REVIEW ON PERFORMANCE AND EMISSION CHARACTERISTICS OF ALTERNATIVE FUEL IN A COMBUSTION ENGINE

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ABSTRACT

The increase in usage of fossil fuels and development of the motorization has led to an enormous rise for petroleum products demand. These fossil fuels are of non- renewable resources they are becoming extinct as years pass by. Therefore, the countries without these resources are in the verge of facing collaboration with foreign countries mainly for the import of crude oil and fossil fuels. Therefore, it is necessary to look for an alternative for these fossil fuels, which can be produced from the resources available within the country. In case of using the edible and non-edible oil as fuel for producing biodiesel, it is studied that it causes less pollution to environment than fossil fuels. In this paper, we have reviewed the performance of biodiesel in the combustion engine and discussed the most suitable method for conversion of ordinary edible and non-edible oil into biodiesel as a replacement for diesel.

KEYWORDS

Fossil fuels, Edible oil, Non-Edible oil, Crude oil, Vegetable oil.

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INTRODUCTION

Alternative fuels also called as non-conventional or advanced fuels are any materials that can be used as fuels, other than fossil fuels. Some known alternative fuels are biodiesel, vegetable oil, bio-alcohol (ethanol), hydrogen, non-fossil methane, non-fossil natural gas, propane and other biomass sources. Due to lack of petroleum fuels available in nature which is also a great threat to the environment, we prefer alternate fuels. Diesel engines are mainly used for transportation, industrial power and agriculture sector. Using straight vegetables oils as fuels in engine will result in bad performance, so we need process and convert the oil into alternate fuels. During the Second World War when diesel was scarce, vegetable oils were used as fuels in emergency conditions [1]. Bio diesel is a fuel which is used to replace fossil fuels and is obtained from renewable sources like animal fats and vegetable oils. This biodiesel is biodegradable and non-toxic and has less pollutant compared with petroleum and diesel. The usage of biodiesel will allow enhance of agriculture, economy and environment [3]. Bio diesel is made from vegetables and animal fats and it does not contain sulphur, aromatic hydro carbons, metal or crude oils residues. Life span of diesel engine is getting higher these days by the usage of biodiesel because it is more lubricating than petroleum and diesel fuels [4]. Another alternate fuel is hydrogen. About 90% of hydrogen is produced by reforming of natural gas. Renewable hydrogen-production methods, such as electrolysis of water using renewable yield electricity, pyrolysis, photo-biological water splitting, photo-electro-chemical water splitting, solar thermo-chemical are the technique used to produce hydrogen gas [10]. Biodiesel consists of fatty acid alkyl esters that can be derived from vegetable oils and animal fats by using a Trans esterification process. There are three different types of catalyst used in trans-esterification process, a strong alkaline catalyst, a strong acid and an enzyme. Biodiesel are obtained from edible and non-edible vegetable oils. Edible vegetable oils such as soybean and canola oil palm oil, rapeseed oil have been used for biodiesel production and non-edible vegetable oils, such as Pongamia pinnate, Jatropha curcas have been found to be best oils for biodiesel production [19]. The Trans-esterification process is the most commonly used commercial process to produce the clean and environmental friendly fuel. Methyl/ethyl/butyl esters of sunflower oil, mahua oil, jatropha oil, soybean oil, rapeseed oil and rubber seed oil have been successfully tested on combustion Engines and their performance has been studied [4].

LITERATURE REVIEW

Metin GUMUS et al., [1]. In this study, hazelnut (*Corylus avellana* L.) kernel oil was tested and studied as an alternative fuel in diesel engines. The hazelnut kernel oil is made to undergo Trans esterification process for reducing the viscosity of the oil. The processed hazelnut kernel oil possesses all the properties of biodiesel used in the diesel engine. The suitable Trans esterification reaction conditions for hazelnut kernel oil are volumetric ratio of the reactants in the ratio 1:5; reaction temperature 65 ◦C and potassium hydroxide is used as a catalyst in this process. This resulted in increased Brake Thermal Efficiency (BTE) and slightly reduced Brake Specific Fuel Consumption (BSFC) for Lower content blends B5 and B20.The maximum BTE increased from 29.96% to 30.80% with B20 blend with diesel. Moreover B5 and B20 improve exhaust emissions.

A. swarna kumari et al., [2]. In this paper, they have used non- edible oil(safflower oil) for blending with diesel for the production of alternate fuel. Using this blend the performance of the diesel engine is tested and studied. The properties of the diesel engine like fuel consumption, volumetric efficiency, brake thermal efficiency and smoke opacity and specific fuel consumption are compared with that of diesel fuel. From the study, the safflower diesel blends have better performance and lower smoke when compared to diesel. For blend B20 there is an increase in thermal efficiency by 5.2%. The engine runs successfully and doesn't need any modifications. At 80% full load the blend B20 has the best fuel with higher brake thermal efficiency (21.9% to 27.1%) than that of diesel fuel by 5.2%. All the blends show better volumetric efficiency with safflower oil blend. Smoke opacity of the b20 blend is low when compared to the diesel.

Oliveira L. E et al., [3] used esters of short chain alcohols to produce a biodiesel as an alternative fuel for mineral diesel. These esters chains are extracted from renewable sources (fats and oils) and its smoke opacity is less. The important feature of fuel is the calorific value; it is the amount of heat transferred during the combustion and indicates the energy available in fuel. The bomb calorimetric is used to find the calorific value. The higher calorific value yields higher performance of the fuel. The calorific value of rapeseed, jatropha curcas, crambe and soybean biodiesel using a calorimetric bomb were calculated and the results were discussed with the ethyl ester composition. The crambe biodiesel possess highest calorific value (ΔH= 40564 J g-1) with the high amount of long chain ethyl ester extracted from behenic acid (C 22:0) with a 57.2% of crambe oil. The jatropha curcas, rapeseed and soybean biodiesel exhibit the same amount of long chain ethyl ester and possess calorific values near to ΔH= 39450 J g-1.

K. Anbumani et al., [4]. In this paper, aubumani discusses the feasibility of plant oils mustard and neem as a substitute for diesel and studied their characteristic and performance on combustion ignition engine were made. Before blending with pure diesel in the ratio of 15:85, 10:90, 20:80 and 25:75 by volume these Oils were esterified with butyl esters. Engine (C.I.) was made to run at different loads and at a speed of 1500 rpm and performance are studied separately on each blend and compared with that of diesel. Results indicated that engine running at blend of 20% of oils shows a much closer performance to that of diesel. Further, mustard oil at 20% blend is esterified and this blended biodiesel satisfies the fuel property standards as per ASTM specifications of biodiesel. It leads to an improved performance of engine and emission characteristics without any considerable change in the engine.

Daniel M. Madyira et al., [5]. In This paper, Daniel M. Madyira reports on analysis and study of using sunflower oil as a diesel blends for the production of biodiesel as alternatives to diesel fuel. Biofuels are now recognized as an alternative viable option. Some of the difficulties of using biodiesel in conventional diesel engines are their higher viscosity, acidity levels that influences the structural performance of the engine and low density which results in low calorific value and leading to incomplete combustion. In this process, in the presence of Sodium hydroxide catalyst and methanol batch Trans esterification is applied to sunflower oil for the production of biodiesel. The biodiesel was characterized and then conducted using Nuclear Magnetic Resonance (NMR), bomb calorimetry, sulphur content tests and Gas Chromatography (GC) and acidity and flash point analysis.

A.S. Ramadhas et al., [6]. In this paper, Ramadhas uses edible vegetable oil to produce biodiesel as an alternative for the diesel used. He discussed the production and characterization of edible vegetable oil and also the experimental work carried out in various countries in this field. Due to the availability of Petroleum in limited reserves, Researchers in different countries carries out different experiments using edible and non-edible oils as combustion engine fuel substitutes. The result of those experiment shows that the thermal efficiency was comparable to that of diesel only with small amounts of power loss during edible vegetable oils. The emissions of biodiesel from edible vegetable oils are higher when compared to diesel but with a reduction in NOx. The result of the analysis shows that Vegetable oil methyl esters give performance and emission characteristics relatively comparable to that of diesel. Hence, they can be a suitable substitute of diesel.

K. Srithar et al., [7]. In this paper, Srithar proposes that Biodiesel produced from vegetable oils has considered as a promising alternate fuel and also says about the performance study and analysis of two biodiesels from mustard oil and pongamia pinnata oil blended at various mixing ratios with diesel. The result of performance of the dual biodiesel in engine and exhaust emissions were studied using a single cylinder, air cooled, direct injection and high speed diesel engine at different engine loads with a constant engine speed of 3000 rpm. The emissions of smoke opacity, nitrogen oxides and hydro carbon of dual biodiesel blends were higher when compared to that of diesel. But the exhaust gas temperature when compared to that of diesel was lower with dual biodiesel. From the experimental study results, the thermal efficiency and mechanical efficiency of Blends were slightly higher than the diesel. Blend B and Blend C are very closer when compared to the diesel values. The Brake Specific Fuel Consumption values of dual biodiesel blends were in accordance to that diesel. Some blends produced slightly lower CO and CO_2 when compared to that of diesel. Thus it produces a considerable advantage of diesel while using the dual biodiesel blends.

D.John Panneer Selvam et al., [8]. In this paper, the production of biodiesel using methyl esters from animal fats as an alternative fuel is tested and evaluated. As biodiesel are oxygenated, non-toxic, sulphur free, renewable and biodegradable it is used as alternative fuel without any significant modifications in engine. In this paper they studied the performance of the neat diesel and its blend at different volumes as (B5, B25, B50, and B75) with diesel. Engine performance of the engine like Brake Power, Brake Specific Fuel Consumption (BSFC), BTE-Brake Thermal Efficiency and emissions of exhaust gases like CO, NOx, HC, and smoke opacity were determined for different load conditions and at constant engine speed of 1500 rpm. The beef tallow methyl esters and its blends can be used as an alternative fuel as it gives lower emission of hydrocarbon, carbon monoxide and smoke when compared with the diesel fuel. But blending at higher proportions with diesel fuel decreases the brake thermal efficiency and increases brake specific fuel consumption. As a result the study reviews that blending at definite proportions produces biodiesel at good performance.

Puneet Verma et al., [9]. In this paper, they discuss about the use of eucalyptus oil as biodiesel. The higher viscosity causes oil impossible to use directly in the diesel engine. The viscosity is removed partially or completely by the process of esterification. The result of blending on eucalyptus oil is found to have Brake Specific Fuel Consumption 2.34% lower than that of diesel. In case of smoke opacity emission it is found to be 64.5% cleaner than that of the diesel. In case of brake thermal efficiency it is found to be .52% lower than that of the diesel. As a result the smoke gets cleaner than diesel in case of eucalyptus biodiesel so it controls air pollution. Since Brake Thermal Efficiency was found to slightly (0.52%) lower than diesel so it would be a potential replacement for diesel.

Mohamed F. Al_Dawody et al., [10]. In this paper, blends of a soybean methyl ester (SME) with diesel fuel are used. They measured the effect of blending over cylinder pressure, heat release rate, unburned hydrocarbon, carbon monoxide, NOx, and smoke opacity. These results provide lower smoke opacity up to 48.23% in case of using biodiesel, and also provide higher (BSFC) with 14.65% higher when compared to diesel fuel. The CO emissions with results shows that, for blend ratio B20% and B100% it is 11.36% and 41.7% lower than diesel fuel. For every blend ratio of SME, it emits lower concentrations of UHC when compared with diesel. NOx emissions are found to be higher for all blends of SME but in case of 20% SME with diesel it gives lower emission of (NOx).

Hwai Chyuan Ong et al., [11]. Cerbera manghas oil is the best suited non edible oil for biodiesel in case of availability. Production of biodiesel from cerbera manghas vegetable was done by Hwai Chyuan Ong. Due to higher viscosity these oil can’t be directly used in diesel engine. The viscosity of crude oil is 32.83 mm2/s and12.64 mg KOH/g acid value which is too higher than 2%).cerbera manghas methyl ester (CMME) is produced from acid-alkaline trans esterification with sulphuric acid as acid catalyst and KOH as alkaline catalysts. Hence a blend of 98.5% of biodiesel was achieved with 9 parts methanol in presence of 1 part sodium hydroxide. The properties of cerbera manghas methyl ester are very suitable for the provisioned biodiesel standards. It can be conclude that cerbera manghas oil can be used a main feedstock for biodiesel based on its properties.

H.G. How et al., [12]. In this paper, H.G. How studied the performance of the four cylinder, direct injection diesel engine with adding additives like bioethanol to biodiesel blends. He used different ratio of blends for testing the engine performance. B20 consisting of 20% coconut biodiesel and remaining amount is of diesel, another type is B20E5 consisting of same mixture as B20 but added an additive of 5% ethanol. The result shows that there was an increase in Brake Thermal Efficiency (BTE) and Brake Specific Fuel Consumption (BSFC) with biodiesel mixed ethanol blends. Apart from that ethanol-biodiesel blend shows low emission of NOx, CO and smoke when compared to that of diesel. In case of adding higher concentration of oxygen content in the ethanol blend it results in successful operation of the engine without any considerable modifications.

C.S. Cheung et al.,[13]. In this paper, C.S. Cheung studied the performance and emission characteristics of 4-cylinder direct-injection diesel engine with fuel consisting of mixed concentrations of biodiesel and diesel. This experiment was carried in different load conditions and at a constant speed of 1800 rpm. This resulted in decrease in particulate emission of HC, CO and a increase in emission of NOx. Thus he concluded that with increasing biodiesel in the fuel the particulate emission of HC, CO are reduced and ignition temperature decreases. It generates volatile soot which can be easily burnt off when compared to diesel.

C. T. Alves et al., [14]. In this paper, Production of biodiesel from waste frying oils was tested with zinc aluminate (ZnAl2O4) as a heterogeneous catalyst produced by the combustion of urea with aluminium nitrate and zinc nitrate. The trans esterification was done and studied at different temperatures between 60 and 200 degree Celsius with an molar ratio of (alcohol: oil) 40:1 about two hour reaction time, stirring at 700- 800 rpm and varying catalyst (from 1% to 10%). The same catalyst was used for three different reaction cycles resulted in 0%loss of biodiesel yield at the best reaction condition. This indicates the feasibility of the proposed method of production of biodiesel from frying oils with zinc aluminate.

Parag Saxena et al., [15]. Reported, the high demand off energy and decreasing petroleum resources and effects of environment has led to the search for alternative fuel which is renewable and bio degradable. The biodiesel fuel was more than the petro diesel in quality and efficiency. They researched properties of biodiesel search as thermodynamic properties, pour point, kinematic viscosity, cloud point, cetane number, cloud filter plugging point, flash point value. Finally they concluded that biodiesel as a potential and sustainable substitute for petro diesel.

Md Ehsan et al., [16]. Reported straight vegetable oils and waste cooking oil are not suitable for to be used directly to diesel engines due to their viscosity. In this paper alkaline based catalyst methods are used to reduce the viscosity and modify the waste cooking oil to useful fuel. CH3 OH (methanol) and NAOH (sodium hydroxide) are mostly used as base catalyst in this process because of low costs and higher reaction rates and higher yields. They used SST (single stage Trans esterification) for convert the fuels.

Shakinaz A. El Sherbiny et al., [17]. Reported biodiesel are produced by many methods such as base catalysts, Trans esterification, and acid catalyst esterification. But all the methods are need a pre-treatment process and time consuming is high. In this paper they selected the jatropha oil for an experiment with using the three m0ethods for producing biodiesel. The third method is microwave assisted technique and this method did not need a pre-treatment process and time consuming is low. The result of these technique microwaves is better than the other two methods.

Hifjur Raheman et al., [18]. Reported experiment in single cylinder direct-injection diesel engine was evaluated using blends of biodiesel with (B20 and B40) produced from the mixture of mahua and simarouba oils (50:50). The experiment is carried for the performance on the brake specific fuel consumption, exhaust gas temperature and emission such as CO, HC and NOx and brake thermal efficiency. Biodiesel are produced by two steps a lid- base process acid pre-treatment.

Syarifah Yunus et al., [19]. Reported experiment was conducted in 4 stroke single vertical cylinder diesel engine by using a jatropha- palm blended biodiesel as fuel. They need is find engine emission of carbon monoxide, carbon dioxide and nitrogen oxides were analysed in usage of biodiesel. All tests were carried out at varied load conditions. Finally the results are emission produced by biodiesel blended is much higher than the diesel fuels due to the large amount of oxygen content in the biodiesel. Thus the properties must be analysed in order to reduce the emission and increase the efficiency of biodiesel.

A.M. Liaquat et al., [20]. In this paper, A.M. Liaquat tested and studied the performance of the biodiesel produced from processed coconut oil in the compression engine without any modification in the diesel engine. In this process he used three different samples of biodiesel blends (CB5, CB15) respectively. At different operating conditions the performance and the emission characteristic of the compression ignition engine. As a result of the experiment carried out with these blends there was a decrease in brake power and torque, while there was an increase in specific fuel consumption for the every speed compared to pure diesel fuel. There was a considerable decrease in the emission of HC, CO and increase in emission of carbon-di-oxide and NOx and also reduction in sound level was observed for biodiesel blends when compared to that of diesel fuel. Thus, as a result of using CB5 and CB15 in ignition engines the performance was well enhanced when compared to that of diesel fuel without any modification in the diesel engine.

A. Sanjid et al., [21]. In this paper, A.sanjid uses mustard biodiesel produced from the mustard oil. The performance and emission of the engine was tested and studied. From the results it was concluded that the calorific value was superior to other biodiesel of 40.404 MJ/kg. He used MB10 and MB20 as blends in the tests and the result showed that BSFC was 8-14% higher than diesel and BTE was 5-6% lower than diesel. There is a decrease in engine torque with the use of the biodiesel blends. The emission of NOx was 9-12% higher than diesel and HC was 24-42% lower than diesel and CO emission was 19-40% lower when compared to pure diesel. As a result this biodiesel blend can be used in diesel engine without any modification.

CONCLUSION

In this paper we have reviewed the use of edible and non-edible oil as biodiesel and performance of the engine with these biodiesel is studied and the best suitable method is conveyed.

- In order to convert the normal edible and non-edible into a suitable biodiesel we have to lower the viscosity of the oil. The best method for this process, transesterfication is recommended. In case of higher viscosity two step acid alkaline transesterfication methods is recommended.
- Use of bioethanol as additive results in decrease in the emission of the NOx when compared to diesel. For every biodiesel blends there is a considerable decrease in the emission of NOx.
- Using eucalyptus oil and coconut oil as a biodiesel blend the performance of the engine was very close to that of the diesel.

- The blends of (Safflower Oil, Vegetable Oils, cooking oil, Cerbera Manghas oil, Hazelnut Kernel Oil, oil from beef tallow) showed average performance of in the combustion engine but showed a considerable variation in the emission of the CO, HC and NOx. The Brake Thermal Efficiency (BTE) was lower than that of diesel and Brake Specific Fuel Consumption (BSFC) was higher when compared to that of diesel.

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