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EXPERIMENTAL INVESTIGATION OF VARIOUS PARAMETERS FOR OPTIMIZED PERFORMANCE OF CI ENGINE USING CORN BIODIESEL

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Abstract

Petroleum based fuels is a finite resource that is rapidly depleting. Consequently, petroleum reserves are not sufficient enough to last many years. Biodiesel is one of the alternative fuel made from vegetable oil, friendly for environment and has no effect on health and can reduce the emission compared with diesel fuel. With this objective, the present work has focused on the performance, combustion and emission characteristics of diesel engine using corn oil and its blends with diesel. In this investigation, the blends of varying proportions of corn biodiesel with diesel (S20, S40, S60, S80 & S100) were prepared, analyzed, and compared the performance and exhaust emission with diesel using 5.2 kW Single cylinder, 4stroke diesel engine. The performance and emission characteristics of blends are evaluated at variable loads and constant rated speed of 1500 rpm and found that the performance of C20 blend of corn oil gives result, that is near to the diesel and also found that the emission CO2, HC of this blend is less than the diesel.

Keywords: *Corn, Biodiesel, Blend, Vegetable oil, Alternative fuel*

1. Introduction

In the last few years, the world's energy demand is increasing due to the needs from the global economic development and population growth. However, the most important part of this energy currently used is the fossil energy sources. The problem is fossil fuels are non renewable. They are limited in supply and will one day be depleted. There is an increased interest in alternative renewable fuels. Biodiesel is one of the most promising alternative fuels for diesel engines.. Biodiesel is defined as a fuel comprising of mono alkyl esters of long chain fatty acids derived from vegetable oil or animal fat. As biodiesel is an environmentally friendly fuel, it is the best candidate to replace fossil-diesel, which has lower emissions than that of fossil-diesel, it is biodegradable, nontoxic, and essentially free of sulphur and aromatics. However, only nitrogen oxides increase using biodiesel as fuels. Maize belongs to the family poaceae. It also known as corn. The leafy stalk produces ears which contain the grain, which are seeds called kernels Maize kernels are often used in cooking as a starch. The six major types of maize are dent, flint, pod, popcorn, flour, and sweet. The maize plant is often 2.5 m (8 ft) in height, though some natural strains can grow 12 m (39 ft). The stem is commonly composed of 20 internodes of 18 cm (7.1 in) length. A leaf grows from each node, which is generally 9 cm (4 in) in width and 120 cm (4 ft) in length. Corn, also known as maize (the terms are interchangeable), is one of the most important crops in the world, and is the largest crop of the Americas. Almost 700 million metric tons of this nutritious and valuable plant is harvested annually worldwide. Because it is cold-intolerant, in the temperate maize must be planted in the spring. Its root system is generally shallow, so the plant is dependent on soil moisture. As a C4 plant (a plant that uses C4 carbon fixation), maize is a considerably more water-efficient crop than C3 plants (plants that use C3 carbon fixation) like the small grains, alfalfa and soya beans. Maize is most sensitive to drought at the time of silk emergence, when the flowers are ready for pollination. Because of its shallow roots, maize is susceptible to droughts, intolerant of nutrient deficient soils, and prone to be uprooted by severe winds.

2. Characteristics of CI engine fuels

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulphur and aromatics.

Biodiesel is made through a chemical process called transesterification where by the glycerine is separated from the fat or vegetable oil The process leaves behind two products methyl esters (the chemical name for biodiesel) and glycerine (a valuable by product usually sold to be used in soaps and other products) and biodiesel is better for the environment because it is made from renewable resources and has lower emission compared to petroleum diesel. The transesterification is achieved with monohydric alcohols like methanol and ethanol in the presence of an alkali catalyst. Biodiesel and its blends with petroleum based diesel fuel can be used in diesel engines without any significant modifications to the engines.

2.1 Extraction of raw oil

- Collecting the Corn seeds
- Impurities are separated by pneumatic system
- Seeds are fed into expellers then squeezed to obtain high quality oil and cake
- The oil is then pumped through a filter press and finally collected in the bottom storage tank

2.2 Biodiesel Transesterification Reactions

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

Physical and chemical properties are more improved in esterified vegetable oil because esterified vegetable oil contains more cetane number than diesel fuel. These parameters induce good combustion characteristics in vegetable oil esters. So unburnt hydrocarbon level is decreased in the exhaust. It results in lower generation of hydrocarbon and carbon monoxide in the exhaust than diesel fuel.

The vegetable oil esters contain more oxygen and lower calorific value than diesel. So, it enhances the combustion process and generates lower nitric oxide formation in the exhaust than diesel fuel.

2.3 SEPARATION OF GLYCEROL FROM BIO-DIESEL

- The excess methanol used in the biodiesel process collect in the glycerine layer that settles out at the bottom
- Separatory funnel because it is good for separating liquids that split into two layers
- The methoxide reacts with the oil and makes two products. One is glycerin and the other is biodiesel
- The glycerin will sink to the bottom and it is collected at the bottom through stopcock .

2.4WASHING OF CORN BIO-DIESEL:

- This step is optional
- To remove the certain amount of dissolved methanol
- After separating this impurity finally we get the pure corn bio-diesel.

2.5 The Properties of Diesel fuel and corn biodiesel

The different properties of diesel fuel and corn biodiesel are determined and shown in table.3.2. After transesterification process the fuel properties like kinematic viscosity, calorific value, density, flash and fire point get improved in case of biodiesel. The calorific value of corn biodiesel is lower than that of diesel because of oxygen content. The flash and fire point temperature of biodiesel is higher than the pure diesel fuel this is beneficial by safety considerations which can be stored and transported without any risk

Table -1: Fuel properties

Fuel Properties	Diesel	biodiesel	Apparatus
Fuel density in $\frac{kg}{m^3}$	830	885	Hydrometer
Calorific value (kJ/kg)	42000	39957	Bomb calorimeter
Flash point in ^{o}C	56	140	Pensky-martien’s apparatus
Fire point in ^{o}C	65	68	Pensky-martien’s apparatus
Kinematic viscosity at 40^{o}C in cst	2.1	6	Redwood viscometer

3. Experimentation

3.1 Engine components

The various components of experimental set up are given below. Fig.3.8 shows the photograph of the experimental set up and Fig.3.9 shows the line diagram. The important components of the system are

- The engine
- Dynamometer
- Smoke meter
- Exhaust gas analyzer

Fig -1: Photograph of experimental setup

4. Results and discussions

4.1 Introduction

This chapter consists of three types of experimental analysis, first one is performance characteristics like brake thermal efficiency specific fuel consumption, exhaust gas temperature ,against brake power, second one is combustion characteristics like pressure, and heat release rate, against crank angle, and finally third one is emission characteristics like carbon monoxide(co) carbon dioxide(co2),unburned hydrocarbon(HC), NOx and against to brake powercarbon dioxide (co2), unburned hydrocarbon(HC) , NOx against brake power.

4.2 Performance characteristics of diesel, blends of Mango seed biodiesel on diesel engine

4.2.1 Brake Thermal Efficiency

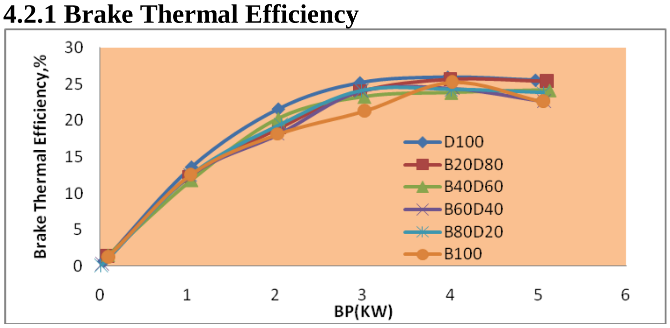

Fig -2: Variation of brake thermal efficiency with brake power

The Fig.2 shows variation of brake thermal efficiency with brake power for diesel,corn biodiesel and their blends are shown in fig.for all the cases with the increase of engine loads thermal efficiency increase.brake thermal efficiency of 20% blends is very close to diesel for entire range of operation. Maximum brake thermal efficiency diesel oil is 25.9% against 25.7% of 20% blend which is lower by 0.2% we can say that of brake thermal efficiency of 20% blend is well comparable with diesel oil.the drop in thermal efficiency is attributed to the poor combustion characteristics of vegetable oils due to high viscosity and poor volatility.

4.2.2 Specific fuel consumption

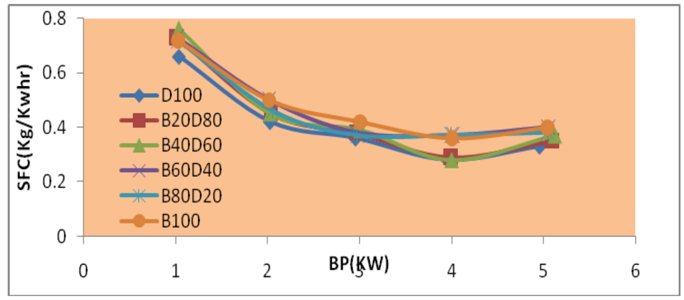

Fig -3: Variation of specific fuel consumption with brake power

Fig .3 shows The variation of specific fuel consumption with brake power for diesel,corn biodiesel and their blends are shown in fig. as the power developed increases the specific fuel consumption decreases for all the tested fuels.this may be due to fuel density,viscosity and heating value of the fuels. BSFC of 20%blend closely matches with diesel oil. Minimum BSFC of 40% blend 60%blend80%blend and 100%blend are 0.28kg/kW-h,0.37kg/kW-h,0.37kg/kW-h and 0.36kg/kW-h against 0.28kg/kW-h of diesel oil.the specific fuel consumption of all blends is more than that of diesel oil.

4.2.3 Exhaust Gas Temperature

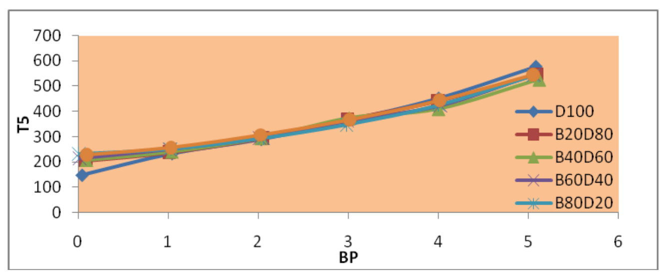

Fig -4: Variation of exhaust gas temperature with brake power

Fig.4 shows the variation of exhaust gas temperature with brake power output for corn biodiesel and its blends with diesel .the exhaust gas temperature of all blends and diesel increase with increase of operating loads .this is an indication of lower exhaust loss and could be possible reason for higher performance.

4.3 Emission characteristics

4.3.1 Carbon monoxide

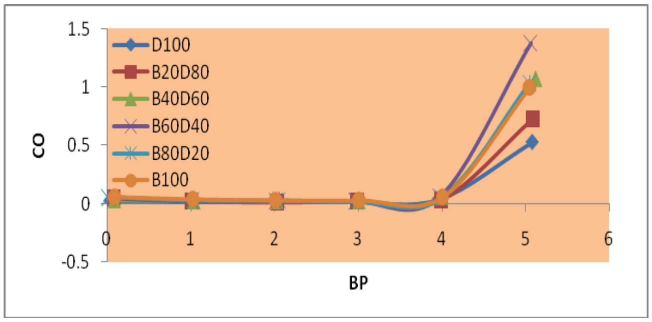

Fig -5: Variation of carbon monoxide with brake power

Fig.5 shows the comparison of brake power with carbon monoxide for different biodiesel blends. the CO emission depends upon the strength of the mixture, availability of oxygen and viscosity of fuel. it is observed that CO emission initially decreases at lower loads sharply increases after 4kw of power for all tests fuels. CO emission of blends is higher than that of diesel . among the blends 20% blends has lower CO emission followed by 100%,40%blend.CO emission of 100%40%and 20%blends at maximum load is 0.53,1.07 and 0.73. CO emission of 60% corn biodiesel is higher than all other blends for entore operating range and the maximum value is 1.38 volume occurs at rated load.

4.3.2 Hydrocarbon

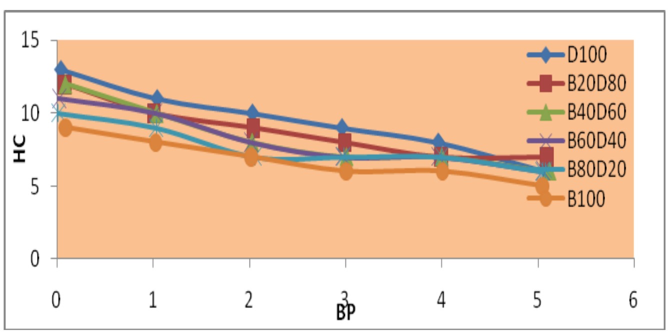

Fig -6: Variation of hydrocarbon with brake power

Fig.6 shows The variation of HC emission with brake power of diesel ,corn biodiesel and their blends are shown in fig. The hydrocarbon emission(HC) is resultant of incomplete combustion .the hydrocarbon emission of diesel is found highest. as the percentage of biodiesel increases the hydrocarbon emission decreases .

4.3.3 Carbon Dioxide

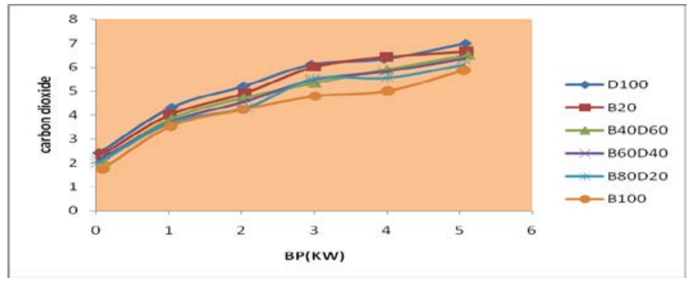

Fig -7: Variation of carbon dioxide with brake power

The variation of carbon dioxide with brake power of the engine is shown in figure10.it is observed that carbon dioxide emission increase with increase of brake power. The minimum carbon dioxide value for the corn oil was 1.76 for corn and it initial brake power 0.04 it was 2.41 for diesel. This is result of low availability of oxygen during combustion

4.3.4 NO_X

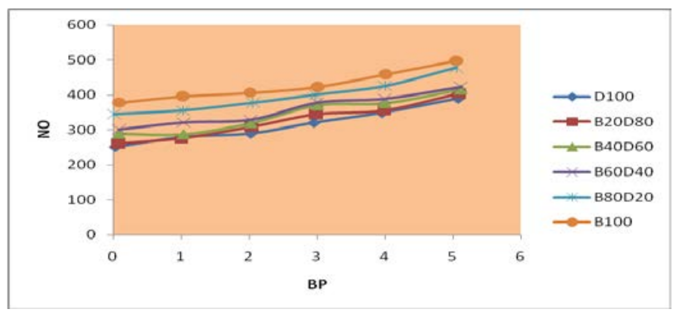

Fig -8: Variation of NOx with brake power

power for diesel and corn blends.

Fig 8 shows that the NOx emission increased with the increase of percentage ratio of biodiesel. NOx emission is primarily a function of total oxygen inside the combustion chamber, temperature, pressure, compressibility, and velocity of sound. Invariably biodiesel has high level of oxygen bound to its chemical structures. Thus, oxygen concentration in biodiesel blends fuel might have caused the formation of NOx . Furthermore, the increase of NOx emission is due to the higher cetane number of biodiesel which will reduce the ignition delay. The increase of NOx emission is a result of the reduced ignition delay. However, the NOx emissions can be reduced through engine tuning or using exhaust catalytic converter. At any rate, the NOx still can be reduced with the advanced technologies such as catalytic converter, EGR and engine tuning.

4.4 Combustion characteristics

4.4.1 Cylinder pressure with Crank angle

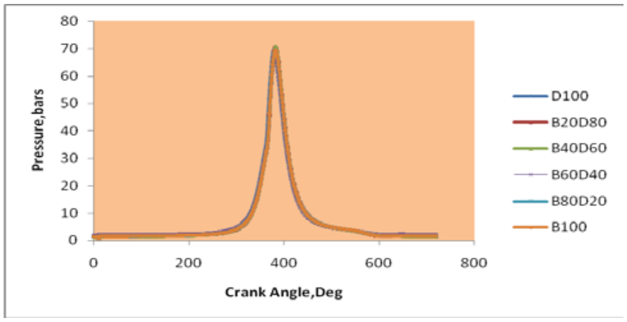

Fig -9: Variation of cylinder pressure with crank angle

In a CI engine the cylinder pressure is depends on the fuel –burning rate during the premixed burning phase, which in turn leads better combustion and heat release. The variation of cylinder pressure with respect to crank angle for diesel and different blends of corn biodiesel are presented in fig .peak pressure and crank angle is 69.58 bars and 382 Deg at 100% pure biodiesel and diesel oil is 69.76bars and 379 Deg .respectively.

4.4.2 Heat Release Rate with Crank Angle

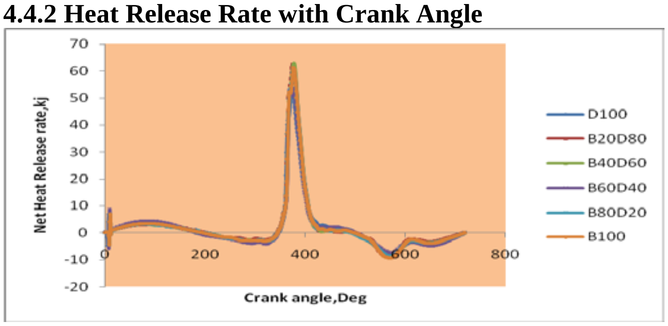

Fig -10: Variation of heat release rate with crank angle

Fig.10 shows The variation of cylinder net heat release rate with respect to crank angle for diesel and different blends of corn biodiesel are shown in fig 11.the peak point of heat release rate with crank angle is diesel oils 53.15(j/ca) and 373.deg.

4.4.3 Commulative Heat Release Rate with Crank Angle

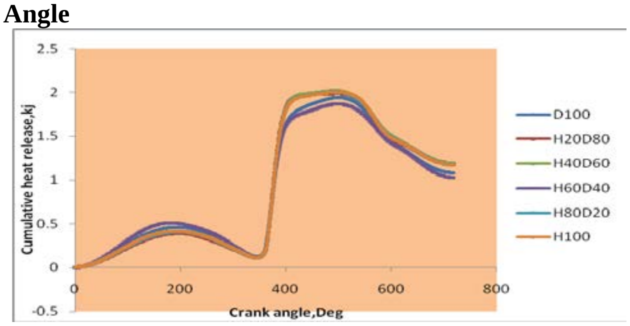

Fig -11: Variation of commulative heat release rate with crank angle

The fig 11 shows the variation of cumulative heat transfer with crank angle. It is observed that that all blends of canola biodiesel traces the same path as that of the diesel. Initially the cumulative heat transfer decreases at first cycle and then increases in the second cycle as shown in the fig11.

5. Conclusions

- Corn biodiesel can be directly used in diesel engines without any engine modifications
- Brake thermal efficiency of 20% blend is equal to diesel compared to other blends
- Specific fuel consumption increases as the concentration of corn biodiesel increases so we can observe that with 20% corn biodiesel blend almost matches with diesel fuel.
- Minimum BSFC of 20% blend 40% blend 60% 80% and 100% blend are 00.29 kg/kW-h, 0.28kg/kW-h, 0.37 kg/kW-h, 0.37 kg/kW-h 0.36kg/kW-h against 0.28 kg/kW-h of diesel oil.
- The exhaust gas temperature of all blends and diesel increases with increases of operating loads
- Combustion characteristics are all blends of mahua biodiesel is almost same as that of diesel
- The emission characteristics like CO, N_{Ox} are increases and HC, CO2,levels are decrease against diesel oil.
- From the above analysis the blend B 20Shows the better performance comparared to other blends.

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