EXPERIMENTAL INVESTIGATION OF INJECTOR ORIENTATION AND ITS EFFECT ON EXHAUST EMISSION OF DIESEL ENGINE IN COMPRESSED NATURAL GAS ENGINE

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ABSTRACT:

This paper focuses on the experimental investigation by changing the injector orientation angle at the manifold and discusses the outcomes from the experiment. This study will concentrate on enhancing the compressed natural gas engine based on computation and experimental study. The paper is discusses about the development of sequential injection dedicated compressed natural gas based from four stroke direct injection diesel engine, and the effect of different parameters on exhaust emissions of diesel engine.

KEWWORDS:

Internal combustion engines, compressed natural gas, dual fuel engines.

INTRODUCTION:

The internal combustion engine is an engine in which the combustion of fuel and an oxidizer (typically air) occurs in a confined space called a combustion chamber. This exothermic reaction creates gases at high temperature and pressure, which are permitted to expand. Internal combustion engines are defined by the useful work that is performed by the expanding hot gases acting directly to cause the movement of solid parts of the engine. [1] The term Internal Combustion Engine (ICE) is often used to refer to an engine in which combustion is intermittent, such as a Wankle engine or a reciprocating piston engine in which there is controlled movement of pistons, cranks, cams, or rods. Internal combustion engines are also an important source of noise [6]. There are several source of engine noise: the exhaust system, the intake system, the fan used for cooling, and the engine block surface. The noise may be generated by aerodynamic effect, may be due to forces that result from the combustion process, or may result from mechanical excitation by rotating or reciprocating engine components. The motion of internal combustion engines is usually performed by the controlled movement of pistons, cranks, rods, rotors, or even the entire engine itself.

In sequential injection compressed natural gas engines, gas is injected by nozzle injector through inlet manifold into combustion chamber and mixed with air before ignition of the gas fuel [6]. Once ignition occurs, there is a rapid energy release resulting from the combustion of the fuel mixed during the ignition delay followed by a slower energy release limited by the availability of gaseous fuel and its mixing rate with air [9]. To get better mixing process of compressed natural gas fuel and air in combustion chamber, by arranging of nozzle hole geometry, modifying piston head, letting the air intake in the form of turbulent and changing the compressed natural gas fuel angle of spray [4] [10]. The main objective of this research paper to find out the various effects on exhaust emission experimentally by using dual fuel engine.

LITTERATURE REVIEW:

Wendy et al, discusses about ignition characteristics of a dual fuel diesel engine. By the calculate approximately cylinder pressure of the engine worked on pure diesel and dual fuel, the ignition delays, impacts of pilot diesel and engine load on ignition attributes are investigated and Emissions of HC, CO, NOx and smoke are estimated and considered as well. The results showed that the quantity of pilot diesel mainly effects the operation of a dual fuel engine at low load working conditions. Smoke is much lower for the made dual fuel engine under all the working conditions [14].

In this paper White TR et al, described the methodology for dual fuel which gives the alternate method for operation of diesel engines on alternative fuels. The Fluent software is being utilized to display the injection of two such fuels simultaneously into an engine. The CFD models have been at first used to utilizing rapid pictorial representation of the planes. Individual introductions and arranging of the planes regarding each other are presently being re-enacted. Various orientations and staging of the injectors with respect to each other are now being simulated. Salient features of the two fuel injectors are being studied to optimize the design of a dual-fuel injector for diesel engines [16].

Kar T and Agrawal AK demonstrate the trial test results of a compressed natural gas direct injection engine which has been created by adjusting a single cylinder diesel engine." The changes have been finished by three ways which are by doing modification in piston head and crown etc. By design and implementing electronic fuel injection system and by setting up a capacitive discharge ignition system. Results showed that at moderate speed brake mean effective pressure is increases which helps to lowered the emissions. By advancing the injection one can reduce the emissions and increase the brake thermal efficiency and volumetric efficiency. [16]

In this review paper Semin RA et al, showed that natural gas shows potential as secondary fuel to meet today's emission norms regulations in numerous nations. However the utilization of natural gas as a heavy vehicles fuel has been considered advanced over the last ten years by the development of light weight high-pressure storage cylinders. For diesel engines converted to run on natural gas, there are two main options discussed, there are dual-fuel engines and normal ignition can be initiated.[12]

Kim MH et al done the computationally the interior stream attributes in the admission complex of six cylinder compression ignition engine for the variety of spacer and chamber width under consistent state. The shown conditions for estimating three dimensional and incompressible flow had been represented. The two conditions k-e model to consider the abnormality of the geometry and smooth movement. The general flow field inside the intake manifold and different amounts, for example, weight, and speed circulation were analyzed. [9]

In this paper the objective of Ismail AR and Bakar RA was to reassess the earlier investigation in the modification fuel injector of gas for port injection in dual fuel engine. Firstly several alternative fuels has been find which are having less pollutant emissions compared to diesel fuel. Natural gas is the best alternative for compatibility of environment than conventional diesel engines had been discussed. [7]

RESEARCH OBJECTIVE:

This study will concentrate on enhancing the compressed natural gas engine based on computation and experimental study. The paper is discusses about the to design and development of sequential injection dedicated compressed natural gas based from four stroke direct injection diesel engine.

EXPERIMENT METHODOLOGY:

The test is performed for the investigation of performance and emission characteristics of the engine when it runs on a diesel and a dual fuel natural gas-diesel system. The first goal of this study is to examine the performance and emissions at different loads for both diesel and dual fuel operations. Then, the effect of various location of injector at various angle and gas is supplied at various pressures. The gaseous fuel used in this experiment is natural gas. Experimental results will serve as validation data for combustion modelling

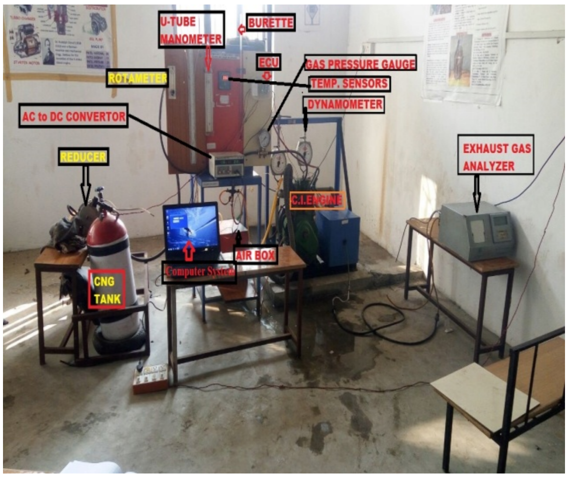

FIG.1 EXPERIMENTAL TEST SET UP

The experimental setup which consists of a single-cylinder, four-stroke, vertical liquid cooled, direct injection, natural aspirated, diesel engine which is connected to rope brake dynamometer for various loading of the engine. Experiments were conducted with pure diesel and dual fuel mode (diesel & compressed natural gas) at different loads when engine speed was constant at 1400 rpm. Prerequisite is also made for interfacing air flow, fuel flow, temperatures and speed measurement. Especially man made electronic control module was used to control the gas flow inside the combustion chamber. The emphasis is on different injector locations viz 0, 45, 60 105, 225,240,315 degrees and varying gas pressure at 225 degree and comparison of the engine performance with Diesel alone and dual fuel mode. The layout of experimental set up is shown in figure.

RESULT AND DISCUSSION:

LOAD (KG) VS NOx (ppm) FOR VARIOUS CONDITIONS:

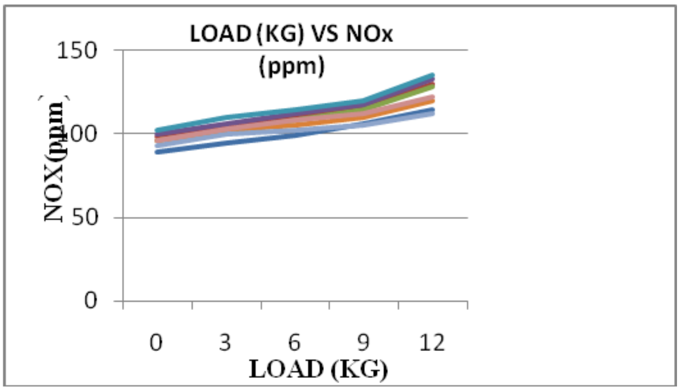

FIG.2 LOAD VS NOx(ppm)

This graph illustrates the Nox which is the most hazardous gas emitted by diesel engine. It is made of Nitrogen Monoxide (NO) and Nitrogen Dioxide (NO2). The critical time for the formation of oxides of nitrogen in compression ignition engines is between the start of combustion and the occurrence of peak cylinder pressure when the burned gas temperatures are the highest. As it can be seen that at low load condition the value of NOx is minimum (89 ppm) when vehicle was running of pure diesel mode. The value of NOx is maximum (135 ppm) when injector is located at 105 degree and engine was running on dual fuel mode. The basic reason for at this degree mixing of air and gas is not appropriate and less turbulent flow as it can be seen from the simulation result. Lower turbulence results the higher nitrogen oxide formation. At full load condition which is the most running condition for any diesel engine the value of NOx is 114 ppm when vehicle is running on full load condition at only in diesel mode. The minimum value of NOx had been achieved 112 ppm by locating the injector at 225 degree and gas was injected by 3 bar pressure inside the manifold while vehicle was running on dual fuel mode.

LOAD (KG) VS O_2 (%) FOR VARIOUS CONDITIONS

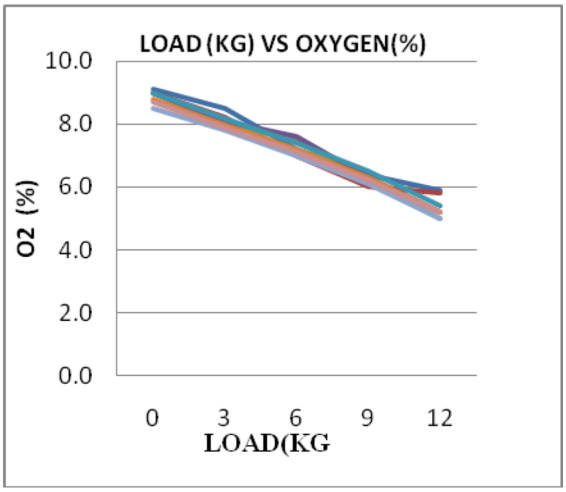

FIG.3 LOAD VS O_2 (%)

It can be seen from above graph the oxygen density plays a vital role in combustion process. Higher oxygen density increases the detonation phenomenon in diesel engine. When O_2 density is less than 50%, the high temperature mainly appears at the peripheral area, and, also, the highest temperature is under 800 K. It can be seen from above graph the value of oxygen remains almost same while engine was running at different load either in pure diesel mode or in dual fuel mode.

LOAD (KG) VS CO_2 (%) FOR VARIOUS CONDITIONS

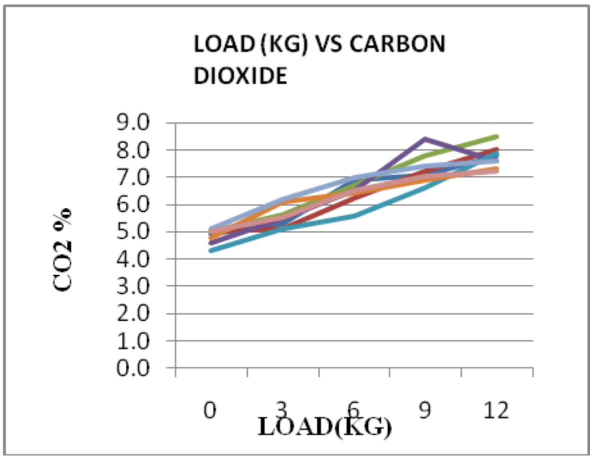

FIG.4 LOAD VS CO_2(%)

The above graph illustrates the Carbon Dioxide (CO_2) emission gas which emits by the engine is very harmful to environment as well as human beings. The percentage of carbon dioxide greatly depends on the carbon content in fuel. The diesel fuel has high carbon content as compared to compressed natural gas. So one can said that the dual fuel engines emit less carbon dioxide as compared to the conventional diesel engine. It can be seen from above graph when vehicle was running in dual fuel mode the percentage of carbon dioxide is less when injector is located at 225 degree and gas is injected at 3 bar pressure inside the manifold. It is also evident from above graph that the value of CO_2 became maximum (8.5%) when injector is located at 60 degree and gas is injected at atmospheric pressure inside the manifold when engine is running on dual fuel mode.

LOAD (KG) VS CO(%) FOR VARIOUS CONDITIONS

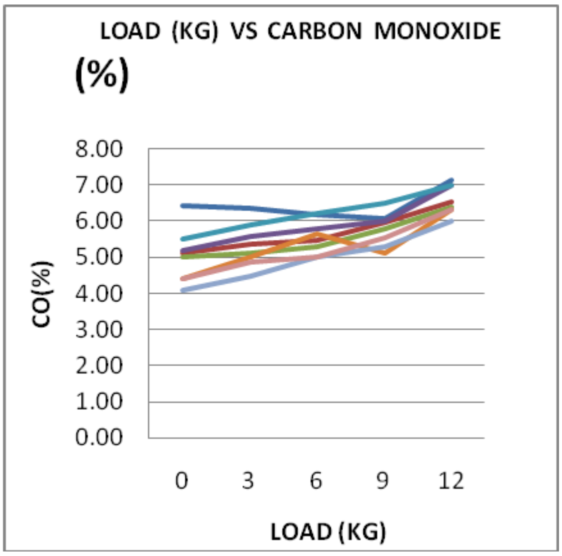

FIG.5 LOAD VS CO(%)

The maximum value of CO emission is 5.4 while engine was running of pure diesel mode. It can be seen from the graph the CO emissions differ when injector location is changed on the manifold. It is clearly evident from above figure CO emission changes when injector is located at various angles. The values of CO emission are 6.54, 7.6,7,7 at 0 degree, 45 degree, 60 degree and 105 degree respectively. It has been noted that in above conditions gas is injected at atmospheric pressure inside the manifold. The value of CO emission decreases up to 6 when injected is located at 225 degree and gas is injected at 3 bar pressure inside the manifold while engine was running on dual fuel mode. The values of CO emission are remaining almost same (6.31) when gas is injected at 2 and 5 bar pressure inside the manifold where location of injector is fixed to 225 degree. So it can be said that in dual fuel engine CO emission is reduced as compare to conventional diesel engine.

LOAD (KG) VS HC (ppm) FOR VARIOUS CONDITIONS

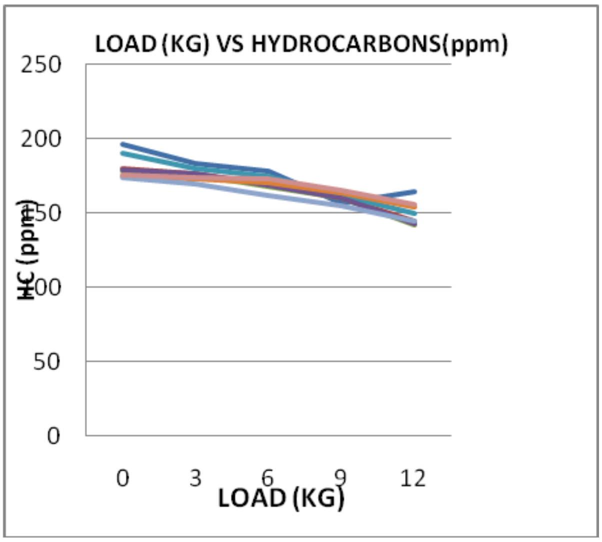

FIG.6 LOAD VS HYDROCARBONS (PPM)

Graph 5.5 shows HC levels in the exhaust for dual fuel and diesel operating modes across the all various injector locations and at various loads. The HC emissions for all cases decrease with increasing loads and reaches to its minimum value at full load condition. The main reason of this the air and natural gas are very lean, especially at low loads. The extent of penetration of the burning diesel jet may play a critical role in oxidizing the lean natural gas/air mixture. At low loads the natural gas and diesel jet penetrations are the lowest, likely contributing to higher HC emissions at low load. The high HC emissions for dual fuel are therefore a product of incomplete combustion, primarily, of the lean air and natural gas mixture. HC emissions are inhibited by the quality of the combustions process inside the cylinder. The movement in HC emissions is similar for dual fuel and diesel, but in dual fuel mode the HC emission reaches to 145 ppm while injector angle at 225 degree and gas is injected at 3 bar pressure as compared to the value of normal diesel mode which is 157 ppm.

CONCLUSION

Engine performance emissions of CO_2, CO, HC, and NOx & O_2 were tested in this experimental investigation.

Four stroke diesel engines at 1500 rpm engine speed at different load and gas is injected from different injector angle as well as different pressure into the manifold which mixes with air before air enters into the combustion chamber From the experimentation following conclusions has been made:

- Under low-speed and low-load operating conditions, the rate of pressure rise is rather high so HC and CO emissions are increased with increase in load. To decrease the emission slightly increase in the pilot diesel can extend the lean burning limit and decrease HC and CO emissions, but has the opposite effect on NOx emission.
- CO emission is increased as load on engine increased. CO emissions are decreased as compressed natural gas is injected in inlet manifold. The lowest value of CO it has found 6% when the injection angle was 225 degree and pressure was 3 bar. Its value is closer to 225 degree 5 bar pressure.
- As load increases from 0 kg to 12 kg CO_2 emissions are continuously increases. If emissions of CO_2 for diesel are compared to diesel blends, it was found to be decreasing.
- The result shows that, as blending increases, NOx emission was continuously decreased as load is increasing gradually. As compared to diesel fuel, NOx emission from blends fuels was increased. At highest load NOx of diesel is about same to compressed natural gas when injection angle was 225 degree and injection pressure was 3 bar. The result shows that, as blending increase, HC emission was continuously decreased.

REFERENCES

1. Abdul S, Ismail R, Bakar RA. Gas fuel spray simulation of port injection compressed natural gas engine using injector nozzle multi holes. European Journal of Scientific Research, ISSN. 2009:188-93.
2. Bakar RA, Kadirgama K, Rahman MM, Sharma KV. Application of Natural Gas for Internal Combustion Engines. In Advances in Natural Gas Technology 2012. InTech.
3. Chintala V, Subramanian KA. A CFD (computational fluid dynamics) study for optimization of gas injector orientation for performance improvement of a dual-fuel diesel engine. Energy. 2013 Aug 1;57:709-21
4. Donateo T, Tornese F, Laforgia D. Computer-aided conversion of an engine from diesel to methane. Applied energy. 2013 Aug 1;108:8-23.
5. Kar T, Agarwal AK. Development of a single cylinder CNG direct injection engine and its performance, emissions and combustion characteristics. International Journal of Oil, Gas and Coal Technology. 2015;10(2):204-20.
6. Kumar ML, Drakshayani S, Reddy KV. Effect of fuel injection pressure on performance of single cylinder diesel engine at different intake manifold

inclinations. Int. J. Eng. Innov. Technol. 2012 Oct;2(4):20-8.

7. Karagöz Y, Sandalcı T, Koylu UO, Dalkılıç AS, Wongwises S. Effect of the use of natural gas–diesel fuel mixture on performance, emissions, and combustion characteristics of a compression ignition engine. Advances in Mechanical Engineering. 2016 Apr 7;8(4):1687814016643228.
8. Panneerselvam N, Murugesan A, Vijayakumar C, Subramaniam D. Performance, emissions and combustion characteristics of CI engine fuel with watermelon (Citrullus vulgaris) methyl esters. International Journal of Ambient Energy. 2017 Apr 3;38(3):308-13.
9. Sivalingam M, Mahapatra SS, Hansdah D, Horák B. Validation of some engine combustion and emission parameters of a bioethanol fuelled DI diesel engine using theoretical modelling. Alexandria Engineering Journal. 2015 Dec 1;54(4):993-1002.
10. Sharma VK, Mohan M, Mouli C. Effect of intake swirl on the performance of single cylinder direct injection diesel engine. InIOP Conference Series: Materials Science and Engineering 2017 Nov (Vol. 263, No. 6, p. 062077). IOP Publishing.