iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** III **Month of publication:** March 2020

DOI:

Experimental Investigation on Performance and Emission of CI engine using B20 Waste Cooking oil with and without Exhaust Gas Recirculation

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Abstract:** Petroleum depletion, Environment degradation are the major problems which has to be looked upon in the coming days. Researchers are working for the best alternative,. Biodiesel is one of the substitutes. More fuel consumption higher density and oxides of nitrogen are some of the issues that should be seriously looked into when biodiesel is used as an alternative. In order to encounter these problems Exhaust Gas Recirculation (EGR) is used. Biodiesel is obtained from Waste Cooking oil by trans esterification process. In this paper an attempt has been made to study the Performance and Exhaust parameters of waste cooking oil biodiesel with and without EGR. Experiments were carried out on four stroke, single cylinder, water cooled Diesel engine [KIRLOSKAR MAKE] to study the Performance and Emission parameters of waste cooking biodiesel (B10 B20) blend with and without EGR. The results obtained at different blends is compared with diesel. It has been observed from the result that, for bio-diesel without EGR increase of 2.2% of brake thermal efficiency for B20 when measured with diesel and B10. Also the maximum Specific fuel consumption (SFC) is observed for diesel (0.2532 Kg/kw-hr) and minimum for B20 (0.235 Kg/kw-hr). So there is 7.65% decrease in SFC of B20. For emission characteristics, it was noted from results, the emission of CO in B20 is reduced by 16.66% as measured to diesel. The maximum NOx emissions at full load were showed for B 20(1294PPM) and for diesel (1142 ppm).It was observed from the results that using EGR technique Performance and emission parameters improved with B20 blend with reduction in NOX. Thermal efficiency increased and fuel consumption was better for B20 blend. With respect to emissions of B20 blend with EGR, reduction in CO and HC were observed with increase in NOx.
Keywords: EGR, CO, HC, NO_X, Cooking oil

I. INTRODUCTION

An alternative for petroleum products is indeed gaining a lot of prominence .Edible oils and Non Edible oils like palm neem, jatropha ,karanja areone of the best alternatives for fossil fuels. Researchers are on the opinion that biofuels might be the suitable alternative for petroleum products[1-4]. It is observed that Biodiesel can be blended to any extent without engine modification. Results show that there is a slight increase in BTE with biodiesel blends. Emissions were moderate with blends of biodiesel compared to baseline diesel.[5-7]. The test were conducted on a stationary single cylinder CI engine with edible oils and observed low PPM,UHBC,NOX and CO. The fuel consumption increased lightly with increase in loads. [8] .Biodiesel plays an important role in replacing fossil fuels. It can be replaced with no engine modifications. It can be blended to high levels. Biodiesel possesses properties similar to that of petrol and diesel. Optimum results were obtained from biofuels and its blends . [9-12]

II. METHODOLOGY

An engine test rig is a facility used to develop, characterize and test engines. A sophisticated engine test rig houses several sensors (or transducers, data acquisition features and actuators) to control the engine state. Experiments were carried out on four stroke, single cylinder water cooled diesel engine [KIRLOSKAR MAKE] to study the Performance and Emission parameters of waste cooking oil biodiesel (B10 B20) . The below figure illustrates the various parts of the test engine. The test engine was coupled with an eddy current dynamometer to control the engine torque for loading the engine. A high speed computer digital based data acquisition system consisting of a sensor is used to measure fuel intake, load, speed and BMEP etc. Exhaust emission parameters were measured with AVL di-gas analyser and AVL smoke meter was used for measuring amount of smoke emitted.

Experimental tests were carried out at five different levels with an increment of 20% along the consecutive loads ranging from 0%,20%,40%60%80% and 100% loads keeping the speed range at 1800 rpm. Initially the test CI engine was run with neat diesel for 20 mins to warm it up before testing other blends. Then, the test was carried for diesel and biodiesel. Performance and emission parameters for various loads were measured using eddy current dynamometer and corresponding emissions with gas analyzer and smoke meter. The obtained results were compared for diesel and biodiesel. Figure 1 shows Computerized Diesel engine test rig and Figure 2 shows Schematic diagram of Experimental set up. First the experiment was carried out without EGR on a computerised diesel test rig (Kirloskar Make) using Waste cooking oil blends and pure diesel running at 1800 rpm at a compression ratio of 17.5:1. The engine was connected with an eddy current dynamometer and suitable torque was applied which resulted in load application The Torque was applied from 0 to 62.9Nm. At 0 Nm the the engine was made to run with diesel for 20mns, after 20mns Torque was applied resulting in the load application with increments of 20%. The results of pure diesel were measured and tabulated for (0 to 100%) loading. Waste cooking oil blends (B10,B20) were then introduced and loads were applied (0 to 100%).The Performance parameters and exhaust emission parameters of Diesel and biodiesel blends were measured at different engine loads. Smoke meter and Exhaust gas analyser were used to measure HC,CO and NOx. After the application of 100% load the engine was made to run for 10 mns with diesel for clean up of biodiesel. Later the above procedure was repeated with 30% EGR using diesel and biodiesel blends.

III. FIGURES AND TABLES

Figure1: Computerized Diesel engine test rig

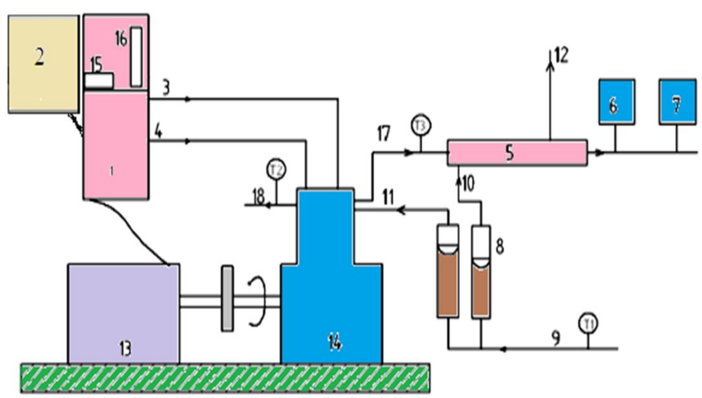

Figure.2: Schematic Representation of the Experimental Set Up

1 = Control Panel
2 = Computer system
3 = Diesel flow line
4 = Air flow line
5 = Calorimeter
6 = Exhaust gas analyzer
7 = Smoke meter

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

8 = Rota meter
9= Inlet water temperature
10= Calorimeter inlet water temperature
11= Inlet water temperature
12 = Calorimeter outlet water temperature
13 = Dynamometer
14 = CI Engine
15 = Speed measurement
16 = Burette for fuel measurement
17 = Exhaust gas outlet
18 = Outlet water temperature
T1= Inlet water temperature
T2 = Outlet water temperature
T3 = Exhaust gas temperature

Table 1: Technical specification of Engine

Manufacturer	Kirloskar oil Engines Ltd
Model	TV-2
No of Cylinder	1
Type of Engine	4-Stroke cycle, Single acting
Cooling	Water
Fuel	Diesel
HP	16HP
Starting	Hand Cranking
Bore	87.5mm
Stroke	110mm
Cubic Capacity	1322cc
Nominal Compression Ratio	17.5:1

Table 2: Properties of various alternative fuels.

Properties	1.Gasoline	2.Diesel	3.WCO
Molecular weight	105	200	305
Density kg/m3	780	830	860-880
Specific gravity	0.78	0.83	0.86-0.88
Boiling point ^{0}	32-220	180-340	220-260
Lower heating value kJ/kg	43,890	42,700	44,000
Flash point ^{0}c	-43	74	128
Autoignition temperature ^{0}c	300-450	250	300-330

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IV. RESULTS

A. Performance Characteristics (without EGR)

With respect to IC engine Performance means how effectively the heat energy supplied by the fuel is converted to work done. A few standard Performance Parameters are tabulated at different load condition.

1) *Brake Power:* The nature of change of brake power with respect to load at different loading condition is as shown in the figure 2. The power which is driving the crankshaft is brake power. Brake Power varies proportionally with load. Maximum power will be generated when the load is maximum. There is a slight increase in of B10 and B20 than base line diesel.

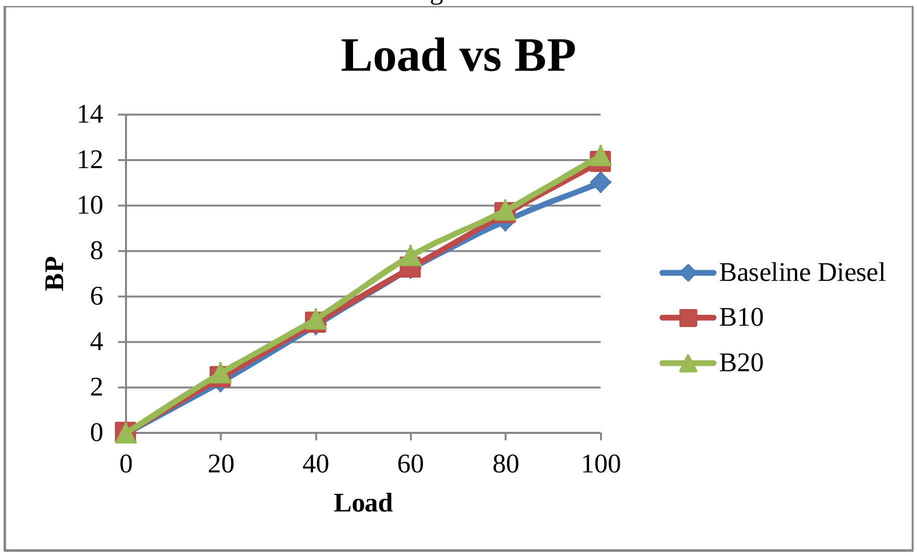

Fig 2: Load vs BP

2) *Brake Thermal Efficiency:* Brake thermal efficiency is the important factor which relates energy input and brake power. Energy input is nothing but mass of fuel consumed and the calorific value of used fuel. The relation between BP and Load is shown in figure 3. It has been observed that B10 and B20, the BTE is slightly higher than the neat diesel. The maximum BTE is seen for B20 (35.51%) and minimum is observed for diesel (33.31%). It can be concluded that there is 2.2% increase in BTE of B20 when measured with diesel . This might be because of proper mixing of air fuel mixture resulting in better combustion.

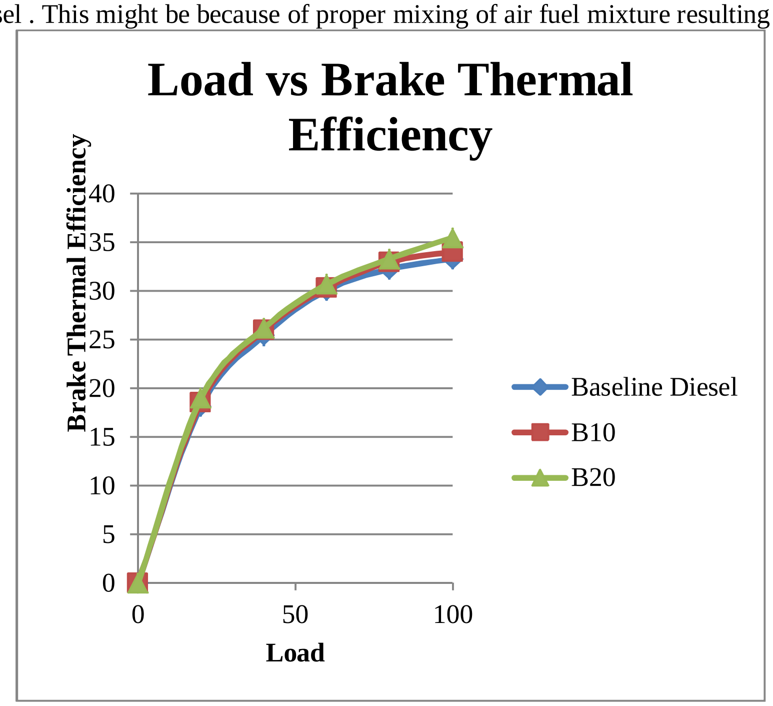

Fig 3: Load vs Brake thermal efficiency

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3) *Specific Fuel Consumption:* The nature of change of specific fuel consumption with load at various loading condition is as shown in the figure 4. SFC shows decrease trends with loads. The maximum SFC is observed for diesel (0.2532 Kg/kw-hr) and minimum for B20 (.235 Kg/kw-hr). So there is 7.65% decrease in SFC of B20. It is due to fact that with higher loads , the in-cylinder temperature increases which results in better combustion of fuel and less consumption.

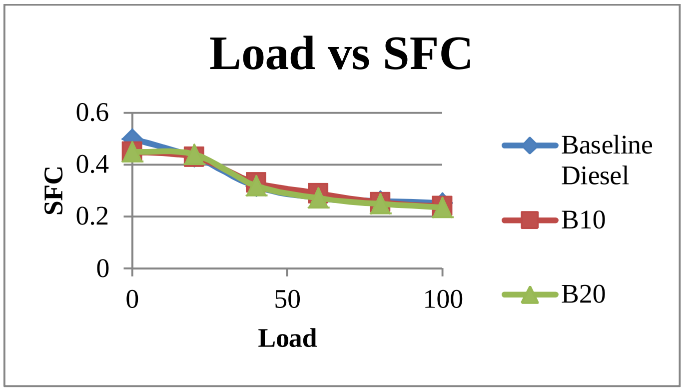

Fig 4: Load vs SFC

B. Performance Characteristics (with EGR30%)

It has been observed that B10 and B20, the BTE is higher when compared to diesel. The maximum BTE is observed for B20 (37.26%) and minimum for diesel (34.24%). It can be concluded that there is 3.2% increase in BTE of B20 when compared with diesel under 30% EGR. This might be because of effective utilization of heat, improved combustion

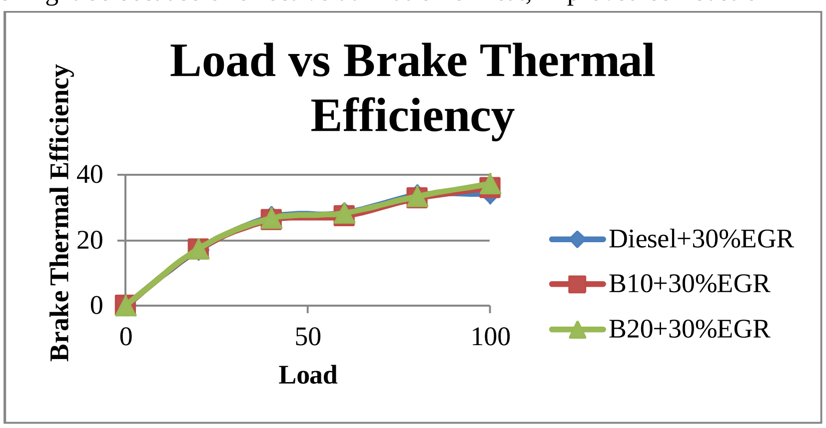

Fig 5:Load vs Brake thermal Efficiency

The nature of change of SFC with LOAD is as shown in Fig 6. SFC shows decrease trends with loads.. The maximum SFC is observed for diesel (0.2432 Kg/kw-hr) and minimum for B20 (.228 Kg/kw-hr). So there is 7.1% decrease in SFC of B20.

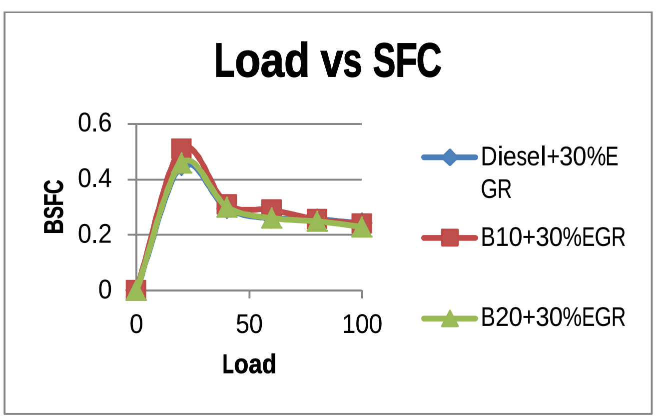

Fig 6:Load vs BSFC

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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C. Emission Characteristics (Without EGR)

1) *Carbon Monoxide:* CO is formed due to insufficient supply of oxygen at higher loads. Lower the temperature of Combustion chamber and absence of oxygen results in CO formation. The nature of change of load vs CO is as shown in Fig. CO shows decrease trends with load increment . It can be concluded from the graph that CO emissions in B20 is lower by 16.66% compared to diesel. It might be due to fine atomization and complete combustion of fuel.

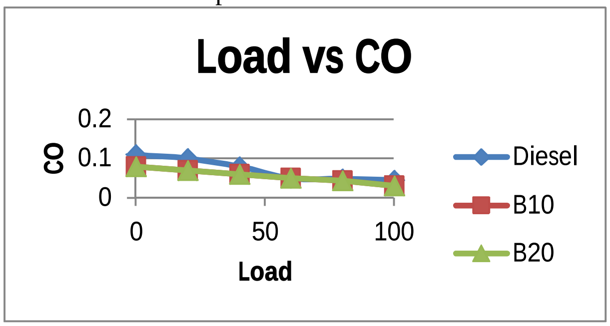

Fig 7: Load vs CO

2) *Oxides of Nitrogen:* The nature of change of oxides of nitrogen with respect to load at different loading condition is as shown in the figure 8. Combustion of fuel leads to increase in the temperature and pressure. This temperature and pressure is sufficient for reaction of nitrogen and oxygen resulting in NOx formation. At higher temperature Nox emissions increases.From the graph the maximum NOx emissions at full load were showed for B20(1294PPM) and diesel (1142 ppm) respectively.

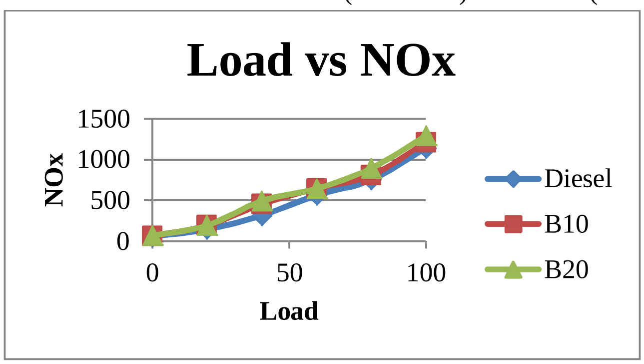

Fig:8: Load vs NOx

3) *Unburnt Hydro Carbon:* Fig10 shows the relation of UHC with load The primary constituent of any fuel is hydrogen and carbon and upon burning with oxygen produces a large amount of heat. Incomplete combustion of fuel leads to the formation of UHC at exhaust. The maximum and minimum HC emissions at full load are observed for diesel (102 ppm) and B20 (98ppm) respectively.

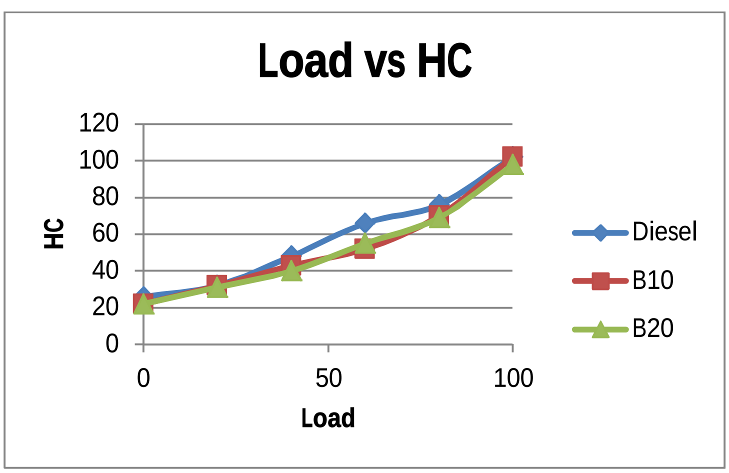

Fig 9: Load vs HC

D. Emission Characteristics(with EGR)

1) *Carbon Monoxide:* CO is formed due to insufficient supply of oxygen at higher loads. Absence of oxygen during combustion results in CO formation. The nature of change of load vs CO is as shown in Fig11. CO shows decrease trends with load increment . It can be concluded from the graph that CO emissions in B20 is lower by 18.22% compared to diesel. This is because of the oxygen content and fine atomization.

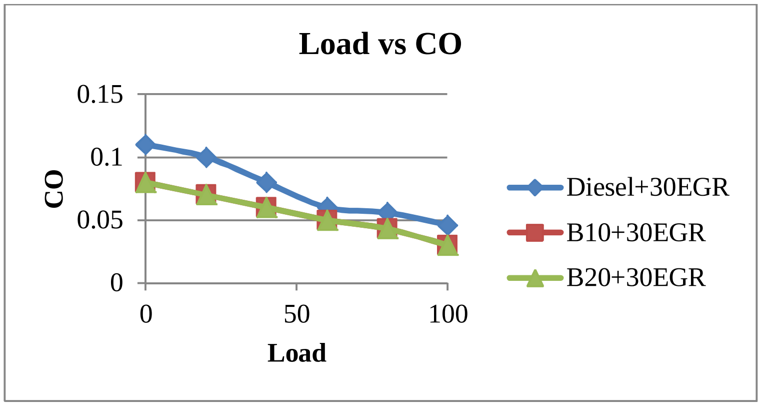

Fig 10:Load vs CO

The nature of change of oxides of nitrogen with respect to load at different loading condition with 30% EGR is as shown in the figure 11. Higher combustion temperature results in the formation of NOx. A part of exhaust emissions is sent into the intake manifold thereby reducing the energy required by fuel for combustion resulting in moderate NOx emissions.From the graph the NOx emissions at full load were showed for B20(1142PPM) and diesel (1048ppm) respectively

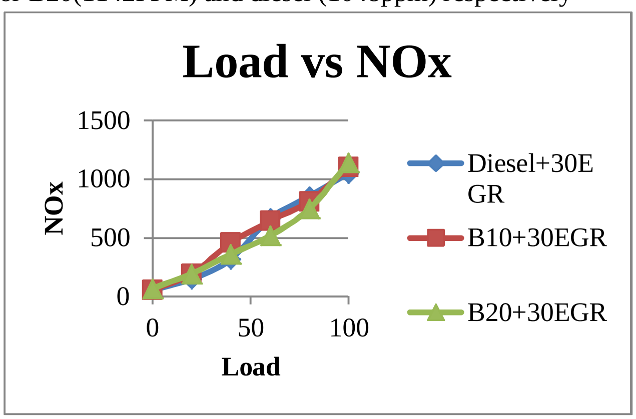

Fig 11:Load vs NOx

Fig12 shows the relation of UHC with load. It can be noted that UHC shows increase trends with load. The maximum and minimum HC emissions at full load are observed for diesel (112 ppm) and B20 (104ppm) respectively.

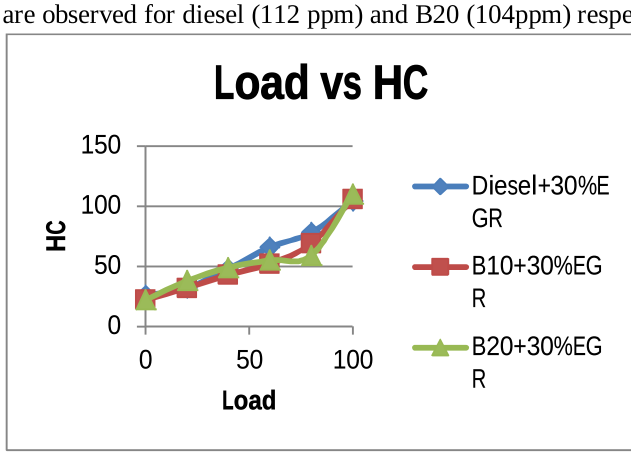

Fig 12:Load vs HC

V. CONCLUSION

The experimental work was carried to study the performance and emission parameters of diesel engine with blends of waste cooking oil (B10 B20 and diesel) with and without EGR.

A. For Performance Characteristics Without EGR

The maximum BTE is accounted for B20 (35.51%) and minimum is observed for diesel (33.31%).It has been observed from the result that, there was an increase in 2.2% of brake thermal efficiency for B20 when compared with diesel and B10. The maximum Specific fuel consumption (SFC) is observed for diesel (0.2532 Kg/kw-hr) and minimum for B20 (0.235 Kg/kw-hr). So there is 7.65% decrease in SFC of B20.

B. For Performance Characteristics with EGR(30%)

The maximum BTE is accounted for B20 (37.26%) and minimum is observed for diesel (34.24%). This shows that there is 3.2% increase in BTE of B20 when compared with diesel under 30% EGR. The maximum SFC is observed for diesel (0.2432 Kg/kw-hr) and minimum for B20 (.228 Kg/kw-hr). So there is 7.1% decrease in SFC of B20.

C. For Emission characteristics without EGR

It was noted from results, the emission of CO in B20 is reduced by 16.66% when compared to diesel.The maximum NOx emissions at full load were showed for B20(1294PPM) and for diesel (1142 ppm).

D. For Emission characteristics with EGR(30%)

The emission of CO in B20 is reduced by 18.22% compared to diesel. The maximium NOx emissions at full load were showed for B20(1142PPM) and diesel (1048ppm) respectively.

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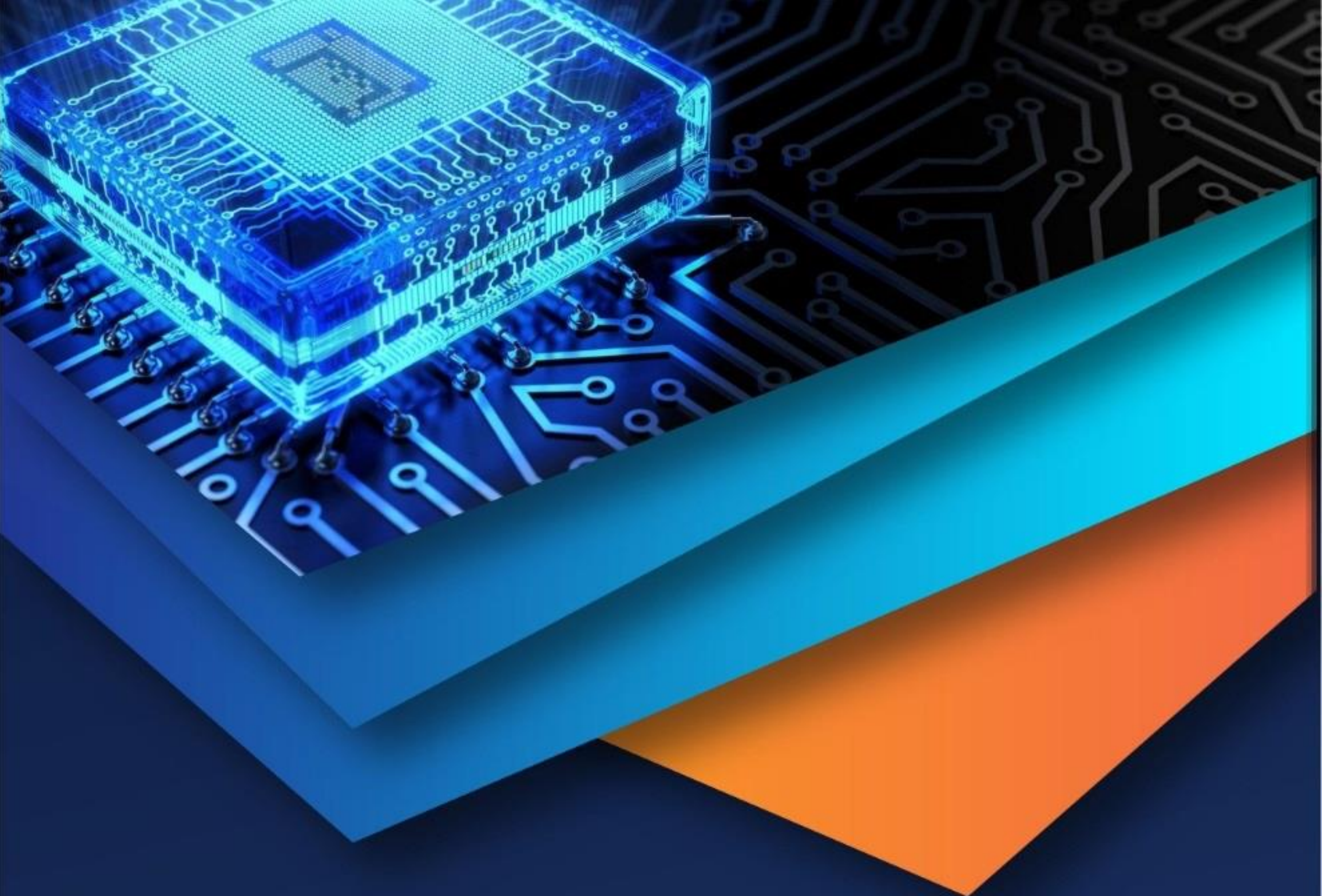

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