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A Parametric Study for Optimization of Gas Injector Orientation and Its Effect on Duel Fuel Engine Using CNG as Fuel

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Abstract

The expansion and explore of injection system has always been influenced by the availability and the form of fuel. This research paper is about the revise of the injection nozzle effect of compressed natural gas engine. In this paper study and replicate different location of sequential injection nozzle at different locations using Computational Fluid Dynamics software to find the best air and fuel mixing in the combustion chamber of the engine. The other effect of the Modified injection nozzle is the velocities of the fuel in combustion chamber that can be determine using the software. The length of bore and stroke of the engine is base on the actual diesel engine and been model using Gambit. The air and fuel mixing is very good and better compare with the original injection nozzle. The velocity of fuel in combustion chamber is the highest compare with other design. A methodology for optimization of gas injector orientation for better thermal efficiency is emerged from this study.

Keywords: Compressed natural gas, alternative fuel, engine development, mixture formation

INTRODUCTION

Diesel engines are used for power generation, mass and passenger transportation and off- road application due to higher thermal efficiency [1]. The great problems of the world in the diesel engines usage until today are focuses on environment protection and economically fuel consumption. The problems need the new design, research and technology to find the new engines or its components so it can use of the alternative fuels another gasoline and diesel fuel, protect and friendly with the environment, high power and efficient in fuel consumption. The first choice of alternative fuel is compressed natural gas. By using compressed natural gas (CNG) as an alternative fuel for internal combustion engine will be reduce the engine performance, but the exhaust gas emission and economic operational by using compressed natural gas (CNG) as a fuel is lower than diesel fuel and gasoline fuel[2]. This study will focus on augment dedicated compressed natural gas (CNG) engine development based on computation and experimental[3]. The project is to design and development of sequential injection dedicated CNG engine based from four stroke direct injection diesel engine.

In sequential injection compressed natural gas (CNG) engines, natural gas fuel is injected by fuel nozzle injector via intake port into combustion chamber and mixing with air must occur before ignition of the gas fuel. 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 [3]. To improve the perfect of mixing process of compressed natural gas (CNG) fuel and air in combustion chamber, for example with arranging of nozzle hole geometry, modification of piston head, arranging of piston top clearance, letting the air intake in the form of turbulent and changing the compressed natural gas (CNG) fuel angle of spray[4,5]. The compressed natural gas (CNG) fuel spraying nozzle is the level of earning variation so that can be done by research experiment and computational of engine power, cylinder pressure, specific fuel consumption and exhaust gas emissions which also the variation of them have been researched the sequential injection of compressed natural gas (CNG) offers several advantages to increase the compressed natural gas (CNG) engines performance [6]. Dual fuel engines combine diesel cycle CI combustion and Otto cycle combustion. The diesel engine under development uses excess air, high compression ratio (17:1) and a direct injection combustion chamber design. During dual fuel operation the gas is injected into the inlet air immediately prior to the inlet manifold, the air-fuel ratios are controlled within the lean burn range (21:1 to 27:1 air fuel ratios) and ignition is achieved by pilot injection of diesel. Compressed natural gas can be used in modified Diesel cycle engines [3]. The equipment required for CNG to be delivered to an engine includes a pressure regulator (a device that converts the natural gas from storage pressure to metering pressure) and a gas mixer or gas injectors (fuel metering devices) [10]. Newer CNG conversion kits feature electronic multi-point gas injection, similar to petrol injection systems found in most of today's cars. Compressed natural gas engine require a greater amount of space for fuel storage than convention gasoline power vehicles [9]. Since it is a compressed gas, rather than a liquid like gasoline, CNG takes up more space for each Gallon of Gas Equivalent (GGE). Therefore, the tanks used to store the CNG usually take up additional space in the trunk of a car or bed of a pickup truck which runs on CNG. This project investigate about internal combustion engine using compressed natural gas as an alternative fuel to reduce the pollution from exhaust gas emission and the operation cost of the engine[11].

To improve of compressed natural gas (CNG) nozzle holes geometries and understand of the processes in the engine combustion is a challenge because the compression-ignition combustion process is unsteady, heterogeneous, turbulent and three dimensional, very complex and the nozzle fuel injector hole is can be variation with any hole geometry[2].

RECOMPENSE OF USING CNG-DIESEL ENGINE

The advantage of converting conventional diesel engine to dual fuel CNG-diesel engine is to convert the engine back to 100% diesel operation easily.

It does not require a spark ignition or an electrical system to start the combustion process, instead like spark ignition engine operating on premixed combustion process.

The dual fuel engine works in a diffusion combustion process with a high pressure. Besides that, conversion of diesel engine is more economical than conversion of spark ignition engine due to less modification on the original diesel engine [11].

Since dual fuel engine operates at low compression ratio such as 16:1, the original diesel engine only needs minimum modification to suit the CNG diesel operation.

The cost of conversion for diesel engine is lower compared to spark ignition engine.

CNG-diesel engine is the increase in power output compared to the original diesel engine which must be within the range of up to 3000rpm.

If more than 3000rpm, the power output of CNG diesel engine would decrease slowly due to knocking in the rapid combustion process.

CNG has high octane rating and high ignition temperature, the CNG-diesel engine has a higher resistant to knock than the conventional diesel engine.

Cng fuel characteristic:

Table: 1: Characteristics Of CNG

Sr No.	Characteristics	Value
1.	Vapor density	0.68
2.	Auto Ignition	723°C
3.	Octane rating	130
4.	Boiling point (Atm. Press) -	162°C
5.	Air-Fuel Ratio (Weight)	17.24
6.	Chemical Reaction With Rubber	No
7.	Storage Pressure	20.6Mpa
8.	Fuel Air Mixture Quality	Good
9.	Pollution CO-HC-NOx	Very Low
10.	Flame Speed m per sec	0.63
11.	Combustion ability with air	4-14

Details of i.c. engine simulation:

Ic Engine System Inputs:

- Engine Speed (rev/min) : 1800
- Crank Radius (mm) : 45
- Piston Pin Offset/Wrench(mm): 0
- Connecting Rod Length (mm) : 232.6
- Minimum Lift (mm) : 0.5

Mesh information for ice:

Table 2: Mesh Generations Details

Domain	Nodes	Elements
fluid ch	43010	216913
fluid exvalve 1 port	31927	104374
fluid exvalve1 ib	5824	4368
fluid exvalve1 layer	44000	38000
fluid in valve 1 port	51228	164558
fluid invalve1 ib	4266	3240
fluid invalve1 layer	25000	19200
fluid layer cylinder	2142	2646
fluid piston	3934	17809
All Domains	211331	571108

Nozzle geometry and mesh at different angles:

Boundary Conditions:

- Air Inlet Pressure = 1.01325 bar
- Gas Pressure = 2 bar

Mesh information at different angles:

Table 3: Mesh Details at Different Angles:

Sr No.	Degree	Number of Nodes	No. of Elements
1.	0^0	48935	161117
2.	45^0	49216	160735
3.	60^0	49319	161137
4.	105^0	48550	161792
5.	225^0	50484	166086

Velocity stream lines at different angles:

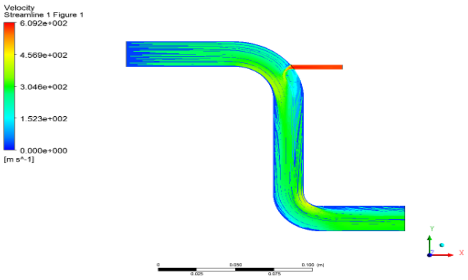


Figure: 4 At 0 Degree

Poorly Mixed Mixture And Very Low Pressure

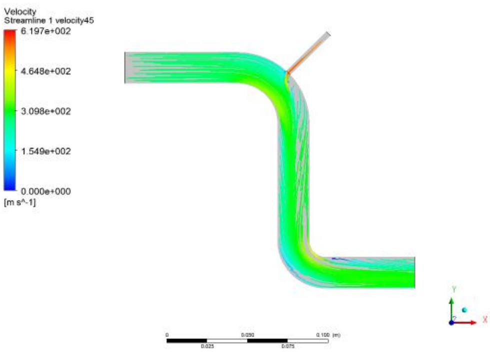


Figure: 5 At 45 Degree

Intermediate Mixed Mixture

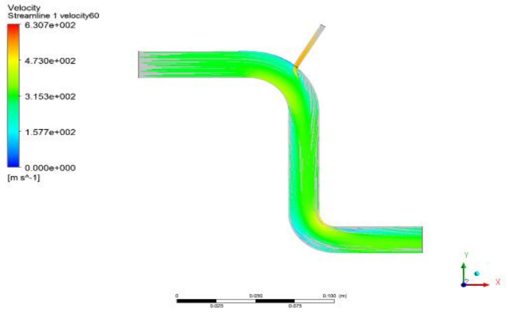
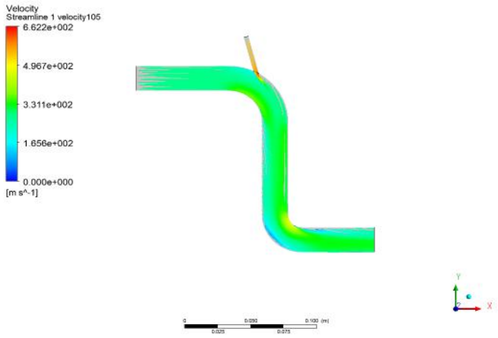


Figure: 6 : At 60 Degree

Better Mixture but Higher Pressure Drop At Edges



x

Figure: 7: At 105 Degree

Very Good Mixture, Highest Velocity But Considerable Pressure Drop At

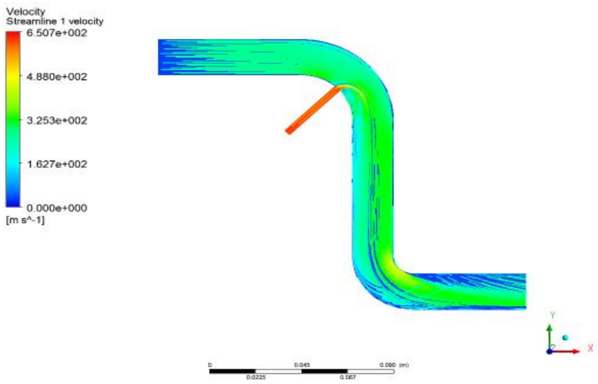


Figure: 8: At 225 Degree

Perfect Mixture and Very Low Pressure Drop at Edges

RESULT AND DISCUSSION

From figure 4 it is clearly manifest that at 0 degree the mixture of incoming air and gas is poor and very low pressure. Figure 5 showed that at 45 degree the mixture is intermediate but loss of pressure is there due to turbulent flow of gas while mixing. Figure 6 showed that at 60 degree the perfect mixing takes place of gas and air but there is considerable pressure drop at edges which is not appropriate for the combustion. Figure 7 showed that at 105 degree very good mixture, highest velocity but considerable pressure drop at edges, figure 8 shows a perfect mixing of gas and very low pressure drop at edges.

CONCLUSION

A methodology for optimization of gas injector orientation for better thermal efficiency is emerged from this study. It is observed from the simulation result that gas injector angle at position of 225^0 with reference to axial axis of intake manifold is the most favourable angle based on better mixture formation characteristics. This study is focused at a constant speed (1800 rpm) diesel engine under CNG-Diesel mode.

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REFERENCES

[1] Semin RA. A technical review of compressed natural gas as an alternative fuel for internal combustion engines. American J. of Engineering and Applied Sciences. 2008;1(4):302-11.

[2] Kim MH, Chung WI, Chyun IB. Three-dimensional flow characteristics and engine performance for the geometry modification of intake manifold in multi-cylinder diesel engine. SAE paper. 2000 Jun 12:05-020

[3] Ismail AR, Bakar RA. Diesel engine convert to port injection CNG engine using gaseous injector nozzle multi holes geometries improvement: a review. American Journal of Engineering and Applied Sciences. 2009 Jan 1;2(2):268-78.

[4] Ismail AR, Bakar RA. Effect of diesel engine converted to sequential port injection compressed natural gas engine on the cylinder pressure vs Crank angle in variation engine speeds. American Journal of Engineering and Applied Sciences. 2009 Jan 1;2(1):154-9.

[5] Ramasamy D, Mahendran S, Kadirgama K, Noor MM. Design of compressed natural gas mixer using computational fluid dynamics. InNational Conference in 2010.

[6] Pandey KM, Roy B. CFD analysis of intake valve for port petrol injection SI engine. Global Journal of Research In Engineering. 2012 Jul 20;12(5-A).

[7] Ehsan M, Bhuiyan S. Dual fuel performance of a small diesel engine for applications with less frequent load variations. Int. J. Mech. Mechatron. Eng. 2010;9(10):30-9.

[8] Donateo T, Tornese F, Laforgia D. Computer-aided conversion of an engine from diesel to methane. Applied energy. 2013 Aug 31;108:8-23.

[9] Kumar NR, Sekhar YM, Adinarayana S. Effects of compression ratio and EGR on performance, combustion and emissions of DI injection diesel engine. International Journal of Applied Science and Engineering. 2013 Mar 1;11(1):41-9.

[10] 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.