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Effect Of Ethanol–Gasoline Blends On Engine Performance Parameters In Copper Coated Two Stroke Spark Ignition Engine

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Abstract-- Renewable energy sources for the gasoline engines alcohols gain importance recently. These renewable energy sources have attracted the attention of researchers as alternative fuel due to their high octane number. In this paper investigations were carried out to evaluate performance parameters of two-stroke, single cylinder spark ignition (SI) engine with gasohol (80% gasoline, 20% ethanol, by vol) having copper coated engine [copper-(thickness, 300 µ) coated on piston crown and inner side of cylinder head] provided with catalytic converter with sponge iron as catalyst and compared with conventional SI engine with gasoline operation. Performance parameters [brake thermal efficiency, exhaust gas temperature and volumetric efficiency] were determined at various values of brake mean effective pressure of the engine. Comparative studies were made on performance parameters with conventional SI engine with pure gasoline operation. Brake thermal efficiency increased with gasohol with both versions of the engine. Copper-coated engine showed improved performance when compared to conventional engine with both test fuels.

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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.

This section deals need and necessity of alternate fuels for SI engine, experimental investigations taken up by different researchers connected to this work, methods to improve the performance of SI engine, modification of combustion chamber, change of fuel composition, research gaps and objectives of the experimentation.

The large amount of pollutants emitting out from the exhaust of the automotive vehicles run on fossil fuels are increasing and these pollutants are proportional to number of vehicles. The civilization of any country is measured on the basis of number of vehicles. Hence the Government has to spend huge foreign currency for importing crude petroleum to meet the fuel needs of the automotive vehicles, in the context of fast depletion of fossil fuels. In view of heavy consumption of gasoline due to individual transport, the search for alternate fuels has become pertinent apart from effective fuel utilization which has been the concern of the engine manufacturers, users and researchers involved in combustion & alternate fuel research.

Alcohols are suitable substitutes as alternate fuels for use in SI engines, as they have properties compatible to gasoline fuels, that too their octane rating is more than 100. If alcohols are blended in small quantities with gasoline, no engine modification is necessary. Engine modification and change in fuel composition are two methods to improve the performance of the engine and reducing pollution levels.

Engine modification [1-4] with copper coating on piston crown, and inner side of cylinder head improves engine performance as copper is a good conductor of heat and combustion is improved with copper coating. The use of catalysts to promote combustion is an old concept. More recently copper is coated over piston crown and inside of cylinder head wall and it is reported that the catalyst improved the fuel economy and increased combustion stabilization.

Nedunchezhian et al.[1] evaluated the performance of a two-stroke copper coated engine (copper coating of thickness 300 microns and binding material of thickness of 100 microns on piston crown and inside portion of cylinder) with pure gasoline and reported that CCCC improved the specific fuel consumption by 4% at full load operation of the engine .

Murali Krishna et al. [2,8] conducted experiments on four-stroke copper coated combustion chamber (CCCC) (copper coating of thickness 300 microns with binding material of thickness 100 microns on piston crown and inner side of cylinder head) with gasohol (20% ethanol blended with gasoline by volume) and reported that CCCC increased efficiency of the engine by 20%. .

Murali Krishna et al. [3] employed four-stroke variable compression ratio (3-9) SI engine ranging from, variable speed (2200-3000 rpm) with methanol blended gasoline (20% by volume) and reported increase of thermal efficiency by 15% in comparison with pure gasoline operation on conventional engine.

Investigations have been carried out by different researchers [6-8] to improve the performance of SI engine with change of fuel composition.

Farayedhi et al. [4] investigated the efficiency of CE with oxygenated fuels of ethanol and methanol used as blends of 10, 15, and 20 % by volume with gasoline and it was reported that these blends improved brake thermal efficiency. The leaded fuel performed better than the oxygenated blends in terms of the maximum output of the engine except in the case of 20 % by vol. methanol and 15 % by vol. ethanol blends. Overall, the methanol blends performed better than the other oxygenated blends in terms of engine output and thermal efficiency. Bahattin [5] conducted experiments on SI engines with blends of E25 (75% gasoline and 25% ethanol by vol.), E50, E75 and E100 fuels at a constant load and speed. The experimental results show that the most suitable fuel in terms of performance and emissions was E50. Then, the compression ratio was raised from 6:1 to 10:1. The engine was tested with E0 fuel at a compression ratio of 6:1 and with E50 fuel at a compression ratio of 10:1 at full load and various speeds without any knock. The cylinder pressures were recorded for each compression ratio and fuel. The experimental results showed that engine power increased by about 29% when running with E50 fuel compared to the running with E0 fuel. Also, the specific fuel consumption and CO are reduced.

Al-Baghdadi [6] carried out investigations on blends of ethanol with gasoline 30% by volume and reported that these blends increased engine power, thermal efficiency and reduces the nitrogen oxides, CO and HC emissions.

However, little work is done in evaluating the performance of two-stroke engine with gasohol (gasoline-80%, ethanol-20%) on CCCC (copper coating of thickness 300 microns on piston crown and inside portion of cylinder head)-Copper coated combustion chamber.

The present paper evaluated the performance of copper coated combustion chamber, which includes determining performance parameters at various values of brake mean effect pressure and gasohol (gasoline-80%, ethanol- 20% by volume) and compared with CE with pure gasoline operation.

2. Materials and Methods

This section deals with fabrication of copper coated combustion chamber, description of experimental set-up employed for the investigations, operating conditions and definitions of used values.

In catalytic coated combustion chamber, piston crown and inner surface of cylinder head are coated with copper by flame spray gun. The surface of the components to be coated are cleaned and subjected to sand blasting. A bond coating of nickel- cobalt- chromium of thickness 100 microns is sprayed over which copper (89.5%), aluminium (9.5%) and iron (1%) alloy of thickness 300 microns is coated with METCO (A trade name) flame spray gun.

Figure.1 shows experimental set-up used for investigations. A two- stroke, single-cylinder, air- cooled SI engine is coupled to an eddy current dynamometer for measuring its brake power. The conventional engine has an aluminum alloy piston with a bore and stroke of 57 mm each. The rated output of the engine is 2.2 kW at a speed of 3000 rpm**.** Compression ratio of engine is 7.5:1.The recommended spark ignition timing is 25^{o}aTDC (after top dead centre). Fuel consumption, speed, air flow rate, exhaust gas temperature are measured with electronic sensors.

Performance parameters of brake thermal efficiency (BTE), exhaust gas temperature (EGT) and volumetric efficiency (VE) are evaluated at different values of brake mean effective pressure (BMEP) of the engine. Brake specific energy consumption was determined at full load operation of the engine. Experiments were carried out on CE and copper coated combustion chamber with different test fuels [pure gasoline and gasoline blended with alcohol (gasoline-80%, ethanol-20% by volume].

Definitions of used values:

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. 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, when different fuels with different properties are used on same engine.

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

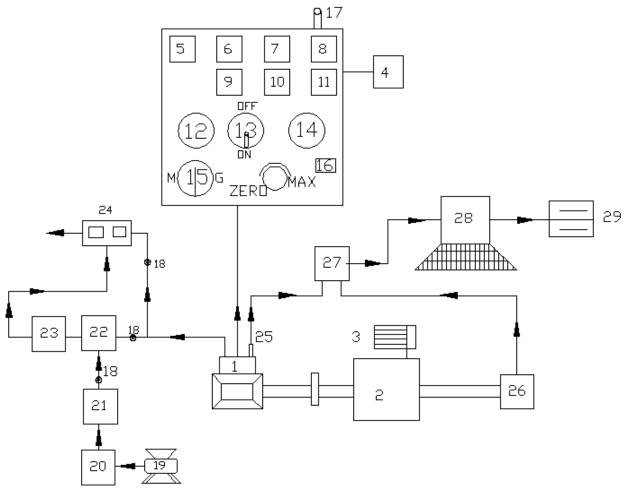
A= Area of the piston = $\frac{3.14 \times D^2}{4}$, Where D= Bore of the cylinder in m

n= Effective number of power cycles= $\frac{N}{2}$, where N=Speed of the engine = 3000 rpm

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

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.



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. Piezoelectric transducer, 26. TDC encoder, 27. Consol, 28. Pentium personal computer, 29. Printer.

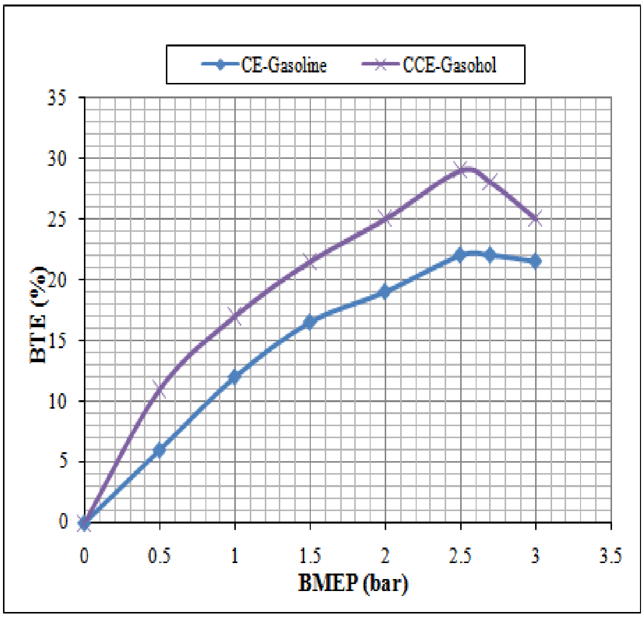
Figure.1 Schematic Diagram of Experimental set up

3.Results And Discussion

This section is divided into i) evaluating performance parameters. Performance parameters like brake thermal efficiency, exhaust gas temperature and volumetric efficiency were evaluated at different values of brake mean effective pressure. Brake specific energy consumption was determined at full load operation of the engine.

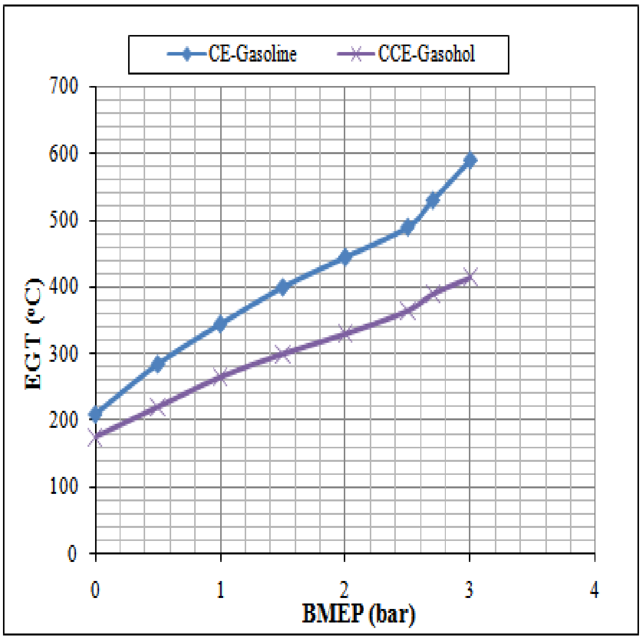
3.1 Performance Parameters

Figure.3 shows the variation of brake thermal efficiency (BTE) with brake mean effective pressure (BMEP) in different versions of the combustion chamber with test fuels of pure gasoline and alcohol blended gasoline at a compression ratio of 7.5:1 and speed of 3000 rpm. BTE increased up to 80% of the full load operation with an increase of BMEP in different versions of the combustion chamber, with different test fuels. Beyond 80% of the full load operation, BTE decreased with test fuels due to reduction of volumetric efficiency and air fuel ratio. Thermal efficiency of two stroke engine is lower as some of the un-burnt charge escape and also due to poor scavenging. Two stroke engines which are scavenged by fresh charge have higher fuel consumption due to opening of inlet and exhaust port at some time and some of fresh charge escapes without doing any work. BTE was observed with alcohol over pure gasoline at all loads due to lower Stoichiometric air requirement of alcohol blended gasoline over pure gasoline operation. Copper coated combustion chamber showed higher thermal efficiency when compared to CE with both test fuels at all loads, particularly at near full load operation, due to efficient combustion with catalytic activity, which was more pronounced at peak load, as catalytic activity increases with prevailing high temperatures at full load.



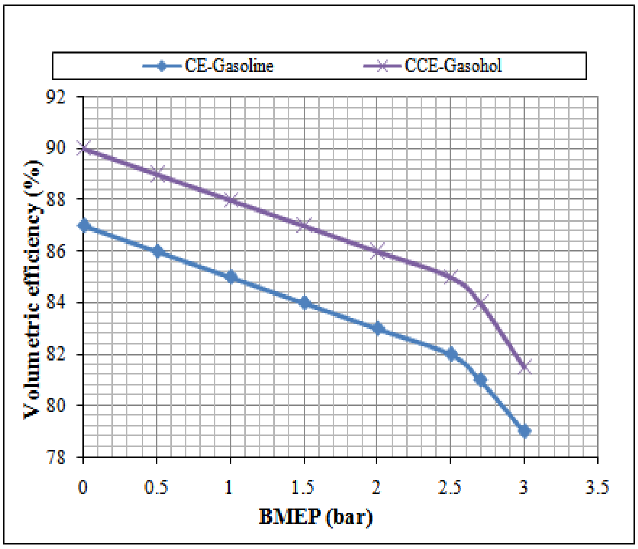
CE- conventional engine: CCE- Copper coated engine: BTE- brake thermal efficiency
BMEP-Brake mean effective pressure

Fig. 3 Variation of BTE with BMEP in different versions of the engine with pure gasoline and gasohol at a compression ratio of 7.5 :1 and speed of 3000 rpm



CE, conventional engine; CCE, Copper coated engine ;
EGT- Exhaust gas temperature:

Fig. 4 Variation of EGT with BMEP in different versions of the engine with pure gasoline and gasohol at a compression ratio of 9:1 and speed of 3000 rpm



CE-Conventional engine; CCE- Copper coated engine; BMEP- brake mean effective pressure; VE- Volumetric efficiency

Fig. 5 Variation of Volumetric efficiency with BMEP in different versions of the engine with pure gasoline and gasohol at a compression ratio of 9:1 and speed of 3000 rpm

4. Conclusions

With copper coated combustion chamber, in comparison with CE,

1. Thermal efficiency increased by 32% with gasohol operation compared to gasoline operation..
2. Exhaust gas temperature decreased by 30%, gasohol operation compared to gasoline operation..
3. Volumetric efficiencies increased by 4% with gasohol operation compared to gasoline operation.

4.1 Research Findings and Future Scope of Work

Investigations on evaluation of performance parameters and combustion characteristics were systematically investigated. Exhaust emissions from SI engine are CO and UBHC. Hence control of these emissions is an urgent task and study of these emissions is necessary.

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