Performance Study on Diesel Engine Using Different Blends of Neem Biodiesel

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ABSTRACT

The developing countries like India were adversely impacted by the overexploitation of fossil fuels and continuing rise in global price of crude oil. Biodiesel is a fuel comprised of mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel is reliable, renewable, biodegradable and regarded as a clean alternative fuel to reduce exhaust emissions. Vegetable oils have become more attractive for the production of biodiesel in the recent past owing to its environmental benefits and the fact that it is made from renewable resources. Biodiesel is produced by the transesterifi cation of triglycerides of edible/non edible oils, and waste vegetable oils using methanol with alkaline catalyst NaOH/KOH. In this proposed research, the Fatty acid methyl esters of Neem are produced through Transesterification process under lab setup and blended with petroleum diesel for various ratios (10%, 20%, 30%, 40% and 50%) to evaluate fuel properties. The experimental investigation was carried out on Single Cylinder water cooled diesel engine using different blends of Neem Biodiesel at variable loads. The results obtained indicated the better fuel properties and engine performance up to Blend B20.

Keywords: Biodiesel, Engine performance, Neem oil, Transesterification.

I. INTRODUCTION

The world energy demand has been increased drastically in few decades. Firstly, the price of conventional fossil fuel is rising rapidly and has added burden on the pocket of common man and economy of the nations who imports it. Secondly, combustion of fossil fuels is the main reason behind the increasing the carbon dioxide (CO_2) level, which result in increase of global warming. The depletion of conventional sources are also becomes the main concern for research world-wide into alternative energy sources for internal combustion engines. Bio-fuels have the potential to become alternative “greener” energy substitute for fossil fuels. It is available in plenty in the world and also the renewable source of energy.

It is not a new idea to use bio diesel in engine, it was first used by Rudolph diesel at Paris Exposition of 1900 [1]. Vegetable oils cannot be used directly in diesel engine because of their high viscosity. The high viscosity may cause blockage in the fuel lines, filters and poor atomization. Surely vegetable oils cannot be used safely in DI diesel engines. The problem of high viscosity of vegetable oil can be overcome by heating, blending and esterifying them. Also vegetable oils have longer duration for combustion and the pressure rise is also moderate, which is not given by conventional fossil fuels [2].

Neem oil is generally light to dark brown, bitter and has a rather strong odor that is said to combine the odors of peanut and garlic. It comprises mainly triglycerides and large amounts of triterpenoid compounds, which are responsible for the bitter taste. It is hydrophobic in nature and in order to emulsify it in water for application purposes, it must be formulated with appropriate surfactants. Neem oil also contains steroids (campesterol, beta-sit sterol, stigma sterol) and a plethora of triterpenoids of which Azadirachtin is the most well known and studied. The Azadirachtin content of Neem Oil varies from 300ppm to over 2000ppm depending on the quality of the neem seeds crushed [3].

Biodiesel is defined as a “fuel comprised of mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats”. Nowadays, most biodiesel is produced by the transesterification of triglycerides of edible/non edible oils, and waste vegetable oils using methanol with alkaline catalyst NaOH/KOH [4]. Fatty acid methyl esters (FAME) biodiesel, appear to be the most popular diesel fuel substitute, since their properties are similar to mineral diesel and can be used in conventional diesel engines without significant modifications.

The use of vegetable oils, such as Neem, palm, olive oil, coconut husk, rice husk, and soybean, as alternative fuels for diesel is being promoted in many countries. Depending upon the climate and soil conditions, different countries are looking for different types of vegetable oils as substitutes for diesel fuels. For example, soya bean oil in the US, rapeseed and sunflower oils in Europe, palm oil in South-East Asia (mainly Malaysia and Indonesia) and coconut oil in the Philippines are being considered. Besides, some species of plants yielding non-edible oils, e.g. Neem, Jatropha, karanja and pongamia may play a significant role in providing resources. All these plants can be grown on a large scale on agricultural/waste/marginal lands, so that there is an abundance to produce biodiesel on farm scale [2].

A number of methods are currently available and have been adopted for the production of biodiesel fuel. There are four primary ways to produce biodiesel: pyrolysis, micro-emulsification, dilution and Transesterification [5]. The most commonly used method for converting oils to biodiesel is through Transesterification process using sodium hydroxide or potassium hydroxide catalyst. The essential purpose of this research is to effectively produce biodiesel from neem oil and study its fuel properties and performance characteristics as a blended fuel in compression ignition engine.

II. METHODOLOGY

2.1 Esterification and Transesterification Process

The raw Neem oil measuring 1litre having FFA of 5.86% is taken in a reaction flask and heated to 40ºC initially with a continuous stirring. Then oil is filtered using a tissue paper. The filtered oil is again heated to 60º - 65ºC for 15minutes in a reaction flask. After the heating of the oil is carried out, then the mixture containing 300ml methanol and 10ml conc. Sulphuric acid is poured into the reaction flask slowly. The reaction takes place at constant stirring with suitable speed and process is carried out at 60ºC for about 1hour. After the completion of process, the mixture is transferred into a separating flask and then allowed to settle down to separate into two phases. The upper layer is dark acid layer and the lower layer is oil.

Now the sample of the esterified Neem oil is taken and the new FFA is measured which is found to be 3.05%. The FFA content of esterified neem oil is less than 4%, therefore Transesterification process is carried out.

The esterified Neem oil is taken in a reaction flask and heated to 60ºC for about 15 minutes with continuous stirring. Then the methoxide mixture containing 300ml Methanol and 5 – 8gms of Sodium Hydroxide is poured into a reaction flask with constant slow stirring at 60ºC. The reaction temperature is maintained about 60-65˚C and process is carried out for another 2 hours. Once the process is completed, the reaction mixture is transferred into a separating funnel and then allowed to settle down into three phases. The upper layer is biodiesel which consists of methyl esters, the middle layer is glycerol and the lower layer is NaOH catalyst. The biodiesel obtained is washed with warm water of 40°C and allowed to settle for 1 hour. A bottom layer of soap water will slowly start to form and the soapy water is drained down carefully. The above procedure is repeated 10 to 15 times, till the clean wash water is got back which indicates that the catalyst is not present in the biodiesel. Later washed biodiesel is heated to 110ºC to remove moisture from biodiesel. Thus neat biodiesel is obtained.

2.2 Experimental Setup

The experiments were conducted on a Kirloskar made four stroke single cylinder water cooled direct inject compression ignition engine without any hardware modifications. Neem biodiesel blends (B10, B20, B30, B40, and B50) and diesel was used to test a conventional engine. The engine was coupled with an eddy current dynamometer to apply different loads. Performance parameters like brake power, brake specific fuel consumption and brake thermal efficiency were evaluated. The engine specifications are given in the Table 1.

Table 1: Engine Specifications

Type	Kirloskar
Details	Single cylinder, four stroke, water cooled
Bore & Stroke	80×110 mm
Rated Power	3.75 KW at 1500 RPM
Compression Ratio	16:1to 25:1
Starting	Hand start with cranking handle

III. RESULTS AND DISCUSSION

The raw neem oil having FFA of 5.86% is treated with two processes. The first process is esterification in which the neem oil is treated with concentrated sulphuric acid as catalyst to remove excess % of FFA. Then the oil with new FFA of 3.05% is taken into second process (Transesterification) by treating with NaOH catalyst and as a result FFA reduces to 1.086%. By processing through above two treatments the oil is washed with warm water and heated to 110^{o}C to remove excess water in it. The dried oil is now free from all impurities. Then the processed neem oil is the biodiesel which further blended with diesel on a 10%, 20%, 30%, 40% and 50% volume basis and fuel properties are determined using standard procedure. Table 2 shows the fuel properties of Diesel, Neem biodiesel and its blends. Biodiesel blends of Neem methyl esters with diesel on 10%, 20%, 30%, 40% and 50% volume basis was prepared and fuel properties are measured following standard procedure. The properties of Neem biodiesel and its blends are compared with ASTM biodiesel standards as shown in Table 2.

3.1 Specific Fuel Consumption

Fig. 1 shows the variation of specific fuel consumption with brake power for Neem biodiesel blends for a conventional engine. From Fig. 1 it is observed that Neem biodiesel blends B10 and B20 have specific fuel consumption close to diesel.

However if the concentration of neem oil in the blend is more than 20%, the specific fuel consumption is found to be higher than diesel at all loads. Biodiesel blend B50 shows higher SFC than other blends at all loads.

As the load increases specific fuel consumption decreases for all fuel blends. It is due to the fact that engine consumes more fuel with biodiesel blends than with the neat diesel fuel to develop same power output due to lower calorific value of biodiesel blends.

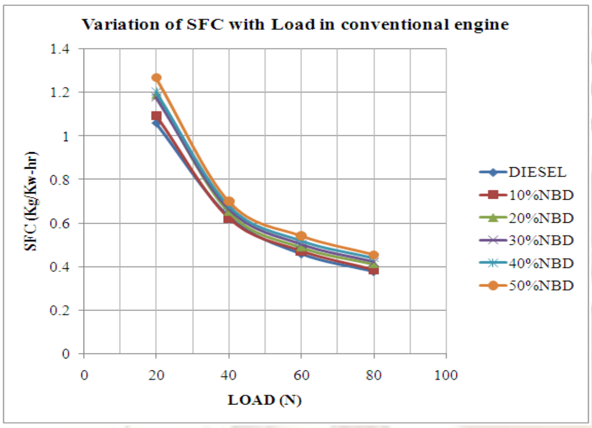

Fig. 1 Experimental setup of single cylinder Diesel engine

3.2 Brake Thermal Efficiency

Fig. 2 shows the variation of brake thermal efficiency with brake power for Neem biodiesel blends for a conventional engine. From Fig. 2 it is evident that the brake thermal efficiency is highest with the blend B10 in all loads which are nearer to diesel. The reason for increase in efficiency at blend of 10% Neem biodiesel may be the property of blend, probably the lower viscosity of biodiesel which helps in better atomization and effective utilization of air resulting in increased efficiency.

Blend B50 shows the minimum efficiency at full load. The decrease in brake thermal efficiency for higher blends may be due to the lower heating value and higher viscosity of blends with a higher proportion of biodiesel.

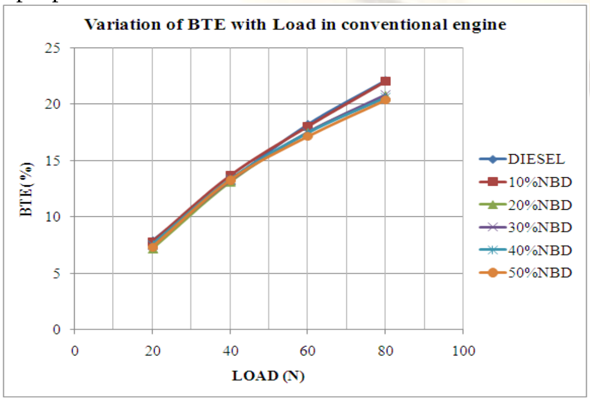

Fig. 2 Experimental setup of single cylinder Diesel engine

IV. CONCLUSION

The present investigation evaluates production of Neem oil methyl ester using sodium hydroxide catalyst and performance of neem biodiesel blends are compared with the diesel in a single cylinder four stroke diesel engine under varying load conditions of engine operations. The following conclusions are drawn from this investigation.

1. The transesterification process used for making biodiesel is simple to solve viscosity problems encountered with vegetable oils.
2. The fuel properties results of all blends show that blends of up to 20% have values nearer to properties of diesel.
3. The existing diesel engine performs satisfactorily on biodiesel fuel without any engine modifications.
4. It is observed from this research that yield of neem biodiesel is low.
5. Engine performance with biodiesel does not differ much the neat diesel. Biodiesel blend B10 shows good results comparable with other blends.

From the above observation, it can be concluded that 20% blend of neem biodiesel with petroleum diesel can be used as alternative fuel without any engine modification. This helps to reduce 20% dependency on petroleum diesel.

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Table 2: Fuel properties of Diesel, Neem biodiesel and its blends

Properties	**Units**	**Diesel**	**Neem Biodiesel Blends**					**B100**
			B10	**B20**	**B30**	**B40**	**B50**	
Viscosity	Cst	3.02	3.78	3.855	3.92	4.074	4.38	6.81
Density	Kg/m^3	816	820.1	825.9	831.4	839.6	843.8	873.2
Flash point	^oC	52	57	62	68	70	74	168
Fire point	^oC	61	67	74	75	77	85	184
Calorific value	KJ/Kg	43796	42111	41863	40780	39460	38643	36496