



Effect of Charge Temperature on Performance of 4s Single Cylinder Twin Spark SI Engine

Nandan Kumar, Rashmi Dwivedi, Prem Kumar Chaurasiya, Sanjay Chhalotre, Sanjay Kumar Singh

Abstract: This study involves the analysis of the performance improvement of the air-cooled SI engine by controlling the charge temperature. The insulated intake manifold has been used to maintaining the charge temperature at the atmospheric temperature level. The effect of variation in intake air temperature coming from atmospheric temperature on the engine performance in terms of brake mean effective pressure, engine power, engine torque are investigated. The result indicated that the mass flow rate of air is increased after using cold and insulated air intake system with average air density of 1.174 kg/m³. This improved air intake mass flow rate increased the brake torque and a reduction in exhaust gas emission. The result shows when the air-fuel mixture allowed for combustion at atmospheric intake air temperature (30°C), the engine produces 1.2003 kW power and 5.7314 N-m torque at 2000 rpm. The engine performance calculated at an engine speed of 1000, 1500 and 2000 rpm.

Keywords: Air density, Intake charge temperature; Spark ignition engine; Heat loss; Emission

I. INTRODUCTION

For a continuation and efficient SI engine operation, the heat transfers after the combustion are extremely important. During combustion, about 25% to 30% of the energy produces by the burning of the air-fuel mixture is passed away from the engine cylinder through the exhaust gas residuals. During the combustion, the combustion chamber temperature increases up to 2000° Celsius. The material like aluminum alloys is used for manufacturing the light-weighted new generation engine components, which are damaged because of seizing effect at this temperature if the heat dissipation rate is not efficient in an air-cooled engine at different engine speed. To cool down the engine by removing the heat from the running engine is the highly critical work. Commonly two types of method are used to cool down the engine or keep the engine temperature at moderate level.

The methods are air cooled by creating fins on outer surface of the engine head and block and by water cooled, where water circulate in predefine paths called water jackets surrounding the cylinder in side of the engine. The lubrication oil also helps too carried away engine heat during circulation in engine component. With continue engine operation it's difficult to maintain the lubrication property of the engine oil and prevent the losses of oil by means of evaporation. Improper cooling of engine damages the engine components like piston, piston rings, valves, gaskets etc. along with reducing the viscosity property of engine lubricant and increases the air fuel mixture evaporation and increases NO_x [1-4]. For efficient and long lasting SI engine performance it should be mandatory to avoid engine knock and pre ignition of charge by controlling the temperature of combustion chamber and exhaust valve [5]. The air –fuel charge prepares by carburetor in the spark ignition engine [6]. The proper combustion of SI engine is controlled by the number of moles of oxygen present in the charge [7-8]. The rate of combustion has been increased by reducing the charge temperature [9]. Getting uniform cooling from all sides of air cooled engine is highly difficult. The cooling of front side of an engine towards the direction of vehicle motion is easy and efficient. The volumetric efficiency of SI engine is affected, if low density intake air allows for combustion [10]. The air-cooled engine transfers the heat by conduction and radiation caused the nearby components like intake manifold, carburetors, and air filter box also get heated. This preheated intake air and air-fuel charge increase the pre cyclic temperature of the IC engine [11]. The moderately heated intake air system, slightly more than the atmospheric temperature increases the fuel evaporation rate which is helpful to mix oxygen moles present in the air with each fuel particles and give homogeneous mixture [12]. But the too much-heated air intake manifold increases the evaporation rate of fuel and reduces the density of intake air. The less-dense air means a lack of oxygen moles which directly affected the performance of the engine [15]. When the intake air passes through the heated intake manifold with the fuel particles, due to the excess temperature the air losses its density result it slows the flame propagation rate in the combustion chamber. the slow flame propagation rate increases the engine thermal losses [16]. During the compression stroke, the temperature and pressure of the air-fuel mixture have rapid increases, which are helpful to minimize the ignition lag period cause a quick start of the cold engine.

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* Correspondence Author

Nandan Kumar*, M.Tech, Thermal Engineering, Sagar Institute of Science and Technology, Gandhi Nagar Bhopal.

Rashmi Dwivedi, Associate Professor, Sagar Institute of Science and Technology, Gandhi Nagar Bhopal.

Prem Kumar Chaurasiya, Associate Professor, Sagar Institute of Science and Technology, Gandhi Nagar Bhopal

Sanjay Chhalotre, Professor, Sagar Institute of Science and Technology, Gandhi Nagar Bhopal.

Sanjay Kumar Singh, Professor, Sagar Institute of Science and Technology, Gandhi Nagar Bhopal

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But if the initial temperature of the intake charge is higher than the atmospheric temperature increases the pre cyclic temperature of the engine from the beginning. For long engine operation, it has increased the rate of knocking tendency because of surface and pre-ignition. Excessive knocking reduces the engine's life [17]. In this practical investigation we measure the effect of variation in intake air temperature coming from atmospheric temperature on the engine performance in terms of brake mean effective pressure, engine power, engine torque. When the charge temperature increases the evaporation of the fuel also increases and gives better distribution of the heavier fuel fractions which reduces the tendency to detonate. Also there is a reduction of the density of the charge with an increase in mixture temperature, which further decreases the combustion pressure reducing the tendency to detonate. The exact proportion of the energy supplied to the engine (as fuel) which is converted into useful work is critically influenced by many physical characteristics of the engine such as engine design, type of the fuel used, Cooling system, etc. In general, about 30 per cent of the energy supplied is converted into useful work; about 30 per cent is lost as exhaust heat and some energy is lost in friction, compression and direct rejection from engine. The rest of the energy, about 30 per cent, has to be removed by the cooling system if it is not to increase the engine temperature while running. Piston, cylinder liner and head are subjected to very high temperatures because they are in direct contact with the hot combustion gases. The lubricating oil used for lubrication also helps to cool down the engine component. Normally the temperature of lubricating oil goes up to 160°C to 200°C in an air-cooled engine. Above these temperatures, the viscosity level of lubricating oil deteriorates very fast as the temperature increase causes damage to the engine. The strength of the materials used for various engine parts usually decreases with an increase in temperature, and thus establishes an upper limit for the temperatures at various points of the engine. For example, for water-cooled engines, the temperature of the cylinder head should not exceed about 270°C while for air-cooled engines, which use light alloys, this limit is as low as 200°C.

II. METHODOLOGY

To protect the intake manifold by the engine thermal losses, through conduction and convection, the intake manifold insulated by Titanium exhaust wrap is made from pulverized lava rock and stranded into a fibre material. It has the ability to handle higher heat for improved performance and durability and with a carbon fibre look. The experiment performs on BAJAJ 125 cc dual spark-ignition single-cylinder air-cooled engine. For measuring the variation in the temperature, the k - type thermocouple temperature sensors are used, this temperature sensor is installed in the various location of the air-cooled engine like air filter box, inside of the intake manifold, outside the intake manifold (after the insulation) and close to the engine block. The effect of charge temperature on engine performance calculating by using electric dynamometer at different engine speed.

III. EXPERIMENTAL SETUP

The experimental test setup engine intake manifold is modified into the insulated intake manifold. The test engine used was a four stroke, single cylinder air cooled petrol engine developing power 11PS at 7500rpm and maximum net torque at 11Nm at 5500rpm. By the help of this experimental setup we take reading at different engine speed and load condition.

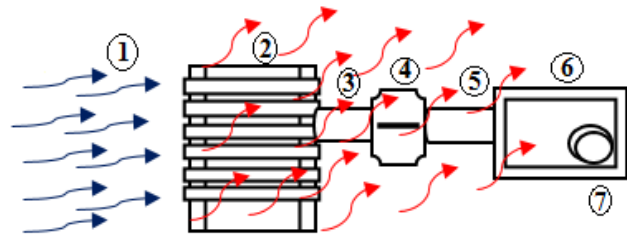


Fig.1. Flow of heat in air cooled engine [4]. 1. Air from ambient, 2. Air cooled 4s engine with fins, 3. Intake manifold 4. Carburetor 5. Air intake hose 6. Air filter assembly 7. Air inlet



Fig. 2. Experimental setup of 125cc Bajaj DTSI engine

Engine specification

Engine	4 stroke , Natural air cooled
Bore X Stroke	52mm X 58.6mm
Displacement	124.45 cc
Idling Speed	1300 - 1500 rpm
Max. Net Power	11 PS @ 7500 rpm
Max. Net Torque	11 Nm @ 5500 rpm
Ignition System	DC, Digital CDI
Starting Aid	Kick/Self
Spark Plug Gap	0.7 to 0.8 mm



Fig 3. Insulation on the intake manifold, 1. Titanium exhaust

insulation. 2. Polymer rubber connector.

Figure 3 shows the ready experimental setup for reading. The insulated intake manifold connected to the engine block by a polymer rubber connector, to maintain the charge temperature at atmospheric temperature. The insulation and polymer rubber connector have blocked the engine heat transfer rate through the convection and conduction.

The heat transfer rate from air cooled engine is depending upon the length of the fin and the spacing between them. Larger inter-spacing between the fins offers a larger cooling area but the heating of the air is less, so more cooling areas is required smaller interspacing between the fins results in smaller flow areas for cooling air and hence the air is heated more and input to the cooling air.

IV. RESULT AND DISCUSSION

For this research the test was conducted on Bajaj dtsi dual twin spark engine for engine power, brake mean effective pressure, torque, mass of fuel, specific fuel consumption, indicated mean effective pressure, indicated efficiency, mechanical efficiency, mass flow rate of intake air, volumetric efficiency, exhaust gas temperature.

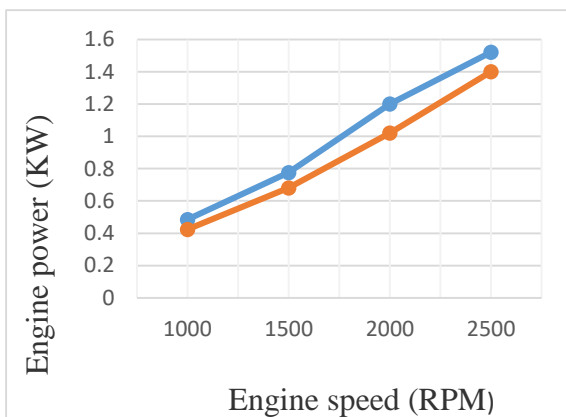


Fig. 4. Engine speed vs engine power (kW)

Fig 4 shows the comparative analysis of engine speed to the engine power, after analyzing the data it shows at 30° Celsius inlet temperature with insulated air intake manifold, the power output at different engine speed gradually increased but with regular intake system the charge temperature goes up to 85° Celsius because of heated intake manifold which further reduce the density of charge air cause reduction in mass flow rate and dropped the engine output power.

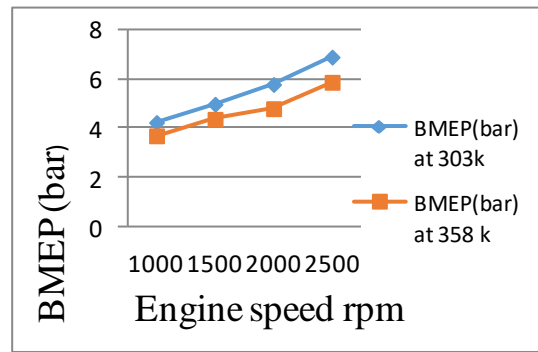


Fig. 5. Engine speed vs BMEP

Fig 5 shows the comparative analysis of engine speed to the bmepp. The mean effective pressure inside of the engine cylinder is continuously vary and it is a good parameter to compare engine power output at different variable parameters. For the naturally aspirated spark ignition engines, the bmepp vary from 850 to 1050 kPa at different engine speed and the maximum torque is obtained at 3000 rpm. After analyzing the experimental data, it shows at 30° Celsius charge temperature with insulated air intake manifold the bmepp at 2000 rpm is 578.05kPa were at 85° Celsius charge temperature the bmepp has drop up to 480.73 kPa.

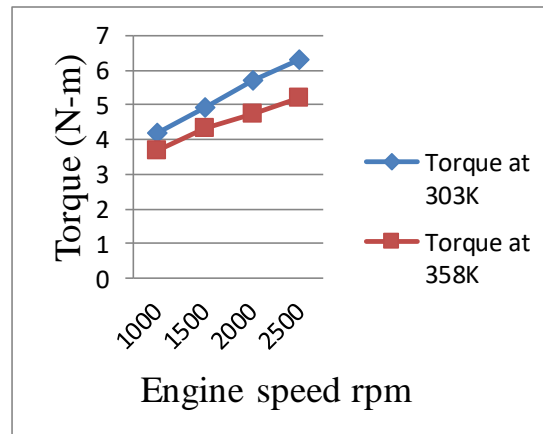


Fig. 6. Engine speed vs Torque

Fig 6 shows the comparative analysis of engine speed to the engine torque, after analyzing the data it shows at 30° Celsius charge temperature the torque available at 2000 rpm is 5.7314 N-m and when the charge temperature reaches up to 85° Celsius the torque produce by the engine, dropped 4.7665 N-m of at the same engine rpm. [18-19].

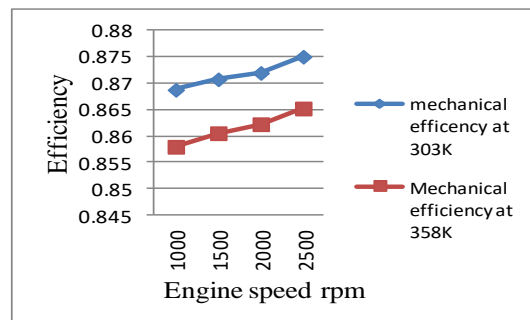


Fig. 7. Engine speed vs Mechanical efficiency

Fig 7 shows the comparison analysis in between mechanical efficiency and engine speed at different charge temperature vary from 30 to 80° Celsius. At low temperature the mechanical efficiency obtained is 87.19% and as the charge temperature increases the mechanical efficiency reduces up to 85.42%. The mechanical efficiency calculated at 2000 engine speed [22-23].

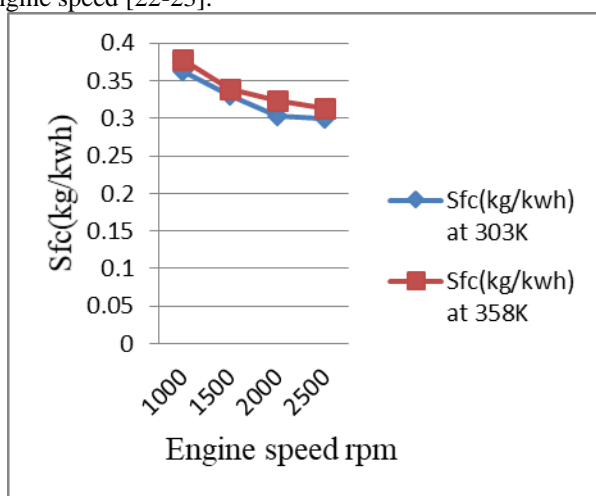


Fig.8. Engine speed vs SFC (kg/kwh)

Fig 8 shows the performance curve in between specific fuel consumption and engine speed. The specific fuel consumption is the fuel flow rate at per unit power output. It shows how economically fuel consumed by the engine to produce output power. The result shows, that the specific fuel consumption at 2000 engine speed is minimum 0.30134 kg/kWh when charge allow for combustion at 30° Celsius temperature. But as the charge temperature increases the specific fuel consumption is also increases up to 0.32320 kg/kWh at same engine speed. [20-21]

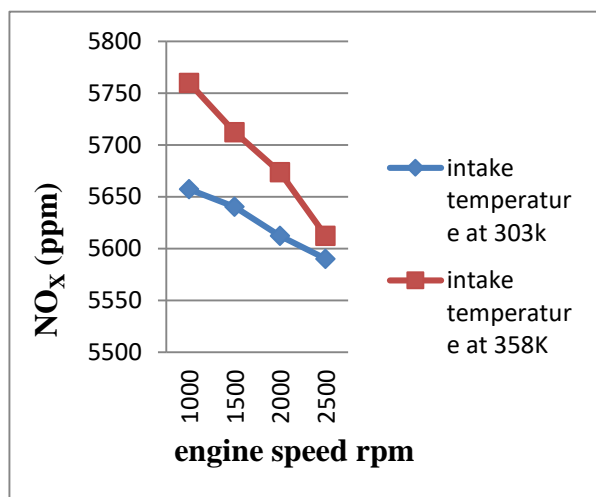


Fig.9. Engine speed vs NO_x

Oxides of nitrogen occurs at high temperature of exhaust gasses. It is a combination of nitric oxide (NO) and nitrogen dioxide (NO₂). Nitrogen and oxygen react at very high temperature in the combustion chamber and produces NO_x. The charge allow for combustion at high temperature increases the pre cyclic temperature of the engine. Cause of this the temperature of combustion chamber increases very rapidly. Fig 9 shows the formation of NO_x emission with respect to variation in charge temperature. The NO_x emission produced at low charge temperature is 5527.7 ppm and as the

charge temperature increases due to engine thermal losses the level of NO_x increases up to 5673.6 ppm. [22-23].

V. CONCLUSION

The temperature of the air-fuel charge affects the performance of the single-cylinder air-cooled SI engine. It is true that the moderate temperature (atmospheric temperature) of the charge helps to prepare a homogeneous charge for, instantaneous and complete combustion. After the start, the engine takes a few minutes to reach a steady-state temperature zone, after that due to variation in driving parameters and load conditions the engine temperature rapidly shootout. The engine temperature maintained by transferring the heat through the mode of heat transfer by conduction and convection when the atmospheric wind velocity passes through the fins available on the surface of the engine head and block. These modes of heat transfer have heated the intake manifold, carburetor, and air filter box which was located behind the engine block. The result of practical experiments shows the surrounding temperature about the block is goes up to 80°C to 90°C and because of this temperature, the intake charge temperature is also increased causes an increase in the pre cyclic temperature of the engine result intake air loses the density which affects the combustion and volumetric efficiency of the engine. In the presence of low-density air, the air-fuel charge is too lean and evaporates very fast result a drop in power output and torque and increases the NO_x emission level.

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Sanjay Chhalotre is pursuing Ph.D. from Maulana Azad National Institute of Technology, Bhopal. Presently he is working as a Professor in Sagar Institute of Science and Technology, Gandhi Nagar Bhopal. He has an industry experience of more than 20 years and has published various research paper in national and international journal. He has guided more than 10 M.Tech. Student His area of interest include Automobile Engineering, Internal Combustion Engine and Renewable Energy



Sanjay Kumar Singh is pursuing Ph.D. from Maulana Azad National Institute of Technology, Bhopal. Presently he is working as a Professor in Sagar Institute of Science and Technology, Gandhi Nagar Bhopal. He has an experience of more than 15 years and has published more than 20 research paper in international journal. He has guided more than 25 M.Tech. Student His area of interest include Thermal Energy.

AUTHORS PROFILE



Nandan Kumar Completed his B.Tech in Mechanical Engineering and currently pursuing his M.Tech in Thermal Engineering from Sagar Institute of Science and Technology, Gandhi Nagar Bhopal. His area of interest his Heat Transfer, RAC and IC Engines.



Rashmi Dwivedi completed her M.Tech. and Ph.D. from Maulana Azad National Institute of Technology, Bhopal. Presently she is working as an Associate Professor in Sagar Institute of Science and Technology, Gandhi Nagar Bhopal. She has an experience of more than 9 years and has published more than 20 research paper in international journal of repute. She has also guided more than 5 M.Tech. Student.



Prem Kumar Chaurasiya completed his M.Tech. and Ph.D. from Maulana Azad National Institute of Technology, Bhopal. Presently he is working as an Assistant Professor in Sagar Institute of Science and Technology, Gandhi Nagar Bhopal. He has published more than 15 research paper in international journal of repute. Currently, he has been awarded with the International Young Scientist Award.