DIESEL ENGINE CONVERSION TO A CNG ENGINE AND EXPERIMENTAL RESEARCH ON EMISSION CHARACTERISTICS

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Abstract
An essential alternative fuel for cars is natural gas, sometimes known as "green fuel." Compared to diesel engines, compressed natural gas (CNG) engines produce less pollution. Because CNG has a very high Octane number and less inclination to knock, a greater compression ratio may be maintained. The current project focuses on the conversion of diesel engines to CNG engines. This work modifies a number of diesel engine components, such as the piston crown shape and the installation of gas injectors in place of common rail. A modified CR computation is also provided. Engine was running at its best compression ratio of 11:1. Also, this paper includes an analysis of the exhaust gas emission characteristics. The CO_2, NOx, CO and HC emissions are lower for CNG engine.
Keywords: Diesel Engine, Natural Gas Engine, Compression Ratio, Emissions.

INTRODUCTION

The desire for increasing energy efficiency and reducing harmful emissions has become the most essential task for the contemporary Internal Combustion (I.C.) engine researchers due to the limited supply of petroleum fuels and the noticeable pollution values.

Petroleum-based fossil fuels are the most often utilized fuel for internal combustion engines. Diesel engines have a great thermal efficiency, but a significant issue is the NOX and particulate matter emissions. Throttle response is not a feature of diesel engines. The direct injection internal combustion engine has arisen in recent years to address the need to increase fuel efficiency, but it still has a problem with dangerous PM emissions [1, 2]. With more automobiles on the road and less oil available, it seems that employment of alternate fuels is unavoidable within the future. To meet the specified demand the alternate fuels utilized in petrol and diesel engines have become the themes of interest nowadays [3]. Due to stringent restrictions laid down by government agencies on tail pipe emissions from internal combustion engines and worldwide shortage of fossil fuels, alternative fuels have gained popularity [4-6]. In another analysis discerned in [7], ZhiliangYao et al. revealed that CNG engines are apace developed since over many years past. This analysis conjointly judged the exhaust emissions of twenty numbers of taxis that are run by bi-fueled CNG-gasoline and indicated that the check vehicles run by CNG emitted less CO2 and CO emissions; but, NOX and HC emissions considerably over those of check vehicles powered by gasoline.

To benefit from the employment of Natural Gas (NG), it's needed interpret its combustion in various conditions and to review the different parameters of Natural Gas (NG) engine.

Table 1. Distinction between Diesel and CNG [10]

Property	Diesel	CNG
Chemical formula	$C_{15}H_{28}$	CH_4
Molecular weight	208	16
Lower Calorific Value,	43	47.7

MJ/kg		
Higher Calorific Value, MJ/kg	47	54.3
Auto ignition Temperature, ^{0}C	210	580
Density, kg/m^3	840	740
Octane Number	--	130
carbon content (%m)	86.1	75
Hydrogen content (%m)	13.9	25

EXPERIMENTAL SETUP

Modifications

To convert a diesel engine into a CNG engine, certain modifications are required and they are as follows.

Table 2. Specifications of Tested Engine

Engine Type	Hyundai Verna U2VGT
Displacement (CC)	1582
Max. Power(kW) @4000rpm	94.00
Max. Torque@1750rpm	259.87N-m
Bore	77.2mm
Stroke	84mm
Compression Ratio	17.8:1
Fuel	Diesel
Number of Cylinders	4
Number of Valves per cylinder	4
System of fuel supply	CRDI
Cooling system	water cooled
Turbocharger	Yes

Compression Ratio:

Compression Ratio (CR) of diesel engine is 17.8:1, CNG engine generally works between 9:1to12:1.

So a modified piston or a new piston requires, with suitably shaped combustion chamber to provide proper mixing of air and fuel. In order to reduce the compression ratio milling is done on the piston crown to produce the required bowl shape. Volume is reduced to reduce the compression ratio.

A plate with a thickness of 2mm is provided between the cylinder head and engine block.

The shape of gasket will be same as that of the piston top head.

From the engine specifications as shown in Table 2, in the present work compression ratio reduced from 17.8:1 to 11:1 by increasing the thickness of gasket and by milling the crown of the piston, a bowl shape is created.

The bowl shape of the piston helps in creating tumble motion.

Bowl shaped piston crown also helps in the increase of area of squish and appropriate mixing of CNG and air.

After milling bowl shape on the top of piston increase in clearance volume is 1.69%.

Crown Volume, V_{crown} = 6.723 cm^3

Increase in clearance volume with increased gasket thickness
The modified compression ratio can be calculated as
CR = _____
CR = _____
CR=11

Spark Plug

Diesel engine does not require a spark plug and is fitted with fuel injector. Conversion of diesel engine replaces the fuel contrivance with an electrical device of Spark Plug. A gaseous fuel engine requires a high voltage spark plug than a petrol engine. A spark ignition system is provided.

Engine Valves
The Natural Gas (NG) is dry in chemical characteristic therefore the valve seats of transformed engine are hardened in order to prevent wear.

Inlet port modification:
A diesel engine requires swirl motion whereas CNG requires tumble motion as it enters with air. Hence helical inlet port is replaced with tangential inlet port by machining to convert swirl motion into tumble. To convert swirl motion into tumble the helical port is replaced with tangential inlet by machining. The swirl and tumble motion is created. The stable circulating flow pattern in a diesel engine is regarded as swirl.

Glow plug replacement:
The shape of the glow plug is a pencil like metal piece with the heating aspect at the tip. In a diesel engine glow plug is used near the inlet port in the combustion chamber to provide sufficient temperature for ignition. A Spark Plug is used in spark ignition engine to ignite the fuel air mixture. Glow plug is with spark plug by making necessary modifications in the cylinder head.

Modifications in fuel injection system:

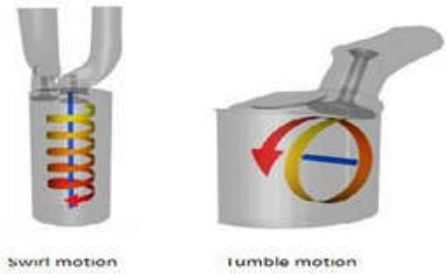


Fig. 1 Swirl Motion and Tumble Motion in a Diesel Engine

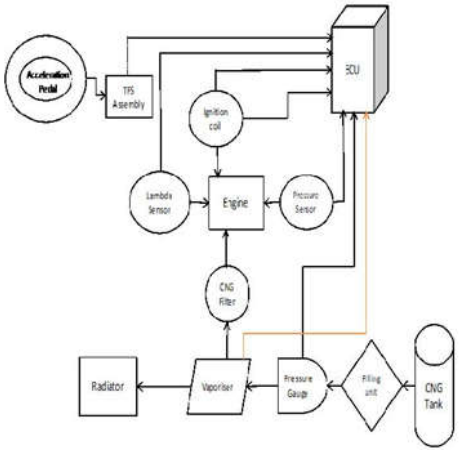
To supply the fuel in a diesel engine, Common Rail Direct Injection (CRDI) system is used into the combustion chamber with required pressure but this pressure is not sufficient to inject CNG into the combustion chamber. A gas injector is used to maintain the required pressure. Fuel is supplied to the Combustion Chamber through fuel

injector. The Natural Gas with a high pressure enters the engine initially through a regulator of gas pressure, which regulates the pressure within the order of five to six bar.

Table 3. Natural Gas Composition

Component	Chemical notation	% by Volume
Methane	CH_4	89.4
Ethane	C_2H_6	4.6
Nitrogen	N_2	4
Propane	$^{C}3^{H}8$	1
Butane	$^{C}4^{H}10$	0.3

Fig. 2 Block diagram – CNG Engine



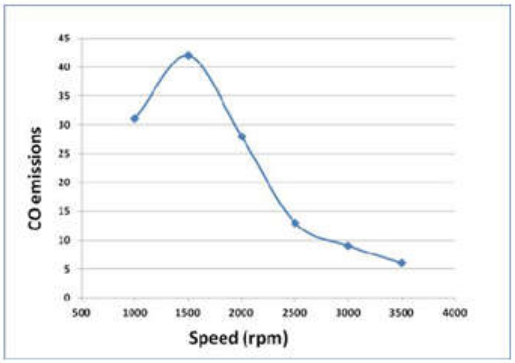
Initially the throttle is varied for a peak function and the speed of engine is varied in the range of 1000 rpm to 3500 rpm with an increment of 500 rpm. The ratio of Air to fuel kept constant by adjusting the quantity of CNG.

Emission characteristics

CO emissions

The carbon monoxide variations for different speeds are represented in figure 3.

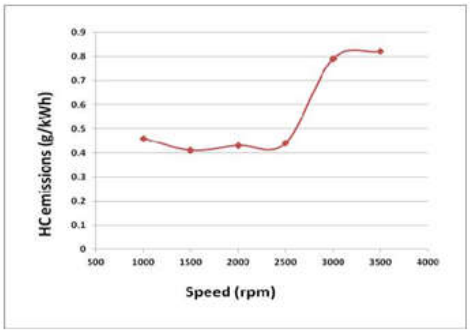
Fig.3 CO emissions at different speeds



HC emissions

The hydrocarbon emissions for different speeds are represented in figure 4.

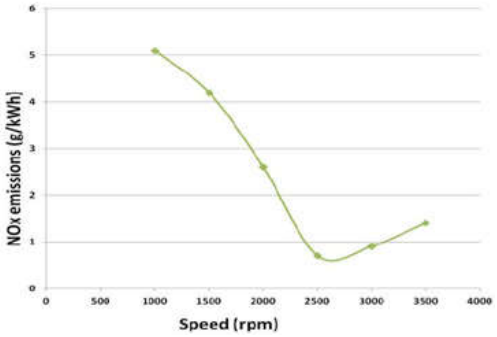
Fig. 4 HC emissions at different speeds



NO_X emissions

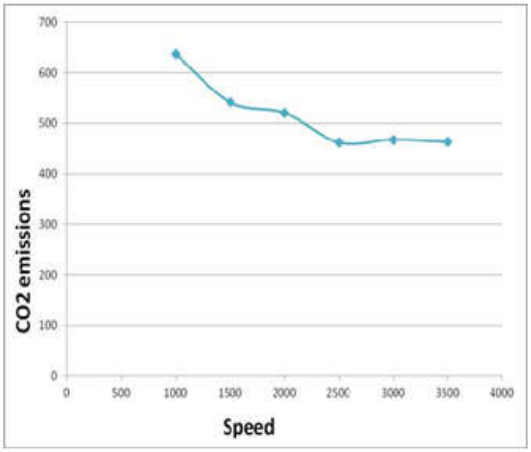
The nitrogen oxide emissions for different speeds are represented in figure 5.

Fig. 5 NO_X emissions at different Speeds **CO_2 emissions**



The carbon dioxide emissions for different speeds are represented in figure 5.

Fig. 6 CO_2 emissions at different speeds



RESULTS AND DISCUSSION

In this experimental work, the Diesel engine is changed to CNG engine with various modifications. The experimental study on the emission characteristics of direct injection natural gas engine was studied. The CNG fuel system consists of gaseous injectors, pressure gauge, and a cylinder with CNG, pressure controller, mass

flow controller, and high pressure pipe line. The experiment conducted at engine speeds varying from 1000 to 3500 rpm with interval of 500 rpm under the full load condition. The flow of CNG find from the equipment of fuel consumption measuring instrument. An air flow meter is installed to find the amount of air supplied to the engine. A flue gas analyzer is fitted to quantify the emissions of engine exhaust. Emissions from the engine contain oxides of nitrogen oxide (NO_X), carbon monoxide (CO), and unburned hydrocarbons (HC). NO_X is resulted due to the reactions of nitrogen and oxygen at higher pressure and temperature. Carbon monoxide emissions are found due to the incomplete combustion of fuel that takes place due to insufficient supply of oxygen. Hydrocarbons are produced in the engine exhaust whilst the gas does not burn absolutely.

CONCLUSIONS

The experimental study of the exhaust gas emissions of CNG is conducted various graphs were plotted. The experimental analysis results indicated that utilizing alternate CNG fuel is a smart resolution to exchange ancient energy sources so as to cut back exhaust gas emissions.

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