AN EXPERIMENTAL INVESTIGATION AND EMISSION ANALYSIS ON I.C. ENGINE WITH OXYGEN FEEDING SYSTEM: A TECHNICAL REVIEW

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Abstract : **In a recent growing world, energy requisition is continuous increase at a same time one of challenging work is improve the efficiency of existing machine with available energy sources. Even development with new technology in internal combustion engine does not create much more effect with overall efficiency. Replacement of existing internal combustion engine is also not an effective way, as production of new engine or new machine directly or indirectly consume traditional energy source and, create environment issue. Natural air inspire engine has used atmospheric air which contain 78% nitrogen and 21% oxygen. For effective combustion more oxygen required which is limited with atmospheric air. This paper provides literature review on analysis of engine performance and emission parameter with excessive oxygen with different method to enrichment.**

I. INTRODUCTION

At present, one of the main problems, in the development ofdiesel engines is represented by the achievement of an increasingly strict control on the systems used forthe pollutant emission reduction. In particular, as far as NOx gas is concerned, EGR systems are matureand widely used, but increased efficiency in terms of emissions abatement, is necessary in order to determineas best possible the actual oxygen content in the charge at the engine intake manifold [1].

World's energy requirement is still supplied with fossil fuels like gasoline. Petroleum based fuels are extinct depending on increasing amount of energy requirement so that increasing prices of fossil fuels, stringent emission regulations and environmental pollution force researchers to investigate new, clean, renewable and alternative fuels. Fossil fuels cause acid rains, air pollution and changes world's heat balance. Despite restrictions taken by Kyoto Protocol, CO_2 emissions and energy demand of transportation have increased by 27% and 37%, respectively whereas 60% decrease in greenhouse gas (GHG) emissions from transportation was aimed until 2050 according to White Paper Report (EC-2011) which are published by The European Union Commission. Renewable Energy Directive (RED) is effective in Europe. According to this directive, minimum 20% of world's energy requirement will be supplied by renewable energy sources till year 2020. Also, RED of EU sets targets of 28% final energy consumption from renewable sources by 2030.The renewable energy consumption in transportation increased from 3.5% to 3.8% between 2010 and 2011 but it must be at least 4.1% to achieve RED. Following these developments, some researchers stimulate their investigations about alternative fuels such as LPG, CNG, LNG, biogas, ethanol, hydrogen etc. [2].

To ensure completecombustion even with latest technologies the engines mustoperate in excess air. To ensure that approx. all fuel molecules receive required oxygen for complete combustion then intake of engine must be carried more oxygen then stoichiometric. Same Excess air boost up the mixing of fuel with air and ensures complete combustion offuel but also wastes heat energy by carryingit in the exhaust gases. It is impossible to attain complete conversion of carbon if sufficient oxygen is not provided to the engine during combustion process and that leads to carbon monoxide resulting in increased exhaust emissions [4].

II. LITERATURE REVIEW ON OXYGEN ENRICHMENT EFFECT

K.Rajkumar et. al. [5] design computerized Single cylinder Diesel engine with data acquisition system was used to study the effects of oxygen enriched air intake on combustion parameters. Increasing the oxygen content with the air leads to faster burn rates and the ability to burn more fuel at the same stoichiometry. Added oxygen in the combustion air leads to shorter ignition delays and offers more potential for burning diesel. Oxy-fuel combustion reduces the volume of flue gases and reduces the effects of greenhouse effect also. And they had studied that the delay period in the CI engine exerts a very great influence on both engine design and performance. This is because of its effect on both the combustion rate and knocking and also its influences on engine start ability Oxygen enriched air have revealed large decrease of ignition delay. Effect of oxygen enrichment does not influences physical delay but it has greater influences on chemical delay. This is due to more oxygen molecules present in the air helps the rate of chemical reaction in fast manner.

Youcai Liang et. al. [6] studied over Oxygen enriched combustion (OEC) & Water Diesel Emulsion (WDE). OEC is potential to improve emissions, thermal efficiency and brake power output of diesel engine. Effect of OEC on particle size and number concentration also had been analyzed. Oxygen concentration of intake air varied from 21% to 24% by volume. Water content in tested fuels was 0%, 10%, 20%, and 30% by volume respectively. The result indicated that lower BSFC, higher cylinder pressure and shorter ignition delay were observed when OEC was applied, while opposite trends were found when using WDE. Reduction of particulate matter (PM) and NOx can be realized simultaneously by applying OE combined with WDE. Particle number concentration of nucleation mode increases with increasing oxygen concentration, while that of accumulation mode decreases. Optimal operating condition was realized when water content in emulsion was below 20% along with low oxygen enrichment. The tests were conducted on a 4-cylinder, 4-stroke, turbocharged intercooled diesel engine (having capacity 3.612 L, 80 KW rated power, 17:1 compression ratio) connected to a dynamometer. It was operated at a constant speed of 2000 rpm under full load. Use WDE can decrease both PM and NOx simultaneously. However, the power output of engine also decreases significantly. The combination of OEC and the WDE appear to be one of the most effective ways to control PM and NOx simultaneously, which will maintain a comparable BSFC. Better performance of engine can be realized when water content in fuel is no more than 20% with low oxygen enrichment.

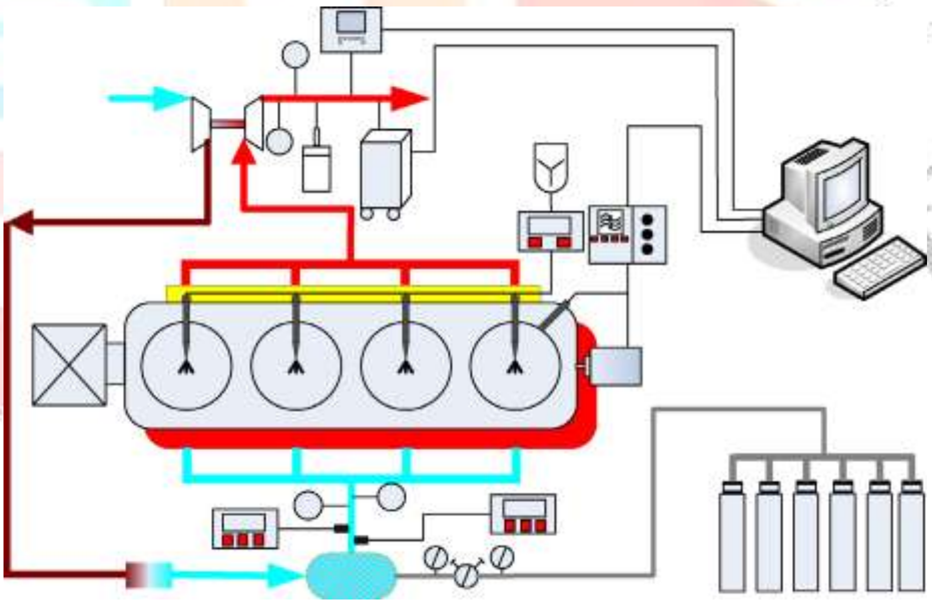

Fig.1 Experimental set up [6]

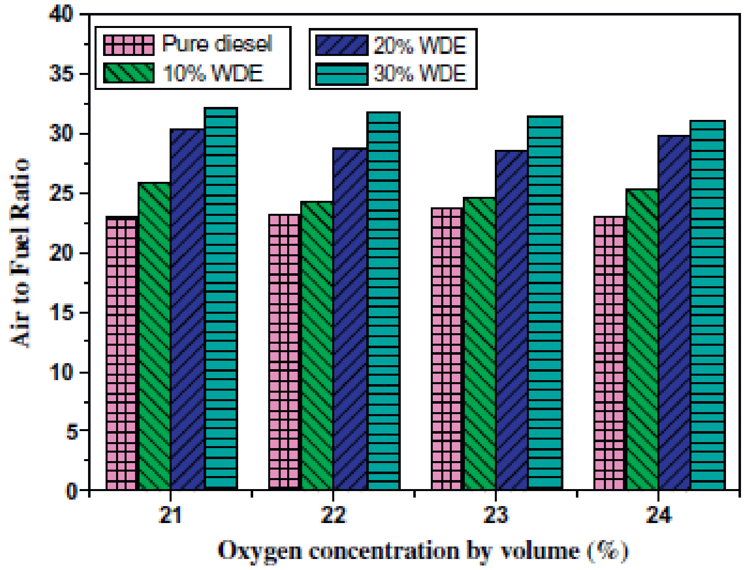

Fig.2 influence of OE and WDE on A/F ratio [6]

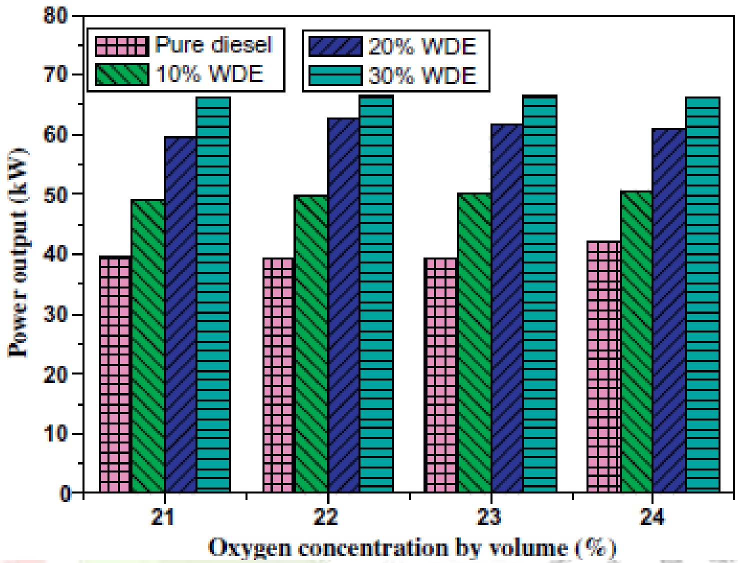

Fig.3 influence of OE and WDE on power output [6]

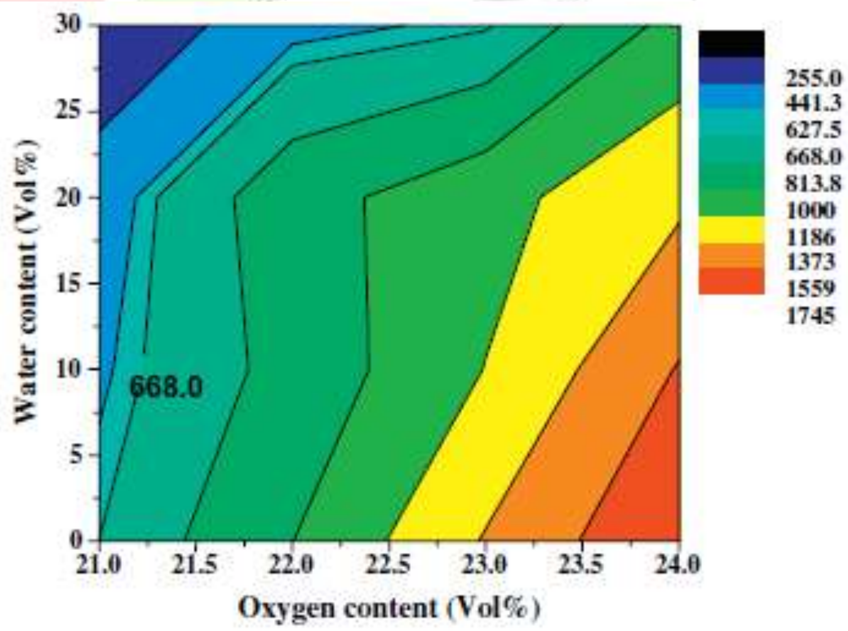

Fig.4 influence of OE and WDE on NOx emission (ppm) [6]

Hu Li, Patrick Biller et.al. [7] Investigated the effect of the oxygen enrichment in the intake air of diesel engines on the combustion and emissions performance using rape seed oil (RSO) as a fuel. They were used 6 cylinder, 6 L (0.006 m3), DI (direct injection), turbo-charged inter-cooled, heavy duty diesel engine, fitted with an oxidation catalyst. The engine was running at 47 kW (50% of its maximum load at this speed) and 1500 rpm constant conditions. They investigate the potential of oxygen enrichment in the intake air method to restrain the deterioration of particulate emissions of the RSO due to its high viscosity so as to explore the possibility of direct use of SVO (straight vegetable oil) in diesel engines, which can reduce CO_2 emissions and save cost. The combustion parameters such as ignition delay, heat release rate, in-cylinder peak temperature and pressure were determined. Engine out particulate and gaseous emissions of the rape seed oil (RSO) were measured at oxygen concentrations from 21% (by volume) (no enrichment) to 24% (by volume) and compared to diesel results. The enrichment of the intake air with oxygen decreased the ignition delay and premixed combustion duration, and increased the in-cylinder peak pressure and temperature. The particulate, CO and hydrocarbon emissions were significantly reduced while the NOx emissions increased as the oxygen enrichment rate increased. 22% oxygen enrichment rate was suggested to achieve lower than diesel particulate emissions with the lowest NOx penalty. Increased NOx could be controlled by other methods. The results show that the oxygen enrichment in intake air method enabled direct combustion of SVO in diesel engines with reduced particulate, hydrocarbon and CO emission.

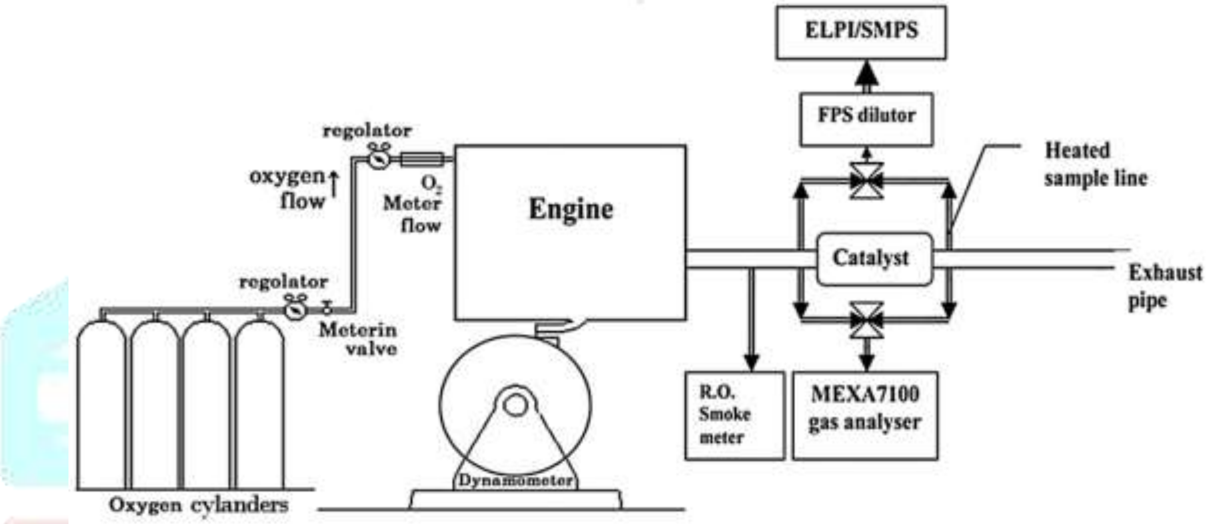

Fig 5 Schematic view of oxygen enrichment test set up [7]

Direct use of pure SVO as a fuel in diesel engines without transesterification can offer greater CO2 savings and lower cost compared to conventional biodiesels fatty acid methyl ester (FAME). However, high viscosity, low volatility of SVOs could lead to deteriorated combustion and emissions. The oxygen enrichment in the air inlet of the engine method as a way to improve the SVO's combustion so as to reduce emissions was investigated in this work. The air inlet oxygen levels tested were from 21% (no enrichment) to 24%.The PM had a large decrease at oxygen concentration 22%, a reduction of approx. 60% compared to no oxygen enrichment. The reductions were much slower afterwards to an almost flat level.The NOx emissions were increased by 150% at oxygen concentration of 24%, an average increase of approx. 50% for every 1% of increment of oxygen enrichment.

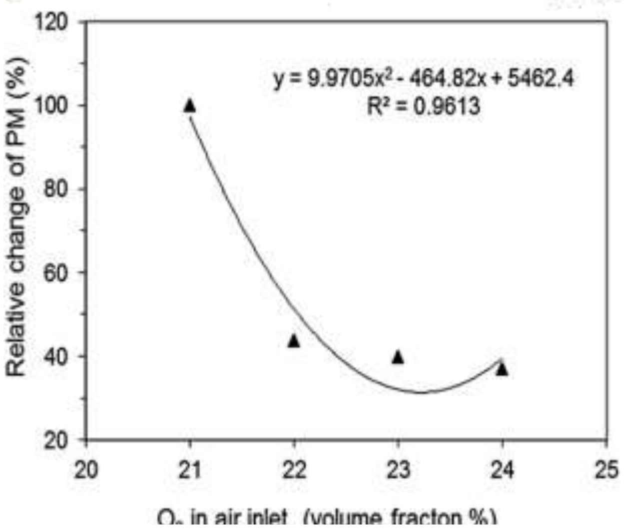

Fig 6. Normalized particulate specific emissions as a function of oxygen rate.

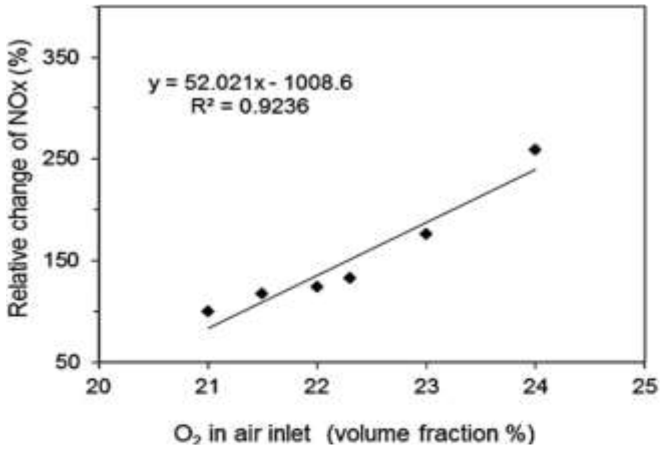

Fig 7 Normalized NOx specific emissions as a function of oxygen rate

P. Baskar, A. Senthilkumar [3] has conducted test on a 0.66 L single cylinder having compression ratio 17.5, rated power 4.33 KW, rated speed 1500 rpm, and direct injection diesel engine to study the impact of oxygen enrichment on pollution and performance parameters by increasing the oxygen concentration of intake air from 21 to 27% by volume. Oxygen enriched combustion is one of the attractive combustion technologies to control pollution and improve combustion in diesel engines. An experimental. The tests results show that the combustion process was improved as there is an increase in thermal efficiency of 4 to 8 percent and decrease in brake specific fuel consumption of 5 to 12 percent. There is also a substantial decrease in unburned hydro carbon, carbon mono-oxide and smoke density levels to the maximum of 40, 55 and 60 percent respectively. However, there is a considerable increase in nitrogen oxide emissions due to increased combustion temperature and extra oxygen available which needs to be addressed.

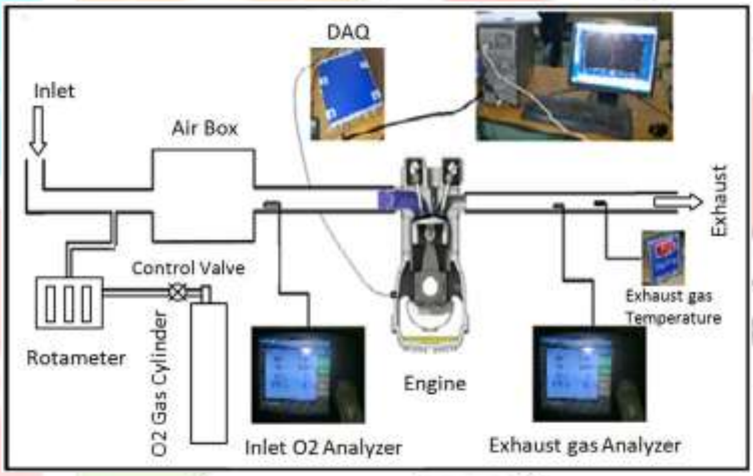

Figure 8. Schematic diagram of experimental set up [3]

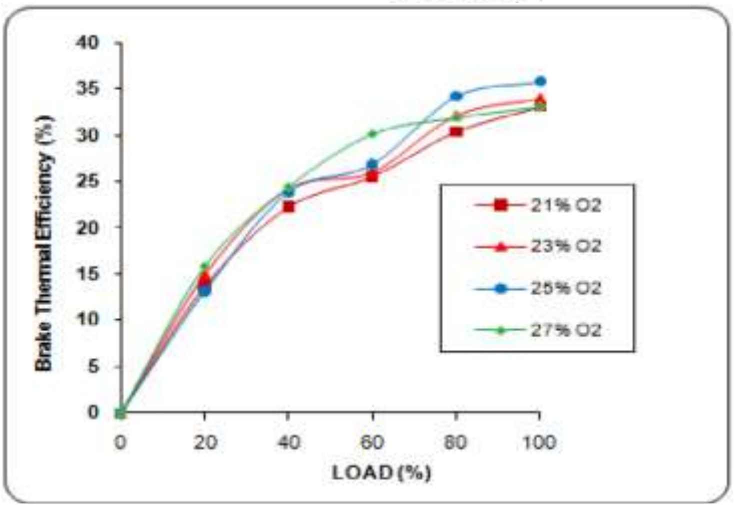

Fig. 9 Brake thermal efficiency in percent as a function of percentage of load [3]

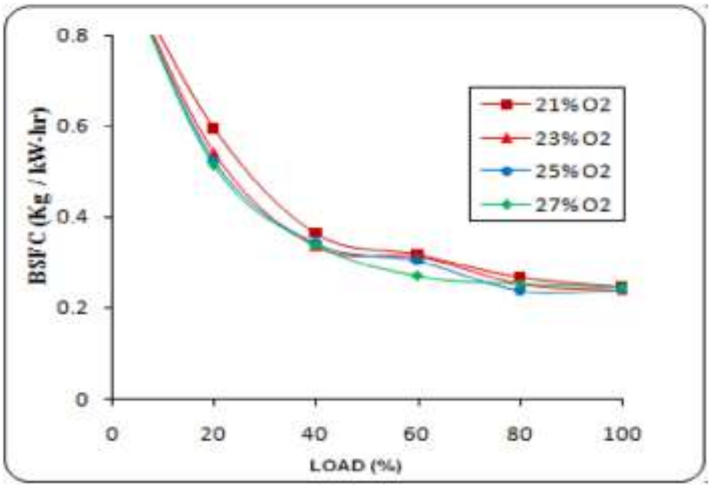

Fig.10 Brake specific fuel consumption in Kg/kW- hr. as a function of percentage of load [3]

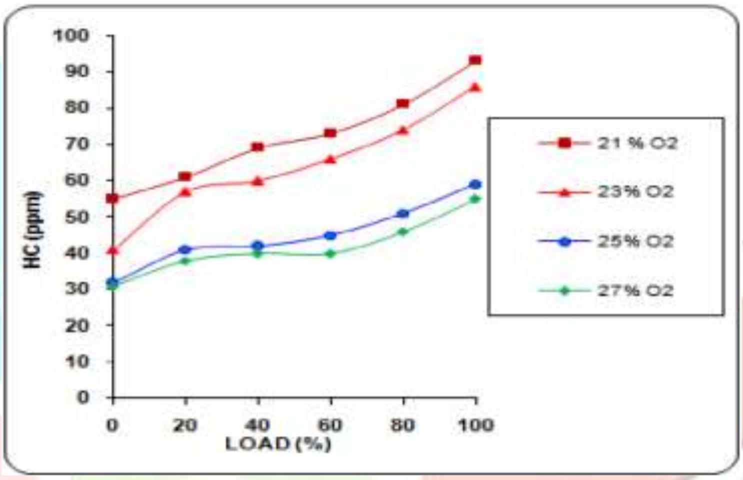

Fig 11. Hydro carbon emissions in ppm as a function of percentage of load [3]

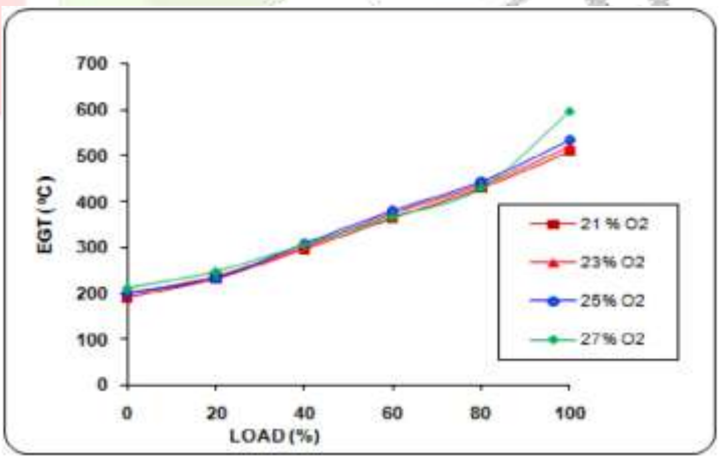

Fig.12 Exhaust gas temperature in °C as a function of percentage of load [3]

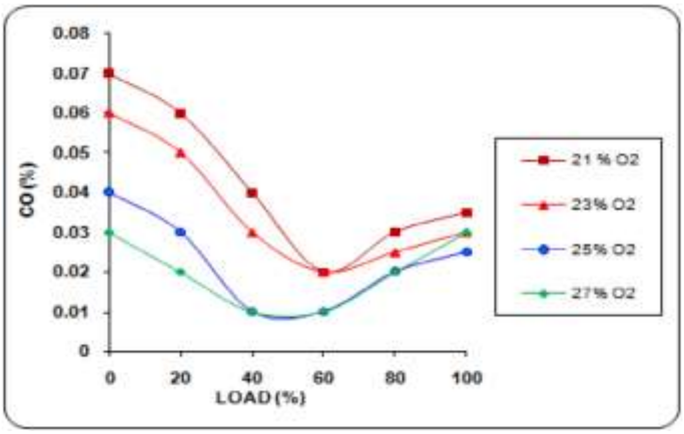

Fig 13 Carbon monoxide emissions in percentage as a function of percentage of load [3]

Karen Cacua, et. al. were tested effect of oxygen enriched air for a diesel-biogas dual fuel engine. The experimental tests were performing at a region placed at 1500 m over the sea level (Medellı´n e Colombia). The local environmental conditions were 298 K and 85.3 kPa. A stationary CI engine was coupled with a generator to run at maximum torque speed (1800 rpm). Experiment was conducted with engine having specification capacity 1.55 L, compression ratio 15.5:1, rated power 20 KW@3000 rpm. The operation and performance characteristics, such as thermal efficiency, pollutant emissions and combustion parameters were determined. Experiments have been carried out with a stationary compression ignition (CI) engine coupled with a generator in dual mode using a typical biogas composition of 60 vol. % CH_4 and 40% vol. %CO_2. For every engine load evaluated, the oxygen concentration in the intake air engine was varied from 21% to 27% O_2 v/v. Ignition delay time and methane emissions were decreased when using oxygen enriched air with respect to normal air (21% O_2), whereas the thermal efficiency was increased.

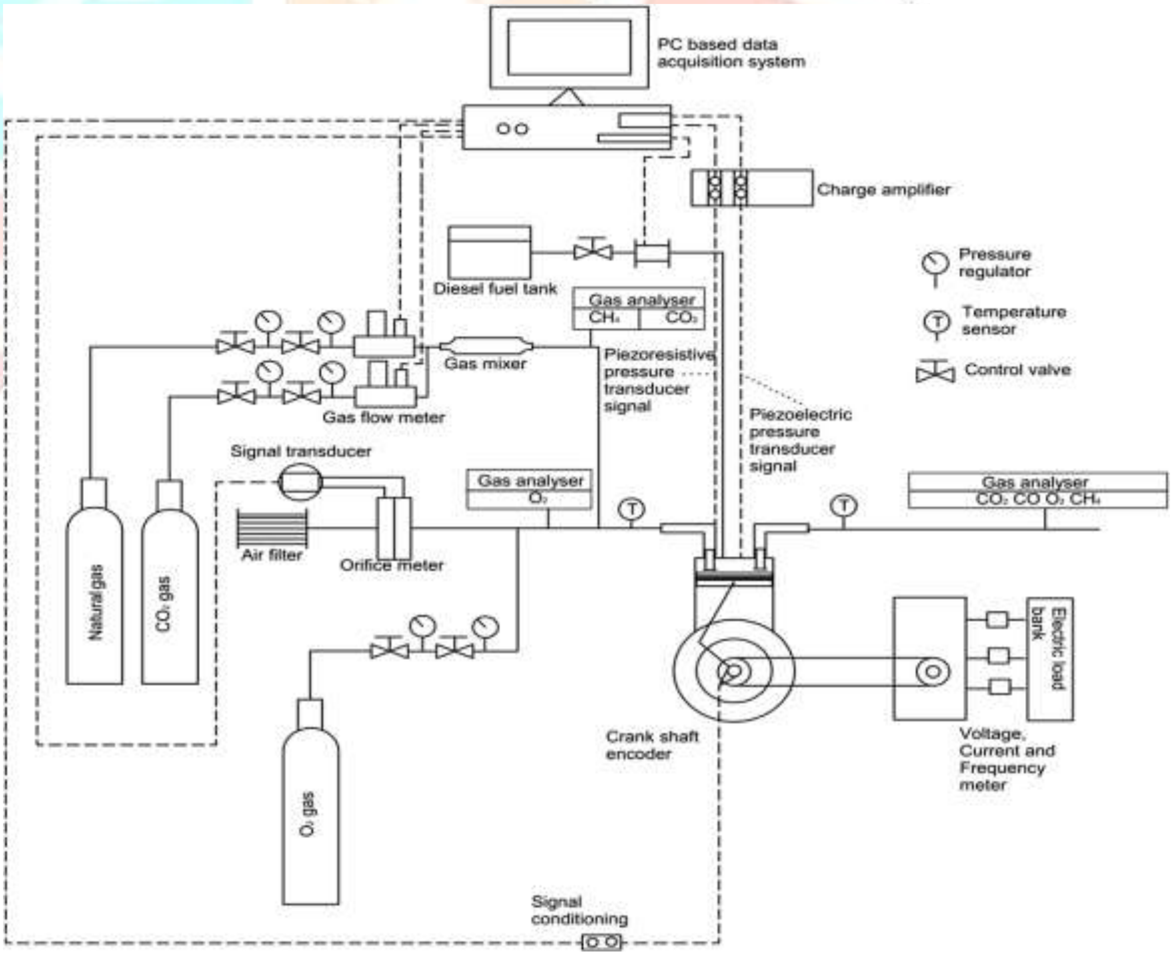

Fig 14 Schematic diagram of the experimental setup [8]

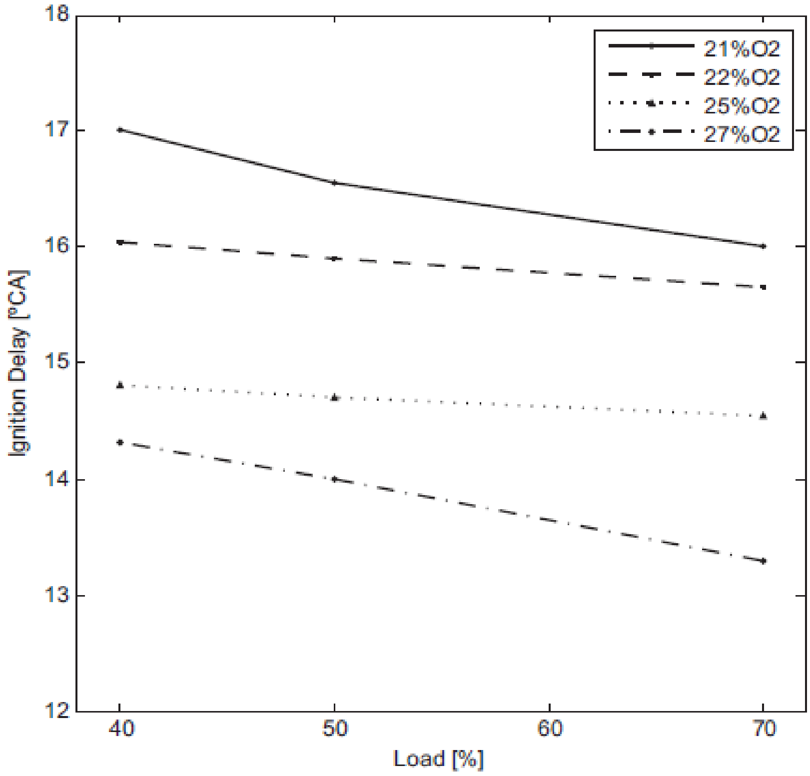

Fig.15 Ignition delay time at 40% , 50% and 70% loads with engine load and oxygen enriched air.

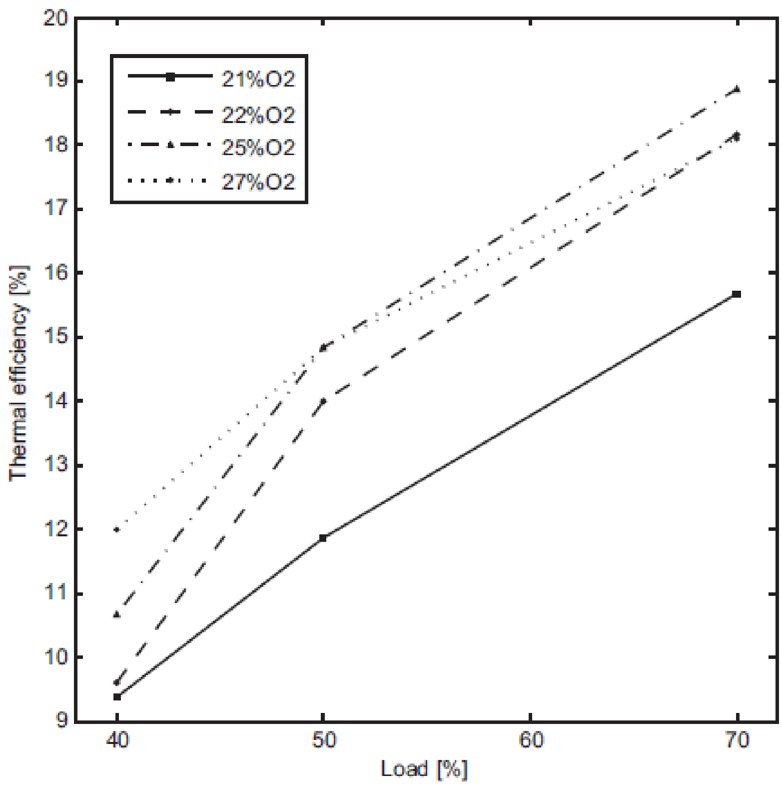

Fig. 16 Variation of thermal efficiency with engine load and oxygen enriched air.

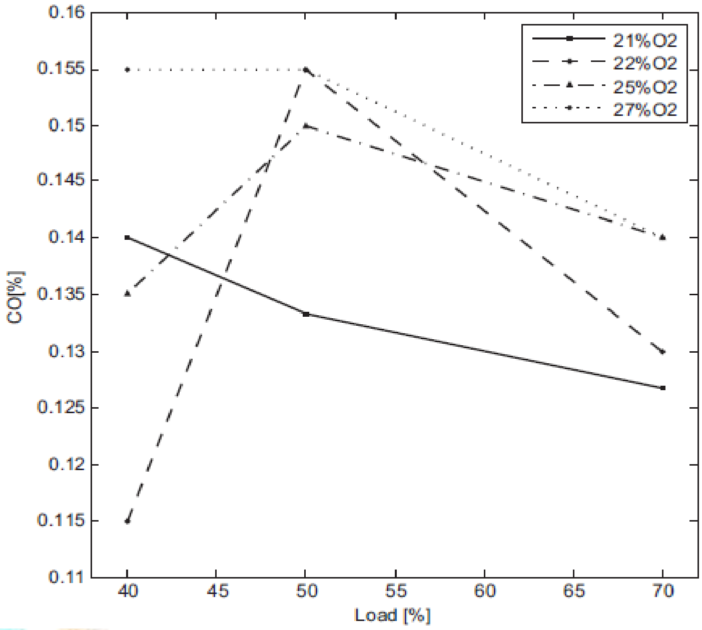

Fig. 17 Variation of carbon monoxide (CO) related to engine load with enrichment oxygen.

III. CONCLUSION

Oxygen enrichment is effective method to improve combustion efficiency. Thermal efficiency can improve via oxygen enrichment but high energy liberation can cause NOx formation. Exhaust gas carried out more heat with excessive air supplied which is further not desirable. It is need to develop some technique which reduce the formation of NOx with oxygen enrichment for combustion process. Effective cooling around engine can fulfill the criteria for control the NOx formation.

REFERENCES

[1] F. Mariani, C.N. Grimaldi, M. Battistoni. Diesel engine NOx emissions control: An advanced method for the O2 evaluation in the intake flow. Applied Energy 113 (2014) 576–588

[2] Yasin Karagoz, Tarkan Sandalcı , Ahmet Selim Dalkılıc. Effects of hydrogen and oxygen enrichment on performance and emissions of an SI engine under idle operating condition. International journal of hydrogen energy 40 (2015) 8607-8619

[3] P. Baskar, A. Senthilkumar. Effects of oxygen enriched combustion on pollution and performance characteristics of a diesel engine. Engineering Science and Technology, an International Journal 19 (2016) 438–443

[4] J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw-Hill Book Co, 1988.

[5] K.Rajkumar, P. Govindarajan Experimental Investigation of Oxygen Enriched air intake on Combustion Parameters of a Single Cylinder Diesel Engine. International Journal of Engineering Science and Technology Vol. 2(8), 2010, 3621-3627

[6] Youcai Liang, Gequn Shu, Haiqiao Wei, Wei Zhang. Effect of oxygen enriched combustion and water–diesel emulsion on the performance and emissions of turbocharged diesel engine. Energy Conversion and Management 73 (2013) 69–77

[7] Hu Li , Patrick Biller , Seyed Ali Hadavi , Gordon E. Andrews , Grzegorz Przybyla ,Amanda Lea-Langton Assessing combustion and emission performance of direct use of SVO in a diesel engine by oxygen enrichment of intake air method. Biomass and Bio energy 51 (2013) 43-52

[8] Karen Cacua, Andre´s Amell, Francisco Cadavid . Effects of oxygen enriched air on the operation and performance of a diesel-biogas dual fuel engine. Biomass and bio energy 45 (2012) 159-167