ISSN 2395-1621

Performance of SI Engine with the Influence of Different Compression Ratios on the CNG- Fuelled Internal Combustion

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ABSTRACT

Petrol engines can run on natural gas with little modification. The combustion characteristic of CNG is different from petrol, which affects performance of the engine. While thinking about oil prices and emissions we need an efficient engine with low emissions. Thus, automobile manufacturers are trying to improve the performance and efficiency of the engine while keeping compliance with the emission norms. Compressed Natural Gas (CNG) is one of the most promising alternatives to traditional fuel energy resources for internal combustion engines of various types. The Auto-ignition temperature, Octane rating and Calorific value of CNG is much better for use in internal combustion engines compared to petrol CNG being cheap compared to other conventional fuels, is an added advantage of CNG compared to petrol are Unique combustion and suitable mixture formation, Due to high octane number of CNG the engine can operates smoothly with high compression ratios without knocking. In the present work Experimental investigations are carried out on a single cylinder two stroke air cooled Bajaj-auto 150cc petrol engine and evaluate the performance parameters. The objective of on-going work is to improve power output by using CNG as an alternative fuel by finding the new or highest compression ratio(CR) for the same engine by modifying cylinder head. The tests are carried out for both petrol and CNG and finally the comparative analysis will be made between petrol and CNG for its performance parameters.

Keywords— CNG, Compression Ratio, cylinder head, emissions characteristics, Octane rating, performance parameters.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

During the last several years the prices of the most common used fuels like petrol and diesel has risen almost twice. That's why, saving fuel is quite important. It is well-known fact, that the petrol engines can be easily converted to run on compressed natural gas (CNG) or liquefied petroleum gas (LPG). The combustion process is quite same and has similar parameters, like working temperature, pressure, etc. One of the most important is the octane rating. The methane, propane and butane have a higher octane number (RON) and that's why, the burning process can be optimized for a

better performance, and lower consumption since the petrol engines are usually not factory equipped for alternative fuel.

Properties of compressed natural gas demonstrate its strong potential to be an alternative fuel its high octane number enables use of higher compression ratio in spark ignition engines consequently improving brake thermal. The option of alternative fuels like CNG becomes all the more attractive primarily due to its advantages and lower cost. CNG being gaseous in nature has higher diffusion rate than petrol and therefore exhibits lower volumetric efficiency compared to petrol at same operating conditions. Flame velocity of CNG is slightly slower than petrol hence higher combustion duration is required for complete combustion. The advantages of CNG compared to petrol are unique combustion and suitable mixture formation. Due to high octane number of CNG, engine operates smoothly with high compression ratios without knocking; CNG with lean burning quality will leads to lowering exhaust emissions and fuel operating cost

The aim of this work is to implement this engine with a CNG gas system. However, it works with only one compression ratio, what causes losses to its efficiency due to a low compression ratio. A variable compression ratio is ideal for engines fuelled by CNG gas and petrol.

This work shows the differences between the original compression ratio of the engine and different compression ratios for CNG. A comparison of these three configurations was made after optimizing the system, aiming at achieving the best performances for all compression ratios.

II. MATERIAL AND METHODOLOGY

For the performance parameter the test set up is prepare so the engine, components and actual arrangement is discussed in the material and methodology.

A. Experimental Setup

The experiments will be carried out at variable load and with the different compression ratios operation to compute performance parameters for Petrol and CNG. The particulars of various components pertaining to the test facility are: Single cylinder petrol engine, Different compression heads, Rope dynamometer, Exhaust gas analyser, CNG pressure reducer, CNG storage cylinder, Oil pump, Tachometer, Oil tank, Petrol tank, Electronic weight (50 kg).

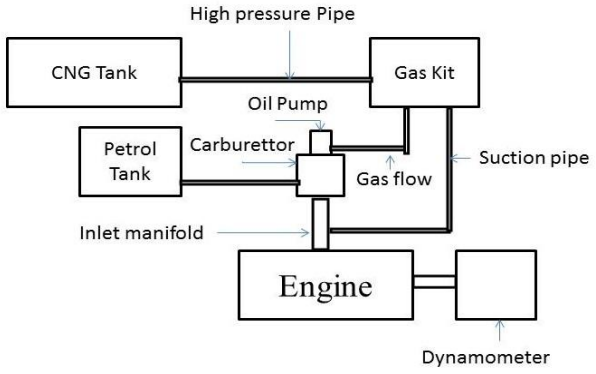


Figure1. Block Diagram of setup

B. Systems for Converting Petrol Engine to Operate On CNG

Simple system of Reducer and Mixercan be used on petrol engines with carburettor to operate on natural gas. For petrol engines converted to operate on natural gas please see additional points below

The installation kit includes Natural Gas Pressure Regulator/Reducer, Gas Mixer CNG, Cylinder and Cylinder Valves, Gas Filling Valve, High-pressure Lines.

C. Engine Technical Specification

TABLE I
ENGINE SPECIFICATION

No		
1	Type	2 Stroke
2	Cooling Type	Forced Air Cooled
3	Displacement	145.45 cc
4	Max Power	6.6 kW at 5000 rpm
5	Max Torque	15.5 Nm @ 3300 rpm
6	Ignition Type	CDI
7	Transmission Type	4 forward and one reverse
8	Clutch Type	Wet multidisc type

D. Actual Setup for project work

The figure 2 shows the actual setup of 150cc test engine. For testing purpose, purchased an engine and the setup for project isdeveloped in institute.The performance parameters are tested on same setup with variable load condition.

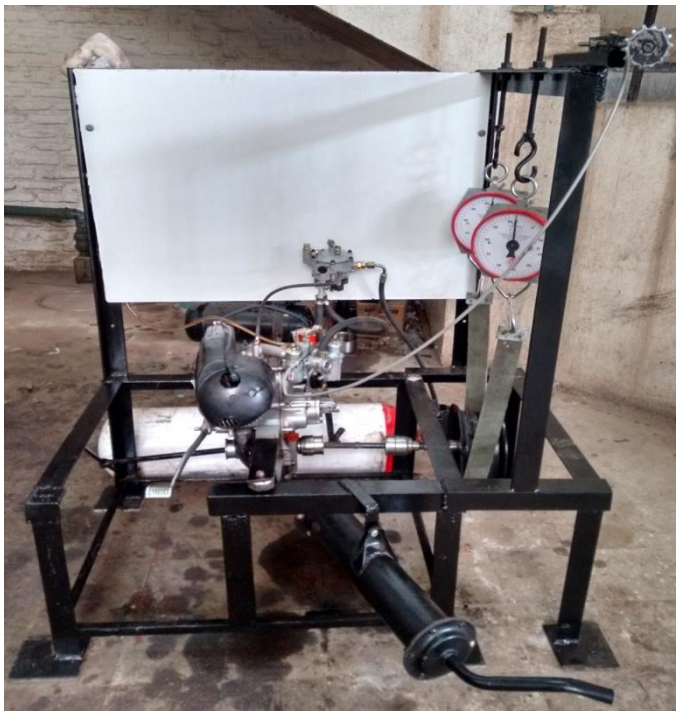


Figure2. Actual project setup

III. MODIFICATION IN COMPRESSION RATIO

Compression ratio is the technology to adjust internal combustion engine cylinder compression ratio. In sparks ignition engine high compression ratio is employed for greater efficiency and low load operation, and low compression ratio is employed at full load allowing to work without problem of detonation. The compression ratio could provide the key to enable exceptional efficiency at light loads without loss of full load performance. A study on the

performance parameter, engine efficiency of variable compression ratio spark ignition engine fuelled with alternative fuels reveals that the brake thermal efficiency and volumetric efficiency improved with higher compression ratio.

There are some method to vary the compression ratios by changing the cylinder head cavity volume, variation of combustion chamber height and variation of piston height.

A. Cylinder head cavity volume

The cylinder head cavity volume is plays major role in variation of compression ratio. This cylinder head cavity volume is measured separately for calculating the clearance volume. If cylinder head cavity volume is at higher side then compression ratio is at lower side and when cylinder head cavity volume is at lower side then compression ratio is at higher side. So every researcher aims to that keep compression ratio at higher side for better engine performance by using lower cavity volume cylinder head.

B. Top dead centre volume

The top dead centre volume is also important parameter which affecting on variation of compression ratio. This volume is measured when piston is rest at top dead canter and this volume measured for calculating the clearance volume with the addition of cylinder head cavity volume. If TDC volume is at higher side then compression ratio is at lower side and when TDC volume is at lower side then compression ratio is at higher side. This top dead centre volume always keeps at lower side for better engine performance.

C. Head gasket thickness

Head gasket thickness is little affecting on the variation in compression ratio. This gasket thickness measured for the calculating the clearance volume with the addition of cylinder head cavity volume and top dead canter volume. For better engine performance the gasket thickness keep at lower side.

D. Piston Height from piston pin to crown

The piston height is little affecting on the variation in compression ratio. This piston height from piston pin to piston crown is helpful for the lowering clearance volume. If piston height is at higher side the TDC volume is at lower side and when piston height is lower side the TDC volume is higher side. For better engine performance keep piston height at higher side.

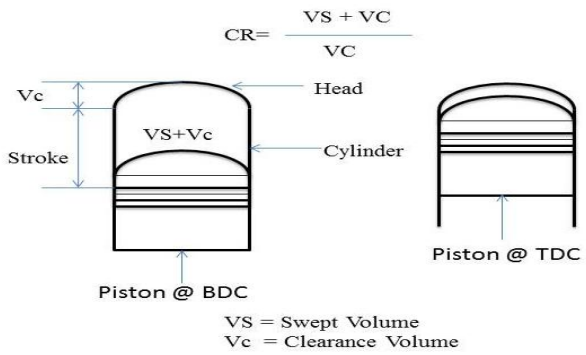


Figure3. Compression Ratio

For the research work the cylinder head cavity volume method is used and prepared a four different head of different compression ratios and one is original so there are five different compression heads of different ratios as fallows

1) Original head gives standard CR of:

$$24cc\ cavity = \frac{145.45+24}{24} = 7 \ldots\ldots\ldots (1)$$

2) First head created gives CR of:

$$21cccavity = \frac{145.45+21}{21} = 7.92 \ldots\ldots\ldots\ldots (2)$$

3) Second head created gives CR of:

$$19cc\ cavity = \frac{145.45+19}{19} = 8.68 \ldots\ldots\ldots (3)$$

4) Third head created gives CR of:

$$17cc\ cavity = \frac{145.45+17}{17} = 9.55 \ldots\ldots\ldots (4)$$

5) Forth head created gives CR of

$$15cc\ cavity = \frac{145.45+15}{15} = 10.1 \ldots\ldots\ldots (5)$$

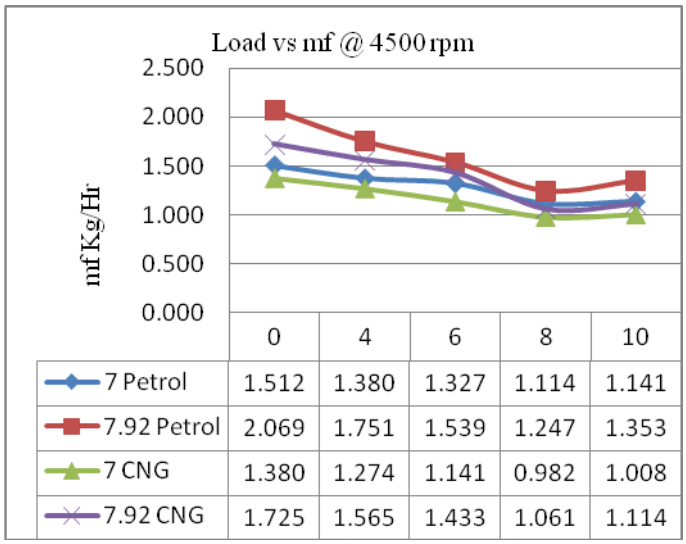
By using this variable heads on same engine various tests have been carried out for performance parameters and emission characteristics

IV. RESULTS AND DISCUSSION

All the test presented in this paper ware carried out at a speed of 4500 rpm for variable loading conditions and at compression ratio of 7 and 7.92 and the result obtained during experiment are discussed below

A. Fuel consumption

Fuel consumption has the decreasing characteristic with increasing load. The graph shows in figure4is the fuel consumption with different loading condition for petrol and CNG at different compression ratio at 7 and 7.92. Lookingfor the fuel consumption using petrol as fuel it is observed that mf for while CR 7 is list value than CR of 7.92.Also looking for CNG as a fuel it is observed that mf for both CR is less than petrol.

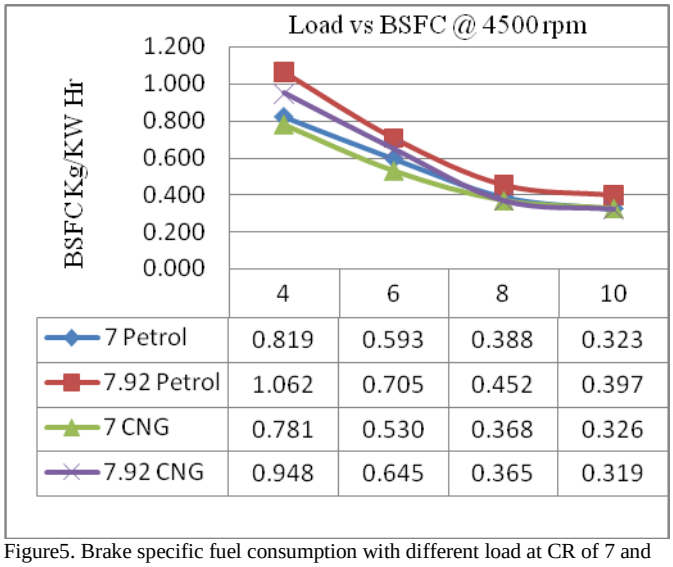


	0	4	6	8	10
7 Petrol	1.512	1.380	1.327	1.114	1.141
7.92 Petrol	2.069	1.751	1.539	1.247	1.353
7 CNG	1.380	1.274	1.141	0.982	1.008
7.92 CNG	1.725	1.565	1.433	1.061	1.114

Figure4. Fuel consumption with different load at CR of 7 and 7.92

B. Brake Specific Fuel Consumption

The brake specific fuel consumption is also a decreasing characteristic with increasing load. From the graph shown in figure 5 it is observed that brake specific fuel consumption for CNG at a CR of 7and 7.92 is reduced as compare to both CR for petrol.

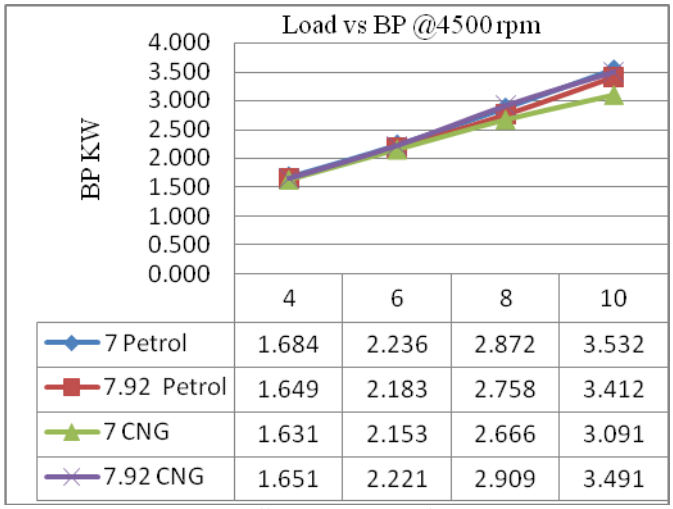


	4	6	8	10
7 Petrol	0.819	0.593	0.388	0.323
7.92 Petrol	1.062	0.705	0.452	0.397
7 CNG	0.781	0.530	0.368	0.326
7.92 CNG	0.948	0.645	0.365	0.319

Figure5. Brake specific fuel consumption with different load at CR of 7 and 7.92

C. Brake power

Brake power increases with increasing in load.From the graph shown in figure 6 it is observed that brake power for CNG for same compression ratio at 7 is decreases than petrol but when the CR is increases 7.92 the brake power is increases for CNG.

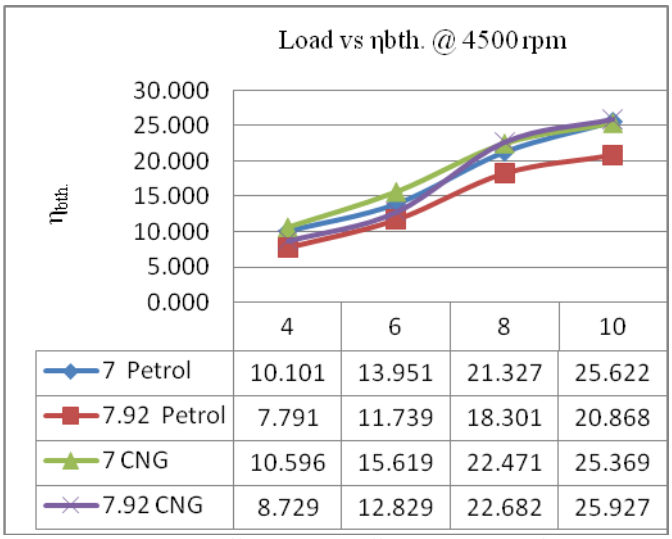


	4	6	8	10
7 Petrol	1.684	2.236	2.872	3.532
7.92 Petrol	1.649	2.183	2.758	3.412
7 CNG	1.631	2.153	2.666	3.091
7.92 CNG	1.651	2.221	2.909	3.491

Figure6. Brake power with different load at CR of 7 and 7.92

D. Brake thermal efficiency

Brake thermal efficiency is the function of actual power gain from the total supplied energy input. The graph shown in figure7 comparisons of thermal efficiency for petrol and CNG. It is observed that thermal efficiency for CNG is more than petrol and again increase with the increase in compression ratio.



	4	6	8	10
7 Petrol	10.101	13.951	21.327	25.622
7.92 Petrol	7.791	11.739	18.301	20.868
7 CNG	10.596	15.619	22.471	25.369
7.92 CNG	8.729	12.829	22.682	25.927

Figure7. Brake thermal efficiency with different load at CR of 7 and 7.92

V. Conclusions

In this study the effect of compression ratio on the performance of single cylinder spark ignition engine fuelled with petrol and CNG was studied base on experimental result

The overall results show that compression ratio can be used as an alternative way for predicting the performance of internal combustion engines which run on CNG.

Most of the CNG fuelled vehicles in India are aftermarket retrofitted conversions from the existing SI engine vehicles. These conversions don't include the modifications in Combustion chamber. As CNG has lean combustion effect on the SI engine. Compression ratio has to be modified for the batter performance and to optimize the power loss and drivability problems caused by conversions.

ACKNOWLEDGEMENT

The author expresses their sincere thanks to guide and P.G. Coordinator Prof. D. Y. Dhande, for giving his valuable guidance. The authors also acknowledges tothe H.O.D. Prof. A. V. Waghmare and sincere thanks to Principal, Prof. Dr. S. P. Danao. The authors would also like to thank Staff of Mechanical Department.

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