Experimental Evaluation of Performance and Emission Characteristics of C. I. Engine using Biodiesel Blends of Waste Cooking Oil at constant CR (18)

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Abstract
The current research says that Waste Cooking Oil is also an excellent substitute as source of fuel for diesel engines, which probably be turned out to be fuel for the future. The big disparity between WCO and pure diesel is viscosity. We have blended WCO with pure diesel in variable proportions ranging as 20%, 30%, 40%, 50% of WCO in pure diesel. Test has been carried out in two sets of experimentation for analysing the performance and emission for pure diesel and also using variable blends of WCO at constant CR (18). Subsequently the performance and emission characteristics were studied and compared with pure diesel shows enhanced engine performance with increase in blend percentage along with load value. It also shows the decline in CO, HC and particulate emission but slightly increase in NOx emission.

Keywords: Waste Cooking Oil, Biodiesel, Diesel Engine, Engine Performance, Emission Characteristics.

1. Introduction

The continual rise in the prices of crude oil and depletion in the reservoirs of the crude oil, increasing hazard to environment due to exhaust emissions, the problem of global warming have adversely impacted the developing countries like India. From the point of view of long term energy security, it is necessary to develop new alternative fuels with properties comparable to petroleum based fuels. Jatropha biodiesel as an alternative fuel for diesel engine offers an advantage because of its comparable fuel properties with diesel fuel. It was described that engine parameters such as CR and Load were found to have major effect on performance and emissions of diesel engine when run with biodiesel and its blend with diesel [1–10]. Hence an experiment is carried out to study the performance of a diesel engine operated with biodiesel blends at varying load.

2. Experiments

Experimental study is carried out on a Kirloskar make, 1C, 3.5 kW, constant speed 1500rpm, VCR C. I. Engine. Performance tests are conducted on an engine at CR 18 and varying load (20%, 40%, 60%. 80% and 100%) using Waste Cooking oil biodiesel with diesel blends (B20 to B50) to determine BSFC, BTHE and EGT. Engine emissions such as CO, HC and NOx were measured by using gas analyzer.

2. 1 Experimental set-up

The specifications of Kirloskar engine are given in Table 1. The engine with & fixed CR can be modified by using some additional variable combustion space. Tilting cylinder block method is one of the arrangements which could be used to change the combustion space volume. Experimental work is being conducted at various loads & therefore an exact and dependable load measuring system is being employed. The load measuring system for current experimental test rig carries a dynamometer of eddy current type, a load cell of strain gauge type and a loading unit. The load is applied by providing current to the dynamometer using a loading unit. The load applied to the engine is measured by a load cell.

Manufacturer	M/s Kirloskar Oil Engines Ltd.
Model	TV 1
Cycle	4 STROKES
Rated Power	3.5 kW @ 1500 RPM
Type of	Direct Injection
No. of Cylinders	Single Cylinder
Bore/Stroke	87.5 /110 mm
Compression Ratio	17.5 : 1 Modified to VCR 12 to18 : 1
Swept Volume	0.661 cc
Type of Cooling	WATER COOLED
Fuel Injection	INLINE

Table 1. Engine Specification Label

2. 1 Biodiesel

Waste Cooking oil biodiesel and its blends along with diesel was taken in the experimental work. Waste Cooking oil biodiesel and pure diesel is purchased from respective commercial supplier and petrol pump as given in Table 2

PROPERTIES	DIESEL	B20	B30	B40	B50	B100
Density (Kg/m^3)	849	851	853	855	856	860
Kinematic Viscosity (mm^2/sec)	4.70	3.75	3.90	4.36	4.92	5.97
Calorific Value (KJ/Kg)	43210	41846	41190	40552	39798	36405

Table 2. Properties of Diesel and waste Cooking Oil Blends

3. Result and discussion

3.1 Engine performance

3.1.1 Brake Specific Fuel Consumption

As soon as engine reached to its stabilized working condition for each test, Fuel consumption, torque applied and exhausts temperature were calculated from BSFC and BTHE and these parameters with their respective variations against load is plotted and presented in figure 1, 2 and 3 at CR 18.

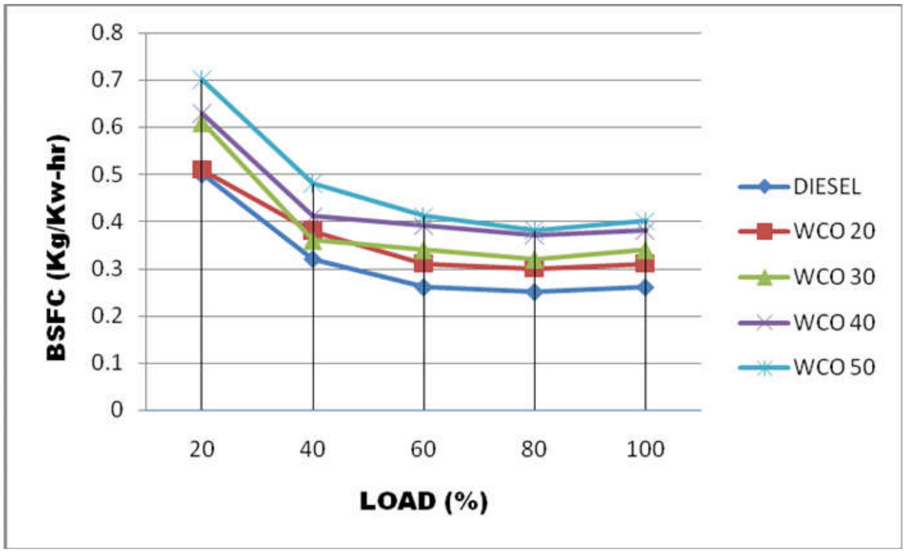

Figure 1.Variation of BSFC with Engine Load at Constant Speed 1500 rpm at CR 18

It clearly gives indication from figure 1 that BSFC line of various blends of waste cooking oil came close to each other as load increases from 20% - 100% which shows comparative performance of biodiesel blends at higher loads. The lowest BSFC values were found by using diesel, B-20 and B-30 at full load were 0.26, 0.31 and 0.34 kg/kW-hr respectively. Variations in BSFC at different blends were less at full load conditions in comparison at part load: this is possible because of increase in temperatures and consequently increased efficiencies of the engine. Because of their low volatility and high viscosity in comparison to pure diesel oil, biodiesel may perform comparatively better at higher CR. BSFC were found a sharply decline with load for all fuels. The actual reason for this is percentage increase in fuel need to activate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. From the above discussions it could be concluded that the BSFC is a function of biodiesel blend, and load.

3.1.2 Brake Thermal Efficiency

Variation of BTHE of VCR engine is found during the work which is shown in Figure 2 as a function of load for CR 18.

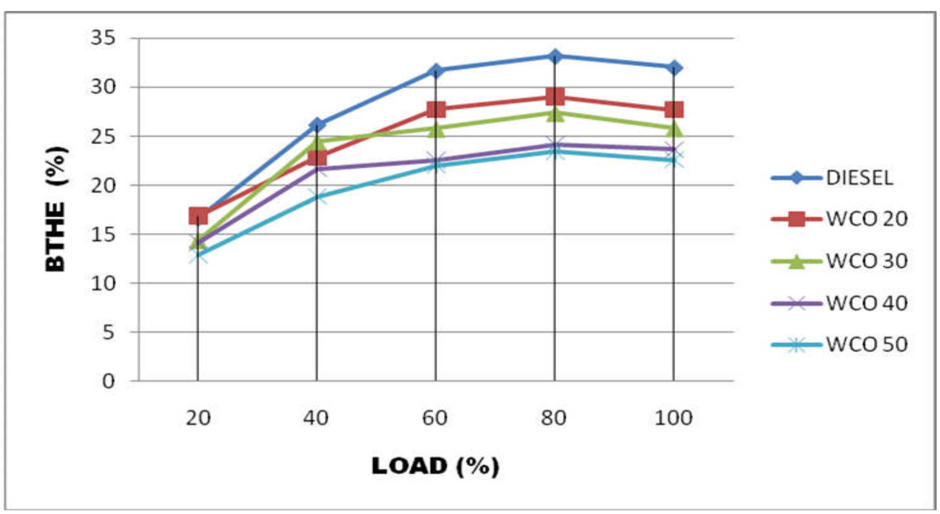

Figure 2.Variation of BTHE with Engine Load at Constant Speed 1500 rpm at CR 18

It is found during the test is that the parameters which were accountable for providing best fuel economy also results maximum BTHE. The highest value of BTHE using diesel was 33.15% whereas it was 29.06% and 27.38% in case of B20 and B30 respectively. B50 gives BTHE of 23.51% which lowest for all blends at same load conditions. With the reference of these results we can arrive at a relation which tells that the engine performance using biodiesel blends as fuel is almost same as that of pure diesel oil in terms of BTHE. Increase in load from 20% to 100% load also increases BTHE for blends of biodiesel. This is just because of blends of biodiesel has lower volatility in comparison with pure diesel oil and that's why combustion characteristics might be relatively better at higher temperatures results of higher loads in comparison with pure diesel with variation in load. The brake thermal efficiency of the engine was low at part loads as compared to the engine running on full load.

3.1.3 Exhaust Gas Temperature

The variation of exhaust gas temperature with the engine load for all the blends of Jatropha biodiesel are shown in figure 3 at the constant speed of 1500rpm at CR 18. Figure 3 shows that as the load increases the exhaust gas temperature increases for the blends of biodiesel. The diesel fuel shows less exhaust gas temperature in comparison with all the biodiesel blends at all loads.

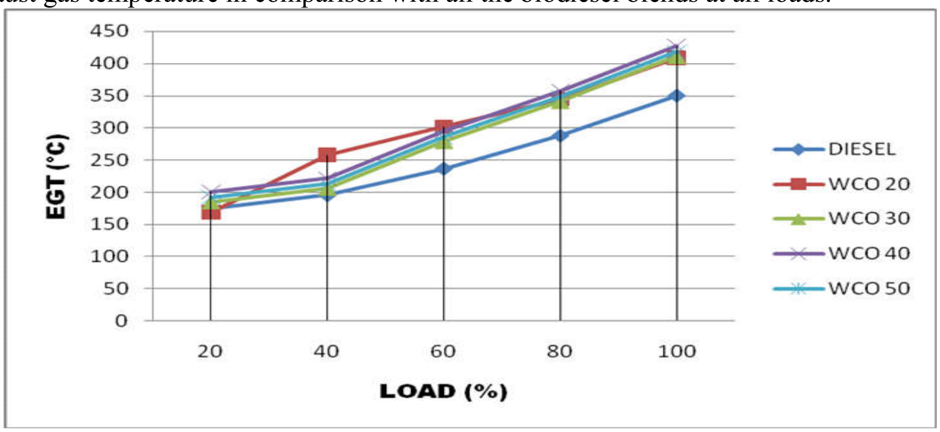

Figure 3.Variation of EGT with Engine Load at Constant Speed 1500 rpm at CR 18

At Full load, EGT of diesel , WCO 20, WCO 30, WCO 40 and WCO 50 are 350ºC, 409ºC ,411ºC ,427 ºC and 418ºC respectively. It is clearly seen from above graph that as blends of biodiesel increases with increase in EGT because more oxygen content of biodiesel blends in comparison with pure diesel which helps to perform complete combustion of fuel. It may be because of higher viscosity, late burning of fuel particles take place on the walls of cylinder which will lead to higher gas temperatures as compared to other blends.

3.2. Engine Emission Characteristics

3.2.1 Carbon Monoxide

Figure 4 shows that the CO emissions for biodiesel blends are lower when compared to pure diesel.

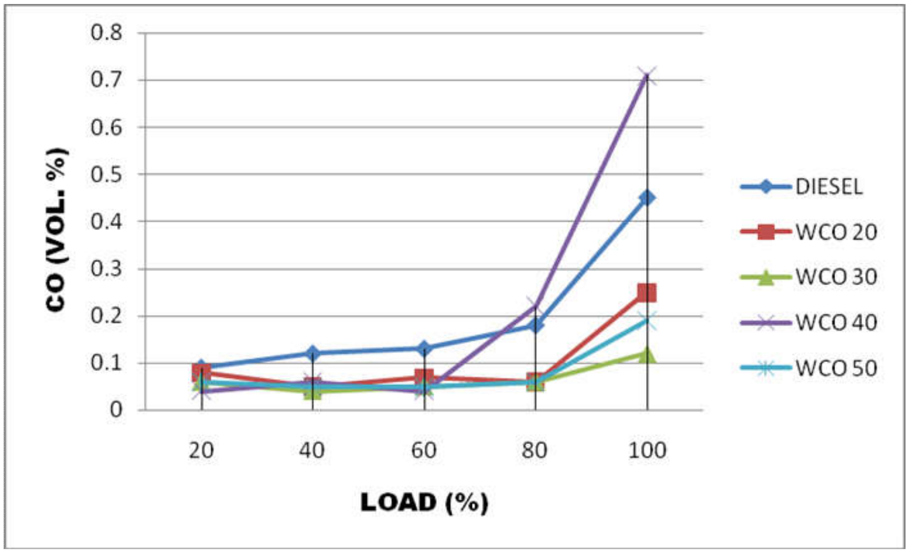

Figure 4.Variation of CO with Engine Load at Constant Speed 1500 rpm at CR 18

CO presence in the EG of fuel tells about the chemical energy of the fuel which is not completely burnt, generally the CO emission is affected by the fuel type, combustion chamber design and atomization rate, engine load and engine speed. It is observed from the above graph that the CO emission decreases with the increase in load up to 80% load and at full load it sharply increases due to the sudden increase may be incomplete combustion at full load. With percentage of biodiesel increasing in blend fuel, CO emissions of blend reduce. The reasons for this behaviour might be to more oxygen in biodiesel and better oxidation reactions during the expansion stroke.

3.2.2 Hydrocarbons

Figure 5 shows the HC emission for biodiesel blends are lower that the diesel for all loads.

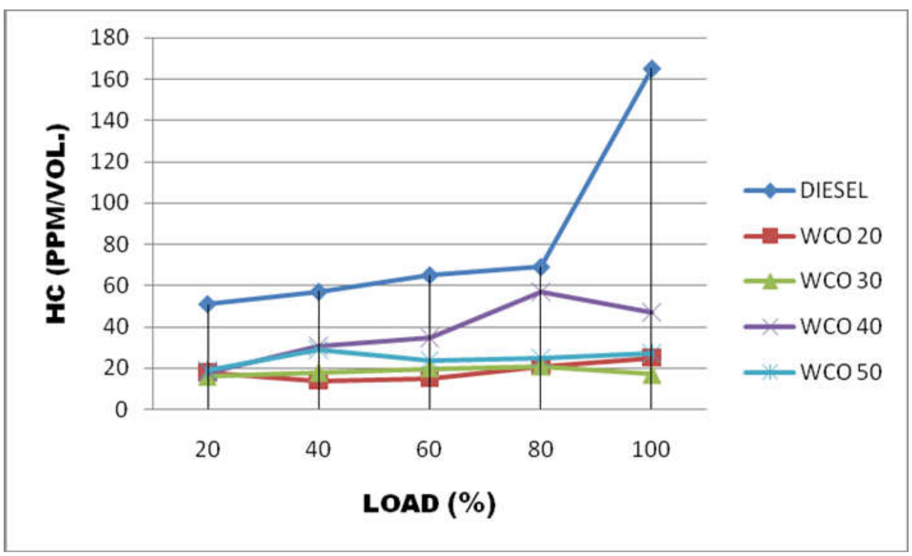

Figure 5.Variation of HC with Engine Load at Constant Speed 1500 rpm at CR 18

B30 & B20 are showing almost similar lower HC and it follows by B50 and B40 for entire load series. This pattern is same with regards to previous studies and merely because of high HC oxidation late in the expansion stroke. Complete combustion of blends takes place producing less amount of unburned HC. Emissions of HC decrease with increase of oxygen inside the combustion chamber oxygenated fuels or oxygen-enriched air where as on the other side, although biodiesel is less volatile than pure diesel fuel which has higher distillation points found during testing. This final fraction of diesel may not be completely vaporized or burnt, thereby increasing UHC emissions. Therefore, lower UHC emissions can be expected when biodiesel and biodiesel-diesel blended fuels are used in a diesel engine.

3.2.3 Oxides of Nitrogen

Figure 6 shows the NOx emissions for the blends of biodiesel and diesel at constant speed 1500 rpm & CR 18. Emission of NOx is more in blends of biodiesel in comparison with pure diesel fuel. NOx emission increases with increase in blend ratio. This can be attributed to the variation of the maximum combustion temperature inside the cylinder for both blends. As we increase the load on engine, injection of fuel increases and heat transfer per cycle decreases which results in high temperature of burning of the gases and causes increase in formation of NOx emission. Biodiesel and its blends emits larger amount of NOx as compared to pure diesel fuel, it is possibly because of high oxygen content in biodiesel fuel where as pure diesel fuel carries less oxygen and this is potential drawback of use biodiesel as a C.I. engine fuel but other pollutant parameter are very less.

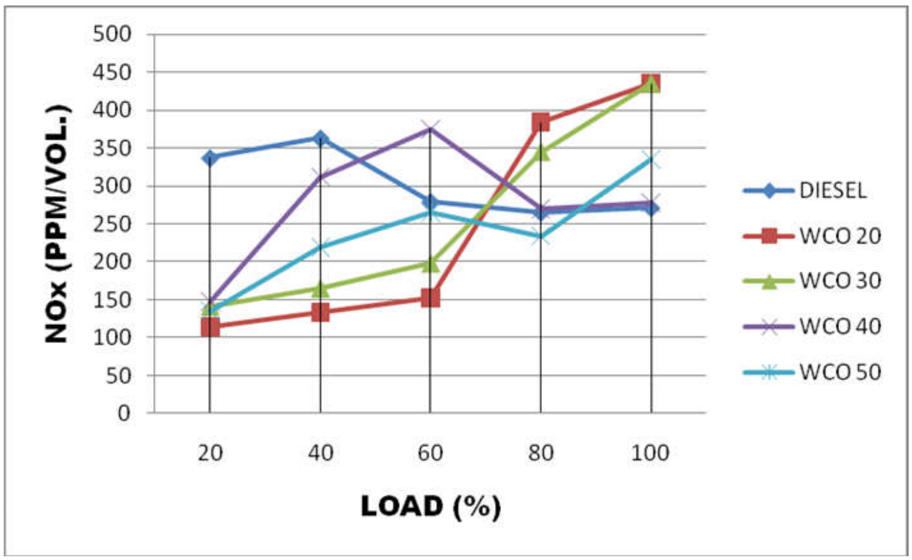

Figure 6.Variation of NOx with Engine Load at Constant Speed 1500 rpm at CR 18

4. Conclusion

As the experimental work says it indicates that BSFC, BTHE and EGT of engine are the function of blends of waste cooking oil and engine load (20% to 100%). With the identical operational conditions, performance of engine decreases with increase in percentage of biodiesel blend but by increasing the load percentage this difference can be minimised and become same as pure diesel contains. Biodiesel may possibly be securely blended with pure diesel. B20 shows similar performance at any of the load as that of the diesel. It is universally accepted now that biodiesel is a renewable and biodegradable alternative fuel suitable for CI engines. It reduces the CO, HC and particulate emissions but marginally increases the NOx emissions which can be lowered by retarding fuel injection timing and/or by using suitable additives (DTBP). The specific fuel consumption of biodiesel is slightly higher as compared to petrodiesel due to its lower heating value & higher density. Brake horsepower & torque are slightly less. In different countries, different blends and neat biodiesel is in use.

5. Refrences

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