Study of Performance and Emission Characteristics of a Two Stroke SI Engine Operated with Gasoline Manifold Injectionand Carburetion

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Abstract

Objectives: Developed a simple electronic controlled injection system was used in a two stroke single cylinder air cooled SI engine which injects the gasoline in the intake manifold aiming to improve the performance and reduce the emission.

Methods/Analysis: The engine test was carried out at constant speed of 3000 rpm at various throttle conditions. In order to get maximum thermal efficiency best injection timing was selected for each throttle position and the results compared with carburetion systems. Findings: The Brake thermal efficiency increases in gasoline manifold injection. However, the NOx emission exhibited a different trend with higher emission compared to carburetted system One of the important features of gasoline manifold injection is it can be lead to a high output power than the gasoline carburetion system. Application/improvement: Under all operating conditions the manifold injection had lower HC and CO emissions than the gasoline carburetion system.

Keywords: Gasoline, Manifold Injection, SI Engine

1. Introduction

Two stroke engines are generally used to power three wheelers, popularly called auto-rickshaws in India. They are also used in high performance small motorcycles, marine outboard motors, snow mobiles, model airplanes and hand held tools. In spite of the fact that two stroke engines are less efficient and more polluting they still remain attractive mainly due to their simple design, compactness, lower weight and durability. The main impediments to the continued use of two stroke engine are poor scavenging, short circuiting of fuel at full throttle conditions and dilution of fresh charge at part loads. In order to make two stroke engines viable to meet the emission norms, electronic fuel injection can be used. In order to understand whether this modified Electronic Fuel Injection (EFI) system results is lower fuel short circuiting and emission several researches have been conducted. In order to improve fuel injection to improve fuel economy and reduce hydro carbon emissions by low pressure electronic injection of gasoline in110cc two stroke SI engine. In2 attempted low pressure electronic injection of gasoline in 96.8 cc motorcycle engine which considerably improved the fuel economy. In3 concluded that the maximum brake mean effective pressure developed is higher for the injected engine compared to carburetted engine but the peak values occur at different air fuel ratios. For the same air fuel mixture quantity the carburetted engine produces lower power output and hence lower brake thermal efficiency. Incomplete combustion and fuel short circuiting can be attributed to these phenomena. In4 employed low pressure injection of compressed natural gas to investigate the performance and emissions of a 398cc, two stroke SI engine. Air fuel mixture was injected at the intake port of the engine. Improvements in brake mean effective pressure, fuel consumption and reduction in HC and CO emissions was reported. In5 order to improve
mixture formation inside the engine air assisted injection system which utilizes the crank case compressed air was developed by previous researchers. The compression wave generated by compression process is used by cobb to inject air and fuel mixtures. In found that fuel stratification long the cylinder axis is influenced by injection timing. In order to reduce fuel short circuiting fuel injection is done after both the parts are closed. In reported that a 59cc two stroke SI engine consumed lower fuel and better emission for a modified case of manifold injection. In have designed and implemented a discontinuous inlet injection system for a 350cc 2stroke SI engine. The performance and emissions were analyzed and optimized for the engines with injector located at the port.

2. Experimental Setup

A single cylinder 2 stroke SI engine (Make TVS) is used in the analysis. The specifications are provided in Table 1. The eddy current dynamometer is used as a loading device. The fuel flow is measured using an electronic weighing machine. Air flow is measured by means of a turbine flow meter. In order to reduce the fluctuation of the incoming air, a surge tank is fitted. An NDIR gas analyzer (Make: HORIBA, Japan) was used to measure exhaust gas emissions of HC, CO, and NOx concentrations. The photograph view of manifold injection system is shown in Figure 1. The schematic of the engine setup is shown in Figure 2.

| Table 1. Engine Specification |
|--------------------------------|
| Type of engine | Air cooled, single cylinder Two-stroke, S.I engine |
| Bore x Stroke | 61 mm x 68.2 mm |
| Make | TVS-king |
| Compression Ratio | 7.7:1 |
| Displacement volume | 199.3cc |
| Power | 3.4 @ 3000 rpm, |
| Mixture induction | Reed valve |
| Scavenging system | Loop scavenging |

3. Electronic Injection System

The engine was modified with an electronically operated fuel injector mounted at the manifold (transfer port). The 12V input DC supply is used to energize the solenoid controlled fuel injector. The fuel is supplied to the injector through 12V DC electrical fuel pump and pressure regulator, providing fuel pressure up to 2
bars. The fuel injector has been designed and calibrated to work seamlessly at all load conditions of the engine. A line diagram indicating the main components of the fuel injectors is shown in Figure 3 the output from the crank angle position encoder is used to control and trigger the multi-vibrator circuits, which are used to control the fuel injection duration. To set the injection duration and timing potentiometers are used. This circuit was used to study the performance of the engine under different injection timings and durations. Initially the flow rate of the injector at different pulse widths was measured. This was done when the engine was run at constant speed of 3000 rpm at different throttle positions.

Figure 3. Injection timing circuit

4. Results and Discussion

Experimental results obtained for manifold injection and carburetion under different throttle conditions at constant speed of 3000 rpm are discussed in this chapter. The engine performance like brake thermal efficiency, air-fuel ratio, brake specific fuel consumption, exhaust gas temperature and emissions parameters such as hydrocarbon, carbon monoxide, oxide of nitrogen of gasoline manifold injection were compared with gasoline carburetion.

The Figure 4 compares the brake thermal efficiency and brake power of gasoline manifold injection and gasoline carburetion. The maximum brake thermal efficiency obtained was 22.1% at brake power 2.9 kW for gasoline manifold injection. But for gasoline carburetion, the brake thermal efficiency obtained was 20.9% only at the same power. Gasoline manifold injection showed marginally better brake thermal efficiency in comparison with carburetion. This is because of better air fuel mixture preparation in the case of manifold injection.

The Figure 5 shows the variation of brake power with air-fuel ratio. It can be seen that the maximum air-fuel ratio is 19.5 for gasoline manifold injection and 14.7 for gasoline carburetion at brake power 2.5 kW. It is obvious that the air-fuel ratio falls with a non-linear behavior from the richest condition at maximum load due to wide open throttle at which more air goes to the engine. This implied that at lean operating conditions, the engine gives the maximum efficiency 22.4% and air-fuel ratio 19.8 compared with 19.9 % maximum efficiency and air-fuel ratio is 14.3 for gasoline carburetion.

Figure 4. Comparison of brake thermal efficiency

Figure 5. Comparison of air fuel ratio

Moreover, HC emissions were lower for gasoline manifold injection compared to gasoline carburetion as shown in Figure 6. The 20% reduction in HC was obtained for gasoline manifold injection against gasoline carburetion at maximum brake power of about 3 kW. However, at a lower load of about 0.5 kW the HC emissions are 970 ppm for gasoline manifold injection and 0.1 kW the HC emissions are 1242 ppm. The reduction in HC emission is due to better air fuel mixture and hence bet-
ter combustion. Figure 7 compares the CO emissions for each load point at constant engine speed. It is observed that the emissions of CO on gasoline carburetion were always significantly higher than that of gasoline manifold injection. The CO emission at full load is 0.9% by volume for gasoline manifold injection but for gasoline carburetion it is 2% by volume. The formation of CO is highly dependent on the combustion stoichiometry, a reduction in CO emissions can be observed in gasoline manifold injection. Figure 8 shows the exhaust gas temperature of gasoline manifold injection which is higher than that of gasoline carburetion. Maximum exhaust gas temperature in gasoline manifold injection was 366° C and in gasoline carburetion was 323° C. The reason for higher exhaust gas temperature is leaner combustion.

Figure 6. Comparison of HC emission

Figure 7. Comparison of CO emissions

Figure 9 shows comparison of NOx emission with brake power. It was observed that NOx emission in gasoline manifold injection is always higher than gasoline carburetion due to the use of leaner mixture. Furthermore the temperature in the combustion chamber is higher due to vaporization of the fuel in this case of gasoline manifold injection.

Figure 8. Comparison of exhaust gas temperature

Figure 9. Comparison of NOx emission

Figure 10 shows the Brake Specific Fuel Consumption (BSFC) with brake power. It indicates that there is large difference between the fuel consumption rates of the gasoline manifold injection and gasoline carburetion for same load. Fuel consumption that depends on thermal efficiency is defined as the mass flow rate per hour, and it may depend on the increase of brake power rather than the increase of fuel quantity. The reason for lower fuel consumption with gasoline manifold injection is leaner air fuel ratio used to get the same power when compared to gasoline carburetion.
5. Conclusion

The following conclusion can be drawn from the performance and emissions studies of gasoline manifold injection and gasoline carburetion in a two-stroke SI engine operated at a constant speed of 3000 rpm:

- The brake thermal efficiency increases with gasoline manifold injection. A power output of 2.4 kW the brake thermal efficiency is about 22.1% for the manifold injection. It is decreased to 20.3% with the gasoline carburetion.

- The HC and CO emission for gasoline manifold injection is lower than the gasoline carburetion system for all operating conditions.

- In gasoline manifold injection the NOX are higher than the gasoline carburetion due to the use of leaner mixtures. This due to higher combustion temperature and oxygen availability due to improved combustion.

- The exhaust gas temperature of the gasoline manifold injection is higher than gasoline carburetion.

- The BSFC is decreased for gasoline manifold injection compared to gasoline carburetion.

Gasoline manifold injection engine can work with leaner mixtures as compared to gasoline carburetion. One of the important features of gasoline manifold injection is it can be lead to a high output power than the gasoline carburetion system.

6. References

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