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EXPERIMENTAL ASSESSMENT OF AN AIR-GAP COPPER CROWN PISTON FOR ENHANCED PERFORMANCE AND REDUCED EMISSIONS IN A METHANOL–DIESEL FUELED CI ENGINE

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Abstract: **All over the world use of petroleum products has been increasing tremendously. This has resulted in scarcity of fuel for internal combustion engines and the problem has become acute during the recent years. The present fossil fuels may get exhaust in another 30 to 40 years. The cost of fossil fuels increasing day by day. The emission caused by these fossil fuels, made us to think of alternate fuels for IC engines. These alternate fuels may be alcohol and vegetable oils. This paper presents experimental work on use of methanol blends with diesel in CI engine andoxidation of aldehydes emission in exhaust gases during combustion itself using un-conventional catalytic converter asair gap copper crown piston in the CI engine. The result shows that there is a marginal increase in Brake thermal efficiency**

Keywords: **Diesel engine,Alcohol, Methanol, Catalytic converter, Unconventional Catalytic converter, Air-Gap copper crown piston, Aldehydes.**

I. INTRODUCTION

An engine is a device, which transforms one form of energy into another form.While transforming energy from one form to another, the efficiency of conversion plays an important role.Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'. Heat engine is a device that transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work. Thus, thermal energy is converted to mechanical energy in a heat engine.

Fuel economy of engines is greatly improved from the past and probably continued to be improved, increased in number of automobiles alone dictate that there will be a great demand for fuel in the near future.Alternative fuel technology, availability, and use must and will become more common in the coming decades. However, the use of an alternative fuel decreases the break thermal efficiency of engines, due to lower calorific values compared to normal diesel fuel.Because of the high cost of the petroleum products, some developing countries are trying to use alternative fuels for their vehicles.

Internal combustion engines are established as the main power source for the automobile vehicles. At present emission norms become strict for any IC engine. The main pollutants are CO, HC, NOx, PM, Soot, etc. from which NOx are one of the most harmful component. Since emissions are byproducts of the combustion process, the main body of diesel engine research is to work effectively to reduce these harmful byproducts of combustion within the engine cylinder and at same time not compromising on fuel economy

II. LITERATURE SURVEY

All over the world, the use of petroleum products has increased tremendously. This has resulted in a great scarcity of fuel for I.C Engines and the problem has become acute during the recent years. As we know that the diesel vehicle population is growing at an alarming rate and the fossil fuel reserves are fast dwindling. The search for an alternate fuel has been underway for the past two decades. In view of this there is an urgent need for the replacement of diesel fuel by alternate renewable sources, which do not need major engine modifications. More recently the light aliphatic alcohols are receiving a special attention as alternate fuels, as well as blending components to conventional fuels due to their good combustion properties. Alcohols can be produced synthetically on a large scale. Countries like Brazil, Canada and Australia are using alcohols in their city service buses. It is noticed that the aldehydes like formaldehyde and acetaldehydes in the exhaust gas are liberated due to combustion of alcohols. These aldehydes are very toxic in nature than any other emissions and they irritate skin, eyes, nose and throat. It is a serious concern as the pollution point of view. The most practical approach is utilizing them in compression ignition engines. Alcohol as a fuel for S.I Engines has been studied in developed countries, where passenger cars are powered by S.I Engines and constitute the primary mode of transportation. But in developing like India, diesel engines are predominant in both vehicles and stationary power plant. Among the alcohols methanol and ethanol are two prime alcohols for replacing petroleum fuels. Basically there is little difference between methanol and ethanol and the same baseline designs will run on methanol as well as on ethanol. Among the fuels which present themselves as possibilities for automotive use, such as ethanol and methanol. Q.A.Baker, et.al [1] the use of alcohol as supplement fuel for medium speed diesel engine was investigated using a two cylinder two stroke test engine. Improvement in thermal efficiency with emulsions observed under many experiments due to more constant volume combustion. (Higher ignition delay and micro explosion of the fuel droplets). Haragopal Rao, et.al [2] and the Haven man, et.al [3] have shown a decrease in thermal efficiency at low engine loads and increase at high engine loads. Rangaiah et.al [4] has done an experiment on ceramic coated diesel engine using diesel methanol

blends employing fumigation and indicated an improvement in brake thermal efficiency and 10% reduction in BSFC on a coated engine over base engine on comparison of diesel operations. A smoother combustion on coated engine was also supported B.T.Nagalingam et.al. [5] have reported the development of a C.I engine working on alcohols alone. M.R.K.Rao and N.Srinivasamurthy, et.al [6] use of alcohol as a fuel in diesel engine has been reported. C.M. varaprasad et.al[7] have reported that the use of alcohols in diesel engines that decreases in thermal efficiencies at low loads due to low cycle temperature and at part loads due to evaporative cooling effects of alcohols. The experiment had done by F.Pischinges et.al [8] on high speed diesel engine has shown an improvement of thermal efficiency at an advanced injection timing of 32^0C before TDC. Dual injection is an effective approach to replace large percentage of diesel fuel. From 50% to 60% diesel replacement at idle and low loads to more than 90% diesel substitution near full load have been reported. Reduction in NO_x and smoke emissions were noted. Lower peak pressures and rate of pressure rise was reported. From the literature review of high latent heat of vaporization of alcohols in low heat rejection engine and to reduce aldehydes emission in the exhaust. For this purpose the semi-adiabatic air-gap copper crown piston has been selected and is explained in the experimental procedure.

III.EXPERIMENTAL WORK

The engine was started on diesel fuel and allowed to warm up thoroughly. Then the engine was run using blend of 85% diesel + 15% alcohol (for both ethanol and methanol blends) and the load test was conducted. The performance was evaluated and the percentages of aldehydes which are present in the exhaust gases are determined by using chemical analysis. The above experiment was carried out on the conventional piston. After completion of the above experiment the conventional piston was replaced by a semi-adiabatic air-gap copper crown piston of 5mm thickness as shown in the Figure shows the semi – adiabatic air-gap copper crown piston. Then the above procedure was repeated on this piston. Comparisons of the performance parameters of conventional piston to the air-gap copper piston are done and the graphs are plotted. The engine specifications are seen in table-1 and the properties of the fuels used are indicated in table-2.

TABLE1

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



Figure 1**:** Air gap insulated copper crown piston

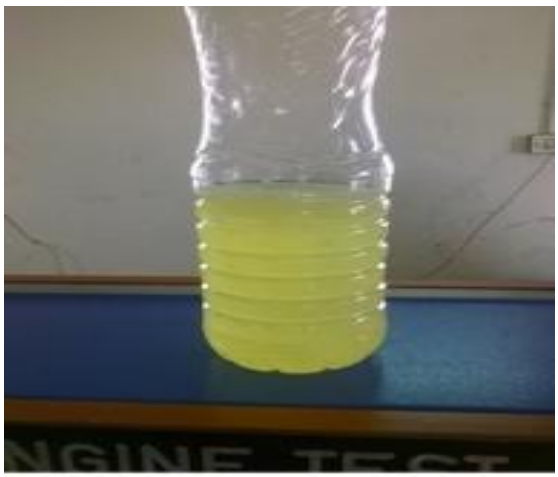


Figure2: Methanol and diesel blend

IV.RESULTSAND DISCUSSION

*4.1.Brake thermal efficiency:*The variation in brake thermal efficiency for conventional and air gap copper crown piston engines respectively. It is found that the Brake Thermal Efficiency was more for air-gap copper crown piston when compared to conventional piston engine. The reasons are air-gap copper crown piston acted as a regenerative hot ignition surface as well as a semi adiabatic engine is caused to increase in operating temperature and smooth combustion. The copper

crown piston also acted as a catalyst for the oxidation of CO to CO_2 during combustion. It is clear from the equation-3 that the additional heat released due to oxidation of CO to CO_2 and semi – adiabaticnes of air gap copper piston are caused to in-crease in the brake thermal efficiency for diesel and alcohol diesel blends.

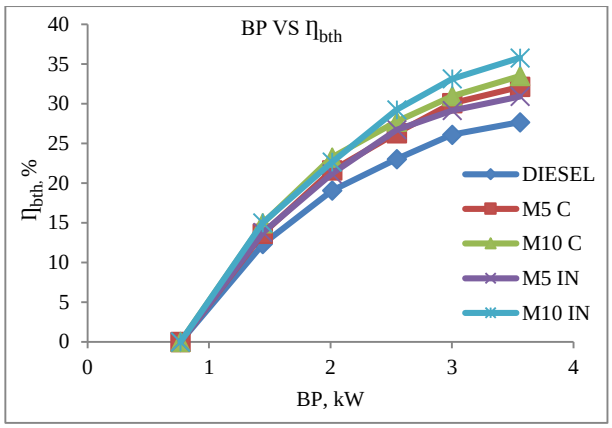


Figure3:Brake power vs. Brake thermal efficiency

4.2 Brake specific fuel consumption:

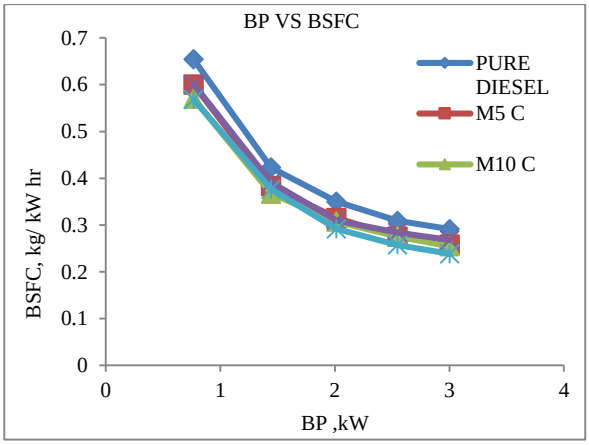


Figure4:Brake power vs.Brake specific fuel consumption

4.3 Mechanical Efficiency:

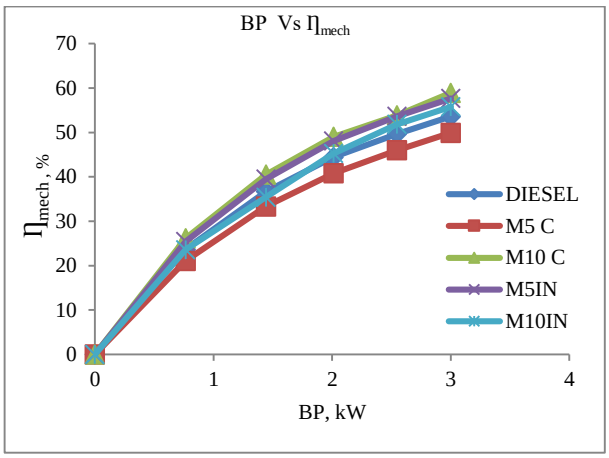


Figure5:Brake power vs.Mechanical efficiency

4.4 Indicated thermal efficiency:

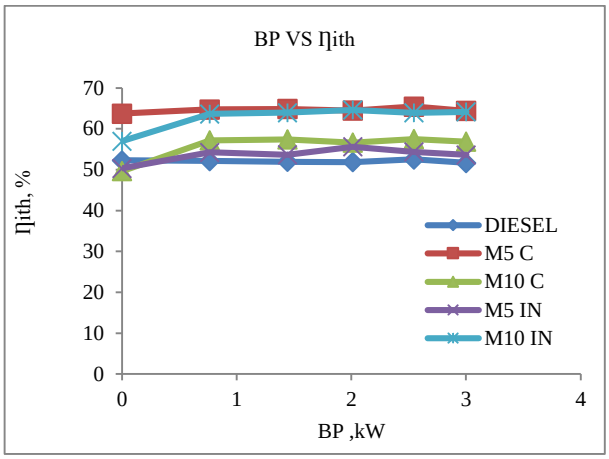


Figure6:Brake power vs.Indicated thermal efficiency

4.5 Indicated mean effective pressure:

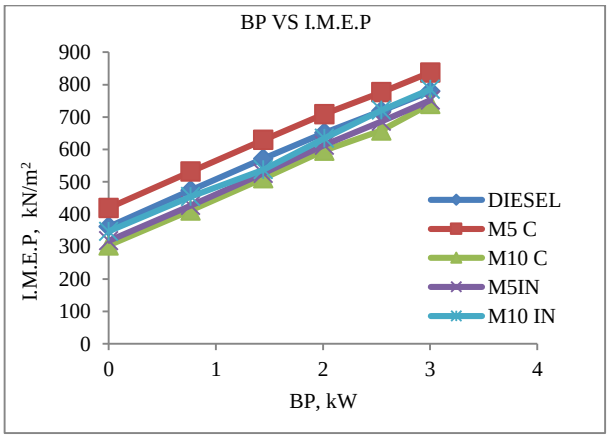


Figure 7: Brake power vs.Indicated mean effective pressure

4.6Exhaust emissions of nitrogen oxides:

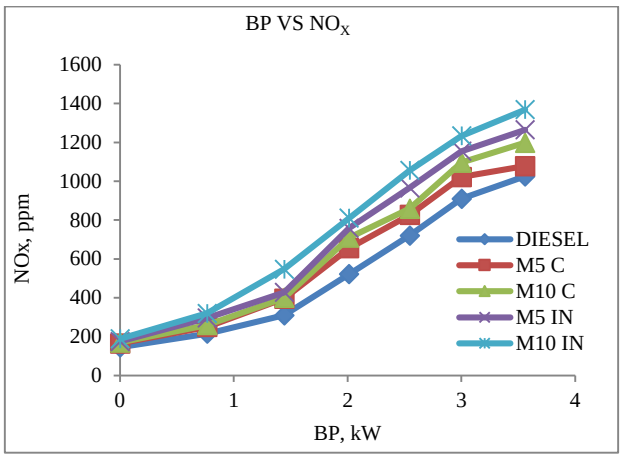


Figure8:Brake power vs.NO_X

4.7 Exhaust gas emissions of carbon dioxide:

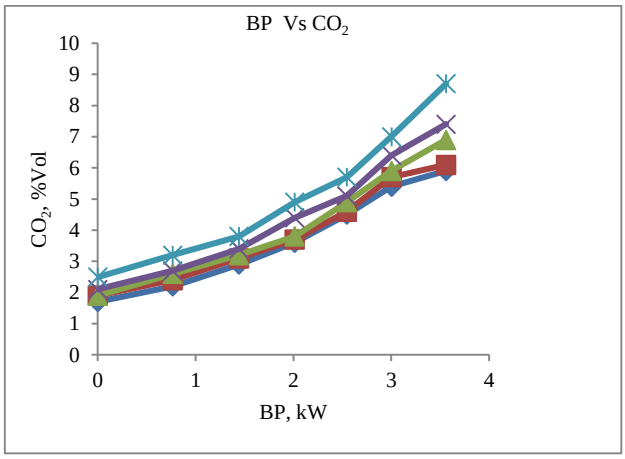


Figure9:Brake power vs.co_2

The performance of conventional and air-gap copper crown piston engines with alcohol blends are discussed as follows.

$Cu + CO_2 + 0.5\ O_2$ ---- $CuCO_3$ ----- Copper carbonate film

Eq.1

$2Cu+O_2$----2CuO ------ Base of copper carbonate

Eq.2

$CuCO_3 + CO$----$2CO_2 + Cu$ Eq. 3

$CuO + CO_2$ ------$CuCO_3$ Eq.4

Methanol ---------- CH_3OH

CH_3OH + 0.5 O_2 ----------HCHO + H_2O

Eq.5

HCHO ----------FormaldehydeEq. 6

HCHO + 2 CuO -------$CO_2 + H_2O$ + 2Cu

Eq7

The variation in aldehydes emission level in the exhaust gases for conventional and air-gap copper crown piston engines respectively. It is found that the aldehydes from the exhaust gases are reduced by 50 percent for air-gap copper crown piston when compared to conventional piston engine. The reason is that the surface area of copper crown piston was just enough to act as a catalyst for aldehydes to reduce them up to 50% and remaining 50% of aldehydes could not able to reduce from the exhaust gases due to lack of available catalyst surface area of the copper crown piston. It is also found from the same figures that aldehydes exist only after 40 percent load onwards in air – gap copper crown piston. The reason is that the fuel consumption up to 40% load is less and less aldehydes were produced during combustion in the exhaust gases. Those small quantities of aldehydes in exhaust gases are reduced by the catalytic action of the copper crown piston. As the load goes on increases after 40% onwards on the engine the fuel consumption also goes on increases and produces more and more aldehydes (heavy quantity of aldehydes) during combustion. This heavy quantity of aldehydes in the exhaust gases which were produced during combustion in enginecould not able to reduce by copper crown piston due to lack of catalytic surface area of the piston. Thus these aldehydes exits only after 40% load onwards in the exhaust gases. It is found that the aldehyde varies from 0.3 ppm at zero loads to 0.8ppm at full load in conventional piston engine. Where as in air – gap copper crown piston's engine the aldehydes varies from zero ppm up to 40 percent load to 0.35 ppm at full load. The reason is that the diesel was blended with 15% ofalcohols and was used as fuel in conventional and copper crown piston engines. In conventional piston engine at zero load the alcohol diesel blend fuel consumption (Diesel + 15% Alcohols) is less and less aldehydes were produced with 0.3 ppm during combustion. As the load increases on the engine diesel alcohol blend fuel consumption also increases and produces more and more aldehydes in the exhaust gases and it would be maximum with 0.8 ppm at full load. Where as in copper crown piston engine at zero load diesel alcohol bend fuel consumption is less and less aldehydes were produced during combustion and are catalytically reduced by the surface are of copper crown piston engine. Thus there are no aldehydes at zero load. As the load increases on the engine diesel alcohol blend fuel consumption also increases and produces more and more aldehydes in the exhaust gases and are reduced catalytically by the copper crown piston up to 40% load. As the load increase beyond 40% on the engine the aldehydes produced during combustion would be taken care up to 40% load with zero ppm aldehydes in the exhaust gases and aldehydes level increases as the load increase beyond 40% and it would be maximum with 0.35 ppm at full load.

The variation of aldehydes in conventional and air-gap copper crown piston engines respectively at full load. It is found that there is a 50 percent reduction in aldehydes emission

from the exhaust gases in air-gap copper crown piston engine. The reasons are already explained in the above explanations.

VI.CONCLUSION

Performance and emission characteristics of diesel (C.I) engine with blend of biodiesel of waste palm cooking oil with diesel and buttress threads inside the inlet manifold are compared with the normal inlet manifold in this experimental investigation. From this investigation, it can be concluded that blend B20 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 buttress internal threads using waste palm cooking oil blend as compared to the engine of buttress internal threads with diesel at all load conditions. It is significant to note that a 6.8% of reduction BSFC for blend B20 with buttress threads against normal inlet manifold at 2Kw 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 biodiesel with buttress internal threads are less this is because of increased turbulence by creating the swirl. Blends B20 give lesser emissions at rated loads of 2Kw and 2.5Kw.
- CO emission of biodiesel is less compared to diesel it is likely due to oxygen content present in the biodiesel.
- It is observed that blends B20 gives less NO_X emission with normal inlet manifold but more for buttress threaded manifold.

VII. SCOPE OF FUTURE WORK

The present work can be extended by various blend proportions. The engine can be tested for better performance with the air gap insulated copper crown piston for various alternative fuels also.

VIII. ACKNOWLEDGMENT

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