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Performance and Emission Evaluation of Diesel Engine for Different Volume Concentrations of Cotton Seed Bio Diesel

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ABSTRACT:

Now a days biodiesel consumption Increased gradually due to energy demand in transport sector, as well as stringent emission norms and depletion of oil resources led to find alternative fuels for internal combustion engines. Many alternative fuels like alcohols, bio-diesel, liquid petroleum gas (LPG), compressed natural gas (CNG), etc have been already using in automobiles. In this context cotton seed oil renewed interest. The cotton seed oil can be converted into biodiesel using a process called as transesterification process. In the present work cotton seed oil is mixed in volume concentrations of 10%,20%,30%,40%,50%,60% with diesel and used as an alternate fuel for single cylinder four stroke diesel compressed ignition engine which can develop 3.75KW power with 1500 rpm speed. Performance parameters such as Brake Power, Specific Fuel Consumption, Indicated Thermal Efficiency, Brake Thermal Efficiency, Volumetric Efficiency, Mechanical Efficiency, Brake Mean Effective Pressure and Indicated Mean Effective Pressure are calculated based on the experimental analysis of the engine.

Emissions such as Carbon Monoxide, Hydro Carbons, CO2,NOx,O2, Smoke density are measured. And evaluated that the perfect volume concentration is 50% foroptimum brake power and less emissions.

Keywords: ***Transesterification process,Internal Combustion engine,various volume concentrations of cotton seed bio diesel, Emissions and efficiencies evalution of engine***

1. Introduction

The shortage of fossil fuels such as coal, oil and petroleum products is due to rapid consumption of energy in the country. Because of the fast depletion of petroleum products and the huge demand of diesel for all the sectors the search for alternative fuels like biodiesel (substitute of diesel) etc, has become necessary. Vegetable oils are renewable, non--toxic, biodegradable, and have low emission profiles[1-5].However, there are some drawbacks related to use of vegetables in diesel engines due to viscosity, lower volatility and heat content[6-8].The high viscosity of vegetable oils causes atomization problems in injector and may lead to ring sticking,formationof deposits, development of gumming incompatibility with lubricating oils[1,9].Most common Trans esterification process is a new technique to reduce viscosity of oils, and reduce preheating, thermal cracking [1-2,10-12]. Trans-etherification process suitable to

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convert vegetable into bio diesel fuel[2,5,11-14].The price of vegetables oils is higher than diesel fuel, so waste vegetables and non-edible crude vegetable oils preferred [11,18]. In the present research cotton seed oil and diesel usedAs biodiesel with different volume percentages 10%,20%,30%,40%,50%,60%

2.The Objectives Of This Project Are :

1.Preparation of biodiesel from cotton seed oil using methanol as catalyst by trans-etherification process
2.To experimentally evaluate the performance of diesel engine fuelled with Cotton Seed Biodiesel in percentage of 10%,20%,30%,40%,50%,60% in volume mixing with pure diesel
3. To experimentally evaluate the exhaust gas emission characteristics of a diesel engine fuelled with Cotton Seed biodiesel and diesel varying loads/power output

3. Trans-Esterification Process and Stages

1.Acid-Catalyzed Transesterification Process
2.Base-Catalyzed Transesterification Process
Biodiesel, an alternative diesel fuel is derived from a chemical reaction calledtransesterifcation of plant-derived oil. It is the chemical conversion of oil to its corresponding fatty ester in the presence of a catalyst. The reaction converts esters from long chain fattyacids into mono alkyl esters. Chemically, biodiesel is a fatty acid methyl ester. Transesterification process helps reduce the viscosity of the oil.The process proceeds wellin the presence of homogenous catalysts such as sodium hydroxide (NaOH), potassium hydroxide (KOH), sulphuric acid The formation of fatty acid methylesters (FAME) through trancesteri fication of seed oils requires raw oil, 15% of methanol &5% of sodium hydroxide on mass basis. However, transesterification is an equilibrium reaction in whichexcess alcohol is required to drive the reaction very close to completion.

Transesterification transform the large branched molecule structure of the oils intosmaller, straight chained molecules similar to the standard diesel hydrocarbons. Transesterification is the process of exchanging the organic group R" of an ester with the organic group R' of an alcohol. These reactions are often catalyzed by the addition ofan acid or base.

Transesterification is common and well-established chemical Reaction in which alcohol reacts withtriglycerides of fatty acids (non-edible oil) in the presenceof catalyst

4. Experimental Set-Up

The experimental tests were conducted on a single-cylinder, four-stroke, and water cooled diesel engine with eddy current dynamometer having a rated output of 3.5 kW at a constant speed 1500 rpm. It was fuelled with CSBD and Diesel fuel separately and was operated at different engine speed conditions. And load conditions vary from 1-3 kgs.
The engine was allowed to run at no load for a while before applying it the diesel was filled in fuel tank to conduct the experiments

- The load was increased gradually in steps of one up to 3 kg at constant speed of 1500rpm at constant injection pressure.
- In each step of increasing the load, the smoke meter and gas analyser probs were located in to the exhaust pipe of the engine and the reading of gas emissions where display by smoke meter and gas analyzer
- After this, the load was increased and same procedure was repeated initially the engine was tested with Diesel and later on CSBD, analysed and compared with Diesel fuel.
- Cooling of the engine was accomplished by circulating water through the jackets of the engine block and cylinder head.
- The experimental data generated were calculated and presented through appropriate graphs.
- Brake specific fuel consumption, brake power, Brake Thermal efficiency, Mechanical Efficiency, Exhaust gas temperature and indicated mean effective pressure weremeasured for performance and analysis, the cylinder pressure net heat release rate,cumulative heat

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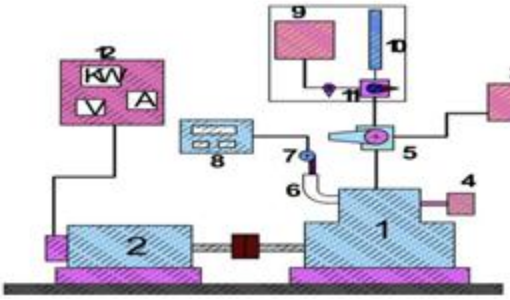
release, mass fraction burned, mean gas temperature fuel line pressure



1.Alamgair Engine 2Alternator 3.Diesel Tank
4.Air Filter 5.Three Way Valve\ 6.Exhaust Pipe
7.Probe 8.Exhaust Gas Analyser 9.Alternative Fuel Tank
10.Burette 11.Three Way Valve 12.Control Panel

5.Results And Discussions

Experiments were conducted when the engine was fuelled with Cotton Seed Oil and their blends with diesel in proportions of which are generally called as CSO-10, CSO-20, CSO-30 and CSO-40 CSO-50, CSO-60 respectively. The experiment covered a range of loads.

Performance parameters such as Brake Power, Specific Fuel Consumption, Indicated Thermal Efficiency, Brake Thermal Efficiency, Volumetric Efficiency, Mechanical Efficiency, Brake Mean Effective Pressure and Indicated Mean Effective Pressure are calculated based on the experimental analysis of the engine. Emissions such as Carbon Monoxide, Hydro Carbons, CO2,NOx,O2, Smoke density are measured. And evaluated that the perfect volume concentration is 50% foroptimum brake power and less emissions.

5.5.1. Mechanical Efficiency (ME)

Figure 5.5.1. shows an increase in Mechanical Efficiency values for diesel and biodiesel with increase of brake power. For biodiesel, Mechanical Efficiency is little bit lower than that of diesel at each load corresponding value due to low volatility and high density of ester which affects the atomization of the fuel and thus leads to poor combustion.At cso 40% at load 1kg little bit higher compare with diesel

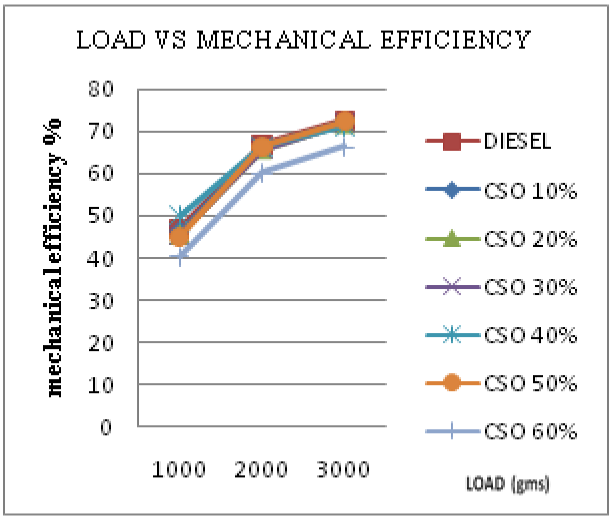


Fig..1.Variation in mechanical efficiency with change in Load

5.5.2. Brake Thermal Efficiency (BTE)

Thermal efficiency is the ratio between the power output and the energy introduced through fuel injection which equals the product of the injected fuel mass flow rate and the lower heating value, thus the inverse of thermal efficiency is often referred to as BSFC (Brake specificfuel consumption). The obtained efficiency in experiments is the brake thermal efficiency since it is usual to use the brake power for determining it.Brake thermal efficiency increases with increasing bio-diesel concentration.and at cso 50% 8% more BTE compare with pure diesel at load 3kg

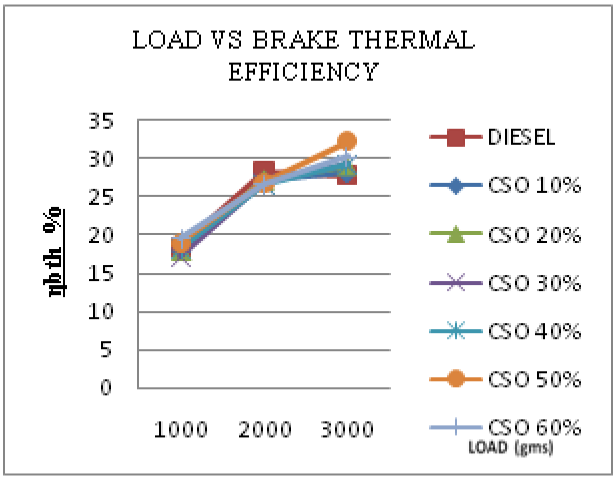


Figure 2.Variation in brake thermal efficiency with change in Load

Indicated thermal efficiency increases with increasing bio-diesel concentration.at low loads but decreases at high loads and high concentrations compare with pure diesel

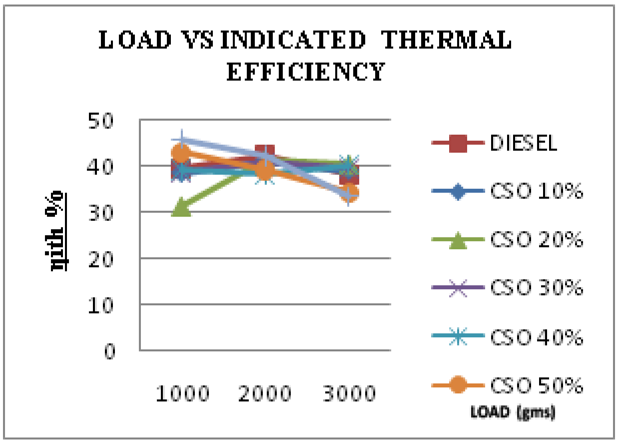


Figure 3.Variation in brake thermal efficiency with change in Load

5.5.4. Volumetric Thermal Efficiency (VTE)

Volumetric efficiency increases with increasing bio-diesel concentration.compare with pure dieselActual Breathing capacity of the engine also slightly increased which leads to increase in volumetric efficiency. It is noted that the volumetric efficiency is raised as the blend of the Cotton seed oil increases in the diesel.

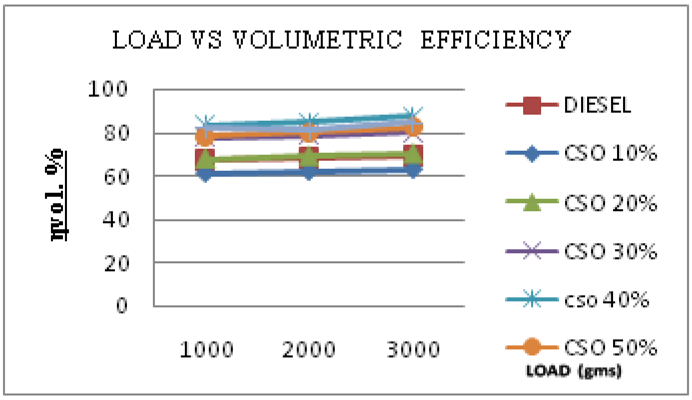


Figure 4 Variation in brake thermal efficiency with change in Load

5.5.6. Indicated Mean Effective Pressure (IMEP)

Indicated mean effective pressure is measured for diesel and biodiesel at different load values and they are compared to each other. A gradual increase in IMEP for both biodiesel and diesel with the increase in brake power is observed. For biodiesel, IMEP is little higher than that of diesel value due to higher peak pressure of biodiesel since it burns earlier because of its higher Concentration which leads to early injection. The increase percentage in IMEP of biodiesel relative to diesel is +10.21%.

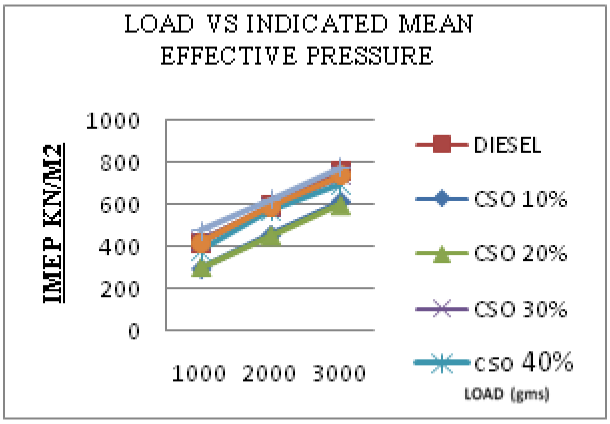


Figure 6:Variation in indicated mean effective pressure with change in Load

5.5.7. Brake Mean Effective Pressure (BMEP)

Brake mean effective pressure is measured for diesel and biodiesel at different load values and they are compared to each other. A gradual increase in BMEP for both biodiesel and diesel with the increase in load is observed. For biodiesel, BMEP is little lower than that of diesel at higer load but biodiesel shows less or equal BMEP at low and partial loads

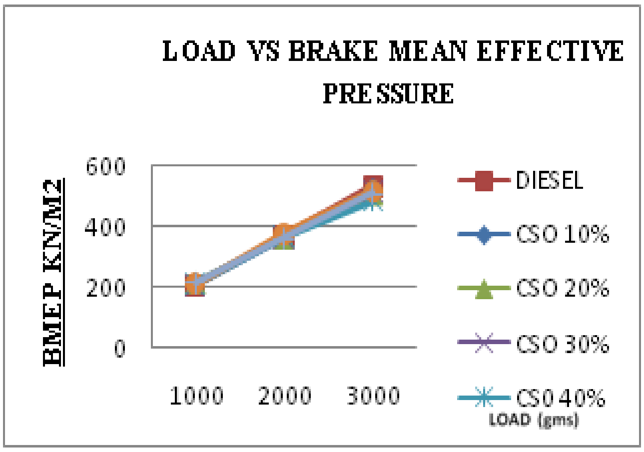


Figure 7.Variation in brake mean effective pressure with change in Load

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5.5.8. Brake Specific Fuel Consumption (Bsfc)

Below Figure shows a decrease in brake specific fuel consumption with the increase in brake power for both biodiesel and diesel. It is well known that brake specific fuel consumption is inversely proportional to the brake thermal efficiency. It is noticed that BSFC decreases in case of using biodiesel instead of diesel at corresponding high load value and increases at lower loads because its lower calorific value because the energy content of these fuels differs which would made a great difference in fuel consumption. At higher loads, the diesel fuel operation returned the lower fuel consumption due to the combined effect of lower calorific value and high density of biodiesel.

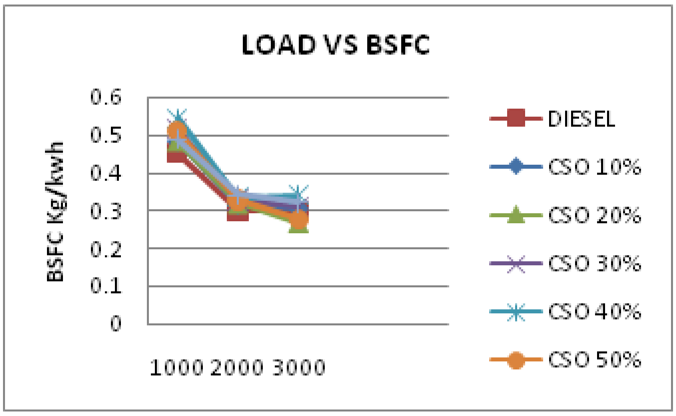

Figure 8. Variation in brake mean effective pressure with change in Load

5.6. Gas Emissions Analysis

This analysis shows the percentage avg. Of (CO,O_2,CO_2,HCandNO_x)emission gases in exhaust.

5.6.1. Carbon Monoxide Emissions (Co)

Carbon monoxide emission concentrations in the exhaust are a measure of the combustion efficiency of the system. At low loads, combustion is more complete and CO emissions are much lower. The diesel shows that decrease in CO emissions at low load, but the CO emissions are increased at high loads due to higher peak pressure which leads to higher knock levels and less smooth combustion leading to increase of CO at high level wheare as bio diesel show decrease of CO emissions with increasing biodiesl concentration

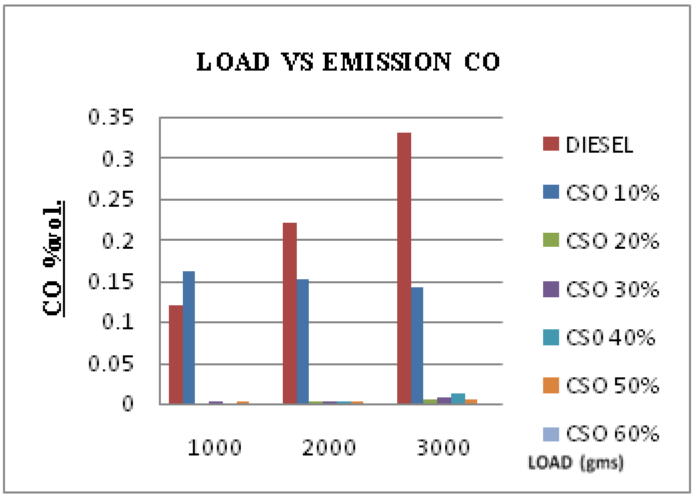

Figure 5.6.1.Variation in co emissions with change in load

5.6.2. Hydrocarbon Emissions (Hc)

Figure 5.6.2.1 shows an increase of HC emissions with load increasing for both biodiesel and diesel. Biodiesel results in better combustion rate as it contains 11% oxygen content and has higher cetane number which leads to completely burn the fuel during combustion thereby formation of HC emission become lower. As diesel fuel viscosity decreases, the spray cone angle increases and the penetration length decreases, hence HC emissions are noted to increase.The lower vapor pressure of biodiesel means fewer evaporative losses and lower unburned hydrocarbon emissions

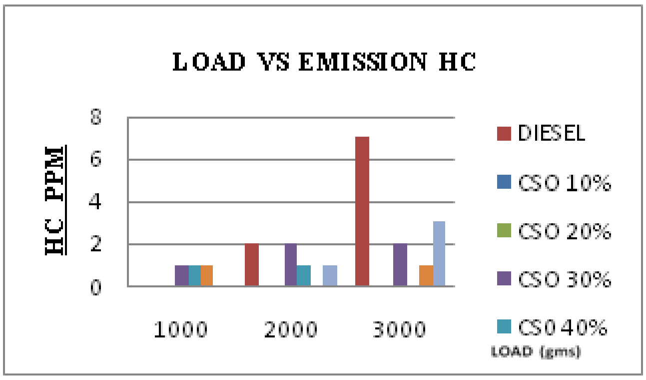

Figure 5.6.2.Variation in HC emissions with change in load

5.6.3. Carbon Dioxide Emissions (Co_2)

Figure 5.6.3.1 shows a decrease in co2 emission of diesel. As the viscosity increases, the cone angle

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decreases and penetration length increases which results in reduction of amount of air entertainment in the spray hence the emissions of CO2 were noted to decrease. It affects combustion characteristics of fuel. For biodiesel CO2 increases with load increase of load

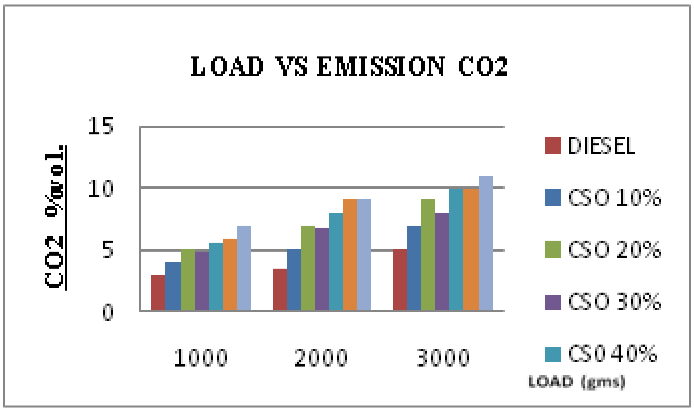

Figure 5.6.3.Variation in CO_2 Emissions with change in load

5.6.4. Oxygen Utilization (O_2)

Oxygen gas (O2) volume percentage value is measured for diesel and biodiesel at different values of load and compared to each other. From chart we notice that O2 emission values decreases for biodiesel.The results conclusively showed that biodiesel fuel operation had the highest O2 utilization. With increasing load vaues

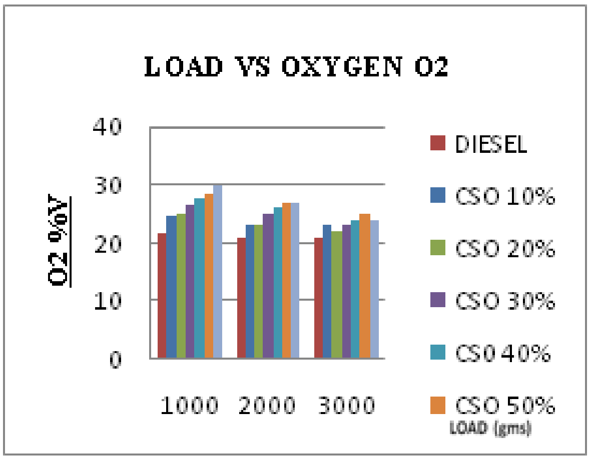

Figure 5.6.4.Variation in O2 Emissions with change in load

5.6.5. Oxides Of Nitrogen Emissions (Nox)

NOx emissions are increased directly proportion to load for both diesel and biodiesel but bio- diesel emitted less NOx emission compare with pure diesel emission the below graph showed the difference between diesel and biodiesel, emissions are less with blend of cso increases in fuel

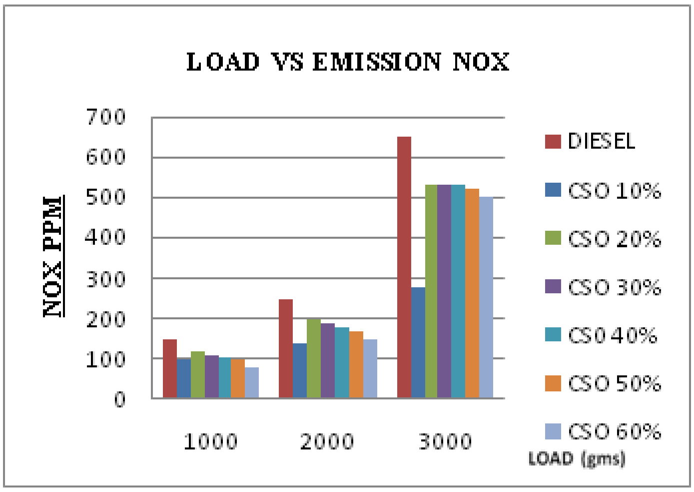

Figure 5.6.5. Variation in NOX Emissions with change in load

5.6.6. SMOKE DENSITY

Smoke density emissions are increased directly proportion to load for both diesel and biodiesel but bio-diesel emitted less Smoke density emission compare with pure diesel emission the below graph showed the emissions difference between diesel and biodiesel, smoke density will increases with blend of cso increases in fuel

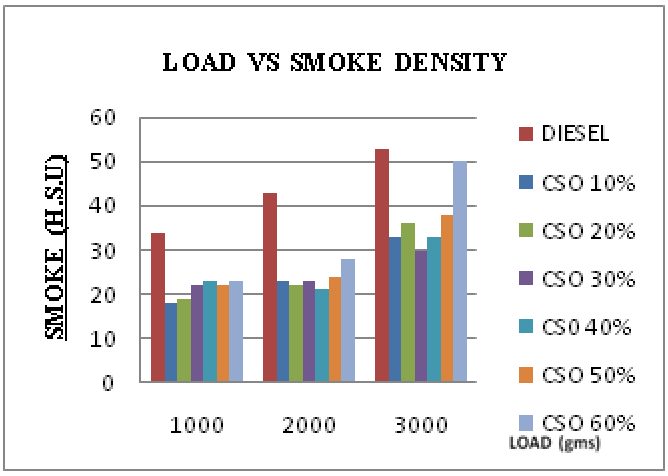

Figure 5.6.6.Variation in smoke densityEmissions with change in load

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Conclusion

Based on the experimental study, the following conclusions are summarized as follows

- Specific fuel consumption increases with an increase in biodiesel concentration. SFC is increasing atB30 by 12.6% at 1 KW load compared to diesel fuel.
- Volumetric Efficiency increases with biodiesel concentration. The increase in volumetric efficiency of biodiesel blends is 13% higher than pure diesel, irrespective bio-diesel concentration.
- Mechanical Efficiency for bio-diesel blends is equal or little bit less than the pure diesel
- Brake thermal efficiency increases with increasing bio-diesel concentration.At low loads
- CO_2 emissions decreased with increasing blend concentration
- In the case of oxides of nitrogen, there is small increase or equal for Cotton Seed Biodiesel compared to Diesel due to higher oxygen content of biodiesel which will form oxides of nitrogen at high combustion temperatures. And loads
- Due to the higher density of Biodiesel, an early injection occur and higher cylinder pressure result which is about (3.19%) at maximum output power. same reasons lead to higher premixed combustion for biodiesel for about (9.6), but for diffusive combustion is less due to higher viscosity and lower volatility of biodiesel .
- Indicated mean effective pressure of cotton seed biodiesel is 10.12% higher than that of Diesel.
- Brake specific fuel consumption for cotton seed biodiesel is higher than that of Pure diesel due to its lower energy content.
- A drastic reduction is unburned hydrocarbon(37.9%)and smoke opacity (32.56) were recorded for cotton seed bio diesel as compared to Pure diesel because of its higher oxygen content which results in better and complete combustion but this leads also increase in oxides of nitrogen. As the carbon to hydrogen ration reduces, the biodiesel tends to produce less smoke opacity.
- Regarding carbon monoxide, there is an increase for cotton seed oil compared to Diesel at maximum output power due to higher peak pressures (and also higher rate of pressure rise which is more than 6) leading to higher knock levels and less smooth combustion.
- From the above analysis the main conclusion is Cotton Seed Oil and its diesel blends are suitable substitute for diesel as they produce lesser emissions than diesel upto a load of 3000 gms and have satisfactory combustion and performance characteristics. And from the results and discussion we can observe that Cotton Seed Oil blend of 50% gives better performance in various aspects, hence it is better to use cotton Seedoil B50 for optimum usage.

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