Performance Parameters and Exhaust Emissions of Four Stroke Copper Coated Spark Ignition Engine with Alcohol Blended Gasoline with Catalytic Converter - A Review

B.Raja Narender[1] Dr.P.V.Krishna Murthy[2] Dr.Md.Yousuf Ali [3]
[1]Anurag Group of Institutions,CVSR College of Engineering,Venkatapur(M),Ghatkesar(M).R.R.Dist,Telangana
[2]Annamacharya Institute of Technology & Sciences, Batasingaram, Hayath Nagar, R.R.Dist, Telangana
[3]Nawab Shah Alam Khan College of Engineering & Technology, New Malakpet, Hyderabad,Telangana.

ABSTRACT

In this paper, evaluate the performance of four stroke single cylinder spark ignition (SI) engine with alcohol blended having copper coated combustion chamber [copper-(thickness, 300 μ) coated on piston crown, and inner side of cylinder head] were investigated. Find Performance parameters like brake thermal efficiency, exhaust gas temperature and volumetric efficiency were determined at various values of brake mean effective pressure of the engine and combustion characteristics like peak pressure, maximum rate of pressure rise, time of occurrence of peak pressure and maximum heat release were evaluated at full load operation of the engine with alcohol blended gasoline. In this study, a comprehensive review of the of Four stroke Copper Coated Spark Ignition Engine using Alcohol Blended Gasoline with Catalytic Converter to keep the output power and emissions of alcohol blended engines compared with Conventional engines with pure gasoline operation.

Keywords: *S.I. Engine, copper coated combustion chamber, aldehydes, Catalytic converter*

I. INTRODUCTION

Studied on performance and decreased emission levels of four-stroke, single cylinder spark ignition (SI) engine with methanol blended gasoline (blend of 20% methanol , 80% gasoline by volume) having copper coated engine with catalytic converter and compared with conventional SI engine with gasoline operation was observed[1].

Reducing pollutants from copper-coated spark ignition engine fitted with catalytic converter containing sponge iron catalyst run with gasohol (20% ethanol and 80% gasoline). The influence of parameters such as airflow rate, void ratio, and temperature of injected air, compression ratio, speed and load of the engine on these emissions are studied. [2].

Experimentation 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 μm) on piston crown and inner side of cylinder head) provided with catalytic converter with sponge iron as catalyst and compared with conventional spark ignition engine with gasoline operation. Copper-coated engine showed reduction in aldehyde emissions when compared with conventional engine with both test fuels [3].

Experiments were conducted to reduce the exhaust emissions from four stroke, variable speed, variable compression ratio, single cylinder, spark ignition (SI) engine, with alcohol blended gasoline (80% gasoline, 10% methanol, 10% ethanol by volume) having copper coated combustion chamber [CCCC, copper-(thickness, 300 μ) coated on piston crown, inner side of cylinder head] provided with catalytic converter with sponge iron as catalyst and compared with conventional spark ignition engine (CE) with pure gasoline operation. [4-5].

Investigations 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 volume) having copper coated combustion chamber [copper-(thickness, 300 μ) coated on piston crown, and inner side of cylinder head [6].

Investigations were carried out to evaluate the performance of variable speed, variable compression ratio, four- stroke, single cylinder, spark ignition (SI)engine having copper coated engine [CCE, copper-(thickness, 300 μ) coated on piston crown and inner side of cylinder head] provided with catalytic converter with sponge iron as catalyst with different test fuels of pure gasoline, gasohol (80% gasoline and 20% ethanol by volume) and methanol blended gasoline (80% gasoline and 20% methanol by volume) and compared with conventional spark ignition engine (CE) with pure gasoline operation[7].

Experimental Investigations carried out for measurement and control of the aldehyde emissions from a variable- variable-speed, compression ratio, copper-coated spark ignition engine fueled with ethanol blended gasoline (20% V/V) and methanol blended gasoline (20%V/V) fitted with catalytic converter containing sponge iron catalyst[8].

II. REVIEW OF EXPERIMENTAL INVESTIGATIONS

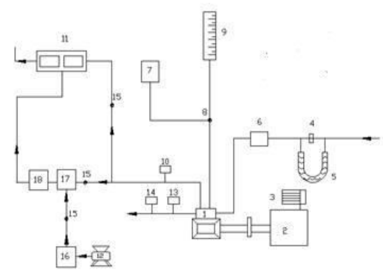
A large number of experimental studies have been carried out on Four Stroke Copper Coated Spark Ignition Engines fuelled with Alcohol blended Gasoline. In many, but not all, cases the operational constraints i.e. air-fuel ratio and peak conditions are maintained constant in both the alcohol blended gasoline-fuelled 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.

III. MATERIALS AND METHODS

This section deals with fabrication of copper coated combustion chamber, description of experimental set up and 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 300 microns 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 [9].

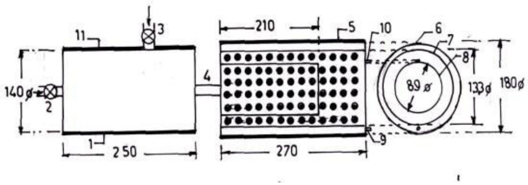
Fig.1. shows schematic diagram for experimental set-up used for investigations. A four- stroke, single-cylinder, water-cooled, SI engine (brake power 2.2 kW, rated speed 3000 A rpm) was coupled to an eddy current dynamometer for measuring brake power. Compression ratio of engine was varied (3 -9) with 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^{o}aTDC. CO and UBHC emissions in engine exhaust were measured with Netel Chromatograph analyzer.



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.Rotometer, 17. Air chamber and 18. Catalyst chamber
Figure 1 Schematic Diagram of Experimental set up

A catalytic converter [10] (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 backpressure 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 [11] 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.

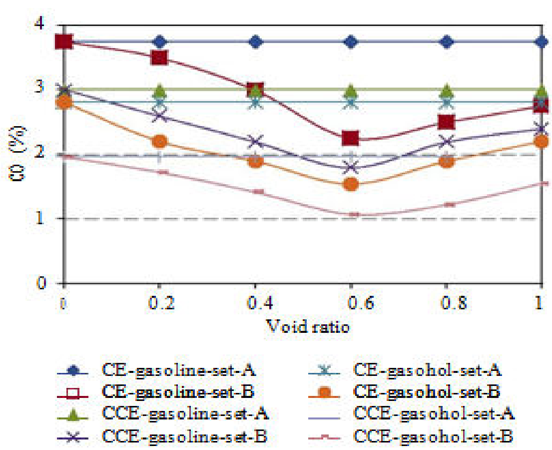


1.Air chamber, 2.Inlet for air chamber from the engine, 3.Inlet for air chamber from compressor, 4.Outlet for air chamber, 5.Catalyst chamber, 6. Outer cylinder, 7. Intermediate cylinder, 8.Inner cylinder, 9. Outlet for exhaust gases, 10.Provision Definitions of used values:

Figure;2 Catalytic converter

IV. RESULTS AND DISCUSSION

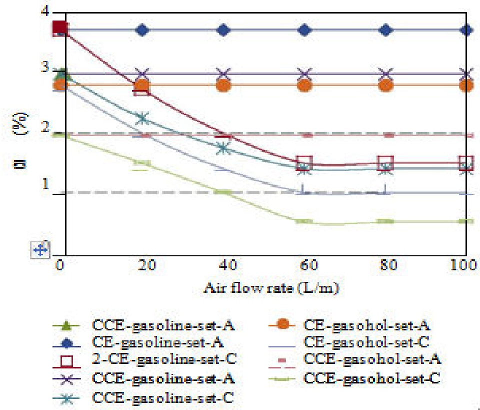
The variation of CO emissions in the exhaust of the engine at the peak load operation of the engine at a speed of 3000 rpm with a compression ratio of 9 : 1 with varying void ratio of the catalyst for different configurations of the engine with different test fuels is shown in Figure 3 [2]



CE-conventional engine, CCE-copper coated engine, load-peak load CE- conventional Engine , CCE-Copper coated engine , Set -, speed- 3000 rpm, Compression ratio-9 : 1 set-A-without catalytic and without air injection ,Set-B with catalytic converter and without air injection,

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

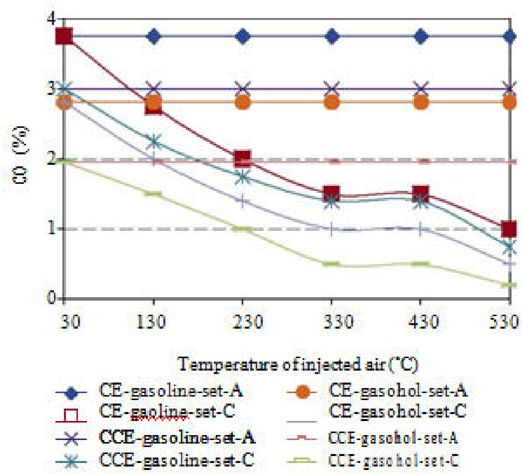
The variation of CO emissions with amount of injected air at peak load operation for gasohol and gasoline at a speed of 3000 rpm with different versions of the engine at a compression ratio of 9: 1 is shown in Figure 4.[2]



CE-conventional engine, CCE-copper coated engine, set-A-without catalytic converter and without air injection, set-C-with catalytic converter and with air injection, load-peak load, speed- 3000 rpm, Compression ratio-9 : 1, void ratio-0.7 : 1

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

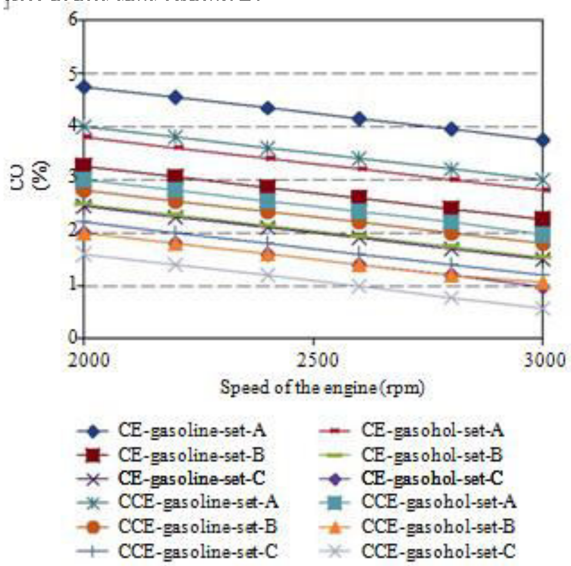
The variation if CO emissions with temperature of injected air at peak load at peak load at compression ratio of 9:1 and speed of 3000 rpm for different test fuels of gasoline, gasoline with different versions of the engine at different operating conditions of the catalytic converter.[2]



CE-conventional engine, CCE-copper coated engine, set-A-without catalytic converter and without air injection, set-C-with catalytic converter and with air injection, load-peak load, speed-3000 rpm, compression ratio-9 : 1, void ratio-0.7 : 1

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

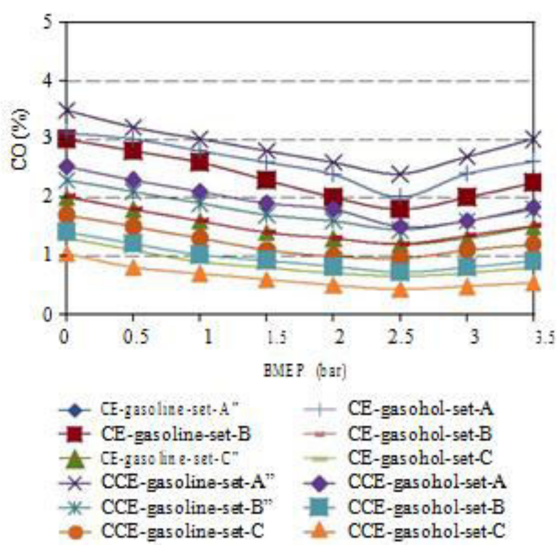
Figure 6 shows the variation of CO emissions in the exhaust with speed of the engine at peak load operation with a compression ratio of 9 : 1 and at a void ratio of 0.7 for different configurations of the engine with different test fuels.[2]



CE-conventional engine, CCE-copper coated engine, Set-A-without catalytic converter and without air injection, Set-B-with catalytic converter and without air injection, Set-C with catalytic converter and with air injection, load-peak load, compression ratio-9:1, void ratio-0.7;1.

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

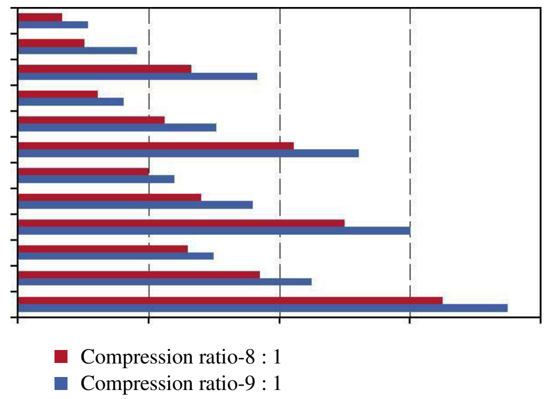
Figure 7 shows the variation of CO emissions in the exhaust with brake mean effective pressure of the engine at a speed of 3000 rpm with compression ratio of 9 : 1 and at a void ratio of 0.7 with different test fuels with different versions of the engine under different operating conditions[2]



CE-Conventional engine, CCE-copper coated engine, set-A without catalytic converter and without air injection, set-B – with catalytic converter and without air injection, set-C with catalytic converter and with air injection, speed -3000 rpm, compression ratio 9:1 . void ratio -0.7:1

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.

Figure 8 shows the bar charts showing the variation of CO emissions at peak load at different compression ratios [2].



1.CE- gasoline –set-A 2. CE-gasoline-set-B 3. CE gasoline-set-C 4. CCE-gasoline-set-A 5.CCE-gasoline-set-B 6. CCE-gasoline-set-C 7.CE-gasohole-set-A 8.CE-gasoholee-Set-B 9.CE-gasohole-set-C 10. CCE-gasohole-set-A 11. CCE-gasohole-set-B 12. CCE-gasohole-set-C

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 emisisons 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-

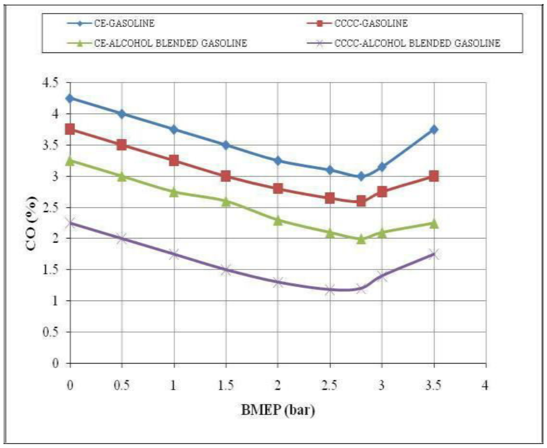
stroke SI engine with different test fuels with different configurations of the engine at different operating conditions of the catalytic converter[3]

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%

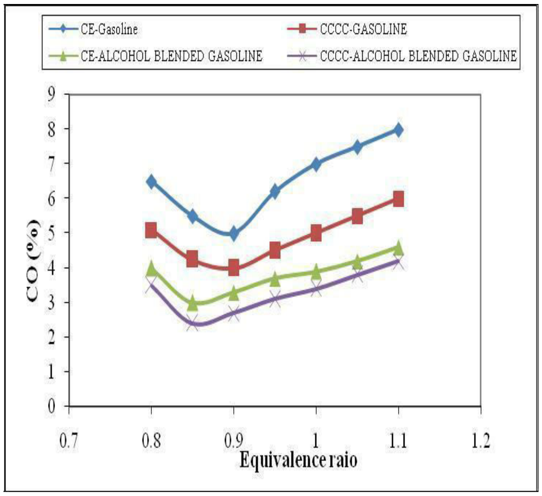
Figure 9: Shows the variation of CO emissions with BMEP in different versions of the engine with both pure gasoline and alcohol blended gasoline [4][5]



CE- conventional engine: CCCC-Copper coated combustion chamber, CO-Carbon monoxide emissions: BMEP-Brake mean effective pressure

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

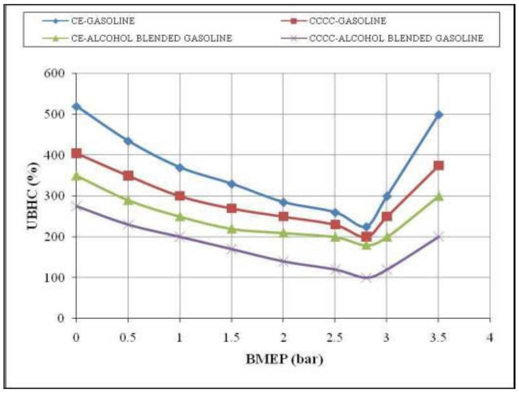
Fig 10: shows the variation of CO emissions with equivalence ratio, ϕ in both configurations of the engine with pure gasoline and alcohol blended gasoline [4]



CE-conventional engine CCCC-copper coated combustion chamber , CO-carbon monoxide emissions

Figure 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

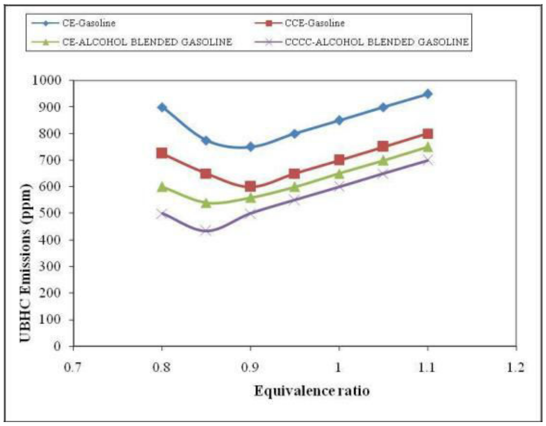
Fig: 11 shows the variation of un-burnt hydro carbon emissions (UBHC) with BMEP in different versions of the combustion chamber with both test fuels[4][5].



CE- conventional engine: CCCC-Copper coated combustion chamber, UBHC-Un-burnt hydro carbons: BMEP-Brake mean effective pressure

Figure 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

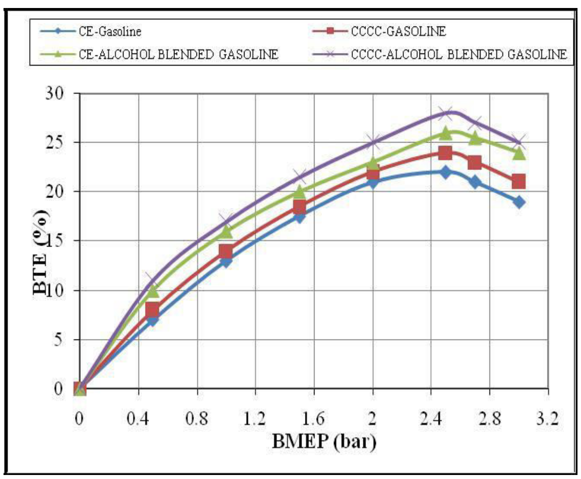
Fig 12: shows the variation of UBHC emissions with equivalence ratio, ϕ with pure gasoline and alcohol blended gasoline with both configurations of the combustion chamber.



CE- conventional engine: CCCC-Copper coated combustion chamber, UBHC-Un-burnt hydro carbons

Figure. 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 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[6].



CE- conventional engine CCCC-copper coated combustion chamber BTE-brake thermal efficiency BMEP-Brake mean effective pressure.

Figure.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

Figure.14 shows the variation of brake specific energy consumption at full load operation with different versions of the combustion with test fuels [6]

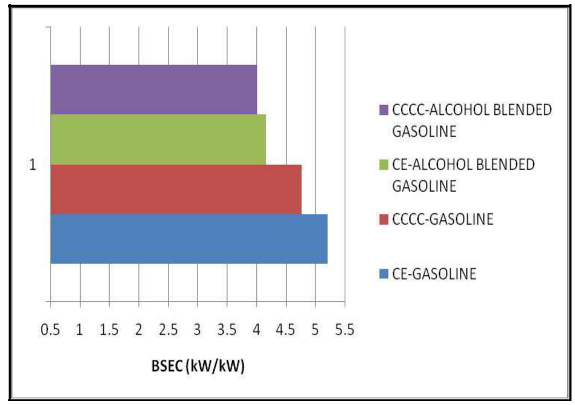
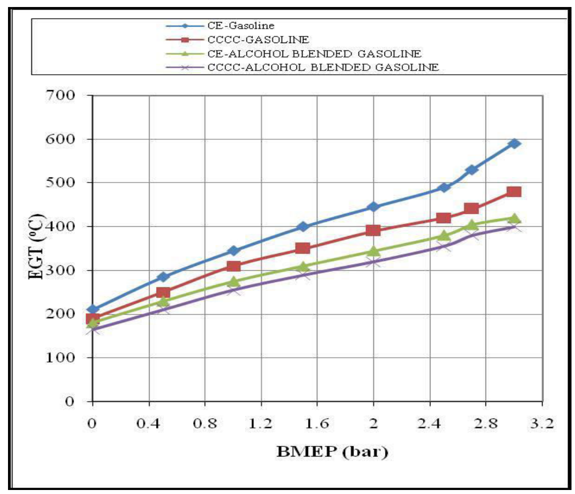


Figure.14 presents bar charts showing the variation of brake specific energy consumption (BSEC) at full load operation with different versions of the combustion chamber with test fuels at a compression ratio of 9:1.

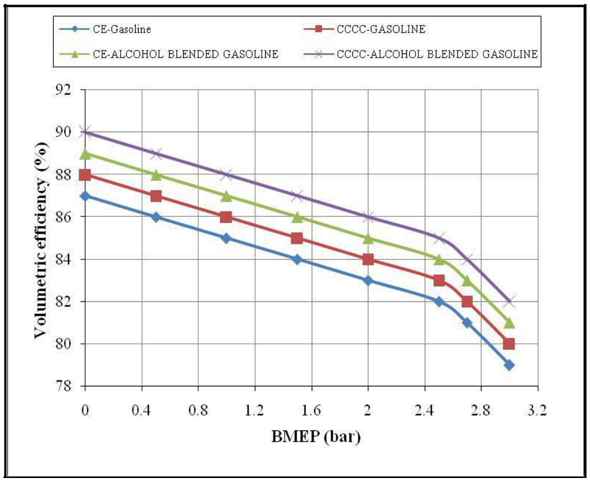
Fig.15 shows the variation of exhaust gas temperature (EGT) with BMEP in different versions of the combustion chamber with test fuels[6]



CE- conventional engine: CCCC-Copper coated combustion chamber. BTE-brake thermal efficiency BMEP-Brake mean effective pressure

Figure.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

Fif.16: shows the variation of volumetric efficiency (VE) with BMEP with test fuels[6].



CE- conventional engine: CCCC-Copper coated combustion chamber, BMEP-Brake mean effective pressure

Figure.16 Variation of volumetric efficiency with BMEP in different versions of the combustion chamber with test fuels at a compression ratio of 9:1 and speed of 3000 rpm

Figure 17 indicates that as compression ratio increased, peak BTE increased in both versions of the engine with test fuels at a speed of 3000 rpm[7]

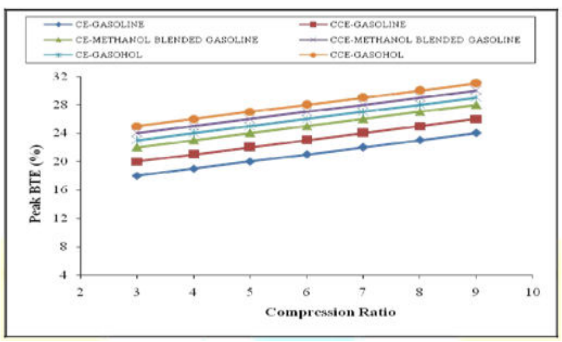


Fig:17 Variation of peak BTE with compression ratio in both version of the engine with test fuels at speed of 3000 rpm

From Figure 18, it is observed that Peak BTE increased with an increase of speed of the engine at a compression ratio of 9:1[7]

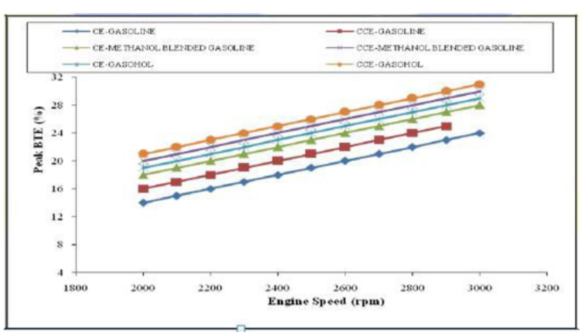


Fig.18 Variation of peak BTE with speed of the engine in both version of the engine with test fuels at compression ration of 9:1

V. 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 paper 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/UHC emissions at peak load decreased by 25-45% with the change of the engine configuration from conventional engine to copper coated SI engine with catalytic converter.

3. In four stoke 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 operation 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.

REFERENCES

[1] M.V.S.Murali Krishana & Kishor "Performance of copper coated spark ignition engine with methanol-blended gasoline with catalytic converter, Journal of Scientific & Industrial Research, Vol-67, July-2008,pp-543-548.

[2]Narsimha kumar,K.Kishore,M.V.S.Murali Krishna "studies on exhaust emissions from copper-coated gasohol run spark ignition engine with catalytic converter" ISRN vol-6,2011.

[3] P.V.K Murthy,S.Narsimha Kumar,M.V.S.Murali Krishna,K.Kishor " Addehyde emissions from two-stroke and Four Stroke Spark ignition engines with catalytic converter running on gasohol" ISSN0350-350x GOMABN 5050,2,137-156.

[4] K.Kishor,M.V.S.Murali Krishna,P.V.K.Murthy " Comparative Studies on Exhaust Emissions from Four Stroke Copper Coated Spark Ignition Engine with Alcohol Blended Gasoline with Catalytic Converter" IJMER,Vol.3,Issue 6, Nov-Dec-2013 pp-3608-3614.

[5] K.Kishor, M.V.S.Murali Krishna, P.V.K. Murthy " Comparative studies on Exhaust Emissions and Combustion Characteristics of four stroke copper coated spark ignition engine with alcohol blended gasoline with catalytic converter" IPASJ International Journal of Mechanical Engineering,Vol.1, Issue 6, Dec-2013, ISSN 2321-6441.

[6] K.Kishor, M.V.S Murali Krishna,P.V.K Murthy " Studies on Performance Parameters and Combustion Characteristics of Copper Coated Four Stroke Spark Ignition Engine with Alcohol Blended Gasoline" International Journal of Engineering Research and Applications ISSN:2248-9622,vol.3, Issue 6, Nov-Dec 2013,pp.1437-1444.

[7]Ch. Indira priyadarshini, M.V.S.Murali Krishna, Y.Nagini, P.Ushasri, P.V.K.Murthy, K.Kishor "Comparative studies on Performance and t Emissions of four stroke copper coated spark ignition engine with catalytic converter with different Catalyst with alcohol blended gasoline" International Journal of Management, IT and Engineering,Vol.3,Issue.5,ISSN:2249-0558.

[8] M.V.S.Murali Krishna, S.Narasimha Kumar, P.V.K Krishna Murthy, K.Kishor "Control of aldehyde emissions from copper coated spark ignition engine fueled with alcohol blended gasoline" International Journal of Engineering Research and Applications,ISSN:2248-9622,Vol.1,Issue.2 pp.337-340.

[9] N.Nedunchezhian N & S.Dhandapani, Experimental investigation of cyclic variation of combustion parameters in a catalytically activated two-stroke SI engine combustion chamber, Engg Today, 2,2000, 11-18

[10] M.V.S.Murali Krishna, K.Kishor, P.R.K.Prasad, and G.V.V.Swathy, Parametric studies of pollutants from copper coated spark ignition engine with catalytic converter with gasoline blended methanol, Journal of Current Sciences, 9(2), 2006, 529-534.

[11] P.V.K.Murthy, S.Narasimha Kumar, M.V.S.Murali Krishna, V.V.R.Seshagiri Rao, and D.N.Reddy, Aldehyde emissions from two-stroke and four-stroke spark ignition engines with methanol blended gasoline with catalytic converter, International Journal of Engineering Research and Technology, (3)3, 2010, 793—802.