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Effect of Cottonseed Oil Methyl Ester on Performance and Smoke of CI Engine

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ABSTRACT:

Biofuel production is reducing the dependency and minimizes the use of fossil fuels. As we know with time, the consumption of conventional fuel is increasing and at the same time depletion of these fuels. To overcome these issues, humans are trying to switch gradually towards alternative fuels. Bio-fuels have more advantages compared to conventional fuels concerned with humans and the environment. There are different types of biofuels available to use for energy and engine applications. In the present work production of bio-diesel from cottonseed oil by transesterification process was carried out. The performance and the smoke tests were carried out on single-cylinder diesel engines with diesel and different blends of diesel and cottonseed oil biodiesel blends B20, B40 and B60. The results obtained were analyzed and compared with the pure diesel operation. The optimized brake thermal efficiency of conversion was observed between 20-40% with cottonseed oil blends. The 40% blend of cottonseed oil releases less smoke for all loads compared to other blends and diesel combustion.

Keywords: Cotton seed oil, Bio-fuel, Engine Performance, Emission

1. INTRODUCTION

The urbanization and development in automobile industries increased the consumption of fossil fuels which has increased many times in the past few years and has posed difficulties such as fossil fuel depletion and scarcity of petroleum fuels and increased its economic value.

The intention of producing biofuels is to reduce the consumption of non-renewable fossil fuels and support the growth of automobile industries. To resolve the issues and to produce energy with the same efficiency alternative fuel resources are to be used such as biofuels, biomass and hydrogen gas, these are the best replacements for non-renewable fossil fuels. Biodiesel is the concept of using vegetable oil as a transportation fuel in 1893 Dr. Rudolf Diesel developed the first diesel engine to run on vegetable oil later the engines and oil were modified according to requirements. The engine was a great success and till today these engines are used prominently in automobiles and heavy machinery. Biodiesel can be produced by using cotton seeds through a process called transesterification and esterification using calcined eggshell as catalyst [1] consisting of a molar ratio of 6:1 and 1% of catalyst concentration yield 93% of biodiesel. Transesterification is the process which is carried out to separate the fatty acids from the glycerol backbone to fatty acid esters (FAE) and free glycerol [2]. Biodiesel can reduce the emissions of carbon monoxide, sulphur dioxide, and particulate matter; with slightly

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increased levels of nitrogen oxides [3]. The biodiesel can sustain a temperature of 44°C and a low temperature of 4°C. Biodiesel gives similar power output compared to diesel and with the same efficiency generates remarkable energy. Diesel engines in Belgium use ethyl oil as fuel for local vehicles, it was mixed with a proportion of 5% diesel oil and a proportion of 29% of diesel fuel used by some fleet's engines running on biodiesel have similar mileage to engines running on other fuels like petroleum. The fuel consumption power rate and torque are unaffected by the use of biodiesel. It also reduces health hazard issues and biodiesel is less toxic than petroleum diesel. Ingredients that cause health problems such as asthma and lung cancer it produces 80% fewer carbons than other fuels even mixed or blended diesel with biodiesel significantly reduces the harmful effect on humans and the environment (refer. vedkumar). The engine can run on the fuel extracted from the cottonseed and converted to Methyl Ester without any major losses of power. The use of Cotton Seed Methyl Ester (CSOME) caused the thermal efficiency rate to decrease by 0.7 % and the brake-specific energy consumption was increased by the rate of 0.01% [1]. Due to the resemblance of their different chemical properties, the cotton seed methyl ester i.e. biodiesel was declared as a versatile alternative fuel [2]. There was an increase in the BTE of CSOME blends B10 and B20 and the BTE of B30 is nearly equal to diesel fuel. BSEC gives better values than diesel fuel and B30 has lower BSFC than B10 and B20. CO and HC emissions are less compared with standard diesel fuel [4]. With lower loads with an increase in the percentage of CSOME in the blends. There was a suitable increase in CSOME percentage in the blends the emission of CO was observed to be low for all testing fuels considerable increase was observed and noted after 60% of the load was reduced in CO emission for higher blends [5].

Because the biodiesel has to low calorific value the brake-specific fuel consumption (BSFC) rate was increased by 13.4% for the height engine notch the emission of nitrogen oxides from the engine where increased by the rate of 8% and the emission decreased by the rate of 32% for diesel [2]. The cottonseed oil was used in a single-cylinder, air-cooled, compression ignition, IC engine as an alternative fuel, in this examination the biofuel/biodiesel was made up of un-mixed pure cottonseed oil through the procedure of transesterification. The extracted fuel through this process was blended with diesel with a proportion of (10-20%) and examined through a test on a single-cylinder direct injection diesel engine to acquire the performance and emission attribute, due to the resemblance of their different chemical properties to the cotton seed oil. The experiment concludes that brake thermal efficiency (BTE) was a bit lower in biodiesel blends than compared to diesel fuel [6]. During the testing of the performance and emission of cottonseed oil in an engine coated with ZrO2 and CeO2 were compared with pure diesel in both coated and uncoated engines. The performance parameters used for comparison were thermal efficiency and brake-specific fuel consumption rate. Analyses were done on carbon monoxide, hydrocarbons, nitrogen oxides, smoke and particulate matter. The test conducted that there was about for 42.8% decrease in CO emission when cottonseed oil was used in coated engines compared to pure diesel oil [17]. The emission of HC was about 12.5% decreased for coated piston diesel compared with uncoated piston, and also marginal decrease in NOx and smoke emission was observed for B25CS. The production of cottonseed oil was similar to diesel oil with no significant changes observed. There was a decrease in BSFC and a marginal increase in BTE compared to pure diesel hence cottonseed oil can be considered one of the effective

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replacements for diesel [4]. Properties of CSOME blends were nearly equal to the diesel fuel the maximum yield of biodiesel from cottonseed oil was 90% by the transesterification process.

There was an increase in the BTE of CSOME blends B10 and B20 and the BTE of B30 was nearly equal to diesel fuel. BSEC gives better values than diesel fuel B30 has low BSEC and B10 and B20 have CO and HC emissions were less compared with the standard diesel fuel. The rate of HC emission was reduced for B30 with 30% NOx emission for CSOME blends a bit higher than diesel fuel. B30 blend had a slightly more increased rate than B10 and B20 they also studied the smoke emission of B10 and B20 had less and B30 recorded more smoke with 2.85% this concluded that cottonseed oil was the most efficient and promising alternative fuel resource for diesel engine due to its higher heat conductivity it can be used as fuel replacing diesel fuel. The major drawback is that cottonseed oil has a high velocity. The examined test results showed that 20% of oil and 80% of diesel (B20) are suitable for being used instead of diesel fuel without any modifications to the engine structure [7]. The examination was conducted by using cottonseed oil blends methyl esters and diesel fuels then further experiments were conducted on combustion performance and emission based on the results of the experimental examinations the observations concluded that the brake thermal efficiency decreased. There was an increase in COME percentage in blended fuel because of the low heating value of biodiesel the full load of BTE of B5 was nearing the baseline data of the diesel fuel i.e. 2% BSEC (brake specific energy consumption) was 60MJ/kwh noted and observed in diesel fuel with few load with an increase of the percentage of COME in the blends. There was a suitable increase in COME percentage in the blends the emission of CO was observed to be low for all testing fuels, considerable increase was observed and noted after 60% of the load was reduced in CO emission for higher blends attribute blends improved combustion and oxygenated fuels such as COME. Because of the high rate of COME-suitable combustion, the in-cylinder temperature increased resulting in higher emission of NOx from the blended fuel compared to the standard baseline data at full load and NOx emission was increased rapidly by 23% for B20 compared to diesel baseline emission of NOx exhibited at the margin for lower blends [8]. In a study conducted by the authors on the Transesterification of WCCO into biodiesel the observations concluded oil/Methanol had a molar ratio of 1:26 Catalyst of 20% temperature of 65°C and reactive time of 45 minutes WCCO oil yielded 96% of biodiesel the BTE of the diesel was 25.4% with 100% load the SPF of biodiesel blends of WCCO and WCCO20 was 25.0761 kg/kWh and 0.5763 kg/kWh with respectively. The EGT of the biodiesel blend was higher than diesel, biodiesel had an improved emission feature with lower HC and CO, and slight changes in ignition were observed with the increase of NOx emissions. The production of biodiesel from cottonseed oil had more potential as an alternative fuel [9]. The author conducted a study on the enzymatic production of biodiesel by methanolysis done by cottonseed oil using immobilized candida Antarctica as a catalyst with t-butanol and methyl ester production and triacylglycerol. The Chromatography was done by HPLC using a batch system.

The enzyme in-habitation caused the undissolved methanol to be let out by adding t-butanol to the reaction. This increased the reaction rate and Esther yield. T-butanol methanol is concentrated at a fixed temperature in a system. The determined method analysis yielded 97% after 24 hours at 30^0C. T-butanol contained 32.5% whereas methanol with 13.5% and 54% of oil and 0.071 G 7G enzyme with a mixture of 95% of Ester yield by using one step waxed bed with a low rate of 9.6M with continuous reaction didnot decrease in ester yields [10].

In this experiment, the cottonseed oil was taken and transesterification was carried out to produce biodiesel. The addition of methanol in the cottonseed oil was carried out for further study and the time taken for the reaction and temperature changes were observed the testingof the fuel was done on a direct injection, single-cylinder diesel engine. The engine was used to operate with no load and full load with diesel. The biodiesel in the engine follows certain parameters normally fuel consumption rate, electrical efficiency, and engine speed were observed. The cottonseed oil chemical properties were studied including specific gravity, moisture rate, acid value, refractive index, and iodine number. The author concluded that the speed and the voltage generated by the biodiesel were similar to diesel fuel.The electrical efficiency of methyl ester observed was similar to cottonseed oil compared to diesel.

The author experimented on a single-cylinder, diesel engine with biodiesel blends (B5, B10, B15, B20) as the fuel the combustion characteristics of the engine were injection delay, pre-mixing, diffusion after burning fuel, combustion rate and combustion duration were analyzed and compared to diesel the observation concluded that the maximum rate of the pressure rise and decreases with the biodiesel comparing to diesel [11,14]. Higher Ceatane in biodiesel blends made the engine run smoothly the ignition delay decreased by 11°C with diesel by 6.5°C with B20 biodiesel. The author observed that ignition delay was decreased by 11°C and 9.5°C, 8.5°C, 7.2°C till 6.8°C with bio-diesel blends of B5, B10, B15 and B20. The highest pressure increase was 52.9 bar for diesel and 55.6 bar for B20 diesel blends [12,13]. The pressure rises and decreases with all biodiesel blends compared to base fuel prominently higher ceatane number tends to reduce the injection delay they also observed an increase in combustion duration with a percentage increase of biodiesel. The use of diesel has been practiced from earlier times but it is known to us that in the future fossil fuels may replenish upon their continuous usage. So, we need to use biodiesel instead of depending on fossil fuels. The study of biodiesel also known as alternative diesel is extracted from different kinds of feedstocks that significantly have different fatty acids in it respectively and include properties related to physiochemicals. Through this study, we can easily understand further deep into the usage of biodiesel on single-cylinder, four- stroke, CI engines. The advantages of biodiesel by its properties and compound structure of well and enriched particles of biofuel in the engine the exhaust emission and performance were compared by applying full load conditions[15.16].

2. MATERIALS AND METHODS

2.1 ENGINE SET-UP

Figure 2.1 Engine Arrangement

Figure 2.2 Engine set-up

An experiment was done through a CI engine. The engine was connected to the electrical dynamometer for powering the engine and loading. The compression ratio can be changed by tilting the arrangement or shutting off the engine. The engine was provided with the necessary instrument for the combustion pressure and movement of crank angle measurement, the signals are associated with a computer through the engine to indicate the supplying interfacing airflow, fuel flow, temperature, and load quantifications. The construction consists of a stand-alone panel air box to fuel tanks manometer fuel measuring unit transmitters for airflow measurements, process indicators, and engine indicators for the cooling of water and a calorimeter for the fuel flow of measurement Rotameter were provided as well. LabVIEW-based engine performance analysis software package "EnginesoftLV" was provided for online performance evaluation.

3. RESULTS AND DISCUSSION

3.1 Brake Thermal Efficiency

Figure 3.1 indicates the output values of brake thermal efficiency among the 4 types of fuels. B40 have the highest output at full load and B20 is almost close to it, even though B60 have the same value compared to diesel output from medium to full load we state by studying the graph, B40 gives better results compared to all. B40 has better performance and deviations of somewhat more value compared to conventional B20 and B40 were almost closer to each other.

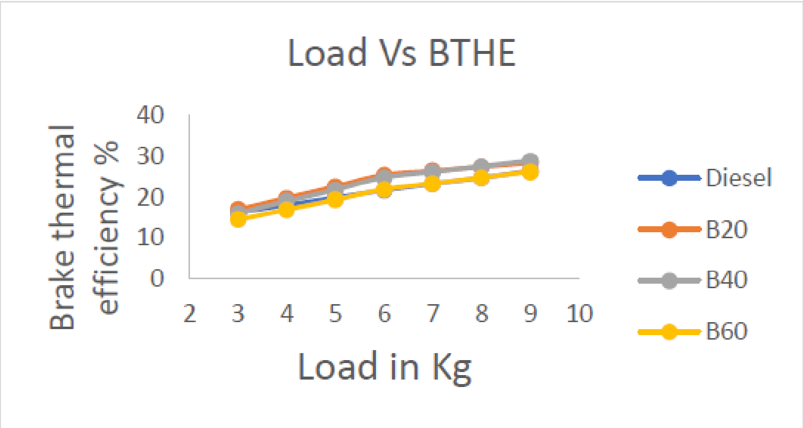

Figure 3.1 Comparison of Brake Thermal Efficiency

3.2 Comparison of Volumetric Efficiency

Figure 3.2 shows the comparison of volumetric efficiency with different fuel blends. Comparing all blends, the volumetric efficiency is almost the same for B40 and diesel, B60 has the lowest value among all, and B20 results next to B60. B40 have better efficiency among all at initial load and up to full load condition its value was very close to diesel, so by this, we can say that B40 have a better efficiency among all blends.

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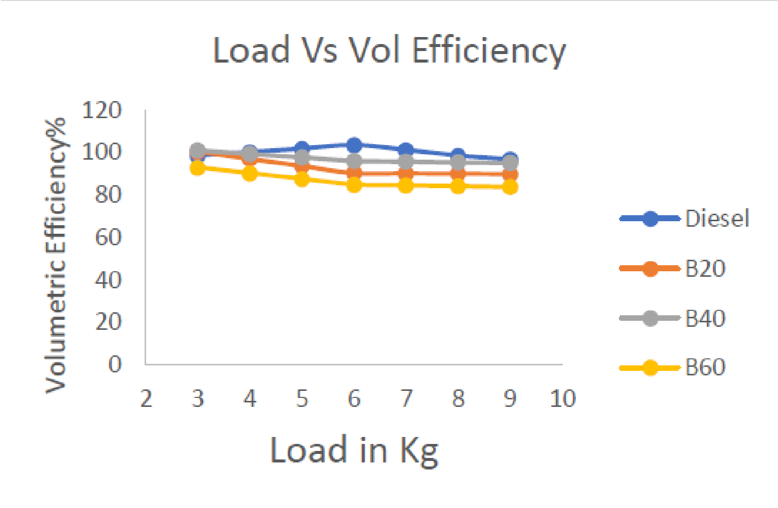

Figure 3.2 Comparison of Volumetric Efficiency

3.3 Comparison of Mechanical Efficiency

According to the above graph, Figure 3.3 we observed that all the fuels have almost the same mechanical efficiency at the starting load condition, and at the top load condition diesel and B20 show closer values to each other. Diesel at the initial load condition shows lower values and gradually goes on decreasing; at a certain point, the mechanical efficiency value increases linearly.

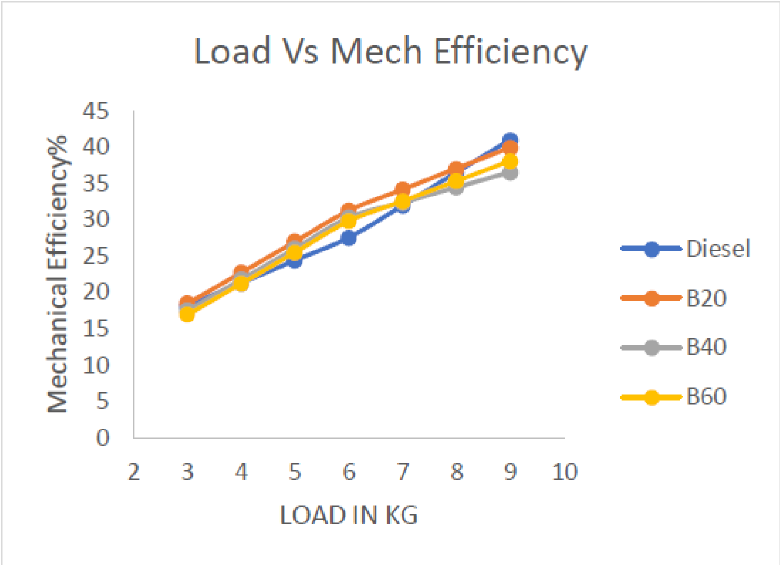

Figure 3.3 Comparison of Mechanical Efficiency

3.4 Net Heat Release Rate

The main intention of studying this combustion parameter is to know the total net heat generated during the combustion process. From Figure 3.4 it was known the deviation difference between diesel and fuel blends was almost double or more than double. It means that blended fuels release more heat compared to conventional fuels and among all fuels, B40 has the highest rate of heat release.

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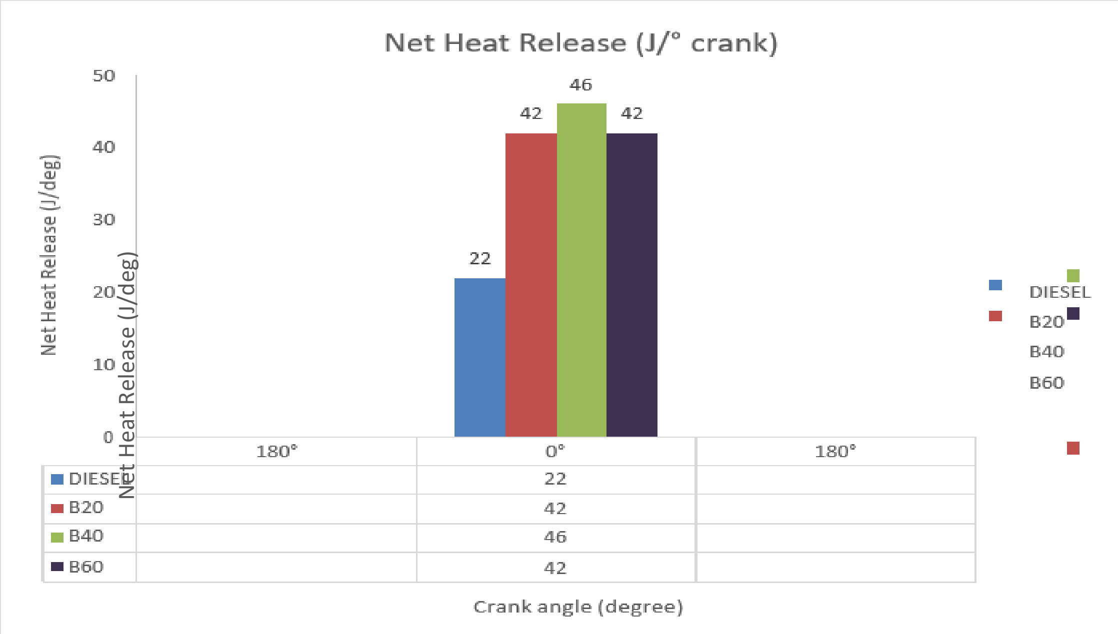

Figure 3.4 Crank Angle vs. Net Heat Release

3.5 Cylinder peak pressure

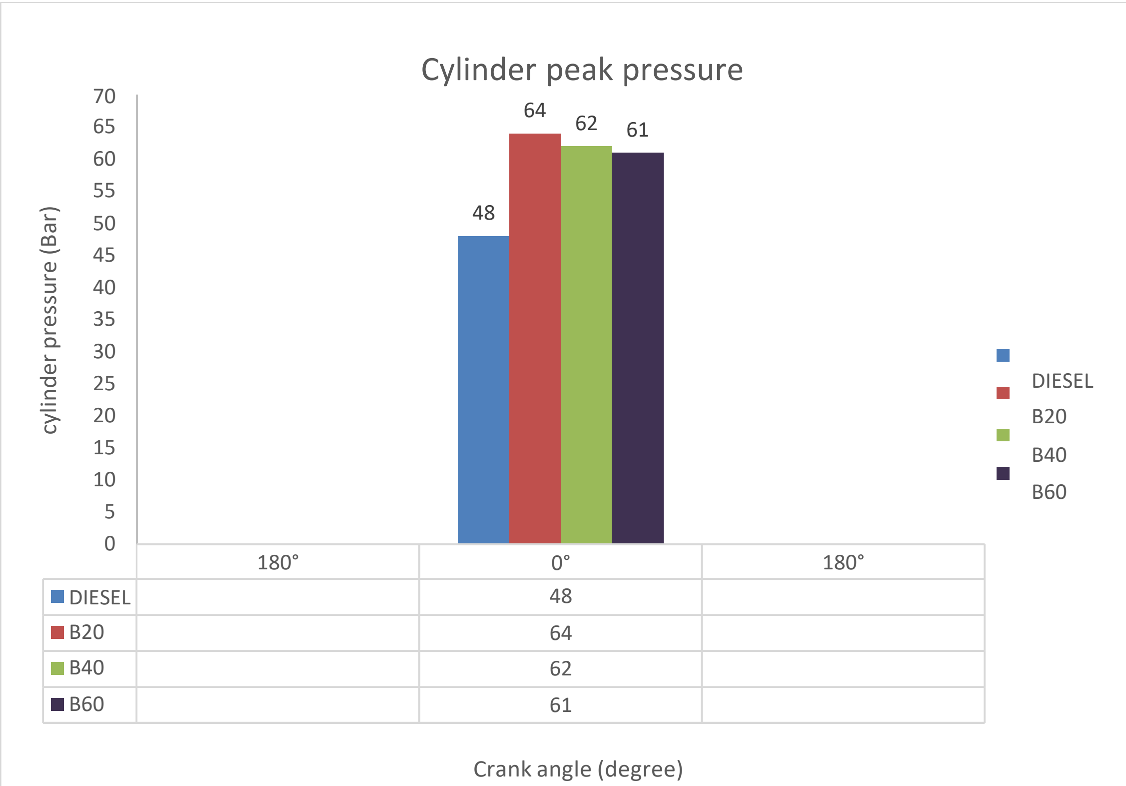

Figure 3.5 Crank Angle vs. Cylinder Pressure

Figure 3.5 shows the the cylinder pressure point of view for conventional fuel (diesel) having the lowest value

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among all the fuels and B20 having the highest value. In the output graph, it was clear that the cottonseed oil fuel blend can produce more pressure inside the cylinder during the combustion process. The B40 and B60 blends have almost the same output compared to each other.

3.6 Hartridge Smoke Unit

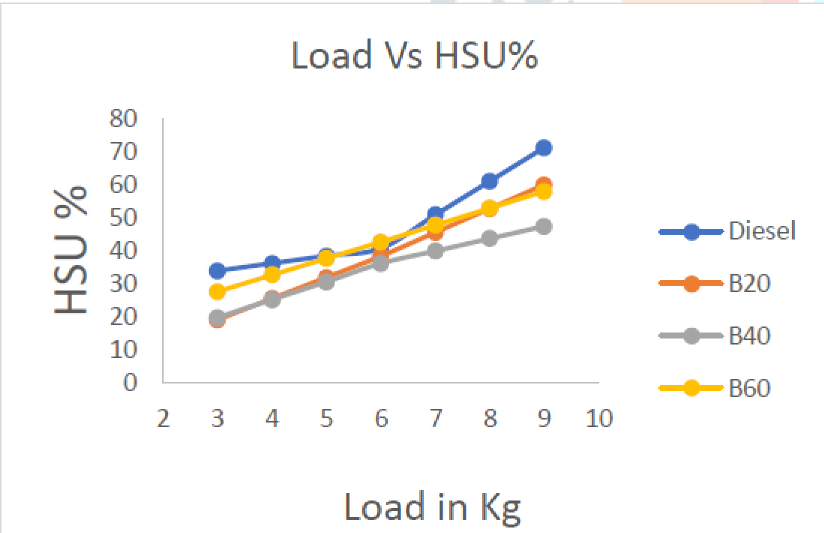

Figure 3.6 Comparison of Hartridge Smoke Unit

From the emission point of view, when we compare the output of all blends with each other, blended fuel got a lower emission value compared to diesel we can observe from Figure 3.6. It was clear to understand from initial to full load condition diesel had maximum HSU and the B60 value was very close to the diesel value and B20 next to it, the B40 has the least value output among all fuel blends at full load condition so it was optimum.

3.7 K value

From the above graph Figure 3.7 the emission point of view, when we make the comparison between the output of all blends with each other, blended fuel gives a lower emission value compared to diesel and from the graph, it was clear to understand, from the initial to full load condition diesel have maximum K value and B60 values were very closer to the diesel value and B20 next to it and the B40 have least value output among all fuel blends at full load condition so it's considered to be better one.

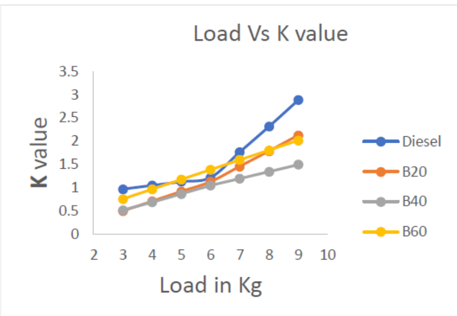

Figure 3.7 Comparison of K value

4. CONCLUSIONS

It was observed that similar engine behaviour in parameters related to the brake thermal efficiency. The optimized brake thermal efficiency of conversion was observed between 20-40% for cottonseed oil blends.The experimental results depict that the engine consumes the same amount of fuel per unit BP for all load variations and cottonseed oil blend combustion and little variation in the volumetric efficiency. The 40% blend was more beneficial to releasing more amount of heat release in the combustion chamber and enhanced the mechanical efficiency as compared to diesel and other blends of cottonseed oil for higher loads. The optimum cylinder peak pressure was observed in 40% and 60% cottonseed oil blend combustion. The 40% blend of cottonseed oil combustion releases less smoke for all loads compared to other blends and diesel combustion. The combustion of cottonseed oil blends produces less smoke emission compared to diesel combustion.

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