International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 5,May 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Effect of Ignition energy on performance and emission of CNG fuelled Bi-fuel Engine: Experimental Investigation

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Abstract: The research on alternative fuels for internal combustion engine has become essential due to depletion of petroleum products and its major contribution for pollutants, where Natural gas is one of the most promising fuel alternatives for the future.Most of the CNG fuelled vehicles in India are aftermarket retrofitted conversions from the existing SI engine vehicles.it is found that power produced by the CNG engine is 8-14% less compare to Gasoline engine. To increase the performance of the Bi-fuel engine there are many parameter which can be optimized. One of them is ignition energy. CNG because of high ignition temperature and low flame speed compare to gasoline for complete combustion higher ignition energy is required.The objective of this research is to improve engine performance and emissions of CNG fuelled SI engine by optimize ignition energy. The Performance and emission both decreased when engine was made to run on CNG instead of Petrol. By increasing ignition parameter like ignition energy performance of Bi-fuel engine in CNG mode is increasing. And further decreasing in emission is foundin CNG mode. BSFC found decreasing, BTE found Increasing, VE found Increasing and HC, CO and CO_2found further decreasing in Bi-fuel engine fuelled with CNG.

I. INTRODUCTION

It is well known that fossil fuel reserves are becoming exhausted at an alarming rate. Moreover, the combustion of such fuel results in emission of noxious pollutants which threaten the very survival of life in this planet. The role of existing internal combustion engines needs to be reviewed now in the context of these two major crises.Compressed natural gas (CNG) has long been usedin stationary engines, but the application of CNG as atransport engines fuel has been considerably advancedover the last decade by the development of lightweighthigh-pressure storage cylinders. Any researcherwas researched about the compressed natural gas asalternative fuel motivated by the economic, emissionsand strategic advantages of alternative fuels.The properties of CNG such as higher ignition Temperature, higher Calorific Value, safety and less pollutant makes it feasible alternative fuel. Natural Gas has considerably higher Octane Number than petrol hence it is suitable for SI engine compare to CI engine.[2]

Compressed Natural Gas (CNG) is attractive for five reasons. (1) It is the only fuel cheaper than gasoline or diesel. (2) It has inherently lower air pollution emissions. (3) It has lower greenhouse gas emissions. (4) Its use extends petroleum supplies, and (5) there are large quantities of the fuel available in North America. [1]

Shamekhi, Amir Hosseinstudied of performance and emissions characteristics of a Mazda B2000i bi-fuel (CNG + gasoline) SI engine and found that At all engine speeds volumetric efficiency reduction was between 10 and 14.2%. BMEP, torque and power decreased between 10.8 and 14 %. BSFC decreased in range of 15 and 24 %. Thermal efficiency increased between 22 and 33 %. Emissions of CO and $CO_2$are decreased. COemissions decreased between 58 and 89 % and theCO2 between 0 and 11 %. The HC emissions demonstrate reduction between 37 and 58 %. [3]WadysawMitianiec says that for complete combustion of CNG require 60mJ ignition energy compare to gasoline.[4]the review shows that by reducing spark plug electrode diameter, increasing spark gap and increasing ignition coil output voltage increase in the ignition energy. CNG because of high ignition temperature and low flame speed compare to gasoline to complete combustion higher ignition energy is required. Which is gives better performance and reduced further emission.

Table1. Properties of gasoline and CNG [2]

Properties	**Gasoline**	**CNG**
H-Content(%weight)	12-15	25
Density kg/m3(Ambient, 25°C)	730	0.66
Vapour density, (compared to air)	Heavier	Lighter
Boiling point(Temp °C)	27-225	-162
Flame propagation(Speed m/s)	0.5	0.43
Motor octane number	80-90	120
Research octane number	92-98	120
Molar mass (kg/mol)	110	16.04
Stoichiometric air-fuel ratio	14.6	17.3
Stoichiometric mixture density (kg/m3)	1.38	1.24
Lower heating value (MJ/kg)	43.6	47.377
Lower heating value of stoichiometric mixture(MJ/kg)	2.83	2.72
Flammability limits (vol% in air)	1.3-7.1	5-15
Spontaneous ignition temperature (°C)	257	540

In this experimental work analysis is carried out for performance and emission analysis with normal ignition coil (35 mJ ignition energy), high energy ignition coil (60mJ ignition energy) with normal spark plug (0.6mm spark gap and 2.2 electrode diameter) and Iridium spark plug (1.2 mm spark gap and 0.6mm electrode diameter) and compare with gasoline and normal CNG condition in single cylinder four stroke SI engine converted in to Bi-fuel engine.

II. EXPERIMENTAL SETUP

The experiments were carried out at constant speed of 2500 rpm and different load conditions to measure performance and emissions of the engine. Various components used in the test facility are:

- Electrical Dynamometer: Electrical dynamometer is coupled with engine by coupling and output of it is lead to resistive load bank and measure ampere and voltage with A-meter and Voltage meter
- Resistive load bank: Consist of lamps and load was varied in range of 0 to 72%
- Air box with U-tube manometer: Air box with U-tube manometer is used to measure air consumption during the combustion.
- Infrared gun to measure exhaust gas temperature
- Digital tachometer to measure rpm of the dynamometer coupled with engine
- Ampere meter to measure output of electrical dynamometer
- Volt meter to measure output of electrical dynamometer
- Burette for petrol flow measurement.
- Exhaust gas analyzer: Four gas analyzer to measure exhaust emission of CO, CO_2, HC.
- CNG Conversion kit.

- Single Cylinder four strokes naturally aspirated 7.5 HP SI engine.

Table 2 Specification of engine

MODEL	GL-400
Make	Greaves Engine
Bore Diameter (mm)	86
Stroke Length (mm)	68
Displacement Volume (cm^3)	400
Compression Ratio	9:1
RPM	3600
Max. Torque- kgm	25@2200 rpm
Ignition	Electronic System
Capacity of oil sump in liter	1.2
Dry weight- kg	40

2.1 Experimental procedure

The test has been carried out for both Gasoline and CNG fuel. SI engine was converted into Bi-fuel engine with CNG as second fuel by CNG conversion kit. Performance and emission parameters are measured by using both ignition coil and both spark plug.

III. RESULTS AND DISCUSSION

The Experiment were carried out at 2500 rpm with 0-72% load variation on Bi-fuel engine and performance parameters Brake power, Brake specific fuel Consumption, Brake Thermal efficiency, Volumetric efficiency, and emission parameter HC, CO and CO_2 are measured

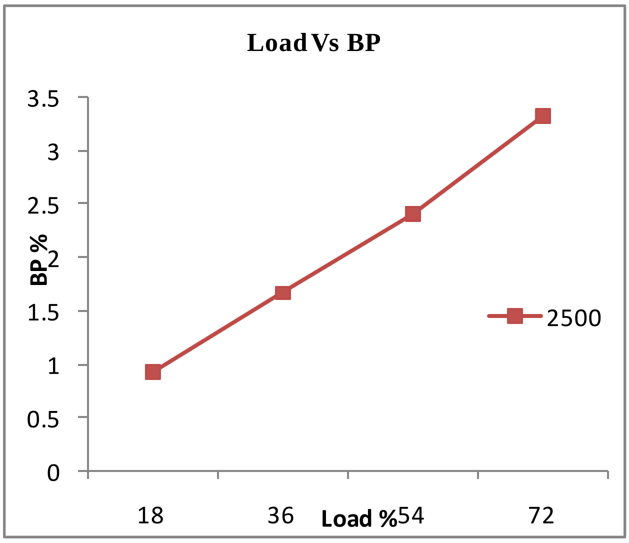

Figure1 load vs BP 2500 rpm

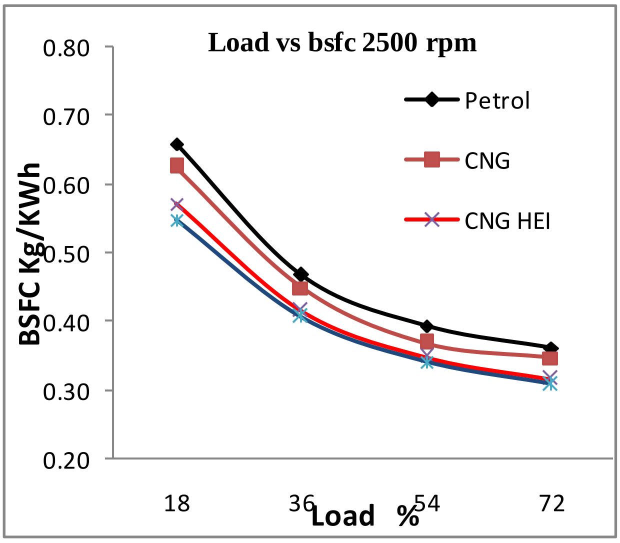

Figure 2 load vs BSFC 2500 rpm

3.1 Brake power

Figure 1show that brake power for the gasoline and CNG found increasing by increasing load on the engine. Maximum power produced by the engine is 3.34 kW at 72% load on engine at 2500 rpm.

3.2 Brake Specific Fuel Consumption

Figure 2 shows that BSFC is decreasing as load on the engine increasing. The reason for the decrease in BSFC with the increase of load is that the friction power remains essentially constant, while the indicated power is being increase. So, the brake power increase more rapidly than fuel consumption, and thereby the BSFC decreases. BSFC found 4.8 % decreasing for CNG mode compare to gasoline at all load condition. BSFC found further 7.5% decrease by using high energy ignition coil(HEIC) in CNG mode compare to normal CNG mode. Also using Iridium spark plug with HEIC 7.7% decreasing.

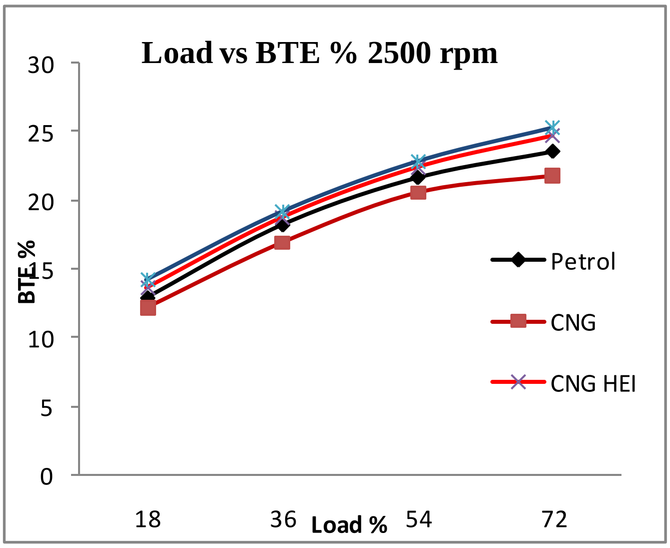

Figure 3load vs BTE at 2500 rpm

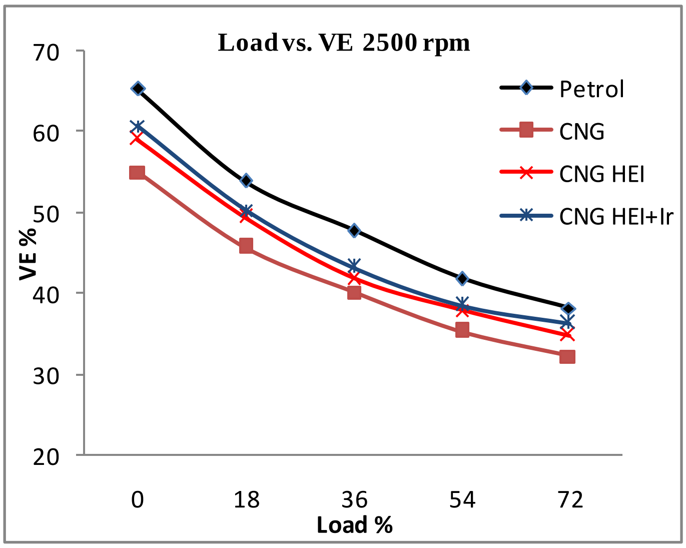

Figure 4 load vs VE at 2500 rpm

3.3 Brake Thermal efficiency (BTE)

Figure 3 shows the BTE found decreasing 6% for CNG compare to gasoline. By using HEIC in CNG mode 4% found increase in BTE. While using iridium spark plug with HEIC 5% found increase in the BTE Compare to gasoline mode at all load condition.

3.4 Volumetric efficiency (VE)

Figure 4 shows as load increases volumetric efficiency decreases. VE found less for CNG compare to gasoline because CNG occupy more volume compare to gasoline. Compare to gasoline 15% decrease VE in CNG mode. By using HEIC 6.5% increase found in VE. And using Iridium spark plug 8.7% found increase compare to normal CNG.

3.5 Hydro carbon (HC) Emission

Figure 5 shows that compare to gasoline 37% HC decrease in CNG mode. While using HEIC further8% found decreasing and using HEIC and Iridium spark plug 10% HC found decreasing. HC founddecreasing considerably because of complete homogeneous mixing of Gas compare to liquid gasoline. Hence unburn hydro carbon mainly contain only methane in CNG mode.

3.6 Carbon Monoxide (CO) emission

Figure 6 shows CO found 60% decrease in CNG mode compare to gasoline mode at all load condition. While using HEIC in CNG mode further decrease 9% found in CO and using Iridium sparkplug further 4% found decrease in CO.

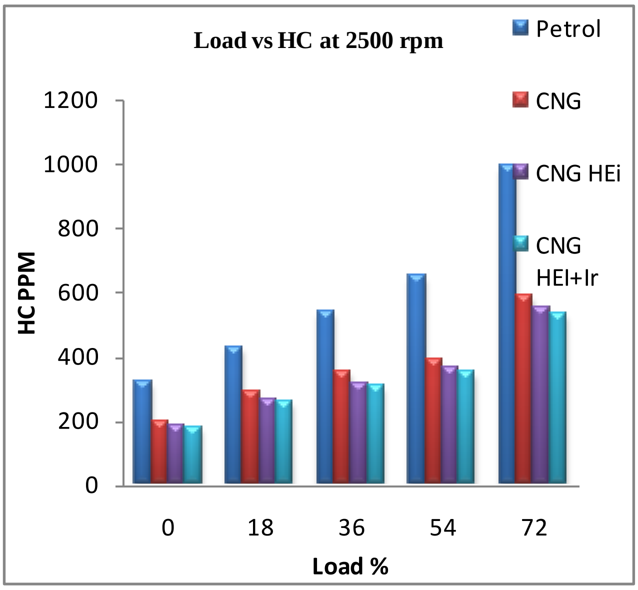

Figure 5 loadvs HC at 2500 rpm

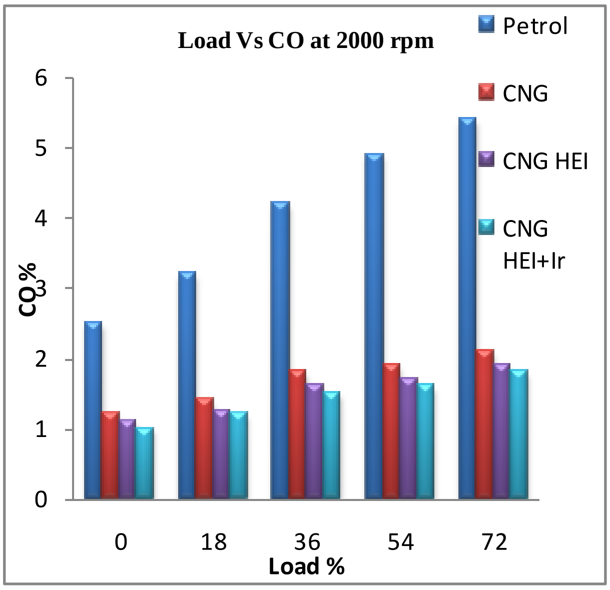

Figure 6 load vs CO at 2000 rpm

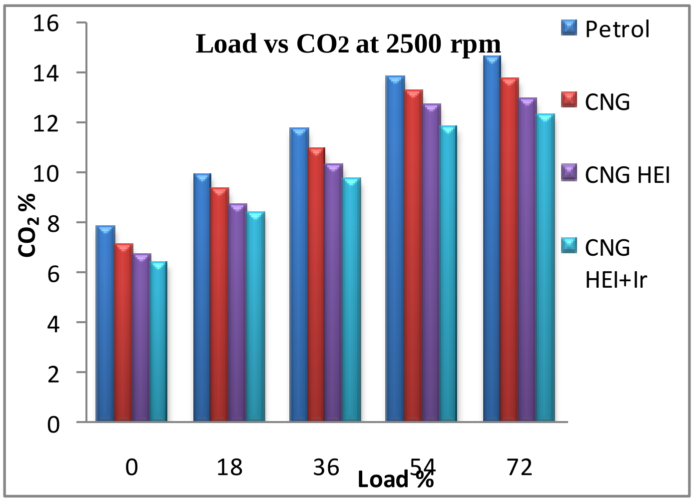

Figure 7 load vs CO2 at 2500 rpm

3.7 Carbon Dioxide(CO_2) Emission

Figure 7 shows that CO_2 found decrease 6.5% in CNG compare to gasoline. While using HEIC in CNG mode further 5.2% decrease found in CO_2 and using Iridium spark plug further 3% found decrease in CO_2.

IV. CONCLUSION

The analysis using optimum ignition energy found the performance which is decreasing when using CNG in Bi-fuel engine is increasing considerably and further decrease in emission which help in achieve future stringent emission regulation.

- It shown that using High energy ignition coil and iridium spark plug BSFC found decreasing 11%, BTE increase 4%, in CNG mode compare to Gasoline mode. While VE found 8% increase by using HEIC and iridium spark plug in CNG mode.
- Emission found further decrease compare to CNG mode by using HEIC and Iridium spark plug.HC found 10% decrease , CO found 15% decrease and CO_2 found 7% decrease compare to normal ignition coil and spark plug in CNG mode.

While converting SI gasoline engine into CNG fuelled Bi-fuel engine modification should be done on Ignition system helps in capability utilization of CNG fuel and increase in performance and make comparable to Gasoline fuel.

REFERANCES

1. Semin, Rosli, Abu Bakar "A Technical Review of Compressed Natural Gas as an Alternative Fuel for Internal Combustion Engines" American J. of Engineering and Applied Sciences 1 (4): 302-311, 2008, ISSN 1941-7020.
2. D. M. Dave, Prof. M. A. Shaikh, D. J. Vala "Optimization of Ignition Parameters for Enhancement of Performance and Emissions of a Four Stroke Single Cylinder SI Engine Fueled with CNG" *IJSRD Vol. 1, Issue 3, 2013, ISSN (online): 2321-0613*
3. Shamekhi, Amir Hossein; Khatibzadeh, Nima,Shamekhi, Abazar "A Comprehensive Comparative Investigation of Compressed Natural Gas as an Alternative Fuel in a Bi-Fuel Spark Ignition Engine"Iran. J. Chem. Chem. Eng.Vol. 27, No.1, 2008
4. WadysawMitianiec "Ignition of CNG mixtures in spark ignition engines" Journal of Kones Powertrain and Transport, Vol. 19, No. 3 2012 pp. 297-304
5. M.U. Aslam , H.H. Masjuki, M.A. Kalam, H. Abdesselam, T.M.I. Mahlia, M.A. Amalina "An experimental investigation of CNG as an alternative fuel for a retrofitted gasoline vehicle" Science Direct, Fuel 85 (2006) 717–724 doi:10.1016/j.fuel.2005.09.004
6. HaengMuk Cho, Bang-Quan He "Spark ignition natural gas engines—A review" Energy Conversion and Management 48 (2007) 608–618, 2006.
7. Pankaj Rajput, Shreya Singh "Optimization of Gasoline to CNG Engine Conversion using Computer aided Engine Simulation" IJERA ISSN: 2248-9622, Vol. 3, Issue 2, March -April 2013, pp.1429-1433.
8. J.D. Dale, M.D. Checkela and P.R. Smyb "Application of High Energy Ignition System to Engines" Prog. Energy Combusr. Sci. Vol. 23. pp. 379-398, 1997 Elsevier Science Ltd.
9. Jeonghoon Song, YounghoSeo, MyounghoSunwoo. "Effects of Ignition Energy and System on Combustion Characteristics in a Constant Volume Combustion Chamber" Seoul 2000 Fisita World Automotive Congress, June 12-15, 2000, Seoul, Korea
10. Sameh M. Metwalley, Shawki A. Abouel-Seoud, Abdelfattah M. Farahat "Emission components characteristics of a bi-fuel vehicle at idling condition"Front. Energy 2011, 5(3): 322–329, DOI 10.1007/s11708-011-0158-6.
11. G. J. Rohwein,L.S. Camilli "Automotive Ignition Transfer Efficiency" 02FFL-204Copyright © 2002 Society of Automotive Engineers, Inc.
12. Heywood JB. "Internal Combustion Engine Fundamentals" Singapore: McGraw-Hill; 1988 p 915.
13. Richard "Introduction to Internal Combustion Engines" 2nd Edition, the Macmillan Press Ltd, 1992.
14. V M Domkundwar "Internal Combustion engine" 3rd Edition, DhanpatRai& co. (p) Ltd. , Delhi 2012
15. S.S. Thepse, "Alternative Fuels Concepts, Technologies and Developments" 2ndEdition, Jaico Publishing House, India, 2011