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A Review Study On Reduction In Exhaust Emissions By EGR, Catalytic Converter And Air Dilution System In CI Engine Fuelled With Diesel, Biodiesel And Diesel-Biodiesel Blends.

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Abstract

Presently world faces two major crises, depletion of fossil fuel and environmental degradation. So for solve both problems, renewable alternative fuel should be necessary with minimum impact on environment. There are many alternative fuel in the world likes biodiesel, alcohols, pyrolysis oil, CNG, LPG etc. But among all of them biodiesel is a most one. In this content, Biodiesel was used as an alternative fuel. But with the use of biodiesel increasing in NOx emission so to comply with upcoming stringent emissions pre and post treatment are necessary to reduce emissions. This paper presents the review of jatropha biodiesel and its blends with and without EGR and other emission reduction post treatment such as catalytic converter and air-dilution systems and their effect on emissions. The review has been carried out to find out best combined emission reduction systems to reduce emission parameters such as NOx, HC, CO, Smoke and Odoure.

Keywords*–jatropha Biodiesel, EGR, Catalytic converter, Air dilution,* Emissions.

1. Introduction

Fuel is one of the major issues in the world yet. Because of the technological development and improvement in living standard of the people, the demand of the petroleum fuel is increased very rapidly. Diesel engines are widely used because of their greater efficiency, durability and better fuel economy than gasoline engines. These increasing in population of vehicles are leads to largely reduction in fossil fuels and increasing environmental pollutions. So for solve both major problem depletion of fossil fuel and environmental degradation, a renewable alternative fuel with lower environmental pollution should be required. Presently in the world there are many renewable energy source but among them bio fuel is one of the most important [13].Bio-fuel has received wide attention because they reduce the emission of gases which is responsible for global warming, promote rural development, contribute toward the goal of energy security and reduce pollution. Another most important advantage of biodiesel is that it can be used in engine without modification. Many counties including India have to begin use of biodiesel to substitute diesel fuel by a certain amount of biodiesel [12]. Bio-fuels can be produced from (edible or non-edible), algae and animal fats. The use of non-edible oils is most preferable than edible oils because non-edible oil is cheaper and higher productivity than edible oils, jatrophacurcasis an example which produces 1590 kg of oil per hectare [14].

Many research in past showed that with used of biodiesel and its blends significantly reduction noticed in HC, CO and smoke emission but increased NOx emission. Emission of NOx is higher for biodiesel and biodiesel-diesel blends than conventional diesel fuel [2]. There are various available method such as injection retarding ,Exhaust Gas Recirculation, Humid Air Induction, Water Injection in the cylinder can be effective methods to reduce the NOx emissions, among all of them EGR is the commonly adopted to reduce NOx emission. With the used of EGR there is a significant reduction in NOx emissions but negative impact is that emissions such as HC, CO and smoke are increased [4].

So that means additional reduction is mandatory to comply with upcoming stringent emission standards. There many exhaust after treatments such as catalytic converter, diesel particulate filter, soot trap etc. can be used combine to reduce exhaust emission at minimum level. As past research reported that with the combine used of oxidation catalytic converter and EGR, there were significant reductions noticed in HC, PM, NOx and CO [8]. Odour and smokes emissions can be reducing by air-dilution system [10, 11]. There for it can be possible to achieve minimum level of emissions of CO, HC, NOx, PM, smokes and odour by combine use of three different systems such as air-dilution, EGR and oxidation catalytic converter.

2. Performance and emissions analysis

2.1 Effect of jatropha biodiesel and its blends on engine performance and emissions

JaysukhGhetiya[1],conducted a test on a7 kw single cylinder, air cooled, constant speed direct injection diesel engine with alternator to evaluate the effect of jatropha biodiesel and its blends on engine performance and emissions characteristics. The result showed that, fuel consumption was increased with increased jatropha biodiesel proportion in blend and for neat biodiesel it was found 14 % higher than diesel shown in figure 1. Result also indicated that brake specific energy consumption was found higher at medium load for jatropha biodiesel and it was lower at higher load shown in figure 2. For the biodiesel and its blends, thermal efficiency was little higher than diesel and it was found that there was a no difference between biodiesel and its blend fuels on efficiency shown in figure 3. Figure 4 showed that the exhaust gas temperature was found 14 % higher for B100 than diesel. The emission of NOx increased with increased load condition and increased biodiesel concentration in blends. NOx emission was found 1 to 18 % higher for blended fuel than diesel fuel shown in figure 5. However, an important result found that at B20 has lower NOx emission than diesel fuel. The CO emission for biodiesel blended fuel and biodiesel found lower than diesel, The CO reduction by biodiesel was 11, 10, 15 and 19 percent at 2.9, 4.3, 5.6 and 6.6 kW load conditions shown in figure 6. The HC emission found that it was increased with increased load condition for all fuel but for the jatropha biodiesel and its blend it was lower than diesel shown in figure 7. HC emission was decrease with increased jatropha biodiesel proportion in blends. Figure 8 showed that the smoke opacity for the jatropha biodiesel and its blends was lower than diesel and, it was decreased with increased biodiesel rate in blends. The smoke opacity decreased by jatropha biodiesel was 14, 15, 18 and 21 % at 2.9, 4.3, 5.6 and 6.6 kW load conditions.

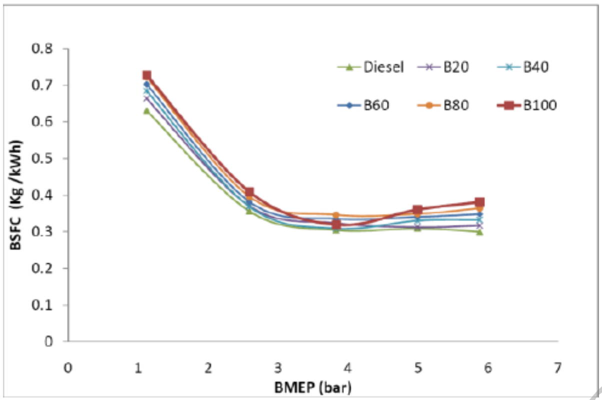

Fig. 1 BSFC v/s BMEP with different biodiesel blends

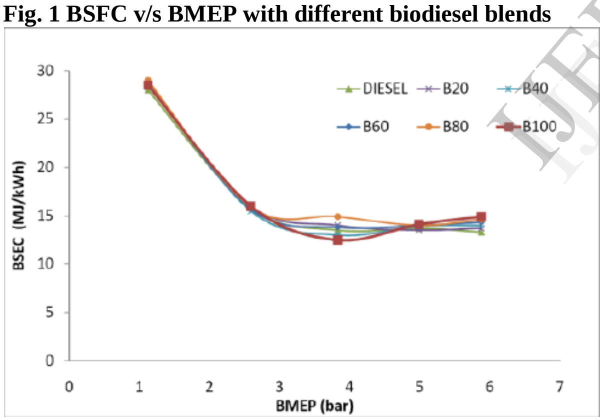

Fig. 2 BMEP v/s BSEC with different biodiesel blends

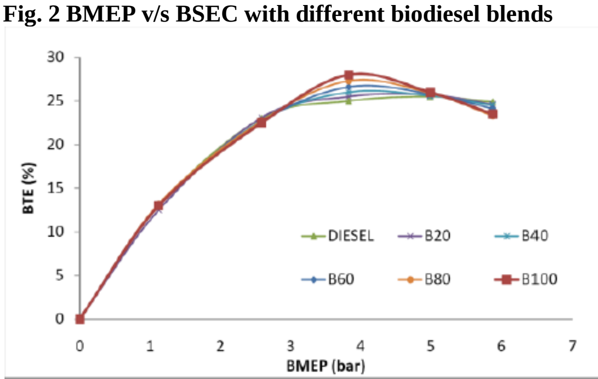

Fig. 3 BTE v/s BMEP with different biodiesel blends

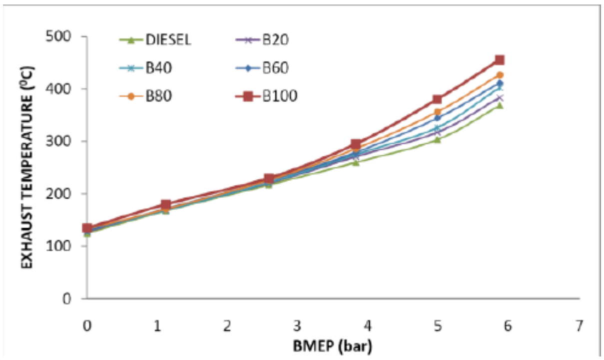

Fig. 4 exhaust temperature v/s BMEP with different biodiesel blends

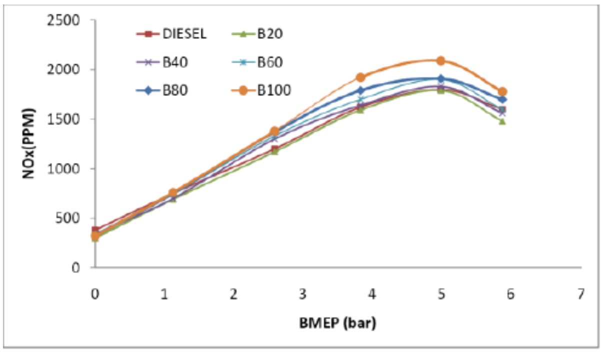

Fig. 5 NOx v/s BMEP with different biodiesel blends

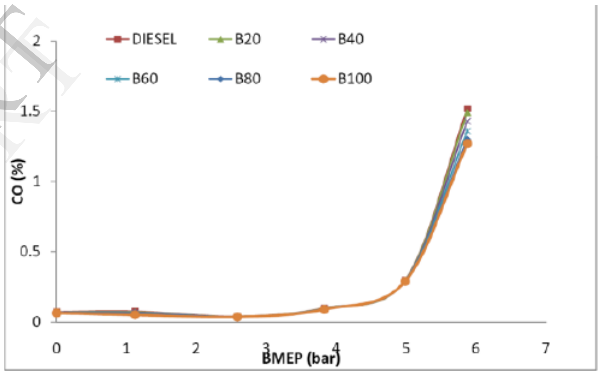

Fig. 6 CO v/s BMEP with different biodiesel blends

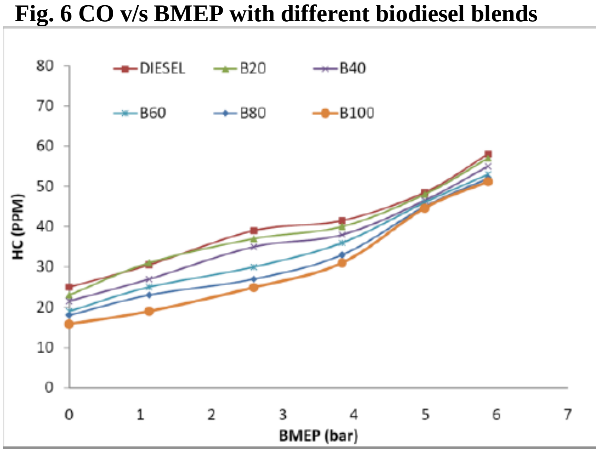

Fig. 7 HC v/s BMEP with different biodiesel blends

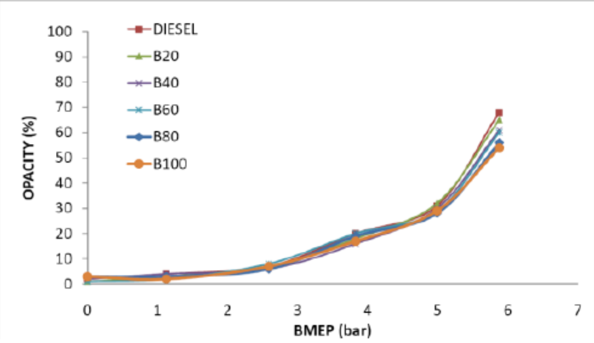

Fig.8opacity v/s BMEP with different biodiesel blends

.**Nitinshrivastava [2],**conducted test to evaluate the performance and emissions characteristic of 4 cylinders, 4-stroke DI CI engine fuelled with jatropha oil methyl ester (JOME), neat diesel and blends of 20% and 50% JOME by weight with diesel. Result showed that BSFC was higher for JOME increased with increasing JOME percentage in blends. About 21% highest BSFC reported for neat JOME. Brake thermal efficiency and brake specific energy decreased with increasing JOME in blend. For the neat JOME, there was a 9.3 % average reduction found in thermal efficiency. However, 20 % blend showed same energy consumption and same thermal efficiency as that of diesel. It has been seen that reduction in HC, CO and smokes emissions with JOME and its blends. However, exhaust gas temperature and NO_X emission showed higher for JOME and its blends. 20 % blend found optimum with higher reduction in HC, CO and smoke in compare to average increased in NOx

V. hanumanthaRao [3], in this study jatropha methyl ester and its blends were used to evaluate their effect on performance and emission characteristic on single cylinder, water cooled diesel engine. Result showed that engine runs smoothly with the methyl ester of jatropha oil and their performance comparable to diesel operation. The brake thermal efficiency found slightly higher for jatropha methyl ester than diesel. 25 % blend of jatropha methyl ester found to be very preferable to improved 19 % thermal efficiency. There was significant reduction in emission and BSFC with the 25 % blends. Exhaust gas temperature was found higher for jatropha methyl ester than diesel and increased with increasing concentration of jatropha methyl ester in blends.CO_2 emission was same for blends and jatropha methyl ester but lower than diesel. CO emission was found lower for biodiesel and its blends than diesel. For 25 % blends CO and CO_2 emission were found between diesel and neat biodiesel. For the methyl ester of jatropha, NOx emission was found slightly higher than diesel. Smoke emission was lower for blends than diesel and at 25 % biodiesel smoke emission found minimum at lower power outputs. Jatropha methyl ester would be a good alternative fuel for diesel engine.

2.2 Effect of EGR on performance and emission characteristic on CI engine fuelled with jatropha biodiesel and its blends.

M.Gomaa[4], carried out test ona 4 - cylinder, water cooled, turbocharger, IDI diesel engine fuelled with jatropha biodiesel and its blends to evaluate the effect of EGR on engine performance and emissions. The result showed that torque output was decreased for both diesel and JBD blends, when EGR was operated. In fact torque loss was increased with increasing EGR rates. Highest torque lose with EGR operated engine with JB5 and JB20 was 14.7 % and 17.6 %, respectively; while it has been shown 26.5 % with Diesel, which was higher than JBD, as compared to the baseline value. For JBD blends thermal efficiency higher than diesel at all operating condition and highest BTE achieved with JBD 20 by 4.6 % without EGR when compare with base line value. But when EGR was used BTE was decreased linearly with increasing EGR rates, maximum reduction was found by 23 %, 16.4 % and 7.4 % for Diesel, JB5 and JB20 respectively ,at 40 % EGR.. BSFC for JBD blend found little higher than diesel, and BSFC increased with increasing EGR rates and it was increased rapidly beyond 20 % EGR. The BSFC of DIESEL, JB5 and JB20 increased by 28.7 %, 9.4 % and 7.6 % respectively at 40% EGR when compare to base line value. The BSEC was found lower for JBD than diesel and it was increased with increased EGR. The EGT (exhaust gas temperature) increased with increasing EGR rates for all tested fuels. The CO emission was lower for JBD blends than diesel fuel at all operating condition; about 75% reduction was observed for JB5 and JB20 than diesel at 0% EGR but CO emissions increased with increasing EGR rates shown in figure 9. The CO_2 emission was higher for JBD blends than diesel and increased with increasing EGR rates, about 53.7 % and 62.0 % increased in CO_2 emission for JB5 and JB20 respectively at 40 % EGR while for diesel it was observed 21.9 %, compared to base line value shown in figure 10. From the figure 11 it has been seen that with increasing EGR rates there was a significant reduction in NOx, maximum reduction in NOx was found about 71 % for both JB5 and JB20 while it was 79 % for diesel. Smoke opacity was lower for JBD blends than diesel and increased with increasing EGR rates for all fuel shown in figure 12. At 40 % EGR, Smoke opacity level of diesel was about 62.4 % which is unacceptable, whereas for JBD blends, 43.8% and 34.5 % for JB5 and JB20 respectively, which was acceptable. Acceptable trade-off between smoke opacity and

NOx emission could be achieved with a 5-15% range of EGR, with least effect on performance when JBD blends was used. All the result conclude that 5 % EGR was preferable for JB5 to achieve acceptable performance and emission, while in case of JB20, 10 % EGR was preferable. NOx and smoke opacity was decreased by 27 % and 17 % respectively in case of JB5 and 5% EGR and 37 % and 31 % decreased in case of JB20 with 10 % EGR.

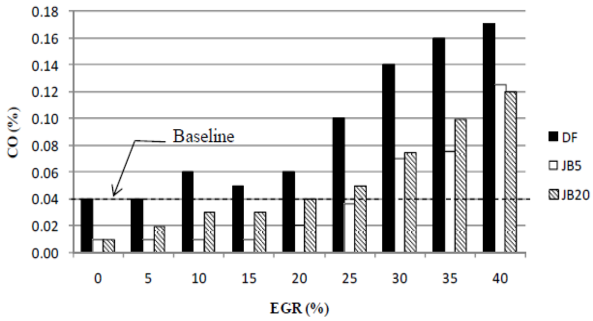

Fig.9 variations of CO emission with various EGR rates

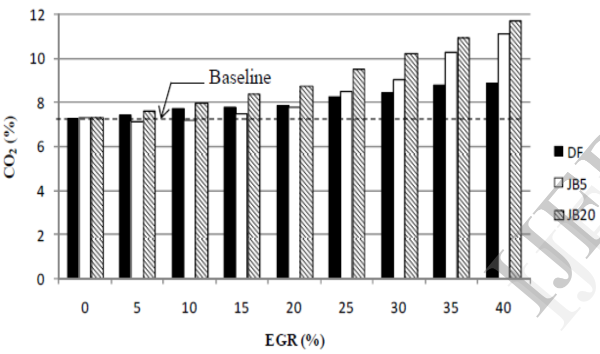

Fig. 10 variation of CO_2emission with various EGR rates

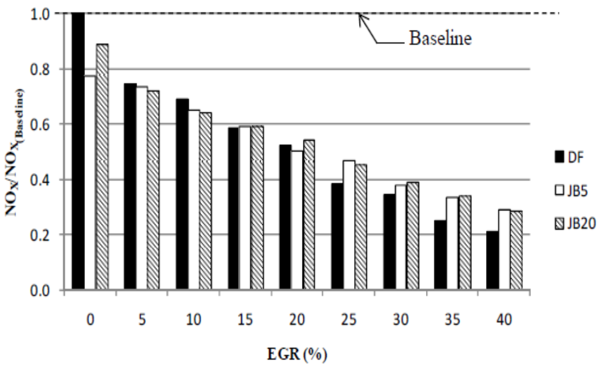

Fig. 11 variation of NOxemission with various EGR rates

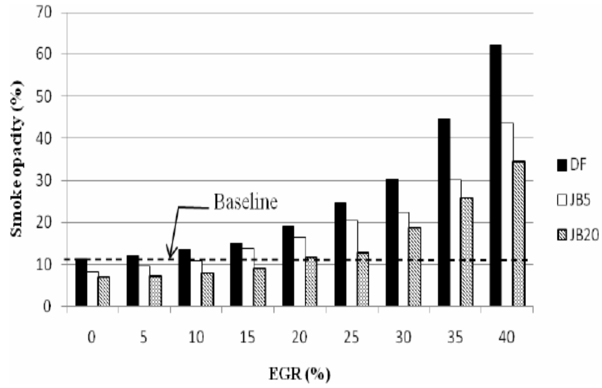

Fig. 12 variation of smoke opacity with various EGR rates

M. K. Duraisamy[5], in this study biodiesel derived from jatropha seeds oils was used to investigate the effect of both biodiesel and EGR on performance and emissions of a fully automated single-cylinder, water-cooled, constant speed DI diesel engine. Result showed that the smoke opacity was higher when EGR was operated and increased with increasing EGR rates, whereas NOx emission decreased with the increased EGR. This was a well-known trade-off between NOx and smoke. On the other hand, if biodiesel was used in diesel engine, smoke intensity is decreased but NOx is increased so that biodiesel with EGR could be used to reduce NOx and smoke intensity simultaneously. Other emissions such as CO and HC were decresed in case of biodiesel. It has been found that 15 % EGR was best which improves the thermal efficiency, reduces the exhaust emissions and the BSFC. The Biodiesel contain oxygen molecule which leads to higher NOx emission, which was effectively decresed by EGR. With the use of EGR HC, CO, BSFC and particulate matter increased. It has been conclude that engine operating with biodiesel while applying EGR results in NOx reductions without inferior in engine performance and emissions.

V. pradeep [6], conducted study on a single cylinder, four strokes, water cooled DI engine fuelled with biodiesel from jatropha oils and with EGR to evaluate the effect of them on engine performance and emissions characteristics. The result indicates that, brake thermal efficiency (BTE) with jatropha biodiesel (JBD) was found comparable to diesel with and without EGR. However, it has been found that BTE of JBD reduced with increasing EGR rates. Reduction in BTE over an EGR range of 0–25% was 6.6% for diesel whereas it was only 4.9% for JBD. BSEC of JBD was found little higher than diesel at all levels of EGR. NO emission was higher for JBD than diesel. HC and CO emission were found lower for biodiesel than diesel but increased with increasing EGR rates for both diesel and biodiesel. Inferior in performance and more smoke was observed with higher rate of EGR 20 to 25 %, but with 15 % hot EGR significantly decresed NO emission without adverse effect on the performance, smoke and other emissions. About 15% of EGR with JBD was found to be very preferable to reduced NO emission lower than that of diesel, without EGR, at all operating conditions. Smoke emission was found lower for JBD at peak loads with and without EGR but at higher load it was higher for JBD than diesel due to their higher viscosity and low volatility. It has been seen that EGR is good technique to reduce all regulated emission from diesel engine but it gives better result when engine was run with EGR and biodiesel.

2.3 Effect of catalytic converter on exhaust emission fuelled with diesel and biodiesel

Hwanam Kim [7],carried out a test on a 4-cylinder CRDI engine with the used of three different types of ultra lowsulfur fuel (ethanol-diesel blend, ethanol-diesel blend with cetane improver, pure diesel) to evaluate the effect of upstream and downstream warm up catalytic converter (WCC) in their exhaust gas emissions under the ECE 13 mode. Result showed that the BSFC curves for all fuels found different at low load condition, and increased by 6.5 % when ethanol blend was used in middle and high load condition. Fuel consumption was found lower for E15-CI than E15, due to cetane improver effect. Brake thermal efficiency of the ethanol blend was found similar or higher than diesel fuel. In all mode it has been seen that the average smoke reduction was found 42.6 and 42.1 for E15 and E15-CI respectively, than pure diesel fuel. CO conversion efficiency with WCC was found about 80 % in each mode except in 1, 2 and 13 modes (low exhaust gas temperature condition). Total hydro carbon (THC) conversion efficiency on the catalyst found 40-60% in each mode except in mode 7.

Wang ying [8],conducted test to evaluated the effects of EGR and commercial oxidation catalytic converter on reduction in exhaust emissions of 4-cylinder, 4 stroke, water-cooled, DI CI engine fuelled with dimethyl ether (DME). Result showed that NOx emission decresed with increasing EGR rates and about 40% reduction was found at 20 % EGR. Figure13 showed the NOx reduction rate with various EGR Rates. It has been found that HC, PM and CO emissions increased with increasing EGR rates show in figure14, 15 and 16. So in this study commercial oxidation catalytic converter was used to reduce HC and CO emission. About more than 80 % CO emission was decresed with oxidation catalytic converter show in figure17. It has been found that value of CO emission was decresed from 8.66 g/kW h (without catalytic converter) to 1.39 g/kW h (with catalytic converter) and dropped about 83.9 % shown in figure18. With use of catalytic converter it was found that, increased of fuel consumption back pressure and engine operating cost. All result showed that combine EGR and oxidation catalytic converter were very effective to reduced exhaust emissions.

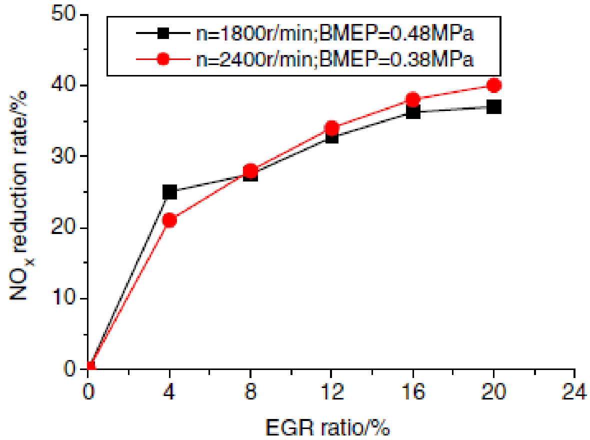

Fig. 13 NOxreduction rate with various EGR rates

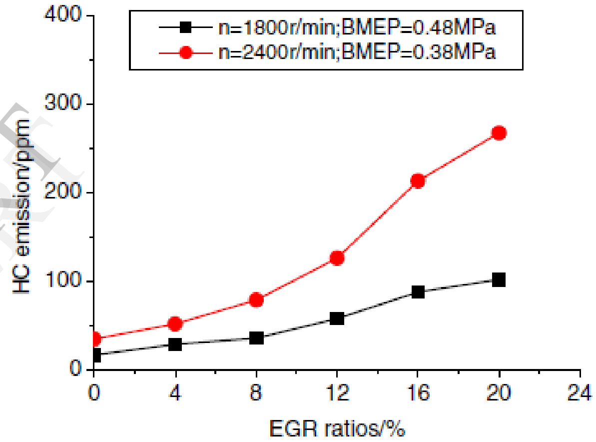

Fig. 14 HC emissions with various EGR rates

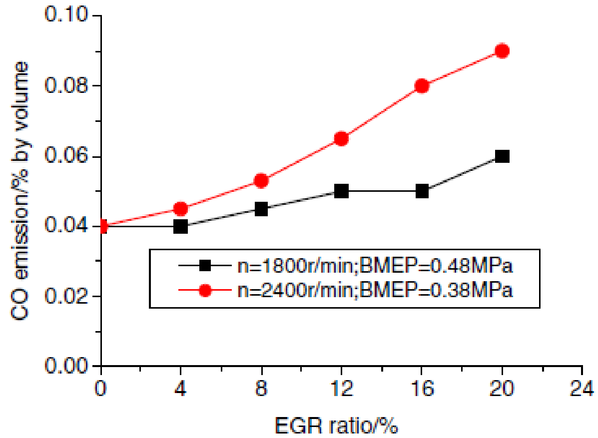

Fig. 15 CO emissions with various EGR rates

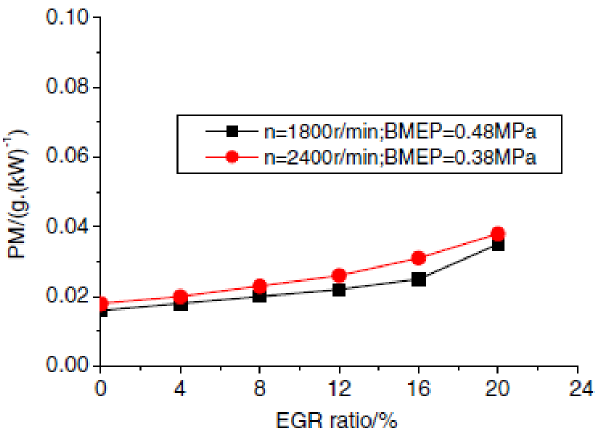

Fig. 16 PM emission with various EGR rates

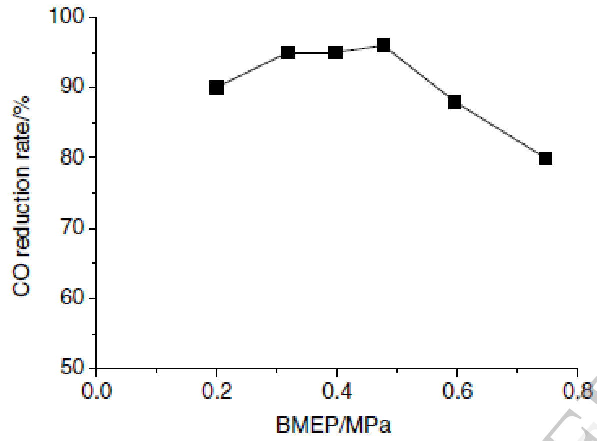

Fig. 17 CO reduction rate oxidation converter under different BMEP (n = 1800 rpm)

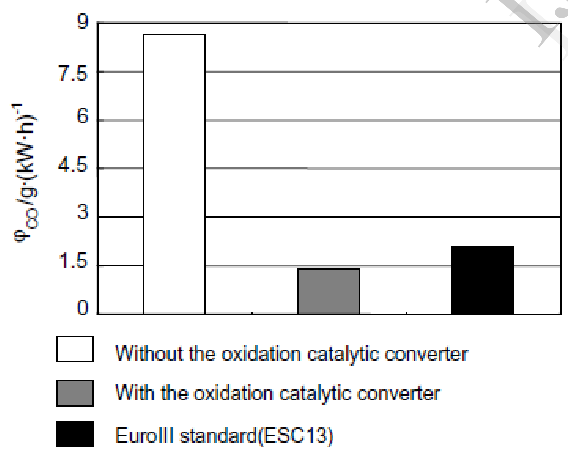

Fig. 18 comparison of CO emission between with and without oxidation catalytic converter

P. Rounce[9], carried out test with used of ULS diesel and rapeseed methyl ether (RME) used to analyzed the combustion and emission with and without after treatment (diesel oxidation catalyst (DOC) and diesel particulate filter (DPF)) on a single cylinder pump-line nozzle direct injection diesel. Result showed that NOx emission for RME was higher than ULS diesel.PM was measured using the bosch smoke number was consider as a measure of the total PM emission, it include soot, HC, water SOF and ash. For RME bosch smoke number found lower than diesel. For control NO_X emission EGR was applied at 30 % rates, NOx was significant reduced but increased CO and HC emission for RME, but it was still lower than ULS diesel. THCs was decreased by about 80 % with the used of DOC for both fuels RME and ULS diesel and CO was found almost eliminated. The PM emission was found higher for ULS diesel than RME. Minimum 98% PM emission was eliminated after the DPF after treatment. Total PM Filtration found with the after treatment was about 94 % by mass and 98 % by numbered for ULS diesel and for RME about 90 % by mass and 98 % by number. It has been concluding that combine effect of DOC, DPF and EGR were very effective to reduced emissions at minimum level to comply with future stringent emissions standard.

2.4 Effects of Air dilution system on exhaust emissions

Murari Mohan Roy [10], Conducted test on single cylinder 4 stroke DI diesel engine for reduced exhaust emission and specially exhaust odour, 3 mix post treatments were used namely, charcoal absorption system, water washing system and air dilution system.. Result showed that more than 0.5 (20%) point odour reduced with charcoal absorption system. It has been found that not only odorous component decreased by water washing system but CO, CO_2 , NOx, smoke and sound level were also reduced with this system. It has been found that only air dilution system reduced 20% odour with total attachment (air dilution + water washing + charcoal absorption) odour was reduced more than 60-65 % than without all system. With total attachment no eye irritation was detected. CO_2 was decresed about 75-88% and CO emission was decresed about 83–86 %. It was found that more than 94 % decresed in NOx emission with total attachment. Noise level was significantly reduced with this after treatment.

Murari Mohan Roy [11], done another investigation with use of three after treatment (silica gel absorber, water-scrubbing, air-dilution) to evaluate the effect on diesel exhaust emissions. Result showed that odour was decresed 1 point after introducing the water scrubber, further 0.5 point odour was decresed when air dilution used combined with water-scrubber shown in figure 19. About 70 % odour decresed with combine used of water scrubbing and air dilution. Figure 20 showed the reduction in eye irritation with and without systems, eye irritation time increased form 3s or 5s to 60 s meaning there was almost no eye irritation after introducing the water scrubber and air dilution systems. Showed the variation of smoke emission in figure 21, about 85 % smoke was decreased by water scrubbing and air dilution system than without system. The 82-84 % reduction in NOx emission was achieved with water-scrubbing and air dilution shown in figure22. CO and CO_2 emission decresed more than 80 % with combine this system show in figure 23 and figure 24. Figure 25 and figure 26 showed that there was no any increase in back pressure and fuel consumption with this system than without system.

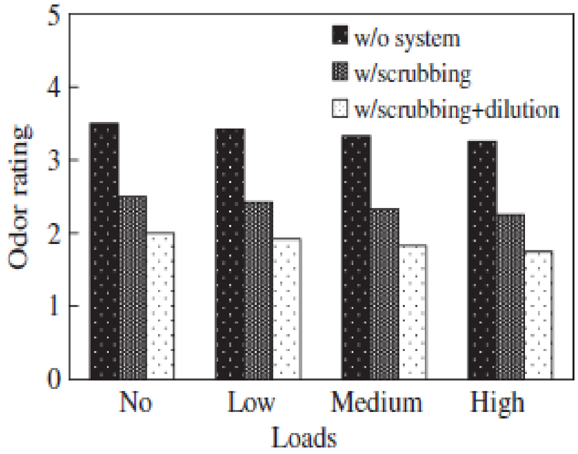

Fig. 19 exhaust odour without and with different systems

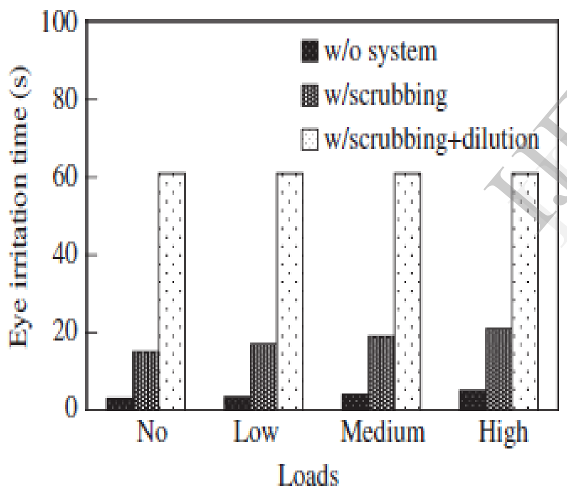

Fig. 20 Eye irritation without and with different systems

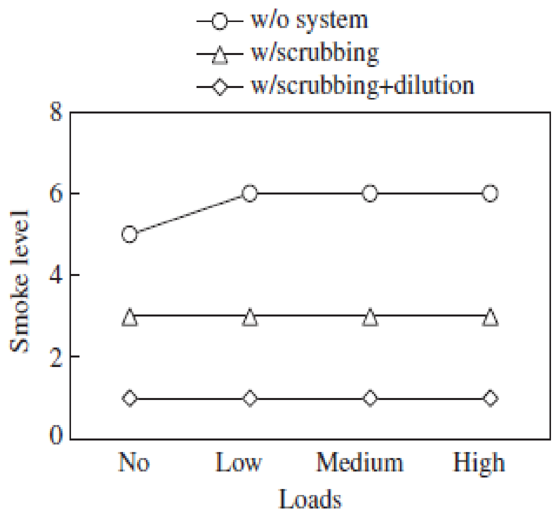

Fig. 21 smoke levels without and with different systems

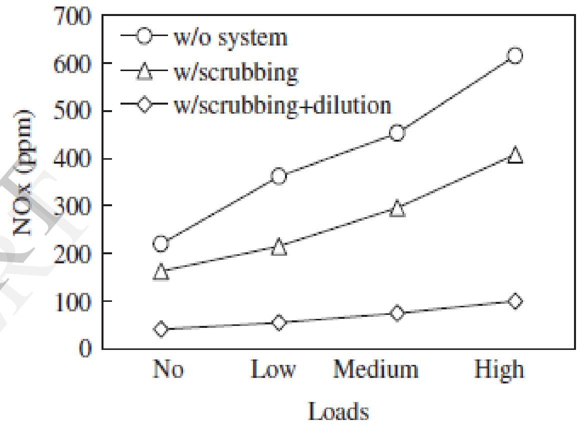

Fig.22 NOx without and with different systems

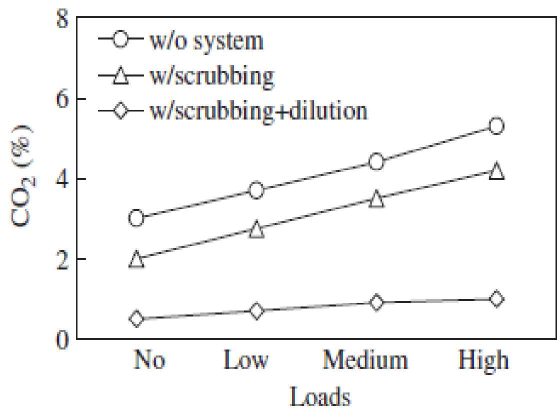

Fig. 23 CO_2 emissions without and with different systems

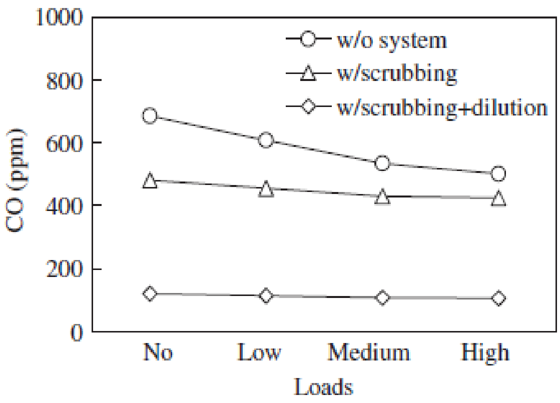

Fig. 24 CO emissions without and with different systems

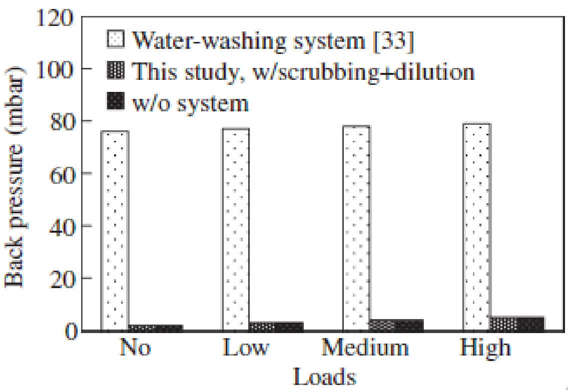

Fig. 25 Comparison of engine back pressure

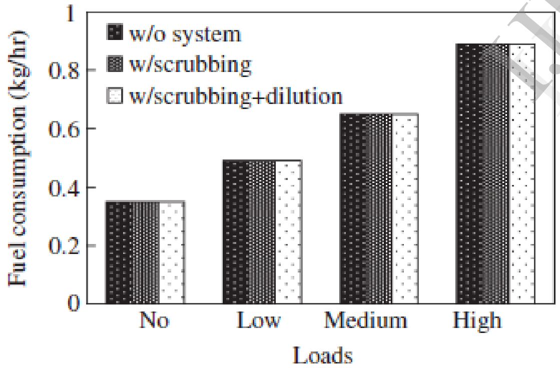

Fig. 26 fuel consumption without and with different systems

3. Conclusions

From above review it is concluded that

- Engine runs smoothly with the methyl ester of jatropha oil (JOME) and their performance comparable to diesel operation. Brake specific fuel consumption and exhaust gas temperature found higher for JOME and its blends than diesel. Brake thermal efficiency found slightly higher for JOME blends than diesel. There was a significant reduction found in emissions such as HC, CO, CO_2 and smoke in case of JOME and its blends than diesel. However, NOx emission found higher for JOME and its blends. The 20 % blend of JOME found very optimum for higher reduction in CO, HC and smoke in compare to average increased in NOx
- There was a significant reduction found in NOx with the used of EGR technique. However it has been found that HC, CO, smoke opacity, EGT and BSFC increased with the EGR. The 15 % EGR very optimum which improves the thermal efficiency reduces the exhaust emissions and the BSFC. EGR gives better result in biodiesel operation than diesel operation.
- Nearer about 80 % reduction achieved in HC and CO emissions with the oxidation catalytic converter.
- About 20 % odour decresed with air dilution system and about 70 % decresed when combine used of air dilution and water scrubbing system. More than 80 % reduction found in smoke, NOx, CO, and CO_2 emission by water scrubbing and air dilution system than without system.

From the above research work it is concluded jatropha methyl ester and its blends are used as an alternative to ordinary diesel fuel. But the use of JOME increases the NOx emission .EGR can be used to reduce NOx emission but HC, CO and smoke opacity increased with the used of EGR. However HC, CO, CO_2, odour and smoke emission can be reduced with the oxidation catalytic converter and air dilution system. So it is possible to reduce all emission at minimum level such as HC, CO, CO_2, NOx, odour and smoke by the combine use of three systems such as EGR, oxidation catalytic converter and air dilution.

4. Acknowledgment

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