Power Enhancement using Oxygen Enriched Air for Multi Cylinder Diesel Engine

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***Abstact*-Today the diesel engine is the one of the most exciting and promising technology in the world. The research efforts directed towards improving the performance of CI engines. Hence it is necessary to study performance parameters of the engine. By increasing oxygen content with air leads to faster burn rates and ability to burn more fuel at the same stoichiometry. Added oxygen in combustion air leads to shorter ignition delay and offers more potential of burning diesel. Oxy-fuel combustion reduces the volume of fuel gases and reduces the greenhouse effect also. This paper presents how performance characteristics get improved by oxygen enrichment.**

Keywords-Power enhancement, oxygen enrichment, combustion, ignition delay. Performance characteristics.

I. INTRODUCTION

Today's conventional internal combustion engine uses only air as it is necessary for combustion process. Air is mixture of various gases which results in loss of heat energy produced by combustion due to undesired combustion of undesired gases. This results in loss of efficiency of that particular internal combustion engine. Due to low cost of diesel fuel diesel engine are more economical as compared to the gasoline engines. Diesel engines are widely use in field where both high power and high torque is required. But diesel engines are suffers from inherent higher particulate matter and nitride oxide emissions. Diesel engines are measure contributors of air polluting exhaust gasses such as particulate matter, carbon monoxide, oxides of nitrogen and other harmful compounds. All polluting exhaust gases form due to incomplete combustion of diesel fuel.. To avoid pollution and heat loss it is necessary to have complete combustion of fuel which can be accomplished by availing extra oxygen for combustion. Diesel engine manufacturers face major challenges to improve performance characteristics of diesel engine by achieving proper combustion of diesel fuel. To improve performance and lower exhaust emission further one of the least exploited variable has been oxygen concentration in combustion air. Use of oxygen enriched air was compared with different level of oxygen enrichment to evaluate combustion parameters.

II. LITRETURE REVIEW

To study the effect of oxygen enriched air on performance characteristics of diesel engine. We referred research papers. Mohammed Fahed [1], had used oxygen enriched combustion (OEC) technology with high emission fuels. The conclusions are oxygen enriched intake air should be used to reduce the amount of stack gas CO emissions. Flue gas reduction Energy efficiency, turndown ratio, flame stability. Kuppusamy Rajkumar [2] investigates the effect of using oxygen enriched air on Diesel engine exhaust emission. And made conclusion that are Increasing the oxygen content with the air leads to faster burn rates and the ability to control Exhaust Emissions ,added oxygen in the combustion air offers more potential for burning diesel. Oxy-fuel combustion reduces the volume of flue gases and reduces the effects of greenhouse effect also. Mattias Nyberg [3] diagnoses the air intake system of an SI-engine. System based on non-linear semi-physical model and use of different residual generation method. And concluded that increases performance of engine. Model based system appropriate. Fredrik Norman [4] investigated the possibility of high-temperature reduction of nitrogen oxides (NOx) in oxy-fuel combustion. K.Rajkumar[5] have studied Added oxygen in the combustion air leads to shorter ignition delays and offers more potential for burning diesel. And different parameters such as like Ignition delay, Combustion duration, Heat release and Cylinder pressure was discussed. S.Sranatha Reddy [6], have achieved reduction of smoke through catalyst based oxygen enrichment technique which proves to be an effective one as it utilizes air from the ambient to produce oxygen-enriched air. The catalyst used for the present study is zeolite. Mojtaba Moghad dam [7] in their study, nitro methane (NM) and nitro ethane (NE) were used as nitrogenated additives to improve brake specific fuel consumption (BSFC), combustion performance and reduce emission from diesel engine. A. Payakani [8] has taken efforts to study performance andemission characteristics of a diesel engine fuelled with biodieseland diesel fuel using EGR. And prove that exhaust gas recirculation (EGR) is a very effective technique to reduce NOx emissions from adiesel engine. Azmi Osman [9] has said that,Air is replaced with oxygen to maximize the combustion efficiency and to enable broader range of fuels to be used. Water is injected

into the combustion chamber to enhance the combustion heat absorption, gas expansion and to function as an energy carrier. Engine secondary heat that will otherwise be wasted to the environment is recovered and reused by the engine. Engine theoretical efficiency and out emissions are predicted to be improved. R. Senthilkumar [10] the experiments were conducted by kriya bio additive in different ratios with diesel. The quantity of bio additives were increased gradually in the order of 1ml, 1.5ml, 2ml, 2.5, and 3ml respectively. Emission parameters such as HC, smoke density, NOx, and CO2, characteristic were determined for diesel and also for bio additive blends. Bio additives mixed with diesel in different ratios by volume based, it is noticed that the bio additive added diesel enhances the cetane number and reduced the emission.

Stuart Nemser [11] made the objective for the research that to NOx emissions by reducing the peak temperatures of combustion. NOx emission reductions as high as 50% are being achieved on diesel engines supplied with membrane generated NEA. Results from some of these tests are presented. C.D. Rakopoulos [12] presented two zone model of a direct injection (DI) Diesel engine divides the cylinder contents into anon-burning zone of air and another homogeneous zone in which fuel is continuously supplied from the injector and burned with entrained air from the air zone. Duraid Maki [13]he has done study experiment on multi cylinder, natural aspiration, four stroke, compression ignition, and water cooled engine is tested under hydrogen diesel different blends and at different operating conditions. A hydrogen induction set up is built in the lab with all of the acquitting sensors and measuring instruments. Experimental tests are done to investigate engine thermal performance and exhaust emission constituents under those blends circumstances. The optimum operating conditions and optimum parameters for those blends are found. Sagar Kadu [14] determine performance of a four stroke, single cylinder C.I. engine by preheated neat Karanja oil and performance parameters considered for comparing are brake specific fuel consumption, thermal efficiency, brake power, Nox emission of the engine. And concluded that, at higher speed there is no significant difference in BSFC when the engine is operated with preheated and unheated vegetable oil fuels. Engine power increases with speed to a maximum value at an engine speed of 3500 rpm. Vipul Jain [15] used Exhaust Gas Recirculation (EGR) System means to use the Exhaust Gas coming from Exhaust Manifold to Inlet Manifold in order to reduce the Emission of NOX, which is particularly very harmful. Using Exhaust Gas Recirculation (EGR) Technique in engines, the emissions are very much controlled. This method is very reliable in terms of fuel consumption. Meisam Ghadikolaei [16] investigated the effect of cylinder air pressure and fuel injection pressure on combustion characteristics of direct injection (DI) diesel engine .The tests have been performed in a constant combustion chamber with single-hole pintle nozzle which the conditions were similar to real DI engine conditions. Alagu [17] presented the article of literature study of the effect of different fuel additives on performance and emission characteristics of CI Engine fuelled with additives of oxygenated and metallo-organic compounds. The papered scribes some properties of synthetic oxygenates and their influence on exhaust emissions from diesel engines. According to the results of examinations, oxygenates are an effective method for obtaining the reduction in the PM, CO and HC emissions. A. I. Ramírez [18] explained fuel injection and atomization processes are known to affect the combustion and emission behavior in diesel engines. In this study, characteristics from a six-hole, heavy duty, Hydraulically-actuated, Electronically-controlled Unit Injector (HEUI) have been investigated. Effects on cylinder pressure, performance, and emissions information were obtained. A. R.Patil [19], this Improvement of fuel properties essential for suppression of pollutant and optimization of engine performance. Now a day's oxygenated additives are widely considered for diesel fuel also. During study of available material It is found that, oxygenated are effective method for reducing PM, CO and HC without significant increase in the NOx emission. P.Sreenivasulu1 [20] tried to bring out the advantages of additives to alcohol fuel on the performance of CI Engines. The Additives such as n-butanol, hexanol, 1-octylamino-3octyloxy-2propanol&N-octyl Nitra mine had been mixed with theblends of diesel & ethyl alcohol and experiments are carried out. The present research work is proposed to carry out the experimental investigation on a ceramic hot surface ignition engine by adding Ethyl nitrate,Butyl nitrate,Diisi propyl ether and Dimethyl ether as additives to ethanol/methanol as a fuel with an objective to find the best one interms of performance, emission and combustion parameters.

III. METHODOLOGY

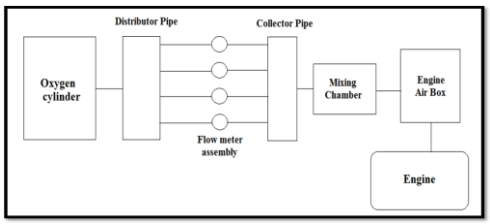

Fig.1 Block diagram setup

Oxygen Cylinder: The oxygen cylinder of 7 cubic meter capacity is used for the present work. Oxygen stored at the pressure of 150psi.

Distributor pipe: The distributor pipe having four drilled hole from which oxygen is passed to flow meters. It is placed in between oxygen cylinder and flow meters. The suction flow rate of oxygen in diesel engine is up to 80-90 lit per min. Therefore to attain this requirement 4 flow meters are used in series. The pipe of 50 mm diameter and 260 mm length is sealed by both ends and at one end inlet valve is drilled through which oxygen is passed from oxygen cylinder.

Flow Meter: Flow meter is device used to measure volume flow of gas. The principle of lifting of mass by density of gas is used in a working of flow meter. In the flow meter pressurized gas from reservoir is injected in a vertical capillary tube having ball of unit mass enclosed in it. The capillary tube is having increasing scale from bottom to top that is 0-25 litre/min. There are four flow meters are used to

maintain the flow. By using four flow meters, we can measure flow up to 100 litre/min.

Collector pipe: The collector pipe is placed in between flow meters and mixing chamber. The measured oxygen from flow meters outlet is collected in collector pipe. Then it is send to the mixing chamber. The collector pipe having four drilled hole from which oxygen is collected from flow meters.

Mixing chamber: - The main purpose of mixing chamber is to mix oxygen in to sucked air. The diameter of original suction pipe of engine is 37mm, so for mixing chamber 37 mm diameter is selected. .The pipe of M.S. of diameter 37mm and length 150 mm is selected. For oxygen mixing one jet is penetrated into this pipe. So when air is sucked by engine, additional required oxygen will be provided by jet and the mixture will suck by engine. The one end of pipe is connected to engine and another end is open to atmosphere, so when there is no suction in engine then there are chances of oxygen loss due to back pressure. To prevent this loss non return valve is used at the open side of suction pipe. The non-return valve of flap type is used. Whole assembly is bolted at opening of air box with help of 4 nut bolts of M12.

Engine: The four cylinder four stroke diesel engine test rig is used for experimental work. The oxygen from mixing chamber is then sending to suction of engine.

IV. EXPERIMENTAL WORK

The various experiments are conducted on four cylinder four stroke diesel engine test rig. Whose specifications are as follows :

Make	*Hindustan Motors*
Bhp	*10hp*
Speed	*4500 To 5000 Rpm*
No. Of Cylinders	*Four*
Compression Ratio	*17:1*
Bore	*0.073m*
Stroke	*0.09m*
Type Of Ignition	*Compression Ignition*
Method Of Loading	*Hydraulic Dynamometer*
Method Of Starting	*Starter Motor*
Method Of Cooling	*Water*

Test engine used in the experiments is a multi cylinder four-stroke, naturally aspirated, constant speed compression ignition engine. Calorimeter was connected at the exhaust manifold of engine to measure the exhaust gas temperature. Oxygen concentration of intake air was increased by injecting pure oxygen from compress cylinder to the mixing chamber. Mixing chamber is connected before air box of diesel engine test rig. To ensure the effective oxygen enrichment, the pure oxygen was injected directly through mixing chamber and intake air oxygen concentration was measured properly using gas flow meters.

Fig.2 experimental setup

V. RESULT & DISCUSSION

Oxygen enrichment in intake air leads to more efficient fuel consumption. By increasing oxygen concentration in intake air the heat that is released from combustion reaction, is also increased. By assuming heat transfer from combustion, the same for all oxygen concentration levels, the rate of fuel consumption is reduced along with increasing oxygen concentration in intake air. We can determine the per cent of fuel consumption with respect to the initial state in which pure air with 21% oxygen by volume had been used. By increasing the amount of oxygen from 21% to 28%, variation of fuel consumption rate in different loads can be seen. The practical fuel consumption achieved for different oxygen concentration levels is compared to theoretical calculations. We have obtained different results for different oxygen concentration.

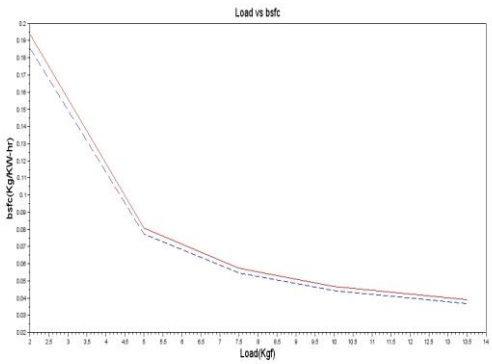

Fig.3 load versus brake specific fuel consumption (BSFC)

The graph shows the variation of brake specific fuel consumption (BSFC) versus load for oxygen enrichment in intake air. Red line shows variation of brake specific fuel consumption with respect to load with normal suction air. Blue dotted line shows variation brake specific fuel consumption with respect to loads with oxygen enriched suction air. The BSFC decreases as in oxygen concentration. At higher loads, BSFC tends to increase a little. Oxygen enrichment decreases the BSFC at all loads.

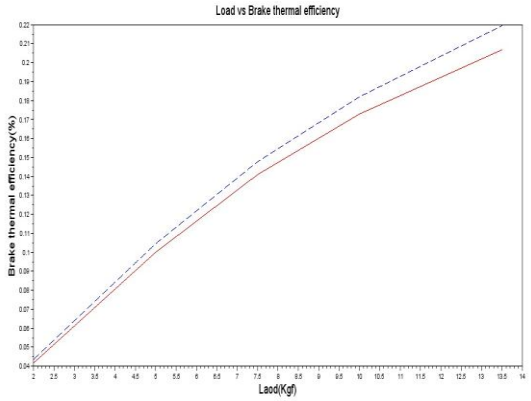

Fig.4 load versus brake thermal efficiency

Graph shows the variation of brake thermal efficiency versus loads. Red line shows variation of brake thermal efficiency with respect to load with normal suction air. Blue dotted line shows variation brake thermal efficiency with respect to loads with oxygen enriched suction air. By increasing oxygen concentration, the brake thermal efficiency is increased at all loads. Increase in oxygen concentration leads to efficient combustion and hence efficiency increases.

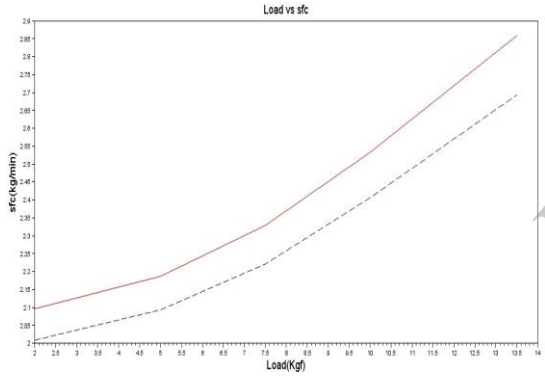

Fig.5 load versus specific fuel consumption (SFC)

Graph shows variation of specific fuel consumption versus different loads. Red line shows variation of specific fuel consumption with respect to load with normal suction air. Blue dotted line shows variation specific fuel consumption with respect to loads with oxygen enriched suction air. Enrichment of oxygen leads to efficient combustion. As combustion is proper power output for same mass of fuel is increases. Therefore for fixed power output mass of fuel decreases with enrichment of oxygen. Therefore specific fuel consumption decreases with increase in oxygen concentration in suction air.

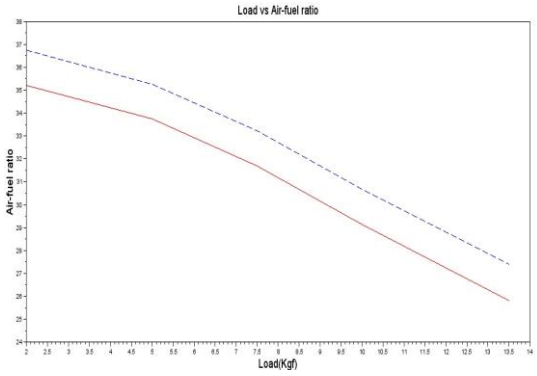

Fig.3 load versus Air-Fuel ratio

The graph shows variation of air fuel ratio versus different loads. Red line shows variation of air fuel ratio with respect to load with normal suction air. Blue dotted line shows variation air fuel ratio with respect to loads with oxygen enriched suction air. In case of oxygen enriched air, for a load, mixture of air and fuel becomes lean i.e lean mixture is required for same power output as compared to power output in case of without oxygen enrichment. Hence air-fuel ratio increases with increase in oxygen concentration for different loads.

VI. CONCLUSION & FUTURE SCOPE

There are different methods for the enrichment of the oxygen such as air separation membrane, using the pressure adsorption theory (PSA) with the help of the zeolite, with the help of the different additives such as karanja oil, etc. But among all these methods the enrichment of the oxygen with the help of the separate oxygen cylinder is the most convenient method. With help of this method we will get the enrichment in the oxygen level. And because of this there is complete combustion will be occur which may enhance the power.

Oxygen enriched combustion technology influences in increasing the cylinder pressure. This may be attributed to the reduction of the ignition delay period which means early starting of combustion and the availability of longer reaction duration result in a more completion of the combustion process due to the excess of oxygen and the higher gas temperature. The use of oxygen enrichment on diesel engine under different loading conditions was studied to discuss various parameters like brake specific fuel consumption, specific fuel consumption, brake thermal efficiency, air fuel ratio.

By increasing oxygen concentration in intake air the heat that is released from combustion reaction, is also increased. The rate of fuel consumption is reduced along with increasing oxygen concentration in intake air. By increasing the load, rate of fuel consumption is gradually reduced. Brake thermal efficiency increases at all loads with increase in oxygen concentration. Brake specific fuel consumption is decreased by oxygen enrichment, at all loads. Increase in oxygen concentration leads to increase in the air-fuel ratio.

The present work can be extended by following modification. (1)The test for emissions can be conducted to

indicate the reduction in particulate matters, hydrocarbon, etc.

(2) The exhaust gas emissions recirculation can be adopted to reduce NOx emission of engine. (3) The turbocharger can be used to improve power of engine. (4) The limitation of scuderi engine can be eliminated by adopting the method of present work.

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