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EVALUATION OF FUEL PROPERTIES OF HYBRID BLENDS AS AN ALTERNATE FUEL FOR DIESEL ENGINES

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ABSTRACT

The fuel properties of diesel, anhydrous ethanol, refined soybean oil as well as their blend were evaluated to substitute the diesel fuel. The relative density, kinematic viscosity, caloric value, flash and fire point, ash content, carbon residue and acid values of renewable hybrid fuels were compared with diesel to assess their compatibility as an engine fuel. The fuel properties of hybrid fuel, i.e., blends of diesel-anhydrous ethanol-refined soybean oil were found to be close to that of diesel. It was observed that when higher level of refined soybean oil were blended with diesel and anhydrous ethanol, the deviation of the fuel properties from the diesel was more.

INTRODUCTION

The continuing hike in global prices of crude oil is reflecting an adverse impact on economy of many countries, especially the oil importing countries posing a severe burden on their foreign exchange. The rapid growth in petroleum consumption over the last three decades are due to robust GDP growth, urbanization, substantial increase in vehicular population and enhanced use of tractors and small diesel engines in agricultural sector. In order to have sustainable food production, industrial growth and pollution free environment emphasis is being laid on the development of renewable liquid fuels.

Non-conventional fuels such as methanol and ethanol have attracted considerable attention because of their clean burning properties, indigenous potential and versatility as renewable fuel. Several methods for converting plant oil into engine fuel have been evolved. Among them, the blending has given quite satisfactory results without involving major conversion techniques as well as low processing cost. Zubik et al (1984) observed that linseed oil, sunflower oil and jatropha oil having their kinematic viscosity could be lower. In the present study, blends of diesel, soybean oil and anhydrous ethanol were prepared and their fuel properties were compared with diesel.

MATERIALS AND METHODS

Hybrid blends of anhydrous ethanol, refined soybean oil and diesel were prepared by mixing them in several proportions. The blends, which did not show any sign of phase separation at the initial stage were kept for three months and their stability was noted by observing the phase separation, change in colour and homogeneity every week. Based on these observations, the final hybrid blends were selected for study. The fuel properties such as relative density, kinematic viscosity, heat content, flash and fire point, ash content, carbon residue and total acidity of these blends were analyzed. The relaive density at 15 C was determined in accordance with IS:1448[P:32}:1992. A redwood viscometer No.1 was used for the measurement of kinematic viscosity in centistokes was calculated from time units as proposed by Guthrie (1960). The caloric value or gross heat of combustion was determined as per IS 1448 [P: 6]: 1984

using an Isothermal Bomb Caloriemeter. A Pensky Martens Flash and Fire Point apparatus was use for measuring the flash and fire points of fuel samples as per IS: 1448[P: 21] 1992. The ash content was studied as per standard ASTM - D 482 - IP 4 issued by Institute of Petroleum (IP), London using an electric muffle furnace. Carbon residue of different fuels was determined by the method specified in ASTM -D 189 -IP 13 of IP. The acid values of different fuels were measured in terms of total acidity as per ASTM - D 974 -IP 1/6 4 of IP.

RESULTS AND DISCUSSION

Relative density

The relative density (RD) of refined soybean oil, anhydrous ethanol and diesel fuel were 0.922, 0.779 and 0.846 respectively. The RD of diesel - anhydrous ethanol (80:20) blend was 0.836. The hybrid fuels blends of diesel-refined soybean oil-anhydrous ethanol mixed in proportion of 70:10:20, 60:20:20, 50:30:20 and 40:40:20 were found to be 0.837, 0.581, 0.859 and 0.866 respectively and refined soybean oil-anhydrous ethanol blend (85:15) was having the Rd of 0.905. The observed values indicate that except refined soybean oil-anhydrous ethanol blend the RD of all blends were approximately close to diesel. Further, it was observed that the RD increased with the increase in proportion of refined soybean oil within the blend whereas an increase in the level of anhydrous ethanol reduced the RD of blends.

Kinematic viscosity

The kinematic viscosity (KV) of liquid fuel is an important characteristic as it determines the ease of flow through pipelines, injector nozzles and orifices and formation of fuel in the cylinder. The KV of refined soybean oil, anhydrous ethanol and diesel fuel was observed to be 37.15, 2.01 and 3.41 cS respectively. The KV of diesel-anhydrous ethanol blend (80:20) was found 2.63 cS. The KV of diesel-refined soybean oil-anhydrous ethanol mixed in proportion already defined was observed to be 3.01, 4.11, 4.98 and 6.50 cS, and blend of refined soybean oil-anhydrous ethanol (85:15) was found 18.77 cS respectively. The KV of soybean oil was found to be extremely high compared to diesel as well as all the blends of refined soybean oil and anhydrous ethanol. The refined soybean oil like other vegetable oils has higher KV due to its molecular composition and structure, increased carbon chain length and reduced number of double bonds compared to diesel (Goering et al, 1981). The KV within the blends increased as the percentage of refined oil increased in the blend. The IS: 1460 - 1974 recommends the range of KV of diesel from 2.0 to 7.5 cS for use in high-speed diesel engines.

Calorific value

The calorific value or heat of combustion of a fuel is an important measure. The observed gross heat of combustion of refined soybean oil, anhydrous ethanol and diesel was 42.54 MJ/kg, 30.11 MJ/kg and 49.12 MJ/kg respectively. The gross heat combustion of diesel-anhydrous ethanol blend (80:20) was found to be 46.71 MJ/kg. The hybrid fuels i.e. blends of diesel-refined soybean oil-anhydrous ethanol mixed in already defined proportion were found to be 45.11, 43.85, 43.65 and 42.51 MJ/kg respectively whereas the blend of refined soybean oil-anhydrous ethano; (85:15) showed gross heat combustion of 39.91 MJ/kg. The gross heat of combustion of refined soybean oil was less than that diesel and this could be attributed to the presence of few hydrogen atoms in the molecule (Goering et al, 1982). The gross heat combustion of diesel-refined soybean oil- anhydrous ethanol blends were found to be close to that of diesel.and diesel

Flash and fire point

Flash point measures the tendency of the sample to form a flammability mixture with air. Flash point can indicate the possible presence of highly volatile and flammable material in relatively non-volatile material. The fire point is an extension of flash point in a way that it reflects the condition at which vapour burns continuously for five seconds. The flash point of refined soybean oil, anhydrous ethanol and diesel fuel was 28.4, 12.2 and 54.0 C respectively. The flash point of diesel- anhydrous ethanol blend (80:20) was found to be 31 C. The flash point of hybrid fuels i.e. blends of diesel-refined soybean oil-anhydrous ethanol mixed in previous proportion was found to be 33, 33, 34 and 34 C respectively whereas the blend of refined soybean oil-anhydrous ethanol; (85:15) showed flash point 35 C. The flash point of refined soybean oil was observed to be much higher than that of diesel. The hybrid fuel blends were found to have 20 C less than that of diesel. The drop is due to presence of anhydrous ethanol in the blend.

Ash content

Ash content of the material provides the information on whether the product is suitable for use as fuel, because ash is responsible for wear of engine parts especially piston and cylinder linear. The percent ash content of refined soybean oil and diesel was 0.0173 and 0.0005 respectively. The ash content of diesel-anhydrous ethanol blend (80:20) was found to be 0.0004%. The percent ash content of hybrid fuels i.e. blends of diesel-refined soybean oil-anhydrous ethanol mixed in previous proportion was found to be 0.0022, 0.0038, 0.0054 and 0.0071% respectively whereas the same in the blend of refined soybean oil-anhydrous ethanol; (85:15) was found to be 0.0147%. The ash content of soybean refined oil was observed to be 35 times higher than that of diesel. The increase in ash content may be attributed to long chain of hydrocarbon of fatty acids. The ash content of all the blends except the blend having refined soybean oil -anhydrous ethanol (85:15) was found in the range of (0.01 max.) of ash content specified by the IS: 1460:1974.

Carbon residue

The carbon residue (CR) of diesel fuel correlates with the amount of carbonaceous deposits of the fuel formed in the combustion chamber of the engine. The higher the CR value, the greater the expected carbon deposits in the combustion chamber. The CR of diesel and refined soybean oil was found 0.171 and 7.31% respectively. The CR content of diesel-anhydrous ethanol blend (80:20) was found to be 0.129%. The CR content of hybrid fuels i.e. blends of diesel-refined soybean oil-anhydrous ethanol mixed in previous proportion was found to be 0.0836, 1.449, 2.252 and 3.127% respectively whereas the same in the blend of refined soybean oil-anhydrous ethanol; (85:15) was found to be 6.869%. Forty thee times higher CR content was observed in refined soybean oil than that of diesel fuel.

Total acidity

Petroleum products may contain acidic constituents present as additives or as depleting oxidation products found during service. The acid value can be used as a guide in quality control of fuels. The observed acid value of refined soybean oil and diesel fuel was 0.532 and 0.221 mg of KOH/g respectively. The acid value of diesel-anhydrous ethanol blend (80:20) was found to be 0.177 mg of KOH/g %. The acid values of hybrid fuels i.e. blends of diesel-refined soybean oil-anhydrous ethanol mixed in predefined proportion was found to be 0.219, 0.236, 0.283 and 0.306 mg of KOH/g respectively whereas the same in the blend of refined soybean oil-anhydrous ethanol; (85:15) showed percent acid value of 0.449 mg of KOH/g. It was evident that the acid values of different blends of were in the range of 0.50 mg of KOH/g recommended for diesel fuel by IS:1460:1974.

The RD, KV, CV, flash and fire point, ash content, CR and acid values of different fuel samples are presented in Table 1.

Hybrid fuel prepared by blending diesel, refined soybean oil and anhydrous ethanol brought the fuel properties close to that of diesel. On the basis of observation, it was found that the hybrid fuel containing anhydrous ethanol up to 20% level and refined soybean oil up to 40% level had their properties compatible with diesel.

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Table 1. Fuel Properties of Hybrid Fuel Blends

Fuel properties	Diesel	Anhydrous ethanol (2000 proof)	Refined soybean oil	Diesel-anhydrous ethanol blend	Diesel-refined oil-anhydrous ethanol blends				Refined soybean oil-anhydrous ethanol blend
				80:20	70:10:20	60:20:20	50:30:20	40:40:20	85:15
Relative density at 15 C	0.846	0.779	0.922	0.836	0.837	0.851	0.859	0.866	0.905
Kinematic viscosity at 38 C (cS)	3.41	2.01	37.15	2.63	3.01	4.11	4.98	6.50	18.77
Heat of combustion (MJ/kg)	49.12	30.11	42.54	46.71	45.11	43.85	43.65	42.51	39.91
Flash point(C)	54	12.2	284	31	33	33	34	34	35
Fire point(C)	59	18.5	290	35	36	37	38	38	38
Ash content(%)	0.0005	-	0.0173	0.0004	0.0022	0.0038	0.0054	0.0071	0.0147
Carbon residue(%)	0.171	-	7.31	0.129	0.836	1.449	2.252	3.127	6.869
Total acidity(mg of KOH/g)	0.221	-	0.532	0.177	0.219	0.236	0.283	0.306	0.449