IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 20, Issue 2 Ser. I (Mar. – Apr. 2023), PP 67-71
www.iosrjournals.org

Comparison of Port and Sequential injection in CNG operated engine to find the most efficient injection system on basis of different parameters

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Abstract
A comparative performance analysis is being carried out on a four cylinders, four stroke spark ignition engine having displacement volume 1086 cc. The CNG port injection (CNG-PI) system and CNG sequential injection (CNG-SI) were run on single engine. The engine was modified in such a way that engine run on both to run on both CNG-PI and CNG-SI system alternately with common CNG tank and other engine loading and measurement system. The engine was equipped with electrical dynamometer having rheostat type loading. The operating parameters can be obtained on computer screen by loading the computer with engine through switch box. The engine was run over the speed range of 900 rpm to 3000 rpm with incremental speed of 300 rpm. The parameters were calculated by the observations done on both CNG-PI and CNG-SI system. The experimental investigation exhibits that, the average 5-6% reduction in BSFC while the engine was running with CNG-SI system as compared to that of CNG-PI system. Also the engine produced 7- 8% higher Brake Torque and hence higher Brake Power. The engine gives 6-7% higher brake thermal efficiency with CNG-SI system as compared to CNG-PI system.

Keywords*: Compressed Natural Gas (CNG), CNG-PI system, CNG-SI system*

Date of Submission: 05-03-2023 Date of Acceptance: 17-03-2023

I. INTRODUCTION

Natural gas is one of the most promising alternative fuel for conventional vehicle engines because, it has cleaner combustion characteristics and huge reserves, It has high-octane number value (130) and good anti-knock property, CNG has higher self ignition temp about (650-700°C) makes it a safer fuel in case of leakage and that means fire hazards occurs very less in CNG vehicles as shown in Table 1**.**Now-a-days, the CNG is used in the stationary as well as transport engine due to its ease availability of conversion technology **[1].** The performance of bi-fuel engine with port injection system is poor in terms of lower Brake Power and less volumetric efficiency **[2].** The volumetric efficiency plays important role in design of CNG injection system as CNG is a compressible fuel because poor volumetric efficiency directly results into lower Brake Power **[3].**In SI engine, the fuel supply system can be classified as carburettor system, single or multi point port injection and gasoline direct injection system **[4].** Similarly, when SI engine is converted into CNG bi-fuel system,

Table 1: Typical composition (vol. %) of CNG [2].

Component	**Symbol**	**Volumetric %**
Methane	CH_4	94.42
Ethane	C_2H_6	2.29
Propane	C_3H_8	0.03
Butane	C_4H_{10}	0.25
Carbon dioxide	CO_2	0.57
Nitrogen	N_2	0.44
Others	(H_2, O_2, S, etc.)	2

The CNG injection system can be categorized into three different injection strategies as follow (a) A mixer system which is more sophisticated now and known as single point port injection (CNG-PI), (b) A multi point port injection which is known as sequential injection having each cylinder has one injector(CNG-SI) and (c) The CNG direct injection (CNG-DI) system in which the CNG is directly injected into the cylinder at the end of compression stroke as in case of diesel engine **[4].**This research work is carried out to compare the various performance parameters of both CNG-PI and CNG-SI system.

II. EXPERIMENTAL PROCEDURE

The four cylinder Spark ignition engine was modified to work on both (CNG-PI and CNG-SI) injection systems at alternative time period. The specifications of the test engine are listed in Table 2.

The CNG tank was common for both CNG-PI and CNG-SI system. The CNG-PI system was installed to the engine with its all components like pressure reducer, flow control valve, pressure gauge and flexible hoses. The CNG-SI system was also projected from same CNG tank to gas injector rail via its pressure reducer, control valve, pressure gauge and various sensors at different locations of the engine.

The major difference in the operation of CNG-PI and CNG-SI system is that, in the CNG-PI system, 2-3 bar pressure is sufficient for a single gas injector to inject CNG fuel in the air induction system (throttle body). It is mixed with the air and then the CNG-air mixture is flowing towards the intake system to enter in the cylinder during suction stroke by opening the inlet valve. In the CNG-SI system, only air is inducted during the suction stroke and the CNG is injected in the cylinder directly at the starting of compression stroke with injection pressure of 4-5 bar. The engine was run alternately with CNG-PI and CNG-SI system keeping the operating parameters constant and the observations were recorded.

Table 2. Engine specification

Items	**Particular**
Engine Make & Type:	Hyundai Santro Xing, 4-cylinder, inline, 4-stroke,12-valves water cooled petrol engine
Bore × Stroke (mm):	67 × 77
Displacement volume (cc):	1086
Number of cylinder:	4
Compression ratio:	8
Ignition:	Spark ignition
Loading:	Electrical dynamometer with rheostat load bank

III. RESULTS AND DISCUSSIONS

The air temperature inside the laboratory was about 24˚-28˚ C during different observations. The engine was first started with petrol fuel and then that was converted to operate with CNG-PI and CNG-SI system alternately. All the observations were recorded after 2-3 minutes set time required for engine operating on a particular speed and load condition.

Brake Torque

The constant load of 2 kW was applied to the engine during the experiment. Engine was run from 900 rpm to 3000 rpm with 300 rpm incremental speed. It was found that, the Brake Torque is gradually increasing with increasing speed of engine for CNG-PI system. And in CNG-SI system the Brake Torque is decreased initially up to 1800 rpm speed and then increased suddenly. As shown in Figure 1. The CNG-PI system produces less Brake Torque than CNG-SI system at same speed and load condition. Because of lack of energy conversion the Brake Torque loss is seen in CNG SI systems, the variation in cylinder pressure also results into lower Brake Torque for the CNG-SI system at initial starting condition. In general, the CNG-SI system shows 7 to 8 % higher Brake Torque than CNG-PI system over the entire speed ranges.

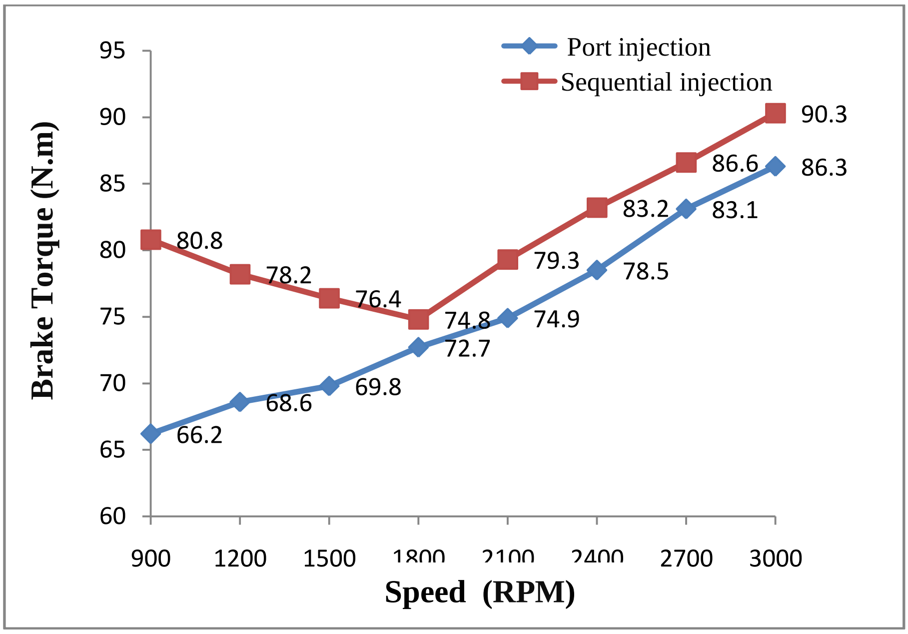

Figure 1. Variation of Brake Torque with engine speed

Brake Power

The constant 2kw load is applied on the engine while conducting test. Figure 2 shows the variation of break power with increasing engine speed from 900 to 3000 rpm speed range .The CNG-SI system produces 4 to 5% higher break power at maximum speed of 3000 rpm than that of CNG-PI system. In the speed range from 900 rpm to 1800 rpm, the CNG-SI system produces approximately 9% higher Brake Power than CNG-PI system because of higher Brake Torque corresponding to volumetric efficiency. And for all speed range Averagely CNG-SI system produces 6 to 7 % higher break power than CNG-PI system.

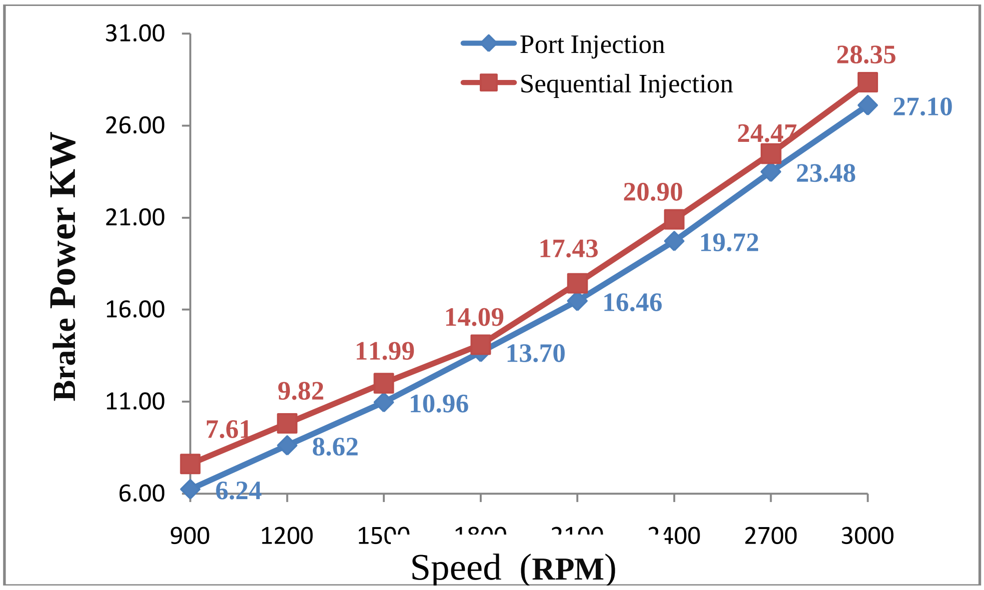

Figure2. Variation of Brake Power with engine speed

Brake Specific Fuel Consumption

Figure 3 shows the variation of Brake Specific Fuel Consumption **(**BSFC) with engine speed for given speed range from 900 to 3000 rpm during starting, the BSFC remains almost constant up to 1500 rpm for the CNG-PI. And then the BSFC decreases after 1500 rpm due to rise in fuel efficiency and again after 2100 rpm it started increasing with speed for CNG-PI system due to increasing frictional effect.

The BSFC for CNG-SI system is higher than CNG-PI system initially up to 1500 rpm due to less conversion of chemical energy into mechanical energy related to volumetric efficiency. After 1500 rpm speed, the BSFC decreases constantly for CNG-SI system due to high speed volumetric efficiency also increases so this effect is seen. Overall, the average BSFC of CNG-SI system is 5 to 6 % lower than that of CNG-PI system at same speed range.

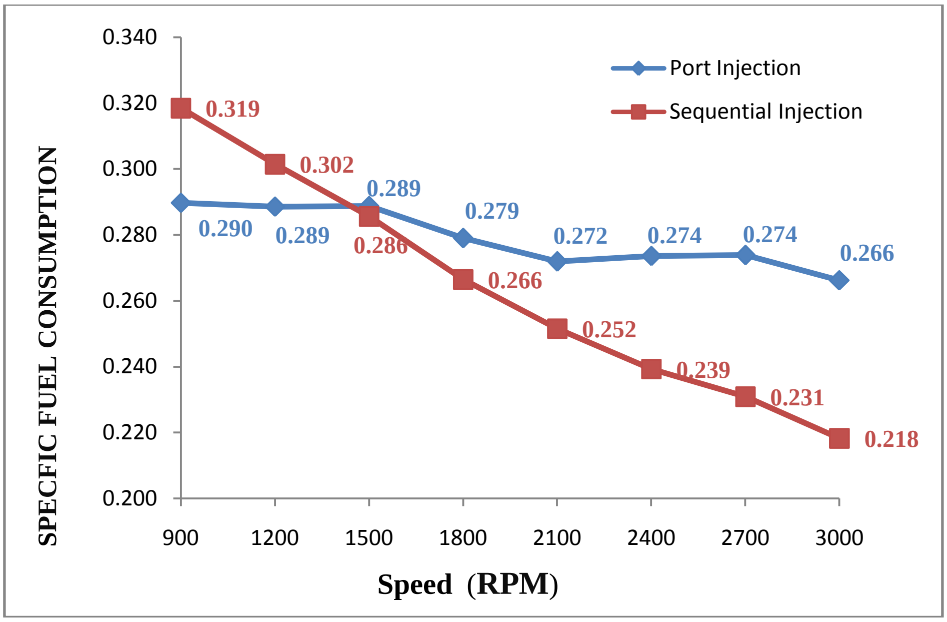

Figure 3. Variation of Brake Specific fuel consumption with engine speed

Brake Thermal Efficiency

The Brake thermal efficiency is a ratio of Brake Power to the fuel consumption into calorific value (CV) fuel (BP/FC*CV).calorific value of CNG taken for reading is (50000).In Figure 4, it is seen that brake thermal efficiency for CNG-PI system remains almost constant up to 1500 rpm and then increases gradually after 1500 rpm to 2100 rpm and then from 2100 to 2700 rpm again the efficiency is decreased and then at end 2700 to 300 rpm means at high speed again thermal efficiency increases.

The brake thermal efficiency of CNG-SI system increases gradually with increasing Speed (rpm).The brake thermal efficiency for CNG-SI system is lower than CNG-PI system initially up to 1500 rpm speed only. Then after 1500 thermal efficiency increases till 3000 rpm. However, the brake thermal efficiency of CNG-SI system is about 6 to 8 % higher than that of CNG-PI system over the speed range from 1500 to 3000 rpm.

This shows that by injecting the CNG directly in the cylinder increases volumetric efficiency which directly affects the Brake thermal efficiency of engine because the specific fuel consumption gradually decreases with increasing speed so the brake thermal efficiency increases.

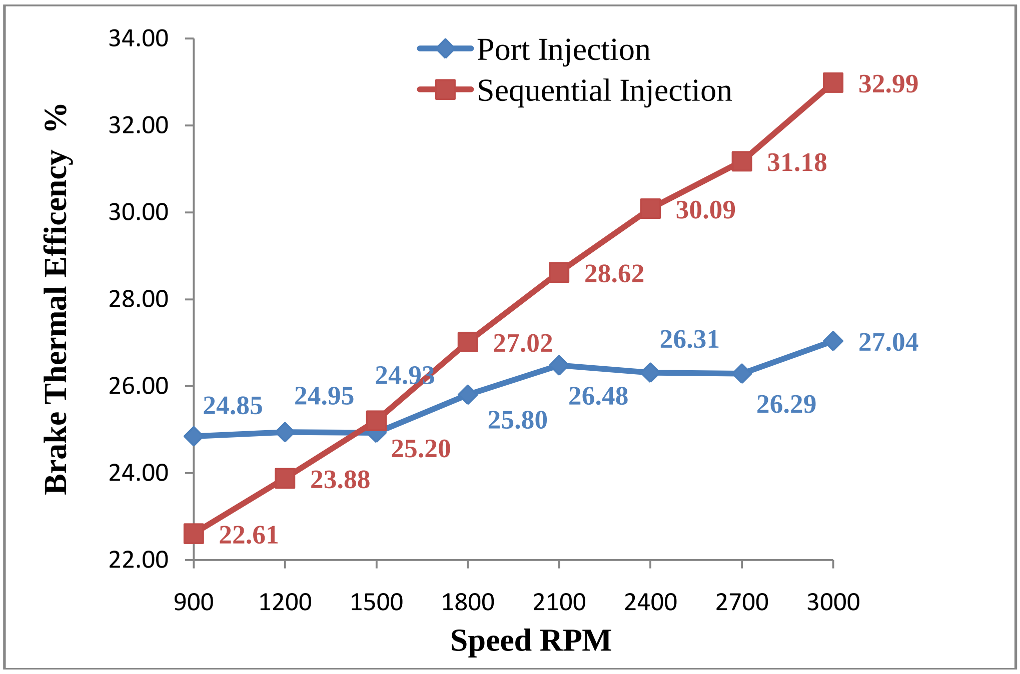

Figure 4. Variation of Brake Thermal Efficiency with engine speed

IV. CONCLUSIONS

After the experimental investigation, the given affirmative conclusions are drawn:

- On an average, the CNG-SI system produced 6-7 % higher Brake Power than the CNG-PI system at same speed range.
- At same rpm range we can see that Brake Torque is 7 to 8 % higher for CNG-SI system than CNG-PI system
- The average BSFC is approximately 6 to 7% lower of CNG-SI system than the CNG-PI system because of high volumetric efficiency.
- The brake thermal efficiency is 6 to 7 % higher for the CNG-SI system than the CNG-PI system due to higher volumetric efficiency more amount of heat energy is converted into mechanical energy of heat energy into mechanical work

REFERENCES

[1]. Semin, R. A. B. (2008). A technical review of compressed natural gas as an alternative fuel for internal combustion engines. Am. J. Eng. Appl. Sci, 1(4), 302-311.

[2]. Kalam, M. A., Masjuki, H. H., Mahlia, T. M. I., Fuad, M. A., Halim, K., Ishak, A.. & Shahrir, A. (2009). Experimental test of a new compressed natural gas engine with direct injection.

[3]. Patel, R., & Brahmbhatt, P. (2018). Performance characteristics comparison of CNG port and CNG direct injection in spark ignition engine. European Journal of Sustainable Development Research, 2(2), 26.

[4]. Aziz, A. R. A., & Shahzad, R. (2010). Combustion analysis of a CNG direct injection spark ignition engine. International Journal of Automotive and Mechanical Engineering, 2, 157-170.

[5]. Amiruddin, H., Mahmood, W. M. F. W., Abdullah, S., Mansor, M. R., & Abdollah, M. F. (2017). Experimental Investigation of Performance and Emissions of a Stratified Charge CNG Direct Injection Engine with Turbocharger. In MATEC Web of Conferences (Vol. 124, p. 07004). EDP Sciences.

[6]. Chehroudi, B. (1993, December). Use of natural gas in internal combustion engines. In International non-renewable energy sources congress (pp. 1-5).

[7]. Shinde, T. B. (2012). Experimental investigation on effect of combustion chamber geometry and port fuel injection system for CNG engine. IOSR J Eng, 2(7), 49-54.

[8]. Geok, H. H., Mohamad, T. I., Abdullah, S., Ali, Y., Shamsudeen, A., & Adril, E. (2009). Experimental investigation of performance and emission of a sequential port injection natural gas engine. European Journal of Scientific Research, 30(2), 204-214.

[9]. Kar, T., & Agarwal, A. K. (2015). Development of a single cylinder CNG direct injection engine and its performance, emissions and combustion characteristics. International Journal of Oil, Gas and Coal Technology, 10(2), 204-220.

[10]. Sankesh, D., Edsell, J., Mazlan, S., & Lappas, P. (2017). Comparative study between early and late injection in a natural-gas fuelled spark-ignited direct-injection engine. Energy Procedia, 110, 275-280.

[11]. Idris, A., & Bakar, R. A. (2009). Effect of port injection CNG engine using injector nozzle multi holes on air-fuel mixing in combustion chamber. European Journal of Scientific Research, 34(1), 16-24.