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USE OF SEMI-ADIABATIC AIR-GAP COPPER CROWN PISTON IN AN ALCOHOL AND DIESEL BLEND FUELED CI ENGINE

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Abstract: **All over the world the use of petroleum products has been increasing tremendously. This has been resulted in a great scarcity of fuel for internal combustion engines and the problem has become acute during the recent years. The present fossil fuels may get exhausts in another 30 to 40 years. The emission caused by these fossil fuels combustion in IC enginesmade us to think of alternative fuels for IC engines. The alternative fuels may be Alcohols and Vegetables oils. The production of sugar cane in our country is more and also alcohol is the byproduct in the production of sugar.Thisrecognize the alcohol as a better replacement because these are derived from the plants and produces little emissions. Butdue to its high latent heat of vaporization, alcohols may not burn in the conventional diesel engines. These alcohols can beignited in the high temperature combustion chambers (Insulated Engines) which retains the heat in the combustion chamber.This helps for the complete combustion and further improves the thermal efficiency.The amount of heat in the combustion chamber mainlydepends on heat transfer through the piston.This paper presents studying the performance and emission characteristics of use of pure diesel and alcohol blends invarying proportions on volume basis and oxidation of aldehyde emission in exhaust gases during combustion itself using un-conventional catalytic converter as semi-adiabatic air-gap copper crown piston in the water cooled CI engine. The experimental work carried out on conventional piston and copper crown piston.The test results indicate that there is marginal increase in Brake thermal efficiency and there is 50% reduction in aldehyde emission in the exhaust gases.**

Keywords:**Single cylinder 4-stroke diesel engine,Alcohol, Ethanol, Catalytic Converter, Un-Catalytic Converter, Air-Gap Copper Crown Piston, Aldehydes, Exhausts emissions.**

1. INTRODUCTION

Thermal energy is oldest form of energy. Thermal energy is usually released from energies such as electrical energy and chemical energy. The device for converting one useful form of energyto another useful form is termed as engine. The conversion of energy plays a major role in an energy conversion process and it determines the efficient use of the energy which is supplied. Heat engine is a system or device that converts heat or thermal energy of a fuel to mechanical energy. [1]

Heat engine typically uses energy provided in the form of heat to do work and then exhaust the heat which cannot be used to do the work. Heat engines may be of internal combustion engines or external combustion engines. In which, there are two major types of internal combustion engines are in use today: (1) the spark ignition engine, which is used primarily in automobiles; (2) the diesel engine, which is used in large vehicles and industrial systems where the improvements in cycle efficiency of these engines make them advantageous over the more compact and lighter-weight spark ignition engine. Each of these engines is an important source of atmospheric pollutants. Automobiles are major sources of carbon monoxide, unburned hydrocarbons, and nitrogen oxides. The automobile engines have been designed based on the criteria of to reduce emissions of these pollutants. Even though, substantial progress has been made in emission reduction, automobiles remain important sources of air pollutants.

Due to the high self-ignition temperature of the alcohol it requires high compression ratios in the conventional dieselengine [1]. But for the high compression ratios the engine will become bulky. Soin order to ignite the alcohols in the combustion chambers, production of high temperatures are necessary. This can be achieved by the insulation of thecombustion chamber surfaces [2, 3 and 4]. Kamo and Bryzik [5] have demonstrated the use of Partially Stabilized Zirconium (PSZ) asthe insulating material and also reported reduction in carbon monoxide, carbon particulates and smoke emission levels. Woshini et. Al [6] reported the performance of ceramic coated engine with PSZ to 7% improvement in fuel consumption and reduction in HC emissions due to premixed combustion. Wallace et [7] have reported the use of a thermal barrier piston in the adiabatic engine and developed the temperature distribution analysis and reported that the piston top temperature were higher by around 4000C for the thermal barrier pistons. According to the Kobori et [8] the insulation in the combustion chamber decreases the premixed fraction and increases the diffusion phase of combustion. Sun et [9] argued that decrease in premixed combustion by 75% with the ceramic insulation increases the BSFC by 9%.

The insulated high temperature components include piston, cylinder head, valves and cylinder liner. So the insulating materials used in the combustion chamber should have lower thermal conductivity, good mechanical strength and mustcapable of withstanding for higher temperatures [8, 11]. With the insulation of the engine the exhaust energy isincreased compared to that of the conventional engine. Therefore, more technical innovations must be developed toextract useful energy from the exhaust and to derive the maximum benefits from this insulated engine concept. Additional power and improved efficiency derived from an adiabatic engine will be possible because the energy lost tothe cooling water and exhaust gas, can converted into useful power through the use of turbo machinery

2. LITERATURE SURVEY

"An Experimental Investigation of Ethanol Blended Diesel Fuel on Engine Performance and Emission of a Diesel Engine,"S. Gomasta and S.K Mahla. In this Technical Paper discusesImprovements in fuel properties is essential for the suppression of diesel pollutant emission along with the optimization of combustion-related design factors and exhaust after treatment equipments like catalytic converter and exhaust gas recirculation. Ethanol is an attractive alternative fuel because itis renewable, bio-diesel and is oxygenated thereby providing the potential for the reduction of particulate emission in compression ignition engines. The effect of ethanol addition on engine performance were evaluated using single cylinder, four stroke, direct injection, Air cooled diesel engine. The experiments were designed to study the effect of their reducing ethanol blended fuel by increasing the fuel temperature and thereby eliminating its effect on combustion and emission characteristics of the engine. The acquired data were analyzed for various parameters such as break thermal efficiency, break specific fuel consumption, break specific energy consumption, exhaust gas temperature, Emission parameters viz. HC, CO, CO2 and Unburned hydrocarbon are also tabulated. The performance parameters were marginally increased but the emission is significantly reduced as the blend ratio is increased.

"Use of Alcohols in Diesel Fuel Emulsions and Solutions in a Medium Speed Diesel Engine," Q.A. Baker. In this paper discusses the effects of cooled EGR on a turbocharged multi-cylinder HCCI engine. A six-cylinder, 12-liter, Scania D12 truck engine is modified for HCCI operation. It is fitted with port fuel injection of ethanol and n-heptane and cylinder pressure sensors for closed-loop combustion control. The effects of EGR are studied in different operating regimes of the engine. During idle, low speed and no load, the focus is on the effects on combustion efficiency, emissions of unburned hydrocarbons and CO. At intermediate load, run without turbo charging to achieve a well-defined experiment, combustion efficiency and emissions from incomplete combustion are still of interest. However the effect on NO_x and the thermodynamic effect on thermal efficiency, from a different gas composition, are studied as well. At high load and boost pressure the main focus is NO_x emissions and the ability to run high mean effective pressure without exceeding the physical constraints of the engine. In this case the effects of EGR on boost and combustion duration and phasing are of primary interest. It is shown that CO, HC and NO_x emissions in most cases all improve with EGR compared to lean burn. Combustion efficiency, which is computed based on exhaust gas analysis, increases with EGR due to lower emissions of CO and HC.

From the literature review, we understand that alcohol–gasoline blended fuels can effectively lower the pollutant emission without major modifications to the engine design. Moreover, the ethanol can be made from biomasses. These factors make it appealing to us in Lithuania. We therefore use engine test facilities to investigate the effects of 10% ethanol–gasoline blend fuels on the engine performance and pollutant emission.Compared with conventional diesel, exhaust emissions like CO and HC are reduced while NOx emissions are increased with biodiesel blends with diesel in an internal combustion engine.

3. ETHANOL AS ALTERNATE FUEL

Ethanol (C_2H_5OH) is a pure substance. However, gasoline is composed of C_4–C_{12} hydrocarbons, and has wider transitional properties. Ethanol contains an oxygen atom so that it can be viewed as a partially oxidized hydrocarbon. Ethanol is completely miscible with water in all proportions, while the gasoline and water are immiscible. To reduce this problem on fuel delivery system, such materials mentioned above should be avoided. Ethanol can react with most rubber and create jam in the fuel pipe. Therefore, it is advised to use fluorocarbon rubber as a replacement for rubber. On the combustion characteristics, the auto-ignition temperature and flash point of ethanol are higher than those of gasoline, which makes it safer for transportation and storage. The latent heat of evaporation of ethanol is 3–5 times higher than that of diesel; this makes the temperature of the intake manifold lower, and increases the volumetric efficiency. The heating value of ethanol is lower than that of the gasoline. Therefore, we need 1.6 times more alcohol fuel to achieve the same energy output. The stoichiometric air–fuel ratio (AFR) of ethanol is about 2/3 that of the gasoline, so the required amount of air for complete combustion is lesser for alcohol.

Ethanol has less HC emissions than gasoline but more than methanol. Both ethanol and methanol have high self-ignition temperatures. Hence, very high compression ratios(25-27) will be required to self-ignite them. Since this would make the engine extremely heavy and expensive, the better method is to utilize them in dual fuel operation.

Figure 1: Ethanol and Diesel blend

TABLE1

ETHANOL PROPERTIES

Property	Diesel	Ethanol
Density (Kg/m^3)	840	810
Colour	-	Yellowish
Kinematic viscosity at 40^{0}c (m^2/sec)	(2.5-6)×10^{-6}	(4.2-5.3)×10^{-6}
Flash point (°c)	51	31
Calorific value (MJ/Kg)	42	27
Specific gravity	0.85	0.81

4.EXPERIMENTAL WORK

In order to analyze the performance, exhaust emissions and the aldehydes which are present in the exhaust gases are determined by using chemical analysis. The above experiment was carried out on the conventional piston using diesel and blends of ethanol i.e. E5 and E10. After completion of the above experiment the conventional piston is replaced by semi-adiabatic copper crown piston of thickness 6 mm as shown in the fig-2 and fig-3 with same blends.Theexperiment was carried out on a single cylinder, water cooled, direct injection diesel engine. Eddy current dynamometer is used for loading i.e. electrical loading. The engineSpecifications are given in Table-2.

A four gas analyzer wasused to measure CO, CO2 and HC emission.A separate NOx analyzer was used tomeasure NOx emission. Both theinstrumentswere pre-calibrated before conducting theexperiments. For the measurement of carbonyl components i.e. aldehydes a separate setupconsisting of an exhaust gas pump, samplingprobe, an impinger and an ice bath wereattached to the exhaust pipe of the engine.

TABLE2

TEST ENGINE SPECIFICATIONS

Particulates	Specifications
Model	AVI
Make	Kirloskar Oil Engine Ltd.
Arrangement of cylinders	Vertical
Lubricant	SAE 20/SAE40
No of cylinders	1
Bore	85mm
Stroke length	110mm
Rated speed	1500 rpm
Rated power	3.68 kW (5HP)
Compression ratio	17.5:1
Starting	Hand start with crank handling
Fuel oil	High Speed Diesel (HSD)
Type of cooling	Water cooled

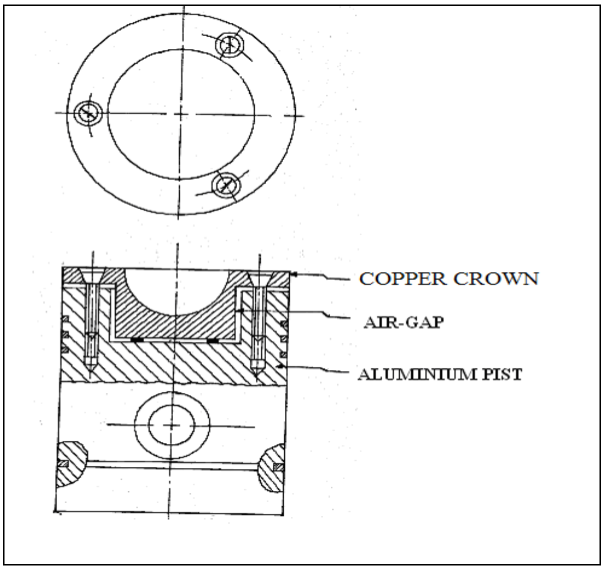


Figure2: Air-Gap Insulated Copper Crown Piston

Figure 3: Semi-Adiabatic Air-Gap Copper Crown Piston

5 RESULTS AND DISCUSSION

5.1. Brake Thermal Efficiency:

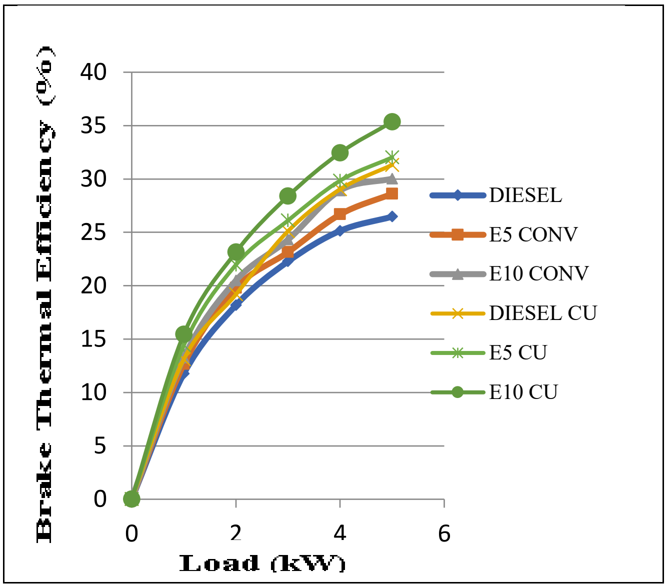


Figure 5: load vs. brake thermal efficiency

Figure 5 shows variation of brake thermal efficiency with different blendof Ethanol and diesel. The brake thermal efficiency of the blend is more compared to the diesel with air-gap copper crown pistonand normal piston. Blend E10 gives better performance results at the rated loads compared to the diesel. Air availability in Compression Ignition engine influences thedistributionandatomizationof fuel injected into the combustion chamberWith optimal turbulence, better mixing of air andfuel is possible which leads to complete and effective combustion so that thermal efficiency increases. Brake thermal efficiency increases with the load for the reason that as the load increases relatively less portion of power is lost.

5.2 Brake Specific Fuel Combustion:

Fig 6: load Vs brake specific fuel combustion

Figure 6 shows variation of Brake Specific Fuel Consumption (BSFC) with load on the engine with ethanol blend on the engine with normal and air-gap piston. Lower BSFC is desirable because it is the measure of the engine's efficiency indirectly. BSFC and engine efficiency are inversely proportional. In general, BSFC is used rather than the thermal efficiency because more or less perfect definition of thermal efficiency does not exist. It is observed from the graph that the brake specific fuel is decreasing for the blend with increasing the load on the engine. For the blend E10 the decrease inBSFC is very precise at loads with copper crown engine with air-gap, compared to the normal aspirated engine. The decrease is due to increased temperature and efficiency.

5.3 Exhaust Gas Emissions of Carbon Monoxide:

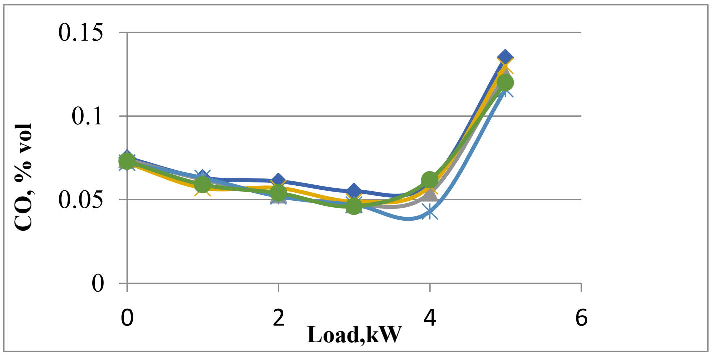
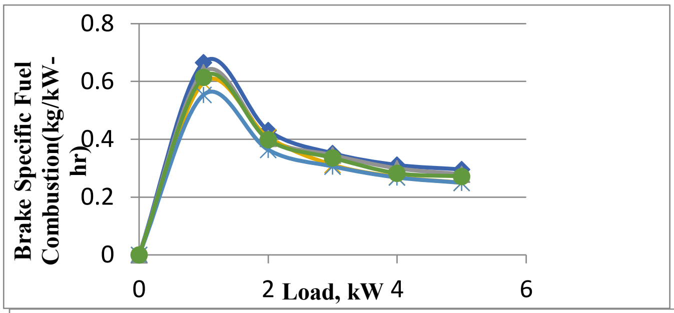


Figure 7: load vs. carbon monoxide

Figure 7 shows the variation of CO emission with engine loading. Carbon monoxide forms during the combustion process. It was observed from the graph that CO emissions are increased with increase in engine load. CO emission of biodieselis less compared to diesel it is likely due to oxygen content present in the biodiesel is more which helps in more complete and rapid oxidation of fuel.Generally, Compression Ignition engines operate with lean mixtures and hence the CO emission would be low. With the higher swirl of air in the inlet manifolds with internalthreads, the oxidation of carbon monoxide in the engine is improved and subsequently reduces the CO emissions. With rich fuel-air mixtures, there is insufficient oxygen to burn fully all the carbon in the fuel to CO_2; also, in high temperature products, even with lean mixtures, dissociation ensures there is a significant CO level.

5.4 Exhaust Emissions of Hydro Carbons:



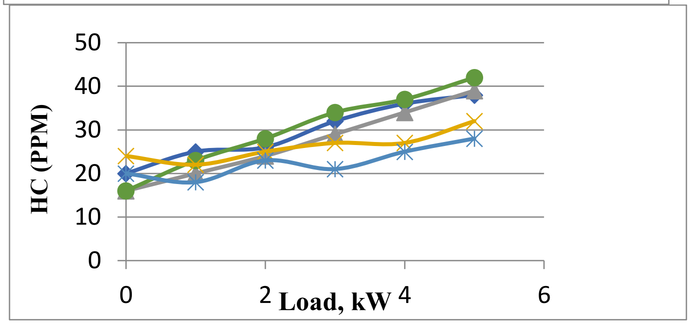
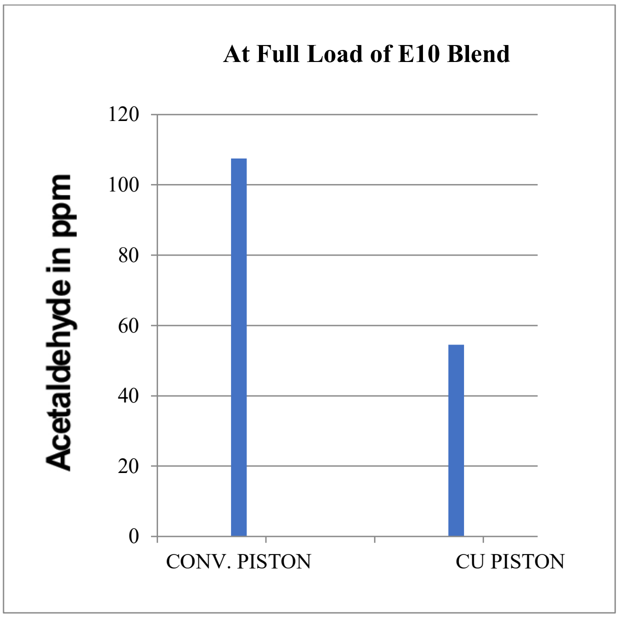


Figure 8: load vs. hydro carbons

Figure 8 variation of HC emission with various loads on normal inlet piston engine and air-gap crown piston engine with biodiesel blend. The possible sources of HC emission in an I.C engine is during compression and combustion, the increasing cylinder pressure forces some of the gas in the cylinder into crevices, or narrow volumes connected to the combustion chamber. Most of this gas is unburned fuel-air mixture. As the engine is fitted with air-gap crown piston, the increase inoxygen availability causes better mixing of fuel and air so that hydro carbon emission is decreasing. It is apparent that E10 blend gives less hydrocarbon emission at rated load compare to diesel chamber. Most of this gas is unburned fuel-air mixture. As the engine is fitted air-gap crown piston, the increase in availability causes better mixing of fuel and air so that hydro carbon emission is decreasing. It is apparent that E10 blend gives less hydrocarbon emission compare to all blends and diesel.



5.5 Exhaust Emissions of Nitrogen Oxides:

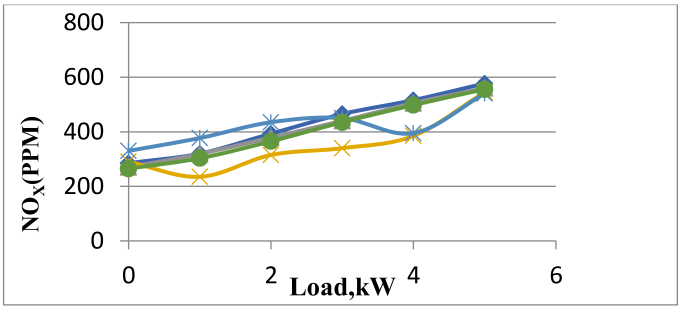


Figure 9: load vs. nitrogen oxides

Fig shows 9 variation of NO_X emission with various loads on normal piston engine and air-gap crown piston engine with 10% ethanol blend. It is observed that blends E5 and E10 gives less NO_X emission with normal piston but more for air-gap crown piston.. The increase in $NO_X$is may be due to higher oxygen content present in the ethanol and may be due to less operating temperature in the cylinder by creating more swirl which leads to less NO_X emission at lower blends.

5.6 Acetaldehyde emissions:

Figure 8:Variation in reduction of Acetaldehydes for both version engines

The results indicate that acetaldehydeemissions were higher atlower loads. Acetaldehyde emission is higher than that of formaldehyde at lowerloads. The maximum concentration of thecarbonyl components is the function of molecular weight. The higher hydrocarbonsare rather oxidized to lower HC components.This leads to more formation of acetaldehyde during the combustion..Increased temperature at stichomythiccondition further enhances the formation ofacetaldehydeCH_3CHO [13]. Fig.-8 shows thevariation of acetaldehyde in conventional and air-gap copper crown piston engines respectively at full load condition of E10 blend [14]. It is found that about 50% reduction in acetaldehydes emission from the exhaust gases in air-gap copper crown piston engine [15].

7. CONCLUSION

Performance and emission characteristics of diesel (C.I) engine with diesel and blends of ethanol (E5, E10) with normal piston and compared with the and air-gap copper crown in this experimental investigation. From this investigation, it can be concluded that blend E 10 gives better performance and emission results compared to the diesel. The results of this study may be summarized as follows.

- It is observed that reduction of BSFC for engine with air-gap crown piston using ethanol blend as compared to the engine normal piston with diesel and blends at all load conditions. It is significant to note that a reduction BSFC for blend E10 with air-gap piston against normal piston at rated load.
- Thermal efficiency is more for the blends compared to the diesel at all the loads because a better mixing of fuel and air due to the creation of turbulence by inlet manifold.
- The emissions of un-burnt hydrocarbon (HC) for ethanol with air-gap piston are less this is because of increased oxygen availability in ethanol. Blends E10 give lesser emissions at rated loads.
- CO emission of ethanol is less compared to diesel it is likely due to oxygen content present in the ethanol.
- It is observed that blends E10 gives less NO_X emission with normal piston but more for air-gap crown piston.

8. SCOPE OF FUTURE WORK

The present work can be extended by varying the thickness, and gap between the copper crown and normal crown metal. The engine can be tested for better performance with the various thickness of air-gap for various alternative fuels also.

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