Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

Performance Enhancement of Multi Cylinder Internal Combustion Engine by Oxygen Enrichment: A Critical Review

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***Abstract*— We, human beings are finding the solutions on energy crisis. It may be in terms of Alternate Energy sources, Increase in Efficiency or Saving of Fuel. For proper combustion carbon from fuel having good calorific value and sufficient amount of oxygen from atmospheric air is required. But as we know we get only 21% Oxygen and about 79% of other gases which produces pollutants like Carbon Monoxide, Nitrogen oxide, Hydrocarbons, Nitric oxide, Sulphur dioxide etc. Oxygenized air helps in proper combustion with reduction in the volume of flue gases and greenhouse effect. This is effective method for reducing CO, HC without significant increase in NOx. Oxygen enrichment also results in rapid combustion of fuel which increases power output, mechanical efficiency and volumetric efficiency with increased amount of heat generation.**

Keywords*— Emission, I.C. Engine, power enhancement, Oxygen enrichment, performance.

I. INTRODUCTION

The civilization is growing transportation become an integral part of life. The biggest problem is the growing population and depletion of fossil fuels. About 100 years ago the major source of energy shifted from recent solar to fossil fuels (Hydrocarbons). Technology has generally led to a greater use of hydrocarbons fuels making civilization vulnerable to decrease in supply. The study made in last decade, on the basis of who had projected peak-oil in 1956, predicts that if the hydrocarbons fuels are consumed at current rate, then by 2020, we will be consuming 80% of inter available resources.

This necessitates the research of Alternative Energy sources or Increase in Efficiency or Saving of Fuel. Now days we are so much suffering from load shading. For Generators we required much fuel. So we required to increase the efficiency of gensets at the low fuel consumption. In racing cars it is required to speed up the engine quickly and to decrease the size of engine.

The main objective of Oxygen Rich Engine is to offer additional advantages on vehicle performance and minimize the environmental impact with less pollution and fuel efficiency.

II. LITERATURE REVIEW

This section includes background and various experimental works previously done on oxygen enrichment. To study the effects of oxygen enriched air on performance characteristics of multi cylinder internal combustion engine, we referred different research papers and patents.

The patent filled by Rodger C. Finvold [1] on 16th Aug.1955 states the use of liquid oxygen power booster for IC engine. Rodger C. Finvold mentions the use of power booster so that oxygen is added to the air and fuel mixture to increase the power of engine, the oxygen being stored in liquid form. Another objective of this invention was to provide a power booster in which the mass flow rate of oxygen is controlled in relation to the engine throttle opening so that the oxygen supply meets the demands of the engine. This invention also states the use liquid oxygen power booster which is adapted for fabrication from many different materials, so that the choice of material can be according to the indicates of availability and price considerations, the exact sizes and proportions being matters easily determined to suit particular conditions and needs.

Three methods of supplying pure oxygen to an internal combution engine were explained by Martin E. Gerry [2] in his patent. As shown in fig 2.1, the pure oxygen which is stored in oxygen cylinder under high pressure may be supplied dirctly from the oxygen cylinder to the combustion chamber of an internal combustion engine. Fig 2.2 shows that, the pure oxygen can be created by heating the chamber which consists of oxygen realeasing chemical compound like zeolite. Fig2.3 shows that, it is possible to create pure oxygen by performing electrolysis of water and the pure oxygen which is created by electrolysis method will be supplied to intake air to enhance the performance of an internal combustion engine.

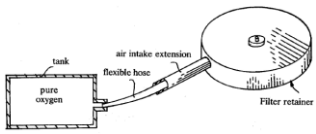

Fig. 1 Supply through tank method [2]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

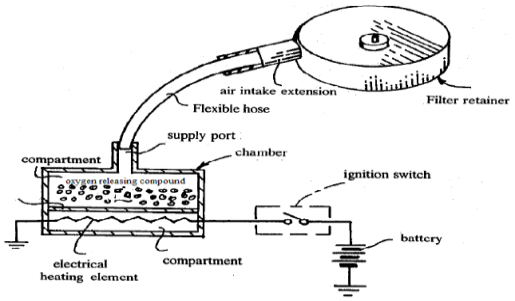

Fig. 2 Heating of compound method [2]

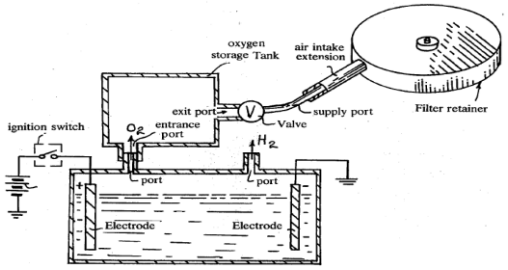

Fig..3 Water electrolysis method [2]

In another patent filed by Harry C. Watson and Eric E. Milkins [3], of Australia states the oxygen enrichment of fuels. It claims the method of operating a diesel or spark ignition engine through enriching the combustion air supply with oxygen while simultaneously adjusting the fuel injection or ignition timing of the engine to compensate for advanced combustion caused by increased oxygen content in the combustion air. Oxygen enrichment of the combustion air permits combustion of otherwise unsuitable or difficult to combust fuels such as residual or heavy fuel oils, alcohol and alcohol blends, seed oil and blends of light gas oils and residual or heavy fuel oils. By oxygen enrichment it is possible to use of biodiesel in IC engine.

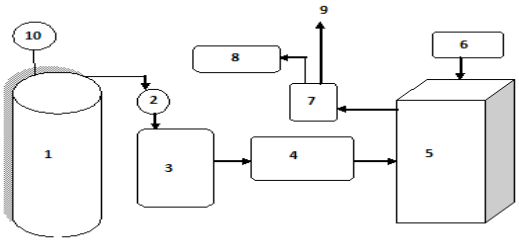

Fig. 4 Experimental setup [4]

1) Oxygen cylinder; (2) Flow meter; (3) Flame trap; (4) Engine; (5) Engine; (6) Loading Device; (7) Exhaust gas; (8) Krypon gas analyzer; (9) To Atmosphere

Paper published by Bharath. P. and Kamalakkannan. K [4] states that by increasing amount of oxygen in the intake air with the help of external source, we can increase the efficiency of I.C.engine. While conducting test on a single cylinder, naturally aspirated, air cooled, constant speed Greaves engine they used an eddy current dynamometer as the loading device and a Krypton gas analyzer was used for the study of the exhaust gases. Performance parameters like break thermal efficiency, break specific fuel consumption were calculated at normal oxygen concentration and at increased concentration of oxygen i.e when the concentration of oxygen was increased from 21%to 27%. From the test, it was also observed that CO reduced by great extent at higher concentration of oxygen in the intake air.

Research by Wladyslaw Mitianiec and Krzysztof Sliwinski [5] determines the emission of toxic exhaust gases like CO and CO2 from multi cylinder spark ignition engine before and after oxygen enrichment.The concentration of oxygen was increased from 21% to 32%.By appling EGR i.e exhaust gas recirculation system,the tempreture of the cylinder decreasd by great extent.Experiments were done on air cooled 2-cylinder 4-stroke spark ignition engine with different amout of oxygen and EGR ratios in order to reduce the NOX emmisions and tempreture of the cylinder during combustion process. By using data which was obtained by performing various tests on the dynamometer,the simulation process was carried out. Results were compared by ploting graph the of volumetric ratios of CO,CO2,HC and NOx at different EGR ratios but speed of the engine was kept constant i.e. 3000rpm. It was observed that the volumetric ratios of CO, CO2 and HC increased with increasing the EGR ratio but the NOx content decreased with increasing EGR ratio. Emmisions of toxic gases like CO and HC decreased by increasing the volume of oxygen from 21% to 32%.On the other hand CO2 emmisions increased with increase in oxygen content in the combustion chamber. It was also observed that mean effective pressure and break specific fuel consumption decreased with increase in volume of oxygen from 21% to 32% at constant speed of 3000 rpm.Equation for gasoline combustion is given below

$$4\ C_8H_{17+}49\ O_2 <=> 32\ CO_2 + 34\ H_2O \qquad [5]$$

Experiment performed by Sunit Jadhav, S. N. Waghmare, Suraj Dalvi and Vinit Kamble [6] on the 4stroke multi-cylinder compression ignition engine. They increase the Oxygen concentration by injecting pure oxygen from compressed cylinder to the mixing chamber. Flow meter was used to measure the oxygen supply. The oxygen concentration in the intake air was increased from 21% to 28% by using oxygen cylinder having 7 cubic meter capacity and the pressure of the oxygen stored in the cylinder was 150psi. Break thermal efficiency, Break specific fuel consumption these parameters were calculated at different loads with and without suppling oxygen in the intake air.The results were compared by ploting the graphs of BTE vs. LOAD , BSFC vs. LOAD and AIR-FUEL RATIO vs. LOAD at various concentration of oxygen .By comparing the results,it was observed that break thermal efficiency has larger value when the concentration of oxygen in the intake air was high i.e more than 21%.Break specific fuel consumption also decreased at all loads by increasing the oxygen concentration in the intake air.The air-fuel ratio increased by increasing the concentration of oxygen.The overall performance of the multicylinder 4 stroke compression ignition engine improved by suppling pure oxygen to the mixing chember.

The experimental work by D.R.Gaikwad and H.M.Dange [7] was carried out on multi cylinder 4 stroke S.I. engine (MPFI i.e. multi point fuel injection).Performance of the SI engine was investigated at different mass flow rate of oxygen and speed of the S.I. engine was also varied from 1000 rpm to 3000 rpm. Performance parameters of the multi cylinder SI engine like mechanical efficiency, break thermal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

efficiency, break specific fuel consumption, volumetric efficiency were calculated after supplying the oxygen at mass flow rate of 5lpm,10lpm and 15 lpm. Exhaust gas emission levels were also analyzed at different mass flow rates of oxygen. After supplying the oxygen to the intake manifold it was observed that the emmision levels of the main pollutants reduced by great extent. By observing all the results it was concluded that the overall performance of the spark ignition engine was enhanced when the mass flow rate of oxygen was 10lpm.

Paper published by Bhavin Mehta, Hardik Patel and Pushpak Patel shows that there is an opportunity to enhance engine performance with reduction in emmisions of the internal combustion engine by using oxygen enriched combustion. Three methods of oxygen enrichment were explained to enhance the performance of CI engine. According to first method the oxygen is injected into the incoming combustion air supply through a diffuser to ensure proper mixing.

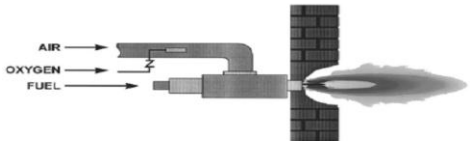

Fig 5 Air enrichment method [8]

According to second method, O2 is injected directly to the flame.This method is generally used for lower levels of oxygen enrichment.

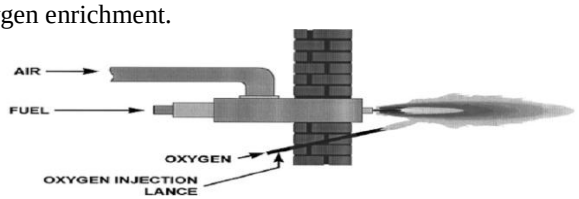

Fig 6 O2 lancing method [8]

Oxy/Fuel method: In this method, high-purity oxygen (>90% O2 by volume) is used to combust the fuel and it has the greatest potential for improving a process, but it also may have the highest operating cost.

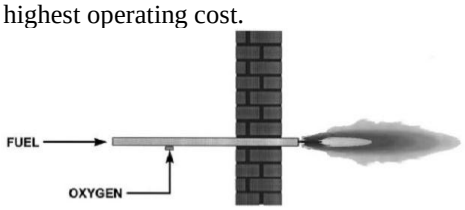

Fig 7 Oxy fuel method [8]

The experiment was performed on a single cylinder,4-stroke,water cooled diesel engine. It was observed that at all loads, Break thermal efficiency increased with reduction in specific fuel consumption. The emmisions of the pollutants like CO and HC decreased by great extent by enrichment of oxygen. But the emissions of the oxides of nitrogen increased significantly by increasing the flow rate of oxygen.

III. DISCUSSION

Various inventors mentioned different techniques for oxygen enrichment. In which Rodger C. Finvold [1], used power booster through which oxygen is added to the air and fuel mixture to increase the power output of an engine. In this paper it is also mentioned that the amount of oxygen should not be more than 28% by volume, otherwise it will result into high heat release from the exhaust of the engine.Martin E. Gerry [2] mentioned three ways of supplying pure oxygen to an internal combustion engine. Harry C. Watson and Eric E. Milkins [3] state the oxygen enrichment of fuels, according to them by oxygen enrichment; it is possible to use of biodiesel in IC engine. Bharath P. and Kamalakkannan.K [4] observed that BHP value increased by 9 to14% by increasing the percentage of oxygen in the intake air at low loads but at high loads BHP value did not increased conciderably even the percentage of oxygen in the intake air was improved to 27%. It was also observed that BSFC decreased by 11% to 18% at higher percentage of oxygen at all load conditions. Simulation test was conducted by Wladyslaw Mitianiec and Krzysztof Sliwinski [5]. Simulation test indicated the non-linear variation of mole fractions of carbon dioxide and carbon monoxide at various amount of oxygen by volume. Experimental work done by S. Indulkar, S. Dongare and S. N. Waghmare [6] proved that there is a oppurtunity to improve the performance of the multicylinder compression ignition engine by enrichment of oxygen. Experimental investigation performed by D. R. Gaikwad and H. M. Dange [7] shows that the break thermal efficiency, volumetric efficiency, mechanical efficiency increased by 10-25% and also the BSFC decreased by 10 to 15% when the oxygen was supplied at the mass flow rate of 10lpm. Bhavin Mehta, Hardik Patel and Pushpak Patel [8], experimental work shows that Break thermal efficiency increased considerably and also the fuel consumption decreased at all loads when the oxygen enriched air was supplied to combustion chamber. CO and HC emissions also decreased by great extent by using oxygen enriched air.

IV. CONCLUSION

Based on the reviewed paper for the emissions and performance, it's concluded that the oxygen enrichment is an effective method for proper combustion of gasoline and therefore must be taken into consideration in the future for transport purpose. There are different methods for the enrichment of the oxygen such as water electrolysis, heating of compound, using the pressure adsorption theory (PSA) with the help of the zeolite, Brown gas (HHO), Biodiesel blending with Gasoline, Varying valve timing , Injection timing, Preheating the suction air 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 without major modification in existing engine setup. And because of this there is complete combustion will be occur which may enhance the power as well as there will be reduction in emissions.

By performing test on gasoline engine with and without supply of oxygen we can obtain results using different engine parameters such as brake thermal efficiency, mechanical efficiency, specific fuel consumption, air-fuel ratio etc. We can also study the variation in Power and emission pattern of IC engine with increasing percentage of oxygen concentration in suction air.

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