Performance And Emission Study of Methyl Ester of Watermelon Seed Oil Operated At Varying Injection Opening Pressure on Single Cylinder DI Diesel Engine

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Abstract- *The depleting fossil fuel resources increase the price of fuel continuously. At one point of time the whole resources may come to end. Keeping this in mind many researchers identified various alternative fuels and tested successfully .In the present investigation an attempt is made to assess the suitability of watermelon seed oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure. In the present investigation biodiesel from watermelon seed oil has been investigated in a constant speed DI diesel engine with varied fuel injection pressures (180 to 220 bar). The main objective of this study is to investigate the effect of injection pressures on performance and emissions characteristics of the engine. The experimental data for various parameters such as brake thermal efficiency, brake specific fuel consumptions (BSFC) are analyzed and emissions such as CO2, HC, NOx and CO are measured using exhaust gas analyzer. The result shows that the maximum brake thermal efficiency for D100 (diesel fuel) and B20 (Diesel 100% + 20% Watermelon oil) are 29.5% and 27.43% respectively at injection opening pressure of 180 bar. For D100 and blend B20 HC and CO2, NOx emissions are lower at 200 bar and full load, NOx emissions (11 PPM and 25 PPM). CO emissions are lower at 220 bar and full load, CO emissions (0.03% and 0.14%).*

Keywords*-* Diesel, Watermelon oil, injection pressures, Performance, emission

I. INTRODUCTION

The world is moving towards a sustainable energy era with major emphasis on energy efficiency and use of renewable energy sources. Bio-fuels can provide a feasible solution to these problems. Bio fuels are fuels derived from alcohol and vegetable oils. However, modification, handling and transportation, ease of production, and investment cost are some of the important parameters that should be considered before using an alternative fuel in an existing diesel engine.

India's energy consumption has been increasing at one of the fastest rates in the world due to population growth and economic development. The Indian power system is the fifth largest in the world, With an annual electricity production of 1,031 British Units (BU), it is among the top five power consumers across the globe, and the demand is expected to touch 1,900 BU. Coal, oil, and natural gas are the three primary commercial energy sources. Coal is the largest source of energy. The use of coal for electricity generation in India is expected to increase by 2.2 percent per annum during 2002–2015. Various forms of energy consumption in India as shown in Fig.1

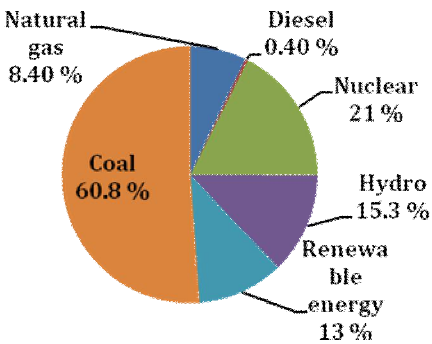

Fig.1: Various forms of energy Consumption in India

Biomass is generally considered to be close to carbon neutral because the CO_2 emitted to the atmosphere during combustion is absorbed while growing the replacement biomass. The carbon neutral diagram is a closed loop system. Renewable resource continues to take up carbon as rapidly as it is released by burning. The Carbon neutral cycle as shown in the Fig.2

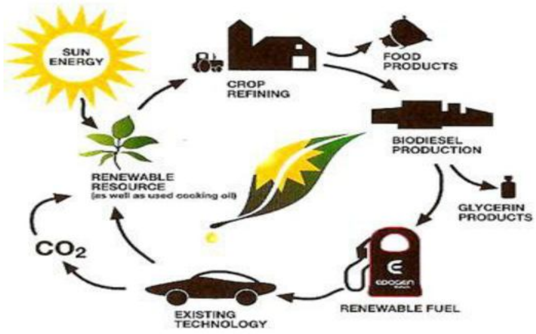

Fig.2: Biomass Carbon neutral diagram

In the present work, biodiesel is produced from non edible oil from Water Melon Seed is used. Watermelon seed contains about 50% oil 30% proteins and high content of unsaturated fatty acids. The regions of its cultivation are Middle East, West African (Nigeria, Ghana, Togo, Benin) and other African countries. It is also used in the making of cosmetics, medicaments and manufacturing of soap. The present study was to investigate the use of Watermelon seed oil as a potential feedstock for biodiesel production.

II. LITERATURE REVIEW

2.1 Introduction of Water melon seed oil

Melon seed (Citrullus lanatus.) oil provides another useful source of biodiesel production. The melon seed (Citrullus lanatus.) popularly known as egusi in Nigeria is from the family cucurbitaceae. The seed is rich in oil, low in cholesterol and contains essential and unsaturated fatty acids. Melon seed oils were extracted at a very high yield. The extracted oil was subjected to oil quality tests and subsequently transesterified to give fatty acid methyl esters or biodiesel.

Fig.3: Pictorial view of Watermelon seeds

2.2 Review of papers

(Oladeji A.ogunwole, July-December 2015) The viscosity of the produced watermelon seed biodiesel was 1.05mm2/s. High Speed Diesel (HSD) has viscosity of 1.3 - 4.1 at 40°C whereas the viscosities of Castor bean oil biodiesel and pongame oil biodiesel are 5.67 and 5.5 respectively, which is slightly higher than the viscosity of High Speed Diesel and watermelon seed biodiesel. It shows that the viscosity of watermelon seed biodiesel were comparable to diesel and other non-edible oils. Since viscosity is the rate of opposition of flow of a liquid, it makes it to be a very important property of biodiesel. Biodiesel have higher viscosity than conventional diesel, though higher viscosity leads to poorer atomization of fuel injectors but the obtained viscosity of the biodiesel was found to be within the biodiesel standard of America.

(**Emmanuel I.Bello, November 2013)** Egunsi melon oil has 78.90% saturation and the major constituent is 62.35 % linoloic acid. After transesterification, the triglyceride of the oil reduced from 98.83 % to 0.004 % for B100. The free, bound and total glycerol values are within the ASTM limits. The physico-chemical properties of the fuel are similar to those of diesel fuel thus confirming that it can be used in diesel engine with little modification.

(Santhosh Kumar et.al, May 2016) Taguchi method coupled with grey relational analysis can be used effectively for investigation of multiple performance characteristics of diesel engine. It was found that diesel engine when operated on B20 watermelon biodiesel blend, with compression ratio of 18 at full load of 9 Kg and Injection timing of 23º BTDC has given optimum engine performance which is defined by maximum thermal efficiency, minimum brake specific energy consumption and lowest emissions.

(Solomon Giwa, March 2010) Fuel properties and fatty acid composition of egusi melon (water melon) oil biodiesel were found to be synonymous to those of soybean, sunflower and safflower biodiesel which have been well established and widely published. It is worth mentioning that EMSO (Egusi Melon Seed Oil) has a remarkably low kinematic viscosity compared to most biodiesel. This present study has justified the use of EMSO as a potential raw material for biodiesel production**.**

(L.Karikalan et.al 2015) Investigated the performance and emission characteristics were determined by varying fuel injection pressure of J20 (Jatropha biodiesel) from 180bar to 240 bar. The result shows that the maximum BTE at 75% load for J20 at 240 bar is 3.04% more than standard fuel injection opening pressure of 200bar.Lowered SFC noticed at maximum load at 240bar, HC emissions lowered by 21.4% at 240bar, CO emissions lowered by 0.03% along with the increased NO_x emissions and exhaust gas temperature. The Smoke opacity is 5.2HSU higher for J20 at 240bar .From this study, it is clear that J20 biodiesel at 240 bar fuel injection opening pressure will give optimum engine performance

(Sanjay Patil.et.al.March 2012) Experiment were conducted on CI engine fuelled with diesel at Injection Pressure of 200 bar to get base line data for comparing engine performance with various blends of Palm oil methyl ester (POME) and diesel as test fuels at different injection pressures. The results indicate that the performance of engine is improved with B60 (60% POME and 40% diesel) at injection opening pressure of 220 bar compared to other test fuels at different injection pressures. In this investigation comparison of test fuel B60 at different injection pressures with diesel at 200 bar is made. It is observed that brake thermal efficiency is improved and brake specific energy consumption is lowered with B60 at 220 bar due to improved atomization. It is also observed that carbon monoxide, unburned hydrocarbons are reduced and NO_x emissions increased compared to other test fuels at different injection opening pressures.

(Ramesha D K et.al oct 2013) Experiments were conducted on 10 HP single cylinders, four stroke, water cooled CI engine using Honge oil methyl esters (HOME) to study the engine performance and emission at different injection pressures of 180, 200 and 220 bar. The results indicates that the maximum efficiency for HOME tested is obtained at 200 bar IP is 34.72%, which is close with diesel fuel lowest BSFC for HOME tested was found to be at 200 bar injection Pressure is 0.259 Kg/KW-hr. The lowest CO emission was observed at 200 bar is 0.32%. NO_x emissions were lower at 200 bar injection opening pressure indicating that effective combustion was taking place during the early part of expansion stroke. From the experimental results it can be concluded that a significant improvement in the performance and emission, if the fuel injector opening pressure is at 200 bar.

(P.L.Puthani.et.al May 2016) Test has been carried for different fuel injection pressure such as 190, 205 and 220 bar respectively. BSFC, BTE, emissions like CO, HC, NO_x and smoke density are measured. Tests are conducted on the engine at different injection pressure for different loads of simarouba blends. The results were Brake thermal efficiency of Simarouba Oil Methyl Ester (SOME) blend B20 i.e. 0.559% near to brake thermal efficiency of diesel at 205 bar injection opening pressure. Compared to pure diesel the biodiesel has better emission properties. CO and HC emission are lesser than that of pure diesel, as SOME contains more oxygen content which results in complete combustion. NO_x values for all SOME blends are higher than the values of pure diesel.

Kennedy Izuchukwu Ogunwa, August 2015) The result of the oil quality parameters of the extracted melon seed oil shows that It is obvious that transesterification has drastically reduced the moisture content and acid value of melon seed oil giving the produced biodiesel better fuel characteristics. There is also a sharp reduction of the kinematic viscosity of the melon seed oil from 21.65 to 5.8 mm^2/s in the biodiesel, a value that is comparable to that of the petro diesel

2.3 Preparation of biodiesel

Transeserification: Transesterification is the process of reacting a triglyceride molecule with an excess of alcohol in the presence of a catalyst (KOH, NaOH etc.) to produce glycerin and fatty esters. The mixture of fatty esters produced by this reaction is known as biodiesel. This process has been widely used to reduce the viscosity of triglycerides. 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 engine.

Process details

- **Preparation of Potassium Methoxide**

Carefully pour the KOH solution into 100 ml methanol. Agitate the mixture until the KOH is completely dissolved in the methanol.

- **Heating and Mixing**

The potassium methoxide solution prepared is mixed with oil. The residue is heated in between 120 ^oF to 1300 ^oF after which it is mixed well using a stirrer at 300 rpm. Continue mixing the contents. Carefully pour the potassium methoxide and shake vigorously for 15 minutes.

- **Settling and Separation**

After mixing the liquid, it is allowed to cool down. After the cooling process, the bio fuel is found floating on the top while the heavier glycerine is found at the bottom. The glycerine is easily separated by allowing it to drain out from the bottom. In this way pure Bio Diesel is prepared.

- **Washing**

Biodiesel and glycerin will separate due to density difference. Glycerin and unreacted catalyst will sink to the bottom and can be easily drained. After separation of biodiesel it must be washed with hot water to remove unreacted methanol and potassium hydroxide

- **Filtration**

In this process, the waste vegetable oil is filtered to remove all the food particles. This process generally involves warming up the liquid a little. After warming up the liquid, it is filtered with the use of a cotton cloth.

- **Removing Water**

All the water contained in the residual gangue is removedwhich makes the reaction faster. The water is easily removed by boiling the liquid at 500 °C for some time.

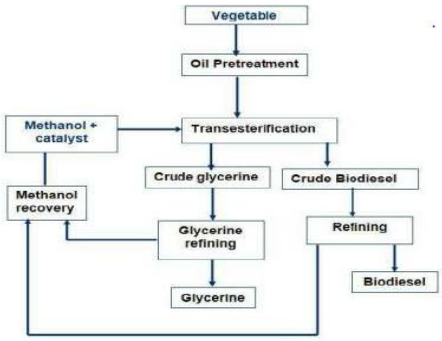

Fig.4: Pictorial view of Transesterification Process

2.4 Advantages and disadvantages of biodiesel

Advantages:

- Biodiesel is agriculture oriented, nontoxic, and biodegradable and a renewable fuel. It has a high cetane number, low sulfur, low volatility and presence of oxygen atoms in the fuel molecule.
- Biodiesel fuel is that it can also be blended with other energy resources and oil.
- Its refineries are comparatively simpler and environmental-friendly in design than typical petrochemical refineries.
- Biodiesel is safe to store and handle due to higher flash point
- It is relatively less inflammable compared to the normal diesel.

Disadvantages:

- When using biodiesel, the problem encountered is the increase in nitrogen oxides emissions which can result in the formation of smog and acid rain.
- Biodiesel when compared to petro-diesel have a lower energy output. In order to produce the same amount of energy, more biodiesel is required than petro-diesel.
- The use of valuable cropland to grow biodiesel crops could result to a rise in cost of food and furthermore leads to food scarcity
- B100 generally not suitable for use in low temperature
- It has high gel point so it should be blended.

2.5 Scope of the work

- Determining the characteristics of diesel and water melon seed biodiesel blend.
- Determining and comparing performance and emission characteristics of water melon seed biodiesel and blends with diesel.
- Find out the optimum blend which can gives the better result
- Determining the performance, emission and combustion characteristics of optimum blend operated at varying injection pressures (like 180, 200 and 220 bar)

Table.1: Properties of Watermelon seed oil and conventional diesel fuel

Fuel properties	Water melon seed biodiesel	Diesel
Viscosity at 40 °C (centi stokes	2.6	3.4
Density (Kg /m^{3})	880	842
Calorific value (KJ/Kg)	40850	42500
Flash point (°C)	191	58
Fire point (°C)	198	67
Ash content of the fuel (%)	1	-
Cloud point	Below -10 °C	-

III. EXPERIMENTATION

The Engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, direct injection computerized Kirloskar make CI Engine. This engine can withstand higher pressures encountered and also is used extensively in agriculture and industrial sectors. Therefore this engine is selected for carrying experiments.

Fig.5: Pictorial view of experimental setup

3.1 Experimental procedure

For getting the base line data of engine first the experimentation is performed with diesel and then with biodiesel

- Preparation of fuel used: Diesel 100% (D100), Watermelon biodiesel 100% (B100), Blends of watermelon biodiesel such as, B10 (100% diesel + 10% watermelon oil), B20 (100% diesel + 20% watermelon oil), B30 (100% + 30% watermelon oil), B40 (100% diesel + 40% watermelon oil).
- Optimization of biodiesel blends
- Fill the diesel in fuel tank
- Start the water supply. Set cooling water for engine at 650 LPH and calorimeter flow at 150 LPH.
- Also ensure adequate water flow rate for dynamometer cooling and piezo sensor cooling.
- Check for all electrical connections. Start electric supply to the computer through the UPS.
- Open the lab view based engine performance analysis software package "engine soft" for on screen performance evaluation.
- Supply the diesel to engine by opening the valve provided at the burette.
- Set the value of calorific value and specific gravity of the fuel through the configure option in the software.
- Select run option of the software. Start the engine and let it run for few minutes under no load condition.
- Choose log option of the software. Turn on fuel supply knob. After one minute the display changes to input mode then enter the value of water flows in cooling jacket and calorimeter and then the file name (applicable only for the first reading) for the software. The first reading for the engine gets logged for the no load condition. Turn the fuel knob back to regular position.
- Repeat the experiment for different load and speed.
- All the performance readings will be displayed on the monitor.
- Using AVL Dismoke 1000 and exhaust gas analyzer CO, CO_2, NO_x, Unburnt hydrocarbons, will be recorded.
- Now clear the diesel present in the engine and use pure biodiesel as a fuel, repeat the same procedure.
- At the end of the experiment bring the engine to no load condition and turn off the engine and computer so as to stop the experiment.

After few minutes turn off the water supply

IV. RESULTS AND DISCUSSION

This section consists of two types of experimental analysis, first one is performance characteristics like brake thermal efficiency, specific fuel consumption, volumetric efficiency, against brake power, second one is emission characteristics like $_{CO2}$ emissions unburned hydrocarbon(HC) , NOx and CO emissions against brake power at pressure 180 bar

4.1 Performance and Emission characteristics of a DI diesel engine using pure diesel (D100), pure biodiesel (B100), and blends of watermelon biodiesel as a fuel, at an injection opening pressure of 180 bar.

Brake thermal efficiency

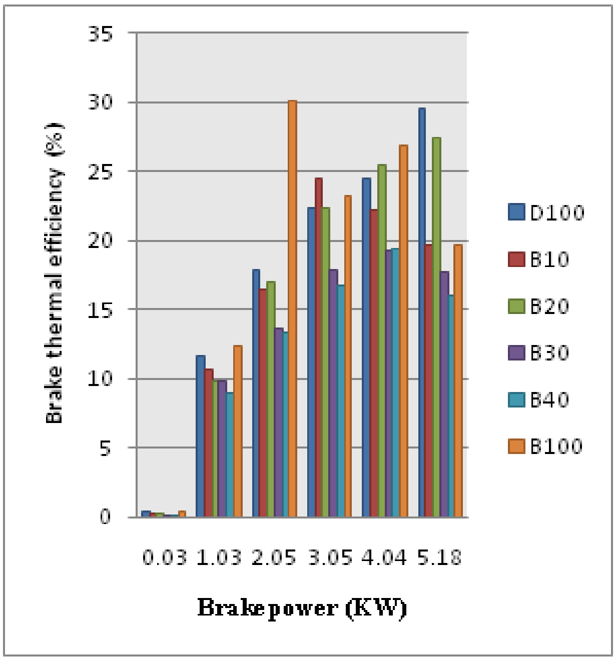

Fig.6: Variation of Brake thermal efficiency with Brake power

Fig.6 shows that variation of brake thermal efficiency with brake power for D100, B100 and watermelon biodiesel blends. The maximum value of brake thermal efficiency for D100, B10, B20, B30, B40 and B100 are 29.5%, 19.69%, 27.43%, 17.75%, 15.98%, 19.67% respectively at full load condition. It is observed from the graph that the brake thermal efficiency for blend B20 is close to the D100 at full load condition.

Brake Specific fuel consumption

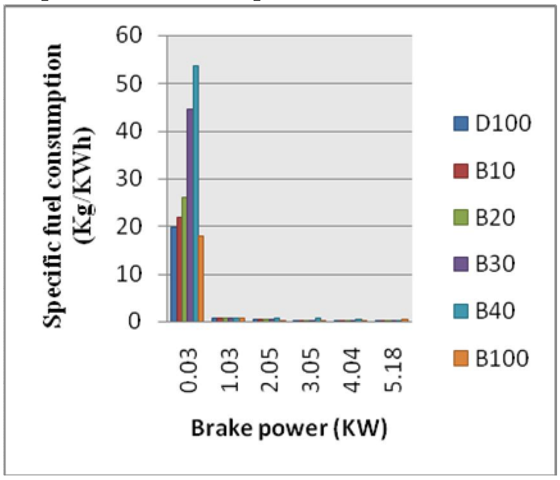

Fig.7: Variation of Brake specific fuel consumption with brake power

The variation of Brake specific fuel consumption with brake power for D100, B100 and watermelon biodiesel blends are shown in Fig.7. As the power increases there is decrease in BSFC for all the tested fuels. From the graph it is clear that the specific fuel consumption is more for initial loads and further it is decrease as the brake power developed. BSFC for D100, B10, B20, B30, B40 and B100 are 0.30, 0.39, 0.38, 0.37, and 0.45 Kg / Kwh respectively at full load condition.

Volumetric efficiency

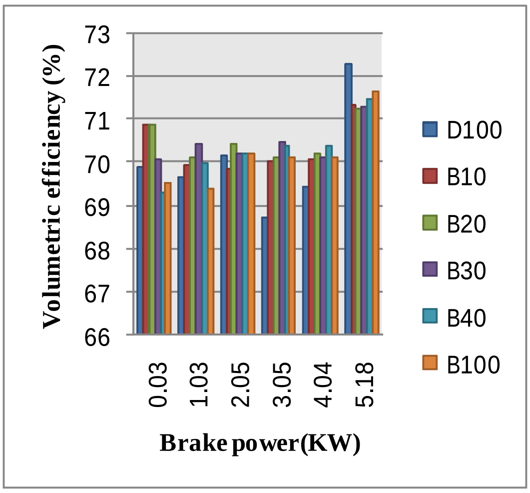

Fig.8: Variation of Volumetric efficiency with brake power

The Variation of Volumetric Efficiency with brake power is shown in Fig.8.The volumetric efficiency for D100, B10, B20, B30, B40 and B100 are 72.29%, 71.31%, 71.22%, 71.28%, 71.45% and 71.63% respectively at full load condition. From the graph it is seen that the D100, B100 and blends of watermelon biodiesel almost have a same volumetric efficiency at full load condition.

Emission Characteristics

Carbon dioxide (CO_2) emissions

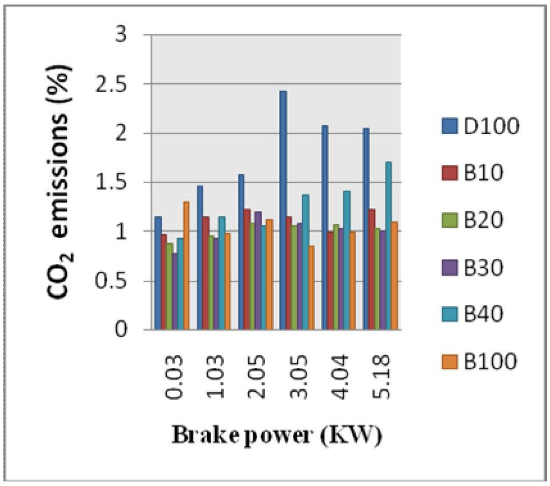

Fig.9: Variation of carbon dioxide with brake power

The variation of carbon dioxide with brake power for D100, B100 and blends of watermelon biodiesel are shown in the Fig.9.CO_2 emission increased with increase in load for all blends. For D100, B10, B20, B30, B40 and B100 CO_2 emissions are 2.05%, 1.22%, 1.03, 1.01%, 1.7% and 1.09% respectively at full load condition. It is noticed from the values that B100 and blends of watermelon biodiesel have less CO_2 emission when compared with diesel fuel (D100) at full load condition.

Hydrocarbon emissions

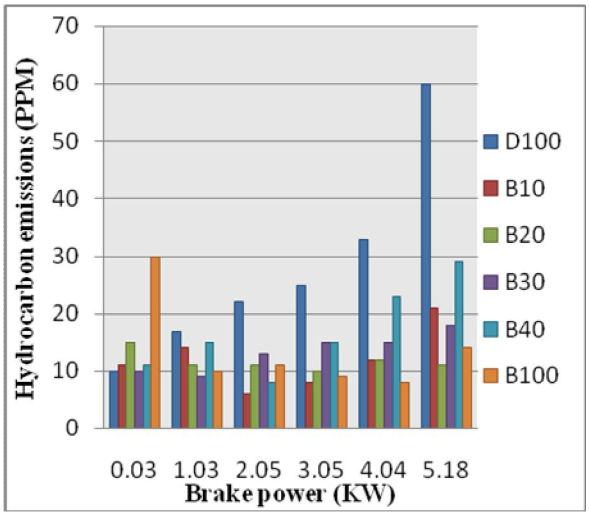

Fig.10: Variation of hydrocarbon with Brake power

Fig.10 shows the variation in the quantity of unburnt hydrocarbons with change in brake power. Unburnt hydrocarbon emission is the direct result of incomplete combustion. For D100, B10, B20, B30, B40 and B100 HC emissions are 60 PPM, 21 PPM, 11 PPM, 18 PPM, 29 PPM and 14 PPM respectively at full load condition. It is observed from the values that B100 and blends of watermelon biodiesel have less HC emissions when compared with diesel fuel (D100) at full load condition. A reason for the reduction of HC emissions with biodiesel is the oxygen content in the biodiesel molecule.

NO_x emissions

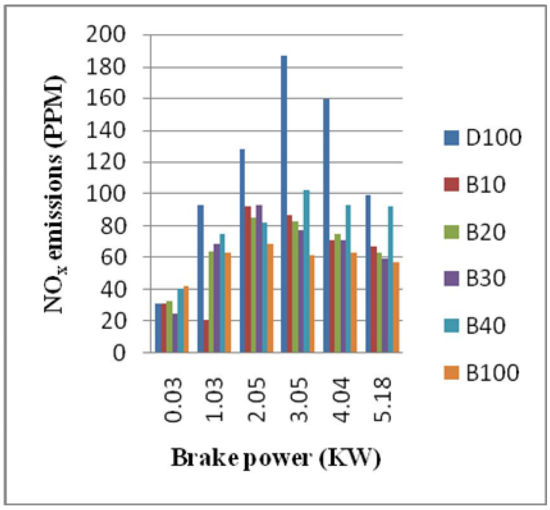

Fig.11: Variation of NOx emissions with brake power

Fig.11 shows the variation of nitrogen oxides emission with brake power output for D100, B100 and blends of watermelon biodiesel. For D100, B10, B20, B30, B40 and B100 NO_x emissions are 99 PPM, 67 PPM, 63 PPM, 59 PPM, 92 PPM and 57 PPM respectively at full load condition. It is noticed from the values that B100 and blends of watermelon biodiesel have less NO_x emissions when compared with diesel fuel (D100) at full load condition.

CO emissions

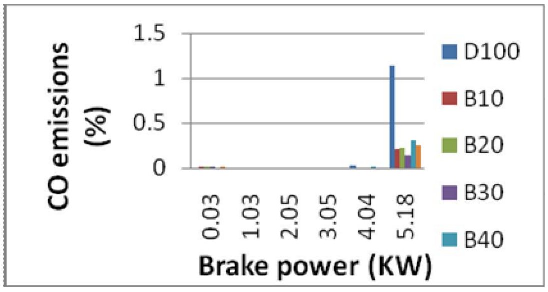

Fig.12: Variation of CO emissions with brake power

Fig.12 shows the variation of carbon monoxide emission with brake power for D100, B100 and blends of watermelon biodiesel. The CO emission depends upon the strength of the mixture, availability of oxygen and viscosity of fuel. The CO emissions for D100, B10, B20, B30, B40 and B100 are 1.14%, 0.21%, 0.23%, 0.15%, 0.32%, and 0.26% respectively at full load condition It is observed from the values that B100 and blends of watermelon biodiesel have less CO emissions when compared with diesel fuel (D100) at full load condition.

The performance and emission characteristics of D100, B100and water melon biodiesel blends are evaluated at pressure of 180 bars. In the next section the performance and emission characteristics for B20 optimum blend can determined by varying injection pressure (200 and 220bar) and results are compared with pure diesel (D100)

4.2 Performance and Emission characteristics of DI diesel engine using optimum blend (B20) and comparing with pure diesel (D100) at various injection pressure

It is observed from the previous tests using various blends of watermelon biodiesel that the B20 has shown better results for both performance and emissions, so further the work was extruded using B20 as a fuel for various injection opening pressure (180, 200 and 220 bar) and evaluated the performance and emission characteristics of a DI diesel engine.

Brake thermal efficiency

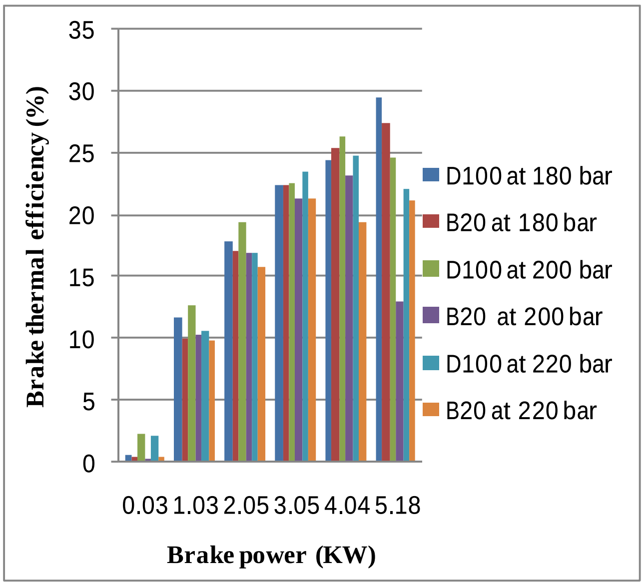

Fig.13: Variation of brake thermal efficiency with brake power

The characteristics bar graph for the brake power against brake thermal efficiency for D100 and B20 are shown in the Fig.13. At injection pressure 180 bar brake thermal efficiency for D100 and B20 is increased, due to better atomization. The maximum values for D100 and B20 are 29.5% and 27.43% respectively at full load condition. The 20 % of watermelon seed oil blended with pure diesel at the injection pressure of 180 bar increases the brake thermal efficiency.

Brake Specific fuel consumption

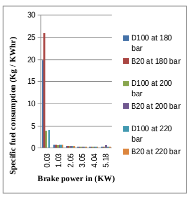

Fig.14: Variation of specific fuel consumption with brake power

The variation of specific fuel consumption with brake power at different injection pressure for the D100 and blend B20 are shown in the Fig.14. It is observed that the specific fuel consumption has decreased with increase in injection pressure. At 220 bar ,the lowest BSFC was recorded for D100 and B20. This may be due to that, as Injection pressure increases, the penetration length and spray cone angle increases fuel air mixing and spray atomization will be improved. The SFC for D100 and B20 blend is 0.32 and 0.34 Kg / KWh respectively at full load condition. From the above graph it reveals that as the injection pressure increases the specific fuel consumption decreases.

Volumetric efficiency

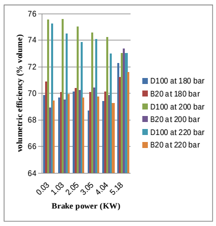

Fig.15: Variation of volumetric efficiency with brake power

The variation of volumetric efficiency with brake power at different injection pressure for D100 and blend B20 are shown in Fig.15. At 200 bar the volumetric efficiency for D100 and blend B20 is maximum. At this pressure the maximum efficiency is obtained for D100 and B20 is 73.06% and 73.59% respectively at full load condition.

Emission characteristics

Carbon dioxide emissions

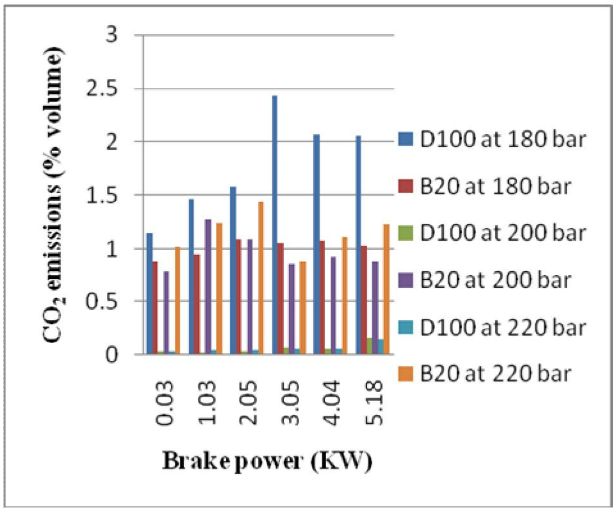

Fig.16: variation of Carbon dioxide emissions with brake power

The variation of carbon dioxide emission with brake power at various injection pressures for D100 and B20 are shown in the Fig.16. It is seen that at injection pressure of 200 bar, CO_2 emission was lower, for D100 and B20 blend. The lowest CO_2 emission for D100 and B20 are 0.16 PPM and 0.87 PPM respectively at full load condition.

Hydrocarbon (HC) emissions

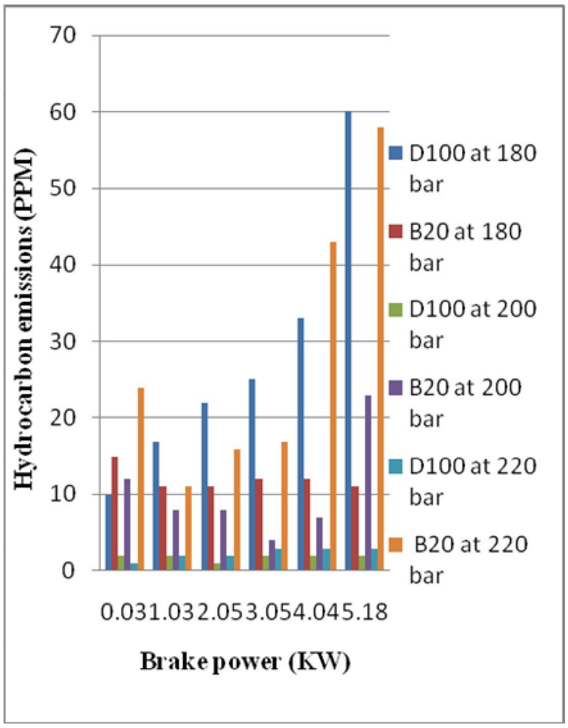

Fig.17: variation of Hydrocarbon emission with brake power

The variation in the quantity of unburnt hydrocarbons with brake power at different injection pressures for D100 and B20 are as shown in the Fig.17. HC emissions are mainly formed due to incomplete combustion. Incomplete combustion is due to the improper mixing of fuel with oxygen available in the combustion chamber or may be due insufficient quantity of oxygen. At 200 bar the emission of HC is less for D100 and B20 biodiesel blend. At this pressure the lowest HC emission for D100 and B20 obtained as 2 PPM and 23 PPM respectively at full load condition.

NO_x emissions

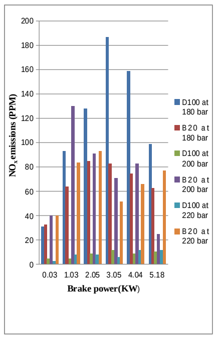

Fig 18: Variation of NO_x emission with brake power

The variation of NO_x emission with brake power at various injection pressure for D100 and B20 are shown in Fig.18. NO_x emission is due to reduced ignition delay .Reduced ignition delay is due to the higher cetane number of biodiesel fuel. At injection opening pressure of 200 bar NO_x emission was lower for D100 and B20. The NO_x measurement for D100 and B20 recorded as 11 PPM and 25 PPM respectively at full load condition.

Carbon monoxide (CO) emissions

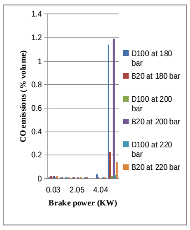

Fig.19: Variation of CO emission with brake power

The Variation of CO emission with brake power at different injection pressure for D100 and B20 are shown in the Fig.19. Carbon monoxide emissions from a diesel engine mainly depend upon the physical and chemical properties of the fuel. The carbon monoxide emission increases when fuel air-ratio becomes grater. At injection pressure of 220 bar the CO emission was less for D100 and B20 blend. CO emission for D100 and B20 are recorded as 0.03% and 0.14% respectively at full load condition.

CONCLUSION

The experiments were conducted on a kirloskar single cylinder, water cooled, naturally aspirated 5.2 kW at 1500 rpm. Watermelon biodiesel blends and diesel were the fuels considered in experimentation. The experiments were conducted for pure diesel, pure biodiesel and biodiesel blends such as B10, B20, B30, B40. The performance and emission characteristics of pure diesel and water melon biodiesel blends are evaluated at pressure of 180 bars. From the results suitable optimum blend (say B20) is found out. In further the performance and emission characteristics for B20 optimum blend can determined by varying injection pressure (200 and 220bar) and results are compared with pure diesel (D100)

- At injection opening pressure 180 bar, the brake thermal efficiency for D100 and B20 are 29.5% and 27.43% respectively at full load condition. Brake thermal efficiency of blend B20 is nearer to the brake thermal efficiency of diesel at 180 bar injection opening pressure.
- At injection pressure of 220 bar, Brake specific fuel consumption for D100 and B20 are 0.32 Kg / Kwhr and 0.34 Kg / Kwhr respectively at full load condition, at this pressure Brake specific fuel consumption of B20 blend is slightly higher than diesel.
- It is observed at 180 bar injection opening pressure maximum volumetric efficiency is obtained for D100 and B20 blend. At this pressure the maximum efficiency for D100 and B20 obtained as 72.29% and 71.22% respectively at full load condition.
- At injection opening pressure of 200 bar, CO_2 emission was lower for D100 and B20 blend of watermelon biodiesel. At this pressure CO_2 emissions are 0.16PPM and 0.87PPM respectively. The lower percentage of biodiesel blend emits very low amount of CO_2
- At injection opening pressure 200 bar, the lowest HC emissions are recorded. At this injection Opening pressure HC emissions for D100 and B20 blend obtained as 2ppm and 23ppm respectively at full load condition
- At injection opening pressure of 200 bar, NO_x emission are lower for D100 and B20 blend. The NO_x measurement for D100 and B20 are recorded as 11ppm and 25 ppm respectively at full load condition.
- It is evident that when the load increases the carbon monoxide emission also increases.At injection opening pressure 220 bar the D100 and B20 blend produces less carbon monoxide emission. CO emission for D100 and B20 are recorded as 0.03% and 0.14% respectively at full load condition.
- Fuel injector opening pressure increases from 180 bar to 220 bar shows significant increase in performance and emission with watermelon biodiesel blend due to better spray formation.
- It is concluded that the blends of watermelon biodiesel with diesel up to 20% by volume (say B20) can replace diesel for running the diesel engine with lesser emissions.

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