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PERFORMANCE ANALYSIS OF FOUR STROKE SI ENGINE WITH PREHEATED INTAKE AIR

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ABSTRACT

The drastic depletion of petroleum fuel from the crust of earth will lead to energy crisis in future. Improving the efficiency of all the systems using petroleum products is a way to manage this scenario until an effective alternative is found. The application of thermocouple modules in automobiles is the result of recent significant development in material sciences. In this paper, an attempt has been made to experimentally investigate the performance parameters such as brake specific fuel consumption, total fuel consumption, brake thermal efficiency, mechanical efficiency, indicated thermal efficiency by preheating the intake air using a thermocouple module on a single cylinder four stroke spark ignition engine. The brake specific fuel consumption and total fuel consumption is found to decrease when the air is preheated indicating the reduction in the fuel consumption. The mechanical efficiency is observed to increase at all loads. The mechanical efficiency, brake thermal efficiency, indicated thermal efficiency have shown an increased value for the preheated intake than the stock intake.

Key words: Performance, Preheating intake air, Brake thermal efficiency, Specific fuel consumption, Peltier module, SI engine.

INTRODUCTION

The high rate of increase in the population and fast changing life style has made a significant and progressive change in the industrial and transport sector. The consumption of the petroleum derivatives has been therefore increased to a soaring level that it is being depleted at a much higher rate than expected. This over growing demand has forced us to overlook into a efficient utilization of petroleum products until a stable and suitable alternative is found. The significant progress made in the material research in the recent times enables the application of the thermoelectric modules in the automobiles. A thermoelectric module consists of several p-n couples that are capable of generating electricity (Seebeck effect) or convert electrical energy into a temperature gradient (Peltier effect)[1]. The thermocouple module creates a temperature gradient that elevates the

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temperature of intake air. The vaporization of petrol in the carburettor is affected by the humidity in the atmosphere[2]. Preheating the intake air eases the vaporization of fuel thereby achieving a fast combustion. The reduction of the water vapour content in the intake air reduces the steam formation, pitting of the engine cylinder, piston and exhaust pipe[3-6]. Zhang et al.[7] studied the impact of increasing the intake temperature on the pressure in the cylinder. The experiment was carried out in a CT2100Q engine which is a double cylinder, four stroke, compulsory water cooling, naturally aspirated and direct injection. The primary analysis revealed that with the increase in intake temperature, the carbon monoxide and hydrocarbon emissions decrease. The emission of oxides of nitrogen increases with the increase in intake temperature.

Kumar and Raj[8] discussed the effects of the intake temperature on the CO and HC emissions. Better vaporization of fuel and in-cylinder combustion potentially reduces the CO and smoke emissions. The engine parameters were experimentally investigated on a single cylinder, four stroke and air cooled compression-ignition engine with a bore of 78 mm, stroke of 68 mm and total displacement of 325 cm^3. The performance parameters include brake thermal efficiency, volumetric efficiency, brake specific fuel consumption, equivalence air fuel ratio and brake power. The intake preheating performs a better economy, which is contributed by the decreased loss and faster combustion.

Nomenclature

BSFC	**Brake specific fuel consumption**
BHP	Brake horse power
TFC	Total fuel consumption
BTE	Brake thermal efficiency
ITE	Indicated thermal efficiency
BMEP	Brake mean effective pressure
OHC	Over head cam

EXPERIMENTAL

The experimental tests have been performed in the Thermal Engineering Laboratory, School of Mechanical Sciences, Hindustan University, Chennai, Tamil Nadu.

The present study aims at the analysis of the effect of increase in the intake temperature on the engine performance parameters. The experimental investigation is done on Hero Honda CD-100, single cylinder, four stroke engine, air cooled OHC. The air is preheated by the thermocouple module. The performance parameters such as brake specific fuel consumption, total fuel consumption, mechanical efficiency, brake thermal efficiency and indicated thermal efficiency were analysed in detail.

Table 1: Engine specifications of Hero Honda CD 100

Type	Air cooled
Stroke	4 Stroke
No of cylinders	1
Bore	50 mm
Stroke	49.5 mm
Displacement	97.2 cm^3
Max power	7.2 BHP at 8000 rpm
Max torque	7.5 N-m at 5000 rpm

The engine specifications of Hero Honda CD 100 are shown in Table 1. The engine was loaded with rope dynamometer. The compression ratio is 8.8:1. The schematic diagram of the experimental set up is shown in Fig. 1.

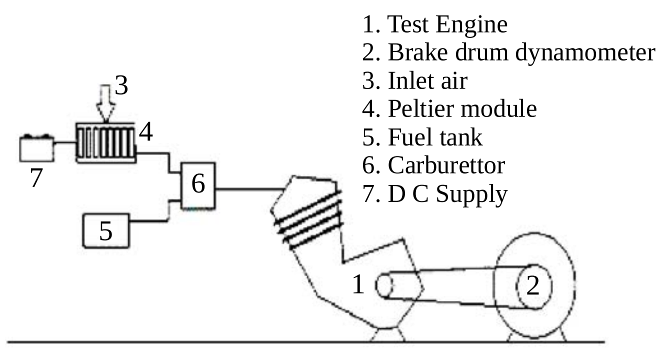

Fig. 1: Schematic diagram of the experimental set up

The thermocouple module used to preheat the intake air is Bismuth Telluride with dimensions 45 mm × 45 mm × 10 mm. A fan is mounted on the heating side of the thermocouple module, which heats the intake air. The thermocouple module produces a heat of 43°C and the preheated intake air temperature is 40.25°C. The engine is loaded using rope dynamometer with a brake drum radius of 0.15 m. The test rig is equipped with a burette set up to analyse the fuel consumption using a stop watch. The pictorial representation of the experimental set up is given in the Fig. 2.

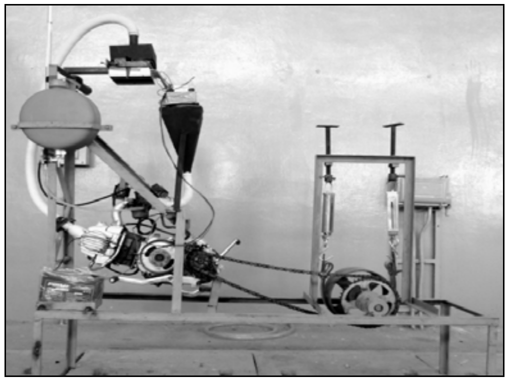

Fig. 2: Pictorial representation of the experimental set up

RESULTS AND DISCUSSION

The effect of increasing the temperature of intake air with respect to the performance parameters is discussed below. Fig. 3 shows the variation of the BSFC with the BMEP for preheated air intake and stock air intake. It is observed that there is an increase in the BSFC with respect to the BMEP with increase in load. The BSFC for the preheated intake air showed comparatively lesser BSFC than the stock intake air.

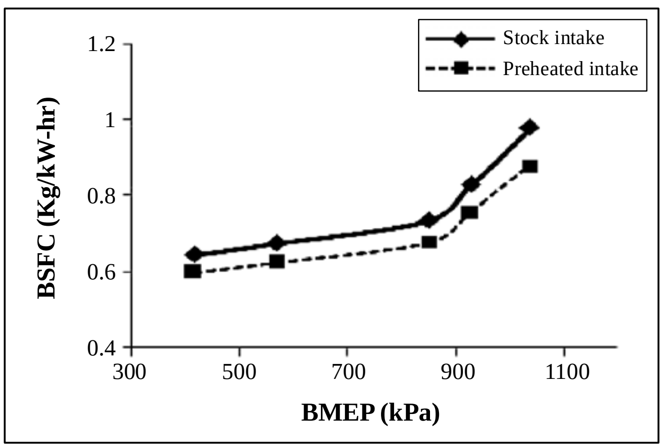

Fig. 3: Variation of BSFC with respect to BMEP

At low load conditions, the BSFC of the stock intake is found to be 0.738 Kg/kW-hr and the preheated intake showed 0.678 Kg/kW-hr. At part load conditions, the BSFC showed gradual increase for both the stock intake and the preheated intake with values 0.677 Kg/kW-hr and 0.625 Kg/kW-hr, respectively. At full load conditions, the values showed 0.981 Kg/kW-hr and 0.877 Kg/kW-hr for the stock intake and preheated intake.

The variation of the TFC with BMEP is shown in Fig. 4. The curves show a decreasing TFC with BMEP. At low load conditions, the TFC for the stock intake is found to be 0.885 Kg/hr and the preheated intake showed 0.815 Kg/hr. At part load condition, the TFC is observed to be lesser than the low load conditions. The stoke intake showed 0.395 Kg/hr and the preheated intake showed 0.359 Kg/hr. At full load conditions, the TFC is found to be very minimal, which varied between 0.430 Kg/hr for stock intake and 0.380 Kg/hr for the preheated intake. These data has revealed that there is a reduction of fuel consumption.

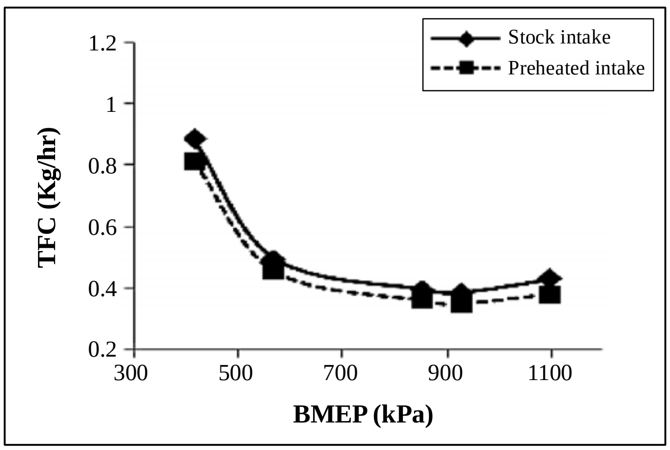

Fig. 4: Variation of TFC with respect to BMEP

Fig. 5 explains the variation of the mechanical efficiency with respect to BMEP. For the low load conditions, the mechanical efficiencies for stock intake and preheated intake is found to be 24.68% and 25.41%, respectively. It is evident from figure that the mechanical efficiency increases with increase in load. At part load conditions, the stock intake showed a mechanical efficiency of 45.64% and preheated intake showed 46.65%. At full load conditions, the stock intake showed 50.61% and preheated intake showed a marginal increase with 51.69%. The preheated intake showed a higher mechanical efficiency than the stock intake.

The variation of the brake thermal efficiency with BMEP is shown in Fig. 6. At low load conditions the brake thermal efficiency is found to be 8.65% for stock intake and 9.39% for preheated intake. Part load conditions showed an increased value for brake thermal efficiencies with 19.39% for stock intake and 21.28% for preheated intake. At full load conditions, the stock intake showed a brake thermal efficiency of 17.79% for stock intake and 20.12% for preheated intake. The values at full load conditions are observed to be less than of the part load conditions. The brake thermal efficiency is also higher for the preheated intake than the stock intake.

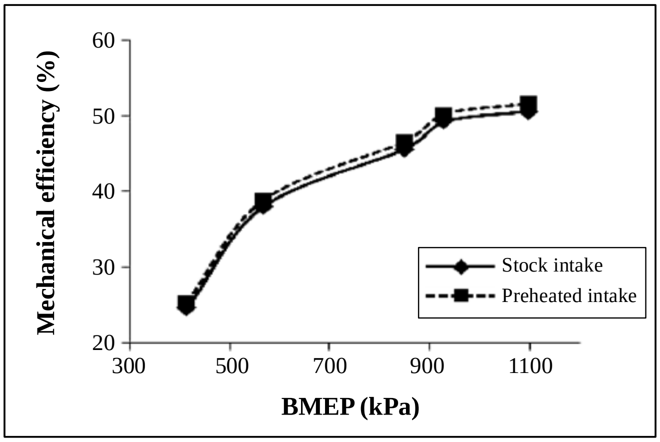

Fig. 5: Variation of mechanical efficiency with respect to BMEP

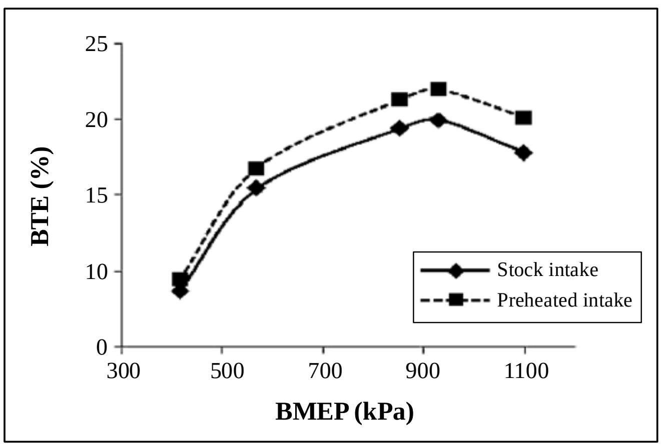

Fig. 6: Variation of BTE with respect to BMEP

Fig. 7 describes the variation of the indicated thermal efficiency with respect to BMEP. At low load conditions, the ITE for stock intake is found to be 35.06% and for preheated intake 36.98%. At part load conditions, ITE shows a maximum of 42.48% for stock intake and 45.61% for preheated intake. At full load conditions, the values of the ITE for stock intake and preheated intake are found to be 35.17% and 38.93%, respecitvely.

There was a rise in ITE with load till part load conditions and then it showed in decrease in ITE from part load conditions to full load condition.

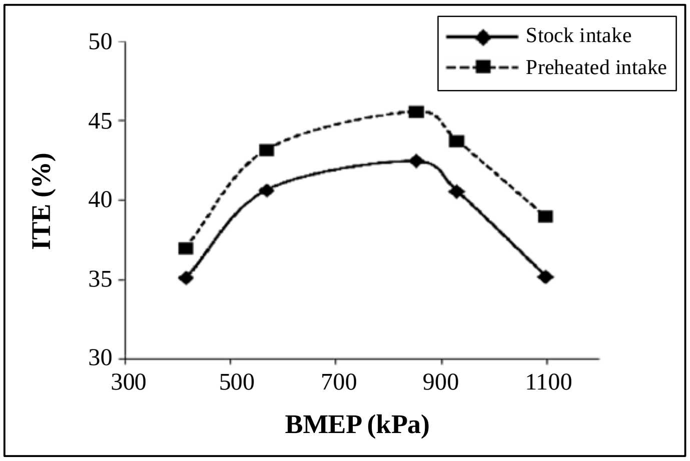

Fig. 7: Variation of ITE with respect to BMEP

CONCLUSION

The feasibility of air preheating using a thermocouple module on engine performance parameters on a single cylinder four stroke spark ignition engine was investigated and the following conclusions were arrived:

- The fuel consumption of the engine is found to be reduced when the air is preheated. The BSFC is reduced from 0.981 Kg/kW-hr to 0.877 Kg/kW-hr at full load conditions. The TFC is also reduced from 0.430 Kg/hr to 0.380 Kg/hr at full load conditions.
- The mechanical efficiency is observed to increase from 50.61% to 51.69% at part load conditions. It also exhibited an increase in mechanical efficiency for entire load.
- The brake thermal efficiency increase from of 17.79% to 20.12% at full load conditions. The brake thermal efficiency shows an increase till part load conditions where it is maximum and then decreases towards full load condition.
- There is an increase in the indicated thermal efficiency from 35.06% to 36.98% at low load conditions. The ITE is found to increase with load till part load conditions and then it decreases when the load is increased from part load to full load.

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