# Performance Improvement of 4-Stroke S.I. Engine Using Vapour Fuel Technology

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***Abstract*—This paper covers information on the performance improvement of four stroke I.C engine by using vapor fuel technology. Due to the thermal losses and incomplete combustion, the efficiency of an I.C engine is in the range of 25% to 30%. The efficiency may increase with the reduction in these losses.There are many losses in the engine like heat loss, friction loss, inertia loss, combustion loss etc. In our project we had concentrated in minimizing the heat and combustion losses. For that it is necessary that maximum amount of fuel energy must be absorbed in combustion chamber of engine.**

**The experiment was carried out on the 4-stroke petrol engine in which the convention fuel intake system had been replaced by another system called "vapor fuel system". In this fuel supply system, the fuel is supplied to engine in form of vapor. So this modification in fuel supply system improved the combustion in combustion chamber minimizing the heat and combustion losses and more power was absorbed by engine so there was the improved performance of the engine. The engine was tested for the both conventional and fuel vapor system and the engine performance was checked for the each case.**

***Keywords*—Complete combustion, Engine Performance Test, Fuel Supply System, Vapor Fuel technology.**

## I. INTRODUCTION

Normally, the petrol engines are 20%-30% efficient. Major losses associated with the engine performance are Exhaust losses (38%), Friction loss (6%), cooling loss (36%) and the useful power available is about 20%.

In conventional engine, Gasoline is supply in the form of mist in the combustion chamber with help of carburettor. Due to this following problems are occurs,

- Incomplete combustion of fuel
- Detonation and knocking

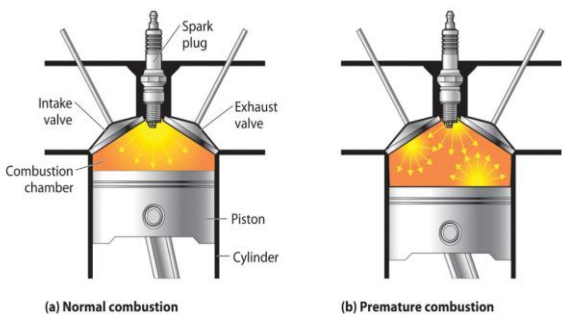



Fig.1 Knocking and Detonation

Detonation and knocking induced in engine because of pre mature combustion as shown in figure.

By analyzing the exhaust gas content, one can know that there are some unburnt HC (Hydro Carbons) that is a fuel loss. These problems were solved by introducing gasoline in the form of vapor. This is called vapor fuel technology. Due to this, complete combustion has been taken place inside the engine combustion chamber.

## II. VAPOR FUEL SYSTEM

To reduce the combustion losses and to make the complete combustion in the combustion chamber, the vapor fuel system is used.

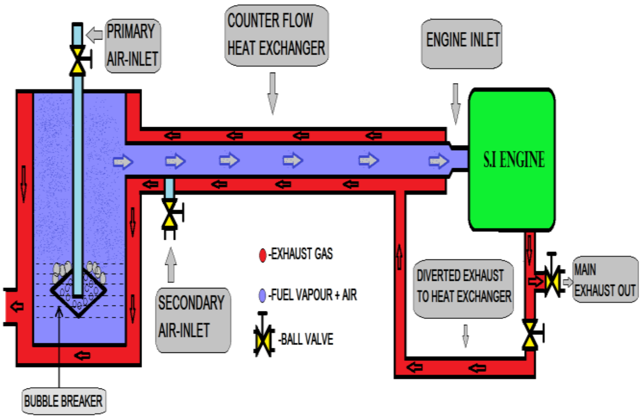



Fig.2 Schematic diagram of vapor fuel system

The major components of the system are,

- Bubbler
- Heat exchanger

By generating bubbles in the fuel tank, so some amount of fuel was vaporized. The heat was supplied from engine exhaust for increasing the fuel temperature so vapor was generated.

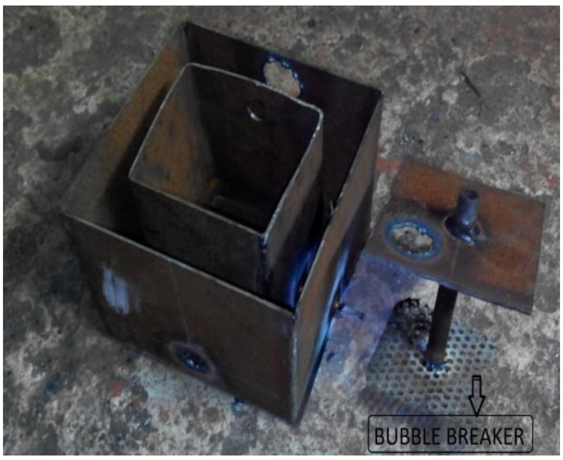



Fig.3 Inside view of bubbler

A diffuser/bubbler plate and/or metal ‘scrub pads’ are placed inside the bubbler to break up larger bubbles into smaller ones to produce better vapor, enriching the fuel mixture to the reaction chamber.

In the above prototype, the exhaust gases are used to heat the intake vapor and this exhaust gas is also passed through the bubbler. The flow of the bubbler is controlled by providing a ball valve. The flow of this gas had been controlled such that the vacuum created in bubbler should not be disturbed; the only use of this exhaust gas was to generate some bubbles to initiate the vapor formation process.

Fig.4 Construction of heat exchanger

In normal Indian condition (temperature 30-35 degree Celsius) enough vapor generation is taken place by using bubbler only, so there is no need to exchange heat between exhaust gases and the fuel. If atmospheric temperature is very law (10-15 degree Celsius) vapor will condense before entering combustion chamber. In order to eliminate this problem heat has been exchanged between fuel and exhaust gases.

A manual valve is used to adjust the amount of air that was fed into the bubbler. For proper operation, the valve is fitted more close to the bubbler to maintain the vacuum created within the bubbler. As that air bubbles gone up through the liquid fuel, vapor has been created in the top portion of the bubbler which is pulled into the reaction chamber by the vacuum of the engine.

The liquid level within the bubbler should never be high enough to allow liquids to be sucked into the combustion chamber. Only the vapor is allowed in the combustion chamber for the process to work properly.

By using bubbler bubbles are generated in the fuel tank. As the bubbler is connected to engine intake by means of pipe, so during suction stroke below atmosphere pressure has been created in the bubbler by means of pipe connected to intake. The bubbler is also connected to atmosphere by another pipe arrangement from which air is entered in bubbler and this pipe is fitted below the fuel level in bubbler so this Air is passed through fuel and generates bubbles, therefore the fuel vapor is created in bubbler. Vapor fuel is passed through pipe and gets heated by the exhaust gases.

Near the engine intake manifold air is mixed with this vaporized fuel and desired air fuel ratio will be maintained by providing a butterfly valve.

The rate of vapor formation is self-adjustable, i.e. by varying speed of engine; rate of vapor generation will also be changed according to the requirement of engine.

Fig.5 Vapor Fuel Injection with Help of Bubbler Kit

The device itself is described as a "self-inducing plasma generator". Put quite simply, the exhaust heat is transferred to the incoming fuel vapor, which must be maintained in a vacuum, and the overall configuration provides a molecular breakdown within the vacuum of all of the heavier elements. Therefore, intensifying the vacuum, the speed of molecular breakdown or reaction is magnified, and less heat is required. Because of the vaporized fuel the combustion will be complete and smoother and tendency of knocking and detonation will be eliminated.

## III. EXPERIMENTAL SET-UP FOR ENGINE TESTING

The performance test has been taken on the engine for the testing of effectiveness of the vapor fuel system. The testing setup for measuring the brake power, fuel consumption is shown in the below figure.

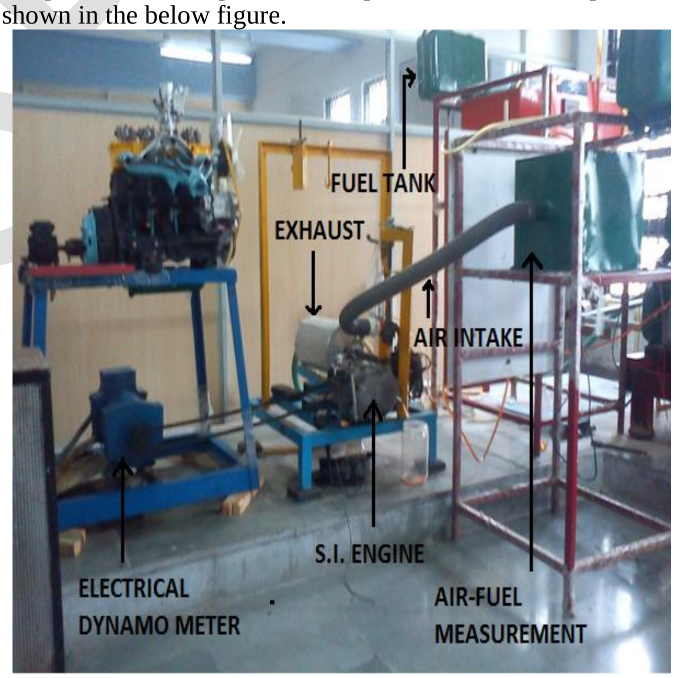



Fig.6 Experimental Set-up for carburettor system

In order to compare performance of different system, the same experiment is performed on our vapor fuel system. The experimental setup is shown below. Here environment condition and other parameters are same as in the carburettor system.


Fig.7 Experimental Set-up for vapor fuel system

The exhaust control valve is operated in order to control amount of heat exchange between fuels and exhaust gases. Primary air inlet valve is provided at the top of the bubbler and secondary air inlet is provided as shown in fig. The secondary air inlet valve is used to control the air fuel ratio and hence speed of the engine.

## IV. ENGINE TEST AND RESULTS

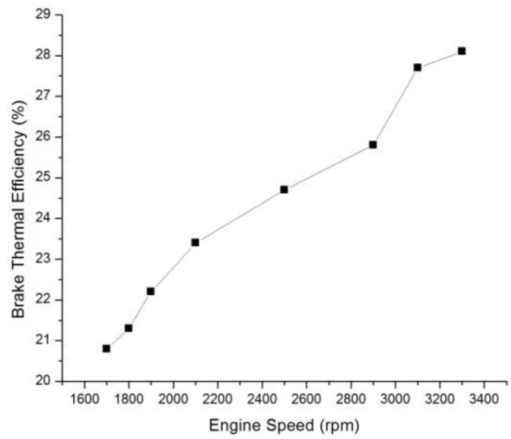
The test on the engine was carried out to check the performance of the engine. The engine had been driven on the various conditions, keeping the speed as a reference. The engine was firstly tested with the conventional fuel supply system, and then it was tested with vapor fuel technology with and without heat exchanger provision.

Table 1. Specifications of the engine

| | |
|---|---|
| Engine | 4 Stroke, Single Cylinder, Air Cooled |
| Displacement | 97.2 cc |
| Bore and Stroke | 50 X 49.5 |
| Compression Ratio | 9:1 |
| Max. Power | 7.5 PS (5.5 KW) @ 8000rpm |
| Max. Torque | 7.95 Nm @ 8000rpm |
| Transmission | 4 Speed, constant mesh, 4 up |
| Clutch | Multiplate Wet |
| Ignition | CDI |
| Fuel Supply | Carburettor Side draft |

Table 2. Engine Test with conventional fuel supply system

| Sr. No. | Speed (rpm) | Break thermal efficiency (%) | B.S.F.C (kg/kW-hr) |
|---|---|---|---|
| 1 | 1700 | 20.8 | 0.3688 |
| 2 | 1800 | 21.3 | 0.3571 |
| 3 | 1900 | 22.2 | 0.3401 |
| 4 | 2100 | 23.4 | 0.3309 |
| 5 | 2500 | 24.7 | 0.3132 |
| 6 | 2900 | 25.8 | 0.2881 |
| 7 | 3100 | 27.7 | 0.2772 |
| 8 | 3300 | 28.1 | 0.2517 |



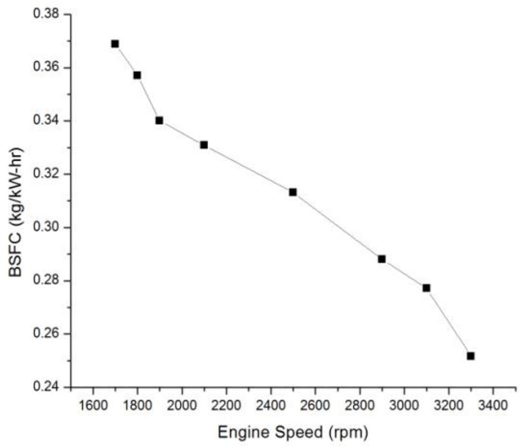




Fig. 8 Engine performance plots for conventional fuel supply system

After this test, the engine fitted with conventional fuel supply system, the components of vapor fuel technology are fitted on it and again the test is carried out.

Table 3. Engine Test with Vapor Fuel Technology without Heat Exchanger

| Sr. no | Speed (rpm) | Break thermal efficiency (%) | B.S.F.C (kg/kW-hr) |
|---|---|---|---|
| 1 | 1700 | 19.9 | 0.3521 |
| 2 | 1800 | 20.3 | 0.3443 |
| 3 | 1900 | 22.1 | 0.3391 |
| 4 | 2100 | 23.5 | 0.3252 |
| 5 | 2500 | 24.9 | 0.3211 |
| 6 | 2900 | 26.1 | 0.2709 |
| 7 | 3100 | 27.9 | 0.2612 |
| 8 | 3300 | 28.2 | 0.2425 |
| 9 | 3500 | 28.9 | 0.2374 |
| 10 | 3800 | 29.3 | 0.2206 |
| 11 | 4200 | 29.8 | 0.2125 |
| 12 | 4500 | 31.4 | 0.2015 |

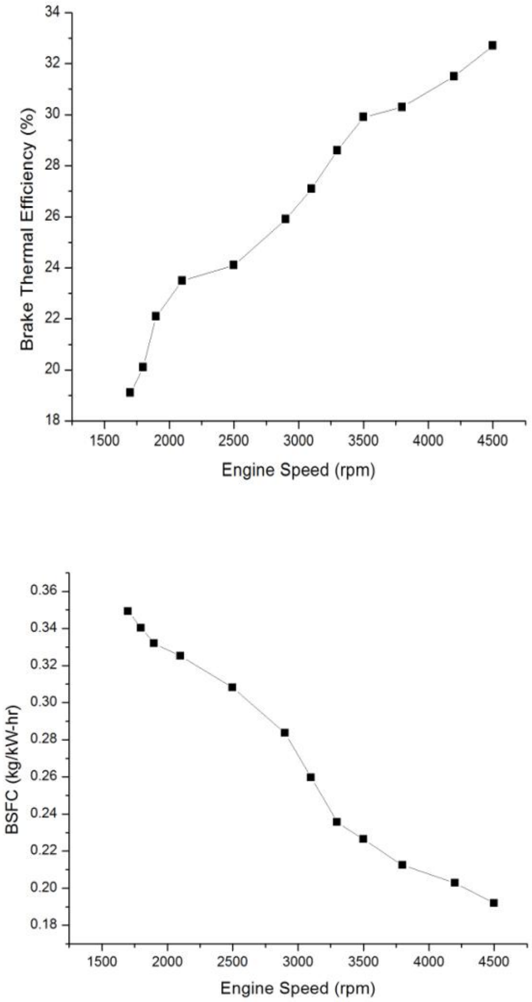



Fig.9 Engine performance plots for Vapor fuel technology without heat exchanger

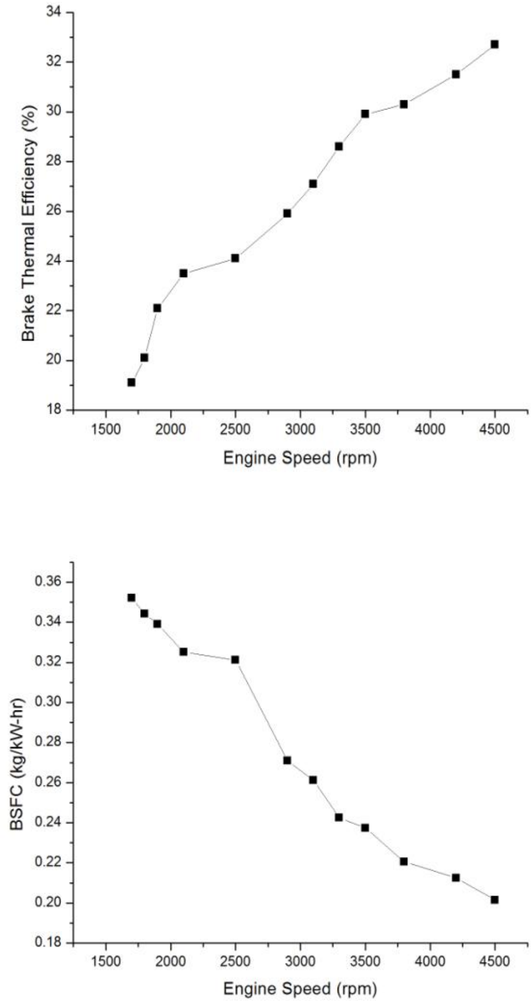



Fig.10 Engine performance plots for Vapor fuel technology with heat exchanger

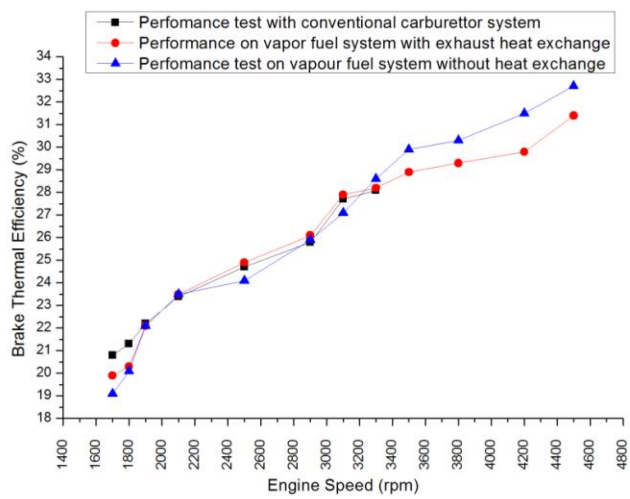
The test on the engine is again performed with the heat exchanger fitted with the vapor fuel attachments.

Table 4. Engine Test with Vapor Fuel Technology with Heat Exchanger

| Sr. no | Speed (rpm) | Break thermal efficiency (%) | B.S.F.C (kg/kW-hr) |
|---|---|---|---|
| 1 | 1700 | 19.1 | 0.3492 |
| 2 | 1800 | 20.1 | 0.3403 |
| 3 | 1900 | 22.1 | 0.3319 |
| 4 | 2100 | 23.5 | 0.3252 |
| 5 | 2500 | 24.1 | 0.3082 |
| 6 | 2900 | 25.9 | 0.2836 |
| 7 | 3100 | 27.1 | 0.2597 |
| 8 | 3300 | 28.6 | 0.2355 |
| 9 | 3500 | 29.9 | 0.2263 |
| 10 | 3800 | 30.3 | 0.2124 |
| 11 | 4200 | 31.5 | 0.2027 |
| 12 | 4500 | 32.7 | 0.1919 |

From the above plots, as the engine speed increases the bsfc (kg/kW-hr) decreases with the increase in brake thermal efficiency (%).

For the better comparison and analysis, the results for each system are compared on the single axis plots, which are as follows:



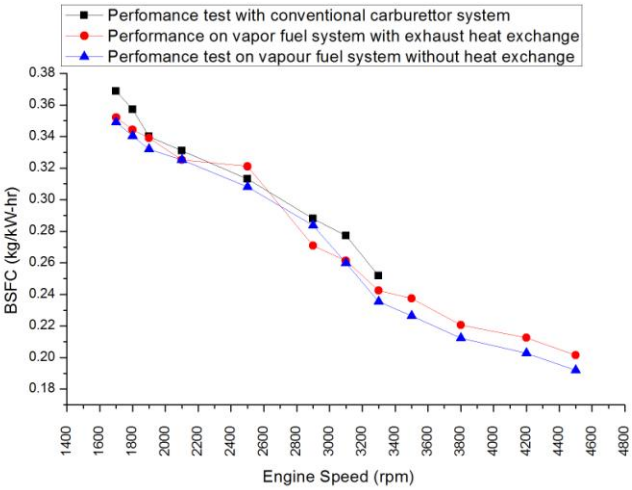



Fig.11 Plots for comparison of various fuel supply system (Conventional, VFT with and without heat exchanger)

## V. Conclusion

From the experimental analysis on both with carburettor and vapor fuel system, the thermal efficiency of 4- stroke S.I engine is increasing from 21-26(%) to 26-34(%) due to complete combustion of fuel in vapor fuel system. Similarly, BSFC of the system is decreased from 0.357-0.267 (kg/KWhr) to 0.28-0.22 (kg/KWhr). The knocking and detonation problem are also eliminated by inspecting practical engine noise due to homogeneous mixture of fuel and air in the combustion chamber.

The test had been carried out on the engine on vapor fuel system with transferring exhaust heat by passing exhaust gas through counter flow heat exchanger. In this condition, the rate of vaporization was very high resulting in rich fuel vapor and air mixture because the ambient air temperature affects the rate of vaporization. As the ambient temperature is high more vapors is generated. In our country and particular in summer season, the ambient temperature lies in range of 35°C- 42°C. Therefore the brake thermal efficiency is reduced which in the range of 19-25(%). But if the exhaust gas flow is reduced to the bubbler, the thermal efficiency is increased and lies in the range of 26-34(%). So, as the ambient temperature affects the rate of vapor generation, in cold countries where the ambient temperature is so low the heat recovery from the exhaust gases leads to increase the thermal efficiency.

So, the vapor fuel system is more promising technique towards the fuel saving and energy efficient engine. One can make the optimization of design and process parameters for this technique or the application of alternative fuels in this system.

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