Effect of hydrogen and oxygen addition as a lean mixture on emissions and performance characteristics of a two wheeler gasoline engine

[1]Hardik Bambhania, [2]Vijay Pithiya, [3]Rajendrakumar Jani
[12] ME Student, [3]Associate Professor
[123]Mechanical Engineering Department
[123]L.D.College of Engineering, Ahmedabad, India

***Abstract* - An internal combustion (IC) engine has a predominant role in a low power generation and a virtual monopoly in mobile applications today. One of the best methods to improve the engine performance and reduce the exhaust emission in a SI engine is by using introduction of twin spark into the combustion chamber. In Present work DTS-i engine is operated with single spark and dual spark mode at 2000rpm and 3000rpm 0, 20%, 40%, 60% and 80% loading condition. Hydrogen and oxygen mixture were introduce into the intake of carburetor. Results shows that brake thermal efficiency for dual spark mode is higher as compared to single spark. Also there has been decrease in CO and NOx emission. But there is increase in HC emission.**

***Index Terms* – Spark Ignition Engine, DTS-i.**

I. Introduction

In recent years, the world has been confronted with an energy crisis due to depletion of resources and increased environmental problems. The widespread use of fossil fuels within the current energy infrastructure is considered as the largest source of anthropogenic emissions of carbon dioxide, which is largely blamed for global warming and climate change In addition to declining crude oil supplies and political instability in the regions with large oil reserves, strict emission regulations are creating a need for alternative fuels. An alternative fuel must be technically feasible, economically competitive, environmentally acceptable, and readily available. Numerous potential alternative fuels have been proposed, including biodiesel, methanol, ethanol, hydrogen, boron, natural gas, liquefied petroleum gas (LPG), Fischer–Tropsch fuel, p-series, electricity, and solar fuels.

One of these alternative fuels, hydrogen, has the highest specific energy content of all conventional fuels and is the most abundant element in the universe. Hydrogen will be a key contribution to sustainable development, because in the future it may be produced in virtually unlimited quantities using renewable energy sources (RES).

II. Experimental setup and test procedure

The four-stroke digital twins spark ignition engine used in this study has a displacement of 150cc and a compression ratio of 9.5:1. It is a single cylinder, naturally aspirated, forced air cooled with a bowl in piston combustion chamber and equipped with a single overhead camshaft (SOHC). The detail specifications of the engine are listed in Table 1.

Table 1 Specification of DTS-i Engine

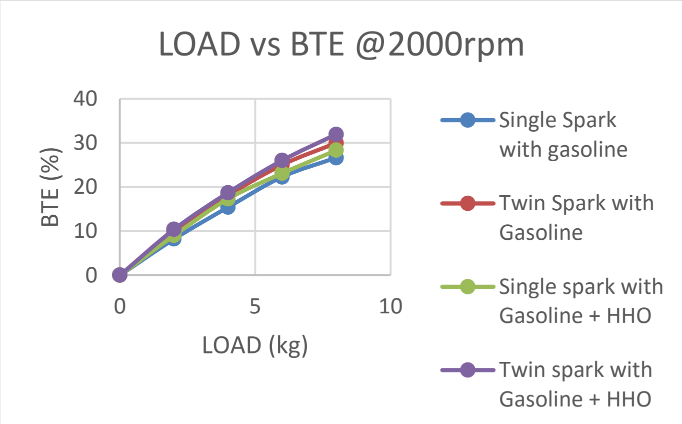
Engine Type	4-Stroke Single Cylinder Air-Cooled
Engine Displacement(cc)	134.21 cc
Compression Ratio	9.5:1
Maximum Power	9.64kw (13.10 ps) @ 8500rpm
Maximum Torque	11.88 nm @ 6500 rpm
Cylinder Bore	67 mm
Stoke	56.4 mm

Ignition	Microprocessor Controlled Digital CDI

The test was carried out on an Engine and torque is measure with the help of Rope Brake dynamometer. The engine crank-shaft is coupled with pulley by universal joint in the shaft for reducing shocks, vibration and prevents failure of shaft. Pulley is attached with the spring balance with the help of leather belt.
The fuel to the engine is supplied by a fuel tank through a burette having capacity of 50 CC by means of which the fuel consumption could be measured with a stopwatch. To avoid cyclic variation average data is considered
Exhaust gas temperature is measured by K Type Thermocouple which is indicated in K Type Temperature Indicator. Speed is measured by using tachometer.
Exhaust gas analyzer is used to measure the level of pollutants in the exhaust of the engine. The instrument is used for measuring HC (ppm), CO (% by vol.), CO2 (%by vol.), NOx and O2 (% by vol.). Probe of it was fitted in the engine exhaust pipe.
The performance parameters like brake power, break thermal efficiency, brake specific fuel and volumetric efficiency conservation were calculated from measured data. Emission analysis was carried for exhaust gas emissions.
The experiments were conducted at 2000 and 3000 rpm. The original spark plug 'A' was made to ignite at its standard ignition timing.
The test was conducted separately in single plug and dual plug mode of operation with pure gasoline as fuel at different load conditions. The different load conditions were 0%, 20%, 40%, 60% and 80% of the load capacity of the engine at 2000 and 3000 rpm. The schematic diagram of the engine test set up is shown in Fig 2.1
Same procedure was repeated for hydrogen and oxygen mixture.

III. Result and Discussion

Results obtained from the experiments conducted with single and dual spark plugs at different loading conditions with constant rpm using pure gasoline under lean mixture are presented in Figures 2 to 12. All the results have been taken as per IS Standard and corrected to the atmospheric condition by multiplying with the correction factor.



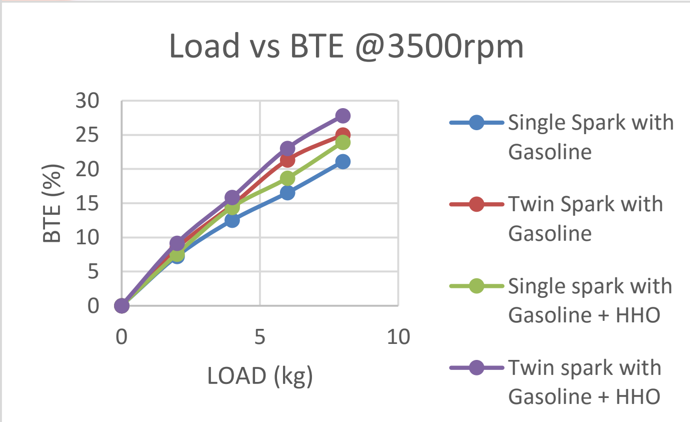


Figure 1 Load vs Brake Thermal Efficiency at 2000rpm

Figure 2 Load vs Brake Thermal Efficiency at 3500rpm

Brake Thermal Efficiency v/s Load

Fig. 1 and Fig. 2 shows variation of brake thermal efficiency with load for constant rpm at 2000 and 3500rpm for Gasoline only and Gasoline plus HHO. .It is clear from graph that efficiency of dual spark is higher in all condition. Variation become more pronounced as load increases. Also it has been found out that as rpm increases from 2000 to 3500 the efficiency decreases. There is maximum upto 12.24% at increase in brake thermal efficiency at 60%load, 2000rpm and upto 11.36% at 80%load 3500rpm using SI engine in dual spark mode, this is due to dual spark gives faster and more complete burning. It is clear from graph that when hydrogen oxygen mixture is introduced with gasoline it gives better performance at all load condition. Brake thermal efficiency of Gasoline plus HHO is more than Gasoline only for single spark and also for dual spark. Also efficiency at 2000 rpm is higher than that of 3500 rpm efficiency.

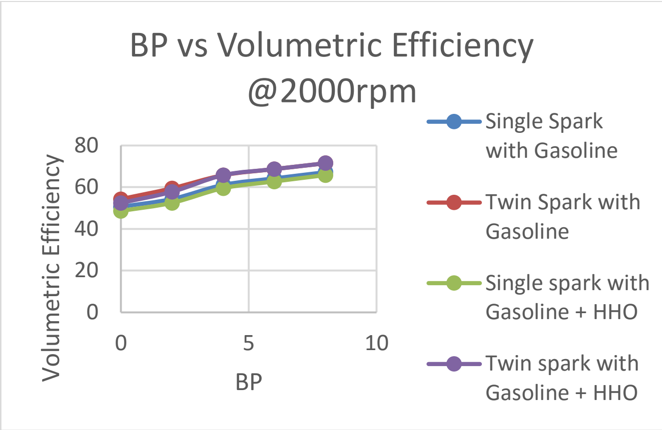


Figure 3 BP vs Volumetric Efficiency at 2000 rpm

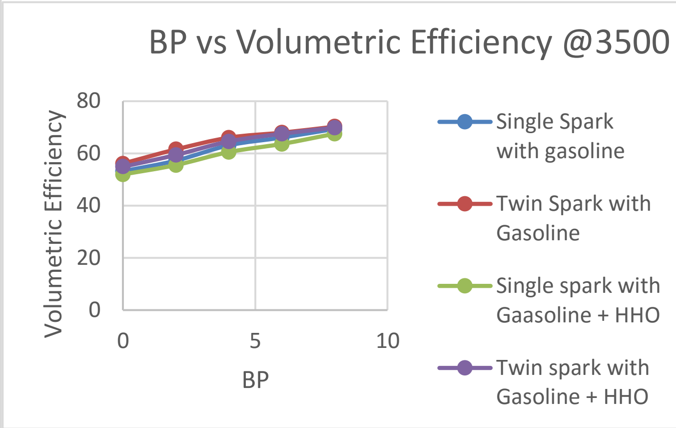


Figure 4 BP vs volumetric efficiency at 3500 rpm

Brake Power vs Volumetric Efficiency

Fig. 3 and Fig. 4 shows variation of brake power vs volumetric efficiency at 2000rpm and 3500rpm.comperision is done for Gasoline and Gasoline plus HHO for Single spark and dual spark. Results show that volumetric efficiency increases with increasing in load. Dual spark exhibits higher volumetric efficiency under all condition. This is due to dual spark enable complete combustion and hence more amount of air utilize in combustion chamber. It has been found out that upto 3.77% increase at 2000rpm and 4.62% increase at 3500rpm. With increase in load the rate of increase in volumetric efficiency becomes slower. Volumetric efficiency of Gasoline plus HHO is lower than Gasoline only specially at lower load. As rpm increase the volumetric efficiency under same load has been decreases because higher speed of valve.

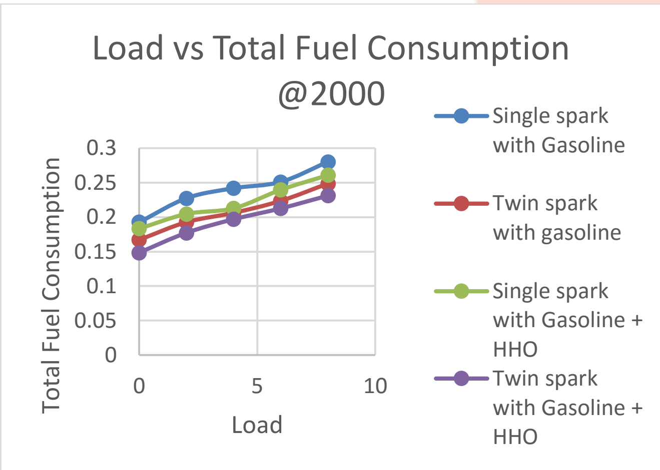


Fig. 5 Load vs Total fuel Consumption at 2000 rpm

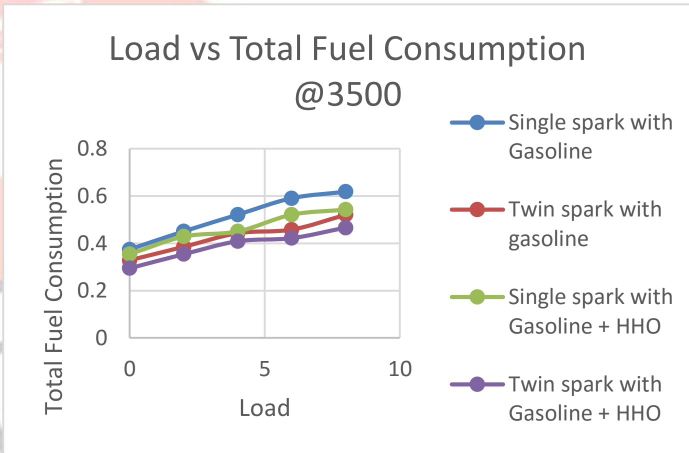


Fig. 6 Load vs total fuel consumption at 3500 rpm

Fig. 5 and Fig. 6 shows variation of brake power vs total fuel consumption at 2000rpm and 3500rpm. Initially at low load total fuel consumption is low but as load increases at constant rpm total fuel consumption increase in order to produce more power. Results obtain states that for all condition dual spark have lower total fuel consumption. Twin spark with gasoline plus HHO has lowest total fuel consumption. At lower load single spark has high total fuel consumption but it slightly decrease with increase in load.

Brake Power vs CO

Figure 7 shows brake power vs CO emission ratio at 2000rpm There is not much difference in CO emission, but comparatively dual spark has lower CO emission till 60% loading condition and at 80% load single spark and dual spark exhibit same CO emission. At lower CO emission is low because of lower amount of fuel burning it increase with load because more fuel is burned. Great reduction in CO emission is observed when HHO is introduced. Twin spark engine has lower emission than the single spark at all condition.

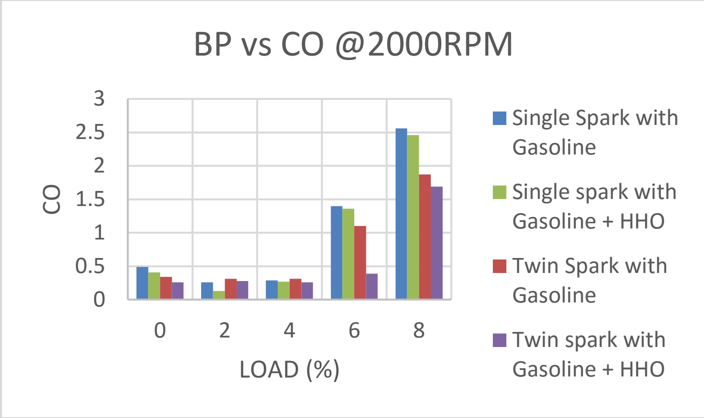


Figure 7 Brake Power vs CO

Brake Power vs HC

Figure 8 shows brake power vs HC emission at 2000rpm for single spark and dual spark for gasoline and gasoline plus HHO. Here as graph indicates for dual spark the HC emission is higher than single spark. This is because the exhaust gas temperature for dual spark condition is more this enhances more HC emission. HHO have higher HC emission for both single spark as well as dual spark engine. Another conclusion can be drawn out that at 80% load there is sudden increase in HC emission.

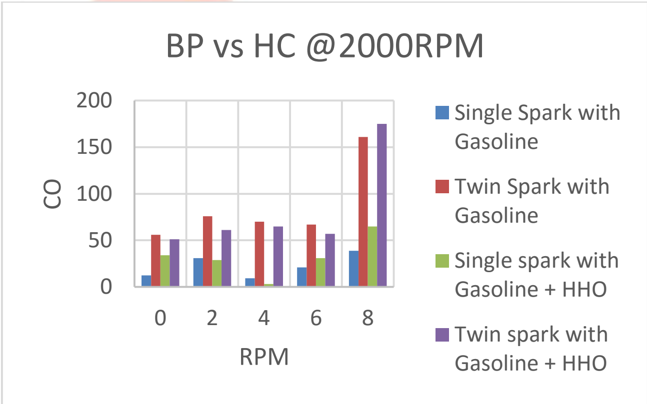


Figure 8 Brake Power vs HC

Brake Power vs NOx

Figure 9 shows brake power vs NOx emission at 2000rpm. As load increases the curve stars linearly but at 80% load a sudden decrease has been found out. Dual spark has low NOx emission as compared to single spark HHO engine higher NOx emission than Gasoline.

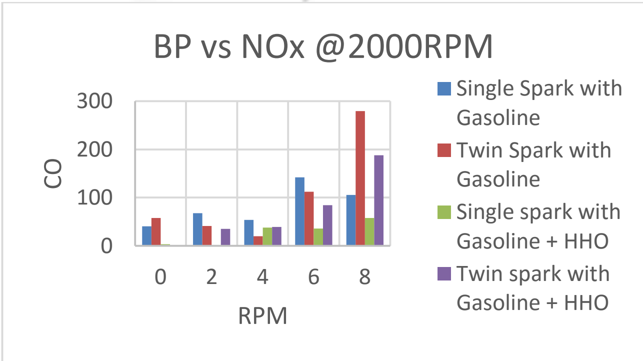


Figure 9 Brake Power vs NOx

IV. CONCLUSION

From the above discussion dual spark has higher brake thermal efficiency as compared to single spark. Maximum upto 12.24% at increase in brake thermal efficiency at 60%load, 2000rpm and upto 11.36% at 80%load 3500rpm using SI engine in dual spark mode Dual spark have lower brake specific fuel consumption. At 20% load with 2000rpm 14.89% and 14.08% at 3500rpm decrease in brake specific fuel consumption has found operated at single spark and dual spark. Volumetric efficiency increases with increasing in load. Dual spark exhibits higher volumetric efficiency under all condition. Volumetric Efficiency increases upto 3.77% increase at 2000rpm and 4.62% at 3500rpm. There is decrease in CO and NOx emission for dual spark. But there in increase in HC emission for dual spark as compared to single spark. This is because with dual spark operation the exhaust gas temperature is higher.

REFERENCES

PAPER

[1] CPBC, 2015, Status of Pollution Generated from Road Transport in Six Mega Cities, CENTRAL POLLUTION CONTROL BOARD, March 2015, Available at http://cpcb.nic.in/upload/NewItems/NewItem_215_Report_Status_RoadTransport_SixCities.pdf

[2] M. BALAT, Hydrogen in Fuelled Systems and the Significance of Hydrogen in Vehicular Transportation, Energy Sources, Part B, 2:49–61, 2007

[3] AYHAN DEMIRBAS,Hydrogen and Boron as Recent Alternative Motor Fuels,Energy Sources, 27:741–748, 2005

[4] Mingyong Wang, Zhi Wang, Xuzhong Gong, Zhancheng Guo, “The intensification technologies to water electrolysis for hydrogen production – A review”, Renewable and Sustainable Energy Reviews 29 :573–588, 2014

[5] Romdhane Ben Slama, “Hydrogen Production by Water Electrolysis Effects of the Electrodes Materials Nature on the Solar Water Electrolysis Performances” Natural Resources, : 4, 1-7, 2013

[6] N. Nagai,M. Takeuchi, T. Kimur, T. Oka, “Existence of optimum space between electrodes on hydrogen production by water electrolysis” International Journal of Hydrogen Energy 28, 35 – 41, 2003

[7] Erol Kahraman, S. Cihangir Ozcanli, Baris Ozerdem,” An experimental study on performance and emission characteristics of a hydrogen fuelled spark ignition engine” International Journal of Hydrogen Energy 32, 2066 – 2072, 2007.

[8] H. Fayaz, R.Saidur, N.Razali, F.S.Anuar, A.R.Saleman, M.R.Islam “An overview of hydrogen as a vehicle fuel” Renewable and Sustainable Energy Reviews 16 : 5511–5528, 2012

[9] Maher A.R. Sadiq Al-Baghdadi “ Effect of compression ratio, equivalence ratio and engine speed on the performance and emission characteristics of a spark ignition engine using hydrogen as a fuel” Renewable Energy 29, 2245–2260, 2004

[10] T. D.Andreaa, P.F. Henshawa, D.S-K. Ting, The addition of hydrogen to a gasoline-fuelled SI engine, International Journal of Hydrogen Energy 29, 1541 – 1552, 2004