

A Review on Significant Parameters and Exhaust Emissions of Four Stroke Copper Coated SI Engine with Alcohol Blended Gasoline through Catalytic Converter

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Abstract

In this paper, the performance of four stroke single cylinder spark ignition (SI) engine with copper coated combustion chamber [copper-(thickness, 300µm) coated on piston crown, and inner side of cylinder head] with alcohol blended gasoline were investigated. Performance parameters like brake thermal efficiency, exhaust gas temperature and volumetric efficiency at various values of brake mean effective pressure of the engine and also investigated the combustion characteristics such as peak pressure, maximum rate of pressure rise, time of occurrence of peak pressure and maximum heat release at full load operation of the engine with alcohol blended gasoline. In this study, a comprehensive review of the four stroke copper coated spark ignition engine using alcohol blended gasoline with catalytic converter. The output power and emissions of alcohol blended engines were compared with conventional engines with pure gasoline operation.

Keywords: Spark Ignition (S.I) Engine, Conventional Engine (CE), Copper coated combustion chamber (CCCC), Copper coated engine (CCE), Catalytic converter (CC).

I. INTRODUCTION

The performance and pollution levels of four-stroke, single cylinder spark ignition (SI) engine with methanol blended gasoline (20% methanol, 80% gasoline, by volume) having copper coated engine with catalytic converter and compared with conventional SI engine with gasoline operation were studied [1] by M.V.S.Murali

Krishana and Kishor [2008]. N.Kumar et.al [2011] were carried out work for reducing pollutants from copper-coated spark ignition engine fitted with catalytic converter containing sponge iron catalyst run with gasohol (blend of 20% ethanol and 80% gasoline by volume). The influence of parameters such as airflow rate, void ratio, and temperature of injected air, compression ratio, speed, load on the engine and emissions were studied [2]. P.V.K.Murthy et.al [2011] worked on aldehyde emissions from four-stroke, single cylinder spark ignition (SI) engines with gasohol (80 vol. % gasoline, 20 vol. % ethanol) having copper coated engine (copper-coated thickness, 300 μ m) on piston crown and inner side of cylinder head) provided with catalytic converter (sponge iron as catalyst). As copper-coated engine [3] when compared with conventional SI engine with gasoline operation showed reduction in aldehyde emissions. K.Kishor et.al [2013] experiments were conducted to control the exhaust emissions from four stroke, variable speed, variable compression ratio, single cylinder, SI engine, with alcohol blended gasoline (80% gasoline, 10% methanol, 10% ethanol by volume) having copper coated combustion chamber provided with catalytic converter (sponge iron as catalyst) compared with conventional SI engine with pure gasoline operation [4]. Investigations [2013] were carried out to evaluate the performance of four stroke, variable speed, variable compression ratio single cylinder spark ignition (SI) engine with alcohol blended (80% gasoline, 10% ethanol and 10% methanol by vol.) having copper coated combustion chamber [copper-(thickness, 300 μ m) coated on piston crown, and inner side of cylinder head by K.Kishor et.al [5]. Investigations were carried out by Indira Priyadarshini et.al [2013], to evaluate the performance of variable speed, variable compression ratio, four- stroke, single cylinder, spark ignition engine having copper coated engine (thickness of 300 μ m) coated on piston crown and inner side of cylinder head provided with catalytic converter with different test fuels of pure gasoline, gasohol (80% gasoline and 20% ethanol by vol.) and methanol blended gasoline (80% gasoline and 20% methanol by vol.) and compared with conventional engine with pure gasoline operation [6]. Experimental Investigations were conducted by M.V.S.Murali Krishna et.al, for measurement and control of the aldehyde emissions from a variable-compression ratio, variable-speed, copper-coated SI engine fueled with ethanol blended gasoline (20% V/V) and methanol blended gasoline (20%V/V) fitted with catalytic converter [7].

REVIEW OF EXPERIMENTAL INVESTIGATIONS

A large number of experimental studies have been carried out on four stroke copper coated spark ignition engines fuelled with alcohol blended gasoline. In many, but not all, cases the operational constraints i.e. air-fuel ratio and peak conditions are maintained constant in both the alcohol blended gasoline-fuelled engine and conventional fuelled petrol engine. Investigations that have been carried out at same

operating conditions indicate acceptable performance characteristics such as fuel consumption, thermal efficiency, Exhaust gas temperature, volumetric efficiency and overall reduction in emissions in alcohol blended gasoline engines. Some experimental investigations have indicated almost no improvement in thermal efficiency and claim that exhaust emissions deteriorated as compared to those of the conventional diesel engine.

II. MATERIALS AND METHODS

This section deals with fabrication of copper coated combustion chamber, description of experimental set up, operating conditions of catalytic converter and definition of used values.

In catalytic coated combustion chamber, crown of the piston 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 300microns is coated with METCO flame spray gun. The coating has very high bond strength and does not wear off even after 50 h of operation.

Fig.1. shows schematic diagram for experimental set-up used for investigations. A four-stroke, single-cylinder, water-cooled, SI engine (brake power 2.2 kW, rated speed 3000 A rpm) was coupled to an eddy current dynamometer for measuring brake power. Compression ratio of engine was varied (3-9) with change of clearance volume by adjustment of cylinder head, threaded to cylinder of the engine. Engine speeds are varied from 2400 to 3000 rpm. Exhaust gas temperature is measured with iron-constantan thermocouples. Fuel consumption of engine was measured with burette method, while air consumption was measured with air-box method. The bore of the cylinder was 70 mm while stroke of the piston was 66 mm. The engine oil was provided with a pressure feed system. No temperature control was incorporated, for measuring the lube oil temperature. Recommended spark ignition timing was 25°aTDC. The CO and UBHC emissions in engine exhaust were measured with Netel Chromatograph analyzer.

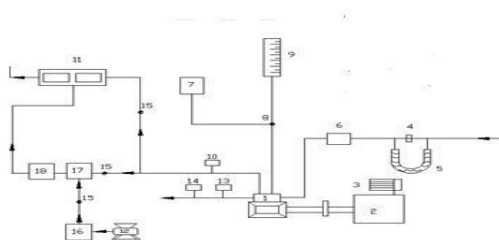


Fig .1 Schematic Diagram of Experimental set up

1. Engine, 2. Eddy current dynamometer, 3. Loading arrangement, 4. Orifice meter, 5. U-tube water monometer, 6. Air box, 7. Fuel tank, 8. Three-way valve, 9. Burette, 10. Exhaust gas temperature indicator, 11. CO-analyzer, 12. Air compressor, 13. Outlet jacket water temperature indicator, 14. Outlet jacket water flow meter, 15. Directional valve, 16. Rotameter, 17. Air chamber and 18. Catalyst chamber

A catalytic converter [8] (Fig.2) was fitted at end of exhaust pipe of engine. Provision was also made to inject a definite quantity of air into catalytic converter. Air quantity drawn from compressor and injected into converter was kept constant so that back pressure does not increase. Experiments were carried out on CE and copper coated combustion chamber with different test fuels [pure gasoline and alcohol blended gasoline (20% by vol.)] under different operating conditions of catalytic converter like set-A, without catalytic converter and without air injection; set-B, with catalytic converter and without air injection; and set-C, with catalytic converter and with air injection. Air fuel ratio is varied so as to obtain different equivalence ratios.

For measuring aldehydes in the exhaust of the engine, a wet chemical method is employed. The exhaust of the engine is bubbled through 2,4-dinitrophenyl hydrazine (DNPH) in hydrochloric acid solution and the hydrazones formed from aldehydes are extracted into chloroform and are analyzed by high performance liquid chromatography (HPLC) to find the percentage concentration of formaldehyde and acetaldehyde in the exhaust of the engine.

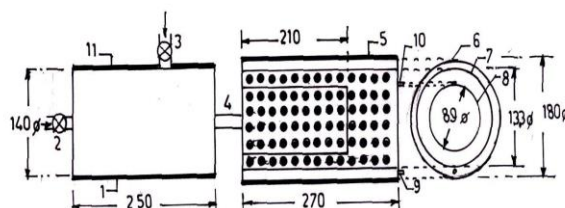


Fig. 2 Catalytic converter

1. Air chamber, 2. Inlet for air chamber from the engine, 3. Inlet for air chamber from compressor, 4. Outlet for air chamber, 5. Catalyst chamber, 6. Outer cylinder, 7. Intermediate cylinder, 8. Inner cylinder, 9. Outlet for exhaust gases, 10. Provision Definitions of used values:

III. RESULTS AND DISCUSSION

The variation of CO emissions in the exhaust of the engine at the peak load operation of the engine at a speed of 3000 rpm with a compression ratio of 9:1 with varying

void ratio of the catalyst for different configurations of the engine with different test fuels is shown in Fig 3 [2].

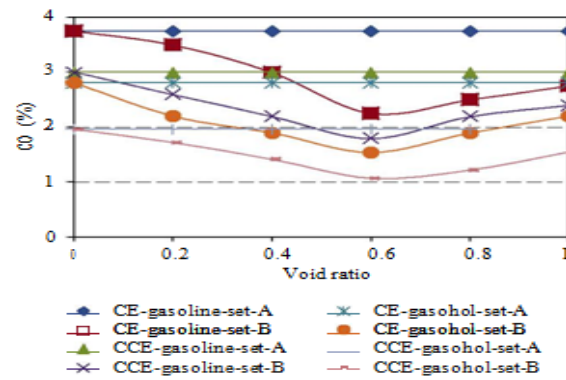


Fig.3. Variation of CO emissions with void ratio of the catalyst for different configurations of the engine for different test fuels.

The variation of CO emissions with amount of injected air at peak load operation for gasohol and gasoline at a speed of 3000 rpm with different versions of the engine at a compression ratio of 9: 1 is shown in Figure 4. [2]

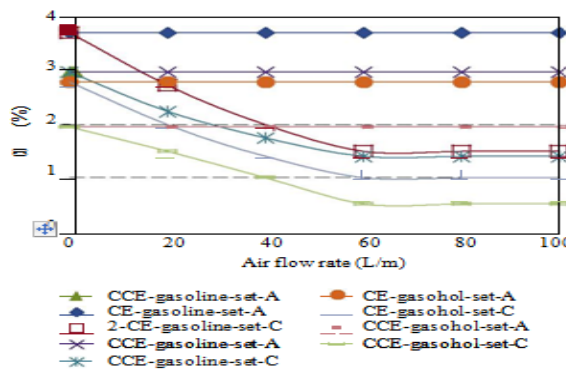


Fig. 4: Variation of CO with amount of injected air for different configurations of the engine with different test fuels.

The variation if CO emissions with temperature of injected air at peak load at peak load at compression ratio of 9:1 and speed of 3000 rpm for different test fuels of gasoline, gasoline with different versions of the engine at different operating conditions of the catalytic converter.[2]

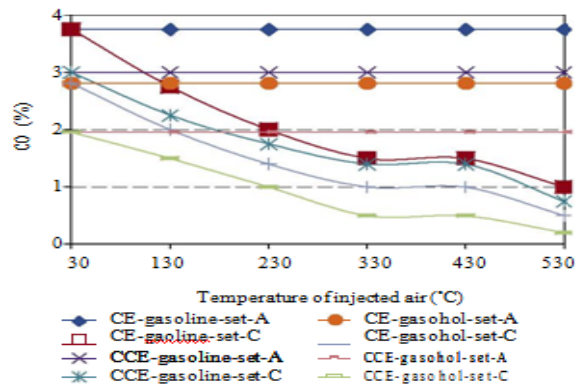


Fig.5: Variation of CO with temperature of injected air for different configurations of the engine with different test fuels.

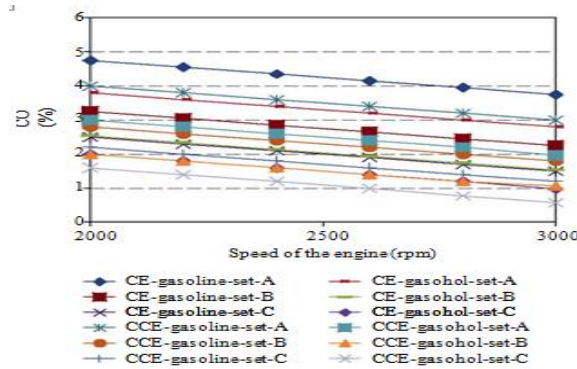


Fig.6: Variation of CO with speed of the engine for different configuration of the engine with different test fuels under different operating conditions of the catalytic converter.

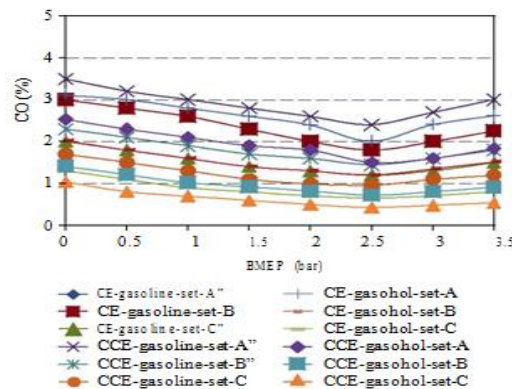


Fig.7 Variation of CO emission with brake mean effective pressure for different configurations of the engine with different test fuels under different operating conditions of the catalytic converter.

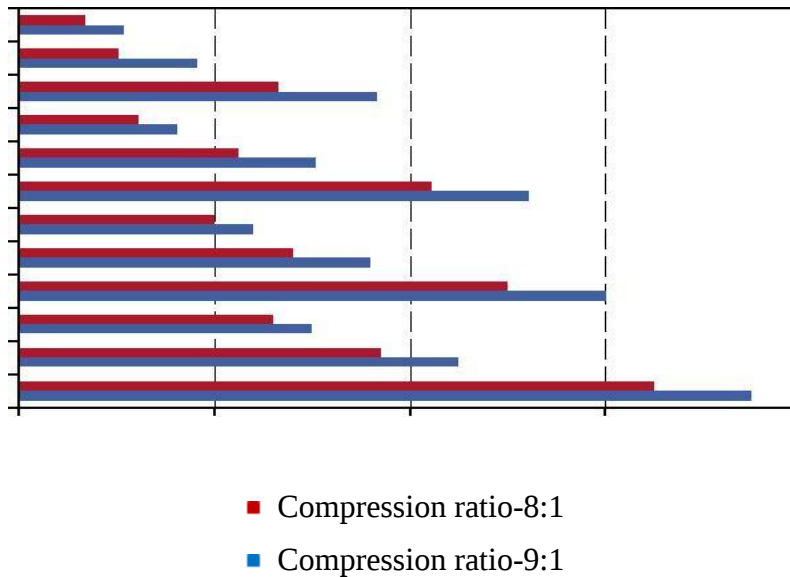


Fig:8 Bar chart showing the variation of CO emissions at peak load at different compression ratios at speed of 3000 rpm and void ratio of 0.7:1.

Table 1: Data of formaldehyde emissions in four-stroke SI engine with different test fuels with different configurations of the engine at different operating conditions of the catalytic converter [3]

Set	Concentration , vol %			
	Conventional engine		Copper coated engine	
	Pure gasoline	Gasoline	Pure Gasoline	Gasoline
Set-A	6.5	12	4.5	9.0
Set-B	4.5	5.6	2.5	5.1
Set-C	2.5	4.8	1.5	3.4

Table 2 shows the data of percentage deviation of formaldehyde emissions with different test fuels in different configurations of four-stroke spark ignition engine in comparison with pure gasoline operation on conventional engine at different operating conditions of the catalytic converter [3]

Set	Formaldehyde emissions (vol %)			
	Conventional engine		Copper Coated Engine	
	Pure gasoline	Gasoline	Pure gasoline	Gasoline
Set-A	-	+84%	-30%	+38%
Set-B	-30%	-14%	-61%	-21%
Set-B	-61%	-26%	-77%	-47%

Table 3: Data of acetaldehyde emissions in four-stroke SI engine with different test fuels with different configurations of the engine at different operating conditions of the catalytic converter [3]

Set	Concentration (vol %)			
	Conventional engine		Copper Coated Engine	
	Pure gasoline	Gasoline	Pure gasoline	Gasoline
Set-A	5.5	10.45	3.5	6.6
Set-B	3.5	4.7	2.5	3.1
Set-B	1.5	3.7	1.0	2.3

Table 4; Data of percentage deviation of acetaldehyde emissions with different test fuels in different configurations of four-stroke SI engine in comparison with pure gasoline operation on conventional engine[3]

Set	Conventional engine		Copper Coated Engine	
	Pure gasoline	Gasoline	Pure gasoline	Gasoline
Set-A	-	+90%	-36%	+20%
Set-B	-36%	-14%	-54%	-38%
Set-B	-72%	-32	-82%	-58%

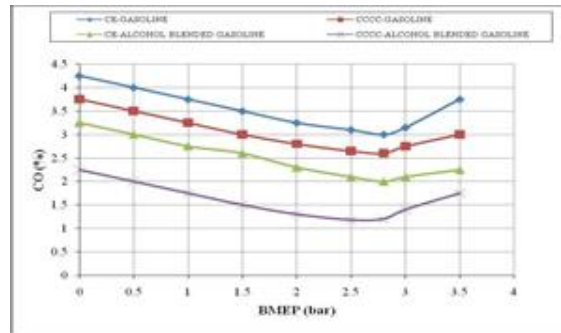


Fig 9: Variation of CO emissions with BMEP in different versions of the combustion chamber with pure gasoline and alcohol blended gasoline at a compression ratio of 7.5:1 and speed of 3000 rpm.

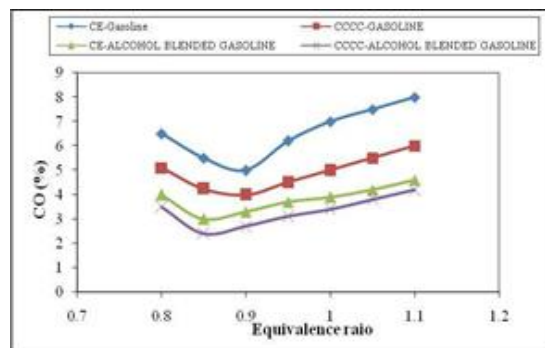


Fig.10: Variation of UBHC emissions with BMEP in different versions of the combustion chamber with pure gasoline and alcohol blended gasoline at a compression ratio of 7.5:1 and speed of 3000 rpm

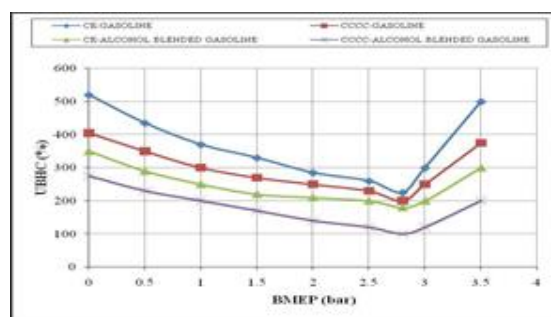


Fig.11: Variation of UBHC emissions with BMEP in different versions of the combustion chamber with pure gasoline and alcohol blended gasoline at a compression ratio of 7.5:1 and speed of 3000 rpm

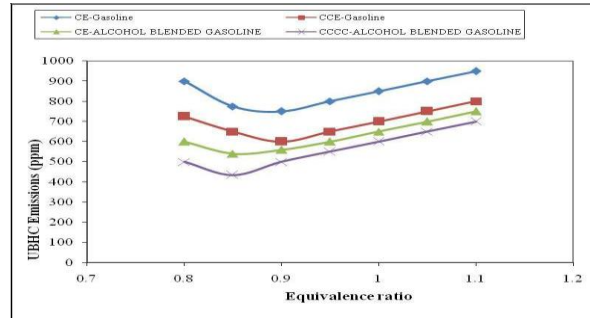


Fig.12 Variation of UBHC emissions with Equivalence ratio in both versions of the combustion chamber with different test fuels with a compression ratio of 7.5:1 at a speed of 3000 rpm.

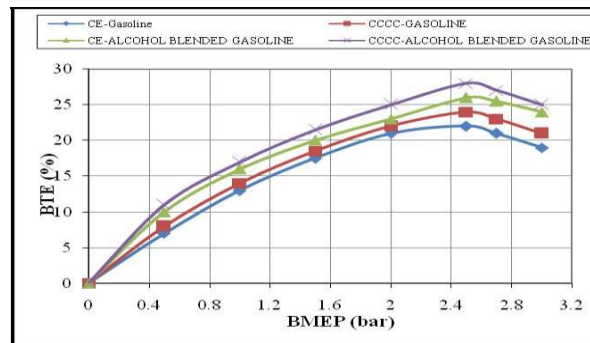


Fig.13 Variation of brake thermal efficiency (BTE) with brake mean effective pressure (BMEP) in different versions of the engine with test fuels at a compression ratio of 9:1 and speed of 3000 rpm.

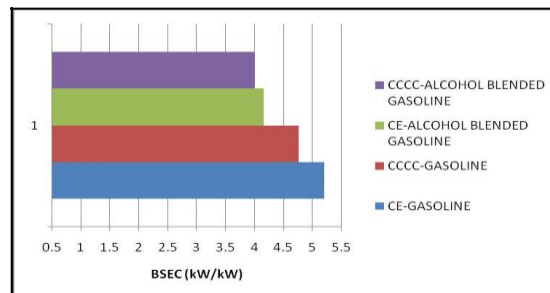


Fig.14 presents bar charts showing the variation of brake specific energy consumption (BSEC) at full load operation with different versions of the combustion chamber with test fuels at a compression ratio of 9:1.

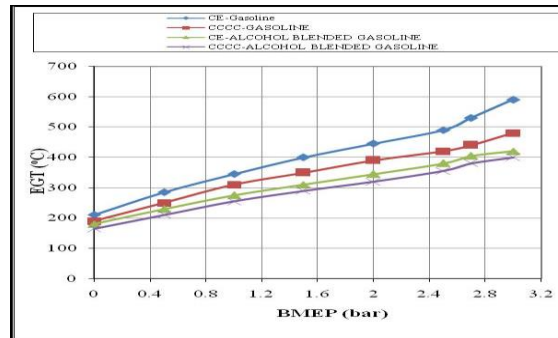


Fig.15. Variation of exhaust gas temperature (EGT) with brake mean effective pressure (BMEP) in different versions of the combustion chamber with test fuels at a compression ratio of 9:1 and speed of 3000 rpm

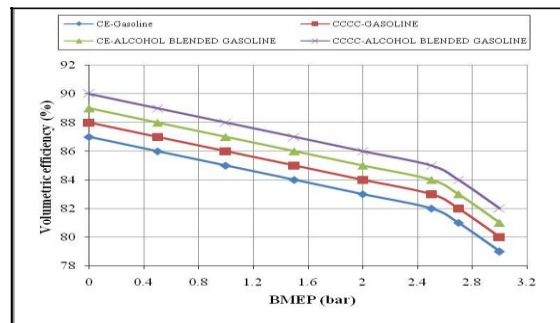


Fig 16 indicates that as compression ratio increased, peak BTE increased in both versions of the engine with test fuels at a speed of 3000 rpm.

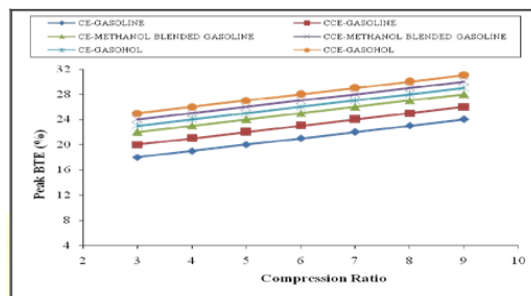


Fig: 17 Variation of peak BTE with compression ratio in both version of the engine with test fuels at speed of 3000 rpm

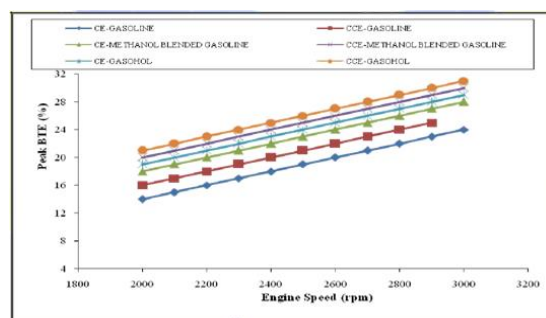


Fig.18 Variation of peak BTE with speed of the engine in both version of the engine with test fuels at compression ratio of 9:1

IV. CONCLUSION

The objectives of performance, fuel economy and reduced emissions using alcohol blended gasoline in SI engines are attainable, but more investigations under proper operating constraints with improved engine design. Based on the reviewed literature for the performance and Exhaust emissions of four stroke copper coated spark ignition engine with alcohol blended gasoline with catalytic converter, Thus a number of conclusions are drawn from the studies of various experimental investigations, These are follows

1. Pollutants decreased by 25-45% with the change of fuel from gasoline to alcohol blended with gasoline in both version of engine under different operating conditions of the catalytic converter.
2. CO/UBHC emissions at peak load decreased by 25-45% with the change of engine configuration from conventional engine to copper coated SI engine with catalytic converter.
3. In four stroke engine, formaldehyde emissions decreased by 45-68% with different sets of operation with pure gasoline on conventional engine and compared with copper coated spark ignition engine with catalytic converter running on alcohol blended gasoline.
4. In four stroke engine, acetaldehyde emissions decreased by 45-77% with different sets of operations with pure gasoline on convention engine and compared with copper coated spark ignition engine with catalytic converter running on alcohol blended gasoline.
5. CO and UBHC emissions decreased by 20% with copper coated engine when compared with conventional engine with both test fuels.
6. Exhaust gas temperature decreased with gasoline operation when compared with copper coated engine.

7. Volumetric efficiencies were compatible with gasoline as well as alcohol blended with gasoline.
8. Thermal efficiency decreases with alcohol blended gasoline with copper coated engine and exhaust gas temperature decreased with gasoline with test fuels.
9. Exhaust emissions decreased with alcohol blended gasoline when compared with gasoline testing under different operating conditions with different sets.

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