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Experiment Investigations on CNG Injection System Performance in Single Cylinder Four Stroke SI Engine

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Abstract — Compressed Natural Gas (CNG) is regarded as one of the most promising alternative fuels, and may be the cleanest fuel for the spark ignited (SI) engine. Now a days CNG kit for SI engine contains various types of injection systems with ECU (Electronic control unit). This research deals with single point injection system. It is used as gaseous fuel injector to mix the gaseous fuel with the intake air in the manifold at one location for all cylinders of an engine. In this case, fuel is injected at a single location much like a gas mixer or carburettor. Single point electronic injection offers the advantages of more precise control of the amount of gaseous fuel entering the intake charge of the engine, as well as the economy of using a minimum number of injectors. This research deals with experimental investigations on fuel injection using CNG in Single Cylinder four Stroke SI Engine(125 cc). Desired pressure (3 to 5 bar) is injected in the intake manifold using CNG injector. Different parameter such as BSFC, BTE, IP, Mechanical efficiency and Exhaust emissions are studied. Comparison of petrol and CNG for the above parameter are done. Form the above study following conclusion are drawn. BSFC of petrol is higher as compared to CNG. BTE of CNG is higher as compared to Petrol. Mechanical efficiency of petrol is higher as compared to efficiency of CNG. Exhaust emissions of CO_2, Co, and HC also decreasing in CNG engine.

Keywords- SI Engine, CNG, injector, Carburetor, Throttle body

I. INTRODUCTION

It is well recognized that the fossil-fuel reserves in the world are diminishing at an alarming rate and a lack of crude oil is expected at the early years of this century. Gasoline and diesel fuel develops scarce and most exclusive. Unusual fuel becomes more conventional fuel in the future decades for inner-combustion engines. Today, the alternative fuel has been growing due to worries that the reserves of fossil fuel all over the area are limited. Moreover the world energy disaster made the fossil-fuel price increases.

Natural Gas (NG) has been found in many zones in oil and gas bearing sands strata located at changed depths under the earth surface. NG is a gassy form of NG was compressed. It has been recognized as one of the capable alternative fuels due to its significant benefits related to gasoline fuel and diesel fuel. These include reduced fuel cost, cleaner exhaust gas emissions and higher octane number. Therefore, the numbers of engine vehicles powered by NG were rising rapidly. NG is safer than gasoline in many respects. The ignition temperature of NG is higher than gasoline fuel and diesel fuel.

Additionally, NG agiler than air and dissipate rising rapidly. Gasoline fuel and diesel fuel will pool on the ground, rising the risk of fire. NG is nontoxic and will not contaminate groundwater if failed. Progressive NG engines undertake significant advantages over the conventional gasoline engine and diesel engine. NG is a normally available type of fossil energy. Conversely, the inquiry of applying NG as an alternative fuel in engines will be a beneficial activity, because the liquid fossil fuels will be finished and will become scarce and expensive. NG has some advantages related to gasoline and diesel from the environmental perspective[Semin, Rosli Abu Bakar (2008)]

Compressed natural gas (CNG) is a clean-burning alternative to gasoline or diesel used in transport. Made of mostly methane (CH4), natural gas is the most usually used alternative vehicle fuel in the United States. It is drained from wells or extracted through crude oil production. While some petroleum is used in the production of natural gas, using it as a transportation fuel reduces petroleum utilization by more than 90% compared to gasoline. In transportation, natural gas is used either as CNG or as liquefied natural gas (LNG). Benefits of this fuel consist of cost savings, reduced emissions, and easiness in vehicle maintenance, and increased energy security.

II. LITERATURE SURVEY

Compressed natural gas is considered to be the best fossil fuel in today's IC engines because it is cheaper, faster, safer and a most convenient. CNG is recognized as a most promising alternative fuel having significant benefits over diesel fuels and gasoline fuel because its cost and emissions are lower and performance characteristics is higher due to its high octane number and also it is a most environment friendly gas. Therefore, number of vehicles are powered by compressed natural gas were growing rapidly. Today there are various types of fuel injection system in IC engines among them direct injection system is the latest technique of fuel injection. Due its wide advantages over other injection systems several study and researches has been reviewed and discussed in this chapter.

Muhammad Imran Khan ET all. (2015) Shows "Technical overview of compressed natural gas (CNG) as a transportation fuel"

"This paper presents the worldwide background, challenges of natural gas fuel and natural gas fuelled vehicles along with environmental and economic aspects of compressed natural gas as a transformation fuel. Technical aspects of compressed natural gas properties, safety problems and its effects on engine performance, efficiency and emissions to natural gas vehicles edition are discussed in detail. The main indicators selected for the relative calculation of natural gas as vehicular fuel are: economic, emission performance and safety facet. The outcomes showed that CNG has some advantages over both diesel and gasoline fuel, including large emission and cost reductions. [1]"

Minggao Ouyang et all. (2015) Shows "Performance analysis of a novel coaxial power-split hybrid power train using a CNG engine and super capacitors"

"In this research, the performance characteristics of a novel coaxial power-split hybrid power train for a travel bus are presented. The power sources are a mixture of a compressed natural gas (CNG) engine and excellent capacitors.

A mathematical model for the coaxial power-split hybrid power train is established. Next, an analysis program is developed based on Matlab and Advisor. The parameters are specified using investigational data. A rule-based control approach is designed and improved from the viewpoint of energy efficiency. The results indicate that the future coaxial power-split hybrid power train can achieve the requirements of the travel bus and growth the energy efficiency dramatically. Furthermore, the average energy efficiency of the excellent capacitors was found to be above 97% over the whole driving cycle. Using excellent capacitors as energy storage devices for the coaxial power-split hybrid power train can excellently recover the kinetic energy during regenerative braking and is a good result for transit buses that need frequent acceleration and deceleration. [2]"

Zia Wadud (2014) Shows "Transport impacts of an energy-environment policy: The case of CNG conversion of vehicles in Dhaka"

"In this paper, Motor vehicles are one of the major sources of air pollution in Dhaka, the capital of Bangladesh. One of the market kindly policies to encourage the fuel switch was to rise the price difference between CNG and petrol and diesel. This has allowed a wide-scale adoption of CNG as the fuel of choice. This paper presents the results of a survey and an econometric intervention analysis to understand the impact of CNG conversion on car proprietorship and car travel in Dhaka. Attention is also given to untangle the self-selection and price-induced travel effects of CNG transformation. Outcomes show that ownership did not increase, but travel of on-road vehicles increased due to the CNG policy. Conversely, added crowding costs are still around one half of the health benefits brought about by the policy. [3]"

Sangeeta, Sudheshna Mokaet all.(2014) Shows "Alternative fuels: An overview of current trends and scope for future"

"This paper presented the worry over fast depletion of relic fuels has encouraged the search for another fuels having competences similar to those found for the conventional fuels being used today. The properties of these fuels and their performance as a fuel. Vegetable oils present actual hopeful situation of functioning as alternatives to fossil fuels. Use of biodiesel in a predictable diesel engine results in a significant reduction in unburned hydrocarbons, carbon monoxide, particulate matter, and nitrogen oxides. Different another fuels have been matched with the conventional fuels and clearly the consumption of the latter can be pointedly decreased by the use the blended fuels."

In order to successfully contend with conventional fuels, these another fuel show ever need to be improved in terms of their properties, production efficiency, and end-use correctness .Hopefully speaking, the extent of research efforts being put in this area should soon make the fossil fuels a thing of the past at least in the transportation sector, and thus ensure that the future generations get a clean and green environment. Remaining petroleum may then better serve as a raw material for medicines, and thus as a boon for mankind. [4]

R. Senthilraja et all.(2016) Shows "Performance, emission and combustion characteristics of a dual fuel engine with Diesel-Ethanol-Cotton seed oil Methyl ester blends and Compressed Natural Gas (CNG) as fuel"

In this paper, Performance of engine and emission characteristics of modified dual fuel engine is highly influenced by its ignition and combustion behaviour. In this study, an experimental investigation was conducted to evaluate the effects of diesel, ethanol, Cotton Seed Oil Methyl Ester (CSOME) and Compressed Natural Gas (CNG) on the performance, emissions and combustion of single cylinder, four stroke and water cooled modified dual fuel engine. The experiments were carried out using various fuel blends and Compressed Natural Gas in normal engine mode and dual fuel engine mode. The test fuels were blends of Diesel, Ethanol and Cotton Seed Oil Methyl Ester. The results indicated that, Nitrogen oxide (NOX) emissions, Carbon dioxide (CO2) emissions decreased at all loads for fuel blends and fuel blends with CNG. While, carbon monoxide (CO) emissions and Hydrocarbon (HC) emissions comparable higher at load for all fuel blends and fuel blends with CNG. [5]

III. EXPERIMENTAL TEST SETUP

3.1 INTRODUCTION

Today, we are using CNG kit for SI engine contains various types of injection systems with ECU (Electronic control unit). It was observed that injection of fuel was mainly done through Single Point Injection, Mixer/Carburetor Injection, Multi Point Injection and Direct Injection. So here, I will deal with single point injection system where CNG and gasoline fuel are compared.

3.2 COMPONENT USE IN PETROL AND CNG TEST SETUP

3.2.1 ENGINE

The CD-125 engine is taken as IC engine in our project because it is easily available in the market and it is in good working condition .The engine which is selected by me is specified as below:

Figure 1. Engine

CNG KIT
CNG is filled in the tank cylinder at 220 bar pressure .The parts are detailed below:

1) GAS TANK
The tank has an ability to contain 20 lit. water and 5 kg of gas in it.The gas is filled in tank at 220 bar.

A. FIRST STAGE REGULATOR
It is a device that reduces the pressure from 220 bar to 10 bar. It has pressure with level indicator for gas level. Same regulator is made for filling gas and also supplies gas to engine.

B. SECOND STAGE REGULATOR
It reduces the pressure from 10 Kg/cm^2 to 2 Kg/cm^2.

2) ALTERNATOR

An alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. Below alternator of 2.5 kW is taken which is coupled with engine. This alternator is rotated generate AC current. This AC current supply to a Load bank and apply the different load.

3) INJECTOR

The idea is to inlet manifold CNG injection instead of using the mixer circuit. Hence in order to inject fuel, that will supply fuel to the injector at a pressure of 3 bar just as the piston starts moving from BDC to TDC during the suction stroke.

Figure 2. Injector

4) THROTTLE BODY

The throttle controls the speed of the engine by controlling the amount of air and fuel apply in the engine. The throttle is a butterfly valve placed after the venture and is opened by pressing on the accelerator pedal. The farther the valve is opened the additional air/fuel mixture is let into the engine and the faster the engine runs. At low engine speeds when the throttle is only open a small there is not enough air flow to pull in fuel.

Figure 3. Throttle Body

5) CARBURETTOR

Carburetor is a device that blends air and fuel for an internal combustion engine. It combines air and fuel creating a highly combustible mixture. It regulates the ratio of air and fuel and it controls the speed of engine.

6) WEIGHT SCALE

Weight scale is measure a weight of the CNG cylinder. And Note down the reading for decreasing the gram of CNG gas. The weight scale capacity is 0 to 200kg.

7) HIGH PRASURRE PIPE

High pressure pipe is use a supply of gas for CNG tank to injector. This pipe is fitting an air tight with a clamp.

8) AIR FILTER

The primary function of the air filter is to clean the air before it is enter into the carburettor to mix with the fuel, which then gets burned to create the compression to run the engine. If the air enter into engine has dirt and other impurities in it, they can build up and clog up engine causing power loss and untimely engine wear.

9) LOAD BANK

Electrical resistance load board which consists of bulbs of different watt were placed in series and used for load measurement. The loading capacity of load board will be 0–5.0 kW.

10) BATTERY

We are using maintenance free battery. It is a lead acid battery. This battery capacity is 12 V and 3Ah.

11) ENGINE SPEED MEASUREMENT

Tachometer was used to measure engine speed which was attached at alternator shaft.

3.3. EXPERIMENTAL SETUP OF CNG ENGINE

Figure 4. CNG Engine Test Setup

IV. RESULT AND DISCUSSION

4.1 Graph based on Comparison between Petrol and CNG on Engine

(1) BSFC Vs BP

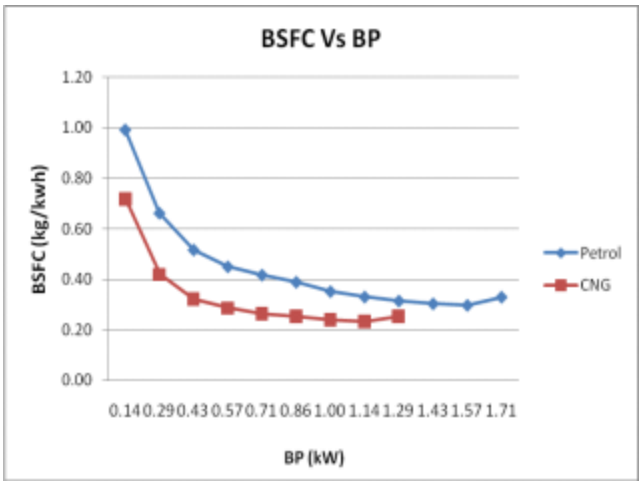

Figure 5. Graph of BSFC Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the BSFC also decreasing for Petrol and CNG respectively.
From above graph we can also see that BSFC of petrol is higher as compared to CNG.

(2) BTE Vs BP

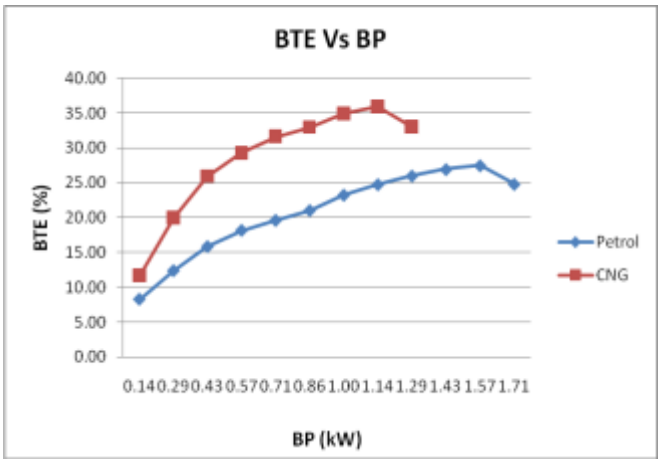

Figure 6. Graph of BTE Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the BTE also increasing for Petrol and CNG respectively. From above graph we can also see that BTE of CNG is higher as compared to Petrol.

(3) Mechanical efficiency Vs BP

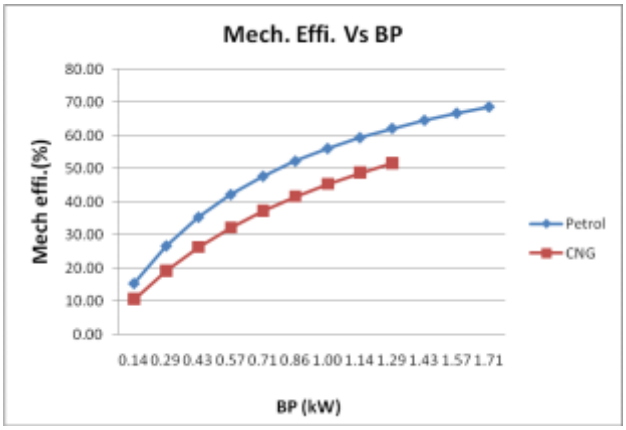

Figure 7. Graph of Mech. efficiency Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the Mechanical efficiency also increases for Petrol and CNG respectively. From above graph we can also see that efficiency ofpetrol is higher as compared to efficiency of CNG.

4.5 Graph based on Comparison between Petrol and CNG for Emission

(1) CO_2 Vs BP

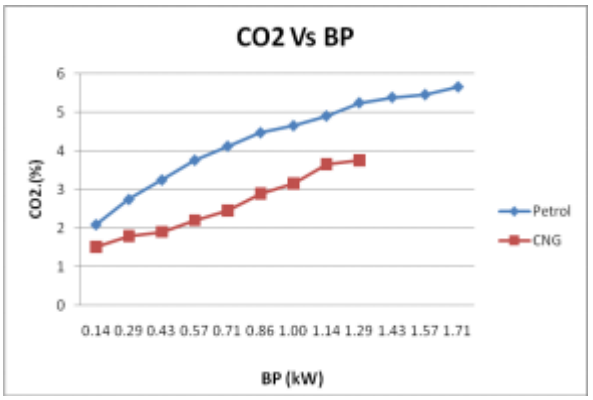

Figure 8. Graph of CO_2 Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the emission of CO_2 also increasing for Petrol and CNG respectively. From above graph we can also see that emission of CO_2 of petrol is higher as compared to CNG.

(2) CO Vs BP

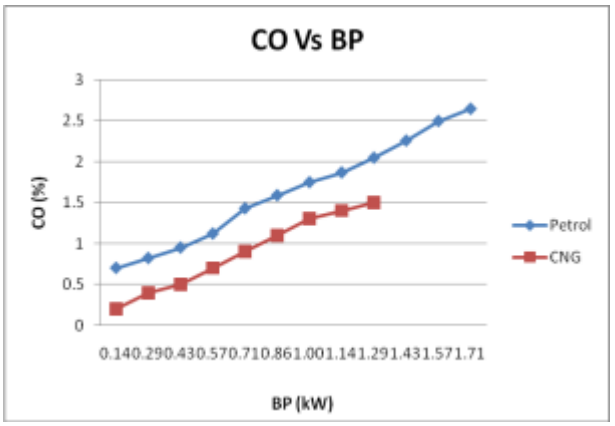

Figure 9. Graph of CO Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the emission of CO also increasing for Petrol and CNG respectively. From above graph we can also see that emission of CO of petrol is higher as compared to CNG.

(3) HC Vs BP

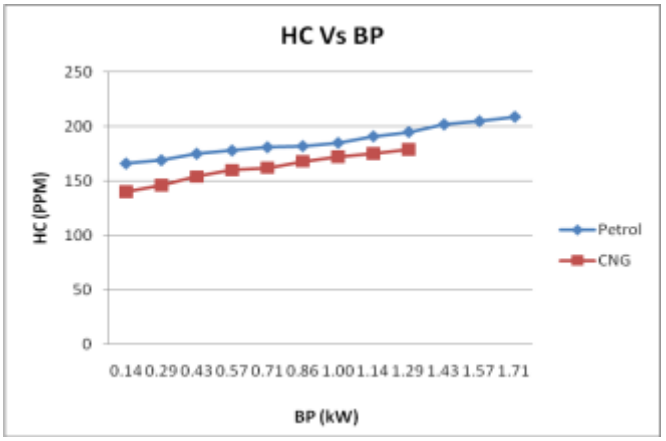

Figure 10. Graph of HC Vs BP for Petrol & CNG

Based on tabulation and above comparison of graph for petrol and CNG, we can see that as power increases the emission of HC also increasing for Petrol and CNG respectively. From above graph we can also see that emission of HC of petrol is higher as compared to CNG.

V. CONCLUSION

The experiment was performed on a single cylinder 125cc, four stroke SI engine by designing inlet manifold injection system with CNG as a fuel and compared with petrol. The performance and exhaust emission characteristics were investigated experimentally. The conclusions were made on the basis of present work.

- BSFC of petrol is higher as compared to CNG.
- BTE of CNG is higher as compared to Petrol.
- Mechanical efficiency of petrol is higher as compared to efficiency of CNG.
- Exhaust emissions of CO_2, Co, and HC also decreasing in CNG engine.

Higher amount of petrol fuel can be saved by replacing Petrol with CNG although there will be a reduction in efficiency. Also CNG fuel is easily available with less cost and also it is a clean burning fuel. Exhaust emissions of CNG engine are less as compared to Petrol engine.

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