ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume XI (XXI), 2012, NR1

INFLUENCES OF BIODIESEL BLENDS COLD FLOW PROPERTIES ON DIESEL ENGINES

Tutunea Dragos
University of Craiova
dragostutunea@yahoo.com

Keywords: blend, diesel, biodiesel, flow properties, viscosity, density.

Abstract: Diesel fuels composition and cold flow properties vary greatly across the European Union. Cold flow characteristics of diesel fuels are influenced by the source of the crude oil they are made from, how they are refined and if they are blended to improve performance during cold weather. The cold temperature properties of biodiesel blends vary across the country depending on the time of year the fuel is produced and the climate. In this study, the density, and viscosity of biodiesel-diesel fuel blends were measured. In order to predict these properties, mixing rule was evaluated as a function of the volume fraction of biodiesel in the blend. For the experiments were used four types of biodiesel. The results of the experimentation show that biodiesel blends with lower biodiesel content can be a suitable option for use in automotive fuel systems in cold weather conditions.

1. INTRODUCTION

The depleting reserves of fossil fuel, increasing demands for diesels and uncertainty in their availability is considered to be the important trigger for many initiatives to search for the alternative source of energy, which can supplement or replace fossil fuels [10]. The first use of vegetable oil in a compression ignition engine was first demonstrated through Rudolph Diesel who used peanut oil in his diesel engine. The use of oils from coconut, soy bean, sunflower, safflower, peanut, linseed, rape seed and palm oil amongst others have been attempted. [5,11]. The source of Biodiesel usually depends on the crops amenable to the regional climate. In the United States, soybean oil is the most commonly Biodiesel feedstock, whereas the rapeseed (canola) oil and palm oil are the most common source for Biodiesel, in Europe, and in tropical countries respectively [7]. Biodiesel fuel can be defined as medium length (C16± C18) chains of fatty acids, and is comprised mainly of mono-alkyl fatty acid esters. Biodiesel fuel has the benefits of being non-toxic, biodegradable and essentially free of sulphur and carcinogenic ring components [14]. When using biodiesel in unmodified diesel engines, one issue that needs to be addressed is that biodiesel fuels have different properties from petroleum diesel. Biodiesel, produced from vegetable oil or animal fats, generally has higher density, higher viscosity, higher cloud point and higher cetane number, and lower volatility and heating value compared to commercial grades of diesel fuel [9]. While much research has been conducted on blends of 2–20% biodiesel in diesel to overcome problems related to low-temperature operability, little research has been conducted on mixtures containing 80% (B80) and 90% (B90) biodiesel, intended as formulations to transport and mix the biodiesel in cold weather. Engine manufacturers have raised concerns about some of these properties as they may affect the engine performance and emissions since the engines were originally optimized with petroleum diesel [15]. The fuel properties of biodiesel must meet ASTM D-6751 and EN 14214 specifications in USA and Europe. The Engine Manufacturers Association (EMA) reported that biodiesel blends up to 5% should not cause engine and fuel system problems (EMA, 2003). Blends of up to 20% biodiesel mixed with petroleum diesel fuels can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. Hence the warranty on most new engines only allows a maximum of B20 (20 vol. % biodiesel and 80 vol. % petroleum diesel) to be used [12]. As the fuel properties of biodiesel differ from those of diesel fuels, the different engine performance and emissions will occur when biodiesel is used in diesel engines. The cold flow properties of biodiesel fuels are dependant on the feedstock (specific type of oil, fat or grease) from which they are made and are a strong function of the level of saturated fat. Animal fats, palm and coconut oils are more highly saturated - higher CN, higher cloud point [3].

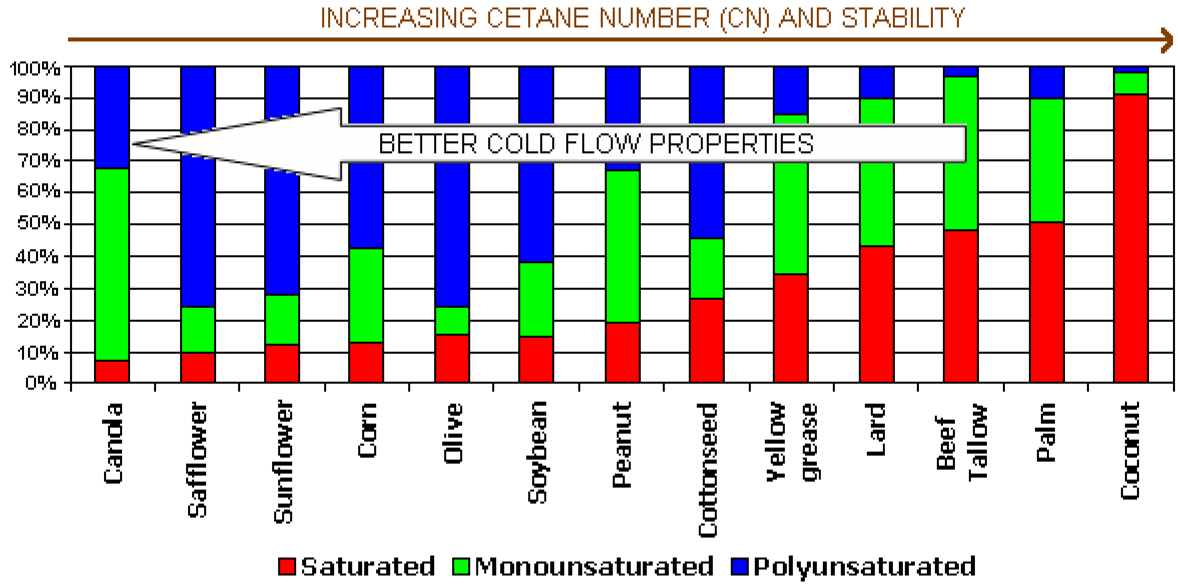

Fig. 1 Relation between composition of vegetable oil and cold flow properties [3]

Therefore, more investigations are needed about the fuel properties of biodiesel and their blends with diesel fuels before using them in a diesel engine. The objectives of this study are to investigate the relationships between some of the basic flow properties of biodiesel and their blends with diesel fuel as a function of fuel temperature.

2. METHODS AND MATERIALS

Diesel fuel was purchased from a local gas station of Craiova on 5th March 2012. Biodiesel of fish oil was purchased from Biomotor Prod. of Deveselu Olt. The biodiesel of rapeseed and sunflower oil was produced in the laboratory of Thermodynamics and Thermal Machines of Faculty of Mechanics of Craiova through methanol route. Density bottle was used to measure the density of the biodiesel, diesel fuel and their blends. The measurements were taken at 15°C. The biodiesel and the blends were cooled and measurements taken with the density bottle when their temperatures reached 15°C. The tests were conducted three times and the average results recorded. Kinematic viscosity was determined using Ubbelohde glass capillary kinematic viscometer in a constant temperature water bath according to the standard method. Three measurements were taken for each fuel sample and the average results recorded.

3. RESULTS AND DISCUSSION

In a diesel engine, the liquid fuel is sprayed into compressed air and atomized into small drops near to the nozzle exit. The liquid fuel, usually, forms a coneshaped spray at the nozzle exit and its viscosity affects the atomization quality, size of fuel drop and penetration [1]. Fuels with high viscosity tend to form larger droplets on injection which can cause poor fuel atomization during the spray, increases the engine deposits, needs more energy to pump the fuel and wears fuel pump elements and injectors. High viscosity also causes more problems in cold weather, because viscosity increases with decreasing temperature [6]. Kinematic viscosity (at 40 °C) is the parameter required by biodiesel and petrodiesel standards. However, the data in the literature vary not only by dynamic vs. kinematic viscosity but also by temperature with some data being not obtained at 40 °C. Kinematic viscosity at 40 °C is limited to 3.5-5.0 mm²/s in the European biodiesel standard norms. The American specifications allow a broader range of values (1.9-6.0 mm²/s). The corresponding limits for petrodiesel fuel is considerably lower (2.0 - 4.5) [8].

Figure 2 shows the viscosity curve for pure biodiesels and its blends. As can be seen in this figure, the curves show that biodiesel of palm presents a higher value than the other biodiesel blends. The viscosity increases with the increase in biodiesel content in the mixture. In Fig. 3 the biodiesel curves show a similar trend for temperature variation and the curves are almost identical as shape with the curve of diesel fuel.

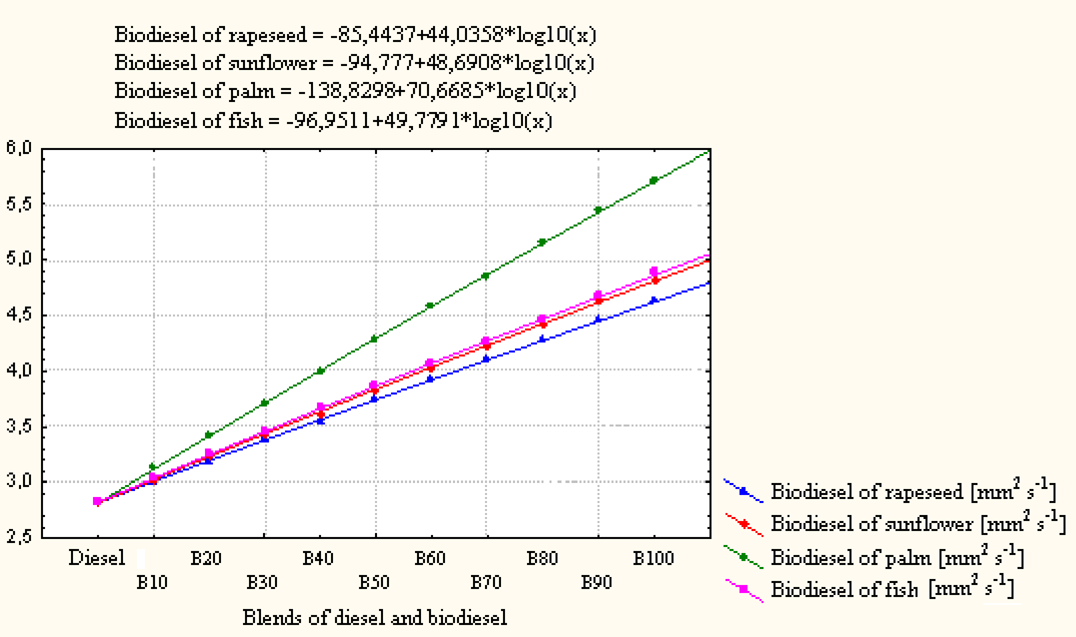

Fig. 2 Viscosity of different blends of biodiesel and diesel

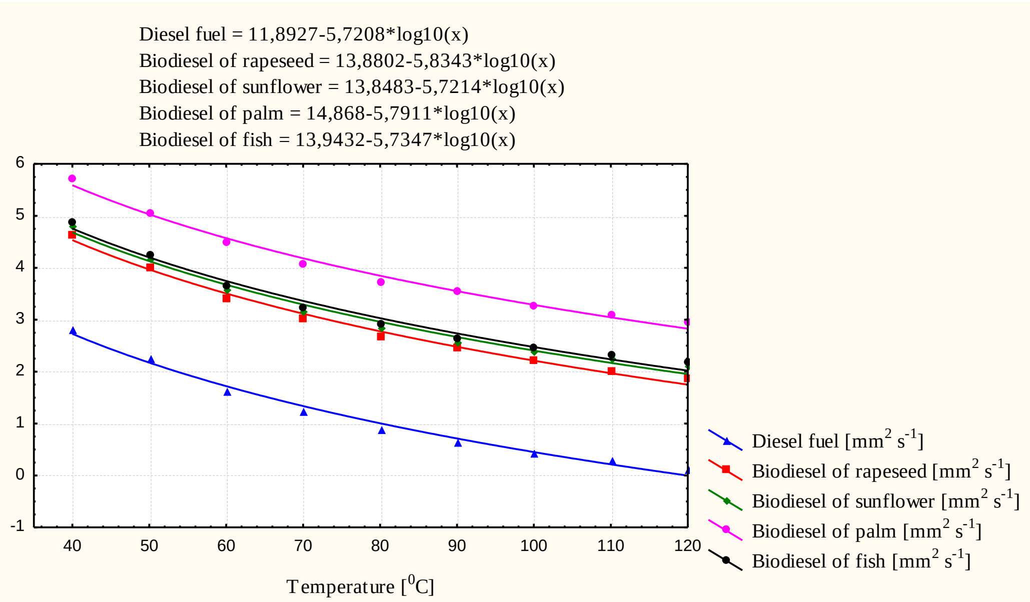

Fig. 3 Variation of viscosity function of temperature for different blends of biodiesel and diesel

Density is a key fuel property, which directly affects the engine performance characteristics. Many performance characteristics, such as cetane number and heating value, are related to the density [13]. Fuel density affects the mass of fuel injected into the combustion chamber and thus, the air-fuel ratio. This is because fuel injection pumps meter fuel by volume not by mass and a denser fuel contains a greater mass in the same volume. Thus, the changes in the fuel density will influence engine output power due to a different mass of fuel injected [1]. Density limits in the European EN norm are in the range of 0,860-0,900 g/cm³.

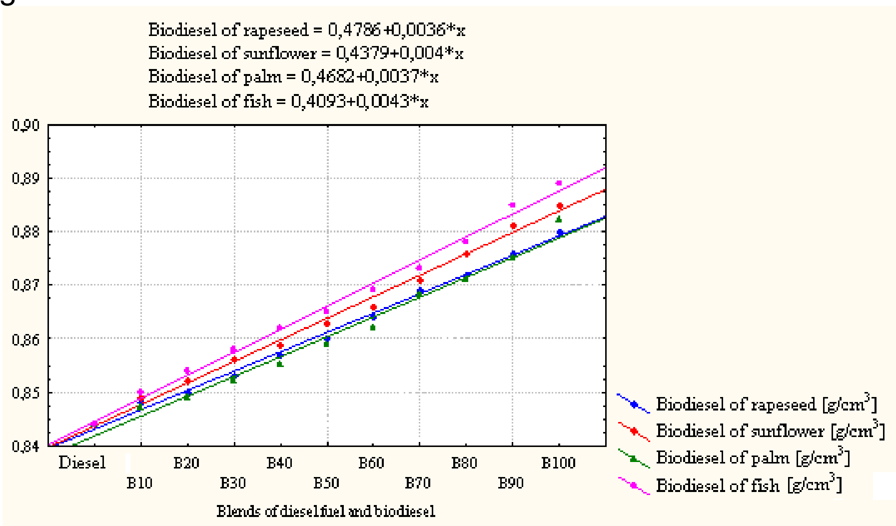

Fig. 4 Density of different blends of biodiesel and diesel

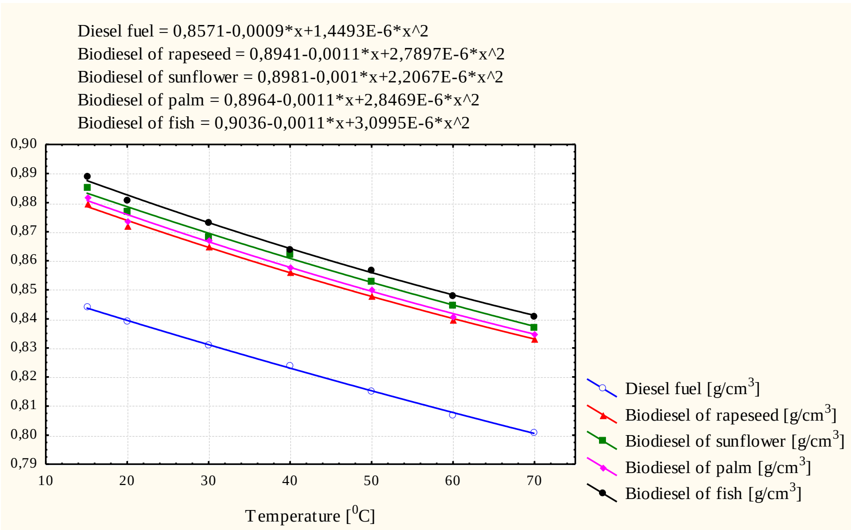

Fig. 5 Variation of density function of temperature for different blends of biodiesel and diesel

The density of the blend up to 20% biodiesel shows close matched points with diesel fuel which decrease with the increase in biodiesel content (Fig. 4). The density of the blend approaches that of diesel fuel as the biodiesel content decreases in the blend.

The measured density as a function of temperature for the pure biodiesel (rapeseed, sunflower, palm and fish) diesel and their blends are shown in Fig. 5. In the figure, the points show the measured values while the lines are linear least square regression lines. In the temperature range studied, the biodiesel fuel and its blends with diesel fuel have a similar linear density-temperature relationship. Hence there are no shape differences in the behavior of the different blends.

3. CONCLUSION

The cold temperature properties biodiesel fuels vary across the countries depending on the time of year when the fuel is produced and the climate. Generally, diesel fuels and biodiesel blends used in countries with cold climates have better cold flow characteristics than diesel fuels used in warmer regions. The cold flow properties of biodiesel fuels (rapeseed, sunflower, palm and fish oil) are dependant on the feedstock (specific type of oil or fat) from which they are made. It was found that viscosity was higher as the proportion of biodiesel in the mixtures increased which could affect the atomization characteristics in the engine. The biodiesel fuel and its blends had a linear density-temperature relationship similar to the diesel fuel. The density of the blends increased with the increase of the biodiesel content. The kinematic viscosity decreased with the increase of temperature. The density of the blends will lie between the values of pure biodiesel and diesel fuel.

ACKNOWLEDGEMENTS

This work was supported by the strategic grant POSDRU/89/1.5/S/61968, Project ID61968 (2009), co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007-2013.

References:

1. Alptekin, E., Canakci, M., Determination of the density and the viscosities of biodiesel–diesel fuel blends. Renew. Energ., 33 (12), 2623-2630, 2008, ISSN: 0960-1481.
2. ASTM Standards: ASTM D2500. Philadelphia: American Society for Testing Materials; 1991. p. 268–70.
3. Biodiesel Cold Flow Basics, Information for Petroleum Distributors, Blenders, and End-Users on Issues Affecting Biodiesel in the Winter Months Prepared by the National Biodiesel Board Winter 2007/2008.
4. Chandler JE, Horneck FG, Brown GI. The effect of cold flow additives on low temperature operability of diesel fuels. SAE Technical Paper Serious Paper No. 922186. Warrendale: Society of Automotive Engineers; 1992.
5. Graboski M.S., McCormick R.L., Combustion of fat and vegetable oil derived fuels in diesel engines. Prog. Energy Combust. Sc., 1998, 24, p. 125-164.
6. Joshi, R. M., Pegg, M. J., Flow properties of biodiesel fuel blends at low temperatures. Fuel, 86 (1-2), 143-151, 2007, ISSN 0016-2361.
7. Knothe G. Current perspectives on biodiesel. INFORM 2002, 13:900–3.
8. Knothe, G., Analyzing biodiesel: Standards and other methods J. Am. Oil Chem. Soc., 83 (10), 823-833, 2006, ISSN: 0003-021X.
9. Öner C, Altun S, Biodiesel production from inedible animal tallow and an experimental investigation of its use as alternative fuel in a direct injection diesel engine. Appl. Energy, 86(10): 2114-2120, 2009, ISSN: 0306-2619.
10. Shay EG., Diesel fuel from vegetable oils: status and opportunities. Biomass Bioenergy 1993;4:227–42, ISSN-09619534.
11. Peterson C.L., Cruz R.O., Perkings L., Korus R., Auld D.L., Transesterification of vegetable oil for use as diesel fuel: A progress report., ASAE Paper 1990, No. 90-610.
12. Petersen SD, School district of Westfield biodiesel production program: A comprehensive overview. http:// dpi.wi.gov/rural/pdf//westfield_biodiesel_synopsis.pdf., 2008.
13. Tat, M. E., van Gerpen, J. H., The specific gravity of biodiesel and its blends with diesel fuel. J. Am. Oil Chem. Soc., 77 (2), 115-119, 2000, ISSN: 0003-021X.
14. Yamane, K., Ueta, A. and Shimamoto, Y. Influence of physical and chemical properties of biodiesel fuels on injection, combustion and exhaust emission characteristics in a direct injection compression ignition engine. Int J Engine Research 2, 4, 249- 261, 2001, ISSN: 1468-0874
15. Yuan W, Hansen AC, Zhang Q, The specific gravity of biodiesel fuels and their blends with diesel fuel. Agric. Eng. Int.: The CIGR J. Sci. Res. Dev., Manuscr. EE 04 004, 2004, ISSN 1115 - 7569