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Study of Modified Internal Combustion Engine to Run with 'Ethanol'

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Abstract— **Moving across the emerging trends of renewable energy sources, ethanol has attracted more attention because it is considered as a renewable resource and is easily obtained from sugar or starch. Moreover, ethanol fuel as an IC engine fuel would be able to solve the issue of carbon emission and environmental pollution. Ethanol can replace conventional gasoline to be used as a fuel for automotive. This paper is about the results and analysis obtained during the test of an IC engine with ethanol before and after modification. As we want to run an IC engine with ethanol, its physical and chemical properties play crucial role. Due to different physical & chemical properties of ethanol than that of gasoline, proper engine parameters should be maintained in gasoline engine to run it with ethanol i.e. the stoichiometric ratio needs to be maintained. An attempt to test gasoline based IC engine using ethanol initially didn't give promising result in terms of efficiency and mileage. Carburetor of engine was modified so as to maintain proper stoichiometric ratio which improved the brake power of engine but with more fuel consumption; resulting to lesser thermal efficiency at the end. Finally, the optimal utilization of ethanol in the modified gasoline engine was done by changing the compression ratio of the engine. Since, ethanol has higher octane rating, it can sustain higher compression ratio and boost up the engine performance. The gasoline & ethanol (with modified carburettor) test was done in 4 stroke gasoline engine test rig and the results like brake power, specific fuel consumption and brake thermal efficiency was analysed. The loss in efficiency in case of ethanol was brought down by increasing the compression ratio of same engine. Due to some feasibility constraint, variable compression ratio (VCR) engine was used for experiments rather than changing the compression ratio of the engine itself.**

Index Terms— **carburetor, compression ratio, ethanol, IC engine, thermal efficiency, etc.**

I. INTRODUCTION

Ethanol fuel is ethyl alcohol, the same type of alcohol found in alcoholic beverages. It is most often used as a motor fuel, mainly as a bio fuel additive for gasoline. The first production car running entirely on ethanol was the Fiat 147, introduced in 1978 in Brazil by Fiat. Nowadays, cars are able to run using 100% ethanol fuel or a mix of Ethanol and gasoline (aka flex-fuel). It is commonly made from biomass such as corn or sugarcane.

Ethanol fuel has a "gasoline gallon equivalency" (GGE) value of 1.5 US gallons (5.7 L), which means 1.5 gallons of ethanol produces the energy of one gallon of gasoline [1]. The properties and others distinguished characteristics of ethanol are as follows: -

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A. Properties of Ethanol

Boiling Point: 70°C **Melting Point**: -114°C
Density: 789kg/m^3 **Calorific Fuel Value**: 29 MJ/kg

Table I. Properties of different fuels

Fuel	CV (MJ/L)	CV (MJ/kg)	Octane Number
Ethanol (E100)	**21.2**	**29.7**	**108.6**
Ethanol 85% blend (E85)	**25.2**	**33.2**	**105**
Pure gasoline/petrol (E0)	**34.8**	**44.4**	**91**

B. Energy Efficiency with ethanol

Ethanol has close to 34% less energy per volume than gasoline [1] consequently fuel economy ratings with ethanol blends are significantly lower than with pure gasoline, but this lower energy content does not translate directly into a 34% reduction in mileage, because there are many other variables that affect the performance of a particular fuel in a particular engine, and also because ethanol has a higher octane rating which is beneficial to high compression ratio engines.

C. Economic Aspect with ethanol

Though pure or high ethanol blend seem to be attractive for users, its price must be lower than gasoline to offset the lower fuel economy. As a rule of thumb, Brazilian consumers are frequently advised by the local media to use more alcohol than gasoline in their mix only when ethanol prices are 30% lower or more than gasoline, as ethanol price fluctuates heavily depending on the results and seasonal harvests of sugar cane and by region. [3]

D. Scenario of ethanol as a fuel in the world

The ethanol-only vehicles were very popular in the 1980s, but became economically impractical when oil prices fell and sugar prices rose late in that decade. Ethanol was preferred over methanol because there is a large support in the farming community and due to government's incentive programs and corn-based ethanol subsidies. [3] Sweden also tested both the methanol 85% blend (M85) and the E85 flex-fuel vehicles (FFVs), but due to agriculture policy, in the end emphasis was given to the ethanol flex-fuel vehicles. [4]

E. Challenges with ethanol fuel

Though technology exists to allow ethanol FFVs to run on any mixture up to E100, [5] in the U.S. and Europe, flex-fuel vehicles are optimized to run on E85. This limit is set to avoid cold starting problems during very cold weather. The alcohol content might be reduced during the winter, to E70 in the U.S. or to E75 in Sweden. Brazil, with a warmer climate, developed vehicles that can run on any mix up to E100, though E5-E10 is the mandatory minimum blend, and no pure gasoline is sold in the country.

F. Chemical Comparison between conventional gasoline & ethanol fuel

1. Formation & Combustion of Ethanol

i) Photosynthesis: (formation of glucose)

$6CO_2 + 6H_20 + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$

264gm 108gm 180gm 192gm

ii) Fermentation: (conversion into alcohol)

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + \text{heat}$

180gm 92gm 88gm

iii) Combustion of Alcohol:

$2C_2H_5OH + 6O_2 \rightarrow 4CO_2 + 6H_2O + \text{heat}$

92gm 192gm 176gm 108gm

In the above reaction, 1 kg of fuel gives **29.7 MJ** of energy and literally no Carbon dioxide. It is because the amount of carbon dioxide used to make certain amount of glucose during photosynthesis is same as the amount of carbon dioxide released during fermentation and combustion of alcohol. In overall phenomenon this process keeps the carbon dioxide amount in the atmosphere balanced.

2. Combustion of octane (a major component of gasoline)

$\mathbf{2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18\,H_2O + heat}$

228gm 800gm 704gm 324gm

In the above reaction, 1 kg of fuel gives **44.4 MJ** energy and 1.42 kg CO2. From this we can say that, the energy released during combustion of ethanol fuel is approximately 30% lower than that during the combustion of gasoline. However, the gasoline produces significantly great amount of carbon dioxide gas and releases to the open atmosphere which leads to global warming and other hazards to the environment.

II. Methodology

As explained earlier, the major objective of this project work is to study and analyze the performance of a 4 stroke internal combustion (IC) engine with ethanol as well as to implement possible engine modification in the existing engine to perform better with ethanol. The methodology used has been classified into the following three phases:-

A. Phase I

Test of existing petrol engine connected to the test rig is done by using commercial gasoline (petrol) and the same engine is run by using ethanol. The different parameters of working can be observed and analyzed using the test rig for both cases. The comparative analysis of results obtained in performance of engine with two different fuels is to be done.

B. Phase II

In the second phase, an attempt is made to bring down the losses encountered in the earlier test. Since, the chemical and physical properties of ethanol are different than that of gasoline; ethanol would need different engine design and working parameters for optimal utilization. The density of ethanol is more than that of commercial gasoline so smooth flow of ethanol inside the carburetor of petrol engine with similar constraints would be a problem. Furthermore, ethanol itself has certain amount of oxygen content which in turn requires lesser amount of air (oxygen) for combustion. So, proper air-fuel ratio or stoichiometric ratio is to be maintained in carburetor (engine) by some modification.

Literature suggests, the carburetor of engine should be modified by increasing the jet diameter. [6] The increase in jet diameter will solve both the issues.

Thus, after the test run of IC engine with ethanol, modification of carburetor and repeating the similar experiment comes in the second phase.

Modification of Carburetor

According to USDA report (2002) [6], we can use the following formula to get the exact required diameter of jet in carburetor for use in ethanol powered IC engine: -

$$D = 3.75\sqrt{\frac{D_0^2}{14.7-5.7\varepsilon}} \qquad (1)$$

Where,

D_o = initial diameter of jet (as in given engine carburetor)

ε = fraction of ethanol in ethanol-gasoline blend

D = final required diameter of jet in carburetor

Hence, by using equation (1), we can find the required diameter of jet and we can perform drilling in that jet to achieve required dimension. After the jet diameter is altered, again test of engine is with ethanol is performed and similar parameters are analyzed as in Phase I.

The output power of engine is supposed to be increased by

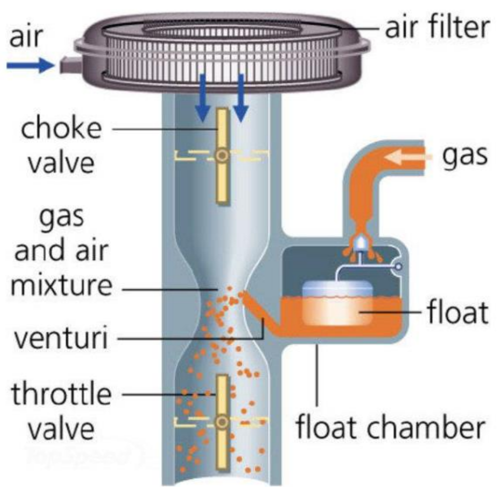


Fig. 1. Schematic diagram of cross-section of an engine carburetor

Fig. 2. Inside view of actual carburetor used (after drilling in jet)

this modification. However, by increasing the jet size of carburetor we are letting more fuel to come out and mix with air so at the end fuel consumption is going to increase as compensation. This leads to one step further innovation in ethanol fuel which is derived by studying the chemical property of ethanol fuel as described in subsequent Phase III.

C. Phase III

Taking in consideration, the higher octane number of ethanol (~108) compared to that of gasoline (85-90) ethanol can withstand higher compression ratio during combustion. Thus, by increasing the compression ratio in the third phase, we can gain significantly high efficiency of engine with ethanol. Compression ratio of engine cylinder can be increased by milling the cylinder head so as to bring the cylinder body closer to the head and decreasing the clearance volume. This type of method is permanent alteration of compression ratio and once after modification, we can't reverse the engine back to run with gasoline. Furthermore, even a difference of milling dimensions lesser than 0.1 mm (approx.) will cause significant increase in compression ratio. So, the milling operation should be accurate, precise and controlled properly. CNC machines can be adopted for this process. Moreover, due to the feasibility constraints like unavailability of CNC milling center, difficulty in controlling the process, and time consumption in doing so, we can choose another alternative for this. Instead of increasing the compression ratio of engine itself, we can do the performance analysis of engine with ethanol by using a variable compression ratio (VCR) engine. VCR engine has the provision of changing the compression ratio of engine to different levels so as to understand the effect of it in engine performance and for the optimal utilization of fuel. In the VCR engine, experiments can be performed with the gasoline in comparison with ethanol with modified carburetor. The comparative analysis of performance of engine at different levels of compression ratios will be made.

III. EXPERIMENTATIONS

The overall experiments performed till the completion of this project can be classified into following three phases: -

A. Phase I

The 4 stroke petrol engine test rig available in Energy Conversion lab of Department of Mechanical Engineering at Sambhram Institute of Technology, Bangalore was utilized for this purpose. In the petrol engine test rig as shown in fig. 3 below, test of engine with both gasoline and ethanol was carried out.

List 1. Engine Specification

Engine Type: Petrol Start, Petrol-run
Make: Crompton Greaves
Maximum Power (P): 2.2 kW
Rated Speed (N): 3000 rpm
Bore (D): 70mm
Stroke Length (L): 66.7mm
Swept Volume (V): 256cc
Compression Ratio (CR): 4.67:1
Starting: By Rope
Loading: Electrical
Cooling: Air Cooling for Cylinder

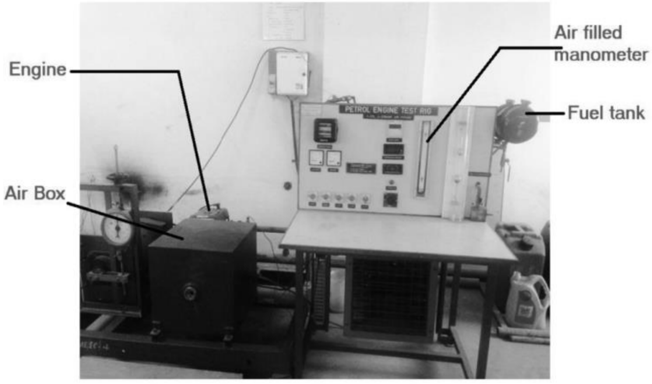


Fig. 3. Experimental setup used

Test Parameters

1) Observations at every 10 cc of fuel to know fuel consumption rate.
2) Time for every 2 rotations of energy meter used to measure power.
3) Water filled U-tube manometer to know the pressure, velocity and in turn air flow rate.
4) Variation of load of engine (Indicated Power) from 0.5 kW to 2 kW at the difference of 0.5kW and observation of corresponding readings.

Calculation

$(BP)_{gen} = 2 \times 3600 \times E_m \times t_e$ (kW) (2)

$(BP)_{eng} = (BP)_{gen} \times 0.7\ (kW)$ (3)

Fuel Consumption Rate $(m_f) = 10 \times \rho \times 60 \times tf \times 1000\ (kg/min)$ (4)

Total Fuel Consumption (TFC) = mf × 60 (kg/hr) (5)

Specific Fuel Consumption (SFC) = $\frac{TFC}{(BP)_{eng}}$ (kg/kWhr) (6)

Heat Input (HI) = $TFC \times 3600 \times CV\ (kW)$ (7)

Brake Thermal Efficiency $(\eta_{bth}) = \frac{(BP)_{eng}}{HI} \times 100\%$ (8)

Head of air $(h_a) = h_w\ (1000/1.25 - 1)$ (m) (9)

Velocity of air flow $(v_a) = 0.62\sqrt{2 \times g \times h_a}$ (m/s) (10)

Mass flow rate of air $(m_a) = \rho_a \times v_a$ (11)

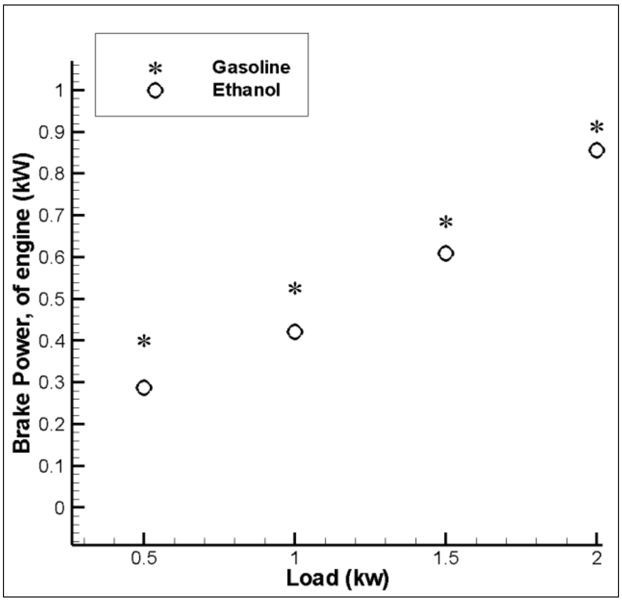
Air – Fuel Ratio (A/F) = m_a / m_f (12)

Where,

$(BP)_{gen}$ = Brake Power at Generator shaft
$(BP)_{eng}$ = Brake Power at Engine shaft
E_m = Energy Meter Constant (375 rotation/kWh)
t_e = time taken for 2 rotations of energy meter
$(BP)_{eng}$ = Brake Power at Engine shaft
0.7 = 70% = Assumed mechanical efficiency of generator

B. Phase II

As mentioned in the methodology earlier, in the second phase, carburetor of the engine was modified. The earlier diameter of carburetor was found to be 1.5mm. After the calculation done as per equation (1), for the 100% ethanol or E100, putting the value of E =1, we got the required diameter to be 2 mm. The similar procedures for experiment were carried out once again with the modified carburetor and ethanol as a fuel. Calculation based on the similar formulae was done and comparative study of results on the engine performance before and after modification were carried out.



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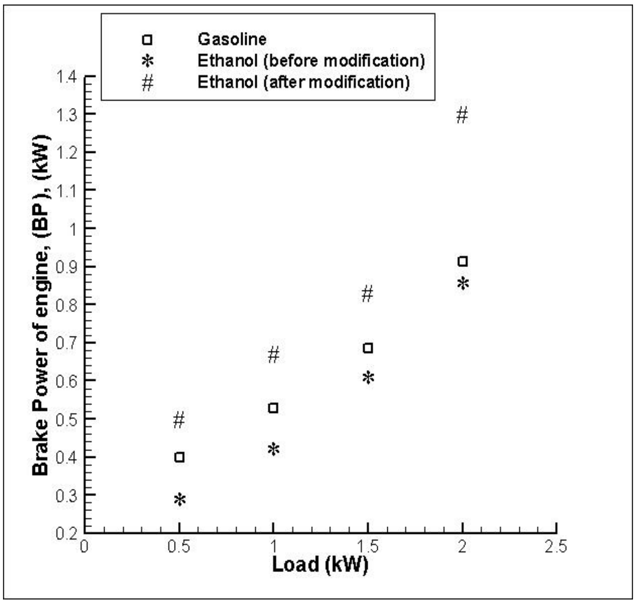

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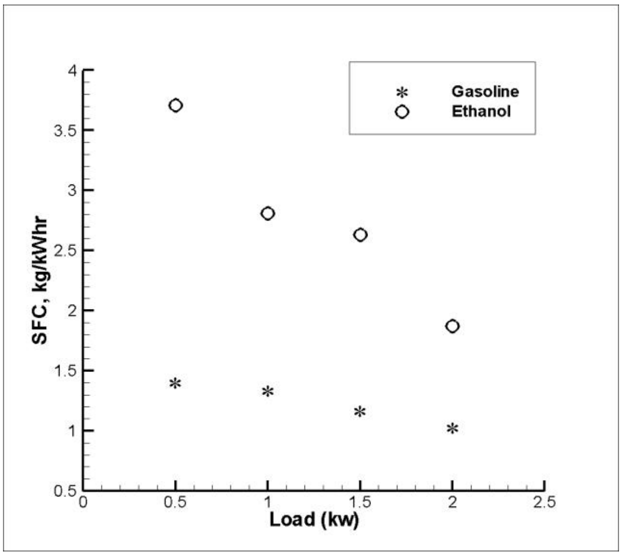

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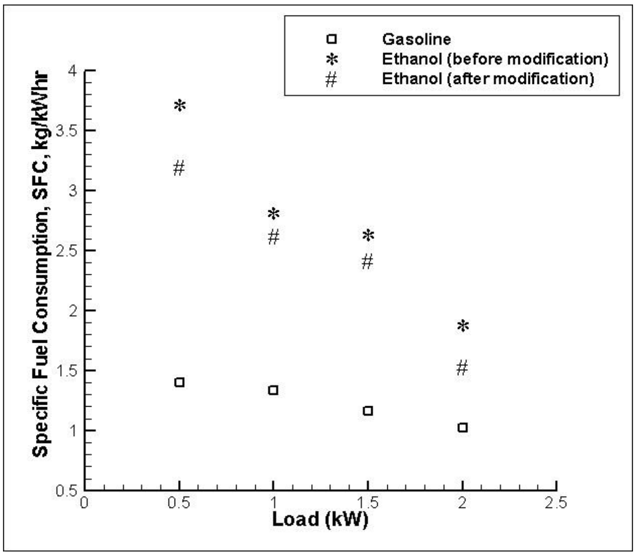

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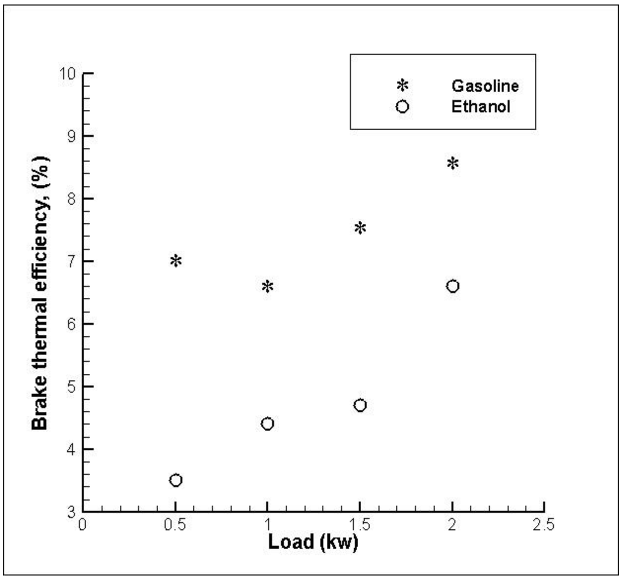

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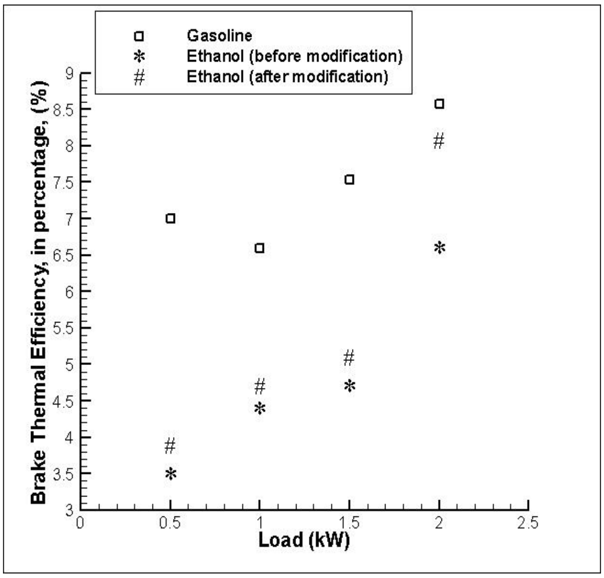


(f)

Fig. 4. Variation of Brake Power of Engine $(BP)_{eng}$ with Load for Phase I (a) and Phase II (b), variation of Specific Fuel Consumption (SFC) with Load for Phase I (c) and Phase II (d) and variation of Brake thermal efficiency $(\eta)_{bth}$ with Load for Phase I (e) and Phase II (f)

C. Phase III

A four stroke petrol engine with the provision of varying the compression ratio from 4:1 to 8:1 is available in Energy Conversion lab of Department of Mechanical Engineering at Sambhram Institute of Technology, Bangalore. That engine has the test rig set up connected to it. For studying the performance of engine at higher compression ratio, that set up was utilized and tested with gasoline as well as ethanol.

List 2. Variable Compression Ratio Engine Specification

Engine Type: Petrol driven, four stroke, singe cylinder, spark ignition
Maximum Power = 2kW
Speed (N) = 3000 rpm
Bore Dia. (D) = 70 mm
Stroke length = 66.7nn
Swept volume = 256cm^3
Compression ratio = 2 – 8 (Variable)
Starting: By DC motor
Loading: Electrical Resistance connected to generator
Cooling: Air cooling for cylinder head
Air Intake orifice diameter = 16mm

Test Parameters

1) Observations at every 10 cc of fuel consumption.
2) Constant load applied to the engine i.e. 2kW.
3) Water filled U-tube manometer for measuring pressure head of air and in turn the air flow rate.
4) Variation compression ratio from 4:1 to 8:1 for both gasoline and ethanol.

Calculation

Brake power of engine is derived from the brake power of generator which is in turn calculated from voltage(V) and current(I) measurement in this case, instead of direct energy measurement by energy meter.

$$(BP)_{gen} = V \times I \quad (13)$$

IV. Results and Discussion

A. Phase I

After the successful completion of experiment in 4 stroke petrol engine test rig with both gasoline and ethanol, the different comparative analysis was carried out as presented in graphs following: -

i) Variation of Brake Power (BP) of engine with Load

At the varying load (Indicated Power) of the engine, the Brake power was calculated by running with both gasoline & ethanol. The brake power of engine at corresponding load is plotted and two different curves were obtained as depicted in fig. 4(a). For each levels of load, the brake power of engine with ethanol was found to be lesser than that with gasoline. The engine which was actually designed to be run with gasoline was forcibly running with ethanol, so due to the various incompatibility parameters including the stoichiometric ratio, compression ratio and other engine mechanisms, the power output for ethanol fuel was not as much as that for normal gasoline. Furthermore, the calorific fuel value of ethanol (29.7MJ/kg) is lower than that of gasoline (47.3MJ/kg) which in turn decreases the brake power of engine.

ii) Variation of Specific Fuel Consumption (SFC) with Load

From the graph of fig. 4(c) it is clear that for each load the corresponding specific fuel consumption or ethanol is more than that of gasoline. Moreover, we can see the trend of variation of specific fuel consumption of ethanol as well as of gasoline. The SFC of both is decreasing as the load increases up to 2kW. Here, the decreasing trend of ethanol is rapid in compared to gasoline so it can be concluded that by suitable modification in engine, we can achieve the SFC of ethanol as low as that of gasoline at higher loads or indicated power. Practically, it would not be feasible to replace the conventional gasoline fuel with ethanol until and unless, the SFC of engine with ethanol is comparable to that of gasoline, since SFC gives idea about mileage.

iii) Variation of brake Thermal efficiency with load

During the experiment we had noticed that the fuel flow rate for ethanol was more than that for gasoline. Though, the Brake Power of engine is almost comparable for both cases, due to the difference in fuel consumption rate, the thermal efficiency of engine with ethanol is much lower than that with gasoline. The graph in fig. 4(e) depicts that the efficiency of engine with ethanol is not as good as with gasoline. However, the increasing trend of efficiency of engine with ethanol with increase in load shows quite good signal that the performance is not so bad. The performance (efficiency) of engine with ethanol can be increased to a certain extent by suitable modification in engine.

Conclusion from Phase I

During the test run of 4 stroke petrol engine with both gasoline and ethanol, without any modification, we got the following results: -

(a) The average loss in engine brake power $(BP)_{eng}$ while running with ethanol compared to that with gasoline was found to be 16.35%.
(b) The Specific Fuel Consumption (SFC) of engine while running with ethanol was relatively but, the value of SFC for ethanol was rapidly lowering down at higher load (up to 2kW) and was approaching towards the SFC for gasoline.
(c) The average loss in brake thermal efficiency of engine while running with ethanol compared to gasoline was found to be 35.92%.

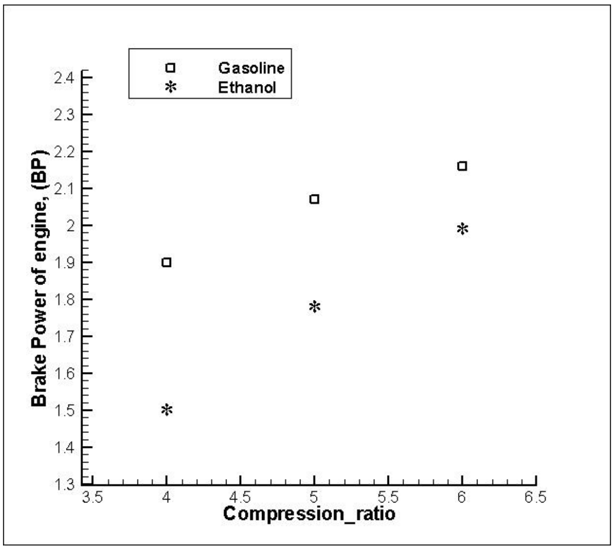
Moreover the problems encountered while testing the petrol engine with ethanol without any modification were Knocking sound, very high fuel consumption rate and ineffective performance in overall. The reasons behind the ineffective performance of ethanol fuel in petrol engine might be as following: -

• Improper stoichiometric condition
• No match between fuel properties and timings of various engine components (spark plug, valves, cams)
• Incomplete Combustion (probable reason, rigid proof couldn't be obtained)
• No optimal utilization of fuel

B. Phase II

As mentioned earlier, the experiment of phase II was carried out after proper modification in carburetor. The comparative analysis of results among the performance of engine with gasoline (E10) and ethanol (E100) before modification & after modification of carburetor is done on the basis of results obtained. The graphs show the analysis as below: -

i) Variation of Brake Power of engine with load



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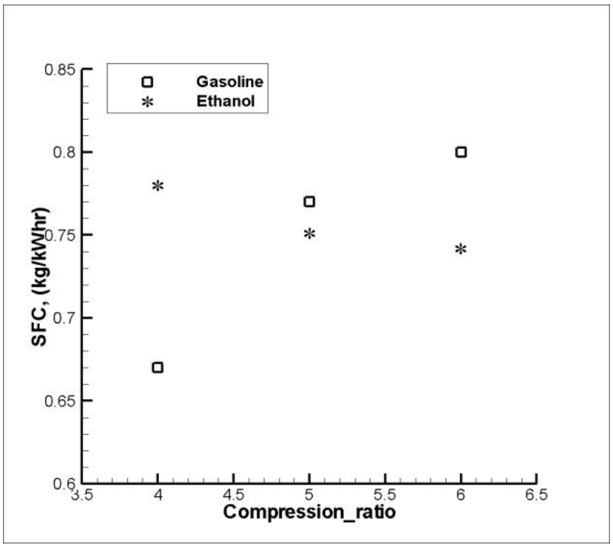

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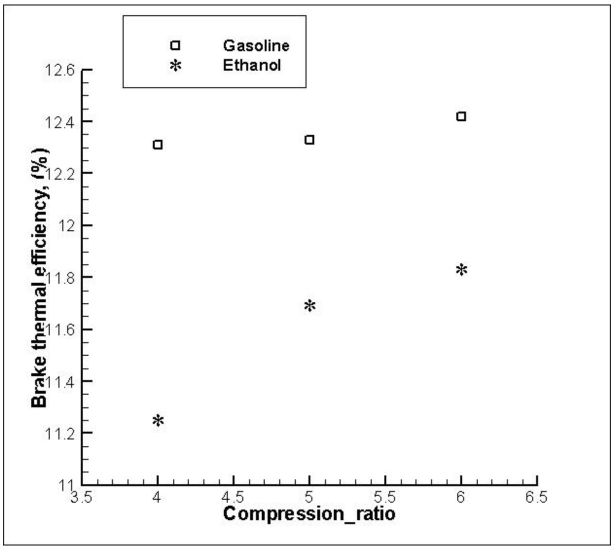

(c)

Fig. 5. Variation of Brake Power of Engine (BP)$_{eng}$ with compression ratio (a), variation of Specific Fuel Consumption (SFC) with compression ratio (b) and variation of brake thermal efficiency(η)$_{bth}$ with compression ratio (c); all at constant indicated power / load of 2kW

The graph in fig. 4(b) shows three different curves for the brake power of engine with gasoline and with ethanol (before modification & after modification of carburetor). Test of engine with ethanol before modification had shown quite lesser output brake power compared to gasoline while, after modification the brake power of ethanol has increased tremendously. The increase in brake power of engine with ethanol after modification is because of the fact that the larger jet size of carburetor has facilitated the larger flow rate of fuel i.e. more fuel consumption and in turn increased the output brake power. However, higher brake power is not the only measure to compare the engine performance since the fuel consumption rate is not taken into account in brake power.

ii) Variation of Specific Fuel Consumption (SFC) with Load

The curve showing the SFC of engine with ethanol (after modification) lies in between the SFC with gasoline & SFC with ethanol (before modification) in fig. 4(d). It is clear that the SFC of engine with ethanol has been minimized significantly after doing the modification in carburetor. The trend in graph plot shows that the SFC in case of ethanol after modification is approaching towards the SFC of engine with gasoline. Since SFC gives idea about the mileage in an automotive engine, it can be understood from the graph that the modification that has been done in carburetor has worked as a tool for bringing the mileage of ethanol engine towards being comparable with gasoline.

iii) Variation of Brake Thermal Efficiency with Load

The curve showing the brake thermal efficiency of engine with ethanol fuel after modification lies in between the curve showing that of gasoline and of ethanol before modification in fig. 4(f). By the act of modification of carburetor in engine, it has been made clear that the brake thermal efficiency has increased by certain extent. The modification done in carburetor seems to be a positive approach towards uplifting the efficiency of engine with ethanol.

Conclusion from Phase II

After the modification of carburetor, thus obtained results of ethanol run engine were compared with the results of initial test run of engine with gasoline. The average gain in output power $(BP)_{eng}$ of the carburetor modified engine while running with ethanol compared to that of initial test run with gasoline was found to be 31.23%. The specific fuel consumption of ethanol after modification was little lesser than that of ethanol before modification. Still it was not possible to bring down SFC to the level of gasoline. The average loss in brake thermal efficiency of engine (modified carburetor) while running with ethanol compared to that of engine with gasoline was 26.60% which was lesser than the loss in initial test run (35.92%).

C. Phase III

Further Improvement of engine to run with ethanol

To overcome the 26.60% loss in brake thermal efficiency, compression ratio was increased. As mentioned earlier, experiments in this phase were carried out in a variable compression ratio (VCR) engine.

i) Variation of Brake Power with Compression Ratio

From the graph in fig. 5(a) it can be seen observed that the brake power of engine with gasoline is always at little higher level than with gasoline. At the compression ratio of 4:1, the difference in brake power of with two fuels is much more. As the compression ratio goes on increasing from 4:1 to 5: 1 and up to 6:1, the brake power of engine with ethanol approaches towards the brake power of engine with gasoline. There was no provision of increasing the compression ratio of engine up to 8:1 or 10:1 or up to 12: 1, so we could not study the effect of such very high compression ratio. The trend of graph shows that, with proper arrangement of test rig and higher compression ratio engine, the performance of engine with ethanol may be predicted to reach up to the level of that with gasoline.

ii) Variation of Specific Fuel Consumption with Compression ratio

As shown in fig. 5(b) At lower compression ratio i.e. 4:1, the specific fuel consumption of engine with gasoline is much lower than that with ethanol. As the compression ratio goes on increasing, the SFC of engine with gasoline goes on increasing while that with ethanol goes on decreasing. Since ethanol has higher octane number, higher compression ratio is favorable for its combustion so its performance on the basis of specific fuel consumption goes on increasing as the compression ratio increases. From the graph as shown above, we can say that by increasing the compression ratio, the SFC of engine with ethanol can be decreased or in other words the mileage can be increased by making proper arrangement for higher compression ratio.

ii) Variation of Brake Thermal Efficiency with Compression ratio

From the graph of fig. 5(c) we can see the trend of increase in thermal efficiency of engine for the cases of both gasoline and ethanol. In case of gasoline, the thermal efficiency is increasing at higher compression ratio but the slope of line at that curve is less i.e. the increment is not tremendous. In case of ethanol, the thermal efficiency is increasing at higher compression ratio. Moreover, the slop of line at the curve is much more, i.e. the increment in thermal efficiency is tremendous. We can conclude from the graph that at very high compression ratio the thermal efficiency of engine with ethanol may come in comparable to that with gasoline.

Conclusion form the experiments in Variable Compression Ratio Engine in Phase III

The overall efficiency of engine with ethanol was lesser than that of petrol at lower compression ratio. At the compression ratio of 4:1, the average loss in Brake Thermal Efficiency of engine with ethanol compared to that of gasoline was found to be 8.53%. At the higher compression ratio of 6:1, the average loss of Brake Thermal Efficiency of engine with ethanol compared to that of gasoline was found to be 4.75%. The efficiency with ethanol was increased significantly with increase in compression ratio. The difference of the output brake power of engine with gasoline and ethanol at higher compression ratio was minimized. The specific fuel consumption (SFC) of engine with ethanol was in decreasing trend at higher compression ratio which is an advantage.

V. Conclusions

Ethanol (C_2H_5OH) can work as an IC engine fuel and an already existing petrol engine can be run by using ethanol rather than conventional petrol (gasoline). The efficiency and output power of engine by using ethanol will be lesser than the corresponding values with gasoline due to relatively lower calorific value of ethanol fuel and other engine parameters. Modification of carburetor by increasing the jet diameter can result into proper stoichiometric condition for ethanol and can increase the engine performance in terms of output power and efficiency. After modified carburetor is used to run the engine with ethanol, the specific fuel consumption (SFC) of engine also gets minimized which in turn increases the mileage of automotive. For the IC engine to run with gasoline, the compression ratio cannot be increased more than 10:1, but due to higher octane rating of ethanol fuel, the compression ratio can be maximized up to 15:1 due to which the engine performance may increase tremendously and ethanol fuel can compete with conventional gasoline at higher compression ratio. During the test of performance of fuels in variable compression ratio (VCR) engine, as the compression ratio increased the efficiency of engine with ethanol was increased tremendously and it was approaching towards the efficiency level with gasoline. In overall, by doing a few suitable modification in engine, we can convert our existing petrol engine into ethanol powered engine and we can minimize the use of conventional, non-renewable energy sources.

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