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Research Article

Comparative Studies on the Combustion Parameters of Modified SI Engine over Base Engine

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Abstract

Experimentation was carried out to analyze the combustion parameters of a single cylinder, air-cooled, Bajaj make, 2.2 kW BP, 3000 rpm, two-stroke, catalytic coated (copper coated on the piston crown and on the inner surface of cylinder head), methyl alcohol-gasoline blend (80% gasoline, 20% methyl alcohol, by volume) operated SI engine. The 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 exhaust emissions at exhaust port opening (EPO) were determined at full load operation of the engine. Alcohol-gasoline blend fueled copper coated combustion chamber considerably improved the combustion parameters over conventional engine with pure gasoline operation.

Keywords: *Copper coating, Methyl Alcohol Blend, PP, TOPP, MRPR, MHR, Temperature of Exhaust Gases at EPO.*

1. Introduction

The fast depletion of gasoline fuels and the increase in the pollution levels from gasoline engines necessitates the search for alternate fuels. Due to the compatibility in the properties with gasoline, alcohols are the better alternate fuels. Methanol is preferred over ethanol, for blending with gasoline as it is not harmful (Sharma *et al*, 1986). Because of its high thermal conductivity that increases preflame reactions and turbulence in SI engines, copper was coated on the piston crown and on the inner surface of cylinder head (Dandapani, 1991), (Nedunchezhian and Dandapani, 1999), (Nedunchezhian and Dandapani, 2000). The combustion parameters are evaluated by a piezoelectric pressure transducer and special p-θ software.

The present paper evaluated the combustion characteristics at full load operation of a copper coated combustion chamber (piston crown and inner surface of cylinder head being coated with copper) with alcohol blended gasoline (gasoline-80% and methanol-20% by volume) and compared with pure gasoline fueled base engine.

2. Materials and methods

In the catalytic coated engine (CCE), initially a bond coating of nickel-cobalt-chromium was sprayed for a thickness of 0.1 mm on the piston crown and inner surface of cylinder head, over which, an alloy of copper (89.5%), aluminium (9.5%) and iron (1%) was coated for another 0.3 mm. Experiments were conducted on copper coated SI engine with gasoline as fuel. Wear and tear was not reported from the engine life test carried out for 50 hours, (Dandapani, 1991).

Plate 1 shows the photographic view of copper coated piston, liner and copper coated cylinder head.

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

Plate 2 show the photographic view of experimental set up employed to evaluate the combustion parameters.

Plate 2 Photographic view of experimental setup

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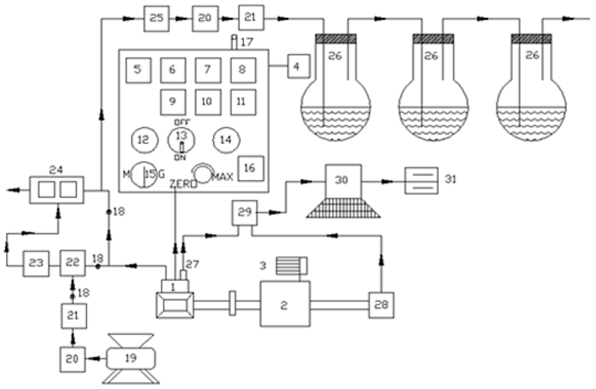
Figure 1 shows the schematic diagram of the experimental set employed to evaluate the combustion parameters.



1.Engine,2.Dynamometer,3.Loadingarrangement,4.Fuel tank, 5.Torque indicator 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

Piezo electric transducer, fitted on the cylinder head to measure the pressure in the combustion chamber is connected to a consol, which in turn is connected to a Pentium personal computer. TDC encoder provided at the extended shaft of the dynamometer is connected to the consol to measure the crank angle of the engine. Pressure-crank angle diagram and Heat release-crank angle diagram were obtained on the screen of the personal computer (**Plate 3**).

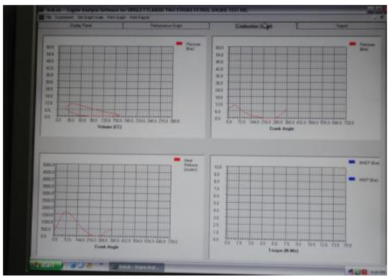


Plate 3 Photographic view of the evaluation of combustion characteristics by P-θ software

Combustion characteristics of the engine are very important when the engine is run with alternative fuel (Ponnusamy, *et al,* 2011). 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 (Govindasamy and Dandapani, 2007). TOPP is another important parameter by means of which the pressure can be calculated with respect to TDC. Near the value of TOPP, better the performance is. MRPR denotes the knocking condition of the engine. It was important to determine the heat release of the engine as it is 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 (Nedunchezhian and Dandapani, 2000). To assess the performance of the engine, temperature of burned gases at EPO is to be determined experimentally. Lower the value, better is the engine performance (Muralikrishna, *et al*, 2012).

3. Results and discussion

Figure 2 shows the comparative diagram of the variation of pressure with crank angle in CE with gasoline and CCE with methanol blended gasoline at peak load operation of the engine.

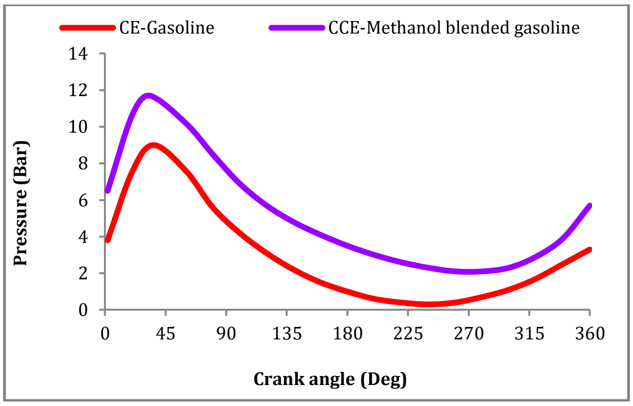


Fig. 2 Variation of pressure with crank angle in CE and CCE with test fuels

From **Figure 2**, PP was found to be higher in CCE with methanol blended gasoline over CE with pure gasoline. This was due to good combustion achieved with methanol blended gasoline as more number of moles are participating in the combustion reaction coupled with catalytic activity pronounced with copper coating.

Figure 3 presents the bar charts which show the variation of TOPP in CE and CCE with experimental fuels.

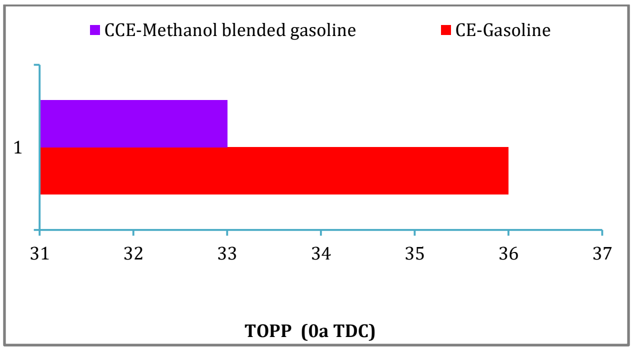


Fig. 3 Variation of TOPP in CE and CCE with experimental fuels

From **Figure 3**, TOPP is found to be minimum with CCE with methanol blended gasoline when compared with CE with pure gasoline operation Methanol addition improved the combustion process, reduced the crevices flow energy, reduced the cylinder temperature, reduced the ignition delay, speeds up the flame front propagation, and reduces the duration of combustion. Hence, TOPP is found to be minimum with CCE with methanol blended gasoline when compared with CE with pure gasoline operation which confirms that CCE with methanol blended gasoline is efficient as its TOPP is nearer to TDC. That means more energy is utilized to actual work rather than wasting the energy (Rammohan, 1995).

Figure 4 presents the bar charts which show the variation of TOPP and MRPR in CE and CCE with experimental fuels.

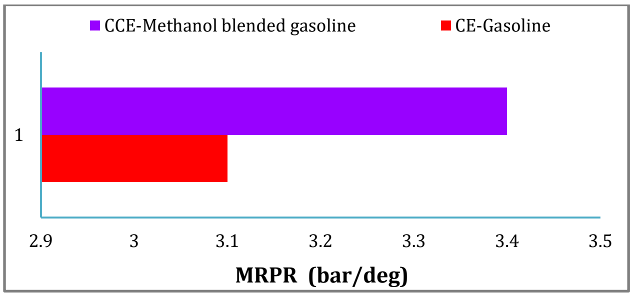


Fig. 4 Variation of MRPR in CE and CCE with test fuels

From the **Figure 4**, MRPR is found to be within the limits from which it can be said that the engine is not in the knocking condition (Muralikrishna, 2004).

Figure 5 shows the comparative diagram of the variation of heat release with crank angle in CE with gasoline and CCE with methanol blended gasoline at peak load operation of the engine.

From **Figure 5**, higher heat release was obtained at the point where the peak pressure is obtained (Krishnamurthy, 2004). 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.

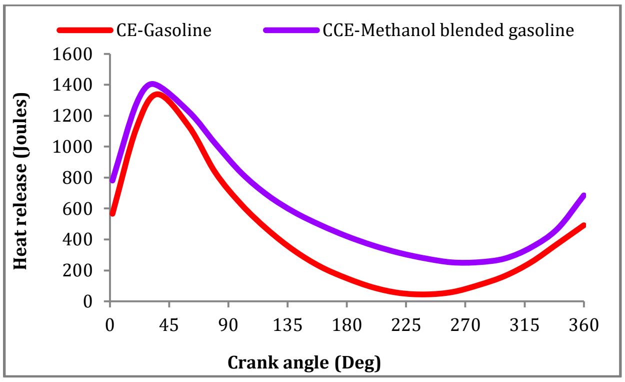


Fig. 5 Variation of heat release with crank angle in CE and CCE with test fuels

Figure 6 shows the comparative diagram of the variation of temperature of burned gases at EPO, with crank angle in CE with gasoline and CCE with methanol blended gasoline at peak load operation of the engine.

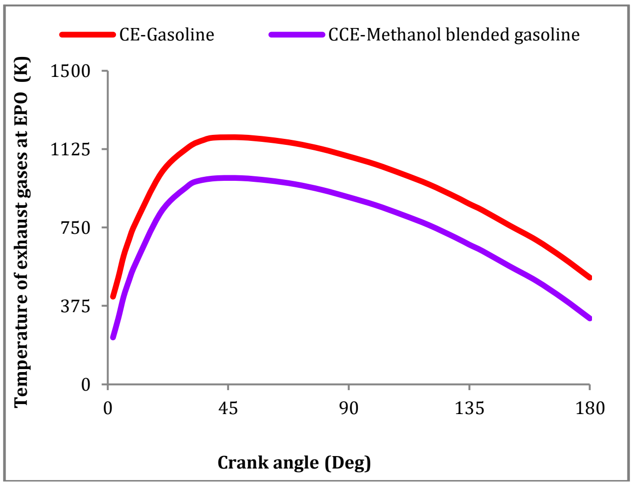


Fig. 6 Variation of temperature of burned gases at EPO with crank angle in CE and CCE with test fuels

From the **Figure 6** it was noted that**,** the temperature of burned gases at EPO was found to be minimum with methanol blended gasoline in CCE. This was due to the efficient combustion of the relatively leaner air-fuel mixtures with methanol blend. Hence it was clear that, CCE with methanol blended gasoline is efficient over the base engine with pure gasoline operation at peak load.

Table 1 shows the comparative data of combustion parameters of modified engine and base engine with the fuels of experimentation.

Table 1 Experimental data of combustion parameters

S. No	Combustion Parameter	Experimental Values		
		Base engine (Conventional engine with pure gasoline operation)	Modified engine (Methanol-gasoline blend fueled copper coated engine)	Percentage (%) deviation of combustion parameters of modified engine over base engine
1	PP, bar	9	11.7	30%
2	TOPP, (^{0}a TDC)	36	33	-8.30%
3	MRPR, (bar/deg)	3.1	3.4	9.60%
4	MHR, (joules)	1339	1405	4.90%
5	Temperature of Exhaust gases at EPO, K	863	668	-195 K

From the **Table 1** it was clear that, methanol-gasoline blend fueled copper coated engine considerably improved the combustion parameters over the base engine with pure gasoline operation.

Conclusions

1) PP increased by 30% with methanol blended gasoline in CCE over pure gasoline in CE.
2) Compared to CE with pure gasoline, CCE with methanol blended gasoline decreased the value of TOPP by 8.3%.
3) Methanol blended gasoline in CCE increased MRPR by 10% over pure gasoline operation in CE.
4) CCE with methanol blended gasoline increased MHR by 5% over CE with pure gasoline operation.
5) Temperature of burned gases at EPO decreased by 195^0K with methanol blended gasoline in CCE over pure gasoline operation on CE.

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