Performance and emission analysis of four stroke twin spark single cylinder SI engine fuelled with gasoline and CNG

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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. The main purpose of this study is to investigate the effects of twin spark using CNG fuel in SI engine. The performance and emission analysis of an engine are investigated by experiment with CNG kit and gas analyzer. From this study the fuel consumption is reduce in twin spark arrangement for the same power output as compare to single spark using both of the fuel gasoline as well as CNG. Engine emission is considerably reduced using twin spark plug.

Keywords: SI Engine, DTS-i engine, CNG fuel, Performance, Emission

I. INTRODUCTION

Gasoline engine is used for automotive application. The automobile plays an important role in the transportation system in India. With increase in population and living standard, the vehicles as well as pollution is increasing day by day. Among all of this, there is steep increase in the number of two wheelers during the last ten years. All these are increasing exhaust pollution. In recent years number of CNG run vehicle is increases day by day because of less emission and economical. The main problem associated with CNG run vehicle is safety.

Number of research papers and studies has been conducted on the use of CNG and effect of Engine emission and Performance in DTS-I engine**.** Effect of parameters like fuel consumption, emissions, torque, load capacity etc has been analyzed. Number of reviews has been taken below to complete the present study.

E. Ramjee and K. Vijaya Kumar Reddy in this paper , Compressed Natural Gas (CNG) has been introduced in the 4-stroke air cooled Bajaj- Kawasaki engine and investigation have been carried out pertaining to engine performance and exhaust emissions. The emission characteristics of HC and CO are better for CNG compared to petrol. For all range of speed the volumetric efficiency is reduced to 10-14%; except thermal efficiency the performance parameters viz. BMEP, Torque, Power, and BSFC are decreased for CNG fuelled engine.

Ismail Altın a, Atilla Bilgin b in this paper the performance parameters of twin spark SI engine has been studied. From the result of the study it was found that centre twin spark plug arrangement is favorable to single – spark plug configuration. This is a result of faster burning and lower heat losses achieved by twin spark engines in comparison to single-spark engines.

Nicolas Hadjiconstantinou, Kyoungdoug Min and John B. Heywood In this Paper, Relation between flame propagation characteristics and hydrocarbon emissions under lean operating condition in SI engines has been studied. Engine HC-emission levels increase when the relative air to fuel ratio from stoichiometry because of decreasing HC oxidation. This is attributed to decreasing flame speeds that result in lower peak cycle pressures and temperature and, eventually flame quenching.

Dashti Mehrnoosh1, Hamidi Ali Asghar2 and Mozafari Ali Asghar3, In this paper a thermodynamic cycle simulation of conventional four- stroke SI engine has been carried out to predict the engine performance and emissions. The first law of thermodynamics has been applied to determine in-cylinder pressure and temperature as a function of crank angle.

Effect of spark timing in the SI engine, if ignition occurs too early, work will be wasted in the compression stroke. On the other hand, if ignition is too late, the indicated power is lower due to lower peak pressure of the combustion. Therefore, there is an optimum spark timing at which the maximum torque is obtained. This timing is called MBT. It is clear that the indicated power is maximum at 20 bTDC for gasoline and 26 bTDC for CNG operations.
Omid Asgari1, Siamak Kazemzadeh Hannani1 and Reza Ebrahimi2 in this paper the experimental and theoretical results for a spark ignition engine working with compressed natural gas as a fuel.The theoretical part of this work uses a zero-dimensional, multi-zone combustion model in order to predict nitric oxide (NO) emission in a spark ignition (SI) engine.

Ramtilak, A., Joseph, A., Sivakumar, G., and Bhat, S., "Digital Twin Spark Ignition for Improved Fuel Economy and Emissions on Four Stroke Engines,". In this paper the

DTS-i concept allows the compression ratio of the engine to be increased from 9.65 to 9.8 At part load conditions the DTS-i technology allows the engine to run leaner at a lambda of 1.2 with excellent stability. On a bore size of 57 mm (150 DTS-i) the maximum flame travel length was reduced by 18 %. The power, torque and specific output per liter were increased, while the fuel consumption

and emissions were reduced due to the rapid combustion brought about by the twin spark plugs.
DTS-i Technology
DTS-I Engine

A. Introduction

Now a day's twin spark plug are fitted in the cylinder head for better combustion, high heat release rate and maximum peak pressure for same mass fraction of fuel as compare to conventional single spark plug engine.

Twin Spark Benefits

In case of twin spark, two spark-plugs fire at the same time. These are simultaneous firing and swirl of the air-fuel mixture results in complete combustion. This action is digitally controlled by the DTS-I System (namely the twin spark plugs, TRICS III and intelligent CDI).

B. Triic-iii

Power and torque requirements constantly change, depending on whether the rider is cruising, accelerating or is at high speeds/max speed. Throttle Responsive Ignition Control System - III is an intelligent system which can quickly adapt ignition timing to suit different riding characteristics.

C. Intelligent CDI

The Intelligent Capacitor Discharge Ignition contains a microprocessor, which continuously senses different speeds and load on engine and responds by altering ignition timing. Working together with the TRICSIII system, the microprocessor's memory provides optimum ignition timings for any given engine rpm, thereby obtaining the best combustion performance.

As CNG has lean combustion effect on the SI engine ignition system has to be modified for the batter performance and to optimize the power loss and drivability problems are reduced by conversions. The Performance of an existing single spark engine has been improved by DTS-I CNG engine

II. EXPERIMENTAL SETUP

The experiments were carried out at constant speed of 3200 rpm and different load conditions to measure performance and emissions of the engine. Various components used in the test facility are: Single Cylinder twin spark ignition Petrol Engine, Rope Brake Dynamometer, Exhaust Gas Analyzer, Fuel Consumption Device, Radiation Pyrometer, Digital Tachometer, CNG conversion kit, CNG Gas Cylinder. The engine Specifications are listed in Table 1.
The tests have been carried out for both CNG and Petrol fuels and for single as well as twin spark ignition For CNG conditions the engine were fitted with CNG Kit.

Maker's Name	Bajaj Auto Limited
Model Name	Bajaj pulsar 150 DTS-i
Type of Engine	Four Stroke Single Cylinder, Air Cooled Engine
Bore	57 mm
Displacement Volume	149.01 cc.
Compression Ratio	9.5 : 1
Maximum power	13.55bhp @ 9000rpm
Maximum Torque	11.25 Nm @ 6500rpm
Carburetor	Ukal Mikuni
Ignition system	Electronic CDI system
Idle Speed	1300 rpm
Lubricating Oil	SAE 20W40

Table (1): Engine Specifications

The following parameters were found for each practical: Brake Specific Fuel Consumption, Brake Thermal Efficiency Exhaust Gas Temperature, Volumetric Efficiency and emission of HC and CO in Exhaust.

III. RESULTS AND DISCUSSION

All the tests with both fuel gasoline and CNG were conducted for constant engine speed of 3200 rpm with varying load on engine. Load is applied by Rope brake dynamometer. First take various observations on Single spark engine by removing second spark plug wire from DTS-I engine and then later on double spark plug Engine. For measurement of fuel consumption time for 10 cc fuel was observed. For measurement of CNG consumption weighing scale method is used. For measurement of air deflection of water level in the U-tube manometer were observed. Exhaust gas temperature is measured with the help of Radiation Pyrometer.

1) Fig.1 and 2 shows the variation of brake specific fuel consumption (BSFC) for single spark plug petrol and single spark plug CNG is higher than Twin spark Petrol as well as twin spark plug CNG with increase in load.
2) Fig. 3 and 4shows the variation of brake thermal efficiency (BTE) with brake power for Single spark plug and twin spark plug for petrol and CNG fuel respectively. The brake thermal efficiency increased with increasing load on the engine, In twin spark plug arrangement it gives good results of brake thermal efficiency at full load condition in both of the fuel petro as well as CNG.
3) Fig.5 and 6 shows the variation of exhaust gas temperatures for single and twin spark arrangement of an engine with fuel as petrol and CNG respectively. The exhaust gas temperature increased with increase in load because more fuel was burnt to meet the power requirement. In twin Spark plug arrangement we can see that exhaust gas temperature is high as compare to single spark plug arrangement in both of the fuel petrol as well as CNG. In twin spark plug engine there is complete combustion of fuel takes place so temp of exhaust gas is higher
4) Fig. 7 and 8 shows the variation of volumetric efficiency for single and twin spark arrangement of an engine with fuel as Petrol and CNG respectively.. In twin spark arrangement the volumetric efficiency is higher because of complete combustion takes place

inside combustion chamber and more amount of air is utilize as compare to single spark engine.

5) Fig 9 and 10 shows the variation of CO emission for single spark and twin spark ignition with fuel as petrol and CNG respectively. The carbon monoxide emission of single spark plug is higher as compared to twin spark arrangement. The carbon monoxide emission is reduced significantly in twin spark CNG as compare to single spark CNG.
6) Fig. 11 and 12 shows the variation of hydrocarbon emissions with brake power in single spark and twin spark plug for fuel as petrol and CNG respectively.

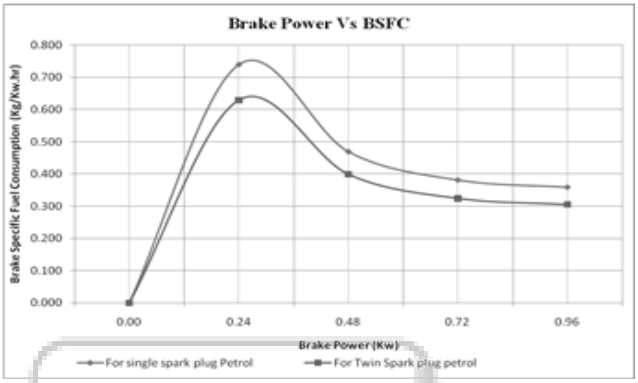

Fig. 1: Variation of BSFC with Brake Power in twin spark petrol

In CNG twin spark plug arrangement the HC emission is considerably reduce as compare to single spark CNG

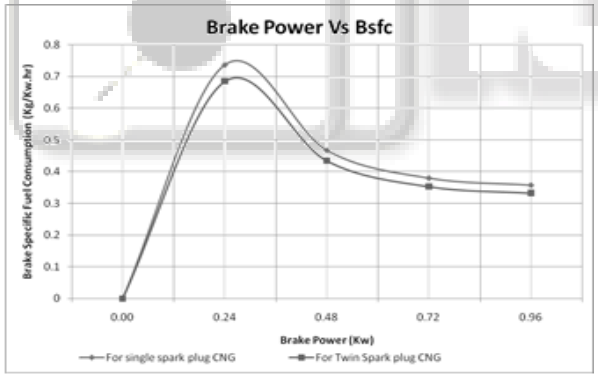

Fig. 2: Variation of BSFC with Brake Power in twin spark CNG

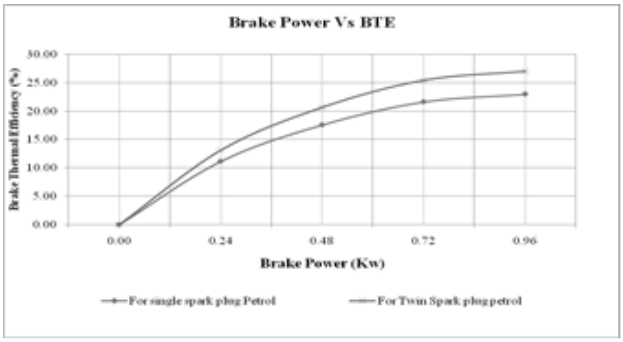

Fig. 3: Variation of Brake Thermal Efficiency with Brake Power in twin spark Petrol

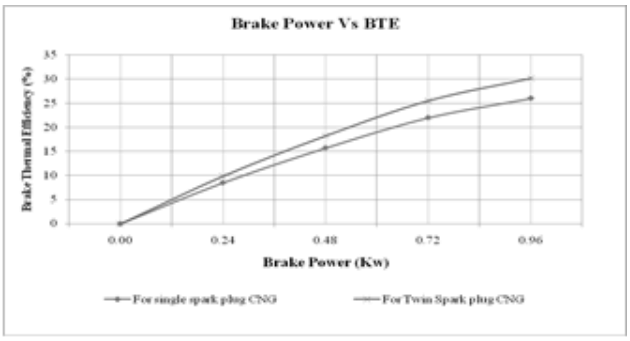

Fig. 4: Variation of Brake Thermal Efficiency with Brake Power in Twin spark CNG

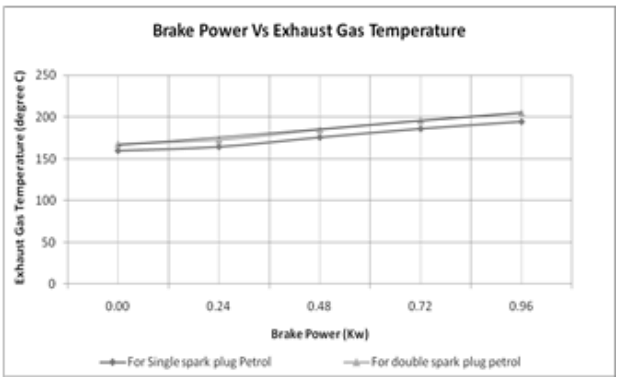

Fig. 5: Variation of Exhaust Gas Temperature with Brake Power in Twin spark Petrol

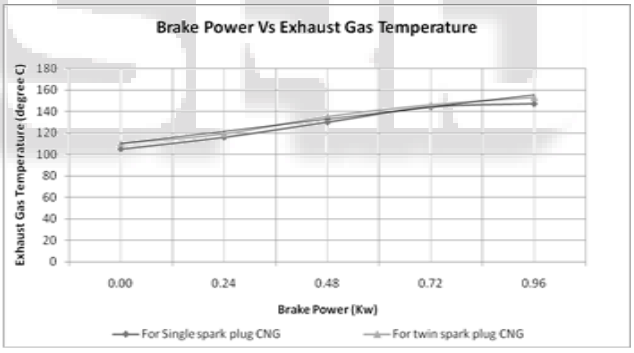

Fig. 6: Variation of Exhaust Gas Temperature with Brake Power in twin spark petrol

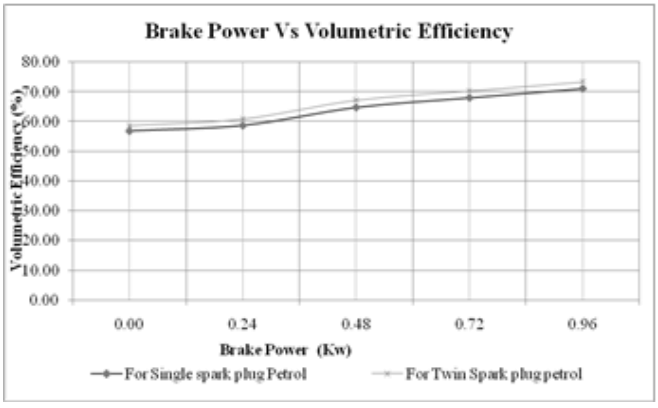

Fig. 7: Variation of Volumetric Efficiency with Brake Power

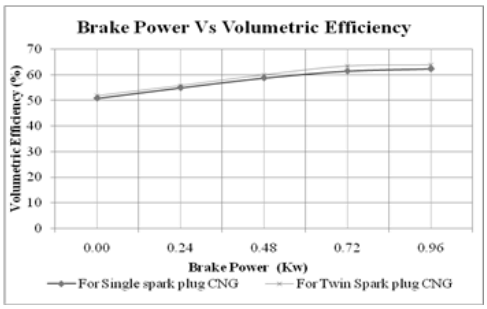

Fig. 8: Variation of Volumetric Efficiency with Brake Power

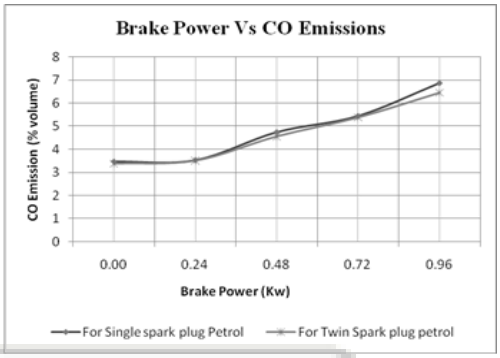

Fig. 9: Variation of CO with Brake Power for fuel as Petrol

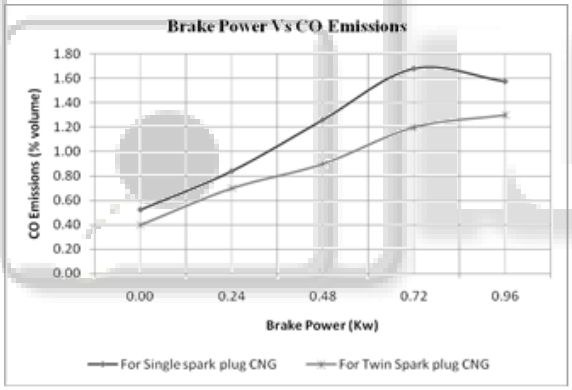

Fig. 10 Variation of CO with Brake Power for fuel as CNG

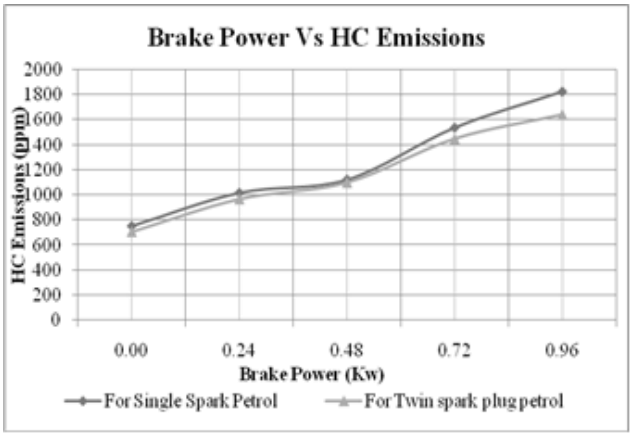

Fig.11: Variation of HC with Brake Power for fuel as petrol

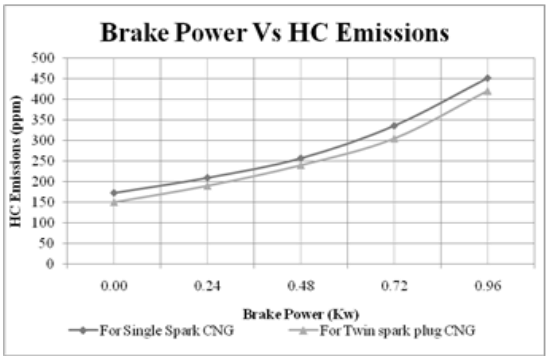

Fig. 12 Variation of HC with Brake Power for fuel as CNG

IV. CONCLUSION

Brake specific fuel consumption is reduced using petrol of about 8 to 10 % while in CNG it is reduced of about 8 to 12 % at part load condition. From the graph we can see that if load increases the brake specific fuel consumption, in single spark CNG also give good results. In twin spark ignition engine Brake thermal efficiency of an engine is increases of about 4 to 5% in both petrol as well as CNG fuel. Volumetric Efficiency is increased of about 2 to 3 % in twin spark arrangement as compare to single spark engine using both fuel petrol as well as CNG. Engine emission is reduced considerably, CO emission is reduced of about 10 to 15% and HC emissions are reduced of about 5 to 12% for twin spark engine.

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