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Experimental Investigation on Performance and Emissions of Single Cylinder Four Stroke Ceramic Coated SI Engine with Blends of Methanol-Petrol

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Abstract:

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. Main purpose of this study is to investigate the performance and emissions of single cylinder four stroke SI engine using different blends of methanol with petrol, without coating & with yttria stabilized zirconia coating on cylinder liner and intake and exhaust valve.

Introduction:

Research for decreasing costs and consumed fuel in internal combustion engines and technological innovation studies have been continuing. 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.

Ceramic coatings applied to IC engine combustion chambers are aimed to reduce heat which passes from in-cylinder to engine cooling system. Engine cooling systems are planned to be removed from internal combustion engines by the development of advanced technology ceramics.

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.

Combustion characteristics is the most important factors which affect exhaust emissions, engine power output, fuel consumption, vibration and noise. When the lost heat energy, useful work are taken into account, the idea of coating combustion chambers with low heat conduction and high temperature resistant materials leads to thermal barrier coated engines.

Although fossil fuels have become the dominant energy resource for the modern world, alcohol has been used as a fuel throughout history.

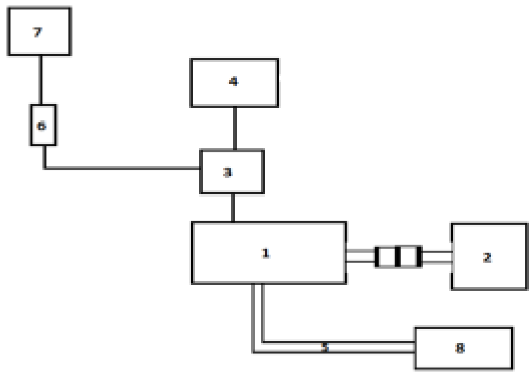
Methanol, ethanol, propanol,and butanol are of interest as fuels because they can be synthesized chemically or biologically, and they have characteristics which allow them to be used in current engines. One advantage shared by all four alcohols is their high octane rating. This tends to increase fuel efficiency and largely offsets the lower energy density of alcohol fuels (as compared to petrol/gasoline and diesel fuels), thus resulting in comparable "fuel economy" in terms of distance per volume metrics, such as kilometers per liter, or miles per gallon.

Methanol and ethanol can both be derived from fossil fuels, biomass, or perhaps most simply, from carbon dioxide and water. Ethanol has most commonly been produced through fermentation of sugars, and 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 is the simpler molecule, and ethanol can be made from methanol. 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. It can also be produced in a laboratory using electrolysis or enzymes.

Literature review:

Senthilkumar Tamilkolundu, et al [1] in this paper, In SI engines, thermal barrier coating like Zirconia have been employed to improve fuel efficiency to reduce corrosion of piston, reduce pollution, low fuel consumption and improve lubrication oil life.These investigations to evaluate the performance and emission characteristics of the Yttria – zirconia coated piston in the multi cylinder petrol engine are presented. It is concluded that the coating of piston results in reduction of heat rejection is more effective and increases engine efficiency. Brake power, indicated power, brake thermal efficiency and mechanical efficiency of yttria-zirconia coated piston engine is increased by is 12%, 6%, 8.65% and 7.2% respectively. 19% reduction in total fuel consumption and 28% reduction in specific fuel consumption is achieved with yttria- zirconia coating. The friction power is reduced by 29% at all load conditions. **Milan Pankhaniya, et al [2]** in this paper, experimental performance tests were carried out at engine speed 2000 rpm and variable load condition, using various blends of M0 to M20 fuels into the effect of methanol addition to gasoline on performance & exhaust emission of SI engine. It is leads to a reduction of CO and HC by about 25% and 10% respectively. It was concluded that among the different blends, the blend including M20 is the most suited for SI engine from the engine exhaust emission point of view.When M20 blends are used the BP is 4.1122 kW found which is higher around 10% than pure petrol at full load conditions. When M5 blends is used the BSFC obtained 0.1615 kg/KW-hr which is lower about 8% and brake thermal efficiency increased by 5% than pure petrol at constant speed condition. The result of gas analysis shows that, when 20% methanol-gasoline blends are used CO emission decrease by 25% and when HC emission decrease by 10% at full load condition. Based on performance and emission analysis of engine using different methanol-petrol blends, optimum blend was found is M20 (20% methanol and 80 % petrol). **P. Lawrence, et al [3]** in this paper the effect of Zirconia coating on the performance and emission characteristics of diesel engine was investigated using ethanol as sole fuel. For this purpose the cylinder head, valve and piston of the test engine were coated with a partially stabilized Zirconia of 0.5 mm thick by the plasma spray coating method. For comparing the performance of the engine with coated components with the base engine, readings were taken before and after coating. To make the diesel engine to work with ethanol a modification was done. The brake thermal efficiency was increased up to 1.64% for ethanol with coating and there was a significant reduction in the specific fuel consumption. The NOx, CO and HC emissions in the engine exhaust decreases with coating. **Siew Hwa Chan, et al** [4] in this paper, This paper presents the work continued from the previous study on a low heat rejection (LHR) engine.Instead of using a single-property yttria-stabilized zirconia (YSZ) coating to achieve the thermal barrier for the piston crown, a varying-properties functionally graded material (FGM) was used in this study.Extensive experiments were conducted on a 3-cylinder SI Daihatsu engine with all piston crowns coated with a layer of ceramic, which consists of zirconia and yttria with varying compositions along its thickness. Measurements of engine performance, in particular its fuel consumption and emissions characteristics, were made before and after the application of FGM coatings onto the piston crowns. To gain more insight of improved engine performance, in-cylinder pressure measurements were conducted which provide direct comparison of pressure–volume diagrams between baseline and that coated with FGM. Measurements of CO, HC and NO*x* concentrations indicated that CO and HC are lower but NO*x* is higher in the FGM-piston tests. **Babazadeh Shayan, et al [5]** in this paper, the effect of Methanol (M5, M7.5, M10, M12.5, M15) on the performance and combustion characteristics of a spark ignition engine (SI) were investigated. In the experiment, an engine with four-cylinder, four stroke, multipoint injection system (Ford, Zetec-E) was used. Performance tests were conducted for brake torque, brake power, brake thermal efficiency, volumetric efficiency, equivalence air-fuel ratio, and brake specific fuel consumption and exhaust emissions (CO, CO2, HC, NOx) were analyzed under wide open throttle operating conditions and variable engine speed ranging from 1500 to 5000 rpm. The experimental results showed that the performance of engine was improved with the use of methanol. It was also shown that CO and HC emissions were reduced with the increase of methanol content while CO2 and NOx were increased.Using methanol–gasoline blends lead to a significant reduction in exhaust emissions by about 24.9% and 23.7% of the mean average values of HC and CO emissions, respectively, for all engine speeds. On the other hand CO2 and NOx emissions increases by about 7.5% and 17.5% respectively.**Idris Cesur, et al** [6] in this paper,the effect of modified ignition timing of an LPG fuelled spark ignition engine on cold start. Hydrocarbon emission (HC) at the wide open throttle (WOT) conditions performance and emission characteristics were investigated when using a thermal barrier layer (TBL) coated piston. The engine was tested at the variable ignition timing. At the first stage cold start HC emission was measured for the first 180 s. Secondly, the performance and HC emissions were measured at the WOT condition. Cold start HC emission in the TBL piston has been decreased considerable. In the case of using TBL piston and variable ignition timing, at the high engine speed the engine torque and brake power have been increased as 15% at the 2700 rpm. Specific fuel consumption (SFC) was decreased at the variable ignition timing expect for 1500 and 1800 rev min-1. Maximum reduction was observed by 8.5% at the 2700 rpm. **Ahmed Sabah Hameed, et al** [7] in this paper, the effect of ceramic coating on the performance and gases emission on diesel engine was investigated. A four-stroke, direct injected, single cylinder, diesel engine was tested at constant speed and at different load conditions without coating. Then, the inlet and exhaust valves faces were coated by about 500µm with ceramic materials. Ceramic layers were made of Yttria- Stabilized Zirconia (YSZ), and NiCrAl as a bond coat. The coating technique adapted in this work is the flame spray method. The engine with valves ceramic coated research was tested for the same operation conditions of the engine (without coating). The results indicate a reduction in both fuel consumption by about 7.6% and particulate emissions by about (13% for HC and 14.5% for CO) with increasing in exhaust gases temperature after coating.Using ethanol as a fuel additive to unleaded gasoline causes an improvement in engine performance and exhaust emissions. Ethanol addition results in an increase in brake power, brake thermal efficiency, volumetric efficiency and fuel consumption by about 8.3%, 9.0%, 7% and 5.7% mean average values, respectively. In addition, the brake specific fuel consumption and equivalence air–fuel ratio decrease by about 2.4% and 3.7% mean average value, respectively.Using an ethanol–unleaded gasoline blend leads to a significant reduction in exhaust emissions by about 46.5% and 24.3% of the mean average values of CO and HC emission, respectively, for all engine speeds. On the other hand, CO2 emissions increase by about 7.5%.v The 20% ethanol fuel blend gave the best results of the engine performance and exhaust emissions. The addition of 25% ethanol to the unleaded gasoline is achieved in our experiments without any problems during engine operation.

Engine setup:



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

Engine 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.
- Burrete is used to measure quantity of fuel passing through carburettor
- Exhaust gas analyser is used to measure level of pollutants of CO,HC.

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