EFFECT OF COMPOSITE MATERIAL IN PERFORMANCE AND EMISSION CHARACTERISTICS OF S.I ENGINE

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Abstract

There are various factors for increasing the performance and reducing the emissions such as the shape of the combustion chamber, location of the spark plug and number of intake valves. Apart from these reasons rise in the temperature inside the combustion chamber would also lead to the decrease in emissions as well as fuel consumption. The idea is to use a different material with low thermal conductivity for the engine components. Piston top, cylinder head and cylinder walls are the parts, which come into direct contact with the hot gases. Of these piston top is the part where the composite material was introduced. The material selected for introduction is a ceramic composite material Aluminium and Silicon Carbide. This ceramic composite material is a low thermal conductive material than the ordinary Aluminium alloy present in the original piston. Previously the piston top had been coated with Alumina for a thickness of one mm using plasma jet spraying. In the present investigation the piston top had been coated for a thickness of 3mm using press-fitting technique and even better results have been obtained than the original piston.

Keywords: Carbon monoxide, Hydrocarbon, Oxides of Nitrogen, Composite Material, Piston

1. Introduction

Approximately eight hundred million vehicles are running on the world's road and mainly powered by the internal combustion engines. The environmental impact of these internal combustion engines is awesome. The internal combustion engine is the main source of these emissions. A German government research has shown that from cradle to grave a typical car engine produces around 56.7 tonnes of carbon dioxide, 2040 million cubic metres of polluted air and 26.5 tonnes of solid rubbish. The rate with which the vehicular pollution is growing is absolutely astonishing. The centre for science and environment has found that during a period 1975 and 1995 the country's economy GDP grew by 2.5 times the vehicular pollution grew by 8 times in India. Strict mass emission standards have been legislated all over the world for keeping a check over the vehicular emissions. Modern devices such as catalytic converter, exhaust gas recirculation valve, positive crank case ventilation valves play a major role in role in reducing the emissions. But they are associated with large number of ill effects and lesser performance. Apart from the above techniques changes in the mechanical design of the engine such as using a low thermal conductive material for the manufacturing of the engine components would also lead to the decrease in emissions. Due to the use of low thermal conductive material the heat would be retained inside the chamber as a result the fuel air mixture would be burnt in an efficient way. This technique of using the engine to be low thermal conductive is called adiabatic engine.

Combustion of fuel mainly depends on three T's time, temperature and turbulence. Increasing any one of the three T's would rise the efficiency of combustion. Of these due to the use of low thermal conductive material the temperature of the combustion chamber would increase eventually would decrease the emission and increase the performance of the engine. Usually the piston is the part where large amount of heat is dissipated. By using the low thermal conductive material over the piston the heat is retained to a large extent. In this paper the piston top is coated to a thickness of three mm using press fitting technique. Due to the rise in the thickness of the ceramic material the heat is retained inside the combustion chamber in a better manner. Which helps in controlling the emissions and performance of the engine.

2. Experimental setup

Figure 1 shows the line diagram of the experimental set up. The experimental work was carried out on a spark ignition engine. The engine selected for the application is a naturally aspirated single cylinder carburettor type engine. The specifications of the engine are given below.

MAKE: HONDA GK 200
TYPE: Single cylinder, Air cooled, Side valve
C.C: 197 CC
BORE: 67 mm
STROKE: 56 mm
C.R: 4.5 : 1
POWER OUTPUT: 3.7 kw at 3000 rpm
LOADING DEVICE: DC swing field Dynamometer

3. Methodology

The engine is run using the original piston which is an alloy of Aluminium. The engine would be tested for time taken for 10 ml of fuel consumption and emissions using exhaust gas kane analyser. Exhaust gas kane analyser is used for measuring unburnt hydrocarbons, carbon monoxide, carbon dioxide, oxygen, ratio of air fuel ratio and Oxides of nitrogen present in the exhaust. The piston is coated with the composite material for a thickness of 3 mm by press fitting technique. The piston is first machined for a depth of 3 mm and a diameter of 57 mm by counter boring operation. The composite material is machined for the same thickness and diameter and then is pressed over the cavity formed on the piston. Again the engine is tested for all the parameters as said before. The engine is also subjected to various loads using the DC swing field dynamometer. And the parameters were tabulated.

4. Composite material

Combination of two or more materials often results in properties superior to that of the base metal called as a composite material. Composite material is made up of two phases one is the matrix phase and reinforcement phase. The purpose of the matrix phase is to adhere and distribute the load uniformly to the reinforcement phase. The reinforcement phase is the one, which gives the strength or the speciality of that composite material

In this paper the composite material used for coating the piston top is the Aluminium and Silicon Carbide. While Aluminium is the base metal present in the piston and the reason for selecting silicon carbide is justified below. Silicon carbide is selected because it has got an excellent wear resistance superior to that of most of the ceramics. Silicon carbide also has got low thermal conductivity than that of the Aluminium and it is in an optimum range due to this coking of hydrocarbons is avoided. It is also resistant to galvanic action and also it is stable for hot gases over a high range of temperature.

5. Testing

The Honda GK 200 engine was first run with the original piston and then it is subjected to various loads ranging from 0.2, 0.6, 1.1, 1.6, 1.9 kilo watts. The load is applied by using the output of the generator by using a bank of bulbs or by resistance bank. The exhaust gas is sampled at a particular point and the exhaust gas kane analyser is used for analysing the gas it is used for analyzing hydrocarbons, Carbonmonoxide, carbon dioxide, oxygen, air fuel ratio and oxides of nitrogen. The graphs are drawn for the emission as well as the performance parameters.

6. Results and discussion

From the figures following results have been obtained:

- Fig. 2 shows the variation of CO emissions with BP of the engine It can be observed that the CO emission marginally decreases with the composite piston. This is due to Oxygen concentration, which is slightly increased with the usage of composite piston.
- Fig. 3 shows the HC variation with the BP of the engine. The result shows the HC decreased by about 10 ppm for composite piston II (Al 81% Sic 19%) This reduction is due to introduction of composite material, which increases the combustion temperature.
- Fig. 4 shows the variation of oxides of nitrogen with the BP of the engine. The result shows that oxides of nitrogen emission increase marginally with composite material when compared with the conventional piston. This is due to high combustion temperature with the help of the composite material due to its low thermal conductivity.
- Fig. 5 and 6 shows the variation of performance parameters specific fuel consumption and brake thermal efficiency with the BP of the engine. It can be observed that the composite material helps the increasing the performance parameters.

Conclusion

From the experiments conducted the following conclusions are made:

- Due to the increase in the combustion temperature the CO and HC emissions are found to be decreasing.
- The Oxides of Nitrogen emissions are found to be increasing with the combustion temperature.
- The performance characteristics considerably increase.

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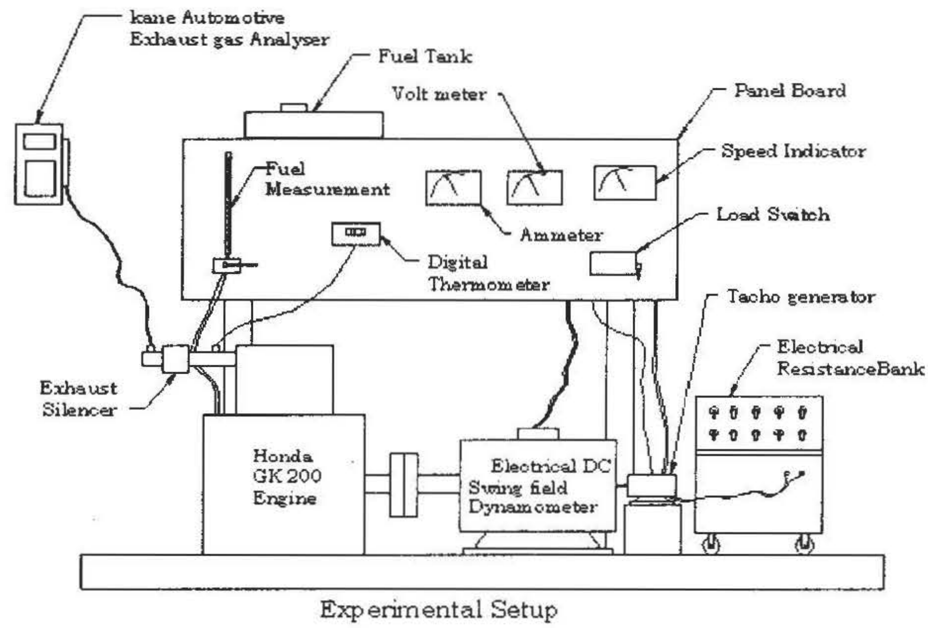

Fig. 1. Experimental Setup

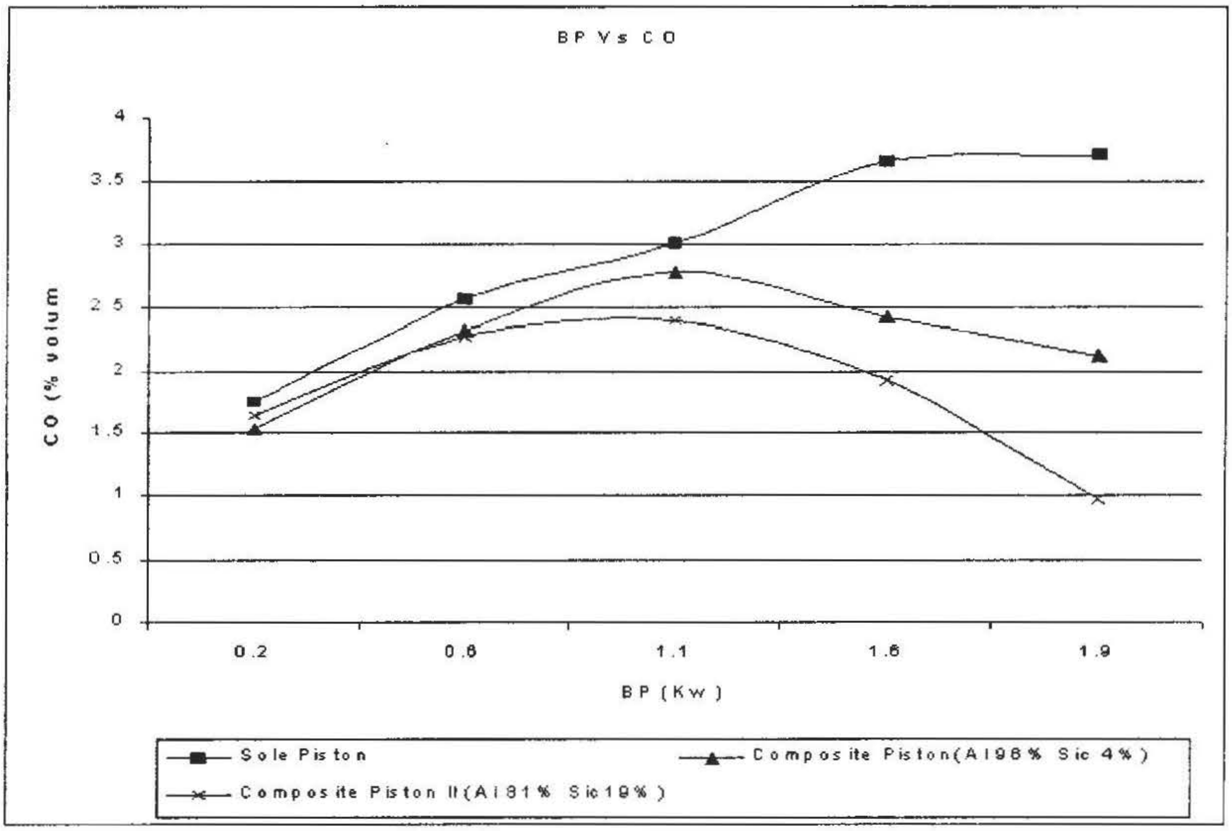

Fig. 2. Brake Power vs Carbon monoxide for Composite Piston I & II

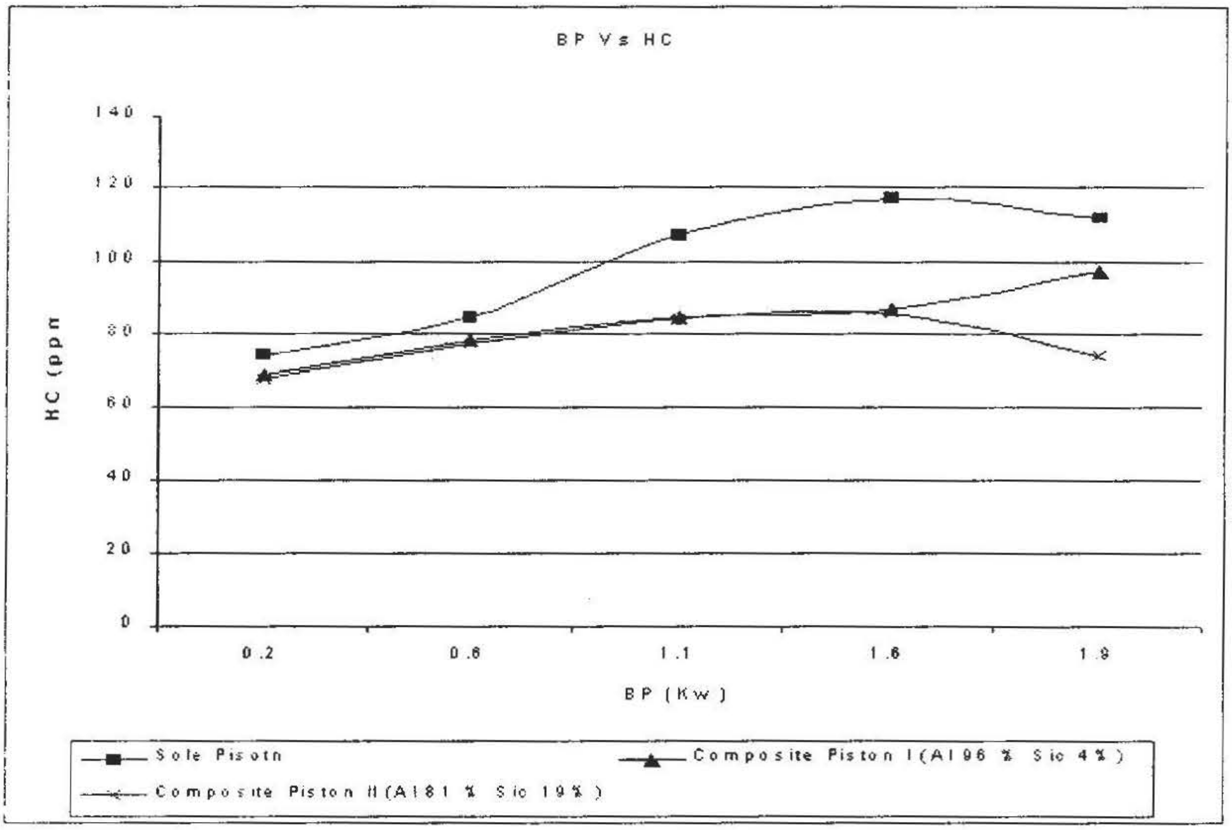

Fig. 3. Brake Power vs Hydrocarbon for Composite Piston I & II

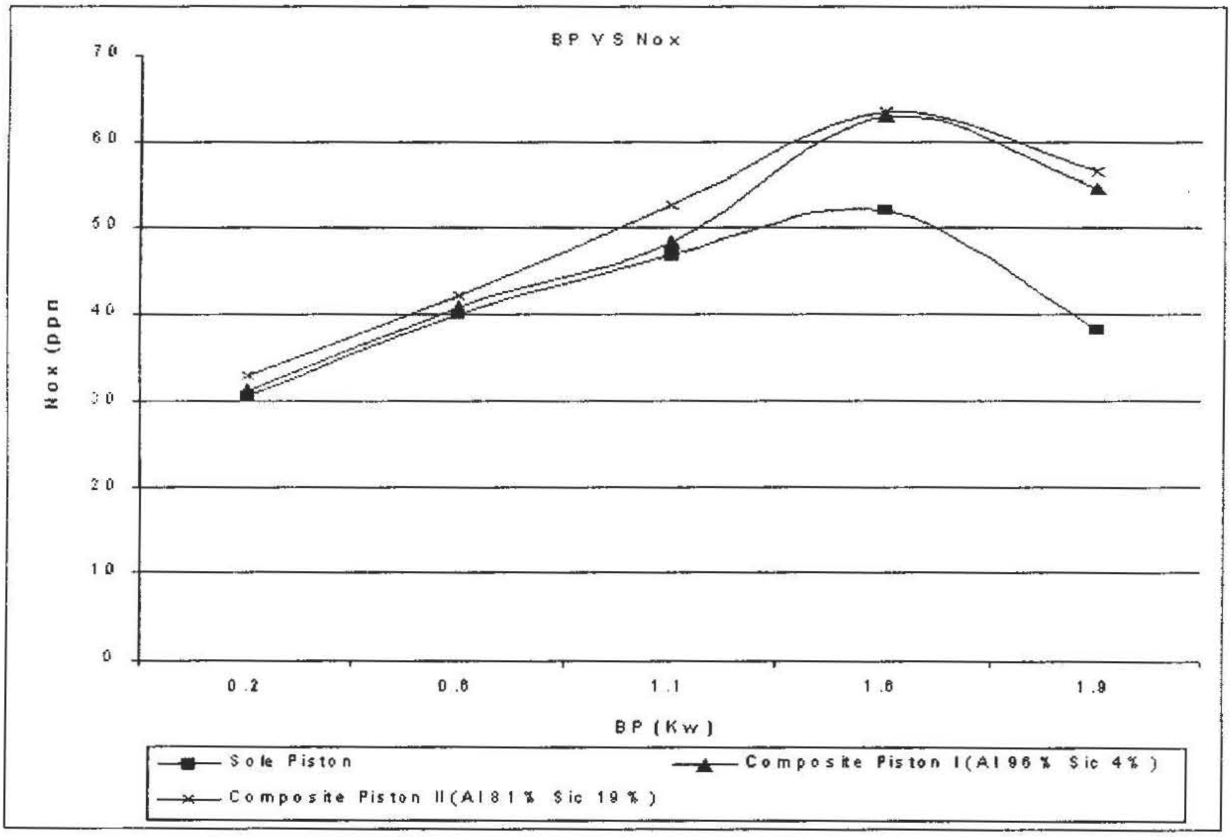

Fig. 4. Brake Power vs Oxides of Nitrogen for Composite Piston I & II

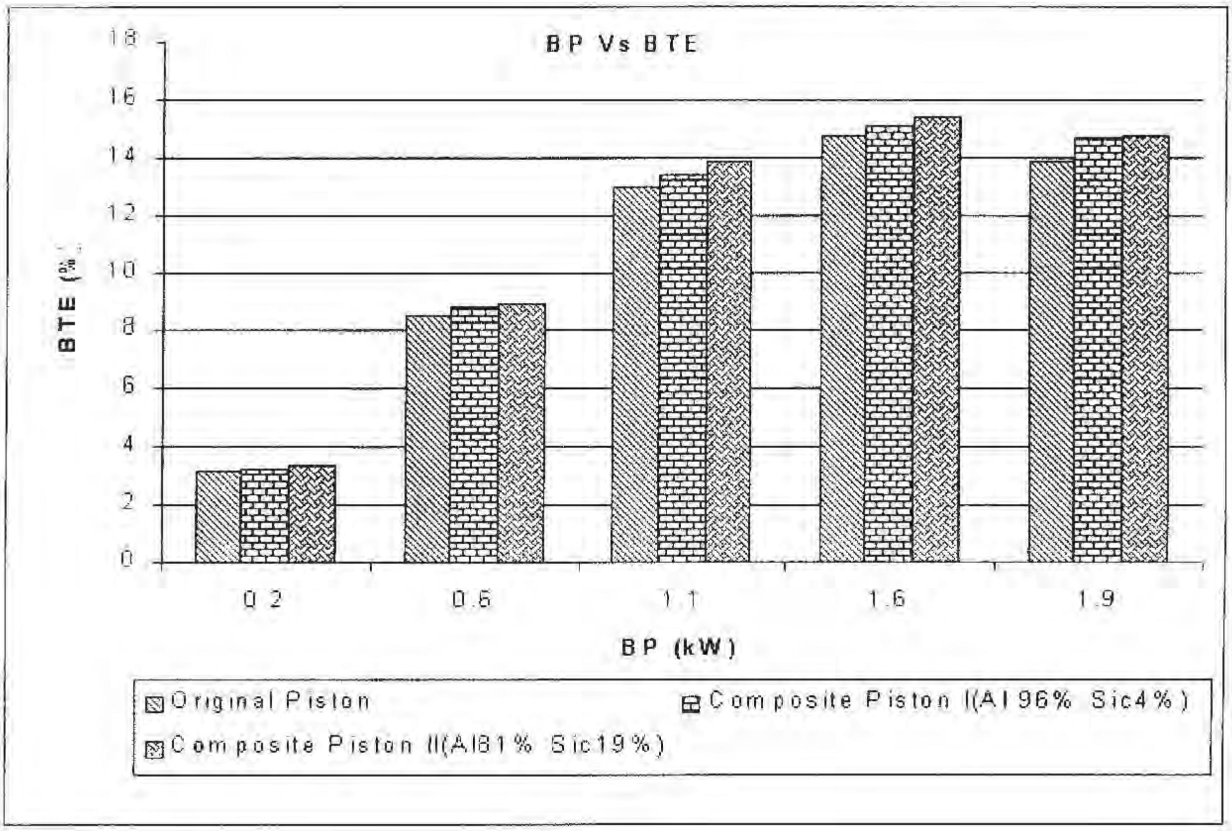

Fig. 5. Brake Power vs Brake Thermal Efficiency

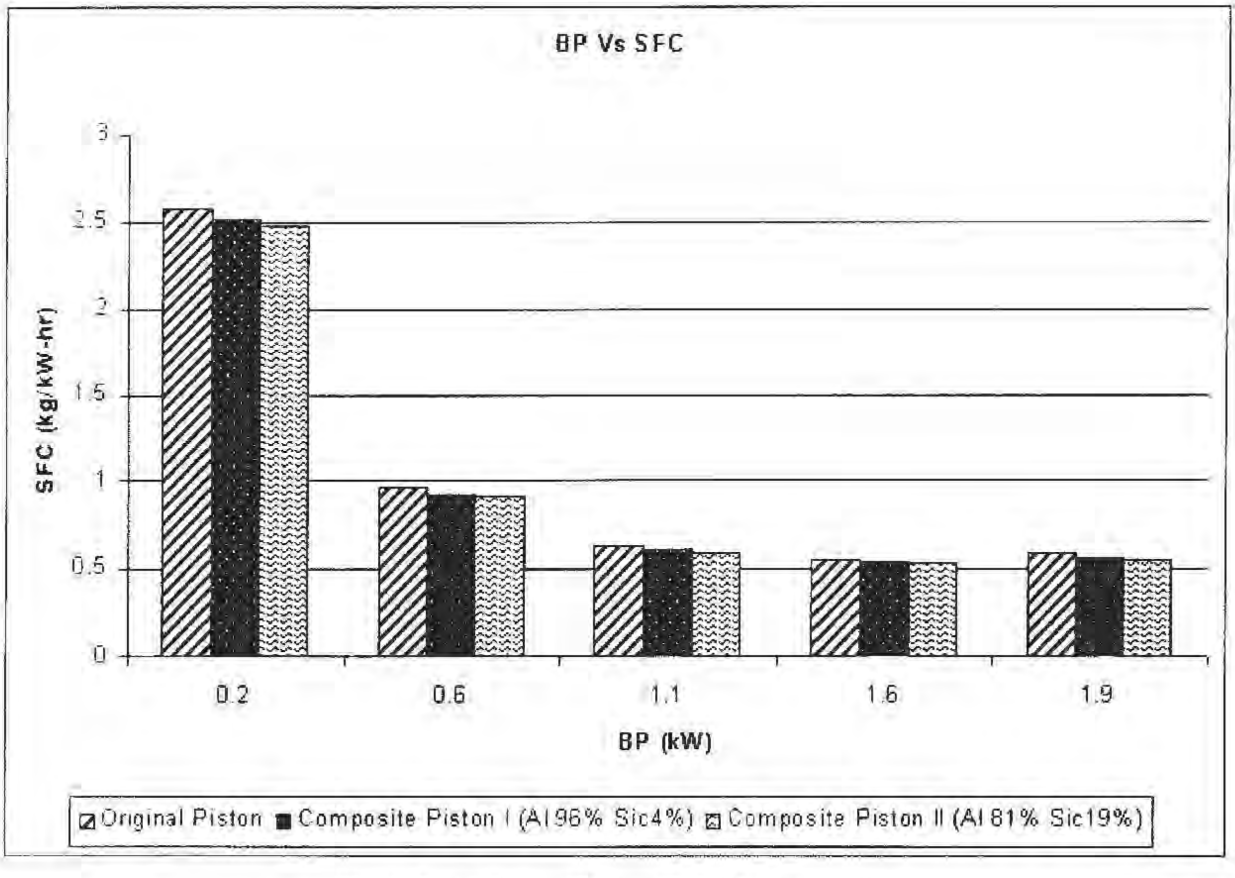

Fig. 6. Brake Power Vs Specific Fuel Consumption