Study of Fuel Properties of Diesel Biodiesel Blend with Nano-Particles as Additives

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Abstract - A number of studies currently focus on the renewable fuels to reduce the reliance on petroleum fuels. Bio fuels such as ethanol and biodiesel have been studied and tested in many countries including India. One of the methods to reduce the use of fossil fuel is blending biodiesel with fossil diesel. Madhuca Indica (MI) offers an alternative application as a blended fuel for diesel. The present work is aimed to investigate experimentally the physic-chemical properties of biodiesel-diesel blend with nano-particles as additives and compared with that of diesel fuel. Aluminium oxide (Al2O3) is used as an additive; 50ppm and 100ppm of nano-particles were added. We studied the fuel properties such as density, viscosity, heat of combustion, flash point; it was found that the fuel properties of fuel blends were close to the standard values of diesel fuel. However, the flash point of the blends was quite similar as that of the diesel fuel. The heating values of the blends are around 41500 Kcal/kg, where as for pure diesel 42000 Kcal/kg. The density and viscosity of the blend is almost same as that of the diesel fuel.

Key Words: Madhuca indica, biodiesel, nano-particles, physic-chemical properties.

1. INTRODUCTION

For the past few decades, a lot of effort has been made to reduce the dependency on petroleum fuels for power generation and transportation all over the world. Among the proposed alternative fuels, biodiesel and alcohols have received much attention in recent years for diesel engines and could be one remedy in many countries to reduce their oil imports [S.A.Sahir 2014]. Biodiesel and alcohol have many advantages over regular diesel as renewable and domestically produced energy resources. Moreover, they are recognised as environmentally friendly alternative fuels [IstvanBarbas 2010]. Biodiesel can be used as a supplementary fuel in diesel engines and it will be implemented in automotive fleets and power genset diesel engines in near future in our country; however it is the major problem for use of biodiesel blends in unmodified or in-use engines, which can be overcome by modifying the fuel quality. Biodiesel is an alkyl ester of fatty acids made from a wide range of vegetable oils, animal fat and used cooking oil by the transesterification process. The researchers [K.A.Subramanian,et al 2014] have worked on the production of biodiesel from non edible feed stock,

Spirulinaplatensis algae biomass. The biodiesel can be considered as an alternative for compression ignition engines, but some of its properties (density, viscosity) are incompetent with diesel fuel. The biodiesel used is mahuva biodiesel; scientifically it is called as madhuca indica. It is abundantly available in the northern part of India. The seeds of madhuca indica are used to produce biodiesel by the transesterification process. The fractional replacement of the fossil diesel fuel with the combination of biodiesel nano particles as an additives in compression ignition engines found to be successful as this blend has similar fuel properties like the commercial diesel fuel. Many scientists and investigators have studied this blend with different biodiesels and proportions of diesel, biodiesel and nano particles to study its suitability as a fuel in the existing CI engines.[Avinash Kumar 2007].

Fangsuwannarak and Triratanasirichai [50] prepared the blends of palm oil biodiesel by increasing concentration from 2–100% in diesel and then added nano-TiO2 with dosing concentration of 0.1% and 0.2% by volume and tested the physical properties of fuel samples using ASTM standard procedure. They observed that kinematic viscosity was reduced by increasing concentration of nano-TiO2 as compared to without additive. However, the calorific value was increased with increasing concentration of additives. Arockiasamy and Anand used 30 ppm cerium oxide and alumina nano particles additive separately in jatropha biodiesel to prepare blend for testing properties and found that slightly increase in viscosity with the addition of both nano-particles in jatropha biodiesel. They also observed that reduction in calorific value and flash point as compared to neat biodiesel.

It is evident that the addition of nano-particles to diesel and biofuel has a significant effect on the ignition and combustion behavior. Risha et al. investigated the combustion behavior of nano-aluminum and liquid water, characterized without the use of any gelling agent for a broad range of pressures, mixture compositions, and particle sizes. Ignition delay and ignition temperature are critical parameters that characterize the performance of a diesel engine. Both efficiency as well as the emission levels from a diesel engine can potentially be improved by optimizing the ignition delay and ignition temperature. Tyagi et al. attempted to improve the ignition properties of diesel fuel by investigating the influence of adding nano-

particles to diesel. They concluded that the addition of nano-particles to the fuel caused significant improvements in its radiative and heat/mass transfer properties, and hence, the droplets ignited at a much lower temperature compared to pure diesel. The application of nano-particles in the combustion system was also reviewed. Gan and Qiao investigated the combustion characteristics of fuel droplets with the addition of nano and micron-sized aluminum particles.

2. RELATED WORK

The properties of the diesel-biodiesel blends with nano-particles mixtures were investigated using commercial diesel fuel, Madhuca indica biodiesel and Aluminium oxide as a nano particle of purity 99.9%. The blends were obtained by mixing diesel, biodiesel and nanoparticle by (v/v %).

The blends were prepared in two steps: First nano particles were immersed with biodiesel to prepare a homogeneous mixture and then diesel was added to the mixture. All the three components were mixed in to a homogeneous mixture by a magnetic stirrer, and then the final blend was kept in a glass bottle with screw cap for observing the physical appearance. Laboratory tests were then carried out using ASTM test standards to determine the following properties: density, viscosity, gross heating value, flash point. The fuel properties were determined for pure diesel fuel (D), pure Madhuca India biodiesel (MI), diesel 80% biodiesel 20% (MI20D80), and for mixture of nanoparticles with 50 and 100 ppm. (MI20D80A50), (MI20D80A100). The results were indicated by bar charts.

3. EXPERIMENTAL RESULTS

Effect of nano additives on fuel properties are presented here. Density and kinematic viscosity of nano emulsion fuels increased marginally probably due to the presence of water.

Table -1: Fuel Properties

Sl No	Fuel	Viscosity	Density	Flash Point	Calorific value
1	Diesel	3.2	816	58	42,000
2	MI	4.9	870	138	39,960
3	MI20D80	3.4	826	75	41,600
4	MI20D80A50	3.38	826	71	41,665
5	MI20D80A100	3.33	829	65	41,670

No significant effect on properties like density, viscosity and flash point was observed with the addition of Aluminium oxide nano-particles in diesel– Madhuca indica biodiesel blends.Table1 shows the fuel properties.

3.1 Density

Density is very important property of any fuel which affects the engine performance characteristics directly. Other properties like cetane number and heating value are also associated with density. Fuel atomization efficiency and combustion characteristics are influenced by its density. The variation of fuel density will affect the output power of the engine due to altered mass of the injected fuel. Generally higher density causes greater fuel flow resistance which results in higher viscosity which may lead to inferior fuel injection. [Alan C.Hansen. et al 2012]. Fig 3.1 shows the densities. The density of the Madhuca indic biodiesel was too high as compared with diesel fuel but the densities of blends were almost same as that of diesel fuel; the density of the mixture with 100ppm of nano-particle is slightly higher than the diesel fuel this may be due to weight of nano-particles. The densities of D, MI, MI20D80, MI20D80A50 and MI20D80A100 are 815, 870, 825, 825 and 830 kg/m3 respectively.
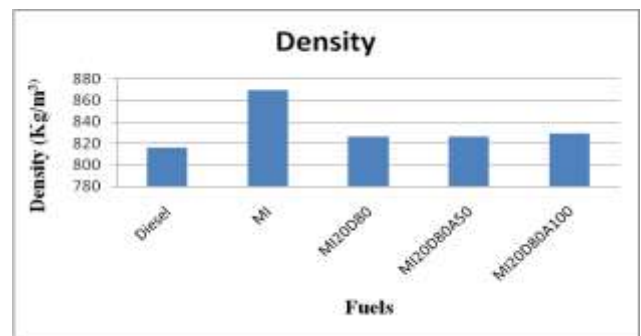

Figure -1: Density of the samples

3.2. Kinematic Viscosity:

Viscosity is very important fuel property. It affects the fuel drop size, the jet penetration, quality of atomization, spray characteristics and the combustion quality. The operations of the injection systems in CI engines are also affected by viscosity [Barbas I, et al]. For every engine there is highest and lowest limit for the viscosity of a fuel for that engine. If very low viscous fuel is used, it could cause the fuel system leakage.
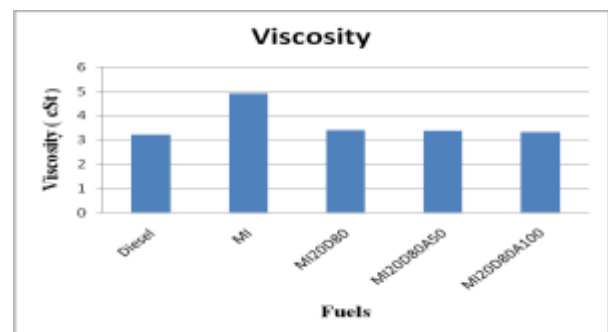

Figure -2: Kinematic Viscosity of the samples

On the other hand high viscosity of the fuel can cause, poor fuel atomization and incomplete combustion, increasing the engine deposits, requiring more energy to pump the fuel and causing the more problems in cold weather.

The viscosities of D, MI, MI20D80, MI20D80A50 and MI20D80A100 are 3.2, 5.8, 3.4, 3.4, and 3.4 cSt respectively. Hence the viscosity of the blends was same as diesel fuel.

3.3 Gross calorific values:

Gross heat of combustion or calorific value of the ternary blend sample was determined by the adiabatic bomb calorimeter with Sl.no: 318062700 make MAC, using IS: 1448 PART-6 test standards. This instrument consists of: the bomb, the container of the water in which the bomb is placed and a surrounding compartment of temperature controlled water. A known mass of the ternary blend sample was taken in clean crucible. The crucible was then supported over the ring. A fine magnesium wire, touching the fuel sample, was stretched across the electrode. A cotton thread was made to attach with the magnesium wire and touches the fuel sample. The bomb lid was tightly screwed and bomb was filled with oxygen to about 20-25 atmospheric pressure. The bomb was then lowered in to copper calorimeter, containing a known mass of water. Electrical circuit is completed by connecting the electrodes to a 6-volt battery and stirring of the water was also started. Due to burning of the sample, heat is liberated. Uniform stirring of the water was continued and maximum temperature attained recorded. The heating values of D, MI, MI20D80, MI20D80A50 and MI20D80A100 are 42000, 40000, 41500, 41700 and 41800 Kcal/kg respectively.
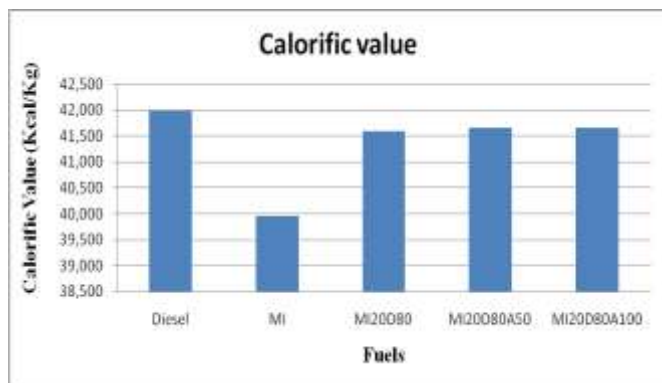

Figure -3: Gross calorific value of samples fuels

3.4. Flash Point

Flash point gives an estimation of the temperature at which the vapour pressure reaches the lower flammable limit. It does not affect the combustion directly. High flash point of fuel makes it safer regarding its handling, transportation and storage. D, MI, MI20D80, MI20D80A50 and MI20D80A100 are 58, 138, 78, 75 and 62 respectively. It shows that the blends with additives have similar flash point as of diesel fuel.
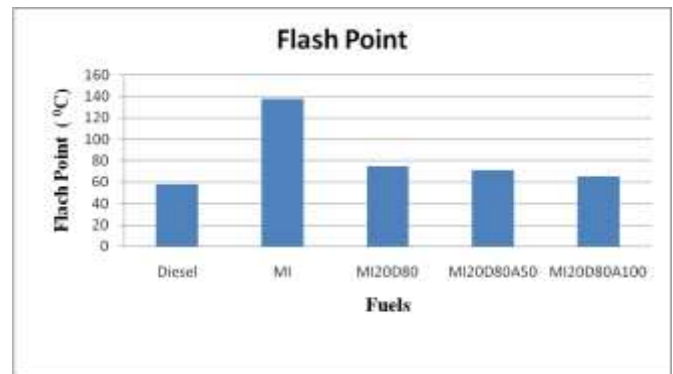

Figure -4: Flash point of sample fuels

3. CONCLUSIONS

Fallowing conclusions can be drawn out:

1. The density of the blended fuels with nano-particle additives have almost same as that of pure diesel fuel.

2. the viscosity of the blends with nano-particles have same values as that of the diesel fuel.

3. The calorific values of the blends with additives have slightly lower than that of diesel fuel.

4. The flash points of the blends with nano-particles have slightly higher values than pure diesel fuel. The lower the flash points higher the risk of storage and transportation.

5. The physical and chemical properties of the blend fuels were more or less same as that of the diesel fossil fuel, hence this fuel can be effectively used as an alternative fuels for compression ignition engines.

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