

# Performance Evaluation of Two Stroke Spark Ignition Engine with Catalytic Coated Cylinder Head with Alcohol Blended Gasoline over Conventional Gasoline Engine

Dr. K. Kishor<sup>1</sup>

Assistant Professor, Department of Mechanical Engineering, CBIT, Hyderabad, India<sup>1</sup>

**ABSTRACT:** Experiments were conducted to evaluate the performance of two stroke single cylinder, spark ignition (SI) engine, with methanol blended gasoline (80% gasoline, 20% methanol, by volume) having copper coated engine [CCE, copper-(thickness, 300  $\mu$ ) copper being coated on the inner surface of the cylinder head] and compared with conventional SI engine (CE) with pure gasoline operation. Performance parameters (brake thermal efficiency, brake specific energy consumption, exhaust gas temperature and volumetric efficiency) were determined with different values of brake mean effective pressure of the engine. Copper coated engine (CCE) with methanol blended gasoline considerably improved the performance in comparison with CE with pure gasoline operation. CCE with methanol blended gasoline increased the brake thermal efficiency, decreased the brake specific energy consumption, decreased the exhaust gas temperature and increased the volumetric efficiency.

**KEYWORDS:** CE, CCE, Inner surface of cylinder head, Methanol blend, brake thermal efficiency, brake specific energy consumption, Exhaust gas temperature, Volumetric efficiency

## 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.

As the fossil fuels are fastly depleting and their prices in the international market are increasing, there is a huge economic burden on Indian government. The pollution levels are increasing with the use of fossil fuels, necessitating the search for alternate fuels. Alcohol is a potential and renewable fuel for SI engine, because its properties are compatible to those of gasoline fuels and hence major engine design modification is not necessary. For individual transport, SI engines are preferred to compression ignition (CI) engines. Performance of the engine can also be improved with the change of fuel composition with alcohol-gasoline blends in SI engines. Out of the two alcohols available (methyl alcohol and ethyl alcohol), methyl alcohol is preferred to ethyl alcohol, as it is not harmful.

Mathur *et al.* [1] explained that methanol can be produced from municipal solid wastes and waste or specifically grown biomass. Though methanol can also be produced from natural gas, there is no point in it as the basic objective is to conserve petroleum gases or liquids. The municipal solid wastes can be converted to methanol. Copper being a good conductor of heat that promotes combustion, coating on the inner surface of cylinder head [2] increased combustion stabilization and improved the performance of the engine. Jain *et al.* [3] discussed that the drivability of a popular Indian vehicle evaluated by using the method of CRC and US Department of Energy with gasoline and 20% methanol gasoline blends. The effect of lean air- fuel mixture was also studied by modifying the carburetor. Both the methods were analyzed and observed that the CRC method does not give due weight age to hot start problems and the U.S. method do not evaluate drivability through light-throttle acceleration, cruise, full throttle acceleration and crowd acceleration. Maji *et al.* [4] carried out a performance test on a two-stroke SI engine (50 cc to 175 cc) and observed abnormal combustion with methanol even at a lower engine compression ratio of 6.8:1. An increased severity of

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abnormal combustion was observed when the compression ratio was increased with a view to utilize higher anti-knock quality of methanol. The energy consumption with methanol was lower than gasoline and 7-8% higher power could be developed at the same compression ratio. Sharma *et al.* [5] estimated that up to 15% methanol in gasoline can be used in existing small two-stroke engines. However, for a comparable drivability M12 was found to give same drivability demerits ratings. An extensive fleet trial on 14 vehicles (consisting of 8 mopeds, 4 scooters and 2 motorcycles) of popular Indian makes was undertaken to study the vehicle performance, material compatibility and long term effects of M12 blend. The vehicles accumulated 1.5 lakh kilometers in a 1 year programme. The results show a very good startability and drivability using M12 fuel. The fuel economy of M12 vehicles varied between +8% to -2% compared to gasoline. The power output remained unaffected. There were no major problems of engine deposits and material compatibility. The study establishes that M12 can be used in existing small two-stroke vehicles without any modifications.

The present paper evaluated the performance of two stroke copper coated SI engine with methanol blended gasoline (gasoline-80%, methanol- 20% by volume) with inner surface of cylinder head being coated with high thermal conductive material like copper, which includes determining performance parameters at various values of brake mean effect pressure and compared with CE with pure gasoline operation.

## II. MATERIALS AND METHODS

This section deals with fabrication of copper coated engine, description of experimental set up and definition of used values.

In the copper coated engine, by flame spraying technique, a high thermal conductive catalytic material like copper was coated on the inner surface of cylinder head. For 100 $\mu$  thickness, nickel-cobalt-chromium bond coating was sprayed. On this coating, for another 300 $\mu$  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 [2], [6].

Plate. 1 shows the photographic view of copper coated cylinder head.



Plate.1. Photographic view of copper coated cylinder head

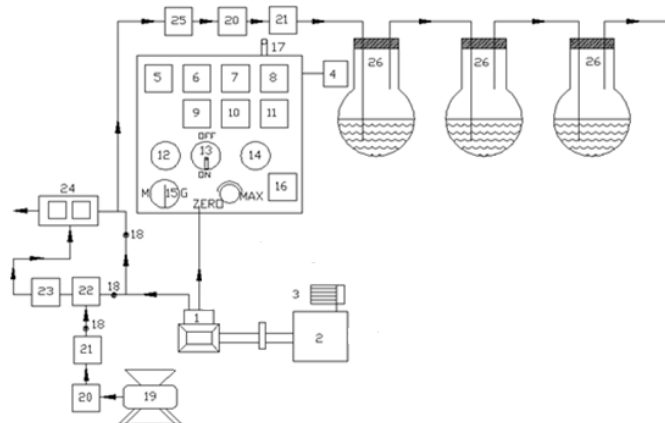
Fig.1. shows the schematic diagram of the experimental set up that was employed to evaluate the performance parameters.

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). The fuel consumption, speed, torque, air flow rate and exhaust gas temperature were measured with digital electronic sensors. A pressure-feed system provides the engine oil.

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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,

Fig.1. Schematic diagram of the experimental set up

Performance parameters of brake thermal efficiency (BTE), Brake specific Energy Consumption (BSEC), exhaust gas temperature (EGT) and volumetric efficiency (VE) are evaluated at different values of brake mean effective pressure (BMEP) of the engine. Experiments were carried out on CE with pure gasoline and copper coated engine (CCE) with methanol blended gasoline (gasoline-80%, methanol-20% by volume).

### III. DEFINITION OF USED VALUES

Brake mean effective pressure: It is defined as specific torque of the engine. Its unit is bar.

$$BP = \frac{BMEP \times 10^5 \times L \times A \times n \times k}{60000}$$

BP =Brake power of the engine in kW;

BMEP= Brake mean effective pressure of the engine in bar

L= Stroke of the piston in m, A= Area of the piston =  $(\pi D^2)/4$  Where D= Bore of the cylinder in m, n= Effective number of power cycles= N, where N=Speed of the engine = 3000 rpm, k = no. of cylinders = 1

Brake thermal efficiency (BTE); It is the ratio of brake power of the engine to the energy supplied to the engine. Brake power was measured with dynamometer. Energy supplied to the engine is the product of rate of fuel consumed ( $m_f$ )and calorific value ( $c_v$ )of the fuel. Higher the efficiency better the performance of the engine is.

$$BTE = \frac{BP}{m_f \times CV}$$

Brake specific energy consumption (BSEC): It is measured at full load operation of the engine. Lesser the value, the better the performance of the engine is. It is defined as energy consumed by the engine in producing 1 kW brake power. When different fuels having different properties are tested in engine, brake specific fuel consumption is not the criteria to evaluate the performance of the engine. Peak BTE and BSEC at full load are important parameters to be considered to evaluate the performance of the engine.

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$$BSEC = \frac{1}{BTE}$$

Volumetric efficiency: It is the ratio of the volume of air drawn into a cylinder to the piston displacement.

Calculation of actual discharge of air: By means of water tube manometer and an orifice flow meter, head of air ( $h_a$ ) can be calculated. Velocity of air ( $V_a$ ) can be calculated using the formula

$$V_a = \sqrt{2gh_a}$$

Actual discharge of air =  $c_d a \sqrt{2gh_a}$ , where  $a$  = area of an orifice flow meter,  $c_d$  = Coefficient of discharge.

## IV. EXPERIMENTAL RESULTS

This section deals with i) variation of brake thermal efficiency, exhaust gas temperature, volumetric efficiency with brake mean effective pressure with test fuels with different versions of the engine, ii) variation of brake specific energy consumption at full load operation with test fuels with CE and CCE, iii). variation of EGT with brake mean effective pressure (BMEP) of the engine, and iv) variation of VE with brake mean effective pressure (BMEP) determined at full load operation of the engine.

### Performance Parameters

Fig.2. shows the variation of brake thermal efficiency (BTE) 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.

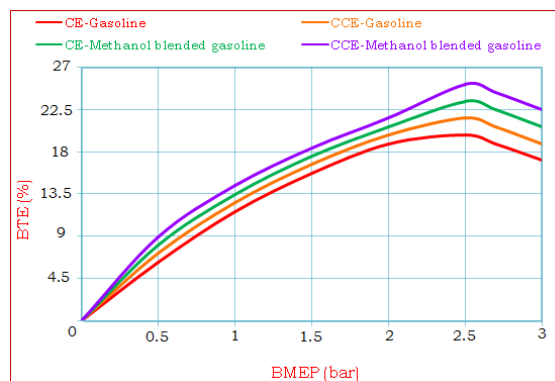


Fig.2. Variation of BTE with BMEP in CE and CCE with test fuels

With methyl alcohol blend, higher BTE was noticed over pure gasoline at all loads on both versions of the combustion chamber. The reasons for improving the thermal efficiency (BTE) with methanol blended gasoline were because of decreased dissociated losses, specific heat losses and cooling losses due to lower combustion temperature. Copper coated engine showed improved performance over CE with the same type of fuel, as copper coating because of its higher thermal conductivity promotes combustion and increases pre-flame reactions [7], [8].

The energy consumed by the engine in producing 1 kW brake power is called Brake specific energy consumption (BSEC).

Fig.3. presents the bar chart showing the variation of brake specific energy consumption (BSEC) at full load operation of CE with pure gasoline and CCE with methanol blended gasoline operation.

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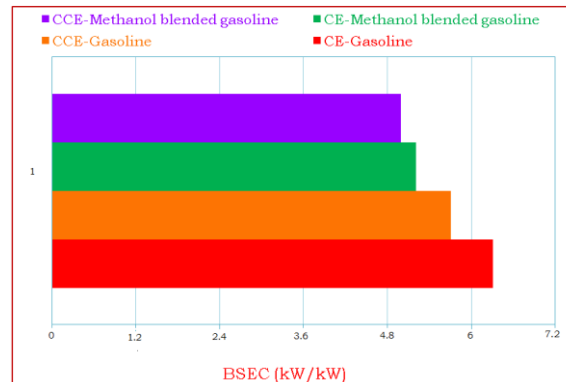


Fig.3. Bar charts showing the variation of BSEC at full load operation with CE and CCE with test fuels

From the Fig.3. it was noticed that, at full load operation of CCE with methanol blended gasoline, BSEC was lower over that of CE. The mass flow rate of burning of methyl alcohol was lower in comparison with pure gasoline. Hence methanol blended gasoline consumes less energy when compared with pure gasoline, as the consumption of energy depends on the consumption of mass of fuel and heating value of the fuel.

Fig.4. shows the variation of exhaust gas temperature (EGT) with BMEP in different versions of the engine with test fuels at a speed of 3000 rpm and compression ratio of 7.5:1, which indicated that EGT increased with an increase of BMEP. This was due to increase of fuel consumption with load.

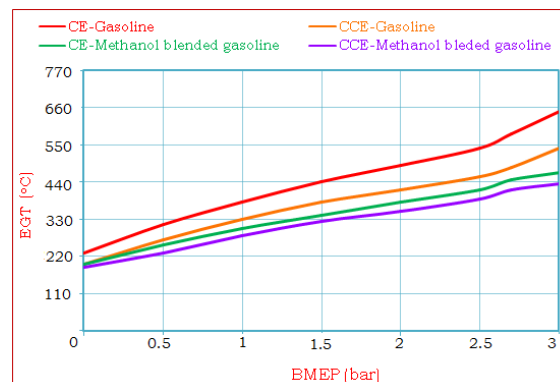


Fig.4. Variation of EGT with BMEP in CE and CCE with experimental fuels

The exhaust gas temperature with pure gasoline operation was higher in both the versions of combustion chamber when compared with methanol blended gasoline operation. Gasoline has higher calorific value, releasing more amount of heat energy and hence heat exhausted was also more. Therefore, EGT was higher with gasoline in CE than CCE with same test fuel. Also, the latent heat of evaporation of methanol is higher, so it absorbs temperature from surroundings leading to drop in temperature of exhaust gases. As the calorific value of methanol blend is lower than calorific value of pure gasoline, the heat released by the blend is less and hence, the exhaust gas heat losses will also be less. Thus there is a reduction of heat loss through exhaust gases with copper coated engine with methanol blended gasoline over CE with pure gasoline.

Fig.5. shows the variation of volumetric efficiency (VE) with BMEP with test fuels at a speed of 3000 rpm and a compression ratio of 7.5:1, which indicated that VE decreased with increase of BMEP due to increase of gas temperature [9].

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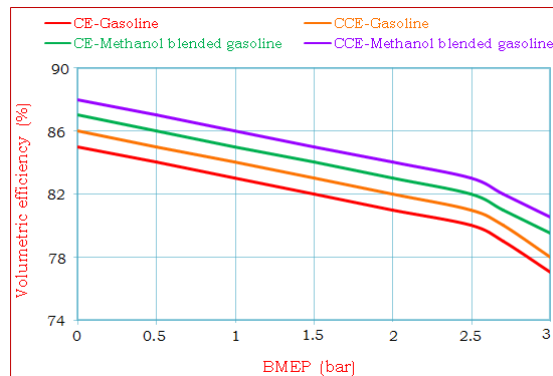


Fig.5. Variation of volumetric efficiency with BMEP in CE and CCE with experimental fuels

As BMEP increases VE was observed to be higher (Fig. 5) with methyl alcohol blend in comparison with pure gasoline due to higher latent heat of evaporation. Copper coated engine gave marginally higher magnitudes of VE than the conventional engine with both experimental fuels. This was due to the decrease of fuel deposits and concentration of fuel at the walls of combustion chamber. This was reported by various researchers [6], [10].

## V. CONCLUSION

1. Thermal efficiency increased by 35% with alcohol blended gasoline operation in CCE over pure gasoline operation in CE.
2. Exhaust gas temperature decreased by 38% with alcohol blended gasoline operation in CCE over pure gasoline operation in CE.
3. Volumetric efficiency increased by 5.5% with methanol blended gasoline operation in CCE over pure gasoline operation in CE.
4. CCE with methanol blended gasoline showed lower value of BSEC in comparison to CE with pure gasoline operation.

## REFERENCES

- [1] Mathur, M. L. and Sharma., "Internal Combustion Engines", Dhanpat Rai Publications (P) Ltd., New Delhi, 2009.
- [2] Nedunchezian, N., and Dhandapani, S., "Experimental Investigation of Cyclic Variation of Combustion Parameters in a Catalytically Activated Two-Stroke SI Engine Combustion Chamber", Engg Today, ISSN: 0974-8377, vol. 2, pp. 11-18, 2000.
- [3] Jain A.K, Gandhi K.K, "Drivability and Fuel Economy of Vehicles Fuelled with Alcohol-Gasoline Blends", Proc.of 6th Int. Symp.on Alcohol Fuels Technology, Ottawa, Canada, pp. 1.202-1.208, 1984.
- [4] Maji S, Pundir B.P, Radzimirski S, "A Methanol Operated Small 2-Stroke SI Engine", VIII<sup>th</sup> Inter. Symp. on Alcohol Fuels, Paris, 1986.
- [5] Sharma J, Singh I.P, Gupta M, Gandhi K.K, "Two-Stroke Vehicles Fuelled with Methanol-Gasoline Blends-A Fleet Study", 8th Int. Symp. on Alcohol Fuels, Paris, 1986.
- [6] Dhandapani, S., "Theoretical and Experimental Investigation of Catalytically Activated Lean Burn Combustion", Ph. D. Thesis, IIT, Madras, 1991.
- [7] Govindasamy, P. and Dhandapani, S., "Experimental Investigation of Cyclic Variation of Combustion Parameters in Catalytically Activated and Magnetically Energized Two-Stroke SI Engine", Journal of Energy & Environment, Vol. 6, pp. 45-59, 2007.
- [8] Nedunchezian, N., and Dhandapani S., "Heat Release Analysis of Lean Burn Catalytic Combustion in a Two-Stroke Spark Ignition Engine" Combustion Science and Technology, Vol. 155, No. 1, pp. 181 – 200, 2000
- [9] Murali Krishna, M.V.S., Narasimha Kumar, S., Krishna Murthy, P.V., Reddy, D.N. and Kishor, K., "Performance Evaluation of a Two-Stroke Copper Coated Spark Ignition Engine with Gasohol With Catalytic Converter with Different Catalysts", International Journal of Emerging Technology and Advanced Engineering (IJETA), ISSN 2250-2459, Vol. 2, No. 3, pp. 165-173, 2012.
- [10] Nedunchezian, N., and Dhandapani, S., "Experimental Investigation of Cyclic Variation of Combustion Parameters in a Catalytically Activated Two-Stroke SI Engine Combustion Chamber", SAE paper, number-990014, 1999.