Experimental Investigations for Performance, Emission and Combustion Parameters of a Modified Spark Ignition Engine Fuelled with Methanol – Gasoline Blends

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Abstract **–In this work experimental investigations were carried out on a single cylinder, variable compression ratio engine operating on different spark ignition timings (25^0,26^0,27^0,28^0,29^0) btdc of a gasoline fuel with methanol (M20). The effect of blending on the cylinder pressure, heat release rate, brake thermal efficiency, volumetric efficiency, carbon monoxide, unburned hydrocarbon were measured. These results are indicated that the use of alcohol fuel and copper coated engine produce lower emissions and higher efficiency compared to gasoline fuel. The measured CO emission of methanol (M20) copper coated engine lower than that of**

Keywords: copper coated engine; methanol; combustion; performance; emission; DOE software.

I.INTRODUCTION

The environment and the increasing demand for conventional fossil fuel has promoted interest in the development of alternative sources of fuel energy for internal combustion (IC) engines. Many studies in literature investigated such single alcohol–gasoline blends. Methanol addition into gasoline, HC and CO emissions decrease obviously [1-3]. Researchers have focused their attention to replace gasoline by alternatives Commonly, the studies have shown a significant reduction in pollutants emissions of such fuel blends, compared to neat gasoline engine has 30% more efficiency than a regular engine [4,5]. The combustion chamber of the catalytic engine was coated with a catalyst material by plasma spraying method. The tests were conducted with different air-fuel ratios and heat release analysis was carried out for both CE and CCE [6,7]. The performance tests were carried out using single cylinder direct injection methanol engine with a high compression ratio (16:1). When the test conducted at 1600 rpm engine speed with the optimum injection and ignition stroke, ignition delay decreased, fewer cyclical change occurred, maximum cylinder pressure increased and a higher thermal efficiency obtained [8-12]. Methanol blended gasoline and reported fuel economy with methanol blended gasoline. Improvement in antiknock potential of gasoline by methanol blending was fully investigated [14-16].

II. PROCEDURE FOR EXPERIMENTAL SETUP

Experiment was carried out on a four stroke, single cylinder, water cooled VCR petrol engine with the specification given in Table1.The Schematic diagram of the experimental Setup is shown in Fig1. The engine connected to eddy current type dynamometer for measuring its torque, load control and brake power. The test rig was interfaced with computer through engine indicator for Pθ software for obtaining various results during operation. In the present investigations the piston crown and inside surface of the cylinder head are coated with copper by plasma spraying. A bond coating of Ni-Co-Cr alloy is applied for a thickness of about 100 microns using a 80 kW METCO plasma spray gun. Over the bond coating copper 89.5%, Aluminium 9.5% and iron 1.0% is coated for 300 microns thickness. The coating had very high bond strength and does not wear off even after 50 hours of operation. Copper coating is made on the surface of cylinder head and piston combination. The tests were conducted at different spark ignition timings (25^0,26^0,27^0,28^0,29^0) btdc at compression ratio of 3 to 9:1 and speed 3000 rpm with petrol as a fuel was carried out at steady state condition. The Methanol was tested as pure fuel, as 20% blend by volume with gasoline fuel were carried out with pure gasoline on copper coated spark ignition engine.

TABLE I. SPECIFICATION OF GASOLINE ENGINE

Engine make	Greaves Cotton Limited
Engine type	4 Stroke, VCR petrol engine
Bore	70 mm
Stroke	66.7mm
speed	3000rpm
spark ignition timing	250btdc
compression ratio	3:1 to 9:1
specific fuel consumption	475gm/h kw

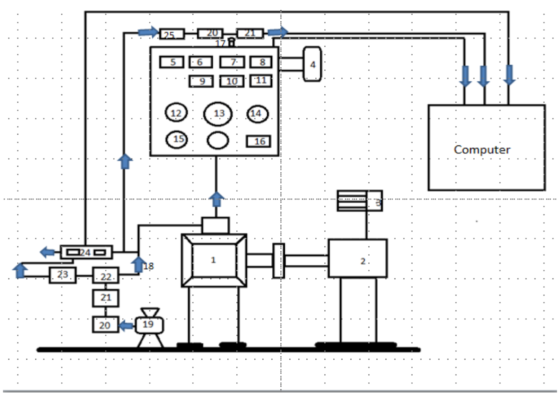


Fig. 1 Schematic Diagram Of The Experimental Setup

1. Engine, 2.Eddycurrent dynamometer3.Loading arrangement, 4.Fueltankmeter,5.Torque 6. Fuel rate indicator sensor, 7. Hot wire gas flow indicator, 8. Multi-channel temperature indicator, 9. Speed indicator, 10. Air flow indicator, 11. EGT indicator, 12. Mains on, 13. Engine on/off switch, 14. Mains off, 15. Motor/Generator option switch, 16.Heater controller, 17. Speed indicator18. Directional valve 19.Air compressor 20. Rotometer 21.Directional valve 22.Air chamber 23. Catalyst chamber 24.CO analyser

TABLE II. PHYSICAL AND CHEMICAL PROPERTIES OF GASOLINE AND METHANOL

	Property	Gasoline	Methanol
1	Chemical formula	mCn H2n	CH3 OH
2	Molecularweight	112	32.0
3	Specificgravity at15.5oC	0.7 to 0.75	0.796
4	Lower calorific value Kcal/kg	10500	4700
5	Boiling point or range oC	30.0	65.0
6	Self ignition temperature	300-450	478
7	Mixing heating value Kcal/kg	714	734.00
8	air		

IV. RESULTS AND DISCUSSIONS

The combustion, performance and emissions parameters are compared for CE-G, CCE-G, CE-M20, and CCE-M20. The engine was tested at different spark ignition timings (250,260,270,280,290) btdc at full load condition. However they are presented only for 270btdc.This condition was chosen because it is the point of minimum air/fuel ratio and maximum efficiency. This provides the best condition for discerning any difference between the engines and fuels.

A. Combustion analysis

Cylinder pressure: Fig 2. Shows the effect of adding methanol to gasoline fuel on the pressure crank angle diagram. It can be seen that the M20 copper coated engine has maximum pressure 32 bar than that of petrol by 80 %. Due to the difference in the heating value for the blended fuel. Wide open throttle and the increase in compression ratio peak pressure increase. Because, the value of pressure and temperature of the mixture during sparking are higher at higher compression ratios and heat release during combustion further increases the pressure and temperature to the higher level. In the same time apparent flame speed increases and consequently combustion duration decreases.

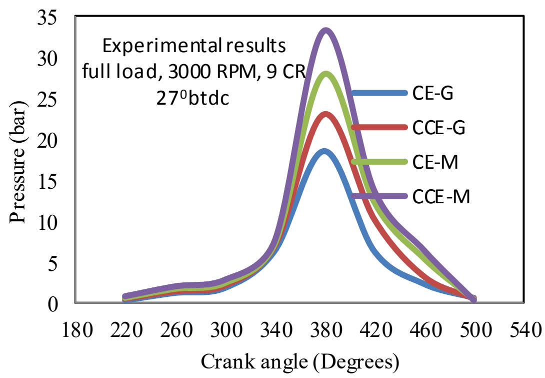
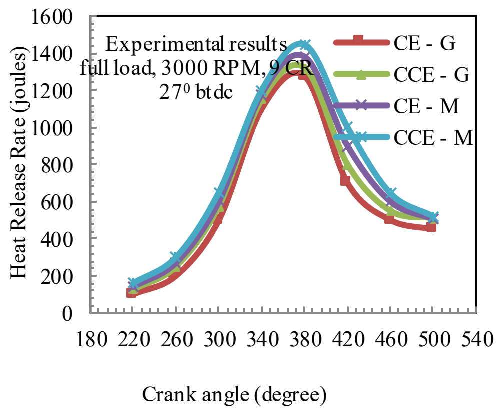


Fig 2. *Variation of cylinder pressure with crank angle*

Heat release: Fig.3 shows the variation of heat release rate with crank angle at full load condition. It can be observed that the value of heat release rate increase with blended fuel. The early start of combustion was caused by the advancement in the ignition timing and shorter ignition delay. The slower premixed combustion rate due to less energy released in premixed phase and also probably due to the lower volatility of methanol. In the diffusion combustion phase, the methanol fuel had rapid combustion because at this phase most of fuel gets vaporized [13].



B. Performance analysis

Brake thermal efficiency (BTE): The retard of spark timing causes a decrease in the combustion duration with respect to time and hence required time require for complete combustion is reduced. This result demonstrates the incomplete combustion at rated speed and compression ratio of engine that causes the decrease in the MBT. It can also be seen that there is an improvement in BTE when methanol blended gasoline is used as fuel as methanol has high heating value. The copper coated engine with both test fuels gave optimum ignition timing at 270 btdc. The graph showed highest BTE, 33.2% at 270 bTDC for methanol blended gasoline operated copper coated engine and lowest of 22% at 290 bTDC as it is too advance timing. In other words, the high thermal efficiency means that a larger portion of combustion heat has been converted into work. However, on average, Copper coated engine with methanol blended gasoline increased peak BTE by 24% in comparison with neat gasoline.

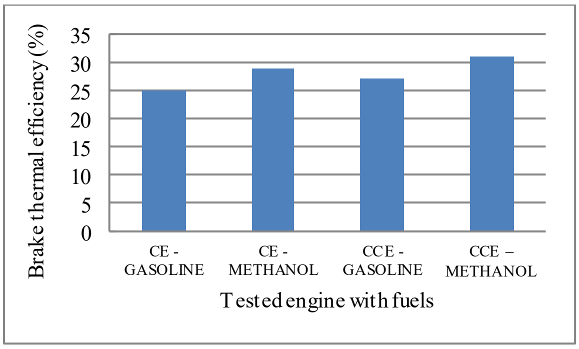


Fig 4. *Comparison of Brake thermal efficiency*

Volumetric efficiency (VE): Volumetric efficiency depends on combustion wall temperature, which in turn depends on exhaust gas temperature. As copper coated engine with methanol registered low EGT, volumetric efficiency was observed to be higher with copper coated engine with methanol operation. The reason the volume flow rate of air into the intake system divided by the rate at which volume is displaced by the system. The results were presented in Fig. 5 for different test fuels of copper coated engine. As the ignition timing increased from 250 to 270 btdc, the volumetric efficiency for CCE-gasoline, CCE-methanol (M20) increased by 2.42% and 4.72%, while it was decreased 1.25% and 3.52% both test fuels.

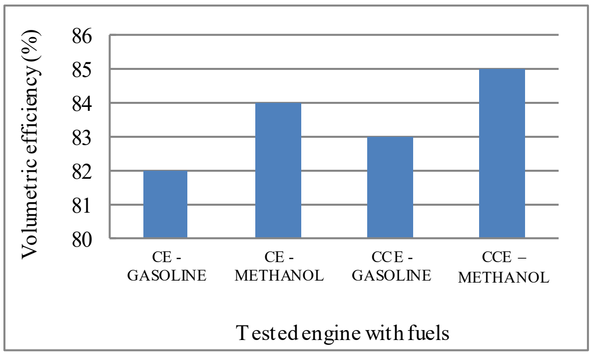


Fig 5. *Comparison of Volumetric efficiency*

Exhaust gas temperature (EGT): Fig .6 shows the effect of ignition timing on EGT It can also be observed that the copper coated engine for methanol blended gasoline operation has lower exhaust gas temperature than the gasoline operation. . With increase in ignition timing from 25^0 to 29^0 bTDC, the reduction in the EGT for CCE-gasoline CCE-methanol (M20) was 27.5% and 43.5% at 27^0btdc

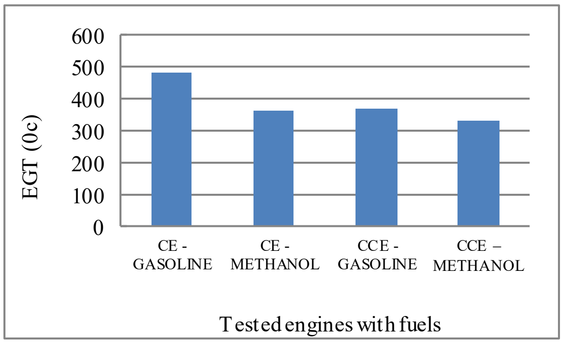


Fig 6. *Comparison of Exhaust gas temperature*

C. Emission analysis

The exhaust emissions were compared for CE(G),CE(M20),CCE (G),CCE (M20) at full load condition Spark ignition timing 27^0c btdc. Exhaust emissions measured were CO and UBHC.

Carbon monoxide (CO): The CO emissions occur due to the incomplete combustion of fuel. The comparative analysis is shown in Fig. 7. CCE (M20) is found to emit significantly lower CO concentration. It is CO emissions were observed to be lower at 27^0 btdc ignition timing with both test fuels. This was because of prolonged combustion and more resident period of fuel with air at advanced ignition timing because high thermal conductivity of copper coating improves combustion there by reducing CO emissions. The reduction in the CO for CE-gasoline CCE-methanol (M20) was 36.7% and52% respectively.

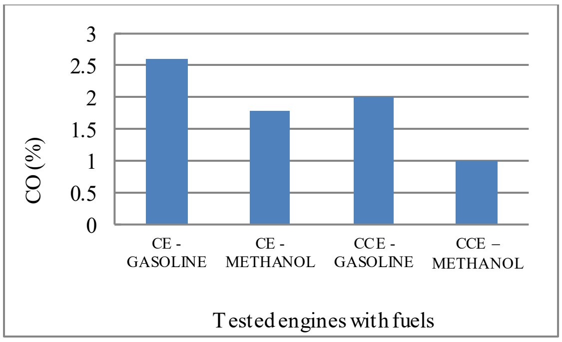


Fig 7. *Comparison of Carbon monoxide*

Unburned hydro carbons: Methanol is superior to gasoline in the aspect of reduction of pollutants, as its vaporization rate is higher than gasoline therefore mixing with air rapidly forms uniform vaporized mixture and burn uniformly. The minimum UBHC emission CE gasoline (400 ppm) and CCE methanol (100 ppm) was obtained 27^0 btdc. The increase in compression caused the air fuel mixing in the combustion chamber more effectively, such that the UBHC emission was reduced considerably.

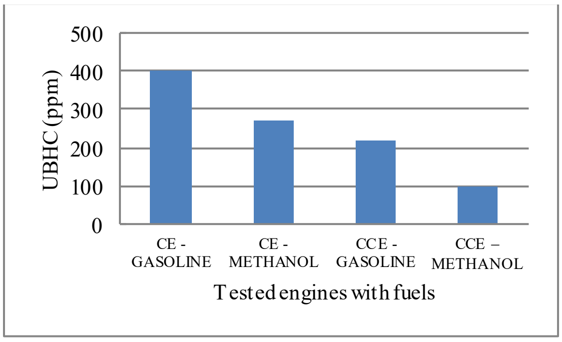


Fig 8. *Comparison of Unburned hydro carbons*

V. CONCLUSIONS

In order to understand the effect of alcohol fuels on copper coated engine performance, the brake thermal efficiency (BTE) and volumetric efficiency (VE) were measured at full load , constant engine speed of 3000 rpm and Spark ignition timing 27^0c btdc.These results are similar to those predicted by ANSYS workbench 15 Design explorer as per Central Composite Design (CCD) based DOE. Also they are in good agreement with the results obtained

TABLE III. COMPARISON OF PREDICATED AND EXPERIMENTAL VALUES

Values	Engine with fuels	Ignition timings (btdc)	BTE (%)	VE (%)	EGT (0C)	CO (%)	UBHC (ppm)
Exp	CCE (M20)	27^0	31	85	330	1	100
Predicated	CCE (M20)	26.7^0	31.238	85.6	339.2	1.33	135

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