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IMPACT OF OXYGEN ENHANCEMENT ON THE EXHAUST OFA SINGLE CYLINDER GASOLINE ENGINE

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ABSTRACT

The *objective of research is to determine efficiency of single cylinder petrol engine by introducing oxygen through air intake and preparing heat balance sheet. Presently setup having single cylinder petrol engine with rope brake dynamometer with spring mass measurement system .Whole setup is used to study the performance of engine by providing oxygen during combustion or enhancement of charge by oxygen. Because of which loss of heat through the exhaust gases will be reduced. It is observed that percentage increase of oxygen in intake air reduce exhaust emission and efficiency of engine increase satisfactorily.*

Keyword: *Heat balance sheet, Thermal efficiency, Exhaust emission, Rope brake Brake power, and Heat loss in cooling, exhaust SFC, bsfc, Oxygen enrichment, air intake etc.*

I. INTRODUCTION

To increase thermal efficiency and reduce fuel consumption is a big challenge in front of engine manufacturer. Fuel and air mixture should burn satisfactorily to reduce fuel consumption so that to active this, new technology has adopted by manufacturer. i.e. microprocessor controlled fuel system which provides the quantity of fuel according to the load and speed condition also lot of research work is going on to active less pollution.Presently petrol engine applications are too broad as compare to petrol engines. The use of oxygen at intake air is beneficial according to the consumption point view. In the experimental setup oxygen cylinder is used with flow meter and pressure gauge. The mixing of oxygen in the air is carried out before intake manifold in the mixing chamber.

II. EXPERIMENTAL SETUP

The variety of observations and reading are noted with different levels of oxygen enrichment and mathematical calculations are carried out for a proper heat balance sheet & other aspect like Brake power, sfc, Break mean effective pressure, Break thermal efficiency, Indicated thermal efficiency, Mechanical and Volumetric thermal efficiency are included in this study. The test engine used a single cylinder air cooled Honda GX160 petrol engine with rope brake dynamometer. The schematic diagram of engine Experimental setup is shown in the figure.1 and technical specification engine also given below

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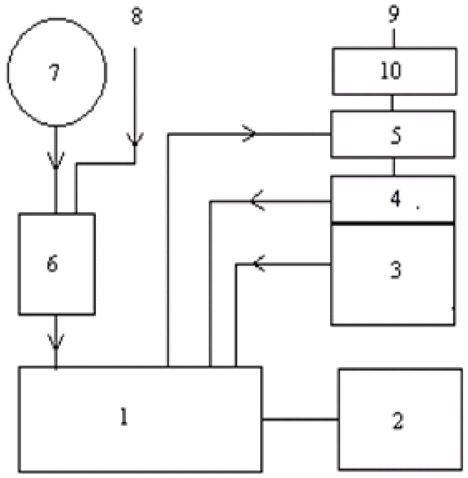
Make	Honda GX160
Type	Air cooled 4 stroke
Bore	68
Stroke	45
Displacement	$163cm^3$
Net power output	4.8 HP
Speed (rpm)	3600
NET Torque	10.3N-m
Compression ratio	9:1
Carburetor	Butterfly
Ignition system	Transistorized magneto
Lubrication system	Splash
Oil capacity	0.58L
Fuel tank capacity	3.1 lit
Fuel	Unleaded 86 octane or higher
Dry weight	15.1 kg

Table 1: Engine specification



(1) Engine (2) Eddy current dynamometer (3) Computer with data acquition system (4) Fuel tank (5) Calorimeter (6) Mixing chamber (7) Oxygen cylinder with flow meter (8) Atmospheric air (9) Exhaust gas to the atmosphere (10) Multi gas analyzer

Fig. 1: Experimental Setup

III. MEASUREMENT OF AIR CONSUMPTION

The method commonly used in laboratory for measuring combustion of air, it consist of an air tight chamber fitted with sharp edged orifice. The orifice located away from the suction connection to engine. Due to suction of engine there is pressure difference in cubical air box which cause the flow through orifice. The volume of chamber should be large as compare to swept volume of cylinder. It is assumed that the intermittent suction of the engine will not affect the air pressure in the air box. As the volume of the box is sufficiently large and pressure in box remain constant. Fuel delivery system: The Fuel from the tank is connected to a solenoid valve. The outlet of the solenoid valve is connected to a glass burette and the same is connected to the engine through a manual ball valve. The fuel solenoid of the tank will remain open until the burette is filled to the high level sensor, during this time the fuel is flowing to the engine directly from fuel tank and also fills the burette.

Once after sensing the top level, the fuel solenoid closes fuel tank outlet line, now the fuel in the burette gets discharge to the engine. When the fuel level reaches the high level optical slot sensor, the sequence running in the computer records the time of this event. Likewise when the fuel crosses the low level optical slot sensor, the sequence running in the computer records the time of this event. And immediately the fuel solenoid opens filling up the burette and the cycle is repeated. Here the injection is direct with multi-hole nozzle. Crank angle and method of loading: A 11 bit 2050 step crank angle encoder was mounted on the camshaft to measure engine crank angle. The engine was instrumented with the piezoelectric transducer to measure the combustion process.

The pressure transducer is connected to the battery powered signal conditioner via an inline charge amplifier/converter. The charge amplifier converts the low level charge to a high level voltage output, which again conditioned in the signal conditioner and fed to the data acquisition card as a differential connection.

The engine and the air cooled eddy current dynamometer are coupled using a tire coupling, the output shaft of the Eddy current dynamometer is fixed to a strain gauge type load cell for measuring applied load to the engine. The engine is loaded using the potentiometer provided on the panel. Data acquisition is the sampling of the real world to generate data that can be manipulated by the computer, typically involves acquisition of signals and waveforms and processing the signals to obtain desired information. The components of data acquisition systems include appropriate sensors that convert any instrument parameter to an electrical signal, which is acquired by data acquisition hardware. Acquired data is displaced, analyzed and stored in computer. Data acquisition begins with physical phenomenon or physical property of an object to be measured. This property may be the temperature or temperature change of a room, the intensity or intensity change of a light source, the pressure inside a chamber, the force applied to an object or many other things. An effective data acquisition system can measure all of these different properties or phenomena. For intake air low levels of oxygen enrichment were used, it did not exceed 4 LPM of the intake air in order to protect the engine. Higher oxygen enrichment levels need special engine modifications because of the expected higher output temperature which is expected to be produced. The intake air oxygen concentration was increased by injecting pure oxygen from a cylinder to the mixing chamber. To ensure effective oxygen enrichment, the pure oxygen was injected directly through mixing chamber in its inlet and the intake air oxygen concentration was measured properly using gas flow meter. Oxygen supply system: For the purpose of tests reported here compressed oxygen stored in the cylinder was used. The oxygen and the atmospheric air were mixed in the mixing chamber provided before entering to the intake manifold of the engine. A separate oxygen sensor located in the engine intake manifold was used to measure the intake oxygen content of the system. The amount of oxygen supplied from the cylinder varies from 1 Liters per Minute (LPM) to 4 L min^{-1}.

3.1 Combustion Vs O2 Combustion

Combustion in petrol engines is more complex and its detailed mechanisms are not well understood. Its complexity seems to challenge researchers attempts to release its many secrets despite the availability of modern tools such as high speed photography used in “transparent” engines, computational power of contemporary computers and the many mathematical models designed to take off combustion in petrol engines. The addition of oxygenated fuel can result in a sizable decrease of particulate matter in the exhaust gases. Oxygen enhanced combustion has become one of the most attracting combustion technologies in the last decades, two developments have increased the significance of it, the first one is new technology of producing oxygen less expensively and the second one is the increased importance of environmental regulations. Oxygen enriched combustion is a proven method to increase available heat value or to reduce fuel consumption. If more oxygen is fed in to the combustion chamber in any engine, then more combustion will be happened and bad emission become less because they will be oxidizes. In the oxygen enriched combustion the fuel/air mixture ignites and burns in a faster rate resulting in high energy release rates.

IV. RESULTS AND DISCUSSION

Carbon monoxide: CO is generally produced due to in complete combustion of a carbon containing fuel. Generally a combustion system operated with high excess air leads to complete combustion and to minimize CO emissions compared with conventional system due to more complete combustion.When using high levels of oxygen enrichment causes thermal dissociation where CO is converted to CO2 at high temperatures. Effect of Ethanol Addition in the Combustion Process leads to a decrease of power and exhaust gas emissions due to oxygen presence in the fuel .With Oxygen enriched combustion, the engine-out hydrocarbon, CO and smoke emissions throughout the whole start-up process were all reduced considerably .Experimental studies of oxygen enriched combustion Leads to drastic decrease of soot emission as well as reduction of CO and HC without affecting BSFC. The benefit of the OEA has shown to decrease emissions of carbon monoxide (CO). From the Table 2 it was very clear that role of Oxygen enrichment plays an important role in decreasing CO emissions. From the Fig. 2 one can observe that oxygen enriched combustion produces good results with lower levels of oxygen enrichment. An average decrease of 25-45% decrease in CO emission was observed with the enrichment level of 1 LPM. A maximum of 61% reduction and 66% reduction in CO was obtained for the enrichment level of 2LPM and 3LPM respectively. It has been concluded that OEC plays a greater role in decreasing the CO emission for lower levels of oxygen enrichment with average load.

CO_2: The CO_2 emissions increased with load for all the fuel modes. Higher percentage of CO_2 in the exhaust indicated higher oxidation of fuel at the constant engine speed and release of more heat for power conversion. It also indicated better combustion as more fuel was converted from CO-CO_2.

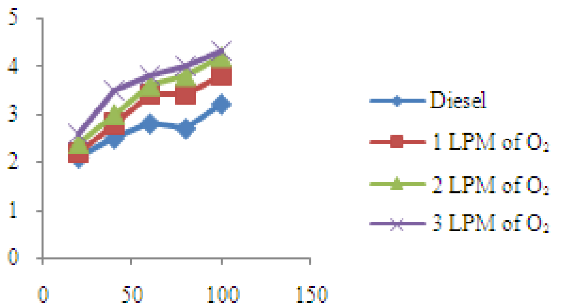


Fig. 2: Variation of CO with % load for varies levels for varies levels of oxygen enrichment

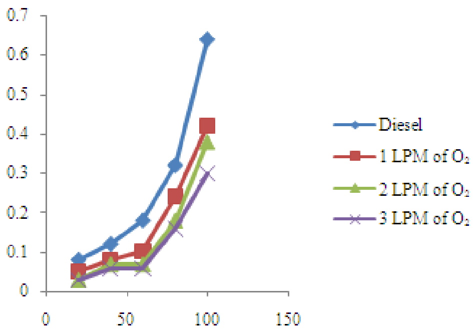


Fig. 3: Variation of CO2 with % load of oxygen enrichment

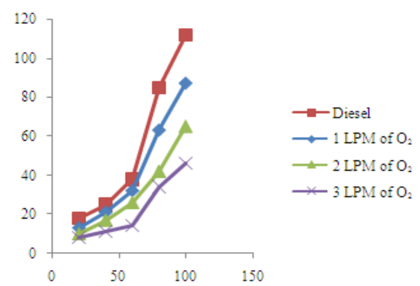


Fig. 4: Variation of NOx with % load for varies levels varies levels of of oxygen enrichment

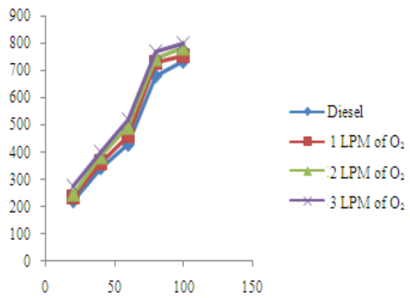


Fig. 5: Variation of HC with % load for of oxygen enrichment

Table 2: Load Vs CO for varies levels of oxygen enrichment enrichment

Load (%)2	Petrol	1 LPM of O_2	2 LPM of O_2	3 LPM of O_2
20	2.1	2.2	2.4	2.6
40	2.5	2.8	3.0	3.5
60	2.8	3.4	3.6	3.8
80	2.7	3.4	3.8	4.0
100	3.2	3.7	4.2	4.3

Table 3: Load Vs CO 2 for varies levels of oxygen

Load (%)3	petrol	1 LPM of O2	2 LPM of O2	3 LPM of O2
20	0.08	0.05	0.03	0.03
40	0.12	0.08	0.07	0.06
60	0.18	0.1	0.07	0.06
80	0.32	0.24	0.18	0.16
100	0.64	0.42	0.38	0.3

Table 4: Load Vs NOx for varies levels of oxygen enrichment enrichment

Load (%)4	**Petrol**	**1 LPM of O2**	**2 LPM of O2**	**3 LPM of O2**
20	220	235	246	278
40	342	362	384	402
60	428	460	492	520
80	680	730	742	780
100	734	754	782	804

Table 5: Load Vs HC for varies levels of oxygen

Load (%)5	**petrol**	**1 LPM of O2**	**2 LPM of O2**	**3 LPM of O2**
20	18	13	10	8
40	25	21	17	11
60	38	32	26	14
80	85	63	42	34
100	112	87	65	46

An average of 5-21% increase in CO_2 was obtained for the enrichment level of 1LPM. A maximum of 29% increase and 33% increase in CO_2 was obtained for enrichment level of 2LPM and 3LPM respectively. When comparing with percentage reduction of CO, the increase in CO_2 percentage was less. It was concluded that oxygen enriched combustion increases CO_2 emissions slightly. But this problem can be managed with exhaust gas recirculation. Moreover increase in CO_2 emissions indicates better combustion since more fuel was converted from CO-CO_2

NOx emissions: There are three accepted mechanism for NOx production (i) Thermal NOx is produced by the high temperature reaction of nitrogen with oxygen.(N_2+O_2= NO, NO_2). Prompt NOx is formed by the relatively a reaction between nitrogen, oxygen and hydrocarbon radicals (CH_4+ O_2+N_2= NO, NO_2, CO_2, H_2O). Prompt NOx is generally an important Mechanism at lower-temperature processes. Fuel NOx is formed by the direct oxidation of nitrogen compounds contained in the fuel (RxN+O_2=NO, NO_2, CO_2, H2O). Higher post-flame temperature and oxygen concentrations during the combustion process result in high No formation rate. Oxygen enriched combustion yields higher NOx Emissions. NOx increases exponentially with increasing oxygen concentration. Form the Table 4 and Fig. 4 it was very clear that NOx emissions increases with load for all levels of oxygen enrichment. An average of 7% increase in NOx was observed for the enrichment level of 1LPM. Similarly a maximum of 14 and 18% increase was obtained for the enrichment levels of 2 LPM and 3LPM respectively. As a conclusion oxygen enrichment in petrol engine increases NOx emissions, but this

Problem can be solved by Exhaust gas recirculation and lower levels of oxygen enrichment Injection Timings can be retarded to reduce NOx emissions without increasing the specific fuel consumption.

HC emissions: By applying OECT Hydrocarbon emissions were reduced substantially. Oxygen content in the fuel is main reason for better combustion and HC emissions. From Fig. 5 the results HC emissions were reduced significantly at medium load and lower levels of oxygen enrichment considerably at full load of the engine for higher levels of oxygen enrichment. From the Table 5 a maximum of 50 and 65% reduction in the HC was observed for the enrichment level of 2LPM and 3LPM respectively. An average of 23% reduction in HC was obtained for the enrichment level of 1LPM.

V. CONCLUSION

Based on the experimental results the following conclusions are drawn.

1) Oxygen enriched combustion causes significant reduction in CO emissions.

2) Oxygen enriched combustion technology leads to slight increase in CO2 and NOx but this problem can be solved with Exhaust gas recirculation.

3) Oxygen enriched combustion reduces HC Emissions considerably.

As conclusion Oxygen enriched combustion can be consider as a method for reducing exhaust emissions.

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