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RESEARCH ARTICLE

PERFORMANCE ANALYSIS OF OXYGEN ENRICHED MULTI CYLINDER S. I. ENGINE.

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Abstract

We, human beings 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 of 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. Oxygen enrichment results in rapid combustion of fuel which increases power output, mechanical efficiency and volumetric efficiency with increased amount of heat generation.

Introduction:-

As the civilization is growing, transportation becomes an integral part of life. In today's life the major challenge is to meet the demands of the fossil fuels as population increases day by day and the sourses of the fossil fuels are depleting. 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.

We need to study various methods to increase the efficiency of the S.I. engine with less fuel consumption. Now days we are so much suffering from load shadding.Stationary engine like Generators require more fuel than that of moving vechicles. The term "oxygen enrichment" refers to any process that results in increasing the concentration of oxygen to a level greater than the level found in air under standard conditions; approximately 21%. Oxygen enrichment is one of the effective method for increasing the efficiency of the engine with reduction in the fuel consumption.

The main objective of oxygen enrichment is to improve the overall performance of the spark ignition engine.To achive this, pure oxygen which is stored in the oxygen cylinder under high pressure is supplied to increase the concentration of the oxygen in the intake air which results into proper combustion of fuel.

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 I.C. 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 differentmaterials, so that the choice of material can be according tothe indicates of availability and price considerations, the exact sizes and proportions being matters easily determinedto 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 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 shows that, the pure oxygen can be created by heating the chamber which consists of oxygen realeasing chemical compound like zeolite. Fig 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.

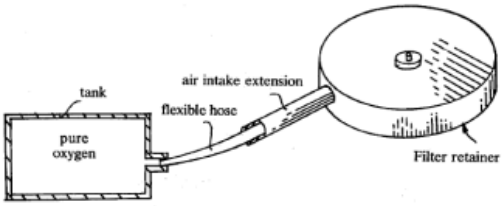

Fig. 1 Supply through tank method [2]

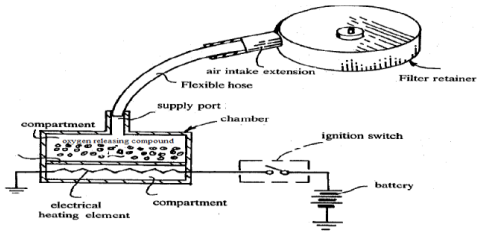

Fig. 2 Heating of compound method [2]

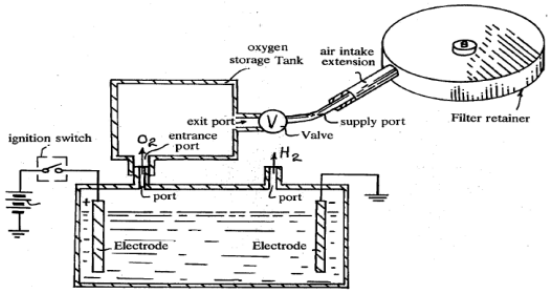

Fig.3 Water electrolysis method [2]

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 I.C. engine

Bharath P, Kamalakkannan K [4]: There are various ways of increasing efficiency of an internal combustion engine. Oxygen in the air helps in the combustion process. So by increasing concentration of oxygen with the help of external source to combustion chamber, we can increase the efficiency of an internal combustion engine. Various experiments were performed to increase the overall performance of compression ignition engines by. The concentration of oxygen was increased from 21% to27%. Further increase in the concentration of oxygen may result in high heat release. Therefore the concentration of oxygen should not be greater than 28%. Load test on C.I. engine was taken. Test was conducted on a single cylinder, naturally aspirated, air cooled, and constant speed Greaves engine. An eddy current Dynamometer was used 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 i.e when concentration of oxygen was 21% and at increased

concentration of oxygen i.e when the concentration of oxygen was increased from 21%to 27%.It was 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%.Reduction of BSFC by 11to 18% was also observed at higher percentage of oxygen for all load conditions. It was also observed that CO reduced by great extent at higher concentration of oxygen in the intake air.

B. Poola and Raj Sekar, Dennis N. Assanis, G. Richard Cataldi [5]: The experimental work was done to study the effects of oxygen enriched combution air on the 12 cylinder, GE 12-7FDL locomotive disel engines. Simulation test was carried out to study the effects of oxygen enriched combustion air on the overall performance and NOx emmisions of the locomotive disel engine. From the simulation test, it was observed that when the amount of oxygen in the intake air was increased to 28% the peak cylinder pressure increased by 4%. Due to increase in peak cylinder pressure,the net power of locomotive engine increased approximately by 13% with reduction in fuel injection timing by 4 degrees. Various experiments were done to investigate the net power of an engine at a perticular engine speed by varying throttle notches from 1 to 8. Performance parameters like BP, BSFC, BMEP and peak cylinder pressure were calculated at various concentrations of oxygen. It was observed that at notch 8 i.e at full load condition the cylinder break output and break mean effective pressure increased by 90% with reduction in break specific fuel consumption by 15% when the concentration of oxygen was increased from 21% to 35%. Fuel injection timing also decreased by 12 degrees by varying the amount of oxygen from 23% to 30% by volume.

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 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[8] shows that there is an opportunity to enhance engine performance with reduction in emmisions of the internal combustion engine by using oxygen enriched combustion.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.

Methodology:-

1. Oxygen Cylinder: The oxygen cylinder of 7 cubic meter capacity is used for the present work. Oxygen stored at the pressure of 150psi.
2. Distributor pipe: Distributor pipe is used to supply oxygen from oxygen cylinder to test rig air box.Proper precaution should be taken againest bending and heating

3. 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 0-10 litre/min.
4. Mixing chamber: The main purpose of mixing chamber is to mix oxygen into sucked air.
5. Engine: The three cylinder four stroke petrol engine test rig is used for experimental work. The oxygen from mixing chamber is then sending to suction of engine.

Experimental work:-

For performance analysis, various experiments are carried out on multicylinder spark ignition engine at different flow rate of oxygen in the intake air.

Table 1: Engine specifications

Engine type	Make Maruti, 3 cylinder,4 stroke, Petrol MPFI
Specifications	Power 27KW, Torque 59 NM,796cc ,CR 9.2
Dynamometer	Hydraulic type
Calorimeter type	Pipe in pipe
Rotameter	Engine cooling 100-1000 LPH; Calorimeter 25-250LPH
Overall dimensions	W 2000*D2750*H1750

To measure the tempreture of the exhaust, calorimeter is connected to the exhaust manifold. Concentration of the oxygen is increased by varying flow rate of oxygen from oxygen cylinder to the combustion chember.

Fig. 4 : S.I. Engine test rig with oxygen cylinder

Results and discussion:-

Oxygen enrichment results into proper combution of fuel which results into reduction in the ignition delay period.

Table 2: Performance parameters

Parameter	**Flow rate**			
	0 LPM	**3 LPM**	**6 LPM**	**9 LPM**
BP (KW)	1.4	2.0	2.8	2.5
BSFC (Kg/KW. hr)	0.807	0.427	0.299	0.28
Ƞm (%)	70.6	77.8	73.6	79.2
Ƞbth (%)	10.14	19.17	27.34	29.22

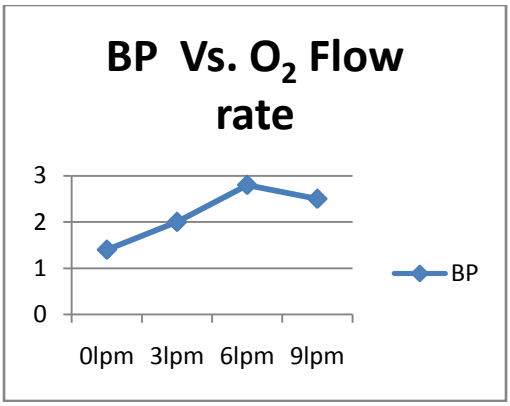

Fig. 5: Break power vs flow rate of oxygen

From fig 5, it is observed that break power increases with increase in flow rate of oxygen.Break power has highest value at 6lpm flow rate.

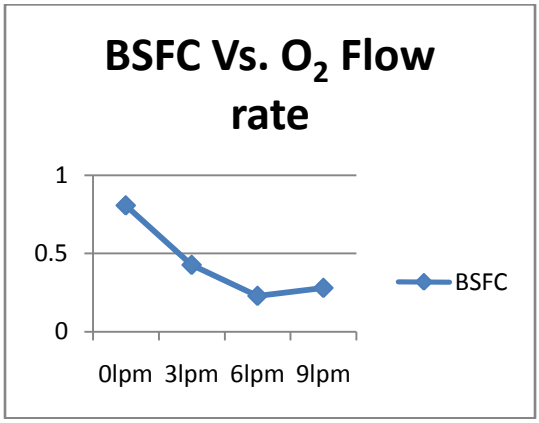

Fig 6: Break specific fuel consumption vs flow rate of oxygen in lpm

Fig 6 shows that Break specific fuel consumption decreases with increase in oxygen concentration. At 6lpm flow rate there is lowest fuel consumption.

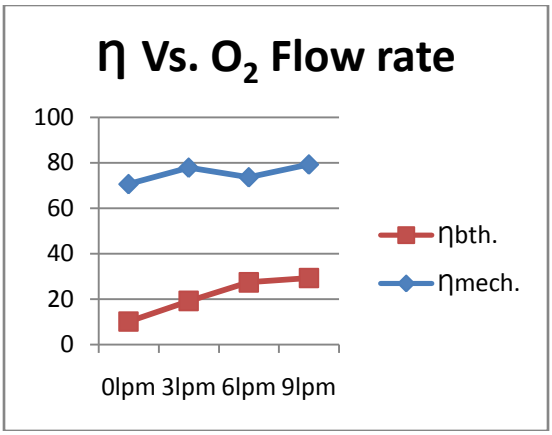

Fig.7: Efficiency vs flow rate of oxygen

Fig 7 shows the variation of efficiency at different oxygen flow rates. Both mechanical and break thermal efficiency increases with increase in oxygen flow rates.

Conclusion:-

- From above experimental investigation, it is concluded that oxygen enrichment is an effective method for improving performance of S.I. engine.
- With increase in oxygen concentration in the intake air break power, mechanical efficiency and break thermal efficiency incraeases.
- Fuel consumption also decreases with increase in oxygen flow rate.
- We got optimum results at 6lpm oxygen flow rate

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