



Control of Exhaust Emissions from Spark Ignition Engine

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Abstract: The present scenario shows that emissions from automobiles leading to global warming which is jeopardy to the entire world and harmful to human health. Burning of fossil fuels has associated with its emissions in the form of nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), unburned hydrocarbons (UBHC). These emissions have both local and global impact. Here a study has been made to know the exhaust emission control techniques for spark ignition engine. This study is conducted on four-stroke, single cylinder and spark ignition (SI) engine. The engine is operated with parameters: variable compression ratio, variable speed. It has a brake power of 2.2 kW and operates at a speed of 3000 rpm. The control of CO and UBHC from exhaust emission is studied. There are so many pre emission control techniques available for spark ignition engine that leads to engine design modifications. A three-way catalyst (TWC) has been used to convert harmful emissions of hydrocarbons, carbon monoxide, and oxides of nitrogen into less harmful gases in order to meet the pollution control regulations. The engine is provided with catalytic converter with different catalysts such as sponge iron and manganese ore.

Keywords: Emission Control, Four Stroke, Catalytic Converter.

I. INTRODUCTION

A. Four Stroke Spark Ignition with Catalytic Converter

Auto mobiles are the major contribute to means of transportation. Researchers in automobile engineering have emphasized on engine design and exhaust emission control from internal combustion engines. Due to increase in mobility especially in large and metropolitan cities, environmental protection has advanced to become an issue of central concern. Emission control regulations have been introduced in all developed and developing countries in order to reduce the emissions of vehicles powered by internal combustion engines. fuel economy and environmental effect from vehicles become a local and global concern there have number of control methods developed to reduce the exhaust emissions from spark ignition engines. Petrol engines are widely used for various applications in automobiles. Spark ignition engine is preferred locomotive prime mover due to its smooth operation and low maintains and it has the advantage of low specific weight, compactness and simplicity in the design. However it has two serious drawbacks poor fuel economy and high-unburned hydrocarbon emission. As the automotive emissions are severely regulated since 1980, a three-way catalyst (TWC) has been used to convert harmful emissions of hydrocarbons, carbon monoxide, and oxides of nitrogen from spark ignition engine into less harmful gases in order to meet these regulations.

II. METHODOLOGY

A. By Changing Engine Design:

A bond coating of Ni-Co-Cr alloy is applied (thickness, 100 μ) using a 80 kW METCO plasma spray gun. Over bond coating, copper (89.5%), aluminium (9.5%) and iron (1.0%) are coated (thickness 300 μ). The coating has very high bond strength and does not wear off even after 50 h of operation [5].

Figure 1 shows experimental set-up used for investigations. A four- stroke, single-cylinder, water-cooled, SI engine (brake power 2.2 kW, rated speed 3000 rpm) is coupled to an eddy current dynamometer for measuring brake power. Compression ratio of engine is varied (3 -9) with change of clearance volume by adjustment of cylinder head, threaded to cylinder of the engine. Engine speed is varied from 2400 to 3000 rpm. Exhaust gas

temperature is measured with iron- constantan thermocouples. Air consumption is measured with air-box method. In catalytic coated engine, piston crown and inner surface of cylinder head are coated with copper by plasma spraying. CO and UBHC emissions in engine exhaust are measured with Netel Chromatograph analyzer. DNPH method [7] is employed for measuring aldehydes in the experimentation. Air-fuel ratios are varied so as to obtain different equivalence ratios.

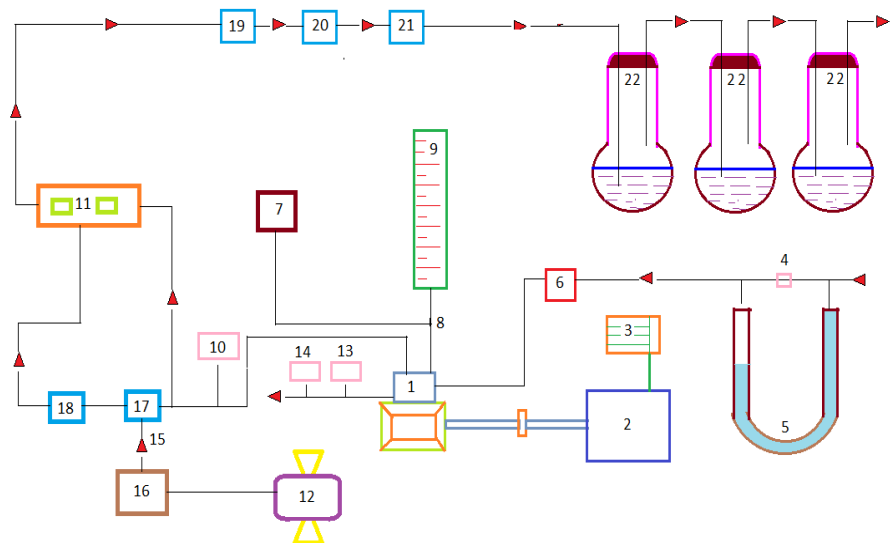


Figure 1: Four-stroke SI engine Experimental set up

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. Rotometer 17. Air chamber 18. Catalyst chamber 19. Filter 20. Rotometer, 21. Heater 22. Round bottom flasks containing DNPH solution

B. By Changing Fuel Composition:

Experiments are carried out on CE and CCE with different test fuels [pure gasoline, methanol blended gasoline (Gasoline 80%, methanol 20% by volume)]. Fuel consumption of engine is measured with burette method. The properties of the Test Fuels used in the experimentation are shown in Table-1.

Table 1: Properties of the Test Fuels

Test Fuel	Density at 25°C	Octane Number (RON)	Calorific value (kJ/kg)
Gasoline	0.72	88	42000
Ethanol	0.79	109	26880
Methanol	0.80	129	19740

C. By Catalytic Converter:

A catalytic converter [10] is fitted to exhaust pipe of engine. Provision is also made to inject a definite quantity of air into catalytic converter. The catalytic converter is provided with easily available and cheaper catalysts such as sponge iron and manganese ore. Air quantity drawn from compressor and injected into converter is kept constant so that backpressure does not increase. Experiments are carried out on CE and CCE with different test fuels pure gasoline, methanol blended gasoline and gasohol 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.

III. RESULTS AND DISCUSSIONS

Performance parameters with conventional engine and catalytic coated engine with different test fuels of gasoline, ethanol blended gasoline and methanol-blended gasoline at different compression ratios and at different speeds of the engine and pollution levels with different operating conditions of the catalytic converter with different test fuels, engine configurations at varied engine parameters has been given in graph form

Table 2: Peak Brake Thermal Efficiency with different parameters

Engine Versions	Compression ratio	FUELS					
		Gasoline		Methanol		Ethanol	
		Speed, rpm					
		2800	3000	2800	3000	2800	3000
CE	8:1	22	23	23	24	24	25
	9:1	23	24	24	25	25	26
CCE	8:1	24	25	25	26	26	27
	9:1	25	26	26	27	27	28

Table 3: Exhaust Gas Temperature for different conditions

Engine Versions	Compression ratio	FUELS					
		Gasoline		Methanol		Ethanol	
		Speed, rpm					
		2800	3000	2800	3000	2800	3000
CE	8:1	610	590	505	480	470	450
	9:1	585	560	475	450	445	420
CCE	8:1	465	445	445	420	425	400
	9:1	440	415	415	390	395	370

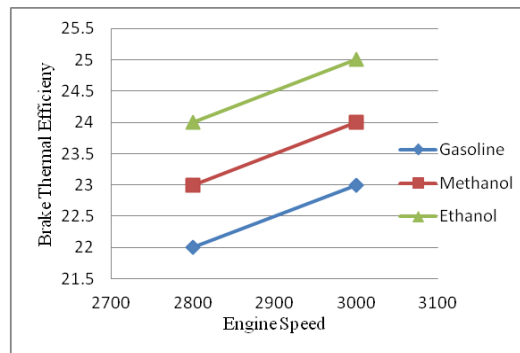


Figure 2: Brake Thermal Efficiency with respect to Engine Speed in Conventional Engine

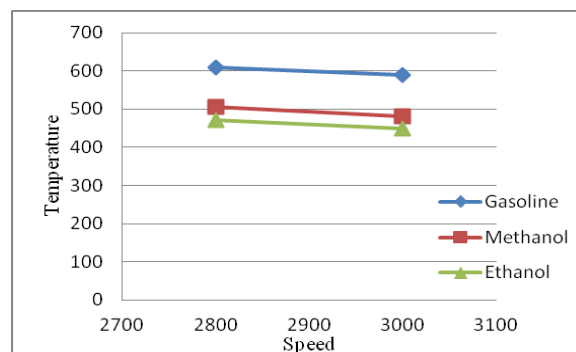


Figure 3: Exhaust Gas Temperature with respect to Engine Speed in Conventional Engine

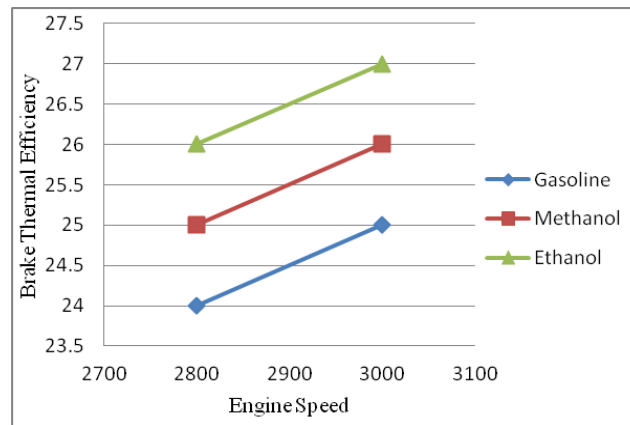


Figure 4: Brake Thermal Efficiency with respect to Engine Speed in Copper Coated Engine

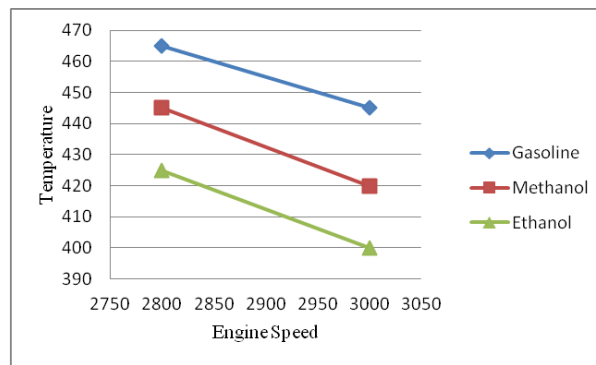


Figure 5: Exhaust Gas Temperature with respect to Engine Speed in Copper Coated Engine

The data from above graphs shows brake thermal efficiency at peak load for different test fuels at different speeds with different versions of the engine. The brake thermal efficiency at peak load increased with increased with different test fuels with different configurations of the engine. This is because of increase in expansion work with increase of compression ratio. Thermal efficiency at peak load also marginally increased with increase of speed of the engine from 2800 rpm to 3000 rpm.

The exhaust gas temperature is lower with methanol- blended gasoline when compared to pure gasoline at all loads in both configuration of the engine. This is because, with methanol blended gasoline the work transfer from the piston to the gases in the cylinder at the end of the compression stroke is too large, leading to reduce in the magnitude of exhaust gas temperature. The combustion temperatures are lower with methanol- blended gasoline when compared to pure gasoline operation due to the high latent heat of evaporation of the methanol leading to produce exhaust gas temperature of lower magnitude when compared to pure gasoline operation. Catalytic coated engine registered lower exhaust gas temperature when compared to conventional engine for both test fuels, which confirm the efficient combustion with the catalytic coated engine when compared to conventional engine.

IV. CONCLUSION

Emission Levels

1. CO emissions at peak load decreased by 20 –30% with Set –A, 20-40% with Set-B and 20-40% with Set-C with the change of the engine configuration from conventional version to catalytic coated engine with test fuels.
2. CO emissions decreased by 25-35% with the change of fuel from gasoline to gasohol in both versions of the engine under different sets while it is 30-46% from gasoline to methanol blended fuel
3. Ethanol blended gasoline (gasohol) recorded higher CO emissions by 18% when compared to methanol-blended gasoline in both versions of the engine under different operating conditions of the catalytic converter.

4. CO emissions increased by 13% with the change of compression ratio from 8:1 to 9:1 while it decreased by 3% with the change of speed from 2800 rpm to 3000 rpm with different test fuels in both configurations of the engine under different operating conditions of the catalytic converter.

IV. FUTURE SCOPE

- Investigations can be extended by inducting 100% alcohol into the engine with change of the spark ignition timing and carburetor settings
- Aldehyde emissions can be measured with alcohol-gasoline blends with various configurations of the engine with varying engine parameters
- Simulation of CO/UBHC measurements in different versions of the engine with appropriate combustion modeling can be taken up and results can be correlated with experimental investigations
- Experiments can be conducted at various throttle openings and the effect of air fuel ratio on the emissions and performance parameters of different configurations of the engine can be studied

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