Research Article

Application of Biodiesel in Metalworking Fluids as a substitute for Petroleum Solvent

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ABSTRACT

Petroleum solvents such as diesel and turpentine are conventionally being used for metalworking cleaning and storing processed metals in metal working industries. This adds to the existing pressure on fossil fuels and also, is not environmentally viable. Thus, an alternative must be found. The study aims at proving that Biodiesel can be a better alternative to petroleum solvents for metal cleaning and storing. Considering the application as a metalworking fluid, the following properties of Fatty Acid Methyl Ester (Biodiesel) and a petroleum solvent (Diesel) like Viscosity, Flash Point, Sulphur content, Solubility in all types oils and Anti-Corrosive action. It was found that the properties of Biodiesel were similar or more favourable to that of Diesel and thus, is a better metal cleaner and storing fluid.

Keywords: Biodiesel, Diesel, anti-corrosion, solvent, ethyl ester, transesterification, edible oil.

INTRODUCTION

The biodiesel industry has steadily grown over the past decade, with commercial production facilities from coast to coast[1]. The industry reached a key milestone in 2011 when it crossed the billion gallon production mark for the first time. It repeated that in 2012 with more than 1.1 billion gallons and set a new record in 2013 by producing nearly 1.8 billion gallons (according to EPA figures). Biodiesel qualifies for both the biomass-based diesel category and the advanced biofuel category by achieving a life-cycle Greenhouse Gas (GHG) emissions-reduction and reduces greenhouse gas emissions by 57 percent to 86 percent (Renewable Fuels Standard, EPA statistics). It is the only alternative fuel to have fully completed the health effects testing requirements of the Clean Air Act. There is extensive research going on for using Biodiesel as a fuel, but, as of now, due to many drawbacks like economic viability[2], availability of raw materials and processing issues, Biodiesel has yet not been established completely as a fuel[3,4]. Thus, apart from its application as fuel, Biodiesel, because of its unique properties, can also be explored for other applications: we have worked on one such application, which is, using biodiesel as a cleaning solvent for cleaning and preservation of processed metals[5-7].

In metal working industries, after processes like grinding, cutting and lapping of metallic parts, the finish products have a layer of waste oil, coolant and metallic dust on them. They have to be washed before moving further to packaging. The fluid with which they are washed should also have an anti-corrosive property to prevent the metal from corrosion during storage.[8-10]

A metal cleaning and storage liquid must have the following properties[5,7] like Low Viscosity, High Flash Point, Low Sulphur content, High solubility in all types oils and Anti-Corrosive action. Petroleum based solvents like Diesel and Mineral Turpentine Oil are presently being used widely for this purposes[11]. These petroleum based solvents have their own disadvantages and limitations like volatility and environmental hazards[12]. In our research we have analysed the various aspects of using Biodiesel as a metalworking fluid as an alternative to petroleum solvents.

MATERIALS AND METHODS

A test sample of Biodiesel (Palm Oil Fatty Acid Methyl Ester) and a test sample of Diesel were taken and both were compared on the bases of the above mentioned properties. Viscosity of both diesel and biodiesel was checked using Redwood Viscometer over a range of temperatures. The procedure for determination of Viscosity; filtered oil was poured into the cylinder up to the tip level mark and water jacket was filled with water up to the level mark and a thermometer was placed into the oil cylinder to measure the temperature of the oil. Then, the water was stirred continuously to maintain steady state temperature of the oil. Temperature was raised gradually by using electric heater and when the temperature reached a particular level, the ball valve was lifted up and oil was allowed to drop into a collecting flask. Time taken for 50 cc of oil in the collecting flask was noted down with the help of stopwatch. The procedure was repeated for various temperatures of 10 °C, 20 °C, 30 °C, 40 °C, 50 °C, 60 °C, and 70 °C. Redwood Viscometer determines the viscosity in terms of seconds, a time taken by oil to pass through a standard orifice and collection of the same oil in 50cc flask.[13,14]

Flash point of both Diesel and Biodiesel were checked using a Pensky-Martens Closed Flash Point Analyser. In the Pensky-Martens Closed Cup Flash Point test, a brass test cup is filled with a test specimen and fitted with a cover. The sample is heated and stirred at specified rates depending on the material that is being tested and ignition source is directed into the cup at regular intervals with simultaneous interruption of stirring until a flash that spreads throughout the inside of the cup is seen. The corresponding temperature is its flash point.[15,16] Sulphur Content of both diesel and biodiesel was checked using a "TEKNIK DIGITAL" Nephelometer. In the instrument, suspended particulate of sulfur were measured by employing a light beam and a light detector set to 90 degree of the source beam. Particle density is then a function of the light reflected into the detector from the particles.[17,18]

Solutions of castor oil with biodiesel and diesel were made of the following varying concentrations to check solubility and miscibility.[5,6] Two identical cylinders were taken in each cylinder 10 ml of Castor Oil was added. In one of the cylinder 90 ml of Biodiesel was added and other was permeated with 90 ml of Diesel. The first solution was having 10 percent of Castor Oil and 90 percent of Biodiesel or Diesel, second solution contained 20 percent of Castor Oil and 80 percent of Biodiesel. The subsequent solutions were made with ratio of Castor Oil to Diesel or Biodiesel increasing by 10 percent. Thus, the last that is the fifth solution had 50 percent Castor Oil and 50 percent Biodiesel or Diesel. Three freshly prepared pieces of iron were taken. One was dipped in diesel, other was dipped in biodiesel and the third one was left as it is as a control. The amount of rusting on all the three was observed after twenty days.[5,19]

RESULTS AND DISCUSSION

The Viscosity of a fluid plays a major role in determining its cleaning activity. Lesser the viscosity, better is the cleaning property. In Fig.1, it is seen that the viscosity of Biodiesel is not significantly higher than that of diesel. Thus, Biodiesel is as suitable for cleaning purposes as diesel. In metal working industries, which involve working with high temperatures and friction, usage of volatile fluids is hazardous. Biodiesel is non-volatile as it is comprises of Fatty acid methyl ester which has an intrinsic property of non-volatility, whereas diesel is highly volatile at room temperature, which may cause to high problems while dealing in high temperature conditions in the industry. The results of the experiments carried out to estimate the flash point of both biodiesel and diesel, showed that Flash point of Biodiesel, that is (64 C or 147°F), is significantly higher than that of Diesel, that is (>130°C or >266 F), which makes Biodiesel safer to store, transport and use.

Sulfur causes adverse environmental effects and should be avoided as much as possible. The experimental results, clearly depict that the Sulphur content of Diesel is very high, approximately 495 ppm, but is negligible in Biodiesel. This makes Biodiesel preferable and eco-friendly. The solubility of both Diesel and Biodiesel was checked. The results are shown below in Table No.1. Freshly prepared metal pieces might have coatings of unwanted oil and metal dust on them. In order to remove this dirt oil, we need a solvent that can dissolve these oils and hence remove them from the surface. From the results of Table No.1, it is evident that biodiesel is a better solvent for such processes and provides clear solutions when mixed with castor oil. After testing the action of anti-corrosion of both Biodiesel and Diesel, it is clear that the metal piece dipped in diesel has more rusting than the metal piece dipped in biodiesel as seen in Fig.2. Hence, Biodiesel has better anti corrosive property and is more suitable than diesel.

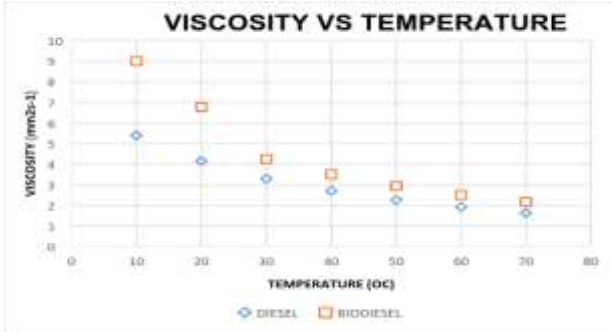

Figure 1: Viscosity Vs Temperature curve comparative study of Diesel and Biodiesel.

Table 1: Comparison of Solution of Castor Oil with Biodiesel and Diesel in the Different Ratios

Diesel/Biodiesel: castor oil ratio	Solution in Biodiesel	Solution in Diesel
90:10	Clear	Clear
80:20	Clear	Slightly hazy
70:30	Clear	Hazy
60:40	Clear	Turbid
50:50	Clear	Separation after some time

Figure 2: Comparison of anti-corrosive action of diesel, biodiesel and control.

CONCLUSION

The comparative studies carried out based on the various characteristics of Biodiesel and Diesel keeping in mind their application as a metal cleaning and storing liquid, the following conclusion can be made: Biodiesel (i) Has viscosity similar to that of diesel (ii) Has Flash point significantly greater than Diesel (iii) Is not Volatile like Diesel (iv) Has significantly less Sulfur content than Diesel (v) Is a better for other oils (vi) Has better anti-corrosive property than Diesel. Thus, compared to Diesel, Biodiesel is more suitable for the application as it is more economical, efficient and eco-friendly.

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