Emission Analysis of a Methyl Alcohol-Gasoline Blend Operated Two Stroke SI Engine with Catalytically Activated Cylinder Head

Dr. K. Kishor

Assistant Professor, Mechanical Engineering Department, CBIT, Gandipet, Hyderabad

ABSTRACT

Experiments were conducted to evaluate the exhaust emissions from two stroke single cylinder, spark ignition (SI) engine, with methyl alcohol blended gasoline (80% gasoline, 20% methyl alcohol, by volume) having catalytically activated engine [CCE, copper-(thickness, 300 µ) copper being coated on the inner surface of the cylinder head] and compared with conventional SI engine (CE) with pure gasoline operation. The exhaust emissions of carbon monoxide (CO) and unburnt hydrocarbons (UBHC) were determined at different values of Brake Mean Effective Pressure (BMEP) with Netel Chromatograph CO/UBHC analyzer. Formaldehyde and Acetaldehyde levels were determined by Dinitrophenyl Hydrazine (DNPH) method. Copper coated combustion chamber with alcohol blended gasoline considerably reduced the pollutants in comparison with CE with pure gasoline operation.

Keywords: Copper coating, CO, UBHC, Aldehydes, BMEP

1. 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.

The emission levels from a two stroke engine are high, thereby necessitating the need for their control. The harmful pollutants in the engine exhaust are CO, UBHC, Formaldehydes and Acetaldehydes. Usha Madhuri *et al.* [1] reported that at idling and full load operation of the engine, the pollutant of CO is high. Further, with the age of the vehicle, the CO emissions in the engine exhaust were high. Sharma [2] explained that among the pollutants which detrimentally affect the living things and the environment, CO causes asphyxia and also may lead to death. The pollutants can be controlled either by changing the composition of the fuel or by changing the configuration of the engine or both. The composition of fuel can be changed by blending the gasoline fuel with alcohol, more precisely methyl alcohol, as it is not harmful. The present paper evaluated the exhaust emissions from two stroke copper coated engine with gasoline blended with methyl alcohol (gasoline-80%, methyl alcohol- 20% by volume) and copper being coated on the inner surface of the cylinder head, which includes measuring the exhaust emissions of CO, UBHC and Aldehydes at various values of brake mean effect pressure (BMEP) and compared with CE with pure gasoline operation.

2. METHODOLOGY

This section deals with fabrication of CCE (inner surface of cylinder head being coated with copper by flame spray technique and description of the experimental set up.

In CCE, a high thermal conductive catalytic material like copper was coated on the inner surface of the cylinder head by flame spraying technique. **Plate 1** shows the photographic view of copper coated cylinder head.

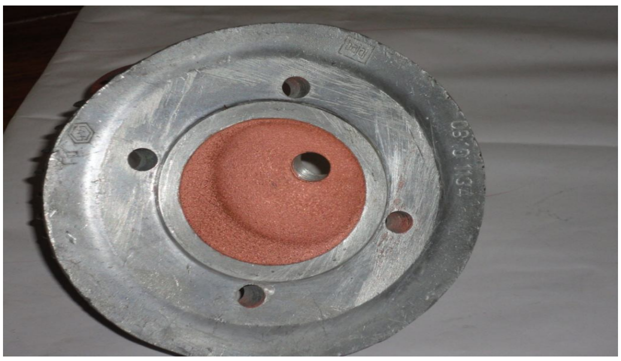

Plate 1 Photographic view of copper coated cylinder head

An alloy of copper (89.5%), aluminium (9.5%) and iron (1%) was coated for a thickness of 300µ with a METCO (Trade name of the company) flame spray gun over the 100µ thickness bond coating of Nickel-cobalt-chromium which was sprayed earlier. The bond strength of the coating was so high that it does not wear off even after operating it for 50 hrs continuously [3], [4].

Figure 1 shows the schematic diagram of the experimental set up that was employed to measure the exhaust emissions.

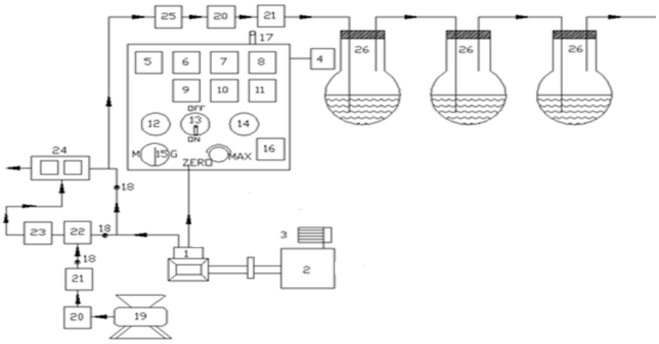

Figure 1 Schematic diagram of the experimental set up

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

An air-cooled single-cylinder 2.2 kW BP two-stroke SI engine with a rated speed of 3000 rpm. A pressure-feed system provides the engine oil. CO and UBHC emissions in engine exhaust were measured with Netel Chromatograph CO/UBHC analyzer. Aldehyde emissions (formaldehydes and acetaldehydes) are measured with wet chemical (DNPH) method [5], [6]. The engine exhaust was bubbled through DNPH in hydrochloric acid solution to form the hydrazones which are extracted into chloroform. By employing High performance liquid chromatography (HPLC), these hydrazones were analyzed to find the percentage concentration of formaldehydes and acetaldehydes.

3. RESULTS AND DISCUSSION

This section deals with i). variation of CO emissions with BMEP, ii) variation of UBHC emissions with BMEP, and iii) data of Aldehyde emissions (Formaldehydes and Acetaldehydes).

3.6 Exhaust emissions

Figure 2 shows the variation of CO emissions with brake mean effective pressure (BMEP) in CE with pure gasoline and CCE with methanol blended gasoline at a compression ratio of 7.5:1 and speed of 3000 rpm.

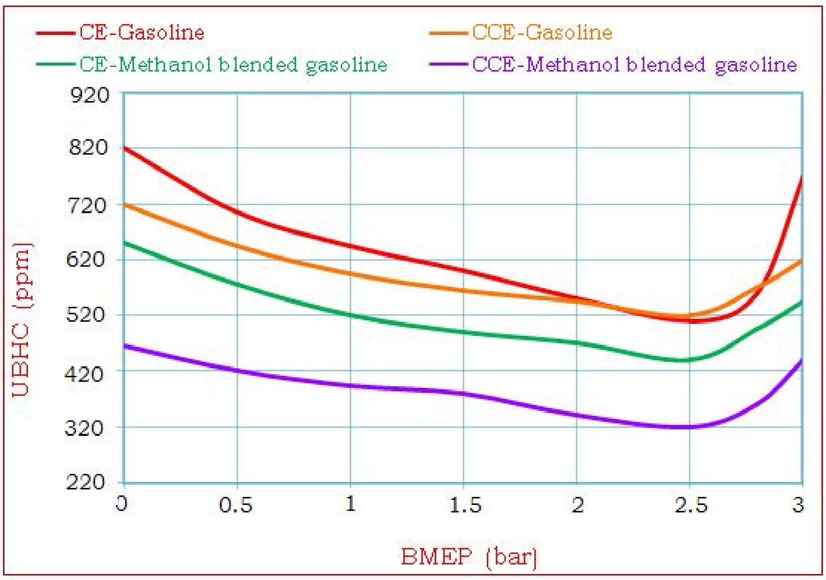

Figure 2 Variation of CO emissions with BMEP in CE and CCE with test fuels

From the **Figure 2** it was noticed that, in both configurations of the engine when compared to the base fuel operation, methyl alcohol blend decreased CO emissions because of the lower value of C/H ratio in the fuel composition. Change of fuel composition coupled with catalytic activity in the combustion chamber improved the combustion and pre-flame combustion reactions and decreased the CO emissions. As catalytic coating improves the combustion and turbulence, the CO emissions were decreased by the catalytic coated engine using both the experimental fuels when compared to the base engine and hence CCE is more suitable in achieving higher thermal efficiency and in decreasing the CO emissions.

The variation of UBHC emissions (ppm) with BMEP in CE and CCE with test fuels was shown in the **Figure 3**.

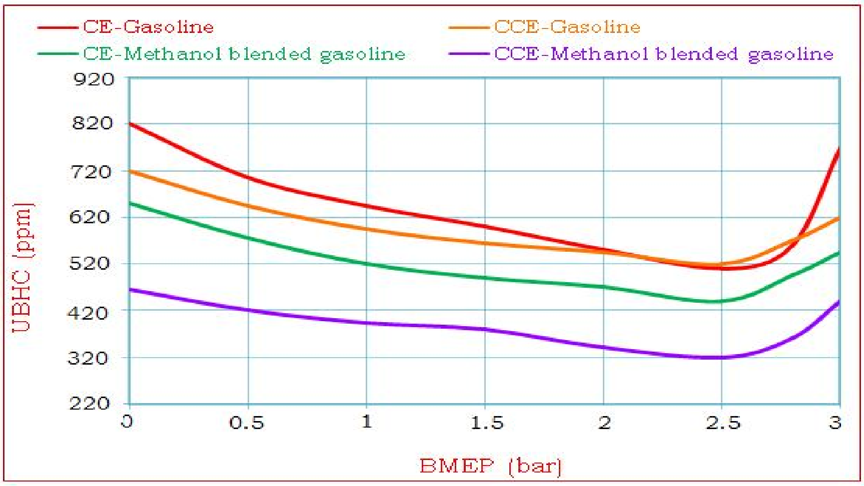

Figure 2 Variation of UBHC emissions with BMEP in CE and CCE with test fuels

From the **Figure 3**, UBHC emissions were found to be less with methyl alcohol blend in catalytic coated engine when compared to the base engine. UBHC emissions not only depend on (C/H) ratio but also on 'quenching effects' i.e., the accommodation of fuel in the crevices of the piston lands and combustion chamber walls. As methanol blended gasoline improves combustion in the presence of copper coating, the deposits and crevice effects were reduced, causing reduction in UBHC emissions [2], [7].

Aldehydes are formed as the intermediate compounds during combustion, when the engines are run with alcohols or alcohol blends.

Table 1 shows the data of Aldehyde emissions (Formaldehyde emissions and Acetaldehyde emissions, % concentration) at full load operation of CE and CCE with experimental fuels.

Table 1: Data of aldehyde emissions (% concentration) from CE and CCE with test fuels

Fuel used→	**Pure gasoline**			**Methyl alcohol blended gasoline**		
Engine version→ / **Aldehyde emissions↓**	**Conventional engine (CE)**	**Catalytic coated engine (CCE)**	**% variation with CCE over CE**	**Conventional engine (CE)**	**Catalytic coated engine (CCE)**	**% variation with CCE over CE**
Formaldehyde emissions	10	7.4	- 26 %	25.9	15.1	- 41.6%
Acetaldehyde emissions	8.4	5.1	- 39.2 %	13.5	10.3	- 23.7 %

With the change of configuration of the engine from CE to copper coated (on the inner surface of cylinder head) engine, a decrease of 26% and 39.2% was observed in the formaldehyde emissions and acetaldehyde emissions with pure gasoline operation of the engine, while when the engine is operated with methyl alcohol bended gasoline, a decrease of 41.6% and 23.7% was noticed in the formaldehyde and acetaldehyde emissions respectively. Because of the increase in pre-flame reactions and turbulence which results in the absence in the formation of highly reactive chemical compounds, CCE was noticed to be more suitable in reducing aldehyde emissions. Similar trends were observed with other researchers [2], [7] with the copper coated cylinder head engine running with pure gasoline.

4. CONCLUSIONS

1. CCE with alcohol blended gasoline operation decreased the CO emissions by 49% in comparison with CE operating on pure gasoline.
2. Methyl alcohol blended gasoline operation in CCE decreased the UBHC emissions by 43% in comparison with CE operating on pure gasoline.
3. Formaldehyde emissions and acetaldehyde emissions decreased by 26% and 39.2% respectively with pure gasoline in CCE in comparison with CE.
4. Methanol blended gasoline operation in CCE decreased formaldehyde emissions and acetaldehyde emissions by 41.6% and 23.7% respectively when compared to CE.

4.1 Research findings and future scope of work

Investigations on measurement of exhaust emissions with copper coating on the inner surface of cylinder head were systematically investigated. In addition to it, copper coating can also be done on the top surface of piston crown, to decrease the pollutants further.

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References

[1] T. Usha Madhuri, K. Ramakrishna, "A Study on Automobile Exhaust Pollution with Regard to Carbon Monoxide Emissions," Nature, Environment & Pollution Technology, pp. 473-474, Volume-2, Number-4, 2003.
[2] B.K. Sharma, Engineering Chemistry, Pragathi prakashan (P) Ltd., Meerut, 2005.
[3] S. Dhandapani, "Theoretical and Experimental Investigation of Catalytically Activated Lean Burn Combustion," Ph. D. Thesis, Indian Institute of Technology, Madras, 1991.
[4] N. Nedunchezhian, S. Dhandapani, "Experimental Investigation of Cyclic Variation of Combustion Parameters in a Catalytically Activated Two Stroke SI Engine Combustion Chamber," Engineering Today, ISSN: 0974-8377, pp. 11-18, Volume-2, 2000.
[5] M.V.S. Murali Krishna, K. Kishor, Ch. V. Ramana Reddy, "Control of Carbon Monoxide Emission in Spark Ignition Engine with Methanol Blended Gasoline and Sponge Iron Catalyst," Ecology, Environment & Conservation. Pp. 13-17, Volume-12, Number- 4, *2008.*
[6] M.V.S. Murali Krishna, K. Kishor, P.V.K. Murthy, A.V.S.S.K.S. Gupta, S Narasimha Kumar, "Comparative Studies on Performance Evaluation of Four Stroke Copper Coated Spark Ignition Engine with Catalytic Converter with Alcohols", International Journal Of Advances In Engineering Research, ISSN: 2231-5152, pp. 6-11, Volume-2, Number-6, 2011
[7] N. Nedunchezhian, S. Dhandapani, "Experimental Investigation of Cyclic Variation of Combustion Parameters in a Catalytically Activated Two Stroke SI Engine Combustion Chamber," SAE paper, Number-990014, 1999.

AUTHOR

K, Kishor received the B.Tech.. degree in Mechanical Engineering, M.Tech. degree in Thermal Engineering and Ph.D. from Jawaharlal Nehru Technological University, Hyderabad in 1987, 2005 and 2014 respectively. Till now, he worked in various capacities in the teaching profession for a total period of 27 years. Since 2004, he is working as Senior Assistant Professor in Mechanical Engineering Department, Chaitanya Bharathi Institute of Technology (CBIT), HYDERABAD