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ANALYSIS OF INFLUENCE OF EXHAUST GAS RECIRCULATION ON A CRDI ENGINE POWERED BY DIESEL-BIODIESEL BLENDS

Kunapuli Siva Satya Mohan, Associate Professor, kunapulisiva46@gmail.com
K. P.V. Krishna Varma, Associate Professor, varmamtech@gmail.com
P. V S Muralikrishna, Sr.Assistant Professor, krishna4bi@gmail.com
M.Rambabu, Assistant Professor, rambabuthermal@gmail.com

Pavan Kumar Ch, Assistant Professor,pavankumarchintalapati@gmail.com

Abstract: In this study cotton seed biodiesel is prepared physically by mixing methanol 20% by volume and used KOH as catalyst by 0.5% by weight to attain better effects. The experimentation is conducted by considering B10 and B15 as blends. At each blend the percentage of EGR is varied from 10% to 25%. In this load is varied as 20%, 40%, 60%, 80%, and 100%. The maximum load is considered as 3.7KW. In this major focus is kept on reducing NO_x percentage by increasing EGR percentage. The graphs like BSFC, BTE, NO_x, CO_2, HC, Smoke Density and Exhaust gas temperature are plotted. It was found that percentage of NO_x is reduced at full load and unburnt hydrocarbons increased to an extent as an effect of EGR. As cotton seed biodiesel has low calorific value, high density and high viscous effected combustion which lead to gradual reduction in the break thermal efficiency

***Keywords*— Biodiesel, Emissions, BSFC, BTE, NO_x, HC**

1. Introduction: The great invention on this planet is internal combustion engine shortly abbreviated as IC Engine. These engines brought up grand revolution and made transportation much flexible and easier. Internal combustion engines ruled roads of this planet in motion from one place to other. The first person to invent commercial IC engines is ETIENNE LENOIR in 1859.Sir Nicholas Otto is the first person to invent moderate internal combustion engine in 1876. As the invention of wheel brought the revolution in 500BC apt to that internal combustion engine brought same revolution in present day scenario till date. As the name suggest internal combustion it is quite clear that combustion takes place inside the cylinder that is in combustion chamber of internal combustion engine. Internal combustion engine has reciprocating mechanism. As the definition of internal combustion engine mentions that the device which converts chemical energy into mechanical energy is termed as IC engines. Here chemical energy in the sense fuel energy or fuel power. The fuel is combusted in presence of filtered atmospheric air on combusting this mixture heat is liberated thus it just get converted into mechanical energy by reciprocating mechanism. Majorly internal combustion engines take natural gas, extracted petroleum products such as gasoline and diesel as their fuel. The emission in internal combustion engines are as NOx, Sox, carbon monoxide and unburned hydro carbons etc. The challenging task of present day scenario is reducing emissions by altering the old technology with newly and moderate technology like Exhaust Gas Recirculation. The principle on which internal combustion engine operates is reciprocating mechanism. Otto cycle and Diesel cycle are the two cycles on which majority of internal combustion engine works. Petrol engine works on Otto cycle and Diesel engine operates on Diesel cycle. High speed engines operates on duel cycle. The present work is use of EGR to reduce emissions in CRDI engine by taking biodiesel blends to increase the break thermal efficiency.

2. Literature Survey:

Faster depletion of fossil fuels coupled with an increase in emissions leads to exploration of innovative and alternative technologies globally (Pramanik 2003). The high viscosity of biodiesel leads to problems in atomization, air fuel mixture formation and vaporization (Tanzer et al. 2014, Purusothaman 2014). According to this study, the sodium methoxide of 1.00 wt.%, reaction time of 60 min, reaction temperature of 550C and methanol to oil ratio of 6:1 could be the most favourable conditions for lowest kinematic viscosity and high yield percentage of biodiesel. The biodiesel derived from wide variety of feedstocks such as jatropha, pongamia, karanja, fish oil, etc., and their blends with diesel has been investigated by various researchers globally. Cotton seed oil biodiesel as a diesel substitute was investigated by so many researchers. The B20 blend of cotton-seed biodiesel and diesel with the additive CeO2 could reduce emissions in diesel engine (Durairaj et al. 2017). The recent investigations on biodiesel preparation from waste cooking oil determine the optimal conditions for obtaining lowest kinematic viscosity (3.91 cSt) and high yield percentage of biodiesel (98.19%) (Gülüm,Yesilyurt and Bilgin 2020). Naga Sarada et.al. (2010) conducted experiments in a diesel engine with cotton seed oil biodiesel-diesel blends at different injection pressures ranging from 180 to 240 bar. The oxygenated additive 1-heptanol in diesel-biodiesel blends reduced CO and HC emissions when compared to pure diesel, with an increase in NOx emissions (Murat 2020). Ignition delay periods of higher cetane fuels are shorter than that of lower cetane fuels in a particular diesel engine (Rao et al. 2009). Higher proportion of NOx emissions is another disadvantage associated with biodiesel (Jagadish, Puli and Murthy 2011). Two different shapes, namely rounded nozzle and sharp edged nozzle were typically used in CRDI engines. The sharp edged nozzles can be preferred at lower injection pressures while at higher injection pressures, round edged nozzles are more suitable (Prabhakar et al. 2013). CRDI system assisted diesel engine using diesel-biodiesel blends with aluminium oxide nanoparticles reduced specific fuel consumption and both HC and smoke emissions significantly. The concentration of HC and smoke emissions for the diesel-biodiesel blends without aluminium oxide nanoparticles were 13.459 g/kW-h and 79 HSU, whereas they were 8.59 g/kW-h and 49 HSU respectively with the addition of nanoparticles (Indrareddy,Venkateswarlu and Ramakrishna 2020).

3. Experimental details

The experimentation conducted on common rail direct injection engine which contains variables as variable compression ratio, usage of different blended fuels such as cotton seed biodiesel and azoles biodiesel etc, variable fuel injection pressure, variable fuel injection

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timing and variable speed at different loads as well. The considerations made in this experimentation or design of experiments are compression ratio is made to be constant that 17.1:1 in engine. Cotton seed biodiesel is considered as fuel in certain proportions like B10, B15 etc. The latest technology that is Exhaust Gas Recirculation is used and percentage on inclusion of exhaust gas in varied like 10%,15%,20%,25% etc to perform the experimentation in the laboratory. In common rail direct injection engine we have,

Fig: 1 Practical experimental setup on which experiment is conducted.

Fuel injection pressure increased till 900 bar to 1000 bar by which this high pressure injection better the performance of the engine with best atomization technique. Thus after conducting experimentation calculations are made based on mathematical approach though which specific fuel consumption, thermal efficiency, and emissions graphs are plotted.

3.1 Engine specification:

Table 1: Specification of CRDI engine

S.no	Specification	Value
1	Engine	Kirloskar AV1
2	Engine type technology	Common rail direct injection

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3	Break power	3.7 KW
4	Mean effective radius	0.195 m
5	Bore diameter	87.5 mm
6	Stroke length	110 m
7	Injection pressure	900 bar
8	Injection timing	-23°(before TDC)

Water cooled eddy current dynamometer is used ad loading device in the experimentation as shown in the experimental setup photo.

3.2 Formulation:

Fuel consumption

1) $fc = \frac{10}{t\ avg} \times sg \times density\ of\ water \times 10^{-6} \times 3600 \quad \frac{kg}{hr}$

sg indicates specific gravity.

2) $SFC \ = \frac{fc}{BP} \frac{kg}{kw\ hr}$

SFC Indicates specific fuel consumption.

BP Indicates break power of the engine.

3) $FP \ = \frac{fc \times cv}{3600} \quad kw$

FP Indicates fuel power

C_V Indicates calorific value of the fuel.

4) $\eta = \frac{BP}{FP} \times 100.$

η_{th} Indicates thermal efficiency

Mathematical formulae used in the calculation are above. These methodical formulae have its own way to define the specification with its units. In common rain direct injection engine due to the effect of fuel injection pressure well atomization takes place in the combustion chamber through

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which it leads to increase in fuel efficiency. Thus eventually calculations are made and respective graphs are plotted in sheet, through which analysing is done on the performance and emissions of the engine. Common rail direction injection is governed by electronic control unit and it is communicated through linking ECU to a laptop. Multiecuscan is software through communication between engine control unit and research scholar is maintained in almost best way.

4. Result Analysis

After completion of all the experimentation and mathematical calculation graphs are plotted on varying load percentage as shown below, graphs like break thermal efficiency, break specific fuel consumption and emissions like nitrogen oxide, carbon monoxide, unburned hydrocarbons, smoke density exhaust gas temperature etc, blends are B10, B15 with varying EGR percentage like 10%, 15%,20%, 25% etc. Thus eventually graphs are plotted and analysis done as shown below.

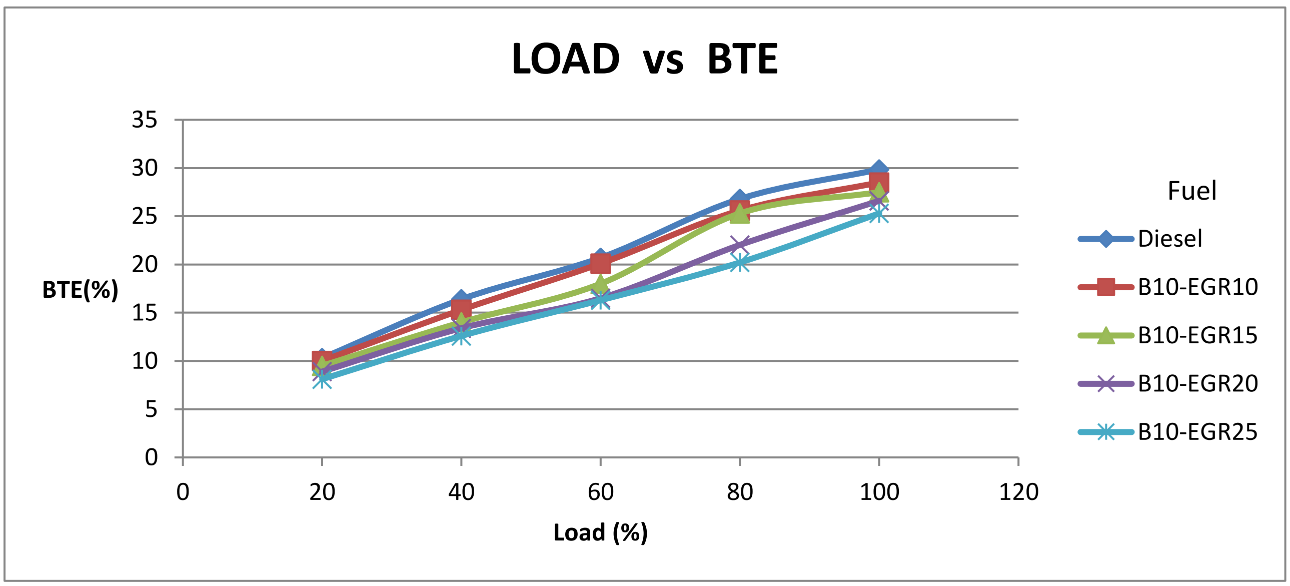

Fig 2: LOAD vs BTE

From the above graph as percentage of EGR increases then there is a fall in thermal efficiency was found. From calculation it is about 21.2% of thermal efficiency found fall at full load condition. Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and break thermal efficiency and analysis is done as drop is efficiency is found in graphical representation.

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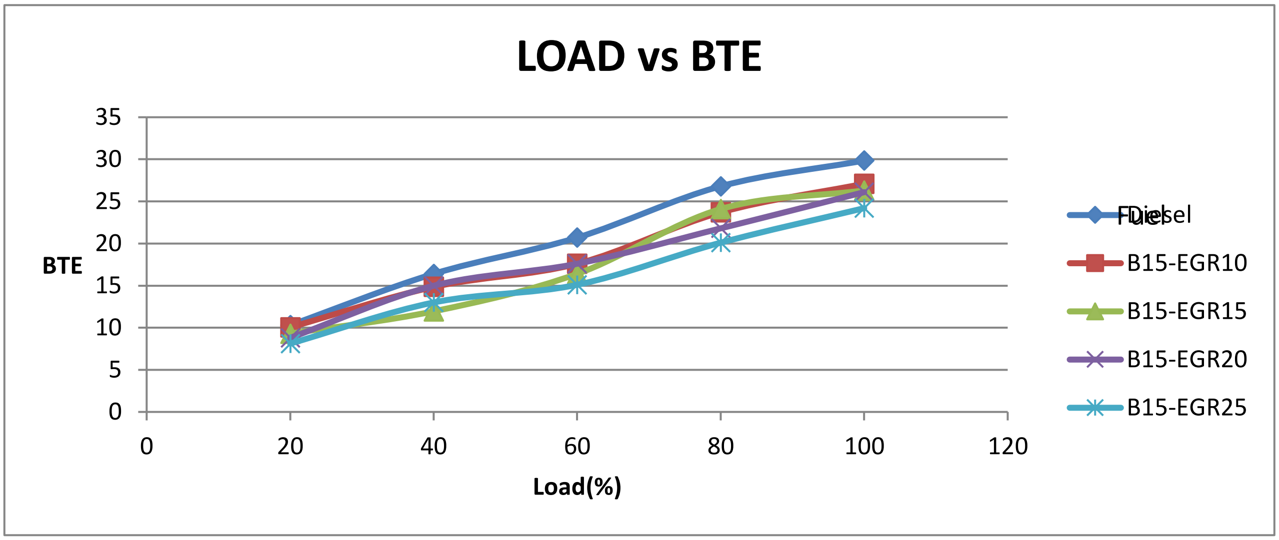

Fig 3: LOAD vs BTE

From the above graph as percentage of EGR increases then fall in thermal efficiency was found. From calculation it is about 21.2% of thermal efficiency found drop at full load condition. Due to the effect of biodiesel and EGR percentage in combustion chamber combustion was affected as result there is a decrease in efficiency was found. Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and break specific fuel consumption and analysis is done as drop is break specific fuel consumption is found in graphical representation.

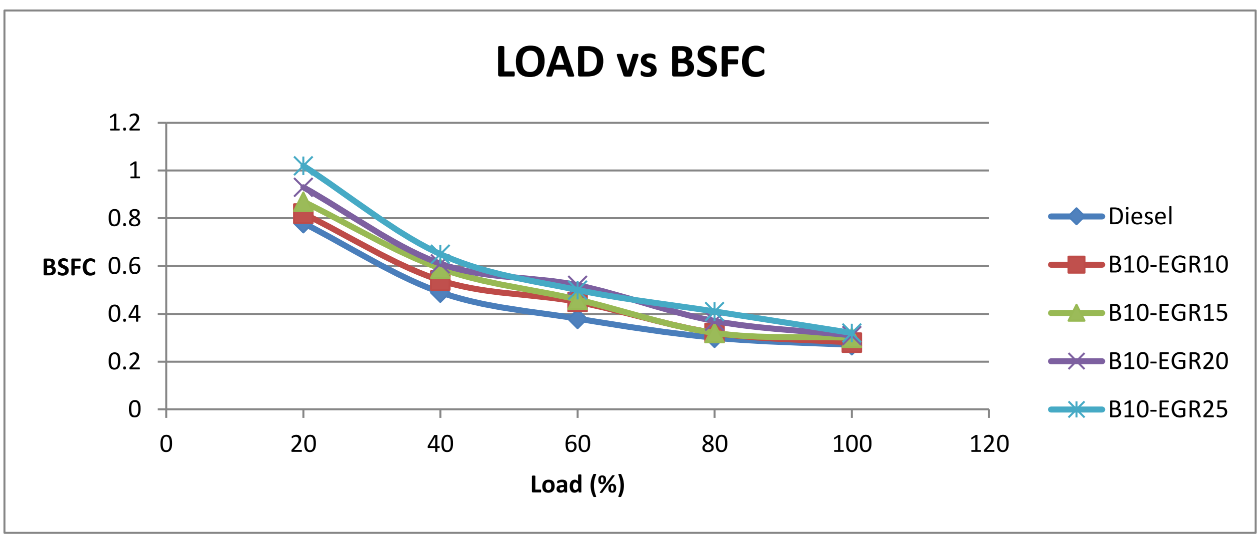

Fig 4: LOAD vs BSFC

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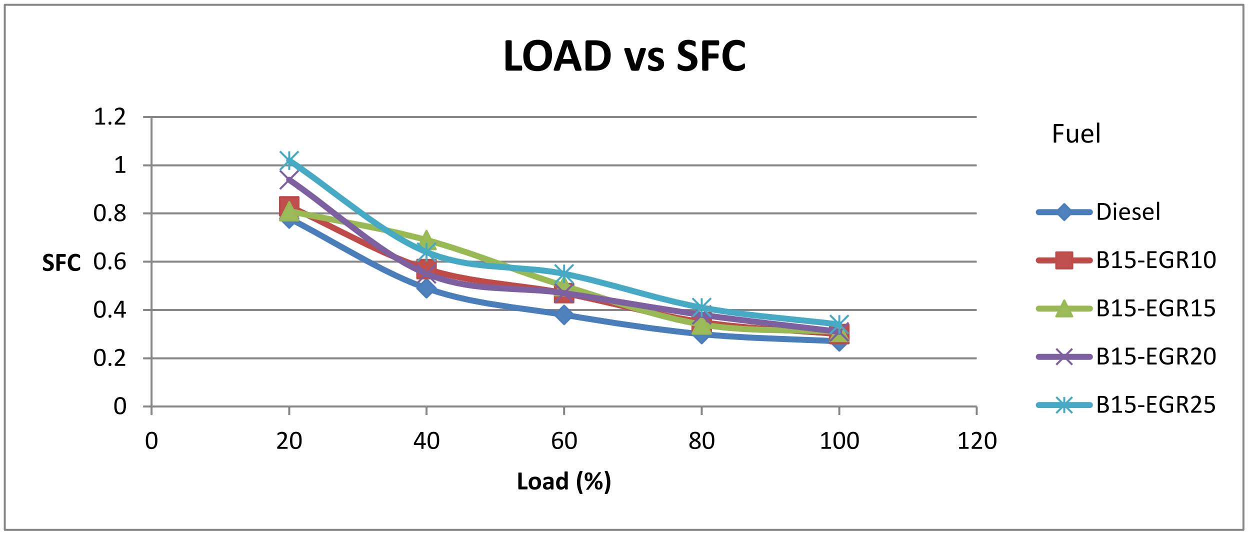

Fig 5: LOAD vs SFC

It is clear from the above graph that gradual decrease in the specific fuel consumption is absorbed as load percentage increase ultimately drop in specific fuel consumption in seen in the graphs. Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and nitrogen oxide and analysis is done as drop is nitrogen oxide is found in graphical representation.

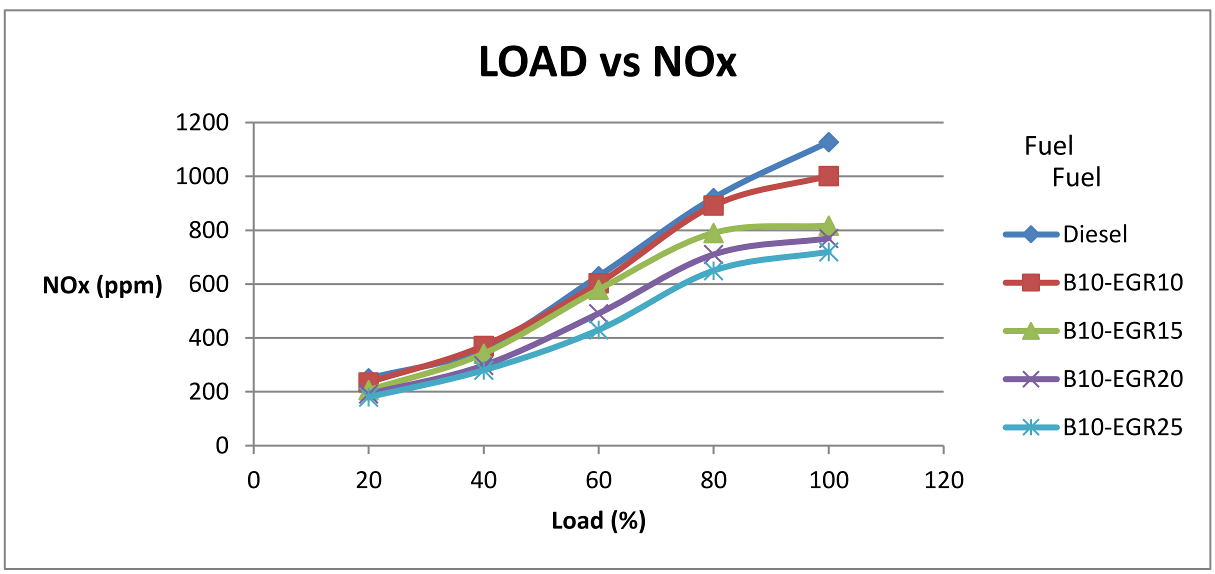

Fig 6: LOAD vs NOx

From the graph it quite clear that about 62.2% of nitrogen oxide is found in the graphical representation. As most of the focus is kept on reduction of nitrogen oxide eventually it has been

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archived. Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and unburned hydrocarbons and analysis is done as increase is unburned hydro carbons is found in graphical representation.

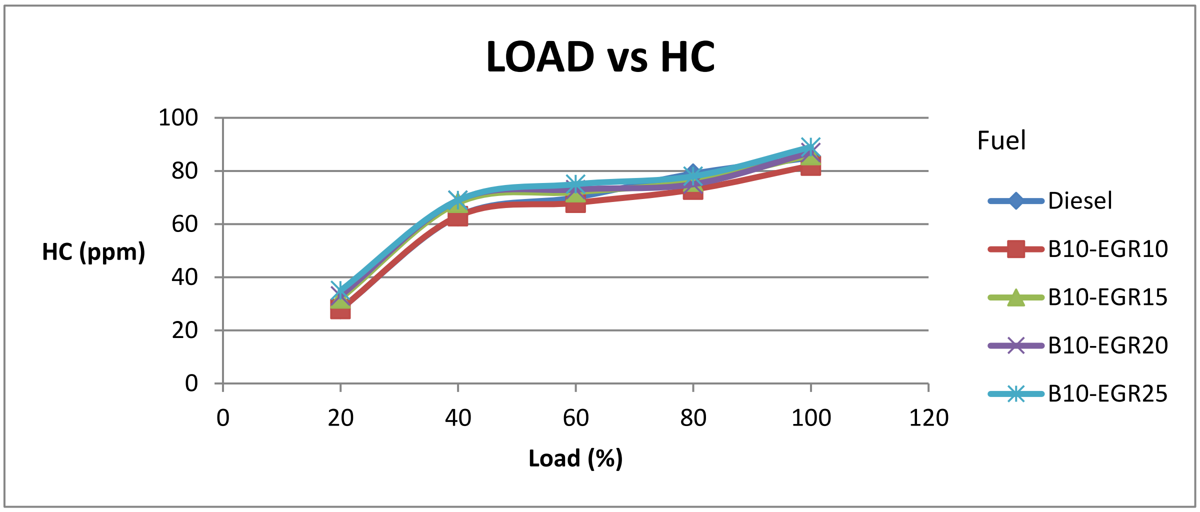

Fig 7: LOAD vs HC

As affect that amount of oxygen content is reduced in combustion chamber as inclusion of EGR percentage effect the combustion, that's the reason that it is quite clear that unburned hydrocarbon are increased gradually as EGR percent as load increased. Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and nitrogen oxide and analysis is done as drop is nitrogen oxide is found in graphical representation.

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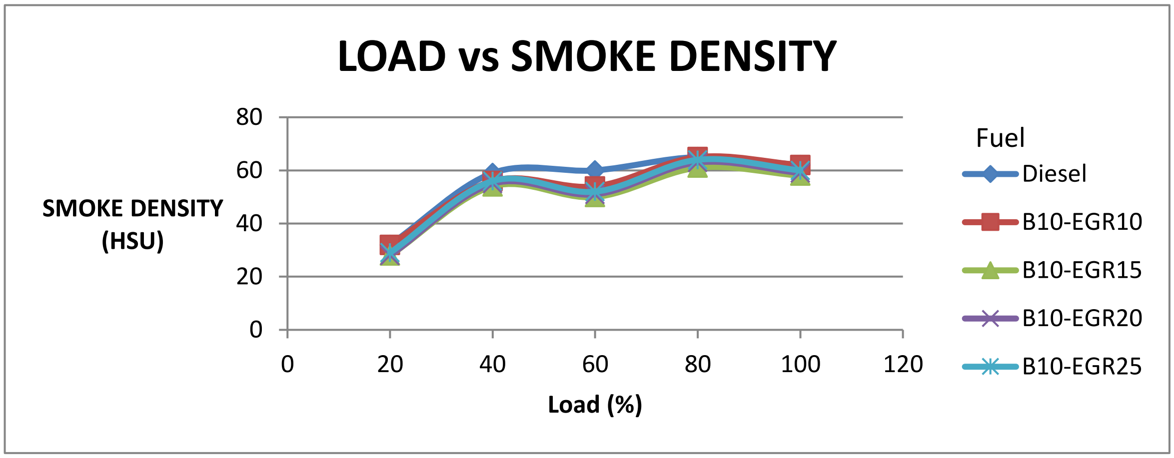

Fig 8: LOAD vs SMOKE DENSITY

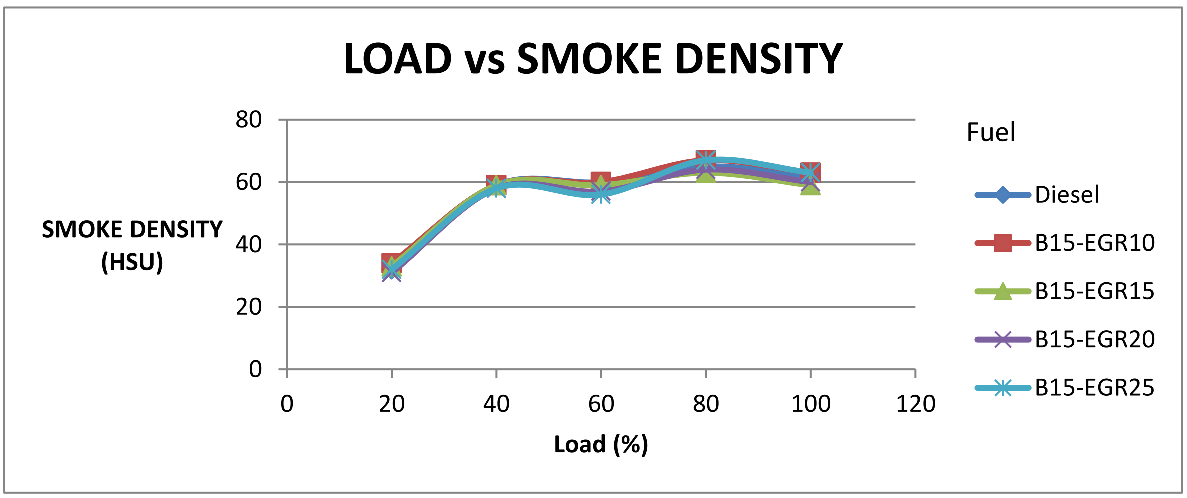

Fig 9: LOAD vs SMOKE DENSITY

As load increases smoke density increased till around 40% of load then started decreasing gradually till 80% of load and started increasing and gradually decreased.

Similarly the graph plotted with B15 and varying EGR percentage, the below graph is plotted between load and nitrogen oxide and analysis is done as drop is nitrogen oxide is found in graphical representation.

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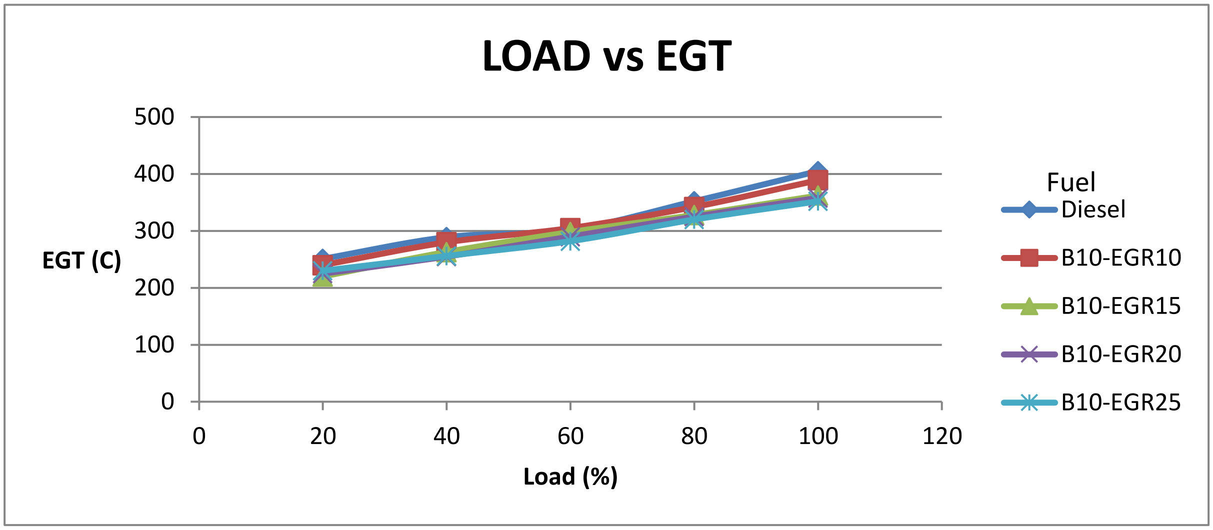

Fig 10: LOAD vs EGT

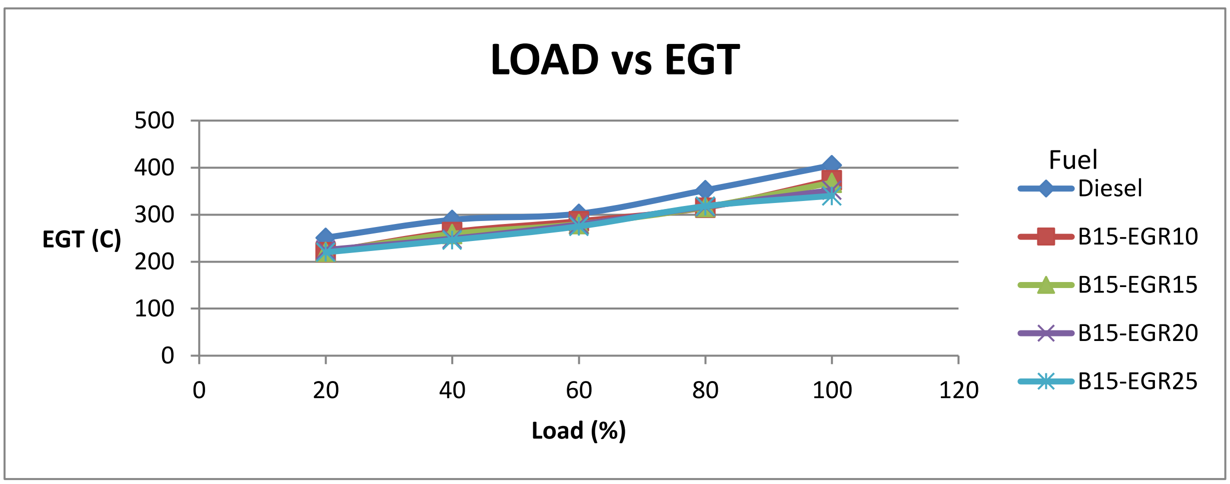

Fig 11: LOAD vs EGT

As oxygen percentage is reduced due to increase in percentage of EGR it is help full to get or attain reduced combustion as exhaust gas sent to the chamber has less temperaturecomparetip inside exhaust temperature thus reduction exhaust gas temperature is archived as EGR percent is increased as load increases.

5. Conclusion

From the profound experimental investigation on Common Rail Direct Injection Engine coupled with EGR has extracted summarised conclusion in following steps.

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- Collective effects of both Exhaust Gas Recirculation and Cotton seed Biodiesel reduced the NOx by 37.9% when compared to standard fuel Diesel.
- Carbon monoxide has increased as EGR percentage increased gradually in the experimentation compare to Diesel fuel.
- Unburned hydrocarbons are also increased as EGR percentage increases due to lack of oxygen content in the combustion chamber.
- Break thermal efficiency also reduced slightly when EGR percentage increased, it found that 7.8% of break thermal efficiency is reduced.
- As emission is the major concern, through this experimental investigation NOx has reduced approximately 40% by using maximum EGR percentage that is 25%.

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