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EXPERIMENTAL INVESTIGATATION OF TWO STROKE BRASS COATED SPARK IGNITION ENGINE WITH GASOLINE AND METHaNOL-GASOLINE BLENDS

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Abstract: The concept of catalytic combustion in spark ignition engines has been tried by various researches which offers improved thermal efficiency and reduced exhaust emissions due to oxidation of fuels with aid of catalyst on the exhaust emissions. In this work an effort made to study the effect of the piston top coated with catalytic materials such as brass using flame spray gun. The performance and emission characteristics of the engine coated with catalytic materials are studied and are compared with the standard engine. experimental investigations are carried out to evaluate the engine performance and exhaust emissions on a two-stroke, single cylinder, spark ignition (SI) engine, with Methanol Gasoline Blends(80% gasoline and 20% methanol by volume) having coated on piston crown with brass (thickness 300µ) and compared its performance with conventional SI engine with pure gasoline operation. Performance parameters and exhaust emissions such as (carbon monoxide (CO) and un-burnt hydro carbons (UBHC)) are determined by operating the engine at various loads. Brass coated combustion chamber with methanol blended gasoline as shown improved performance and reduced pollutants in comparison with conventional S.I engine with pure gasoline operation.

Keywords: Methanol Gasoline blends, Brass coated on piston crown, brass coated thickness 300 µ, single cylinder 2-stroke spark ignition engine, and exhausts emissions.

I. INTRODUCTION

The majority of the energy used today is obtained from the fossil fuels. Due to the continuing increases in the cost of fossil fuels, demands for clean energy have also been increasing. Therefore, alternative fuels sources are sought. Some of the most important fuels are biogas, natural gas, vegetables oil and its esters alcohols and hydrogen. In alcohols, methanol and ethanol are used most often as fuels and fuel additives. Methanol can be produced from natural gas, gasification of coal or biomass .However, coal is not preferred as a feedstock because conversion process is complex and costly than using other feedstock in commercial methanol production [1]. Methanol hasmuch higher octane number than gasoline [2]. This allows to Methanol engines to have much higher compression ratios, and so increasing thermal efficiency. Compared with gasoline, the lower boiling point, faster flame propagation speed, high oxygen content (50 % wt.),and simple chemical structure of methanol all help to reduce the CO and hydrocarbon (HC emissions) [3]. Nevertheless, as significant disadvantage of methanol relative to gasoline is that it has lower energy content and higher Reid vapour pressure [4]. Many researchers have focused on ethanol-gasoline blended fuels. Brinkman et al. measured the octane number of methanol–gasoline blends. They found that the research and motor octane numbers increased with increasing methanol amount in the fuel blend.*Shenghua et al.* [5] operated a three-cylinder SI engine with several fractions of methanol (10%, 15%, 20%, 25% and 30%) in gasoline under the full load condition. They saw that the engine power and torque decreased, while the brake thermal efficiency improved with the methanol fraction increase in the fuel blend. *Bilgin and Sezer* studied the effect of methanol addition to leaded and unleaded gasoline on the engine performance. They stated that the maximum brake mean effective pressure (BMEP) was obtained from M5 fuel blend. *Abu-Zaid et al.*[8] researched the performance of an SI engine when using 3%, 6%, 9%, 12%, 15% methanol blended gasoline, and reported that the maximum power output and the minimum brake specific fuel consumption were obtained from M15 fuel blend. Start of combustion advanced and rapid burning phase became shorter with the methanol addition to gasoline. The maximum cylinder gas pressure (P_{max})of the methanol–gasoline fuel blends became higher compared to pure gasoline under the same engine speed and throttle opening. In a similar study, *Yanju et al.* [6] tested three typical methanol–gasoline fuel blends M10, M20, and M85 in an SI engine. They stated that with the increase of the methanol fraction in gasoline, the COemission decreases and the reduction is 25% for M85, and the low methanol ratio fuel blends have no significant effect on reducing the NO_Xemission while M85 gives an 80% reduction. Liu S. et al. [7] stated that when methanol–gasoline fuel blends being used, the engine emissions of carbon monoxide (CO) and hydrocarbon (HC) decrease, nitrogen oxides (NOx) changes little prior to three-way catalytic converter (TWC).

In this work, engine performance and exhaust emission with different methanol–gasoline were investigated. Experiments were performed at different loads (no load, 2 kg, 4 kg, 6 kg and 8 kg) with gasoline and gasoline- methanol blends (M 10, M 20 and M 30).the results will compared between basic piston and brass coated piston. The coating will be doing on piston crown 300 microns thickness.

II. LITERATURE SURVEY

M. Al- Hasan investigated the effect of using unleaded gasoline–ethanol blends on SI engine performance and exhaust emission. A four stroke, four cylinder SI engine (type TOYOTA, TERCEL-3A) was used for conducting this study. Performance tests were conducted for equivalence air–fuel ratio, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide (CO_2) and unburned hydrocarbons (HC), using unleaded gasoline–ethanol blends with different percentages of fuel at three-fourth throttle opening position and variable engine speed ranging from 1000 to 4000 rpm. The results showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and equivalence air–fuel ratio. The CO and HC emissions concentrations in the engine exhaust decrease, while the CO2 concentration increases. The 20 vol.% ethanol in fuel blend gave the best results for all measured parameters at all engine speeds.

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*Sandeep Ramachandran*presented a thermodynamic model for the simulation of a spark ignition engine running on alternate hydrocarbon fuel. This paper aims to develop a simple, fast and accurate engine simulation model without the need for a great deal of computational power or knowledge of precise engine geometrical data. The model is based on the classical two-zone approach, wherein parameters like heat transfer from the cylinder, blow by energy loss and heat release rate are also considered. Curve-fit coefficients are then employed to simulate air and fuel data along with frozen composition and practical chemical equilibrium routines.
*K Venkateswarlu, M Ramesh, K Veladri*tested the effect of methanol-gasoline blends. Their work described the improved engine efficiency with higher compression ratios by using methanol-gasoline blends (mixing-methanol in small proportions with gasoline) as methanol had high anti-knock characteristics. Existing engines were not generally suitable to operate on higher contents of methanol, as the engine needs major modifications. The present work considered methanol blended fuels M-10, M-20 and M- 30 (number denotes the percentage of methanol in gasoline) as alternative fuel for four stroke variable compression ratio spark ignition (SI) engine. Experimental results demonstrated that an increase of 48% in brake thermal efficiency had been observed compared to gasoline operation. An increase of 8% in volumetric efficiency was found and a reduction of 24% in BSFC was observed.
Based on this survey Performance evaluation of two stroke single cylinder spark ignition engine with methanol blended gasoline having brass coated engine (brass thickness 300 microns) coated on piston crown and compared with conventional SI engine with the operation of Gasoline. There is an increase in brake thermal efficiency with methanol blended gasoline with both engine types. Brass coated engine showed improvement in performance than conventional engine with both test fuel samples. Catalytic converter with air injection significantly reduced pollutants with both test fuels on both engine types. Adulteration of automotive fuels, particularly gasoline with cheaper fuels is widely spread out through south Asia. Some of the adulterants decrease the performance and life of the engine. At the same time, it increases the emission of harmful pollutants causing environmental and health problems. This present investigation is carried out to study the exhaust emissions from a single cylinder spark ignition engine (SI) engine with methanol blended gasoline with different versions of the engine, such as catalytic coated engine and conventional engine with different proportions of the methanol ranging from 0% to 30% by volume in steps of 10% in the methanol gasoline blend. The catalytic coated engine is used in the study has brass coating thickness 300microns on piston crown. Brass coated engine with catalytic converter significantly reduced pollutants when compared to conventional engine. These pollutants decreased by 20% with catalytic coated engine when compared to conventional engine with methanol blended gasoline operation.

II. METHANOL BLENDS (M 10, M20 and M 30)

Derived from natural gas, methanol is a hydrocarbon, comprised of carbon, hydrogen and oxygen. Its chemical formula is CH_3OH. Methanol is an alcohol and is a colourless, neutral, polar and flammable liquid. It is miscible with water, alcohols, esters and most other organic solvents. It is only slightly soluble in fats and oils. Detailed physical and chemical properties of methanol are provided in the following pages. Methane produces methanol using a catalytic process with natural gas and steam as the feed stocks. The natural gas is catalytically reformed to carbon oxides and hydrogen. The resulting synthesis gas mixture is circulated under pressure and moderate temperature in the presence of a metallic catalyst and converted to crude methanol. The crude methanol is distilled to yield commercial chemical grade methanol. Other common names for methanol include methyl alcohol, methyl hydrate, wood spirit, wood alcohol, and methyl hydroxide. Methanol is used as a building block for many chemicals and products. Other uses include windshield washer antifreeze, fuels, waste water treatment and biodiesel production.

Figure:1 Methanol (CH_3OH)

Gasoline available in market is blended with Methanol in different blends. These are M-10 (10% Methanol + 90% gasoline) M-20 (20% Methanol + 80% gasoline) M-30(30% Methanol + 70% gasoline) initially density of gasoline is known from which density of different blends were calculated. Same is done for finding the calorific value of all the blends.

Figure: 2 Blends M10, M20 & M30

Blend properties

BLEND	DENSITY IN (kg/m^3)	CALORIFIC VALUE (MJ/kg)
M 10	773.7	42.248
M 20	777.3	40.47
M 30	780.9	37.904

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Where: M10=90%Gasoline+10%Methanol
M20=80% Gasoline + 20% Methano
lM30=70% Gasoline + 30% Methanol

III. BRASS COATING

The brass coating doing on piston crown 300 microns thickness as shown in figure. the coating process is one of the thermal spray coatings as explained given below.

High Velocity Oxy-Fuel Spray (HVOF): The high velocity oxy-fuel spray (HVOF) process is a relatively recent addition to the family of thermal spray processes.As it uses a supersonic jet, setting it apart from conventional flame spray, the speed of particle impact on the substrate is much higher, resulting in improved coating characteristics. The mechanism differs from flame spraying by an expansion of the jet at the exit of the gun. Fuel gases of propane, propylene, acetylene, hydrogen and natural gas can be used, as well as liquid fuels such as kerosene.

Specifications of Copper

- *Coating*Coating thickness is 300 microns
- Coating process is thermal spray gun machine
- Coating powder is Brass
- Powder size 25 microns above

IV. EXPERIMENTAL SET UP

We are doing project work on two stroke air cooled, single cylinder engine brass coated piston as shown in below figure with methanol blends (M10,M20 &M30).The coating will done on the piston crown 300microns thickness.

Experimental set up

After coating (BRASS)

Dial type load

Experimental procedure

Initially the engine is tested using without blending the petrol. The procedure is as given below.

1. The engine is started and run for few minutes to reach a steady state condition.
2. The engine once it reaches a steady state condition takes the engine rpm using non contacting tachometer
3. At no load, take time taken for 10CC of fuel consumption.
4. Apply 2 kg load take reading of 10CC fuel consumption and speed in rpm. Same procedure is done with 4, 6 & 8 kg
5. Methanol is blended with petrol & the blend contains 10%, 20%, 30% methanol and 90%, 80%, 70% petrol respectively (called M10, M20, M30)
6. The power developed by the engine is measured.
7. Replace the basic piston with brass coated piston and repeat the same procedure from 1 to 6.7. Similarly take the readings of HC emissions and CO emissions using pollution check-up vehicle at each load
8. Finally compare the results using graphs between basic piston and brass coated piston

Test engine specifications

Technical Specifications of TVS MAX 100	
Type	Motorcycle
Engine Displacement	98.00 cc
Engine Type	2 Stroke air cooled, single cylinder.

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Engine Starting	Kick Start
Maximum Power	7.8 bhp @ 5500 rpm
Transmission	4 Speed
Top Speed	82 kmph
Direction of rotation	Clock wise
Bore diameter	50mm

V. RESULTS AND DISCUSSIONS

From the experimental investigation of brass coated engine the following results could be arrived.

1. From the experimental results at idle speed the HC emissions for standard engine is found to be 2400ppm, whereas HC emission is for the engine with brass coated piston is 1985ppm. (i.e.) 415 ppm of emission is reduced for brass coated engine compared to standard engine. It is represented in graph 6.
2. CO emission in standard engine is found to be 2.55 % of volume whereas the engine with brass coated piston gave only 2.01%of volume. From the results it is noted that 0.54 % of emission is reduced in the engine with brass coated piston at idle speed condition. It is represented in graph 5.
3. Brake thermal efficiency of conventional engine is found to be 23.13% with gasoline fuel whereas Brake thermal efficiency of the engine with brass coated piston is found to be 27.70 %.with 4.57% is improvement. It is represented in graph
4. Specific fuel consumption of conventional engine is found to be 0.86 kg / KW – sec at full load whereas Specific fuel consumption of the engine with brass coated piston is only 0.83 kg / KW – sec. It is represented in graph 2.
5. Mechanical efficiency, Indicated thermal efficiency also enhanced using brass coated piston. It is represented in graphs 3 &4

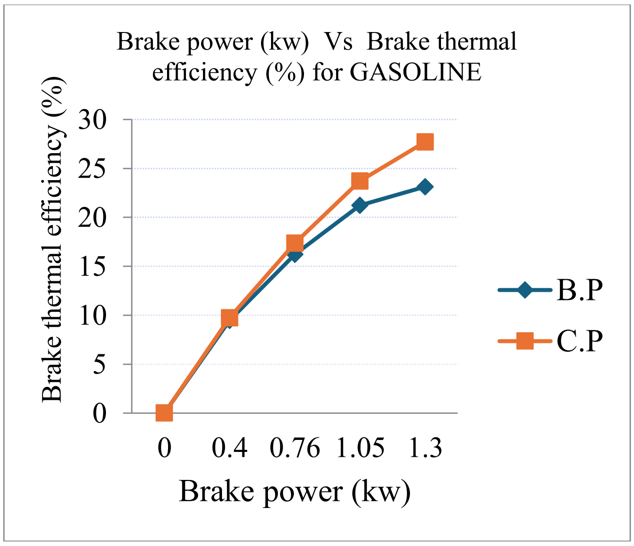
The above comparisons are drawn between basic piston and brass coated piston with gasoline as fuel. As the coated piston has yielded better results, further experimentation was carried out with brass coated piston with methanol blends like M 10, M 20 & M30.

The experimental results and the effect of methanol addition to gasoline fuel on the performance and emissions of a spark ignition engine have been presented and discussed. It must be mentioned here that the methanol blending is based on volume replacement ratio. The effect of the load at different methanol blends is presented on the brake power, brake thermal efficiency and specific fuel consumption, respectively. The brake power in found to be increasing off with increase of Methanol in the blend up to 20 %, there after a slight decrease is noted at given load.

In line with the brake power the thermal efficiency also increasing with the increasing in Methanol in the blend at a given load up to 20 %. The brake thermal efficiency is based on Brake power and calorific value of the engine. Brake thermal efficiency is found to be gradually increasing with increase in percentage of Methanol additives. The specific fuel consumption decreases as the percentage of methanol addition increases for constant load .The variation of SFC with B.P for different percentage of with the gasoline are presented. The lower SFC increase of Methanol blends as compare to gasoline is because of its oxygen content. So complete combustion is predicted in combustion chamber.Graphs 5, 6, 11 &12 shows the variations of exhaust pollutants, namely, carbon dioxide and HC respectively with methanol blending ratio at different loads .The results show that the concentration of carbon monoxide decreases with increase in methanol blending ratios up to 20 %. This is due to the reduction in carbon atoms concentration in the blended fuel and the high molecular diffusivity and high flammability limits which improve mixing process and hence combustion efficiency. The concentration of CO decreases with the increase in percentage of methanol in the fuel. This may be attributed to the presence of O_2 in methanol, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO_2). It is observed that hydro carbon (HC) decreases with increasing load for all the percentage of methanol. It is noticed that with the increase in percentage of Methanol in the blended HC is reduced. The hydrocarbon emissions are inversely proportional to the percentage of methanol added in the fuel. In the case of pure gasoline, a slightly higher concentration of HC is noticed in the exhaust at all loads. Since methanol is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust.

COMPARISION OF BASIC PISTON & COATED PISTON WITH GASOLINE

1. Brake power (kW) Vs Brake thermal efficiency (%) for GASOLINE



2. Brake power (kW) Vs Specific fuel consumption (kg/ kw-sec x 10^{-4}) for GASOLINE

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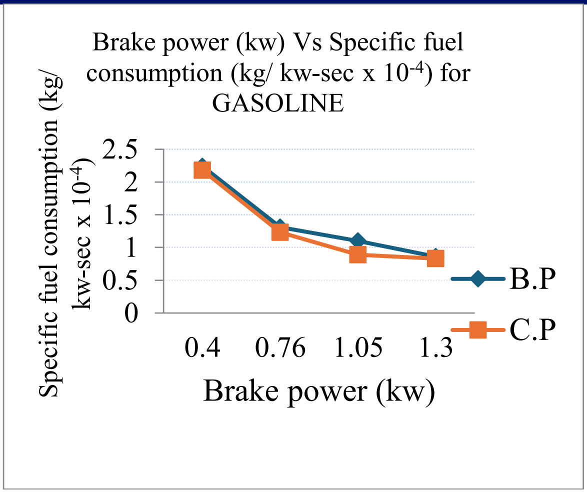
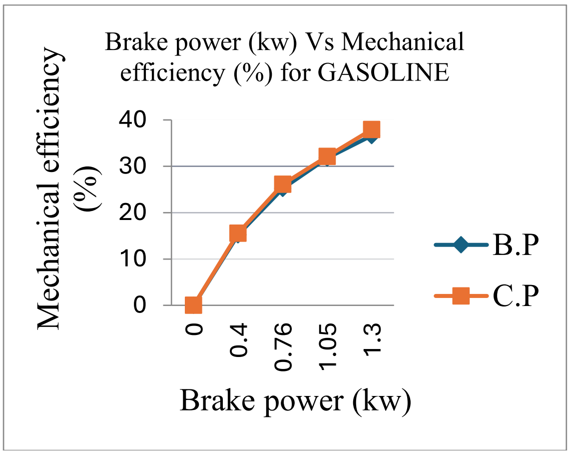
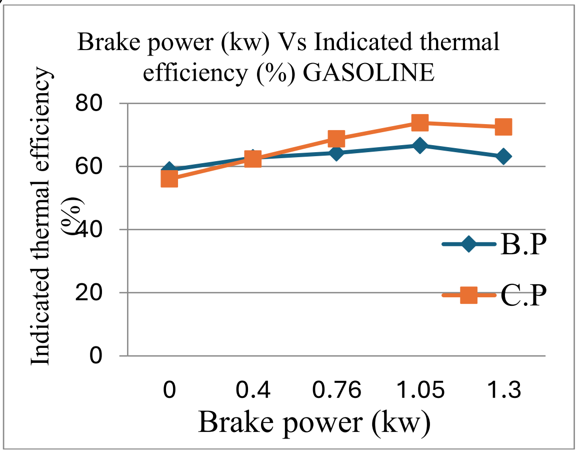


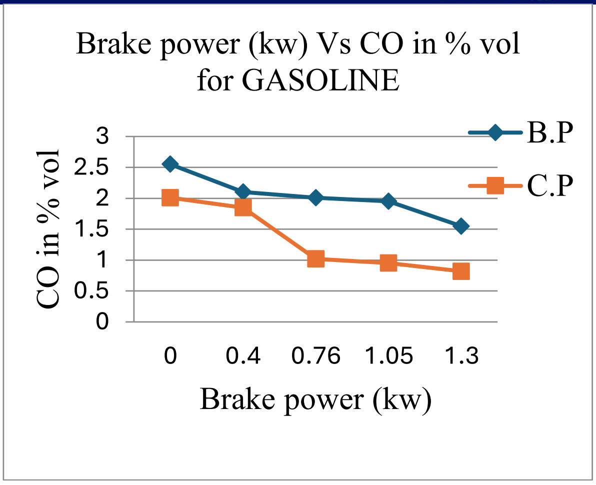
2. *Brake power (kw) Vs Mechanical efficiency (%) for GASOLINE*



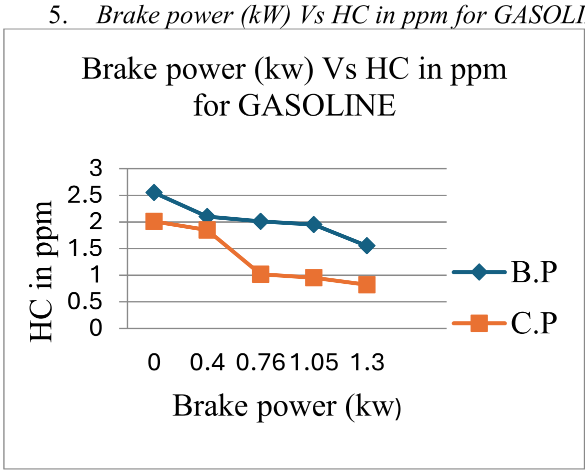
3. *Brake power (kW) Vs Indicated thermal efficiency (%) for GASOLINE*



4. *Brake power (kW) Vs CO in % Vol for GASOLINE*

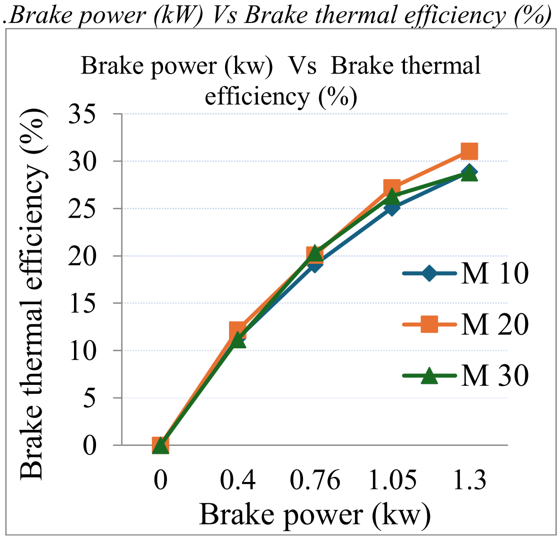


5. *Brake power (kW) Vs HC in ppm for GASOLINE*



FOR BRASS COATED PISTON

6. *.Brake power (kW) Vs Brake thermal efficiency (%)*



7. *Brake power (kW) Vs Specific fuel consumption (kg/ kw-sec x 10^{-4})*

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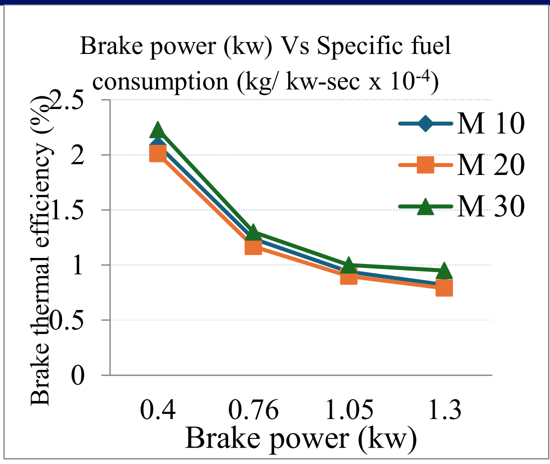
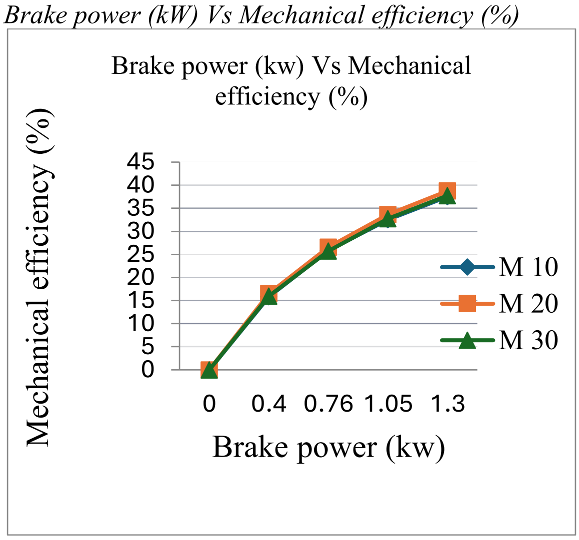
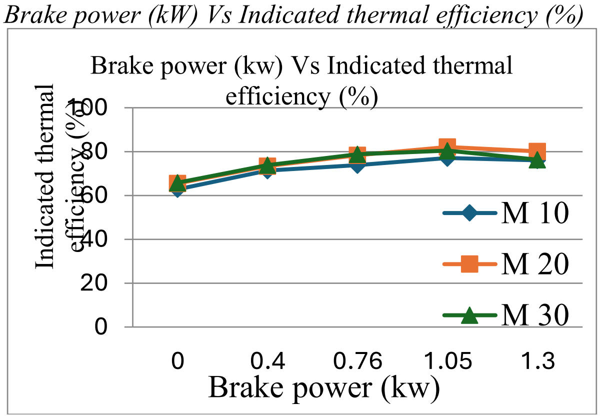


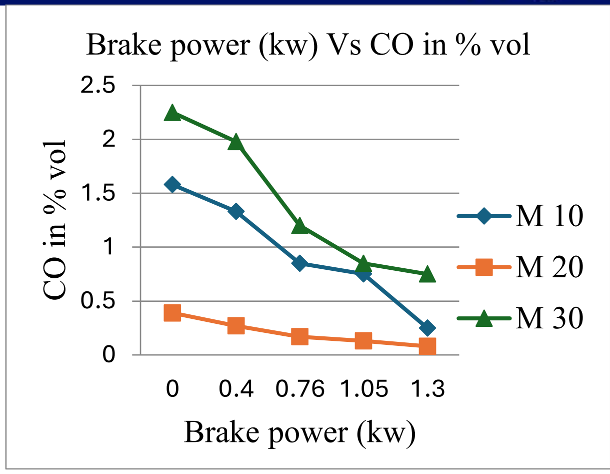
8. *Brake power (kW) Vs Mechanical efficiency (%)*



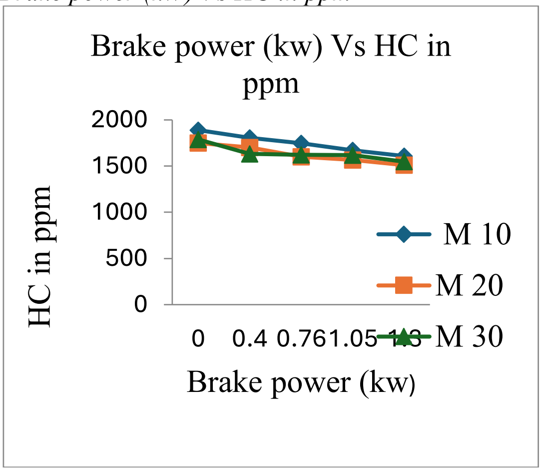
9. *Brake power (kW) Vs Indicated thermal efficiency (%)*



10. *Brake power (kW) Vs CO in % vol*



11. *Brake power (kW) Vs HC in ppm*



VII. CONCLUSIONS

Conclusions of basic piston and brass coated piston with gasoline

1. All the performance parameters like brake thermal efficiency, mechanical efficiency and indicated thermal efficiency in case of engine with brass coated piston is found to be increasing at 4.57%, 0.92% and 9.39% when compared with conventional enginewhen operating at 8 kg load.
2. The SFC is noticed to be reduced by 0.9 kg / KW-sec for engine with brass coated piston due to complete combustion of fuel when compared with conventional engine when operating at 8 kg load.
3. The emissions are CO & HC are found to be lower in case of engine with brass coated piston as compared to that of conventional engine is enhanced.

Conclusions of basic piston and brass coated piston with blends M 10, M 20 & M 30

1. 20 % Methanol in the blend has better performance characteristics as compared to M 10 and M 20. The Specific fuel consumption is found to be lowest in case of M 20 as compared to M 10 and M 30.
2. The brake power is found to be higher by 3.55 % in case of M 20 with brass coated piston to that of M 20 with basic piston.
3. Maximum reduction of CO and HC is noticed in the case of M 20 with brass coated piston. It is noted that 20 % of Methanol in gasoline (M20) is optimum blend and with M 20 as fuel blend give with brass coated piston has betterperformance characteristics as compared to the basic piston without any coating.

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