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EXPERIMENTAL INVESTIGATION ON MATERIAL COMPATIBILITY OF BIODIESEL FUEL, PART-1 FUEL PIPE

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Abstract

From the point of view of protecting the global environment and the concern for long term supplies of conventional diesel fuels, it becomes necessary to develop alternative fuels comparable with conventional fuels. Biodiesel obtained from vegetable oils holds good promises as an eco-friendly alternative to diesel fuel for the use in IC engine. Material compatibility is a major concern whenever the fuel composition is changed in the fuel system of IC engine. Changes in fuel composition and the introduction of alternative fuels often create many problems in fuel pipe. In the present study, impact of plain Diesel, Jatropha biodiesel, and 20% ethanol blended Jatropha biodiesel are investigated on the physical properties of Fuel pipe included swelling (mass change, volume change, hardness, and elongation),and it is compared with pure diesel. These properties were measured according (ASTM) D 2240-81 after immersing fuel pipe in the tested fuels (for 1440 h at room temperature).The changes in physical properties of fuel pipe was in the order of 10 % as compared to that of diesel, which can be taken care of by augmenting certain properties of fuel pipe while using biodiesel in long run.

Index Terms: fuel pipe, Plain Diesel, Jatropha biodiesel, 20% ethanol blended Jatropha biodiesel.

Nomenclature:

M	mass, *kg*
V	Volume, m^3
L	Length, *m*
w	Width, *m*
H	Height, *m*
D	Diameter

Abbreviations:

JOME	Jatropha oil Mythayl Ester
E20	20 % Ethanol
D	Diesel

Introduction

Energy is one of the major inputs for the economic development of any country. Crude Oil accounts for about 36 % of India's total energy consumption. India has spent more than Rs.1, 10,000 croer on oil imports at the end of 2004 [1]. The situation has led to the search for an alternative fuel, which should be not only sustainable but also environment friendly. For developing countries, fuels of bio-origin, such as alcohol, vegetable oils, biogas, synthetic fuels, etc. are becoming important for IC engines. The direct use of vegetable oils in fuel engines is problematic due to their high viscosity (about 11–17 times higher than diesel fuel) and low volatility, This leads to deposits of fuel injector [2].The experimental results of various researchers give support the use of biodiesel as a viable alternative to the diesel oil for use in the IC engines. The American Society for Testing and Materials (ASTM) defines biodiesel fuel as mono alkyl esters of long chain fatty acids derived from a renewable feed stock such as vegetable oil or animal fat [3]. The most abundant oil sources are Sal, Mahua, Neem, Pongamia and Jatropha oil. Based on extensive research, Jatropha and Pongamia have been identified as the potential feed stocks for biodiesel production in near future [4].Jatropha, a crop native to North American region is now distributed in several regions (Africa, India, South East Asia and China) across the World [5]. Jatropha curcas is a drought-resistant perennial, growing well in marginal/poor soil. Jatropha the wonder plant produces seeds with an oil content of 37%. Jatropha curcas is therefore becoming the future source of biodiesel for India [6]. The Materials compatibility is an important component of this research. The blending of renewable components, such as biodiesel or ethanol, into diesel fuel may impact the integrity and performance of various fuel system elastomers. Overall, for each elastomer type, the ethanol-containing fuel had the largest impact on elastomer properties after storage. Thus these elastomers may not be fully compatible in all applications with fuels containing 15% ethanol [7]. Biodiesel impact on the performance of elastomers in fuel system component. Includes fuel system O-rings and hose materials. Tests were performed at 100 C for 23, 670, and 1008 h followed by examination (% mass change, % volume change, % hardness change, tensile change, and elongation change) [8].

2. Experimental Work

Experiment was being conducted on the measurement of change in the physical properties of fuel pipe used in IC engine such as mass, volume, elongation, and hardness. These change in physical properties gained by measuring it before and after immersing test. For carrying out the immersion test, fuel pipe specimens (elastomer material) are preweighed and suspended using Teflon thread separately in various fuel like jatropha biodiesel [JOME], jatropha biodiesel+20%ethanol [JOME+E20], and un doped commercial plain diesel [D-6], In stopped measuring cylinders. These static immersion studies were carried out for a period of 60 days (1440hr) at ambient temperature 30^0C. During the test period the temperature variation was observed between 30 and 40 °C due to climatic changes. The engine part Fuel pipe (Hose material) was cut in to small pieces of size. Fuel pipe (hoses material) 30 mm x 4mm, Outer dia. 12.1 mm, Inner dia-7.7mm. The prepared specimens were then weighed up to an accuracy of ± 0.1mg before exposing in biodiesel, biodiesel blend, and commercial pure diesel. After completing one measurement test specimen was removed from fuel, quickly dipped in acetone, and blotted lightly with filter paper to remove excess oil from the surfaces to measure the other property.

2.1 Mass change

The mass change was done by weighing specimen in air before and after immersion in the selected fuel. This % change in mass was evaluated by following formula:

$$\% \text{ Mass change} = \frac{(M_2 - M_1)}{M_1} \times 100$$

2.2 Volume change

The volume change of specimen was performed by measuring its length, width, and height with the help of Vanier caliper before and after immersion in the selected fuel. The Venire Caliper is a precision instrument that can be used to measure internal and external distances extremely accurately. Volume of specimen is given by following formula:

$$\% \text{Volume change} = = \frac{\pi}{4}(D_0^2 - D_1^2)H$$

2.3 Elongation change

The elongation change of specimen was gained by measuring its length through Vanier caliper before and after immersion in the selected fuel. This change was evaluated by following formula:

$$\% \text{ Elongation change} = \frac{L_2 - L_1}{L_1} \times 100$$

2.4 Hardness change

The hardness change of the specimen was conducted by measuring its hardness according to (ASTM) D 2240-81 using a Shore before and after immersion in the selected fuel. Durometer Hardness was used to determine the relative hardness of soft materials, usually plastic or rubber. The test measures the penetration of a specified indent or into the material under specified conditions of force and time. The specimen was first placed on a hard flat surface. The indenter for the instrument was then pressed into the specimen making sure that it was parallel to the surface. The hardness was read within one second (or as specified by the customer) of firm contact with the specimen. The hardness numbers are derived from a scale. Shore A and Shore D hardness scales are common with the A scale being used for softer and the D scale being used for harder materials.

3. Result and Discussion

3.1 After Immersion Test Result for Fuel Pipe.

Fig-1: Immersion Test Results for fuel pipe Sample with plain Diesel.

Fig-3: Immersion Test Results for fuel pipe Sample with JOME+E20

Figures 1 to 3 indicate the effect of static immersion test on the changes in the physical properties of the fuel pipe material when immersed in selected fuel candidates for studying the material compatibility issues. The immersion tests were conducted for 1440 hours. Higher gain in mass indicates that the material has higher absorbing tendency for a particular fuel. This was observed for Jatropha biodiesel (JOME). Higher density of Jatropha biodiesel might also be the reason for the additional weight gain in fuel pipe component. Generally due to immersion of components, fuel absorption takes place and biodiesel has excellent solvent properties, biodiesel can dissolve elastomers. This ultimately results change in volume of components. The increase in volume in all the cases resulted as the extent of liquid absorption usually exceeds that of extraction. Elastomers that is stable in diesel (D-6). Higher change in length over that of before the test was observed in case of Jatropha biodiesel (JOME).This perhaps due to higher absorption of biodiesel in fuel pipe specimen. Higher fall in hardness was recorded in case of Jatropha biodiesel (JOME) followed by ethanol blended biodiesel. Higher gain in mass results in higher change in volume or length which ultimately results in higher fall in hardness value.

3.2 Determination of % Mass Change in fuel pipe

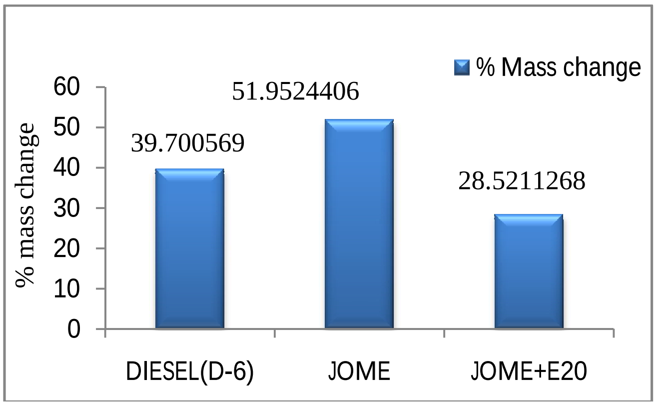

Chart-1: Effect of immersion test on % mass change for fuel pipe

Chart 1 shows the changes in mass of fuel pipe when immersed in Diesel (D-6), biodiesel and ethanol blended biodiesel. Higher gain in mass indicates that the material has higher absorbing tendency for a particular fuel. This was observed for Jatropha biodiesel. Higher density of Jatropha biodiesel might also be the reason for the additional weight gain in fuel pipe component. In the entire tested specimen, a gain in mass was observed. The gain in mass or increase in percentage of mass in case of ethanol blended biodiesel was minimum. This may be attributed to the fact that ethanol erodes some part of the fuel pipe material.

3.3 %Volume change in fuel pipe

Chart 2 shows the result of immersion test on % volume change of fuel pipe for Diesel (D-6), JOME, (JOME+E20) for duration of 1440hrs.

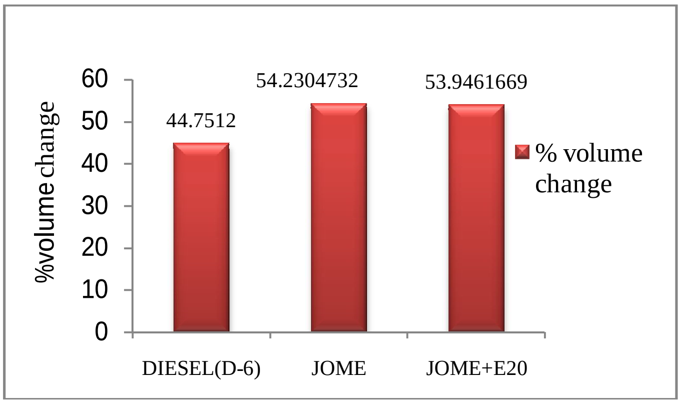

Chart-2: Effect of immersion test on % volume change for fuel pipe

Generally due to immersion of components, fuel absorption takes place and biodiesel has excellent solvent properties, biodiesel can dissolve elastomers [9]. It is a solvent that may attack some elastomer under specific condition. Elastomers that are stable in diesel (D-6) which ultimately results in swelling of components or change in volume of components. The increase in volume or swelling in all the cases resulted as the extent of liquid absorption usually exceeds that of extraction.

3.4 %Elongation of Change in fuel pipe

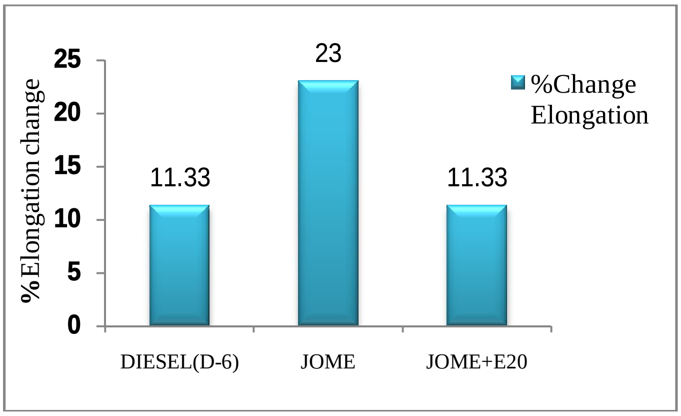

Chart-3: Effect of immersion test on % Elongation change for fuel pipe

Chart 3 shows that value of the elongation of fuel pipe material change in diesel (D-6), JOME, JOME+E20 that is increasing with increases in time from 24hrs to 1440hrs. Similar results were obtained with diesel (D-6) and ethanol blended biodiesel. However, higher change in length over that of before the test was observed in case of biodiesel. This perhaps due to higher absorption of biodiesel (% gain in mass) in fuel pipe specimen.

3.5 % Hardness change in fuel pipe

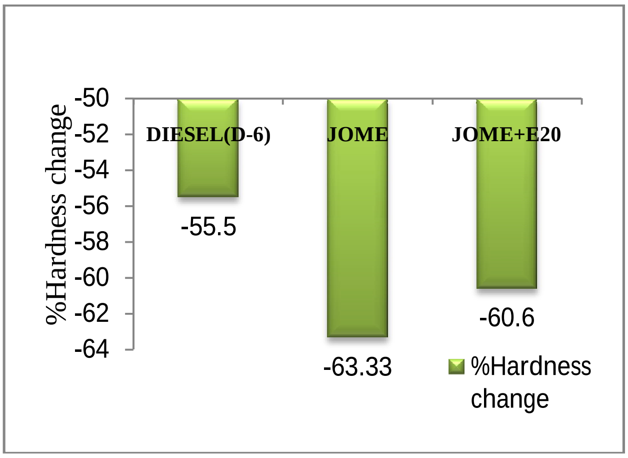

Chart 4: Effect of immersion test on % Hardness change of fuel pipe

Chart 4 shows the effect of immersion test on % change in hardness of fuel pipe when immersed with different selected fuels. Higher fall in hardness was recorded in case of biodiesel followed by ethanol blended biodiesel. These results of hardness were in tune with other results obtained for fuel pipe in terms of gain in mass and change in volume. Higher gain in mass results in higher change in volume which ultimately results in higher fall in hardness value.

4. Conclusion

In order to replace the diesel fuel with alternative fuel like biodiesel and its blends in the existing engine, an attempt was made to address the important issue of material compatibility of biodiesel. The Material component which was likely to get in touch with biodiesel and its blend in long run was selected and their compatibility with biodiesel and its blend was studied with reference to that of diesel.

Following conclusions can be drawn from the present work.

1. Physical properties of elastomers changes due to its excellent solvent properties.
2. It was observed that in the immersed elastomer sample, like fuel pipe there was net gain in mass, volume and elongation of this component. Amongst the selected fuel candidates, like plain diesel (D-6), JOME and JOME+E20 higher gain in mass volume and elongation in component was observed in case of Jatropha biodiesel (JOME). The gain in mass, volume and elongation in biodiesel over diesel in fuel pipe were 12.25 %, 9.47 % and 11.67 % respectively.
3. Thus it can be concluded that generally due to immersion of components, fuel absorption takes place which ultimately results in gain in mass, change in volume of components and ultimately increase in elongation.
4. It is a general belief that as the elongation increases (due to swelling etc) the hardness decreases. It was observed that in the immersed elastomer sample like fuel pipe there was net decrease in hardness value of this component when

immersed in selected fuels. The decrease in hardness in biodiesel over diesel in fuel pipe was 7.83%.

5. Thus it can be concluded that the changes occurring in the physical properties of all the components when immersed with biodiesel are within ± 10% as compared to that of diesel. The variation of 10 % change can be taken care of by suitably augmenting the properties of elastomers when it is to be used with 100 % biodiesel.
6. Thus in general it can be concluded that biodiesel can very well act as a substitute with diesel for CI engines. However certain improvements in the physical and structural properties of elastomers and metallic components need to be augmented marginally to ensure complete safety of the engine and hence the vehicle.

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