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Influence of Injection Pressure on Performance and Emission Measures of Direct Injection Diesel Engine with Emulsified Kapok Methyl Ester

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Abstract

Non edible Kapok biodiesel emulsifiedblend with diesel were tested for their use as substitute fuels for diesel engines. In this work, the effects of fuel injection pressure are experimentally studied on performance and emission characteristics of single cylinder direct injection diesel engine using emulsified Kapok Methyl Ester blended with diesel in different injection pressure (180, 220 and 240bar). Brake specific fuel consumption is decreased with increase in injection pressures due to complete combustion of fuel. For injection pressure of 240 bar the BSFC is lowest compare with 180 and 220bar. Emissions are lower with emulsified blends at 240 bar but NOx emissions are more compare than other injection pressure. It is concluded that KME emulsion can be used in diesel engines in different injection pressures the engine with superior performance and reduced emissions at high power outputs

Keywords: Kapok Methyl Ester, Emulsion, Injection pressure, combustion, Emission

1. INTRODUCTION

The depletion, increasing demand and price of the petroleum prompted extensive research worldwide on alternative energy sources for internal combustion engines. Use of bio fuels such as vegetable oil could reduce the dependency on petroleum products and the pollution problem. The use of straight vegetable oils (SVO) in diesel engines presents problems primarily due to their high viscosity and lower volatility [1]. The fuel penetration distance become longer and the mixture formation of the fuel and air was improved when the combustion duration became shorter as the injection pressure became higher. When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during the combustion will increase. This situation leads to inefficient combustion in the engine and causes the increase in NOx, CO emissions. When the injection pressure is increased fuel particle diameters will become small. The mixing of fuel and air becomes better during ignition delay period which causes low smoke level and CO emission. But, if the injection pressure is too high ignition delay become shorter. So, possibilities of homogeneous mixing decrease and combustion efficiency falls down. Therefore, smoke is formed at exhaust of engine[2]. An increase in injection pressure is found to enhance the atomization at the nozzle outlet, resulting in a more distributed vapour, hence better mixing. The nozzle opening pressure was set by adjusting the spring of the injector and values were 170,190,210 and 230 bar. Smoke levels steadily fall with increase in the injector opening pressure due to improved mixture formation because of well-atomized spray [3].The performance and emission characteristics of diesel engines depends on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, shape of combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl etc. The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization for better penetration of fuel in order to utilize the full air charge and to promote the evaporation in a very short time and to achieve higher combustion efficiency. The fuel injection pressure in a standard diesel engine is in the range of 200 to 1700 atm depending on the engine size and type of combustion system employed [4-5].The engine has original injection pressure of 200 bar. The tests were conducted at three different injection pressures (180, 200 and 220 bar) with decreasing or increasing washer number. All tests were conducted at four different loads (5, 10, 15, and 20 N m) for constant engine speed of 2200 rpm. The experimental test results proved that brake thermal efficiency, heat release rate, peak cylinder pressure, smoke number, carbon monoxide and unburned hydrocarbon emissions reduced as brake-specific fuel consumption, brake specific energy consumption, combustion efficiency, and nitrogen oxides and carbon dioxide emissions increased with increasing amount of methanol in the fuel blend [6].

2. Materials and Methods

2.1 Kapok seed oil

Kapok (CeibaPentandra) which is also known as silk-cotton is a native of America and West Africa, and the seeds were introduced to Southeast Asia via India. The seed contains 25 to 28 % oil content and the oil color is yellow with a pleasant mild odor. Triglycerides are the basic and major constituents of any vegetable oils, they around 90 to 98%, and remains are small amounts of mono- and diglycerides. Triglycerides are esters of three fatty acids and one glycerol, and these all are having a considerable amount of oxygen molecules in its structure. The common fatty acids available in vegetable oils are stearic, palmitic, oleic, lenoleic, lenolenic and etc.

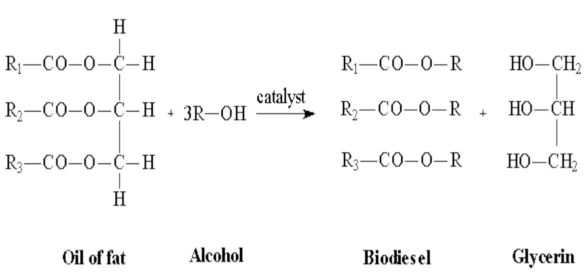

Fig .1. Chemical Reaction of Synthesis of Biodiesel

In the converting process of high free fatty acid (FFA) feed stock into biodiesel, the addition of excessive catalysts may create more problems than it solves. It can also prevent the separation of the glycerol from the ester. So that the following well known techniques like, enzymatic method, glycerolizes, acid catalysis and followed by alkali catalysis can be used, to obtain the satisfactory yielding of biodiesel by a chemical process.

2.2 Selection of surfactant

Nonionic surfactants Span 80 (HLB 4.3) and Tween 80 (HLB 15.0)were selected. Inorder to increase the stability of emulsion, combinations of thetwo surfactants were used. Span 80 (Sorbitanmonoleate) andTween 80 (Polysorbate 80 or Polyoxyethylenesorbitanmonoleate)are non-ionic surface active agent. Both are regarded asnon-toxic, non-irritating, non-corrosive in nature without anysource for secondary pollutants formation in engines and they do not generate any toxic byproducts during combustion.

KB20 (20% Kapok biodiesel and 80% diesel) was prepared. An homogeniser was used to prepare the emulsified fuel samples by mixing KB20 with 10%, water by volume and surfactant (HLB 5) at 5%, concentration by volume using various test speed of the homogeniser (2000, 2500 and 3000 rpm (revolutions per minute)) for 15 min duration at room temperature. The blends are stirred using magnetic stirrer.

3. Experimental Setup

The experimental setup consists of a stationary single cylinder Direct Injection (DI) diesel engine with an electro-dynamometer, AVL DiGas 444 gas analyzer with six sensor modules and a smoke meter. The engine was tested at the rated speed of 1500 rpm, with five different levels of load in percentage of full load. An engine is operated on diesel at IP of 200 bar and 20% blends of Kapok Methyl Ester 5% span 80 and tween 80 and 10% water (B20S5W10) and diesel as test fuel at IP of 180 bar, 220 bar and 240 bar. Various physical and chemical properties are shown in table1.

Table1. Properties of Biodiesel

Properties kinematic	DIESEL	KME	B20S5W10
Viscosity (Cst), 40°C	4.0	4.2	4.5

Specific gravity	0.830	0.86	0.845
Calorific value (kJ/kg)	43200	39500	39700
Cetane number	50	51	48
Flash point ºC	70	148	90

4. REASULT AND DISCUSSION

4.1. Performance characteristics

4.1.1 Brake Thermal Efficiency (BTE)

Fig.2 shows the variation in Brake thermal efficiency with Brake power at different injection pressures (180, 220 and 240bar).It is observed that the brake thermal efficiency with B20 at injection pressure 240bar is increased due to better atomization. It is found from that the graph the brake thermal efficiencies obtained at full load at an injection pressure of 180bar is 24.43%, at 220bar it is 26.12%, while at 240 bar injection pressure, the brake thermal efficiency obtained is 30.45%.

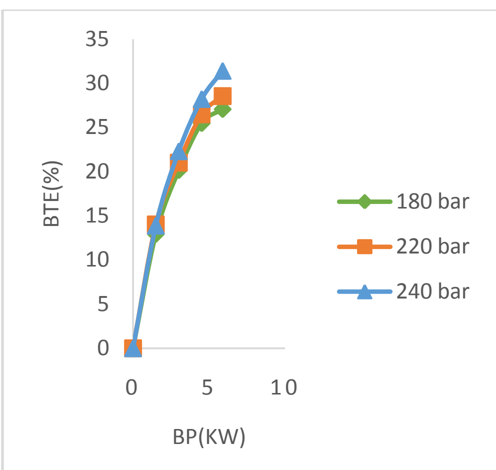

Fig 2. Brake power vs BTE

4.1.2Brake Specific Fuel consumption (BSFC)

Fig.3 shows the variation in specific fuel consumption with Brake power at different injection pressures (180, 220 and 240bar).It is observed that the injection pressure increases BSFC decreases due of complete combustion of fuel. Increase in injection pressure assists in better mixing of fuel with air.They have found from that the graph at the injection pressure for 240bar fuel consumption is less compared than injection pressure 180bar and 220bar.

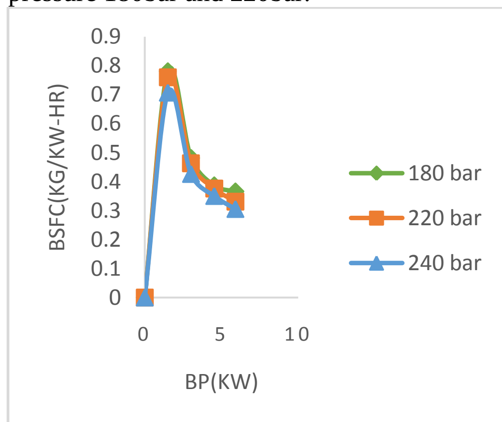

Fig 3. Brake power vs BSFC

4.2 Emission characteristics

4.2.1Carbon Monoxide (CO)

Fig.4 shows the variation in carbon monoxide emission with Brake power at different injection pressures (180, 220 and 240bar). It is observed that the CO gradually decreases with increasing injection pressure. At maximum load with the injection pressure of 240 bar, the CO is 10% reduced than other injection pressure. This is due to better atomization and more oxygen content present in the biodiesel can facilitate complete combustion, and the Kapok methyl ester has a low carbon content compared to diesel, and thus resulting in a reduction of CO emissions.

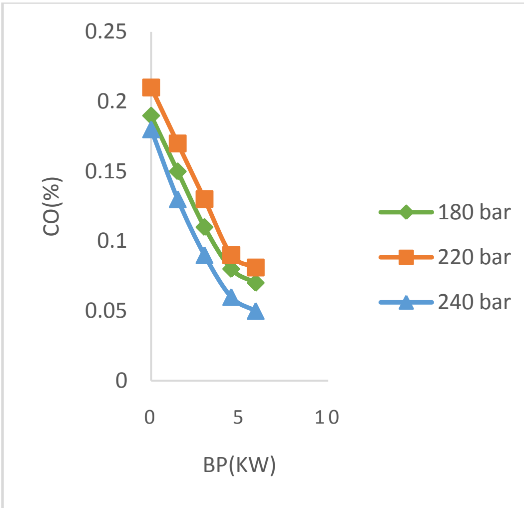

Fig 4. Brake power vs CO

4.2.2 Hydro Carbon (HC) Emissions

Fig.5 shows the variation in hydrocarbon emission with Brake power at different injection pressures (180, 220 and 240bar). It is observed that the hydrocarbon emission gradually decreases with increasing injection pressure. This is due to fuel air mixing in the combustion chamber was more excellent and leads to reduction in HC emissions. Therefore, the injection pressure 240bar has less HC emission compared with IP 180 and 220bar.

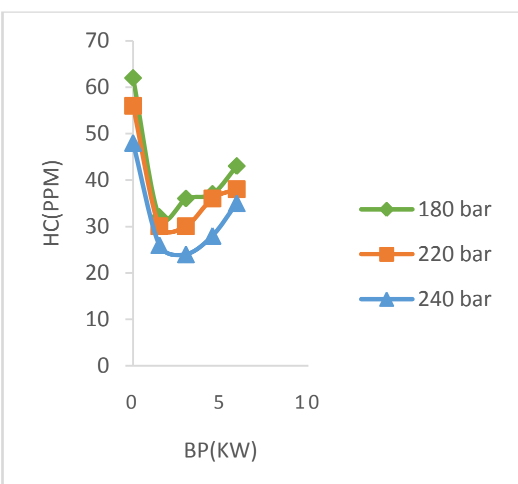

Fig 5. Brake power vs HC

4.2.3Nitrogen Oxide (NOx) Emissions

Fig.6 shows the variation in hydrocarbon emission with Brake power at different injection pressures (180, 220 and 240bar). It is observed that the oxides of nitrogen gradually increase with increasing injection pressure. At maximum load with the injection pressure of 240bar, the NO_x is 620ppm. This is due to injection pressure decreased the particle parameter and caused the emulsified biodiesel–diesel fuel spray to vaporize quickly. Further, larger injection pressure generates faster combustion rates, resulting in high combustion temperature and leads to increase in NOx emissions.

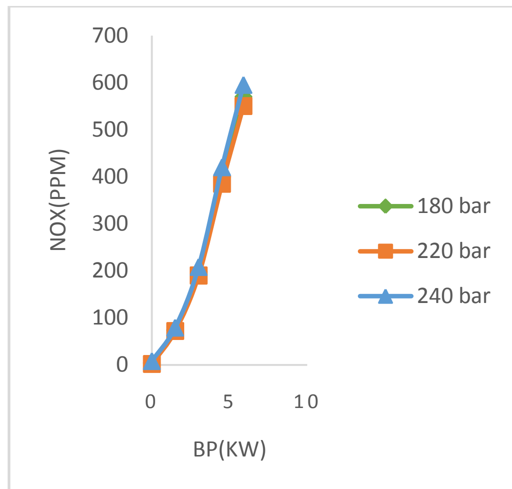

Fig 6. Brake power vs NOx

4.2.4 Smoke opacity

Fig.7 shows the variation in hydrocarbon emission with Brake power at different injection pressures (180, 220 and 240bar).It is observed that the unburned carbon molecules appear as smoke in the exhaust gases, or impinge on the combustion chamber wall and in the exhaust system. The main reasons for lower smoke is due to lean blends of biodiesel have more oxygen content, no aromatic substances, higher thermal efficiency, lower fuel consumption and shorter ignition delay.

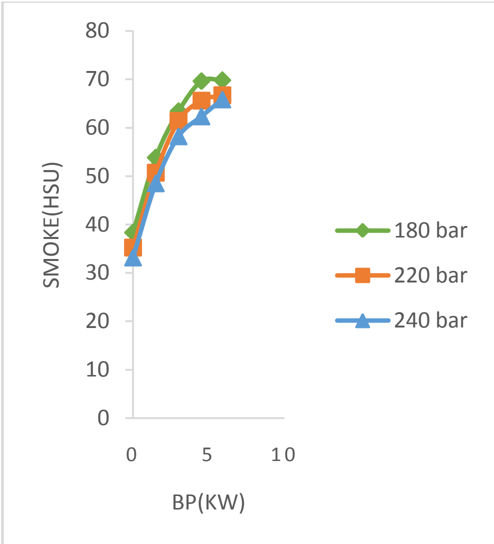

Fig 7. Brake power vs Smoke

5. CONCLUSION

In this study emulsified KME is selected as testing fuel and different injection pressures of (180,220 and 240bar) and diesel have been prepared. Engine is operated with emulsified biodiesel blend at different injection pressure and the performance parameters were computed and the following conclusions are drawn.

Engine performance is improved with B20S5W10 at injection pressure of 240bar due to improved atomization of fuel. Brake specific fuel consumption is decreased with increase in injection pressuresdue to complete combustion of fuel.For injection pressure of 240 bar the bsfc is lowest compare with 180 and 220bar. Emissions are lower with emulsified blends at 240 bar but NOx emissions are more compare than other injection pressure.

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