TBC) are used to prevent heat transmission, and ceramic materials are mainly used. In a previous study, the authors tested the efficiency of a diesel engine coated with TBC that ran on diesel and various diesel-biodiesel blends. Its usage in thin films has virtually eliminated problems caused by inadequate adhesion or separation due to differences in coefficients of expansion between the shielded substrate and the thermal barrier coating.[5] It was performed performance tests on a diesel engine coated with TBC operated with diesel and different diesel-biodiesel blends. An objective of the present work has allowed us to observe the degradation of the thermal barrier coatings applied to the combustion chamber components.

Experimental Procedure

The fuel used in all of the experiments was neat diesel which included a proportion of 20% biodiesel (B20), B40, B60, B80 and B100 biodiesel at the time of the samples. The blending proportion details are shown in Table 1. Biodiesel based on chlorella sp. algae oil complies with the American Society for Testing and Materials standards ASTM 6715 and EN 14214. To conduct the absorption studies whole specimens of type O ring gaskets made of nitrile-butadiene rubber were submerged (NBR). Gravimetric analyses on at least four samples using an analytical balance with a precision of ±0.01 mg were used to monitor the kinetics of fluid absorption by the products. Many of the measurements were done at room temperature. To reach thermal equilibrium, the samples were taken out of their aging one hour before processing. Tensile strength tests were performed on full-section specimens in hoses to assess the mechanical properties of the specimens according to ASTM D3039M95. Tensile checks were performed on the O-rings by ASTM D1414M 95. The elastic modulus, maximal load, and tensile strength of the material were determined using strain records taken at a pace of 50 mm/min. The efficiency experiments were carried out in a Kirloskar engine with thermal barriers covering the valves and pistons. A hydraulic dynamometric brake with a capability of 500 horsepower was used. The engine was used for 40 hours on a B50 cutoff, with oil samples taken after 10 hours of running.[6] The lubricating oil used was 15W40 castor oil from the castor oil corporation. The engine was disassembled after the long-term evaluation and TBC-coated sections (pistons and valves) were carefully removed for study. The four oil samples were analysed in the laboratory for oil analysis.

Table 1 — Blending proportion details

Blend Name	Details
B20	20% biodiesel and 80% diesel
B40	40% biodiesel and 60% diesel
B60	60% biodiesel and 40% diesel
B80	80% biodiesel and 20% diesel
B100	100% biodiesel

Analysis of Results

Absorption Tests

The biodiesel absorption results for the fabric-polyester hose (black hose) as seen in Fig. 1. In both instances there is a significant absorption in the early stages of the process shown by a rise of sample mass accompanied by a reduction of mass before the test stabilises. Only the lowest levels of biodiesel were able to maintain a balance in absorption (B20). In the case of B20, the final percentage of the mass rise was similar to 4%, and in the case of B40, it was close to 6%. Even for exposure periods extended with an approximately linear slope after stabilisation which prevailed at approximately 1000 hours in both equilibrium was not achieved in the case of cuts B60, B80 and higher.[7] The curve structure indicates that the mechanism is permanent and that diffusion processes cause major mass shifts. Fig. 2 shows the effects of

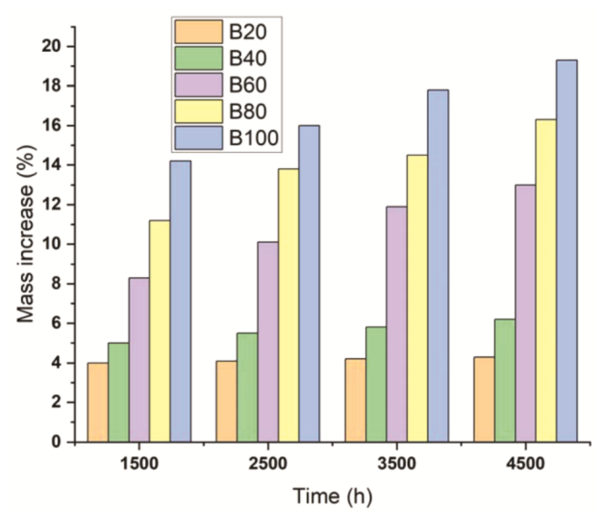

Fig. 1 — Biodiesel absorption for the fabric-polyester hose

biodiesel absorption by polyvinyl chloride (PVC) hoses (yellow hose). In both situations a rise in weight can be observed, signalling fuel absorption, accompanied by a substantial decrease in the overall weight of the samples for cuts more significant than B100. It is explained by the breakdown and migration of polymer components such as plasticizers (which have flexibility) and colorants on the lighter parts of the biofuel components. The results obtained for biodiesel absorption on the NBR 'O'ring are shown in Fig. 3. In such situations an improvement in weight means that the fuel has been absorbed.[8]

Similarly, pronounced absorption in the early stages of the examination, accompanied by stabilisation is appreciated in both situations. Only the cuts lower than biodiesel could maintain a balance in absorption (B20). In the case of B20 the final percentage of mass growth was equivalent to 4%, whereas the 100% reduction resulted in a rise of up to 18%. On Part, relocation caused a 500-hour weight loss in both situations. This effect is marked for cuts more significant than B80.

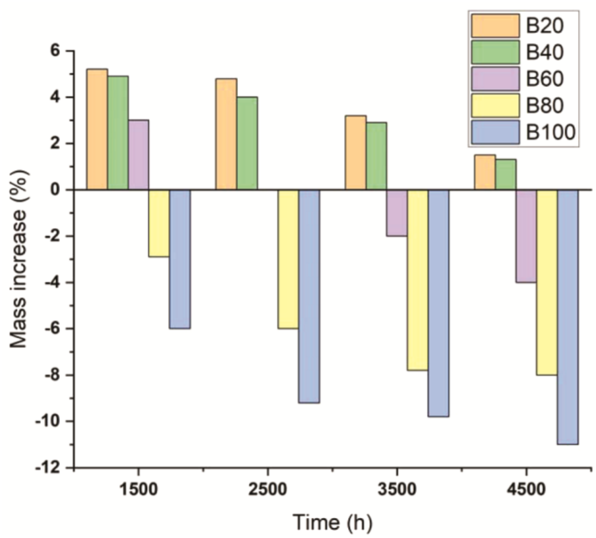

Fig. 2 — Biodiesel absorption for the PVC hose

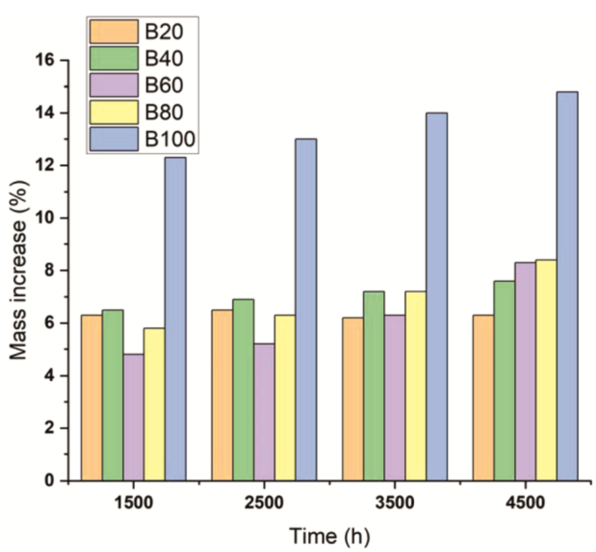

Fig. 3 — Biodiesel absorption for the NBR oring

Mechanical Behavior

Fig. 4 shows the effects of the fabric-polyester hose's mechanical checks. The values of the specimens not subjected to any fuel before the test (s/exp) are described by the first two bars. In cuts greater than B20, a significant decrease in mechanical properties may be found coinciding with the maximum absorption observed for such cuts. The values for maximal elongation appear to stable for cuts over B20, likely because these hoses have the cloth as insulation which avoids more deformation. The effects of the mechanical experiments on the PVC hose are shown in Fig. 5. It can be observed that the highest loads are sustained without a significant reduction in resistance. Instead, deformation behaviour is impaired, confirming the fact that plasticizers are migrating. This impact becomes more apparent in cuts higher than B20 which coincides with the increased absorption and resulting mass loss shown in these cuts. It is also observed changes in the coloration of the tested hoses confirming the migration of dyes. In Fig. 6, the results were obtained in the mechanical tests in the NBR gaskets ('O´ring). It is possible to observe that a loss does not occur with significant mechanical properties in strength and elongation at break for cuts below B40. In higher cuts

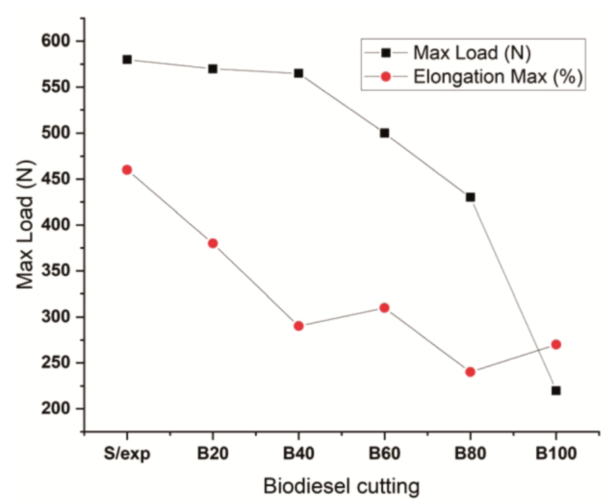

Fig. 4 — Mechanical properties of the fabric-polyester hose

a slight drop is found in the maximum stresses and total elongation.[9]

Lubricating Oil Tests

The effects of the different properties of the lubricating oil after 10, 20, 30, and 40 hours of use with B20 fuel are given in Table 2. At 40°C there is a first tendency for the viscosity to decline followed by an improvement to final values close to the original ones. At 100°C, however, the viscosity has a small propensity to increase. Both results contradict each other, with a reduction in viscosity with time due to lubricant dissolution with gasoline. During the period of the analysed results, the density values are unaffected. However, wear particles "debris" and moisture that rises in content with the use of oil will be expected to cause density values to increase. The tests showed no major differences in the moisture content of the lubricating oil. Moisture in the lubricant has corrosive effects on the metal components of the parts and allows lubricating oil additives to degrade. The rise in moisture content is mostly attributed to the temperature differential between the oil and ambient air and the physical phenomenon of high humidity vapour strain. Finally, the operation's flashpoint indicates a small downward slope.[10] The dilution of the oil with gasoline causes the flashpoint to decrease with the application. This dilution weakens the Vander Waal powers of the lubricant molecule's bonds, allowing it to vaporise more easily. It was determined that the length of the test performed was insufficient to detect clear patterns in the variables tested.

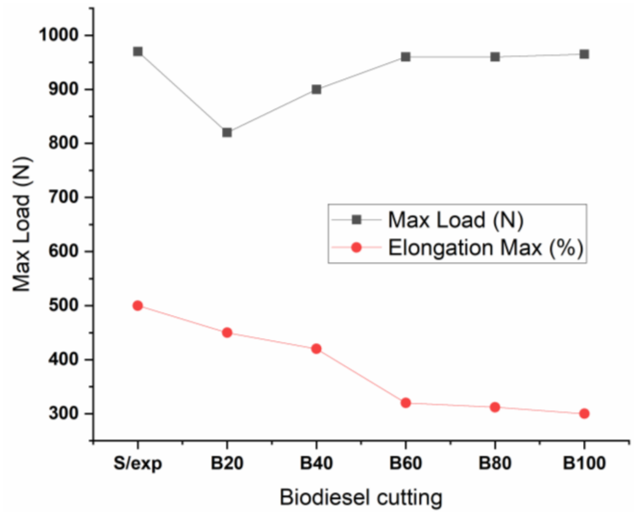

Fig. 5 — Mechanical properties of PVC hose

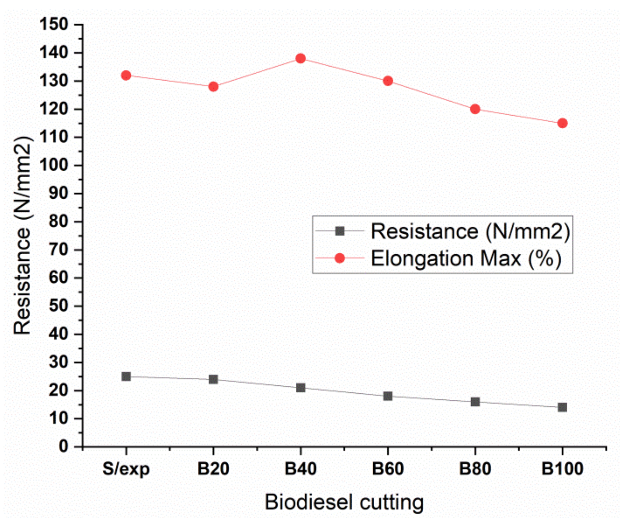

Fig. 6 — Mechanical properties of the O'ring

Integrity Analysis of Thermal Barriers after Prolonged Use

In Fig. 7, the appearance of a new valve with and without coating and its condition after 60 hours of engine use. The edges of the ceramic coating on the valve head reveal landslides indicating that the valve head is in the midst of a cycle of erosion which would inevitably conclude with the complete detachment of the thermal insulating sheet. This may be attributed to the thermal fatigue phenomenon since TBC has a somewhat different coefficient of thermal expansion than valve material. Perhaps the thermal amplitude experienced by this part is lower than that experienced by the valves requiring more cycles to be nuclear the fault.[11] The state of the coating after 60 hours is shown in Fig. 8. The same pattern that seems to be positive behaviour is not valued. Until the clear ceramic layer "Top Coat," this kind of thermal barrier is deposited with intermediate layers called "Bond

Table 2 — Variation of the different properties of the lubricating oil with the test hours

Hours	0	10	20	30	40
Viscosity at 40°C (cSt)	165	156	117	127	161
Viscosity at 100°C (cSt)	16	16.1	16	16.2	17
Viscosity Index	91	98	134	125	104
Density (kg/cm^3)	0.896	0.896	0.899	0.898	0.899
Water by distillation (%)	1 % Max	0.1	0.1	0.1	0.1
Flash point (°C)	231	231	209	216	211

Fig. 7 — valves after 60 hours of operation

Fig. 8 — State of the coating after 60 hours

coat." These layers are deposited to reduce the impact of dilation coefficient differences between the products used. To resolve the issue of observed landslides materials of the bond coat with other properties must undoubtedly be chosen for the valve event. More detailed research in this area is required such as determining the best kind of ceramic to use and observing the degree of combustion product penetration and degradation. The lower temperature of efficiency by using biodiesel blends could theoretically extend the existence of thermal barrier covers.

Conclusions

The fabric-polyester specimens (black hose) demonstrate pronounced absorption in the early stages of the experiment accompanied by a reduction of mass before recovery in all cases. A balance in absorption was achieved only for the lowest biodiesel cuts (B20). In the case of B20 the final percentage of mass gain was similar to 4%. In the absorption test of polyvinyl chloride (PVC) hose specimens (yellow hose) a rise in weight is observed in both situations which is accompanied by a large decrease in the overall weight of the samples for cuts greater than B20. When it comes to the absorption test of NBR ‘O'rings, it's clear that there's a lot of absorption in the beginning, accompanied by stabilisation.[12]It appears that a balance of absorption was only reached for the cuts deeper than biodiesel (B20). In both situations a weight loss in the region of 500 hours may be attributed to the migration of light components. The mechanical testing on fabric-polyester hose samples reveals a substantial drop in mechanical properties indicating that this impact on cuts is more significant than B20. The dye migration was verified by changes in the coloration of the checked hoses. After many hours lubricating oil degradation testing revealed a decrease in viscosity accompanied by an improvement.[13] The density and humidity percentage remain unaffected and the flashpoint has a marginal propensity to decrease with operating hours. In the future it is recommended that more extensive running experiments be conducted with the results being compared to pure diesel oil or industrial diesel oil (B20). TBCs also eroded along the edges of the cylinders likely owing to thermal exhaustion. The pistons seem to be in good condition.

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