Effect of Compression Ration on CNG Fulled SI Engine

Tushar Vithalkar, D. Y. Dhande
Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Pune, India
tushar.vithalkar177@gmail.com, dindhande2001@gmail.com

Abstract — The combustion characteristic of CNG is different from petrol, which affects performance of the engine. Thus, automobile manufacturers are trying to improve the performance and efficiency of the engine. Compressed Natural Gas (CNG) is one of the most promising alternatives to traditional fuel energy resources for internal combustion engines. 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.

I. INTRODUCTION

Most of SI engine available in a market are retrofitted engines they use a conversion kit to operate on CNG without any modification in engine. As the combustion properties of both the fuel are different due to which the engine does not produce desired output. While going to CNG it is good alternative fuel for SI engine due to its properties like octane number, calorific value, self-ignition temperature from this it is possible to operate engine with a higher compression ratio without knocking.

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. FUEL PROPERTY ANALYSIS

CNG is good alternative fuel for SI engine due to is fuel properties such as octane number, calorific value, self-ignition temperature the effect of this property as discuss below.

A. Octane number

Octane number is the ant knocking property of a fuel. CNG having higher octane number than petrol hence it is possible to operate engine on higher compression ratio while running on CNG. This directly effects on the power output of engine, thermal efficiency and fuel economy.

B. Composition

Going to composition petrol has a higher percentage of carbon compound or CC bonds on the other hand percentage of CH bond in CNG is lower which directly get effect on emission characteristics of an engine.

### TABLE I. FUEL PROPERTIES

<table>
<thead>
<tr>
<th>No</th>
<th>Fuel Properties Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Properties</td>
</tr>
<tr>
<td>1</td>
<td>Formula</td>
</tr>
<tr>
<td>2</td>
<td>Density kg/m3 (Ambient,25°C)</td>
</tr>
<tr>
<td>3</td>
<td>Vapor density</td>
</tr>
<tr>
<td>4</td>
<td>Boiling point Temp °C, atmp</td>
</tr>
<tr>
<td>5</td>
<td>Auto Ignition (SIT) temperature °C</td>
</tr>
<tr>
<td>6</td>
<td>Octane Number</td>
</tr>
<tr>
<td>7</td>
<td>AF ratio, Stoichiometric (mass)</td>
</tr>
<tr>
<td>8</td>
<td>Flame propagation Speed m/s</td>
</tr>
<tr>
<td>9</td>
<td>Common Compression</td>
</tr>
<tr>
<td>10</td>
<td>Lower Heating value MJ/kg</td>
</tr>
<tr>
<td></td>
<td>MJ/liter</td>
</tr>
</tbody>
</table>
C. Density

Density of gaseous fuels especially CNG is lower as compare to petrol hence while operating on CNG fuel engine volumetric efficiency gets reduced.

D. Stoichiometric AF ratio

The stoichiometric air fuel ratio of petrol is lower than CNG so when engine operate for same amount of air less amount of gaseous fuel get burns. So for same condition less amount of fuel required while running on CNG.

E. Calorific value

Calorific value of CNG is more as compare to petrol so it get result on thermal efficiency that is the thermal efficiency of CNG engine is more.

III. 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.

A. Engine Technical Specification

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

B. Systems for Converting Petrol Engine to Operate On CNG

Simple system of Reducer and Mixer can 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 may include following parts

1) Natural Gas Pressure Regulator/Reducer
2) High pressure pipe
3) NGV Tanks And Their Valves
4) Mixer
5) Oil pump
1) Regulator

The pressure reducer shown in figure 2 is suction type of pressure reducer which is operate on engine inlet manifold suction pressure there is one tube from inlet of engine which operate the pressure reducer according to engine speed and working condition.

The gas from tank which is store at 220 bar pressure comes in pressure reducer and reduced to working pressure.

![Figure 2. CNG pressure reducer](image)

2) High pressure pipe

The installation of the high-pressure piping can be depending on placement of CNG tank, pressure reducers and filling valve. It is made up of steel having thickness of 0.1-0.15 cm and also cover with rubber packing. The pipe is made that it can sustain pressure up to 260 bar.

![Figure 3. High pressure pipe](image)

3) NGV Tanks and Their Valves

CNG gas is filled at a very high pressure near about 220 bar. The tank used is made up of cast iron and having one inch thickness the tank shown in figure 4 is able to store 4 kg of gas for that 4 kg gas the tank require is of 35 kg wait which is wait of empty tank.

The valve is attached to the tank near about 30 rounds of Teflon tape can be wounded while mounting these valve.
to avoid leakages and the on off control knob is over the valve.

Figure 4. CNG tank

4) Mixer

The mixture is attached before carburettor or in between carburettor and filter. The gas that is CNG comes from pressure regulator to mixer and mixed with air this mixer having small holes inside which circulate the flow of fuel

Figure 5. Mixer

5) Oil pump

In case of two stroke SI engine the oil is required to be mixed with fuel. For that oil pump of suction type is used. It consists of mixer, which mix-up the gas and oil in proportionate amount. The oil reservoir of 1.5 litres capacity is used.

Figure 6. Oil pump

C. Actual Setup for project work

The figure 7 shows the actual setup of 150cc test engine. For testing purpose, purchased an engine and the setup for project is developed in institute. The performance parameters are tested on same setup with variable load condition.

Figure 7. Actual project setup

IV. 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.

\[ CR = \frac{VS + Vc}{Vc} \]

Figure 8. 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 7, 7.92, 8.68, 9.55, 10.59.

IV. RESULTS AND DISCUSSION

All the test presented in this paper were 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. Brake Specific Fuel Consumption

The brake specific fuel consumption decreasing characteristic with increasing load. From the graph shown in figure 9 it is observed that brake specific fuel consumption for CNG at a CR of 7 and 7.92 is reduced as compare to both CR for petrol.

![Figure9. Brake specific fuel consumption with different load at CR of 7 and 7.92](image)

C. Brake thermal efficiency

Brake thermal efficiency is the function of actual power gain from the total supplied energy input. The graph shown in figure 11 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.

![Figure11. Brake specific fuel consumption with different load at CR of 7 and 7.92](image)

V. CONCLUSION

CNG is a good alternative fuel for SI engine. The SI engine is designed to operate according to the combustion properties of petrol as a fuel. When this engine is operated with CNG as gaseous fuel it does not provide a satisfactory output that is performance and engine efficiencies because the combustion properties of CNG and petrol are overmuch different from each other.

From the research it is concluded that when we operate this engine on CNG that is gaseous fuel compression ratio or increasing in compression ratio is the process to increasing engine output, combustion characteristics, performance and efficiencies.

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 to the 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.

REFERENCES


