

A Comparative Investigation on Performance and Emissions of Single Cylinder Four Stroke Ceramic Coated SI Engine with Blends of Methanol and Petrol-A review paper



Engineering

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ABSTRACT

In this study, yttria stabilized zirconia is used as ceramic coating in low heat rejection engine concepts. The coating is carried out by plasma spray method on cylinder liner and intake and exhaust valves of single cylinder four stroke SI engine. A comparative evaluation is carried out between different blends of methanol-petrol. The effect of different blends and ceramic coating on engine performance and emissions are observed.

Introduction:

Engine efficiency improvement efforts via constructional modifications are increased today; for instance, parallel to development of advanced technology ceramics, ceramic coating applications in internal combustion engines grow rapidly. To improve engine performance, fuel energy must be converted to mechanical energy at the most possible rate. Coating combustion chamber with low heat conducting ceramic materials leads to increasing temperature and pressure in internal combustion engine cylinders. Hence, an increase in engine efficiency should be observed. Methanol burn at lower temperature than petrol. Using methanol as blends with petrol in spark ignition engines can offer an increased thermal efficiency and increased power output due to high octane rating and high heat of vaporization.

Initiation of the engine can be easier like shortened ignition delay in ceramic coated IC engines due to increased temperature after compression because of low heat rejection. More silent engine operation can be obtained considering less detonation and noise causing from uncontrolled combustion. Engine can be operated at lower compression ratios due to shortened ignition delay. Thus better mechanical efficiency can be obtained and fuel economy can be improved.

Another important topic from the view point of internal combustion engines is exhaust emissions. Increased combustion chamber temperature of ceramic coated internal combustion engines causes a decrease in hydrocarbon and carbon monoxide emissions but an increase in nitro oxide. When increased exhaust gases temperature considered, it is obvious that consequently total thermal efficiency of the engine is increased. Ceramics have been used since nearly at the beginning of low heat rejection engines. These materials have lower weight and heat conduction coefficient comparing with materials in conventional engines.

Advantages of ceramics:

- High chemical stability
- High hardness values
- Low densities
- Resistant to high temperatures
- Resistant to wear
- Low heat conduction coefficient
- High compression strength

Zirconia (ZrO₂):

Zirconia has an important place among coating materials with its application areas and properties essential to itself. The most important property of zirconia is its high temperature resistance considering ceramic coating application in internal combustion engines. Ceramics containing zirconia have high melting points and they are durable against thermal shocks. They have also good corrosion and erosion resistances.

Zirconia can be found in three crystal structure. These are monolithic (m), tetragonal (t) and cubic (c) structures. Mono-

lithic structure is stable between room temperature and 1170°C while it turns to tetragonal structure above 1170°C. Tetragonal structure is stable up to 2379°C and above this temperature, the structure turns to cubic structure.

Usually cracks and fractures are observed during changing phases because of 8% volume difference while transition to tetragonal structure from monolithic structure. To avoid this and make zirconia stable in cubic structure at room temperature, alkaline earth elements such as CaO (calcium oxide), MgO (magnesia), Y₂O₃ (yttria) and oxides of rare elements are added to zirconia. Zirconia based ceramic materials stabilized with yttria have better properties.

Mechanical properties of cubic structure zirconia are weak. Transition from tetragonal zirconia to monolithic zirconia occurs at lower temperatures between 850-1000°C and this transition has some characteristics similar to martensitic transition characteristics which are observed in tempered steels. In practice, partially stabilized cubic zirconia (PSZ) which contains monolithic and tetragonal phases as sediments, is preferred owing to its improved mechanical properties and importance of martensitic transition.

Yttria (Y₂O₃):

Melting point of yttria is 2410°C. It is very stable in the air and cannot be reduced easily. It can be dissolved in acids and absorbs CO₂. It is used in Nerst lamps as filament by alloyed with zirconia and thoria in small quantities. When added to zirconia, it stabilizes the material in cubic structure. Primary yttria minerals are gadolinite, xenotime and fergusonite. Its structure is cubic very refractory.

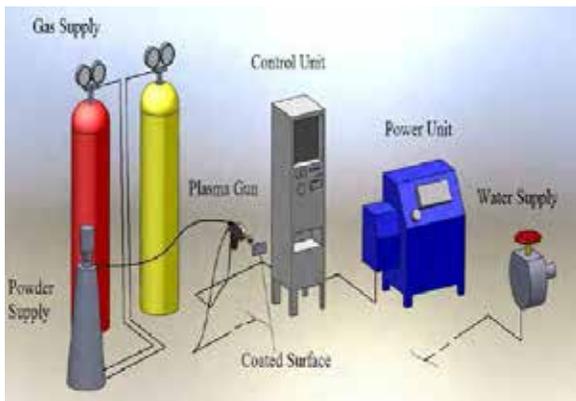
Plasma spray coatings:

Plasma is a dense gas which has equal number of electron and positive ion and generally named as fourth state of the matter. This method has two primary priorities; It can provide very high temperatures that can melt all known materials and provides better heat transfer than other materials. High operating temperature of plasma spray coating, gives opportunity to operate with metals and alloys having high melting points. Also using plasma spray coating in inert surroundings is another positive side of the method. Oxidation problem of the subject material is reduced due to inert gas usage in plasma spray such as argon, hydrogen and nitrogen. All materials that are produced in powder form and having a specific grain size can be used in this method.

The main objective in plasma spraying is to constitute a thin layer that has high protection value over a non expensive surface. The process is applied as spraying coating material in powder form molten in ionized gas rapidly to coated surface. The system primarily consists of power unit, powder supply unit, gas supply unit, cooling system, spraying gun and control unit.

Direct current electrical arc is formed between electrode and

nozzle in plasma spray coating gun. The inert gas (usually argon) and a little amount of hydrogen gas which is used to empower inert gas mixtures are sent to arc area of plasma gun and heated with electrical arc. Gas mixture temperature reaches to 8300°C and it becomes ionized. Hence, high temperature plasma beam leaves from gun nozzle. In this system, ceramic grains are supplied to plasma beam as dispersible form. Grains molten by the hot gases are piled up on target surface and hardened. Argon/helium gas mixture increase gas flow and hence ceramic grains speed. Coating layer structure by the plasma spray coating contains equal axial thin solid grains. In some layers, an amorphous structure is attained because of fast solidification.



Plasma spray coating system

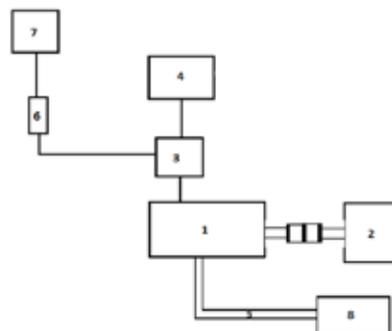
Methanol:

Methanol burn at lower temperature than petrol. Using methanol as blends with petrol in spark ignition engines can offer an increased thermal efficiency and increased power output due to high octane rating and high heat of vaporization. Most methanol is produced from natural gas, although it can be produced from biomass. Methanol has most commonly been produced from synthesis gas, but there are more modern ways to obtain these fuels. Enzymes can be used instead of fermentation. Methanol can be produced industrially from nearly any biomass, including animal waste, or from carbon dioxide and water or steam by first converting the biomass to synthesis gas in a gasifier.

Property of Methanol-Petrol:

Experiment setup:

Property	Methanol	Petrol
Density(20°C)(kg/m ³)	796	740
Calorific value (MJ/kg)	19.5	44
Viscosity(20°C) (cP)	0.6	0.42
Heat of vaporization(KJ/kg)	1104	330
Boiling temperature(°C)	65	30-225
Octane number	110	92
Auto ignition temperature(°C)	464	257
Flame velocity(m/s)	55	40
Boiling point(°C)	64.7	149-270
Specific heat(KJ/kg°C)	2.6	2.009
Stoichiometric air-fuel ratio	6.5	14.6



Line diagram of engine set up

- 1 Engine
- 2 Dynamometer
- 3 Carburettor
- 4 Air filter
- 5 Exhaust pipe
- 6 Burrette
- 7 Fuel tank
- 8 Exhaust gas analyzer

Experiment specification

Displacement	134.21 cc
Bore	58 mm
Stroke	50.8 mm
Compressor ratio	9.5:1
Rated power	9.64kw at 8500 rpm
Rated torque	11.88 Nm at 6500 rpm
Number of cylinder	Single
Number of stroke	4
Ignition system	Microprocessor controlled digital CDI
Spark plug	DTS-i
Transmission	4 speed constant mesh
Lubrication	Wet sump, Forced
Starting system	Kick start

Methodology:

- There are two types of experiments
- 1) Without coating with blends of 0%,5%,10%,15%,20%. 2) With coating with blends of 0%,5%,10%,15%,20%.
- Engine is mounted on a test bed on engine crank shaft brake drum is coupled with rope brake dynamometer.
- Load measurement is taken by dynamometer at 0.5kg, 2kg, 4kg,6kg, 8kg.
- Speed is measured by digital tachometer at different load.
- Stop watch is used for time measurement for fuel consumption.
- Burrette is used to measure quantity of fuel passing through carburettor.
- Exhaust gas analyser is used to measure level of pollutants of CO,HC.

Conclusion:

By using methanol with petrol in four stroke SI engine, increase in brake power, brake thermal efficiency, decrease in fuel consumption, decrease in CO and HC emissions. By using ceramic coated cylinder liner and intake and exhaust valves, grater performance than without coating are obtained.

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