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Synthesis & Characterization of Biodiesel on the Performance & Emission of Diesel Engine

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Abstract: ***The preference given to biodiesel in a diesel engine has gained importance over the past two decades, due to its environmental and economic benefits. There are two methods of reducing the exhaust gas emission of the CI engine. First method is to reduce emissions by using exhaust gas treatment devices like catalytic converter, diesel particulate filter. However, use of this method increases the fuel consumption and affects the performance of the engine. A nanoparticle or Nano powder is a microscopic particle with at least one dimension less than 100 nm and is mixed with either one of the substances like water, oil or ethylene glycol in a required proportion(in ppm) to make Nano additives.***
In this work, we prepared biofuel from used cooking sunflower oil and also Nano additives. Then the blends of biodiesel (B-0, B-20, B-50, and B-100) tested on diesel engine to get optimum blend on performance and emission characteristics. Nano additives at different proportions will be added to this optimum blend to get the best proportion of blend with optimum quantity of Nano additives based on emission and performance characteristics.
Keywords: Biodiesel, Nano Additives, blends, CI Engine.

I. INTRODUCTION

The concern of current energy situation, major research is focused on sustainable energy solution with major prominence on energy efficiency and use of renewable energy sources. The diesel engines lead the field of commercial transportation and agricultural equipment due to its simplicity of operation and higher fuel efficiency. The consumption of Diesel fuel is several times higher than that of petrol fuel. Due to the scarcity of petroleum products and its increasing cost, efforts are on to develop alternative fuels specially, to the diesel oil for fully or partial replacement. It has been originate that the vegetable oils are hopeful fuels because their properties are similar to that of diesel and are produced simply and renewably from the crops. These oils have equivalent energy density, centane number, heat of evaporation and stoichiometric air –fuel ratio with that of the diesel fuel. Blending, emulsification, thermal cracking and Transesterification are the methods to use the vegetable oil as fuel in diesel engine. With soaring price of petroleum-based products, Biodiesel is becoming an increasingly affordable option relative to petroleum diesel.

Biodiesel is a chemically altered alternative fuel for use in diesel engines .It produced from vegetable oils and animal fats. Biodiesel is created commercially by the transesterification of vegetable oils with alcohol. These can also can be bent from the biomass sources. Biodiesel is the name given to these esters when they're intended for use as fuel. Glycerol (used in pharmaceuticals and cosmetics, among other markets) is produced as a co-product.

Addition of Metal oxides nanoparticles with neat diesel, biodiesel found out that there is a reduction in ignition delay and small improvement in brake thermal efficiency are notable highlights and a significant decrease in kinematic viscosity and increased cetane number. These metal oxide nanoadditives also acts as oxygen donating catalyst i.e. provides oxygen for oxidation of CO or absorbs oxygen for reduction of NOX (only in case of biodiesels) in addition to it decreases Hydrocarbon (HC) emissions as well as soot (carbon black) by promoting complete combustion. In the case of pure diesel emission of NOX is found to be increased. And a little improvement in calorific value and cetane number of diesel and biodiesel was seen. However, viscosity, flash point and density of fuel were slightly increased. Some results shows decrease in brake specific fuel consumption with dosing of metal oxide nanoparticles due to enhanced combustion of fuel. At higher concentration of nanoparticles higher CO emissions was absorbed due to reduction catalytic oxidation.[1] The fuel adulteration method is widely used to improve performance and achieve good emission control of a diesel engine without any modifications of existing engine. We need to select Nano additives in such a way that it should decrease the exhaust emissions as well as increase oxidation intensity in combustion chamber. The Nano additive which is mixed with fuel should maintain chemical stability in the mixture at all the conditions and also should not decrease the effectiveness of particulate filters.

The Nano additive should not increase the emissions of the environmentally harmful substances. It is evident from recent studies that the diesel engine performance improves appreciably with nanoadditives for all cases of diesel, biodiesel but increasing the concentration of nano fluids leads to increase in Nox and insensitive performance. Hence, the estimation of optimum dosage is essential for every nanoadditives. [2] Vegetable oils have equivalent energy density, cetane number, heat of vaporisation with that of the diesel fuel but viscosity is more than a few times higher than that of diesel. Viscosity results on flow properties of fuel such as spray atomization, vaporization and air-fuel mixture. Blending, emulsification, thermal cracking and trans-esterification are some methods used to convert vegetable oil as fuel in diesel engine. Unburned hydrocarbons, CO & sulphur levels are comparatively less in exhaust gas while using biodiesel as fuel but a rising in levels of NOx is reported with biodiesel. It is created commercially by the trans-esterification of vegetable oil with alcohol (Methanol or ethanol).The direct use of oil as fuel causes deterioration and decomposition of engine parts. The trans-esterification process resolves this problem. Biodiesel is simple to use, biodegradable, non-toxic and lesser risk when oil spillages.[3]

The maximum yield of esters occurs at temperatures ranging between 60 and 80oC. Another important parameter which has tremendous influence on the yield of ester is the molar ratio of alcohol to oil. In most of the industrial processes of biodiesel synthesis a molar ratio of alcohol to oil used is 6:1.In this work, they also compared the catalytic activities of NaOH and KOH for the transesterification of waste cooking oil with FFA content of 2.76 and concluded that the KOH transesterification proceeds faster than NaOH-catalyzed reaction. KOH has been considered as a best catalyst for transesterification of used cooking oils. Hence, many researchers have used it for the transesterification of waste cooking oil.[4]

The fatty acid profile of biodiesel corresponds to that of parent oil or fat and is a major factor influencing its fuel properties. Due to the presence of significant amount of fatty acids with double bonds, oxidative stability over an extended period of time has been found to be of significant concern and an important criterion for biodiesel fuel quality.

It is reported that stability of biodiesel is inferior to petro-diesel and therefore, the blending of biodiesel with petro-diesel will affect its fuel stability significantly. As biodiesel chemically is an ester molecule there is every possibility that in the presence of air or oxygen it will be hydrolysed to alcohol and acid. Presence of alcohol will lead to reduction in flash point and presence of acid will increase total acid number. All these make methyl ester relatively unstable on storage and cause damage to engine. Recently, several studies have examined the oxidation stability of biodiesel as a way to solve long-term storage problems. Studies on the deterioration of various biodiesels under different storage conditions have also been reported, including those made of methyl esters of rapeseed oil, used edible frying oil, and soybean oil and long-term storage stability of biodiesel from Karanja oil and found that it is possible to increase the stability considerably by adding the antioxidants. Treatment with oxidation inhibitors is a promising approach because it facilitates the use of existing storage tanks and fuel handling systems without requiring upgrades or redesign. Antioxidants such as tert-butylhydroquinone (TBHQ) or butylated hydroxytoluene (BHT) are known to retard effects of oxidation. [5].

II. METHODOLOGY AND TESTING

A. Methodology

The methodology adopted is outlined as the production of methyl esters of sunflower oil by transesterification process, optimization of the important parameters like stirrer speed, concentration of catalysts like NaOH, KOH and reaction time for producing higher yield of methyl esters from used sunflower oil, determination of the properties of these esterified oils by standard method, developing an experimental setup with necessary loading devices and other instrumentation to study the performance, and emission characteristics of the diesel engine fuelled with different blends of the selected oil, conducting experiments and analysing the performance and emission characteristics of the diesel engine running on biodiesel blends, single cylinder experimental setup was established with necessary instrumentation to study the performance, combustion and emission characteristics of the diesel engine fuelled with methyl esters of used sunflowers oil and its blends with diesel having blend ratios of 20%, 40%, 60%, 80% and 100% on volumetric basis.

The present work involves experimental investigation to achieve the cited objectives. The aim is to have more data on bio diesel properties, performance, emissions and combustion in engines and finally the optimum blend of the oil is determined based on the criteria such as higher brake thermal efficiency and lower specific fuel consumption and lesser emissions.

The overall process is normally a sequence of three consecutive steps, which are reversible reaction. In the first step, from monoglyceride glycerine is obtained. In all these reactions esters are produced. The stoichiometric relation between alcohol and the oil is 3:1. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product.

B. Comparisons of fuel properties

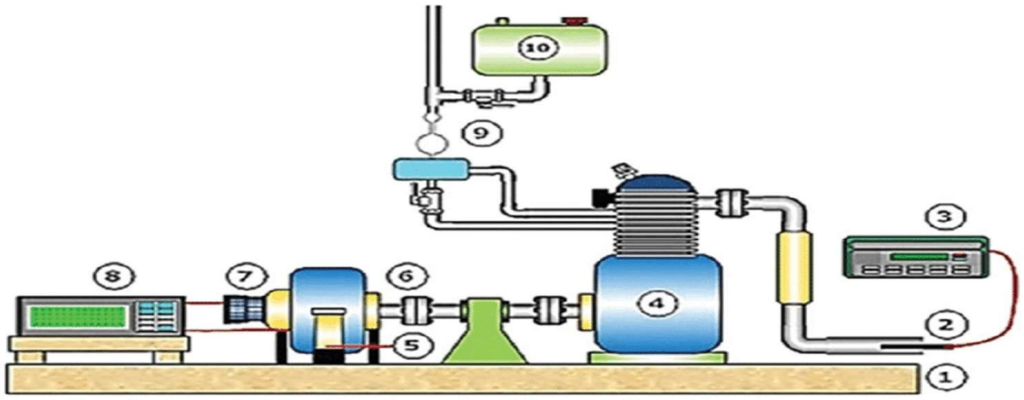
Property	Sunflower methyl ester (Biodiesel)	Diesel
Flash Point (°C)	158	68
Fire Point (°C)	172	82
Viscosity (mm2/sec) at 40°C	2.8705	3.18
Density (kg/litre)	0.8609	0.832
Ph. Value	7.105	6.8

Table 1. Comparison of fuel properties

C. Experimental Setup

The engine performance test was conducted on single cylinder, four-stroke, naturally aspired, direct injection, water cooled, 3.7 KW output power with computerized diesel test rig. The engine was directly coupled coupled to a swinging field dynamometer and the engine characteristics are cited in specification of engine.

For every fuel change the fuel line was purged out of the residual fuel. The engine is made to run under full load for at least 30mins to stabilize on new fuel conditions. Test-rig was provided with necessary equipment and instrument for recording the air flow, fuel flow, and temperature and load measurements. The fuel level and lubrications oil levels are checked and three-way cocks is opened.so that the fuel flows to the engine. The cooling water is supplied to the engine cooling water jacket. The electrical power is supplied to the panel instrumentation. The engine is unloaded by supplying current to the electrical dynamometer. The engine is started by manual crank.

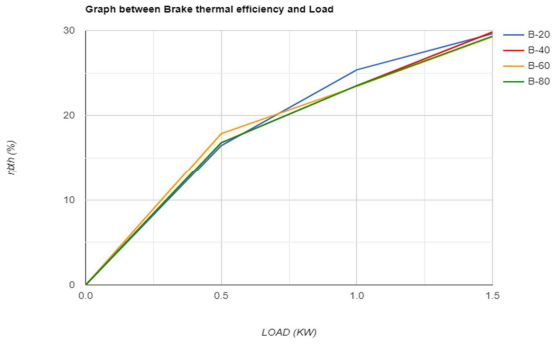


1) engine chassis, 2) exhaust gas analyzing probe, 3) exhaust gas analyzer, 4) single cylinder diesel engine, 5) load cell, 6) dynamometer, 7) tachometer, 8) control unit, 9) fuel burette, 10) fuel container

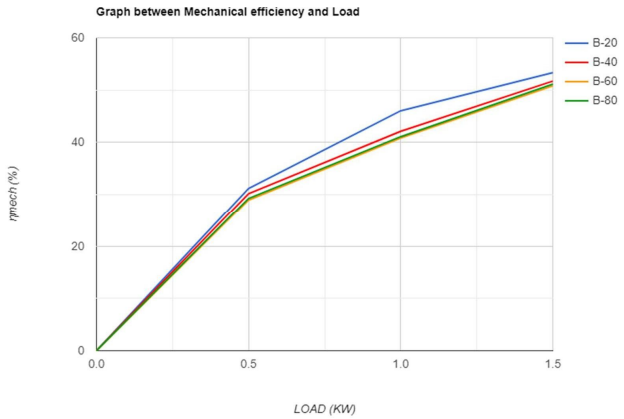
III.OBSERVATIONS

Engine performance is an indication of the degree of success of the engine performs its assigned task, i.e., the conversion of the chemical energy contained in the fuel into the useful mechanical work. The performance of an engine is evaluated on the basis of the following:

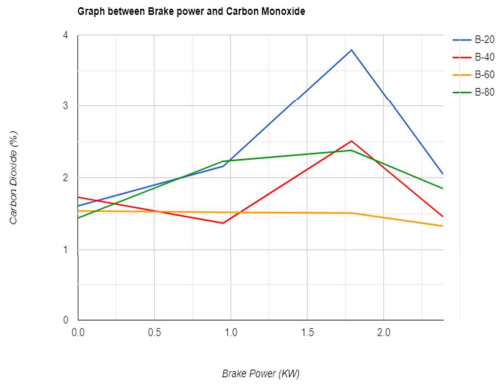
A. Graph between Brake thermal efficiency and Load



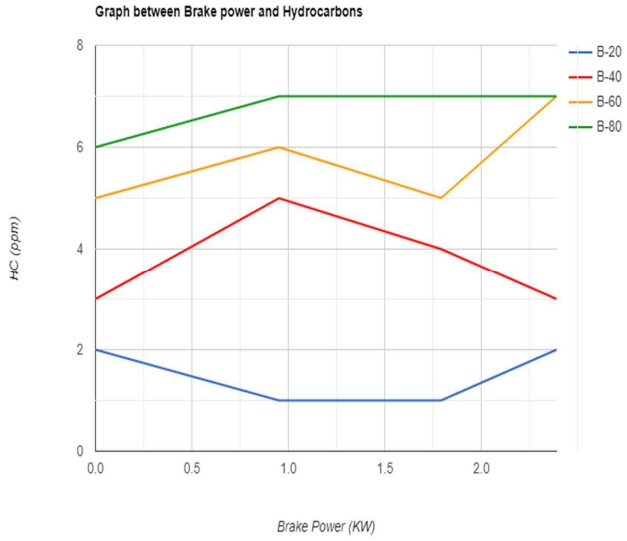
B. Graph between Mechanical efficiency and Load



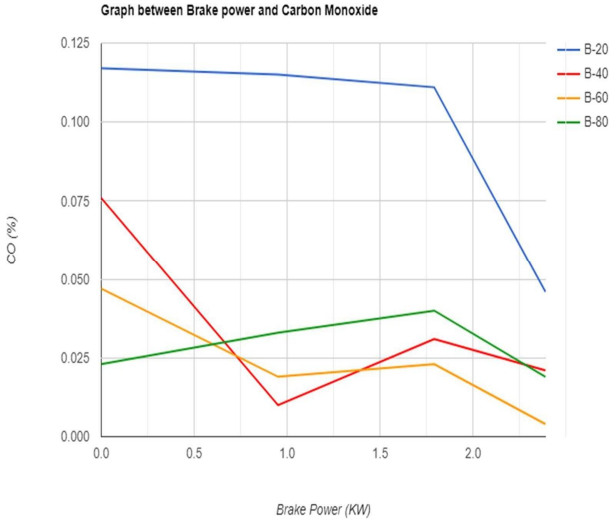
C. Graph between Brake power and Carbon Dioxide



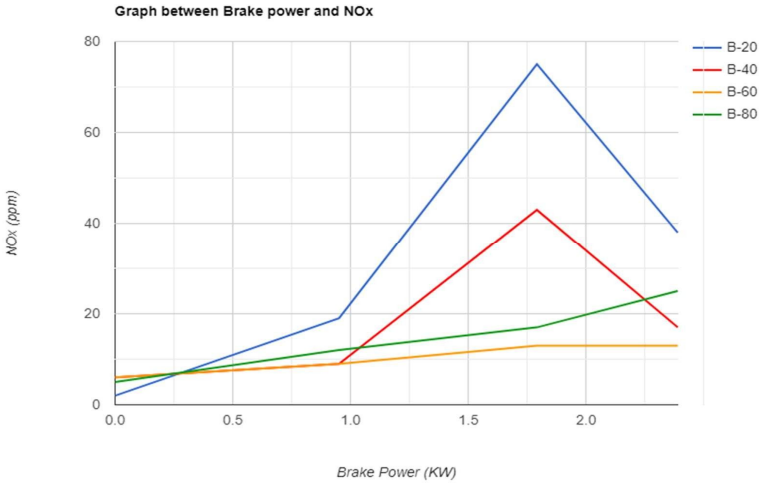
D. Graph between Brake power and Carbon Monoxide



E. Graph between Brake power and Hydrocarbon



F. Graph between Brake power and NOx



IV. CONCLUSIONS

In the present work, Biodiesel is a fuel made from organic oils & chemically known as free fatty acid methyl ester (FAME) depending on the general characteristic value of the common vegetable oil found in the market it is found that vegetable oil is the best alternative to produce the biodiesel due to its high carbon content, cloud point, kinetic viscosity & relative density. Moreover, it is the relatively cheaper in the market. Alkali transesterification procedure is adopted for the conversion & then the synthesized biodiesel is used for characterisation .Due to larger fatty acid carbon chain of raw material the produced biodiesel contains high carbon content & cetane number. Testing indicated that there will be some problem with biodiesel in operating with low temperature due to having higher pour point perhaps due to greater degree of saturation. But high flash point & high viscosity indicate a high level of safety for biodiesel. It is biodegradable & non- toxic in nature. The finished product may be less cost effective than conventional diesel with respect to the present market price. So, this can be burnt in normal diesel engine just like the usual diesel. Based on the performance and emissions parameters B40 has good Brake thermal efficiency and acceptable range of emission values when compared to other blends. By considering chapter 7 (results and discussions), we concluded that B40 of used sunflower oil can be used as an alternative fuel which can meet our requirements to replace pure diesel oil for daily purposes.

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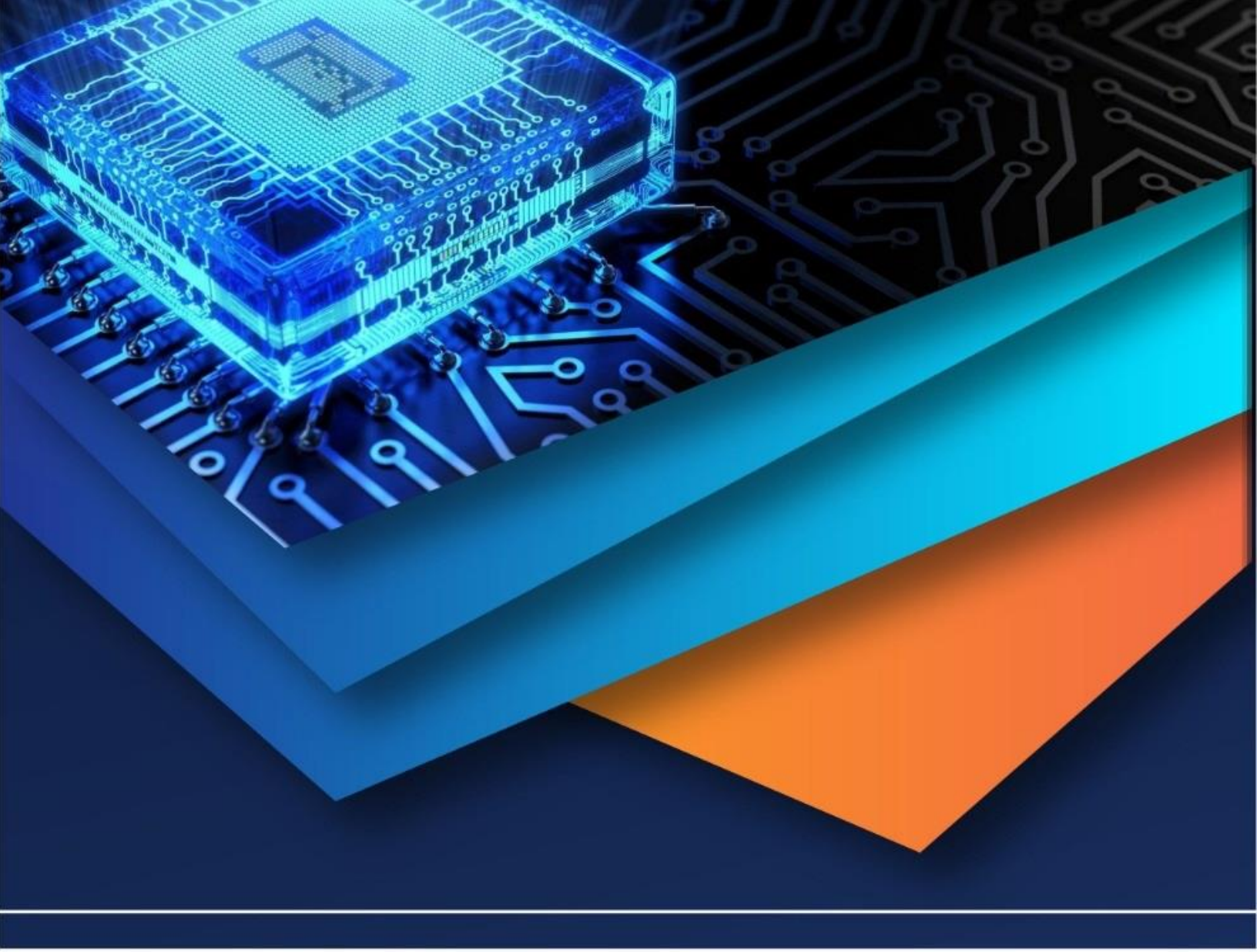

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