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Experimental Investigation On Emission Parameters Of Transesterified Adelfa Oil (Methyl Ester Of Nerium Oil)

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Abstract: Faster depletion of fossil fuels, day to day increase of automotives and increasing cost of petroleum fuel triggered the interest of researchers to arrive at an alternative fuel which is most suitable to compression ignition engines. It is already proven that vegetable oil could be used in the compression ignition engines, by Mr. Rudolf Diesel, inventor of diesel engine in an exhibition. Further researchers reported few problems such as, clogging of fuel filter, nozzle choking, starting trouble during winter season etc., with prolonged usage of vegetable oil. Transesterification process is used for producing the NOME from raw Adelfa oil, to reduce its viscosity and to make it more suitable for compression ignitions without major modification. In this experimental work esterified Adelfa oil is being tested and compared with petroleum diesel. Adelfa (Nerium Oil Methyl Ester- NOME) is blended with diesel by 20% by volume and various emission tests have been carried out. Promising results show a good sign of using A20 (Adelfa 20% by volume with diesel) as a fuel for compression engines.

Keywords: *Adelfa, NOME, transesterification.*

Introduction

The increase of automotives is keep on increasing day by day and cost of the petroleum fuel is also increasing rapidly. Hence it is alarming that, arriving at an alternative fuel that suits the present automotives is highly essential. Though there are many choices, best among them is esterified vegetable oil (methyl esters of vegetable oil), known as biodiesel. As the biodiesel fuel is renewable, biodegradable and environment friendly most of the researchers show interest on the various biodiesel fuels such as Jatropha, Cotton seed, Karanja, Mahua etc., There is growing interest in biodiesel (fatty acid methyl ester or FAME) because of the similarity in its properties when compared to those of diesel fuels [1]. Also, most of the researches report that there is lesser emission, when the diesel engines are operated with biodiesel fuel. Diesel engines operated on biodiesel have lower emissions of carbon monoxide, unburned hydrocarbons, particulate matter, and air toxics than when operated on petroleum-based diesel fuel [1]. The source for biodiesel production is chosen according to the availability in each region or country [2]. In this experimental work, Transesterification process is used for producing biodiesel from the source vegetable oil. Biodiesel prepared from vegetable oil after transesterification reaction shows a similar performance to diesel at all loading conditions and can be used as alternate fuel to diesel without any modifications in engine design [3]. The direct use of vegetable oils for both direct and indirect injection type diesel engines is unsatisfactory due to their high viscosities and low volatilities [4]. The diesel fuel cannot be replaced totally by the vegetable oils (in conventional diesel engines) because of the low cetane number, high ignition temperature, high viscosity and incomplete combustion leading to increased emissions and decreased performance [5]. Viscosity is the major problem for the bio-diesel which imposes lot of problems for engine [6]. Transesterification process removes fatty acids in the form of glycerol, thereby reduces the viscosity. Hence biodiesel can be blended with diesel and used in compression ignition engines without any modification. Though biodiesel show a marginal decrease of brake thermal efficiency, it shows appreciable results in terms of emission norms.

Biodiesel Production By Transesterification

During transesterification process, displacement of alcohol from an ester by another alcohol takes place. Hence, this process is also known as alcoholysis. To reduce the viscosity of triglyceroids, this process is widely used. If alcohol used is methanol, then it is termed as methanolysis. Methanol and ethanol are used most frequently, especially methanol because of its low cost and its physical and chemical advantages (polar and shortest chain alcohol) [7]. Transesterification is the process used to make biodiesel fuel as it is defined in Europe and in the USA [7]. Of the several methods available for producing biodiesel, transesterification of natural oils and fats is currently the method of choice [7]. Transesterification with alcohols reduces the viscosity of the oil and other properties have been evaluated to be comparable with those of diesel. In the present work, methyl esters of Adelfa (Nerium) oil were prepared by transesterification.

Adelfa (Nerium) oil is taken in a three way flask. The pellets of NaOH are mixed with methanol in a beaker. The solution obtained is mixed with Adelfa oil in the three way flask and stirred well. The methoxide solution with Adelfa oil is heated upto 70^{o}C with continued stirring, for one hour. The solution obtained is poured in a beaker and allowed to settle down for 8-10 hours. The glycerin is settled down at the bottom and methyl esters (coarse biodiesel) are formed at top. Methyl esters of Adelfa oil is separated and heated above 100^{o}C to remove untreated methanol. The impurities such as NaOH are removed by washing it with water. The cleaned biodiesel is the methyl esters of adelfa (nerium) oil. There is a reduction of molecular weight to one third when the triglycerides are converted into methyl esters through alcoholysis.

Table 1 shows, the properties of the petroleum diesel and methyl esters of Adelfa oil. From table 1, it is clear that the calorific value is almost close to diesel, but the viscosity and density is more. These properties forecast a result of, marginal decrease in brake thermal efficiency with reduced emission as the carbon content is low in esterified Adelfa oil.

Table 1 : Comparison of properties of diesel and methyl esters of Adelfa oil

	Calorific value, MJ/kg	Kinematic viscosity at 40^{o}C cST	Density, kg/mm^3	Flash point ^{o}C	Fire point ^{o}C
Diesel	43.2	3.1	830	56	64
Methyl esters of Adelfa oil	42.19	3.7	850	70	83

Experimental Apparatus And Methodology

A kirloskar SV1 engine is used with AVL smoke meter to measure the smoke opacity. The AVL smoke meter works on light extinction principle. It consists of a flexible sampling hose with appropriate exhaust gas probe. The amount of the light passing through the smoke column is sensed as an indication of smoke level. Crypton 290 series emission analyser is used to measure unburnt hydrocarbons, oxides of nitrogen and carbon monoxide emissions. Measurement of NO_X is achieved by means of a chemical sensor fitted next to the oxygen sensor. The test engine is allowed to run until the stable condition is achieved. Proper settings and adjustments have been done in the calibrated testing equipments, recommended by the manufacturers. Then the engine load is increased gradually from zero load condition to full load condition. The load conditions taken are 0%, 25%, 50%, 75% and 100%. The standard injection pressure and injection timing are 200 bar and 27^{o} before Top Dead Centre (bTDC) respectively. Esterified Adelfa oil is blended 20% by volume (A20) with diesel and used as the test fuel. Petroleum diesel fuel has been taken as the reference fuel.

Figure 1 Alcoholysis (transesterification) process

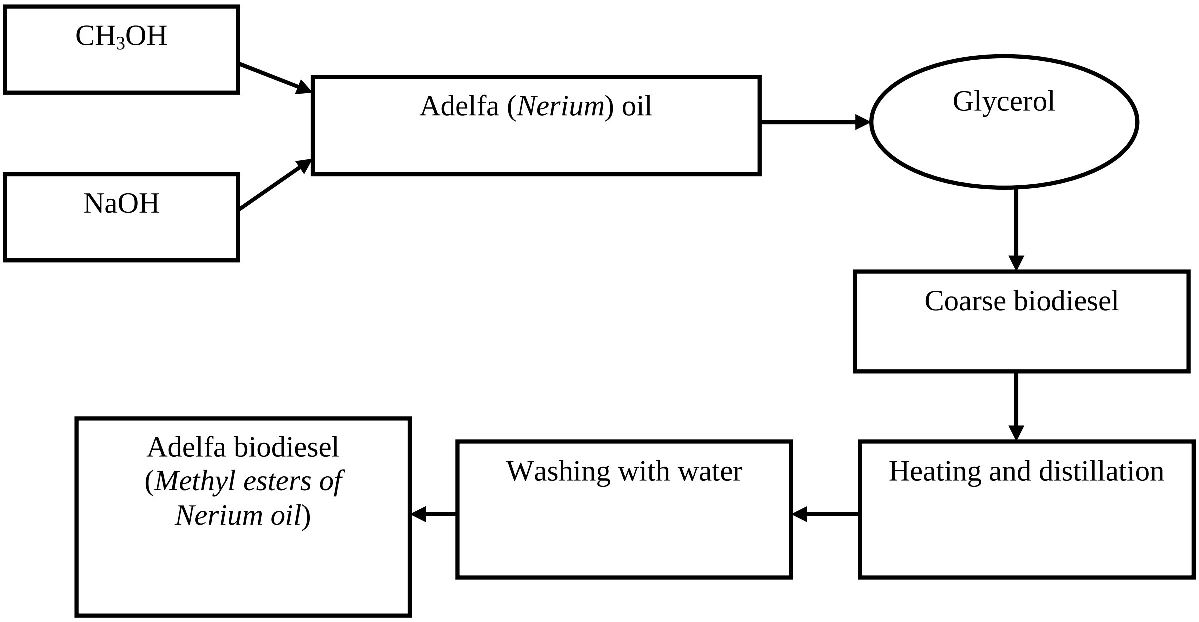
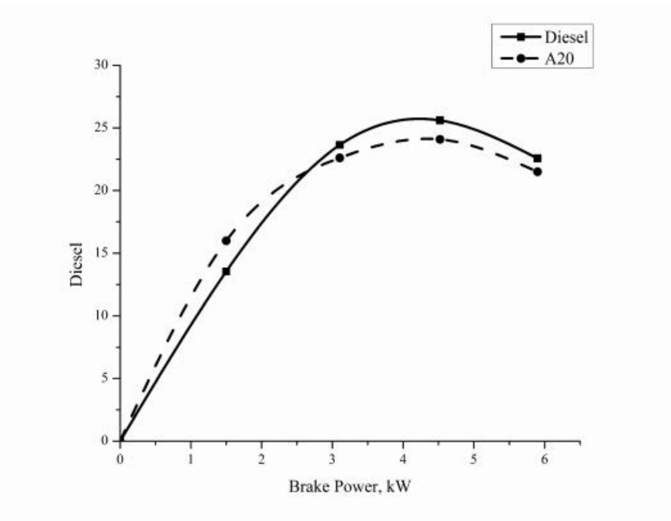


Figure 2: Brake power Vs brake thermal efficiency



Results And Discussion

Brake Thermal Efficiency

Thermal efficiency is the true indication of the efficiency with which the chemical energy input in the form of fuel is converted into useful work [8]. Figure 2, shows the brake power is maximum at three fourth of load condition and it is low at the full load condition. It may be due to the reason that better combustion of fuel due to oxygen content in A20. The higher flash point, poor volatility and flammability may have an influence on the auto-ignition and combustion processes of biofuels [9].Rich fuel mixture and poor combustion due to the less time available for burning may be reason for decrease in the brake thermal efficiency for both diesel and A20 (methyl esters of adelfa oil blend) biodiesel. The brake thermal efficiency of an engine depends on number of factors but the most meaningful property is heating value and specific gravity [9]. There is a marginal decrease of 4.72 % in brake thermal efficiency is observed when methyl esters of adelfa oil blend is used. This is due lower heating value of methyl esters of adelfa oil which leads to a slower burning compared to diesel.

Emission Parameters

Hydrocarbon Emission

Figure 3 compares the hydrocarbon emission of reference fuel (petroleum diesel) and the test fuel (adelfa 20% by volume, A20). It is found that at three fourth of load, the hydrocarbon is the least for both reference and test fuel. The shorter ignition delay associated with biodiesel higher cetane number could also reduce the over mixed fuel which is the primary source of un-burnt hydrocarbons [11]. The hydrocarbon emission of A20, is found to be 8.125% lower than petroleum diesel at three fourth of load condition. The oxygen content in esterified methyl esters of Adelfa oil blend (A20), enhances complete combustion, which further reduces the hydrocarbon emission. Hydrocarbon (HC) emissions result when fuel molecules in the engine burn only partially [12].

Carbon Monoxide Emission

Carbon monoxide (CO) gas produced due to the incomplete combustion of carbon-containing substances [13]. Figure 4, shows the bar chart which compares the carbon monoxide emission of petroleum diesel and A20 biodiesel. The carbon monoxide emission significantly better with A20 biodiesel compared to diesel. CO emission is formed due to the incomplete combustion of organic material where the oxidation process does not have enough time to occur completely [14]. At three fourth of load the carbon monoxide emission of A20 was found to be 16.36% lower than diesel. This may be due to the complete combustion of fuel due to the presence of sufficient oxygen content which converts all the Carbon monoxide (CO) into Carbon dioxide (CO2). Biodiesel is less compressible than diesel fuel and therefore the injection starts earlier and causes longer combustion duration [15].

Figure 3: Brake power Vs hydrocarbon emission

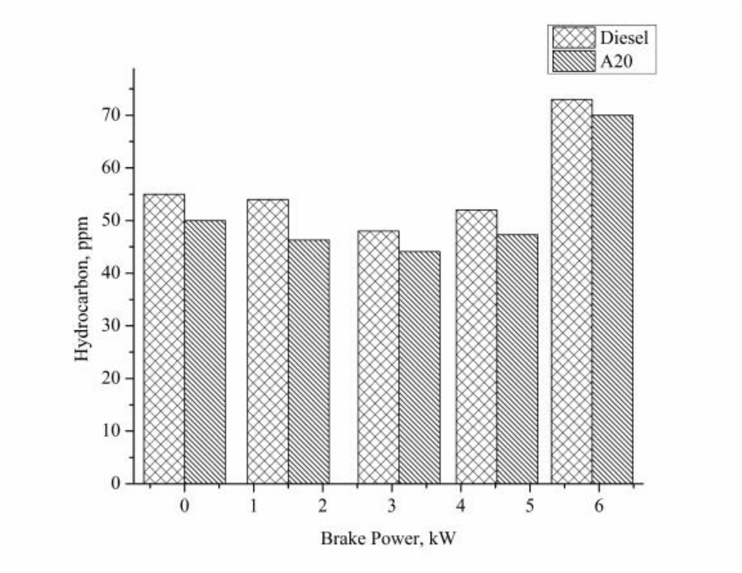
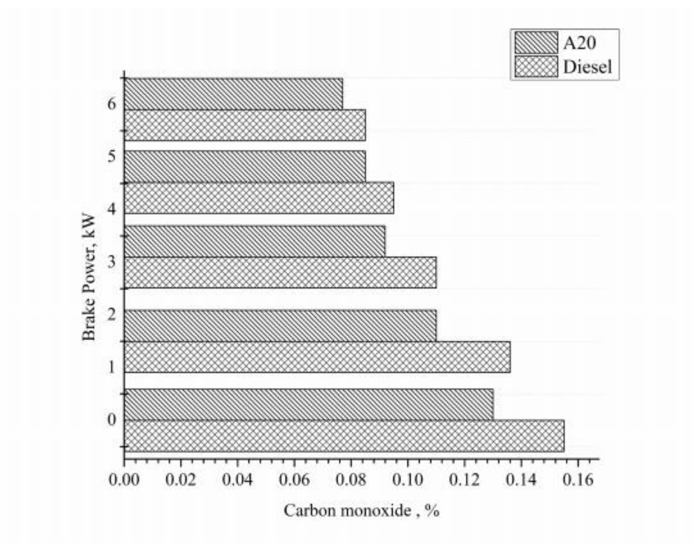


Figure 4: Brake power Vs carbon monoxide emission



Smoke Opacity

Smoke is produced during acceleration, overloading or even during full load operation of the engine. Under these conditions more fuel is burned and the prevailing temperatures inside the combustion chamber become very high [10]. Thermal cracking of molecules due to the high temperature, leads to soot formation. Figure 5 shows the bar chart, which compares the smoke opacity emission of reference and test fuel. Smoke opacity is measured in terms of Hatridge Smoke Units (HSU). A 5.2 HSU increase of smoke opacity was found with methyl ester of Adelfa oil. Though smoke opacity is slightly more with A20 biodiesel, it is not a great increase. It may be due to poor atomization which further leads to a poor combustion and also due to the higher viscosity.

Oxides Of Nitrogen (NO_X) Emission

Oxides of nitrogen emission increases with increase in brake power. An increase in after-combustion temperature causes an increase in NOx emission [9]. The amount of NOx produced is a function of the maximum temperature in the cylinder, oxygen concentrations, and residence time [14]. Figure 6 shows the bar chart, comparing the oxides of nitrogen emission of diesel and A20 biodiesel. The NOx emission is more with methyl esters of Adelfa oil, at all load conditions, when compared to diesel. The increase in NOx emission is about 129 ppm, A20 is used. Previous research reports state, that, even though biodiesel engines emits more NOx, these emissions can be controlled by adopting certain strategies such as the addition of cetane improvers, retardation of injection timing, exhaust gas recirculation, etc [8]. In previous reports it is suggested that, Diethyl ether (DEE), an oxygenated additive can be added to diesel/ biodiesel fuels to suppress the NOx emission.

Figure 5: Brake power Vs smoke opacity emission

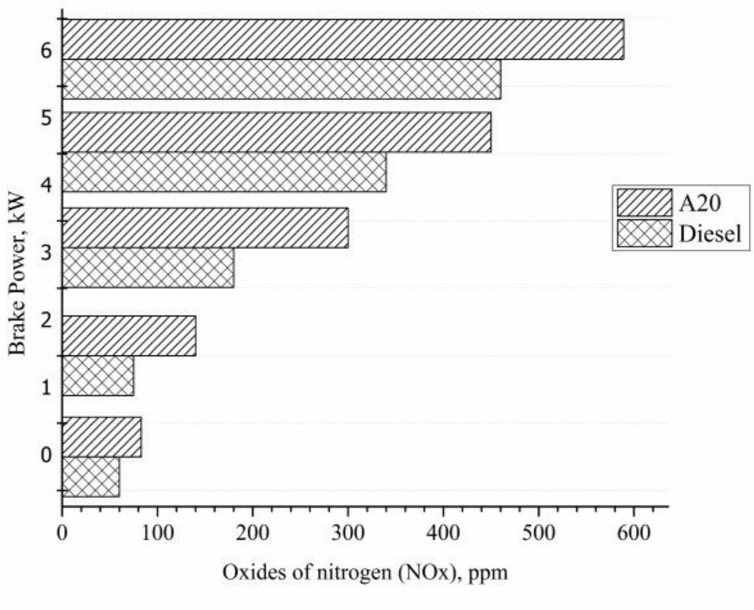
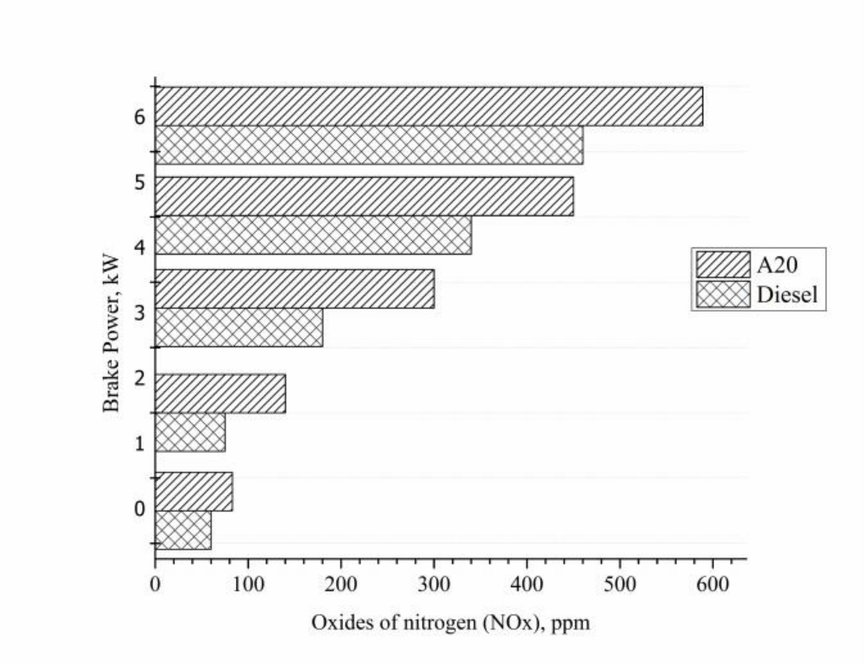


Figure 6: Brake power Vs Oxides of nitrogen emission



Conclusion

The following are the results obtained in this experimental investigation with test fuel methyl esters of Adelfa oil (A20) and diesel (reference fuel)

- A marginal decrease of 4.72% of brake thermal efficiency was found, which may not show a greater difference compared with operating conditions of diesel.
- Appreciable decrease of 8.125 % hydrocarbon emission was achieved when methyl esters of Adelfa oil is used as the test fuel.
- The remarkable decrease of 16.36% carbon monoxide emission was found with A20 biodiesel as the fuel.
- An increase of 5.2 HSU of smoke opacity was found with methyl esters of Adelfa oil, which is a slight variation with diesel.
- An increase of 129 ppm of oxides of nitrogen emission was found, which may be controlled by optimization of injection pressure and injection timing.

In this experimental investigation, 82.5% of overall result show promising sign of using A20 (methyl esters of adelfa oil) as a fuel in diesel engines without any modification. However, engine modifications such as variation of injection timing, injection pressure may be carried out as a continual work. Also for the oxides of nitrogen emission reduction, fuel additives such as Di ethyl ether (DEE), which has a higher cetane number, can be blended with the biodiesel fuel.

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