

# **Evaluation of Combustion Characteristics of Two Stroke SI Engine with Catalytically Activated Piston with Alcohol Blended Gasoline**

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**ABSTRACT:** 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, 300 $\mu$ ) 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**

The paper is divided into i) Introduction, ii) Materials and Methods, iii) Results and Discussions, iv) Conclusions, Research Findings, Future scope of work followed by References.

Fast depletion of gasoline fuels their ever increasing costs and the increase of pollutants with these fuels forces a search for 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.

Nedunchezian *et al.* [1] studied the cyclic variation of combustion parameters with the results of experimental work on a two-stroke catalytically activated SI engine. A comparative study was carried out with the base engine for finding out the effect of catalytic activation. Copper was selected as catalyst and was coated by plasma spraying technique on the top surface of piston crown and on the inner surface of combustion chamber walls. With a piezoelectric pressure pickup and PC based data acquisition system, cylinder pressures were recorded for 2000 continuous cycles. The covariance (COV) were calculated for the 2000 cycles and compared with base engine. Shortened combustion duration and acceleration of pre-flame reactions were observed as a result of copper coating. In comparison with the base engine, the cyclic variation of combustion parameters was observed to be less and there is a group of cycles which deviate from the normal cycles. Dhandapani [2] reported that when a high thermal conductivity material like copper was coated on the inner surface of cylinder head and on the top surface of piston crown, the fuel economy and combustion reactions were improved. Nedunchezian *et al.* [3] investigated the cyclic variation of combustion parameters by conducting tests on a two-stroke catalytically activated SI engine. A comparative study was carried out with the base engine for finding out the effect of catalytic activation. The acceleration of pre-flame reactions and shortening of combustion duration

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 1, Januray 2016

were observed with catalyst coating. When compared with the base engine, the cyclic variation of combustion parameters was found to be less and a deviation from the normal cycles was observed.

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.

## II. MATERIALS AND METHODS

This section deals with fabrication of copper coated piston, description of experimental set up and the measurement of combustion characteristics.

In the catalytically activated engine, the top surface of piston crown was coated [1], [4] with a high thermal conductive catalytic material (alloy of copper (89.5%), aluminium (9.5%) and iron (1%)) for a thickness of 300microns over another bond coating (nickel-cobalt-chromium) that was previously sprayed for a thickness of 100 microns with a METCO flame spray gun.

Plate. 1 shows the photographic view of catalytic (copper) coated piston



Plate.1. Photographic view of copper coated piston

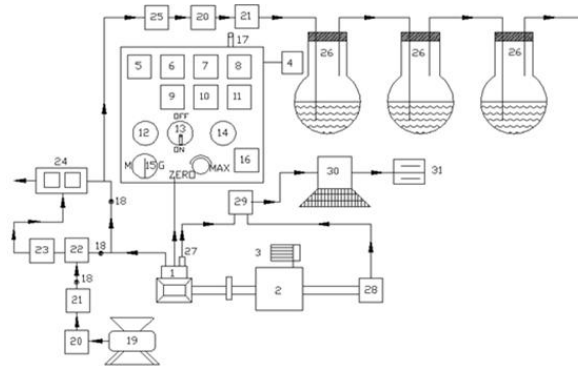
Fig. 1 shows the schematic diagram of the experimental set up that was employed to measure the combustion characteristics.

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 [5], [6]. 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 [6], [7] 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- $\theta$  software package from the signals of pressure and crank angle.

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Vol. 5, Issue 1, Januray 2016



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.

Fig.1. Schematic diagram of the experimental set up

### III. EXPERIMENTAL RESULTS

The variation of combustion characteristics of CE and CCE with test fuels is discussed in the following paragraphs.

#### Combustion Characteristics

The experimental values of peak pressure (PP) obtained from the special software package at full load operation of CE and CCE using experimental fuels was presented as bar chart in the Fig.2.

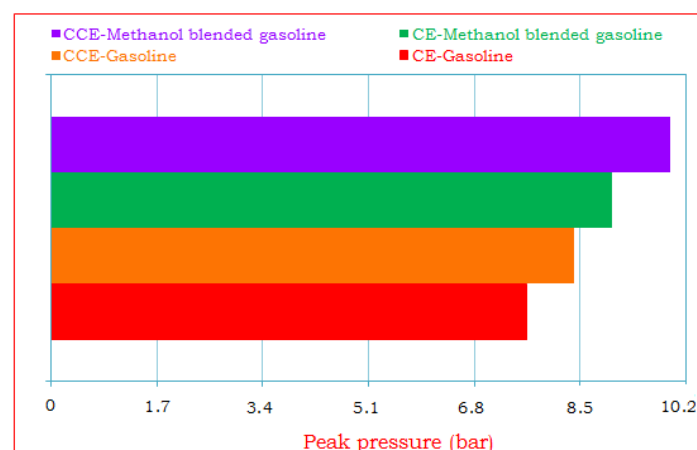


Fig.2. Bar chart showing the experimental values of PP at full load operation in CE and CCE with test fuels

PP was found to be higher in the catalytic coated engine with methyl alcohol blend. This was due to good combustion achieved with methyl alcohol blend as more number of moles are participating in the combustion reaction and further catalytic activity with catalytic coating. Similar trends were observed by Muralikrishna [6].

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 Fig.3.

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 1, Januray 2016

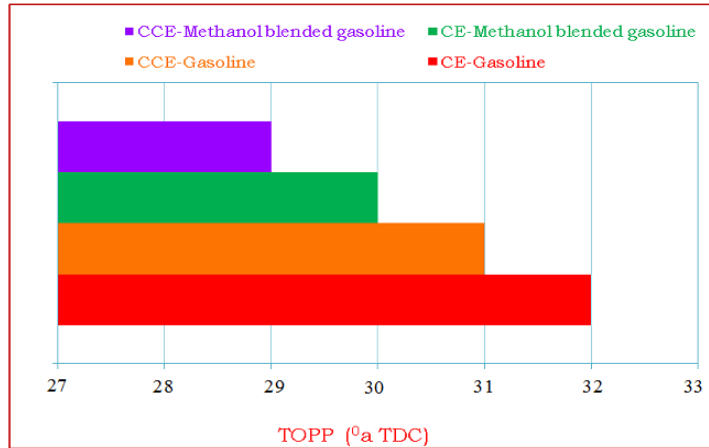


Fig.3. Bar chart showing the experimental values of TOPP at full load operation in CE and CCE with test fuels

From the Fig.3, 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 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. The trends are matching with Muralikrishna [6] and Krishnamurthy [7]. 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 Fig.4.

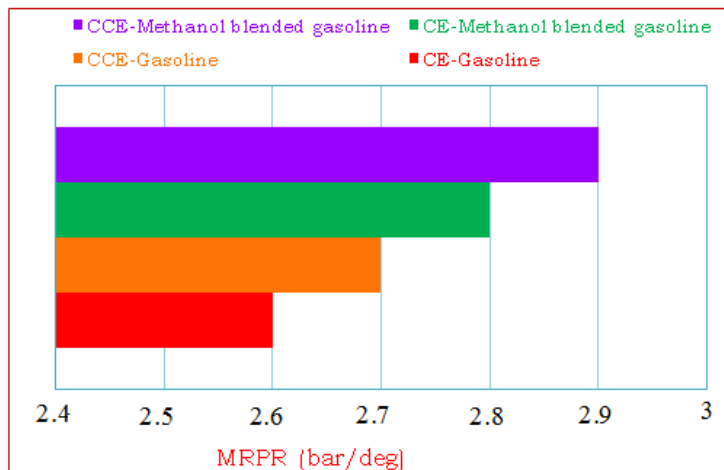


Fig.4. Bar chart showing the experimental values of MRPR at full load operation in CE and CCE with test fuels

It was clear from the Fig.4. that, MRPR followed similar trends as that of PP [6], [7]. MRPR was found to be within the limits 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.

Fig.5. presents the bar chart showing the experimental values of maximum heat release (MHR) in the base engine and catalytic coated engine with experimental fuels.

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Vol. 5, Issue 1, Januray 2016

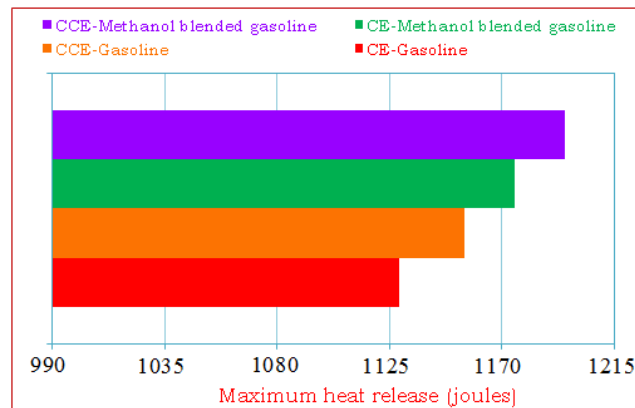


Fig.5. Bar chart showing the experimental values of MHR at full load operation in CE and CCE with test fuels

From the Fig.5, MHR was found to be more with methyl alcohol blend in catalytically activated engine [8] 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.

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.

Fig.6. 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.

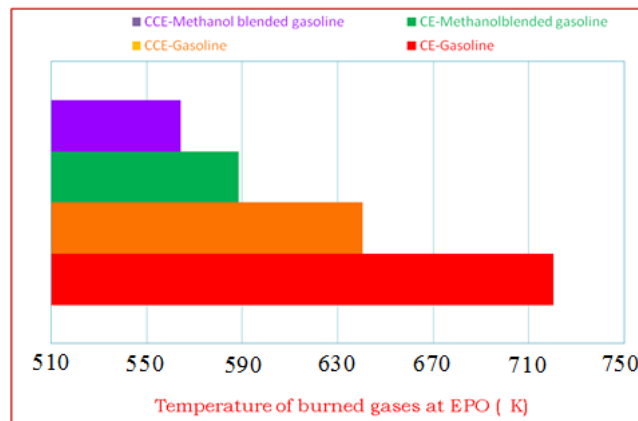


Fig.6. Bar chart showing the experimental values of temperature of burned gases at EPO in CE and CCE with test fuels

It was understood from the Fig.6. 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. CONCLUSION

1. PP increased by 30.2%, TOPP decreased by 9.3%, MRPR increased by 11.5% and MHR increased by 4.9% 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 167 K in comparison with the base engine operation.

# International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly Peer Reviewed Journal)*

**Vol. 5, Issue 1, Januray 2016**

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