Combustion Characteristics of Copper Coated Two-Stroke SI Engine with Methanol Blended Gasoline over Conventional Gasoline Engine

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Abstract- **Combustion characteristics of the engine are very important when the engine is run with alternative fuel. Experiments were conducted to evaluate the combustion characteristics of two stroke single cylinder, spark ignition (SI) engine, with alcohol blended gasoline (80% gasoline, 20% methanol, by volume) having copper coated engine [CCE, copper-(thickness, 300µ) coated on piston crown] and compared with conventional SI engine (CE) with pure gasoline operation. Combustion characteristics [peak pressure (PP), time of occurrence of peak pressure (TOPP), maximum rate of pressure rise (MRPR), maximum heat release (MHR) and temperature of burned gases at exhaust port opening (EPO)] were determined at full load operation of the engine. Combustion characteristics were determined by special software package. Copper coated combustion chamber with alcohol blended gasoline considerably improved the combustion parameters in comparison with CE with pure gasoline operation. Copper coated combustion chamber with alcohol blended gasoline increased the PP, decreased the TOPP, increased the MRPR, increased the MHR and decreased the temperature of burned gases at EPO.**

Keywords – Catalytically activated piston, alcohol blended gasoline, PP, TOPP, MRPR, MHR, Temperature of burned gases at EPO

I. INTRODUCTION

Fast depletion of gasoline fuels their ever increasing costs and the increase of pollutants with these fuels forces a searchfor alternate fuels. Alcohols (methyl alcohol and ethyl alcohol) are the probable alternate fuels, because of their compatibility with petroleum fuels. No major engine design modification is needed, if small quantities of alcohols are blended with gasoline. The change in fuel composition like blending of petrol with methanol is one of the methods adopted to improve the combustion characteristics of the engine. Special P-θ software arrangement is provided in order to note down the PP, TOPP, MRPR and MHR by means of TDC encoder, pressure transducer and consol. PP is an important parameter by means of which the engine efficiency can be determined. TOPP is another important parameter by means of which the pressure can be calculated with respect to TDC. Nearer the value of TOPP, better the performance is. MRPR denotes the knocking condition of the engine and hence it is necessary to determine these combustion characteristics of the engine, if any new alternative fuel is to be tested.

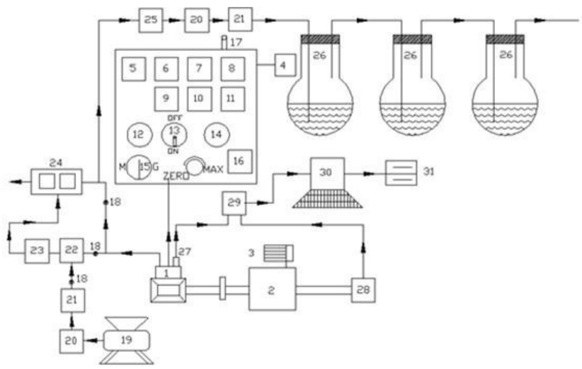
The present paper evaluated the combustion characteristics of copper coated combustion chamber, which includes determining combustion characteristics [peak pressure (PP), time of occurrence of peak pressure (TOPP), maximum rate of pressure rise (MRPR), maximum heat release (MHR) and temperature of burned gases at exhaust port opening (EPO)] at full load operation, with alcohol blended gasoline (gasoline-80%, methanol-20% by volume) and compared with CE with pure gasoline operation. Methanol blended gasoline in CCE found to improve the combustion characteristics over CE with pure gasoline operation.

The rest of the paper is organized as follows. Experimental Programme was explained in section II. Experimental results and discussion are presented in section III. Conclusions are given in section IV.

II. EXPERIMENTAL PROGRAMME

In the catalytically activated engine, by flame spraying technique, a high thermal conductive catalytic material like copper was coated on the cylinder head inside surface and top surface of piston crown. For 100µ thickness, nickel-cobalt-chromium bond coating was sprayed. On this coating, for another 300µ thickness, an alloy of copper (89.5%), aluminium (9.5%) and iron (1%) was coated with a METCO (Trade name of the company) flame spray gun. The bond strength of the coating was so high that it does not wear off even after operating it for 50 hrs continuously [1, 2]. Figure 1 shows the Photographic view of copper coated piston, liner and copper coated cylinder head.

Figure 1 Photographic view of copper coated piston, liner and copper coated cylinder head



1.Engine,2.Electrical swinging field dynamometer, 3. Loading arrangement, 4.Fuel tank, 5.Torque indicator/controller sensor, 6. Fuel rate indicator sensor, 7. Hot wire gas flow indicator, 8. Multi- channel temperature indicator, 9. Speed indicator, 10. Air flow indicator, 11. Exhaust gas temperature indicator, 12. Mains ON 13. Engine ON/OFF switch, 14. Mains OFF, 15. Motor/Generator option switch,16. Heater controller, 17. Speed indicator, 18. Directional valve, 19. Air compressor, 20. Rotometer, 21. Heater, 22. Air chamber, 23. Catalytic chamber, 24. CO/HC analyzer, 25. Filter, 26. Round bottom flasks containing DNPH solution, 27. Piezoelectric pressure transducer, 28. TDC encoder, 29. Consol,30. Pentium personal computer, 31. Printer.

Figure 2. Schematic diagram of the experimental set up

Figure 2 shows the schematic diagram of the experimental set up that was employed to measure the combustion characteristics.

An air-cooled single-cylinder 2.2 kW BP two-stroke SI engine with a rated speed of 3000 rpm was provided with an electrical swinging field dynamometer for the measurement of brake power (BP). For measuring the pressure in the combustion chamber of the engine, the cylinder head was provided with a piezoelectric pressure transducer and for measuring the crank angle, the dynamometer extended shaft was provided with a TDC encoder [3], [4]. These two (piezoelectric pressure transducer and TDC encoder) were connected to a consol, which in turn was connected to a personal computer on the screen of which Pressure-crank angle diagram [4, 5] and Heat release-crank angle diagram were obtained. At full load operation of the engine, the combustion characteristics such as peak pressure (PP), time of occurrence of peak pressure (TOPP), maximum rate of pressure rise (MRPR), maximum heat release (MHR) and temperature of burned gases at EPO, were evaluated by a special P-θ software package from the signals of pressure and crank angle.

III. Experiment and Result

Figure-6.54 is the typical diagram showing the variation of pressure with crank angle in the base engine, while Fig-6.55 gives the variation of pressure with crank angle in the catalytic coated engine with methyl alcohol blend at full load operation.

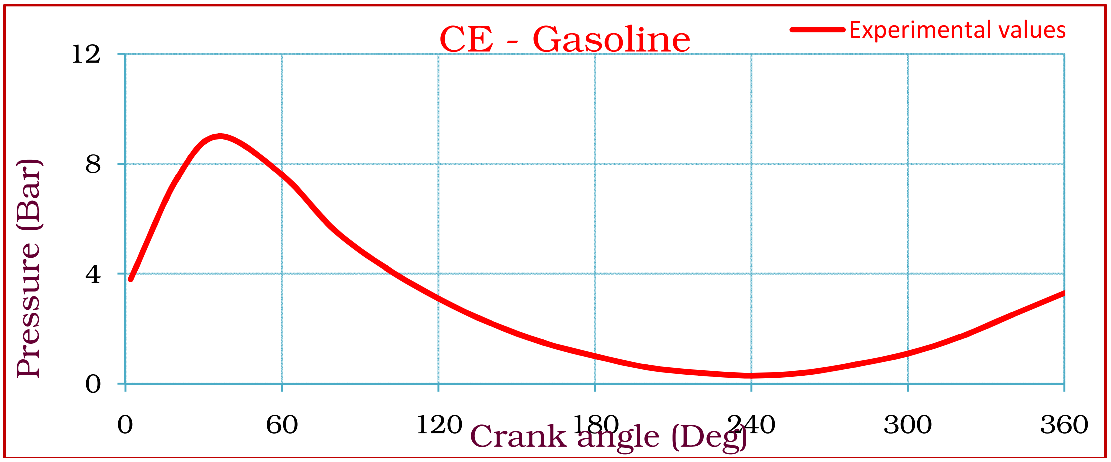


Figure 3 Typical diagram of the variation of experimental values of pressure with crank angle in the base engine at full load operation of the engine

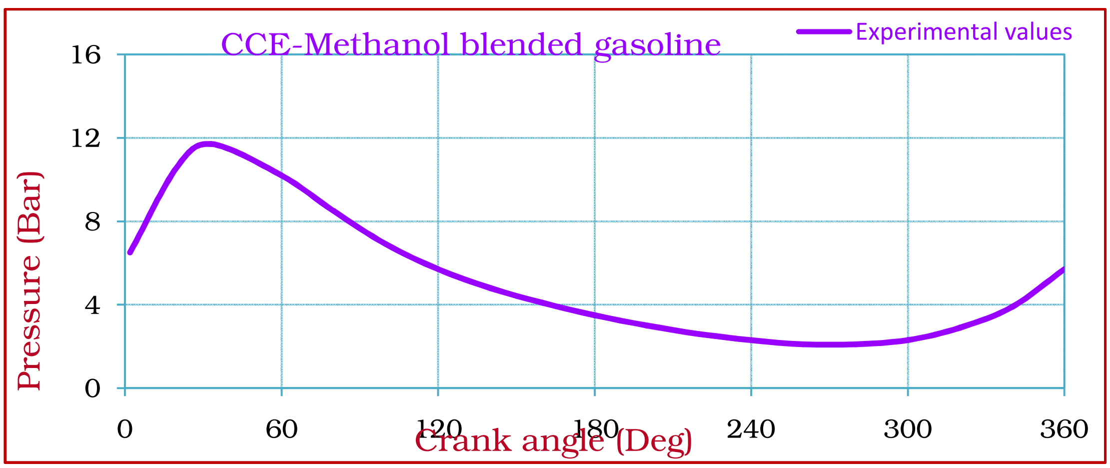


Figure 4 Typical diagram of the variation of experimental values of pressure with Crank angle in CCE with methyl alcohol blend at full load operation

From these diagrams (Figure 3 and Figure 4), other combustion characteristics were determined and compared with the data of each other. Peak pressure was found to be higher with methyl alcohol blend in the configuration of CCE, which confirms that catalytic coated engine was more suitable in achieving higher efficiency.

The experimental values of peak pressure (PP) obtained from the special software package at full load operation of the base engine and catalytic coated engine using experimental fuels was presented as bar chart in the Figure 5.

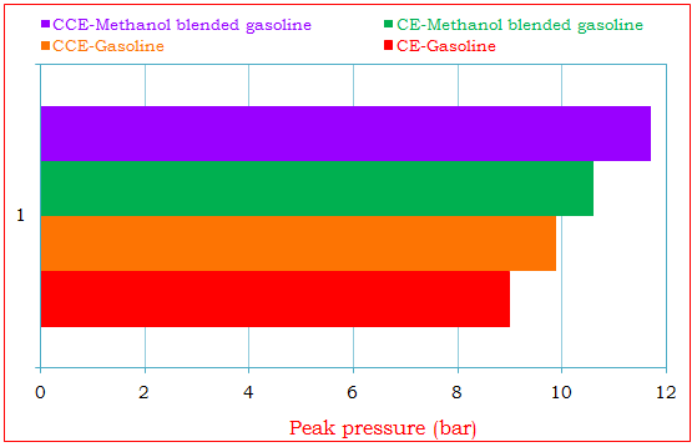


Figure 5 Bar chart showing the experimental values of PP at full load operation in CE and CCE with test fuels

From the Figure 5, PP was observed to be more with catalytically activated engine using methyl alcohol blend. Peak pressure increased with methyl alcohol preparation in comparison with the base fuel (3).

The experimental values of time of occurrence of peak pressure (TOPP) with the base engine and catalytic coated engine using experimental fuels at full load operation were shown in Figure 6.

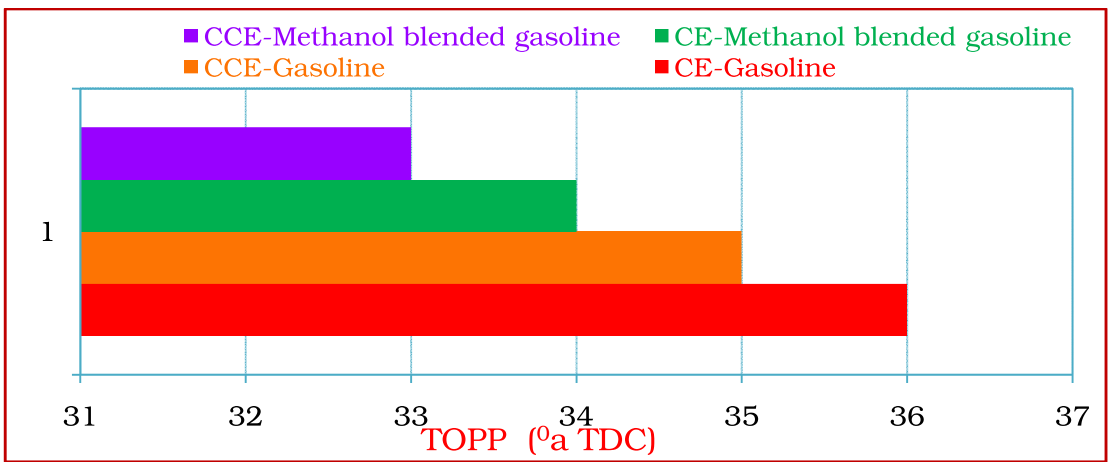


Figure 6 Bar chart showing the experimental values of TOPP in both the engines at full load operation

From the Figure 6, TOPP was observed to be minimum (closer to top dead centre) with catalytic coated engine using methyl alcohol blend in comparison with the base engine operation. This showed that, the performance was enhanced with good combustion with the catalytic coated engine. This was due to the high temperatures exhibited by the the walls of combustion chamber of the base engine causing prolongation of combustion giving the peak pressures which are far from the top dead centre. But this would not happen with catalytically activated engine using methyl alcohol blend due to the reduction of combustion chamber wall temperatures causing bringing of the peak pressures nearer to the top dead centre. However, base engine exhibited lower peak pressures and higher TOPP [3, 4] as the piston was already executing power stroke. The catalytic coated engine with the base fuel enhanced the combustion process because of the catalytic activity and hence, peak pressure was noticed to be greater than the base engine with the same experimental fuel. Greater values of peak pressure and lower TOPP established an improvement in the performance of the catalytic coated engine using methyl alcohol blend leading to higher utilization of energy on the piston. Addition of methyl alcohol aids the process of combustion, decreased the energy flow in to the crevices, reduction in the temperature of cylinder, decrease of the ignition delay, increase in the speed of propagation of flame front and decreased the combustion duration. Hence, it was concluded that, TOPP was found to be minimum with catalytic coated engine using methyl alcohol blend in comparison with the base engine so as to establish that CCE with methyl alcohol blend was efficient as its TOPP is nearer to TDC. That means more energy is utilized to actual work rather than wasting the energy.

The experimental values of maximum rate of pressure rise (MRPR) at full load operation of the base engine and catalytic coated engine using experimental fuels were presented in the Figure 7.

It was clear from the Figure 7 that, MRPR followed similar trends as that of PP. MRPR was found to be within the limits [5] from which it can be said that the engine is not in the knocking condition.

It was important to determine the heat release of the engine as it was useful to calculate the energy supplied by the engine which is the product of fuel burning rate and calorific value of the fuel. Higher the heat release, better the performance of the engine is.

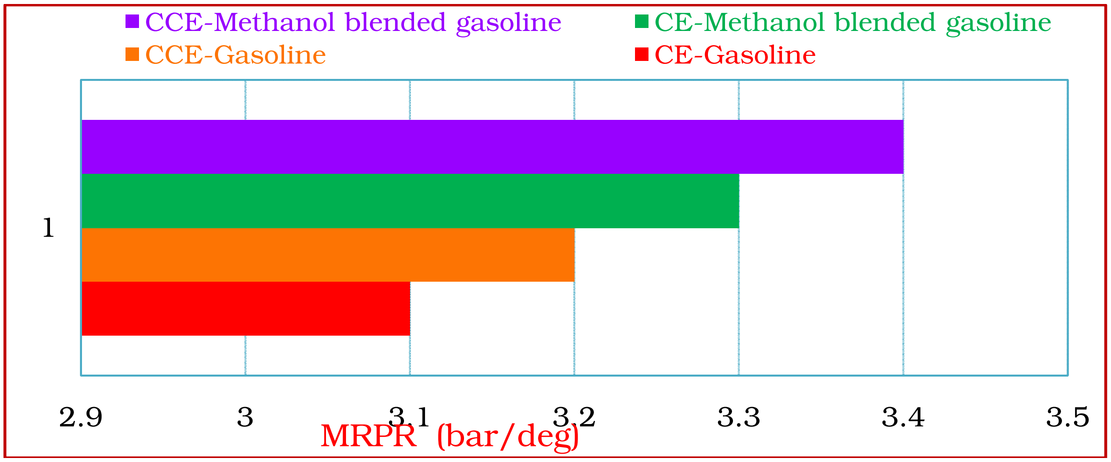


Figure 7 Bar chart showing the experimental values of MRPR in both the engines at full load operation

Figure 8 is the typical diagram showing the change of heat release with crank angle in the base engine at full load operation.

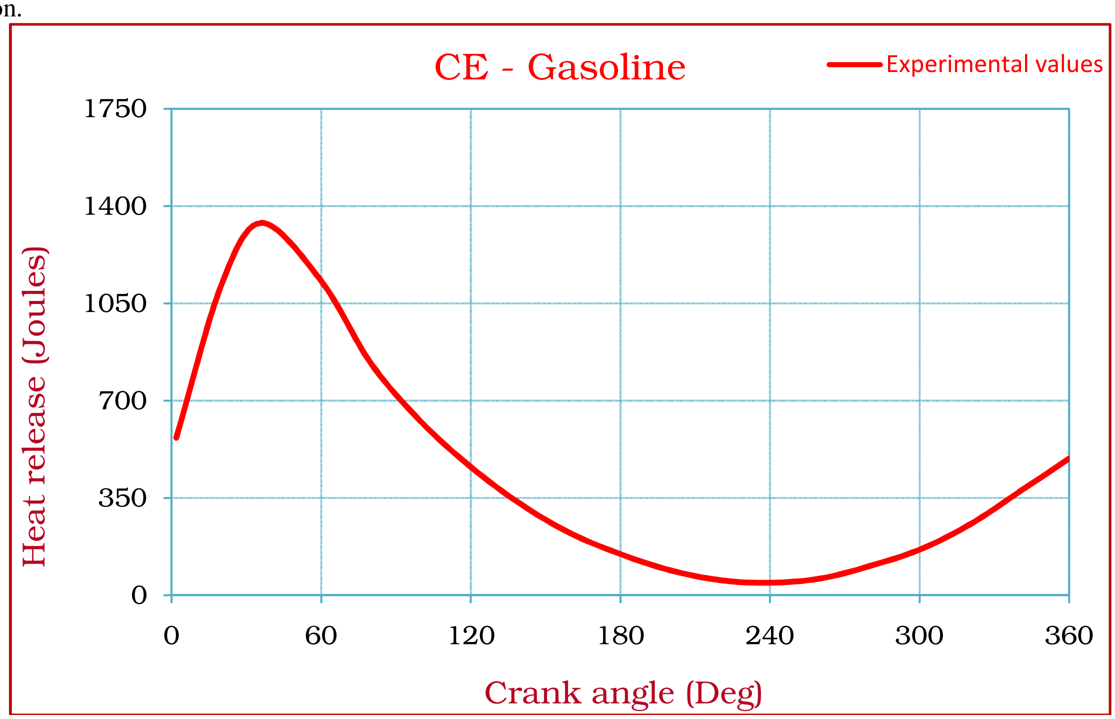


Figure 8 Typical diagram of the variation of experimental values of heat release with crank angle in the base engine at full load operation of the engine

Figure 9 gives the variation of the heat release with crank angle in the catalytic coated engine with methyl alcohol blend at full load operation.

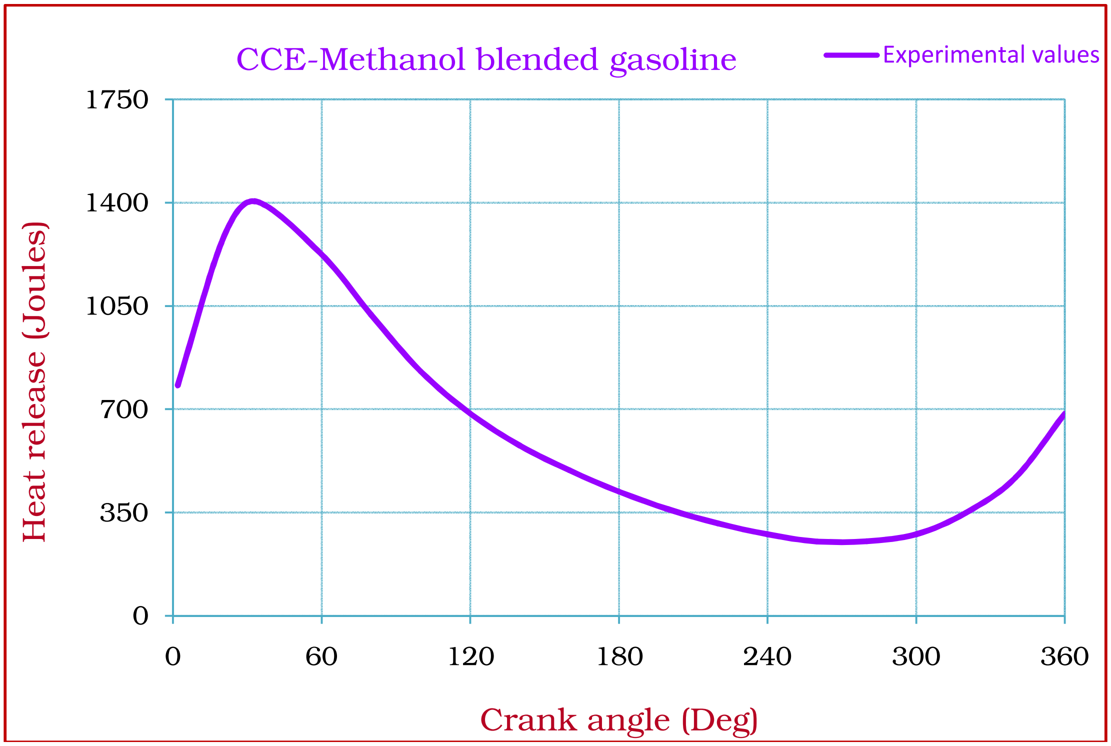


Figure 10 Typical diagram of the variation of experimental values of heat release with crank angle in CCE with methyl alcohol blend at full load operation

Higher heat release was obtained at the point where the peak pressure is obtained. From these diagrams, MHR was found to be more with methanol blended gasoline in the configuration of CCE which confirms that CCE is more suitable in achieving higher efficiency for methanol blended gasoline.

Figure 11presents the bar chart showing the experimental values of maximum heat release (MHR) in the base engine and catalytic coated engine with experimental fuels.

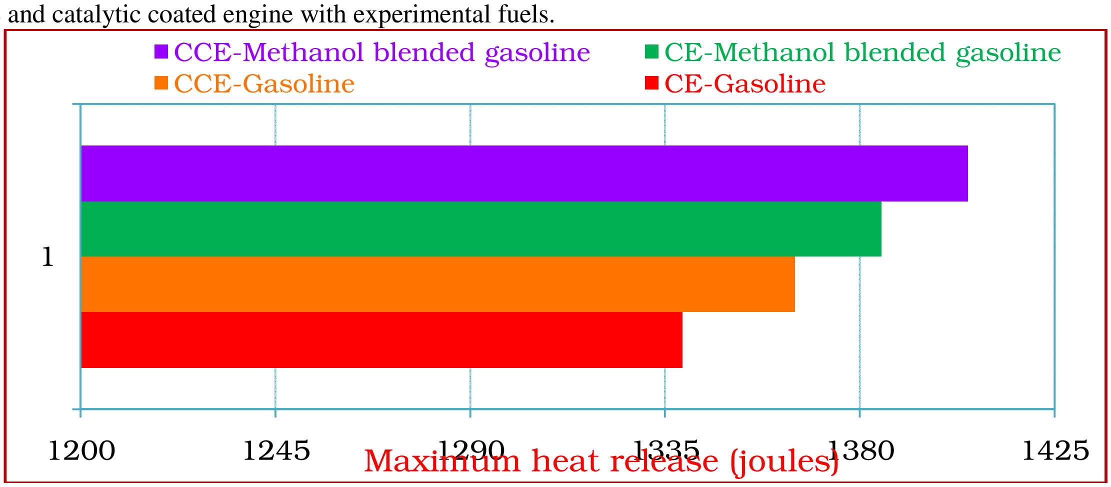


Figure 11 Bar chart showing the experimental values of MHR in both the engines with experimental fuels

From the Figure 11, MHR was found to be more with methyl alcohol blend in catalytically activated engine when compared with the base engine which shows that methyl alcohol blend in catalytic version of the engine is efficient as it gives more useful energy. The increase in MHR (calculated from the diagram of MHR provided by the software package) indicates that the combustion in catalytically activated engine with methyl alcohol blend was enhanced in comparison with the base engine because of the combustion of lower stoichiometric air-fuel ratio, which confirmed that combustion was improved with catalytic coated engine with methyl alcohol blend.

It is important to determine the temperature of burned gases at EPO of the engine experimentally, as it is useful to assess the performance of the engine. Lower the value, better the performance of the engine is.

Figure 12 was the typical diagram showing the fluctuation of temperature of burned gases at EPO with crank angle in the base engine while, Figure 13 gives the variation of the same in the catalytic coated engine with methanol blend at full load operation.

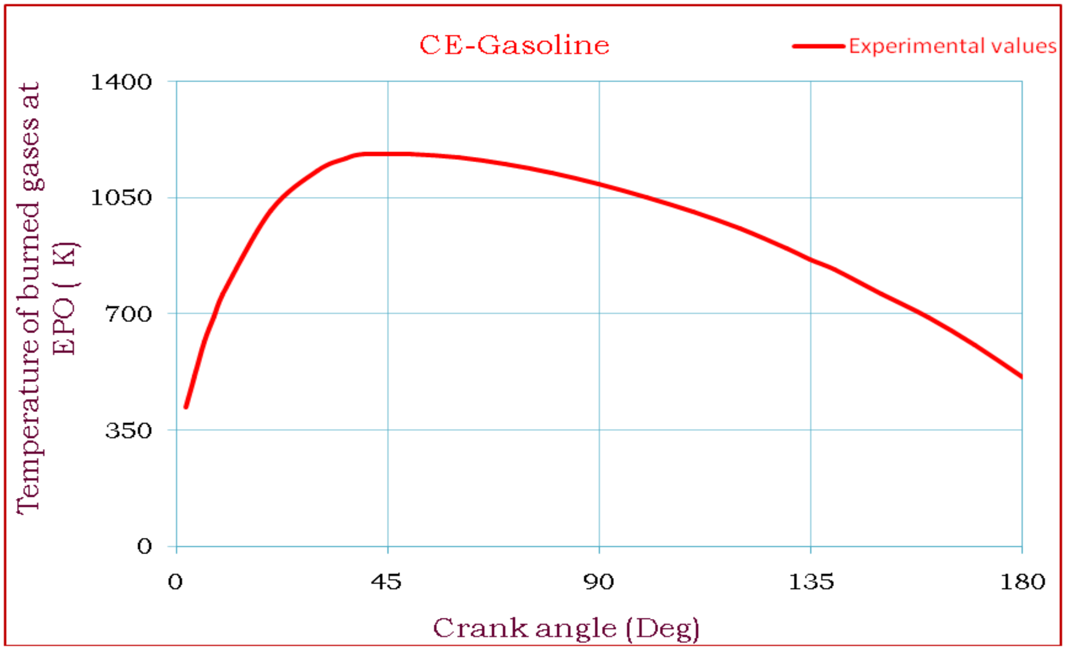


Figure 12 Typical diagram of the variation of experimental values of temperature of burned gase at EPO with crank angle in the base engine at full load

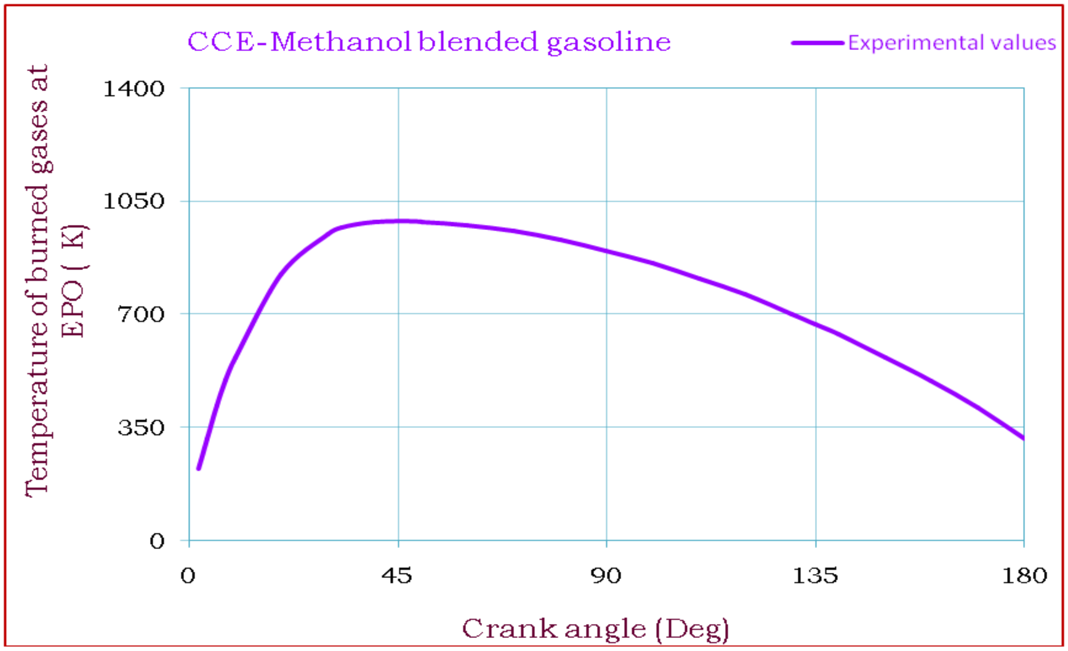


Figure 13 Typical diagram of the variation of experimental values of temperature of burned gase at EPO with crank angle in CCE with methyl alcohol blend

From these diagrams it was understood that the temperature of burned gases at EPO is found to be minimum for methanol blended gasoline in the configuration of CCE which confirms that CCE is more suitable in achieving higher efficiency for methanol blended gasoline.

Figure 14 presents the bar chart which shows the experimental values of temperature of burned gases at EPO in the base engine and catalytic coated engine with experimental fuels.

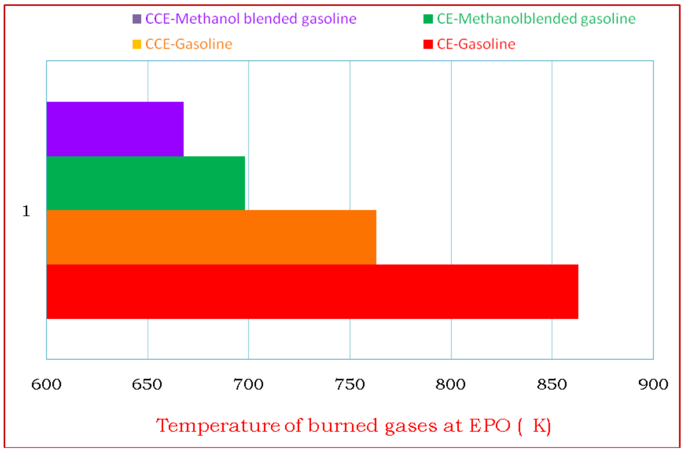


Figure 14 Bar chart showing the experimental values of temperature of burned gases at EPO in the base engine and catalytic coated engine with experimental fuels

It was understood from the Figure 14 that, CCE with methyl alcohol blend gave lower value of temperature obtained at EPO in comparison with the base engine with experimental fuels, which again confirms that CCE with methyl alcohol blend was found to be more suitable in achieving higher efficiency over the base engine.

IV.CONCLUSIONS

1. PP increased by 30%, TOPP decreased by 8.3%, MRPR increased by 10% and MHR increased by 5% with methyl alcohol blend in the catalytic coated engine when compared to the base engine operation.
2. Methyl alcohol blend in the catalytic coated engine decreased the temperature of burned gases at EPO by 195 K in comparison with the base engine operation.

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