International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 12, December - 2013

Effect on Performance and Emissions of SI Engine Using Ethanol as Blend Fuel Under Varying Compression Ratio.

Farha Tabassum Ansari , Abhishek Prakash Verma , Alok Chaube

Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur MP, India.

Abstract:

In this paper the investigation has been carried out to estimate the performance and emissions of single cylinder four stroke spark ignition engine. The test carried out using fuel blends of 20%, 40%, 60%, 80% of ethanol with gasoline, compression ratio varying from 8:1 to 10:1, and at different loading conditions. The performance parameters like brake power, Brake Thermal Efficiency, Specific fuel consumption, Brake specific energy consumption, and the emissions like CO, HC were measured in this investigation. The results were compared with pure gasoline and pure ethanol run. It is found that the addition of Ethanol to the gasoline engine causes better engine performance, the exhaust emission reduced effectively, also the brake power and thermal efficiency of the engine is increased.

Keywords: Alternative Fuel , Ethanol, Variable compression engine, SI engine

The demand for gasoline is increasing every day. In view of the limited petroleum reserve, replacement of gasoline by liquid fuel produced form renewable sources is a high priority in many countries worldwide. Ethanol is the best alternative to gasoline. Ethanol can produce from lingo-cellulosic material like wood, agricultural, forest residues and municipal waste [2] has potential to be valuable substitute for gasoline fuel, since Ethanol possesses characteristic, properties that have positive influence on engine performance as well as exhaust emissions. The engine shows better performance with reduction in hydrocarbons and carbon monoxide with use of ethanol with gasoline, although there are some drawback with use of pure ethanol, [11].Phase stability is main concern when hydrous ethanol is used with petrol, the heating value of ethanol is lower than that of gasoline, however characteristic like auto-ignition temperature and flash point is higher than gasoline which make is easier and safe in transportation and storage. [4]

Nomenclature	
BSEC : Brake Specific Energy Consumption	BTE : Brake Thermal Efficiency
BSFC : Brake Specific Energy Consumption	CO : Carbon monoxide
VCR : Variable compression Engine	HC : Hydrocarbon
E0 : Pure gasoline	E60 : 60% Ethanol + 40% Gasoline
E20 : 20% Ethanol + 80% Gasoline	E80 : 80% Ethanol + 20% Gasoline
E40 : 40% Ethanol + 60% Gasoline	E100 : Pure Ethanol

RC Costa [3] Influence of compression ratio in SI Engine was investigated by varying three compression ratios viz. 10:1, 11:1, and 12:1. Higher compression ratio increases cylinder pressure thus increasing work done on piston and hence increasing BMEP, Torque, brake thermal efficiency, however increase in compression ratio decrease Specific fuel consumption. Engine was fuelled with E22 and pure Ethanol E100, the highest torque and BMEP was observed at high compression ratio (12:1). At high speed compression ratio 10:1 and 11:1 provide same torque and BMEP with E22, where as hydrous Ethanol produce slightly higher torque at 11:1 compression ratio.

Topgul[6] The effect of compression ratio on engine performance and exhaust emission was examined at stoichiometric air-fuel ratio, full load and minimum advance timing for best torque in single cylinder hydra spark ignition Engine. The engine torque increase with increase in compression ratio. The test fuel were gasoline(E0), E10, E20, E40 and E60 as fuel blends. The highest engine torque was obtain at 13:1 compression ratio with E40 and E60 fuels, when compared with lower compression ratio of 8:1, because of sufficient octane number E40 and E60 fuels are advantageous in terms of engine performance.

M Celik [12] In this study, the engine whose compression ratio was 6/1 was tested with gasoline, E25, E50, E75 and E100 fuels at a constant load and speed. It was determined from the experimental results that the most suitable fuel in terms of performance and emissions was E50. Then, the compression ratio was raised from 6:1 to 10:1. The engine was tested with E0 fuel at a compression ratio of 6:1 and with E50 fuel at a compression ratio of 10:1 at full load and various speeds without any knock. The experimental results showed that engine power increased by about 29% when running with E50 fuel compared to the running with E0 fuel. Moreover, the specific fuel consumption, and CO, CO2, HC and NOx emissions were reduced by about 3%, 53%, 10%, 12% and 19%, respectively.

Ceviz and Yuksel [9] shows that a small amount of cyclic variability (slow burns) can produce undesirable engine vibrations. On the other hand, a larger amount of cyclic variability (incomplete burns) leads to an increase in hydrocarbon consumption and emissions. This paper investigates the effects of using ethanol–unleaded gasoline blends on cyclic variability and emissions in a spark-ignited engine. Results of this study showed that using ethanol–unleaded gasoline blends as a fuel decreased the coefficient of variation in indicated mean effective pressure, and CO and HC emission concentrations, while increased CO2 concentration up to 10vol. % ethanol in fuel blend. On the other hand, after this level of blend a reverse effect was observed on the parameters aforementioned. Lower percentage of ethanol in fuel blend gives the best results.

Table 1. Properties of gasoline fuel blended with various percentages of ethanol [10]

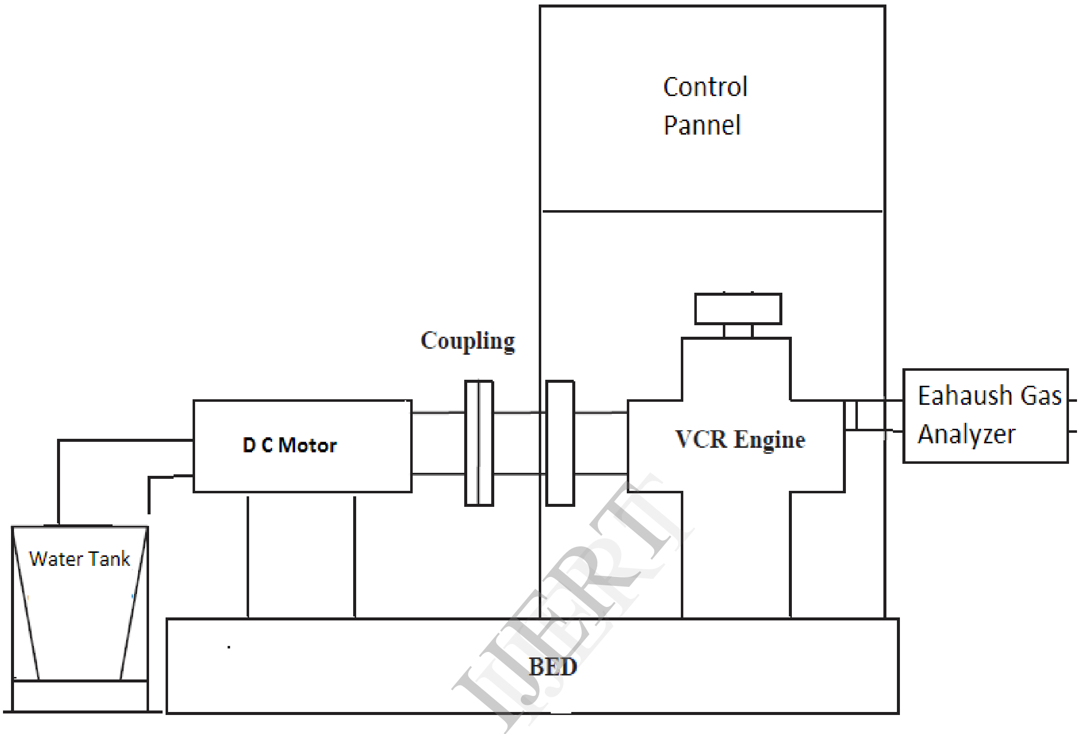
Sample code	% Ethanol	% Gasoline	Calorific Value (kJ/Kg)	Octane number	Specific gravity
E0	00	100	43932	91	0.7474
E20	20	80	41286	94	0.7605
E40	40	60	37448	97	0.7792

E60	60	40	34541	100	0.7812
E80	80	20	30703	104	0.7834
E100	100	00	26981	129	0.7890

3. Experimental setup and test procedure:

The experimental setup consist of Single cylinder Four-stroke petrol engine, the detail specification of engine is given in table 1.

Fig 1.



Schematic Diagram of experimental set-up

Table 2. Engine Specification

Make of manufacturer	Enfield, Spark Ignition, Air and water cooled
Number of cylinder	1
Rated speed	2800 rpm
Rated Power	2 kW
Bore	70 mm
Stroke	66.7mm
Compression Ratio	2.5:1 to 10:1
Loading	Water Rheostat
Starting	Crank Start

The engine is equipped with DC Machine and water rheostat in order to apply the required load. A series of experiment was carried our using gasoline, ethanol and various blends of it. All the blends was tested under varying load condition During each trial engine was started so that attains stable condition important parameter related to thermal performance of the engine such as fuel consumption applied load, the ammeter and voltmeter reading were measure and recorded .

It was allowed to run for sufficient time to consume the remaining fuel from the previous experiment .The engine emission parameter like CO, HC and Exhaust temperature was noted and recorded. Engine test were performed at 2700 rpm. Throttle was adjusted to maintain engine rpm to 2700 at different load condition. Water rheostat was adjusted by moving electrode for different amperage readings thus providing load to engine, brake power were calculated by voltage and ampere readings, temperature sensor is placed nearby of exhaust port to measure exhaust gas temperature, burette is placed for fuel consumption readings. An Exhaust gas analyser is placed near silencer of engine and various readings of CO, HC were noted at different load condition.

Specification of AVL DiGas
Table 2

Measured Quality	Measurement range
CO	0… 10 % vol
HC	0… 20000 ppm
NOx	0… 5000 ppm

Result and Discussion

The effects of ethanol addition to gasoline on SI engine at a constant engine speed (2700 r.p.m) and at seven different engine load (zero, 330 , 600,900, 1200,1500,1800watt) were investigated in this paper. In this section, the effects of the blended fuels on the engine performance and exhaust emissions discussed in detail.

Total fuel consumption

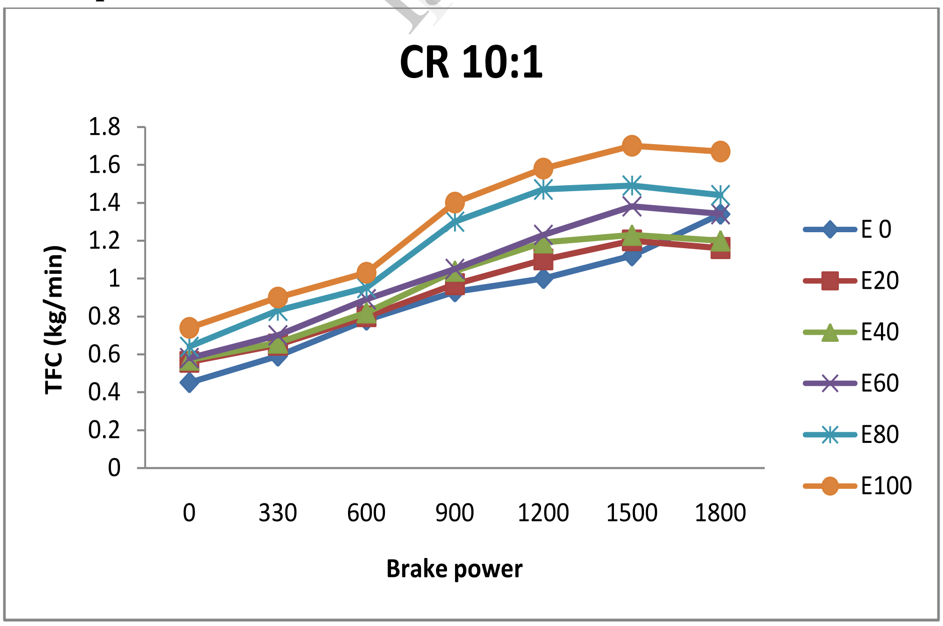


Fig 4.1Total Fuel Consumption V/s Load at CR 10:1

The fig 4.1 shows the variation of fuel consumption with respect to increasing load at CR 10:1. The result found that with increase in load, fuel consumption is also increasing at all fuel blends. With increase in Ethanol % in gasoline, fuel quality is decreased since calorific value of ethanol is comparatively much lower than pure gasoline. There is about 1.24 - 1.58 times increase in fuel consumption at compression ratio 10:1, at all range of loads when compared with pure gasoline.

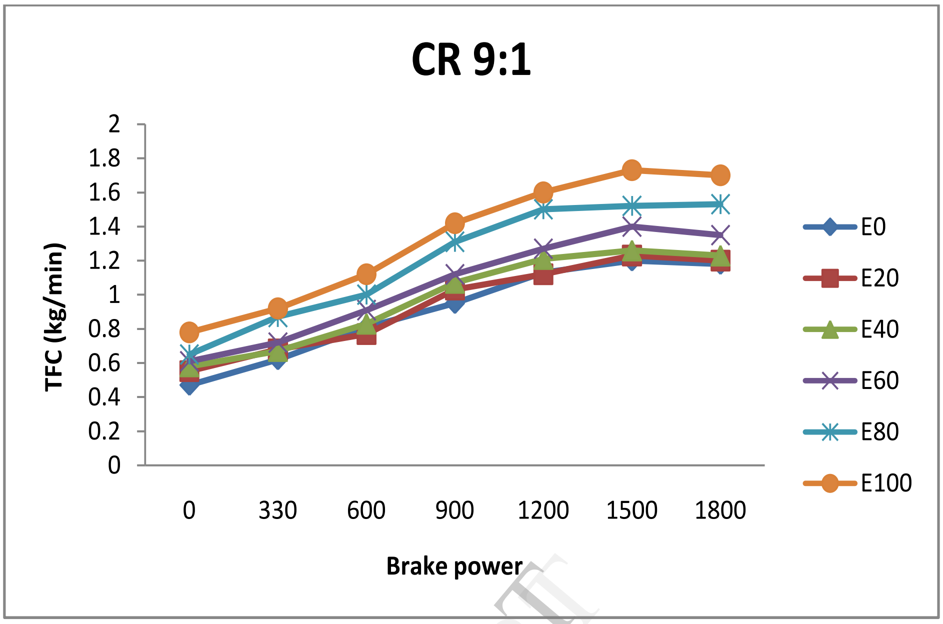


Fig 4.2 Total Fuel Consumption V/s Load at CR 9:1

In fig 4.2 shows that at low compression ratio (9:1) fuel consumption is increased as compared high compression ratio 10:1. But at part load fuel consumption of E40 and E60 is 1.2 % of that with gasoline for same load and compression ratio; this can be due to proper combustion inside cylinder. Presence of Oxygen in Ethanol ensures proper combustion. Fuel consumption for pure ethanol is much higher at lower loads, because of lack of air supply(due to less opening of accelerator valve).Ethanol has high latent heat of vaporization and room temperature of air is constant (assumed), so for the same quantity of fuel to be vaporise air needed is more as compared to gasoline.

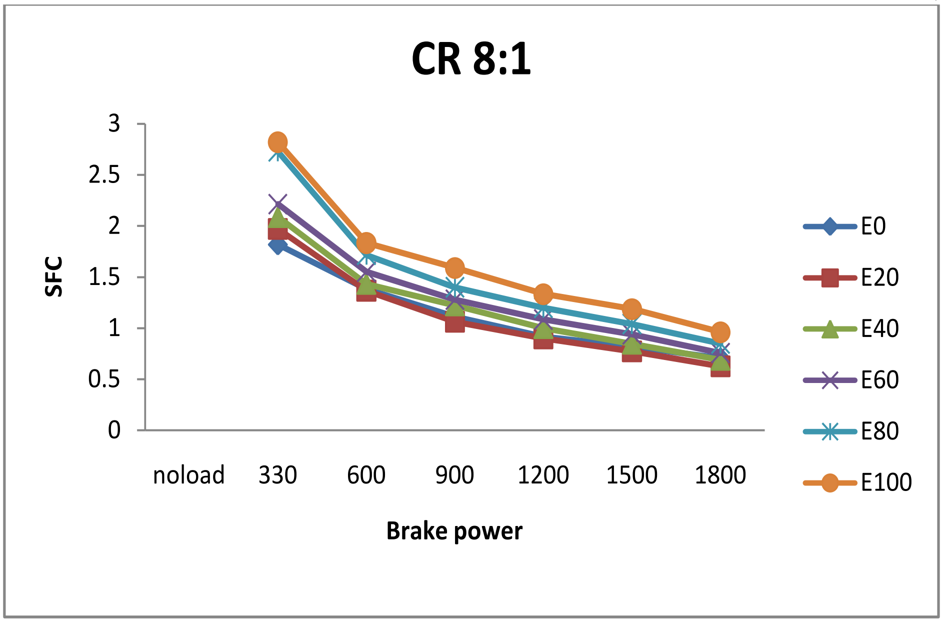


Fig 4.3 Total Fuel Consumption V/s Load at CR 8:1

Fuel consumption at compression ratio 8:1 is shown in fig 4.3, at lower compression ratio fuel consumption increase for low loads on engine. At compression ratio 8:1 fuel consumption is raised 1.6 time as compared to gasoline. Only E20 shows less fuel consumption at high load, this is due to rich oxygenated fuel, but engine cannot be operated at full load all the time.E80 and E100 has almost same trend followed through all the ranges of loads. Ethanol has maximum fuel consumption at all ranges of loads i.e. about 1.13 to 1.6 times.

Specific Fuel Consumption:

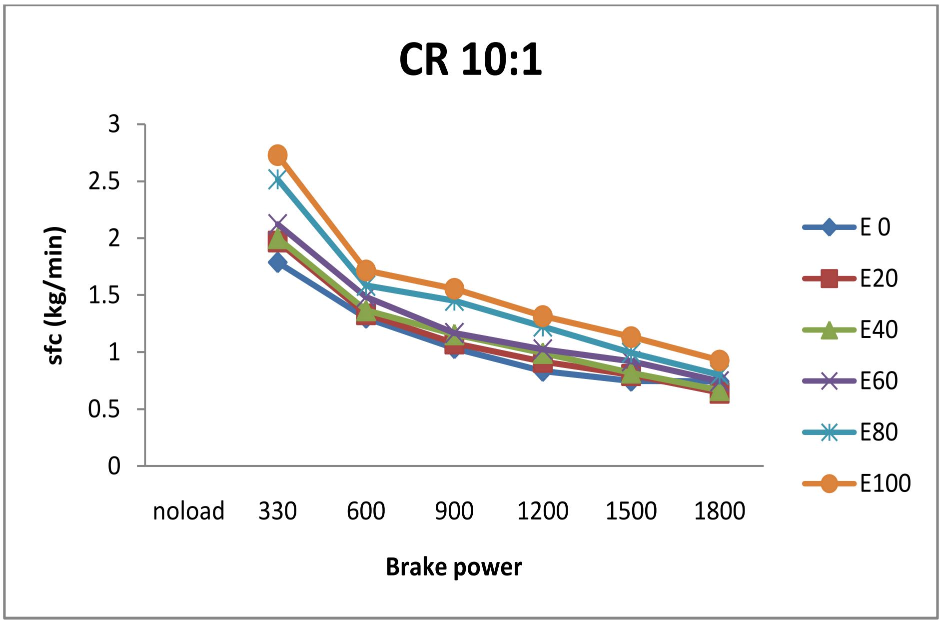


Fig 4.4 Specific Fuel consumption Vs Load at CR 10:1

Ethanol addition reduces the heating value of the gasoline–ethanol blends, therefore, more fuel is needed (by mass) to obtain same power when blended fuels are used instead of gasoline. However, as mentioned previously, ethanol addition to gasoline makes the engine operation leaner and improves engine combustion and performance, as shown in fig 4.4 specific fuel consumptions measured for different loadings at compression ratio 10:1.

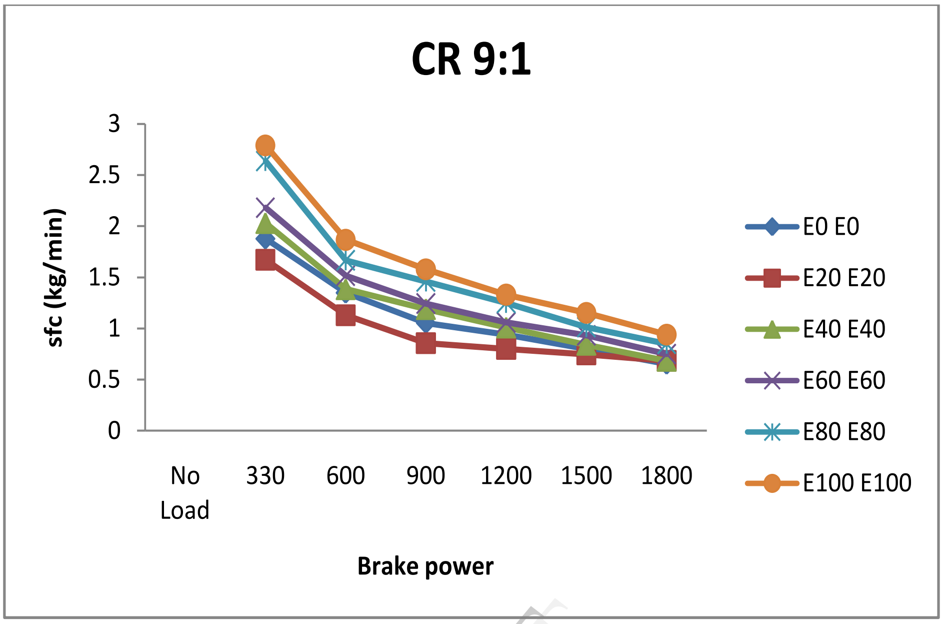


Fig 4.5 : Specific Fuel consumption Vs Load

As for the effect on the engine specific fuel consumption, with decrease in compression ratio (9:1). This can be understood with the help of Fig.4. 5 which show a reduction of the heat loss. This wasted heat could have been converted to useful work and, hence, to the improvement of specific fuel consumption.

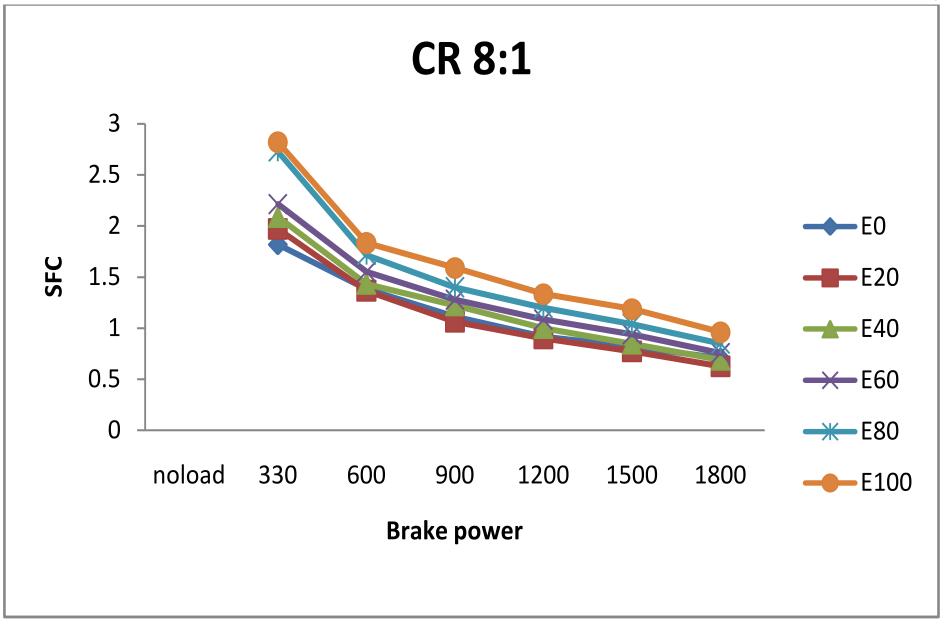


Fig 4.6 : Specific Fuel consumption Vs Load

Brake Thermal Efficiency (BTE)

Presence of oxygen in ethanol composition allow better combustion product, complete combustion results in high temperature and pressure inside cylinder thus results in higher power output. Following graphs shows specific fuel consumption at compression ratio of 10:1, 9:1 and 8:1.

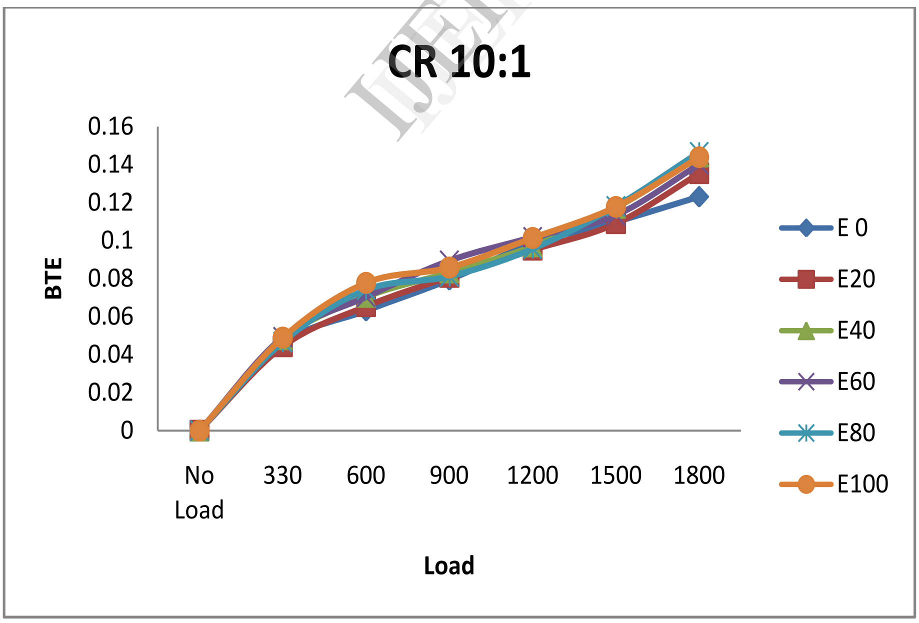


Fig 4.7 : Brake Thermal efficiency Vs Load

Fig 4.7 Shows BTE Vs Load. As increase in load, brake thermal efficiency of engine is increased for Fuel blend up to E60. The vaporization of fuel continues during the intake and compression stroke. This tends to decrease the temperature of the working charge, which reduces compression work of engine At high engine speed there is less time for completion of combustion which takes place in later stage of cycle, which increase thermal efficiency. .

When the latent heat of the fuel used is low, as in the case of gasoline, the effect of cooling is not sufficient to overcome the effect of additional vapour. Increasing the latent heat of the fuel blend used by increasing the ethanol percentage increases the effect of cooling, which results in increase in increase thermal efficiency thus higher engine power output. Variation is in between 1.15 to .80% reduction at full load when compared to pure gasoline.

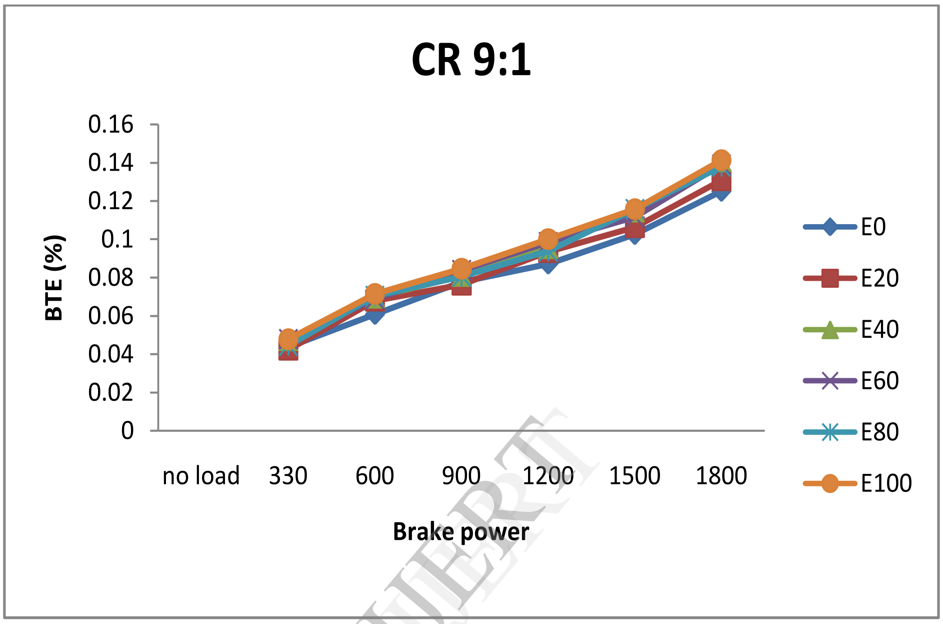


Fig 4.8 : Brake Thermal efficiency Vs Load at CR 9:1

Decrease in compression ratio increase in Brake thermal efficiency up to blending of 40%, then after decrease, since volume of cylinder is increased; thereby increase mass of intake charge. fig 4.8 shows brake thermal efficiency V/s Load. BTE varies from .6 to 1.15 percentage when compared to pure gasoline.

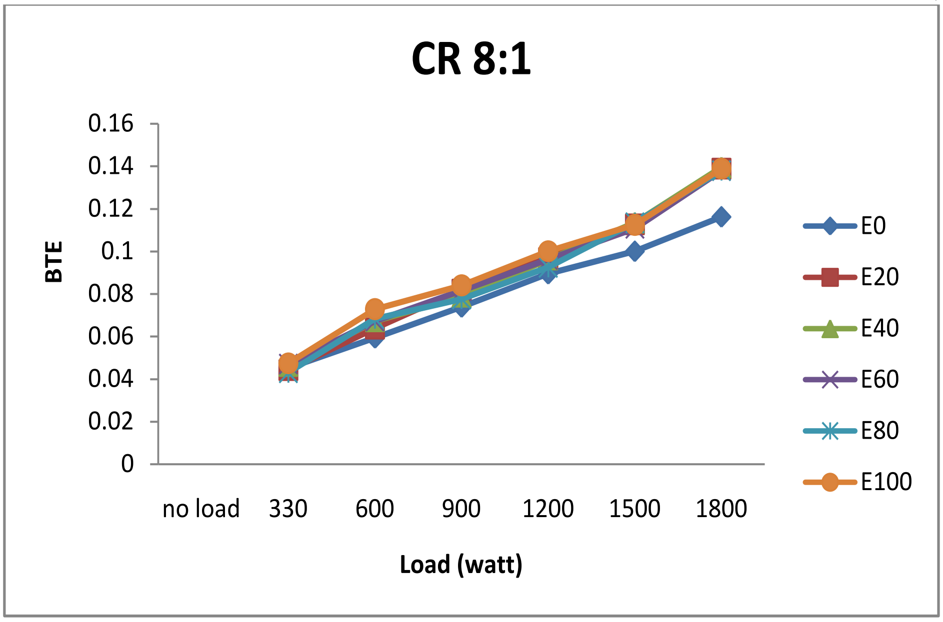


Fig 4.9 : Brake Thermal efficiency Vs Load at CR 8:1

From the previous discussion, increasing ethanol percentage increases the air–fuel ratio, i.e., decreases the heat transfer to the cylinder walls (heat losses) due to incomplete combustion, and therefore, increases the value of maximum pressure which results in high thermal efficiency. At compression ratio 8:1 Brake thermal efficiency is increased for all range of test fuel blends.

Major difference is observed with E40 and E60 fuel at higher loads. Increase in thermal efficiency varies 1 to 1.8 %.

Carbon monoxide

In fig 4.10 we can see that the percentage of carbon mono oxide (CO) is very high as the load increase. Because at higher load fuel consumption is greater than the lower load. Pure ethanol gives minimum amount of CO at all loads. It is a product of incomplete combustion due to insufficient amount of air in the air- fuel mixture. When is mixed with gasoline, the combustion of the engine becomes better and therefore, CO emission is reduced. The concentration of CO is decreased as the volume percentage of ethanol fuel is increased in the fuel mixture. 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.

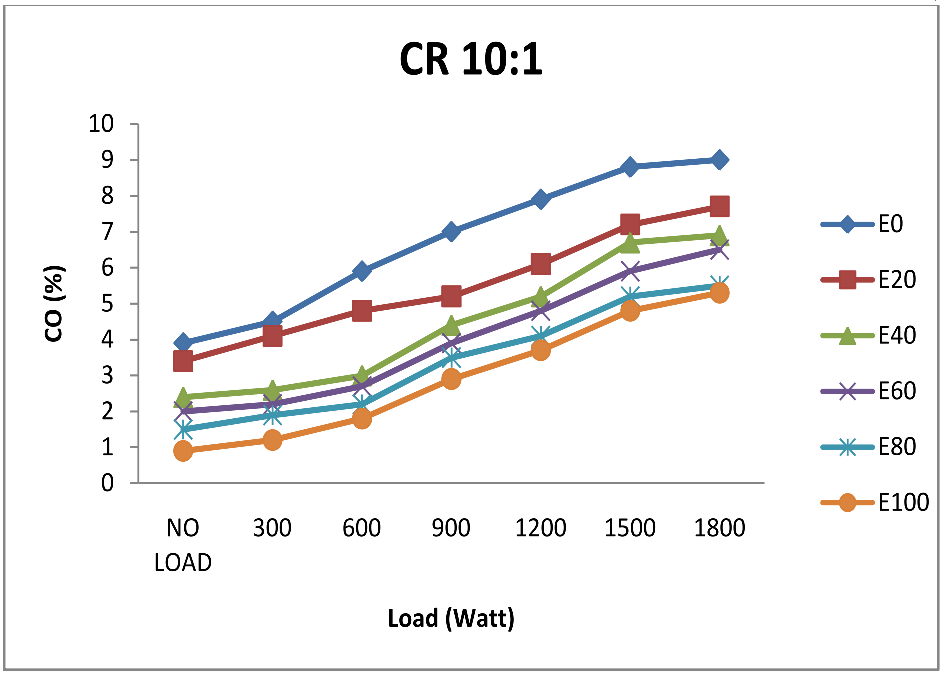


Fig 4.10 CO Vs Load

In fig 4.11 shows the effect of the ethanol blending on the HC emission. It is a product of incomplete combustion due to insufficient amount of air in the air- fuel mixture. When Ethanol containing oxygen is mixed with gasoline, the combustion of the engine becomes better and therefore, CO emission is reduced. At 9:1 compression ratio the carbon dioxide emission is slightly greater than 10:1 compression ratio.

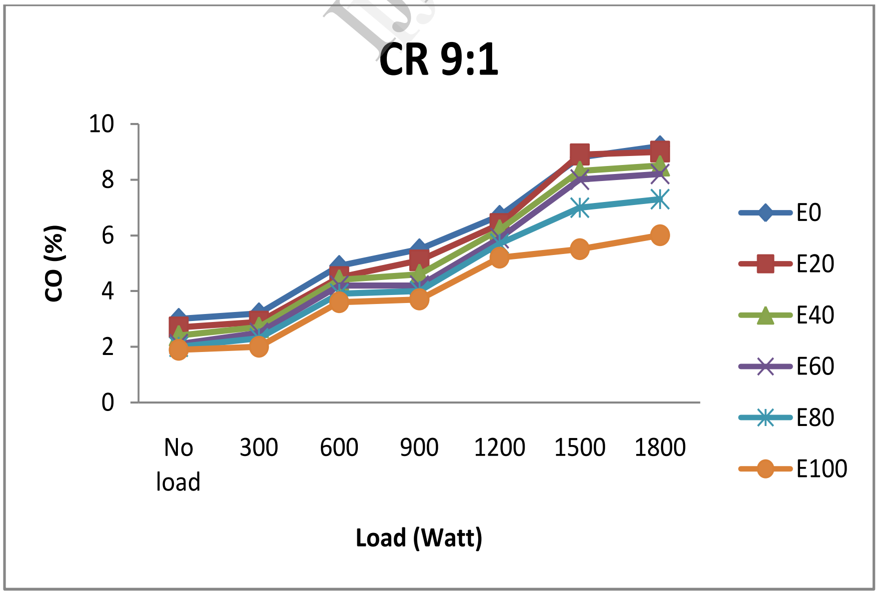


Fig 4.11 CO Vs Load

In fig 4.12 show that variation of CO with ethanol. CO emission with pure ethanol less than the each fuel blend and pure gasoline at all engine load. This means that when ethanol ratio in increased with gasoline, more oxygen is combining with mixture and proper combustion takes place. At 8:1 compression ratio compared with10:1and 9:1, the CO of E100 fuel reached minimum value.

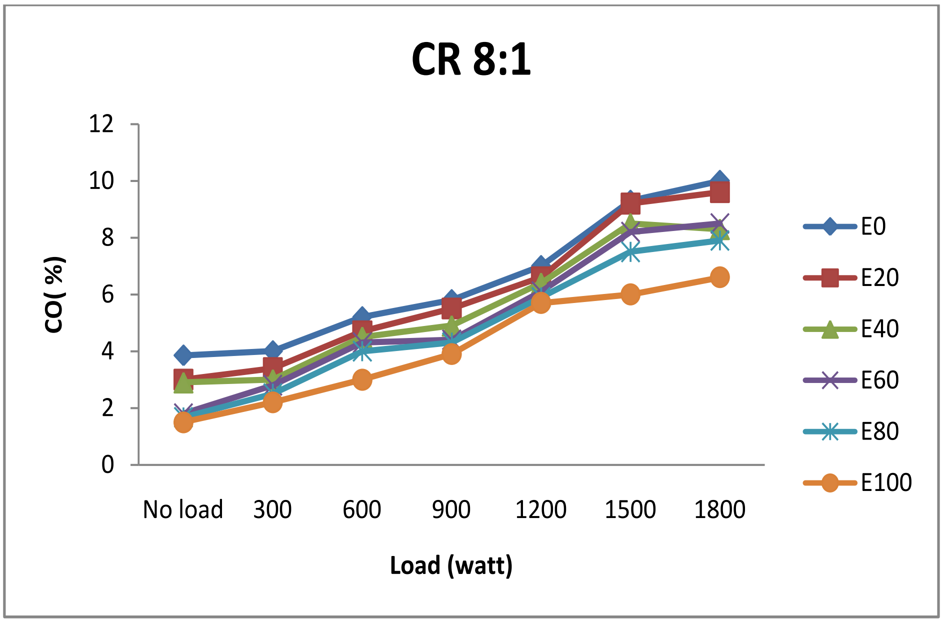


Fig 4.12 CO Vs Load

Hydrocarbon

In this experimental study it was found that that the higher percentage of ethanol increases the combustion characteristic which plays an important role in HC emission show in Fig. 4.13. Rich air fuel ratio with insufficient oxygen prompts the incomplete combustion of fuel as a misfire produces the unburnt hydrocarbon. When ethanol is added to the blended fuel, it can provide more oxygen for the combustion process and leads to the so-called "leaning effect". This indicates that the engine tends to operate in leaner conditions, closer to stochiometric burning as the ethanol content is increased. Its final result is that better combustion can be achieved therefore the concentration of HC emission decrease as the ethanol content increase.

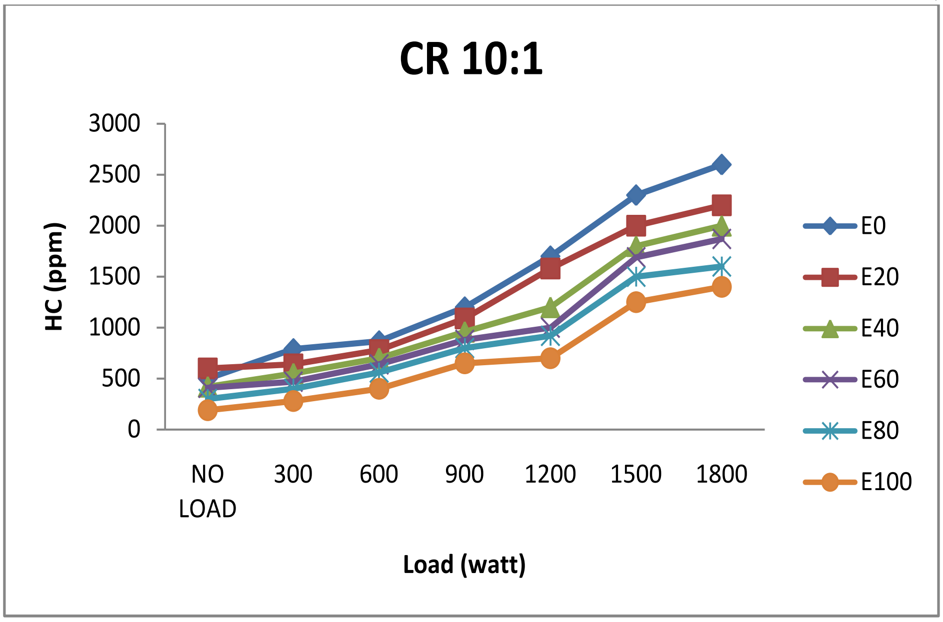


Fig 4.13 HC Vs Load

Fig 4.14 shows the variation of HC emission level with respect to Brake Power for an SI engine. It is evident that it is a strong function of air fuel ratio. With a rich fuel mixture there is not enough oxygen to react with all the carbon, resulting in high level of HC in the exhaust product. In result it is seen that when ethanol percent is increased the hydrocarbon emission is decreased Significantly. At this compression ratio HC emission is greater than 10:1 compression ratio.

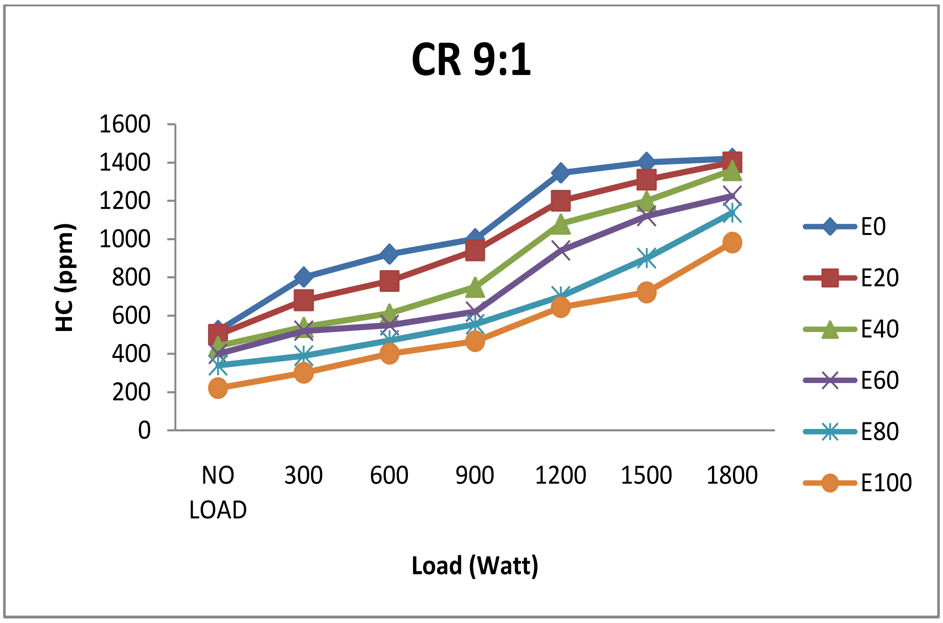


Fig 4.14 HC Vs Load

In fig 4.15 show that the result which is that as load increase the hydrocarbon is also increase. But when the percentage of ethanol is increased with gasoline the hydrocarbon emission is reduced significantly. Ethanol is oxygen containing additive and it improve the combustion characteristic. When proper combustion is placed the hydrocarbon emission is reduced.

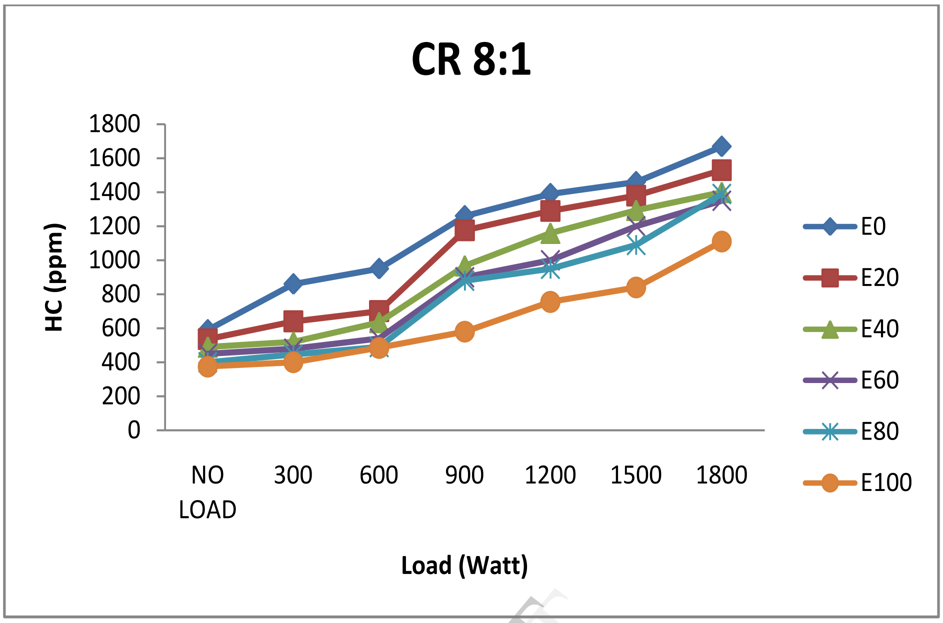
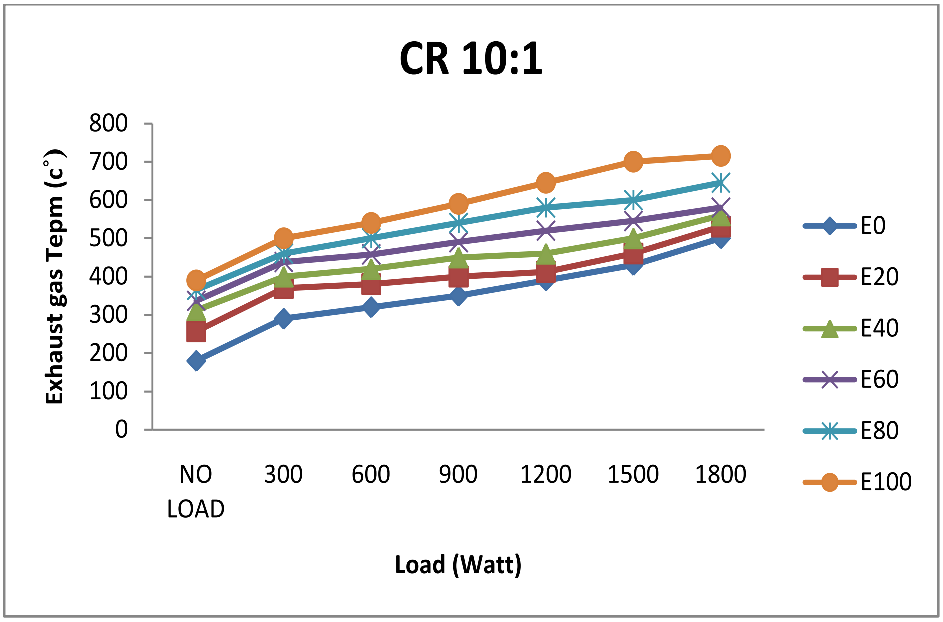


Fig 4.15 HC Vs Load

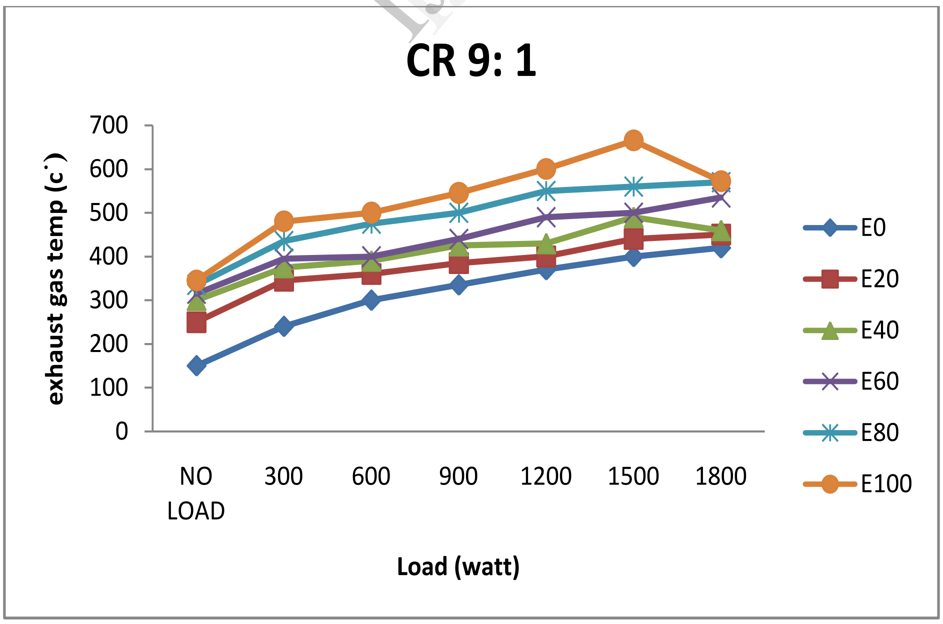
***Exhaust Gas Temperature**:*

In graph 4.16 shows the variation of exhaust gas temperature with respect to load. However from 10:1 compression ratio for fuels with low octane number like E0, the detonation increases, due to the poor combustion, the exhaust gas temperature decrease. This situation is prevented using fuel with high octane number. In result it is seen that when ethanol percentage is increased the exhaust gas temperature are also increased due to complete combustion at all engine load.



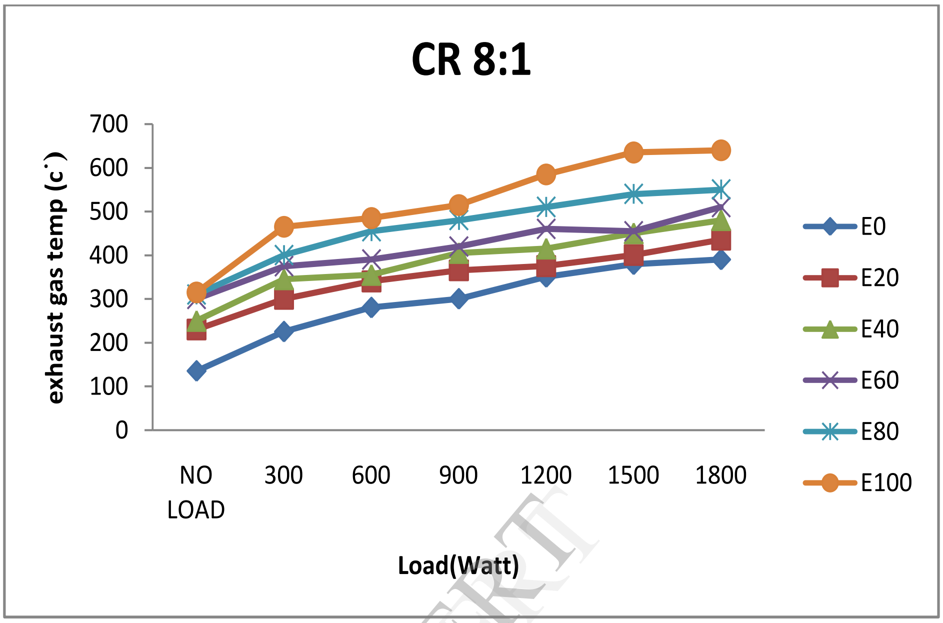
4.16 Exhaust gas Temperature Vs Load

At low compression ratio exhaust gas temperature is decreased which is show in fig 4.16 .when ethanol percentage increased mixture makes stochiometric and proper combustion takes place. The result is that exhaust gas temperature increased with ethanol volume at all engine loads.



4.17 Exhaust gas Temperature Vs Load

In fig 4.17 shows that the variation of exhaust gas temperature with respect to load at 8:1 CR. In result as we increase that with incresing ethanol percentage combustion characteristic also increase and give maximum temperature at all engine load. The temperature is also depends on the engine running time. At 8:1 compression ratio the exhaust gas temperature less compared with 9:1 and 10:1.



4.18

Graph 4.18 Exhaust gas Temperature Vs Load

5 Conclusions

- Increasing compression ratio reduces fuel consumption, this is due to reduce in cylinder volume, which reduce mass of charge intake.
- Presence of oxygen in ethanol composition allow better combustion product, complete combustion result in high temperature and pressure inside cylinder thus higher output power. Increased pressure and temperature inside cylinder which results in higher power output.
- E40 and E60 fuel shows better results, when both performance and emission is considered, average values of each test condition is closer to E60 fuel.
- Oxygenated additive enhance proper combustion inside cylinder, which increase exhaust gas temperature. Therefore proper cooling for engine is required when engine is running with ethanol blends.

- The fuels containing high ratios of ethanol had important effects on the reduction CO emissions. The maximum decrease of CO was obtained with E100 fuel at 2700 rpm engine speed. In all compression ratio (8:1, 9:1, 10:1) the CO emission was lower at 10:1 with ethanol edition. The HC emission is effectively reduced with ethanol edition. The maximum reduction of HC emission at (10:1) higher compression ratio with pure ethanol.
- Exhaust gas temperature tended to increase with increasing compression ratio generally. Due to the poor combustion, the exhaust gas temperature decreases. This situation is encouraged to use fuel with high octane number and engine with higher compression ratio. The exhaust gas temperature is found maximum with E100 fuel .As the compression ratio increases, the exhaust gas temperature enhanced with improved combustion characteristics.

6. Reference

1. Carlos A. Cardona, Oscar J. Sanchez Bio resource Technology .
2. Cellulosic Ethanol from Municipal Solid Waste: A Case Study of the Economic, Energy, and Greenhouse Gas Impacts in California.
3. Costa RC, José R. Sodré, Compression ratio effects on an ethanol/gasoline fuelled engine performance, Applied Thermal Engineering 31 (2011) .
4. Fikret Yuksel , Bedri Yuksel, The use of ethanol–gasoline blend as a fuel in an SI engine, Renewable Energy 29 (2004)
5. Hu seyin Serdar Yu cesu , Tolga Topgul, Can Cinar, Melih Okur, Effect of ethanol–gasoline blends on engine
6. L.M. Das, Y.V.R. Reddy, Evaluation of alternative fuels for internal combustion engine, in: First Trabzon International Energy and Environment Symposium, July 1996.
7. M. Bahattin Celik, Experimental determination of suitable ethanol–gasoline blend rate at high compression ratio for gasoline engine, applied thermal eng. 28(2008) .
8. M.A. Ceviz, F. Yüksel, Effects of ethanol-unleaded gasoline blends on cyclic variability and emissions in a SI engine, Appl. Therm. Eng. 25 (2005).
9. Tangka J. K., Berinyuy J. E., Tekounegnin and Okale A. N. Physico-chemical properties of bio-ethanol/gasoline blends and the qualitative effect of different blends on gasoline quality and engine performance .
10. Zlata Muzikova , Milan Pospisil, Gustav Sebor, Volatility and phase stability of petrol blends with ethanol, Fuel 88 (2009) .