ABSTRACT

This thesis consists of emission characteristics and effect of global warming by PETROL, DIESEL, HYDROGEN, AMMONIA, CNG, METHANOL, CNG, DYMETHYL ETHER AND NATURAL GAS. Comparison via charts at different speeds with different configurations of ethanol and methanol. Gasoline is a liquid composed of hydrocarbons, refined from crude petroleum, and characterized by a boiling point. It is difficult to regularly refine these oils, and their scarcity in natural resources makes it problematic to refine them. Gasoline engines produce fewer toxic emissions, like NOx, CO, and CO2. On the basis of economical and natural concerns, gasoline can be put back by many alternative fuels. It can be powered by alternative energy sources, like hydrogen, natural gas, ethanol, acetylene, propane, biogas, etc. The performance of these types of fuels in an internal combustion engine is very charming and appropriate for nature. Hydrogen is sustainable, and the amount of energy necessary to create hydrogen is small. Hydrogen engines are more prominent at approximately 30% compared to gasoline engines in terms of direct injection. Ethanol causes 80% less CO emissions after it has been properly blended with gasoline. Natural gas fuelling stations are expanding in popularity. After the natural gas percentage is increased in the fuel, high efficiency is achieved at a sustainable performance in the 0.7–0.9 equivalent ratio. (G + 1000 g/h acetylene) has a higher brake thermal efficiency (G + 500 g/h acetylene). These vehicles, after all, have seen considerable increases in terms of fuel economy, total performance, and substantially reduced emission standards. This study aims to compare various alternative fuels with gasoline by analysing their availability, engine tests, toxic element emissions, price, etc. Furthermore, a selection criterion for alternative fuel is given in various measuring scales that will be helpful for choosing alternative fuels because fossil fuels are running out. Similar in the cases of other fuels has done an in-depth study.

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EMISSION CHARACTERISTICS AND ITS EFFECT ON GLOBAL WARMING
1.1 Petrol Fuel:

HC Concentration:

- We have several types of emissions occurring due to petrol fuel in that the four main fuel emissions are carbon monoxide, carbon dioxide, hydrocarbons and oxide of nitrogen.
- Investigation is done at the engine speed of 2000 rpm with full throttle valve opening were selected.
- Different concentrations of fuels contain different emission concentrations at different speeds.
- Some of them were listed here, the HC (hydro carbon) concentration in the exhaust gas emission at 2000 rpm with full throttle valve opening, for gasoline fuels was 345 ppm.

HC concentration		**max ppm**
• E5(M5)	-	341
• E10 (M10)	-	301
• E20(M20)	-	282
• E40(M40)	-	265
• E60(M60)	-	273
• E80(M80)	-	380

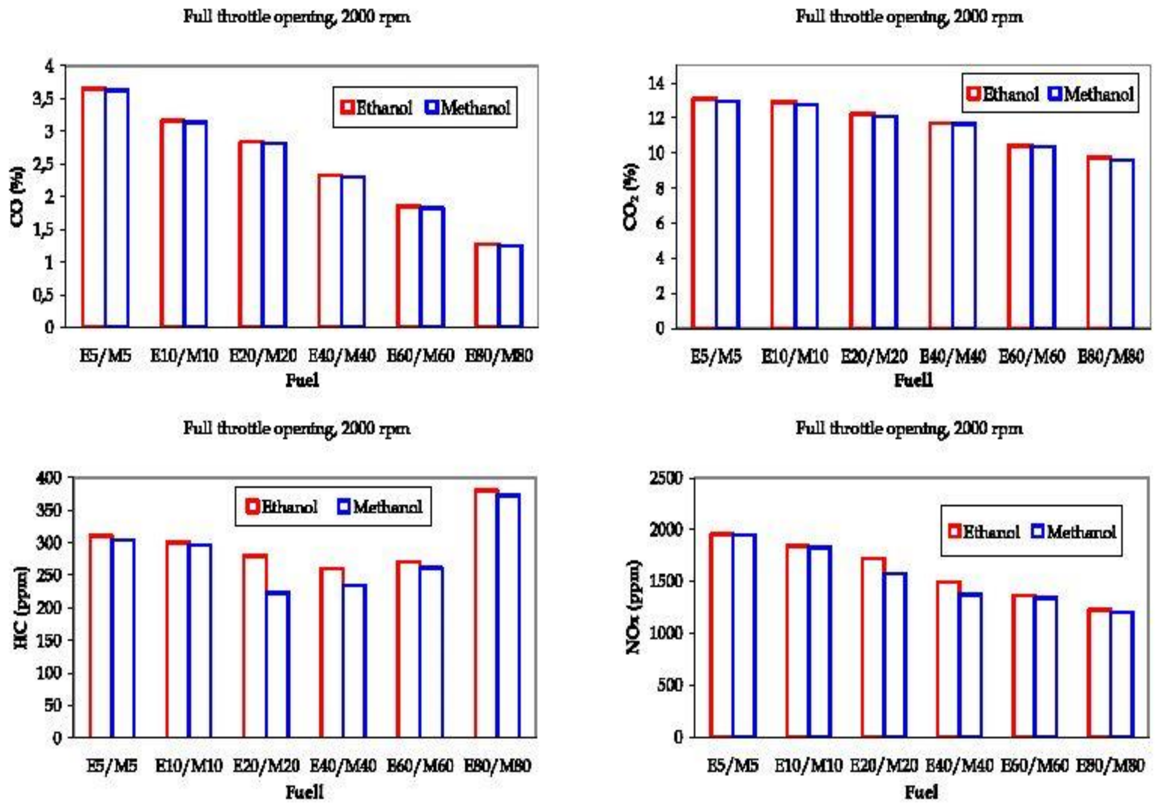


Fig 1.1(a)- CO, CO2, HC and NOx vs concentration of Ethanol and methanol at constant speeds.

- the above results indicate the ethanol and methanol can be treated as partially oxidised hydrocarbon when they are added to the blended fuel.
- E20(M20) means 20% of ethanol and 20% of methanol in petrol.
- the lower temperature causes misfire and partial burn in the regions near the combustion chamber wall.
- Therefore, HC emissions increase, and engine power can slightly decrease.

NOx Concentration:

- The percentage of ethanol and methanol in the blends increased, NOx emissions were decreased.
- The NOx emission in the exhaust gas emission at 2000 rpm with full throttle valve opening, for gasoline fuel was 2247 ppm.

Concentration		max ppm
E5(M5)	-	1957
E10(M10)	-	1841
E20(M20)	-	1724
E40(M40)	-	1498
E60(M60)	-	1366
E80(M80)	-	1207

- The blends temperature at the end of the intake stroke decreases and finally causes combustion temperature to decrease. As a result, engine-out NOx emissions decrease

Petrol contributes to air pollution:

Petrol is a toxic and highly flammable liquid. The vapours given off when the petrol evaporates and the substance produces when petrol is burned contribute to air pollution. Burning petrol also produces carbon dioxide which causes greenhouses effect.

Effect of Greenhouse gases:

- **Required emissions control devices and cleaner burning engines**
  Emissions control devices on passenger vehicles were required beginning in 1976. In the 1990s, the EPA established emissions standards for other types of vehicles and for engines used in gasoline-burning non-road equipment.[2]
- **Removed leaded gasoline for use in vehicles**
  Lead in gasoline proved to be a public health concern. The move away from leaded gasoline began in 1976 when catalytic converters were installed in new vehicles to reduce the emissions of toxic air pollutants. Vehicles equipped with a catalytic converter cannot operate on leaded gasoline because the presence of lead in the fuel damages the catalytic converter. Leaded gasoline for use in vehicles was completely phased out of the U.S. fuel system by 1996. Leaded aviation gasoline is allowed for use in piston-engine aircraft. The U.S. government is supporting research on alternative, lead-free fuels for those types of aircraft.[3]
- **Required the use of reformulated gasoline**
  Beginning in 1995, the Clean Air Act Amendments of 1990 required cleaner burning reformulated gasoline to reduce air pollution in metropolitan areas that had significant ground-level ozone pollution.

- **Required the supply of ultra-low sulphur gasoline**
  As of January 1, 2017, refiners are required to supply gasoline with 97% less sulphur content than the gasoline made in 2004. Gasoline with lower sulphur content reduces emissions from old and new vehicles and is necessary for advanced vehicle emission control devices to work properly.
- **Reduced the risk of gasoline leaks**
  Gasoline leaks happen at gas stations every day. As people fill up their gas tanks, gasoline drips from the nozzle onto the ground and vapours leak from the open gas tank into the air. Gasoline leaks can also happen in pipelines or in underground storage tanks where they can't be seen. Beginning in 1990, all underground storage tanks had to be replaced by tanks with double lining. The double lining provides an additional safeguard for preventing leaks.
- Methyl tertiary butyl ether (MTBE), one of the chemicals added to gasoline to help it burn cleaner, is toxic, and a number of states started banning the use of MTBE in gasoline. Later MTBE was replaced with ethanol which is non-toxic.

1.2. Diesel fuel:

Emission Characteristics of HC: It can be seen that the HC emissions under different atmospheric pressures show significant divergences when the mix proportions, engine speeds, and loads change. With increasing speeds and loads, the effect of atmospheric pressure on HC emission was not significant. At 2200 r/min and 81 kPa, the mix proportions had great effects on the HC emissions, especially at light load (50 N.m), which rendered the increase by 47%~ 293%. The increase of HC emissions of E30 was great. The HC emission increased with the increasing percentage of ethanol in blends. However, the HC emissions of ethanol-diesel blends nearly reached the level of prototype at 3200 r/min.

Because the ethanol has higher latent heat of vaporization, which reduces the gas temperature and promotes the chilling of cylinder wall, the HC emission rises evidently with the increasing content of ethanol at low speed and load of engine. When engine speeds and loads go up, the temperature of gas and combustion chamber wall increases, which accelerates the formation of mixture gas and promotes the combustion of fuel.

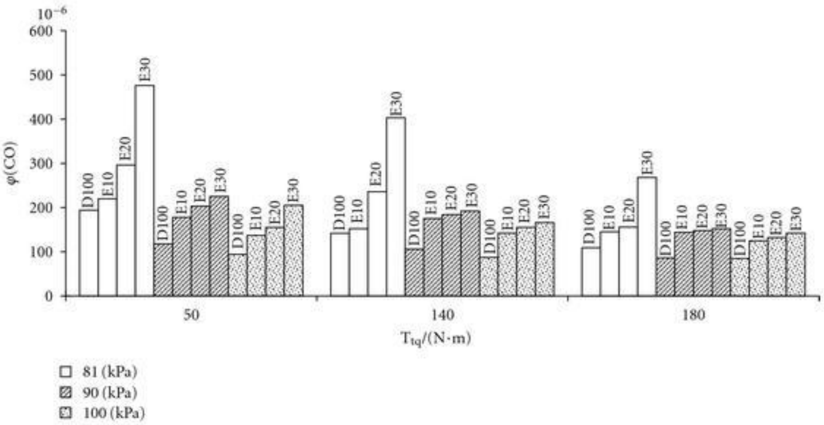


Fig 1.2(a): Comparison of HC emissions of different atmospheric pressure and mix proportion at speed 1400 rpm

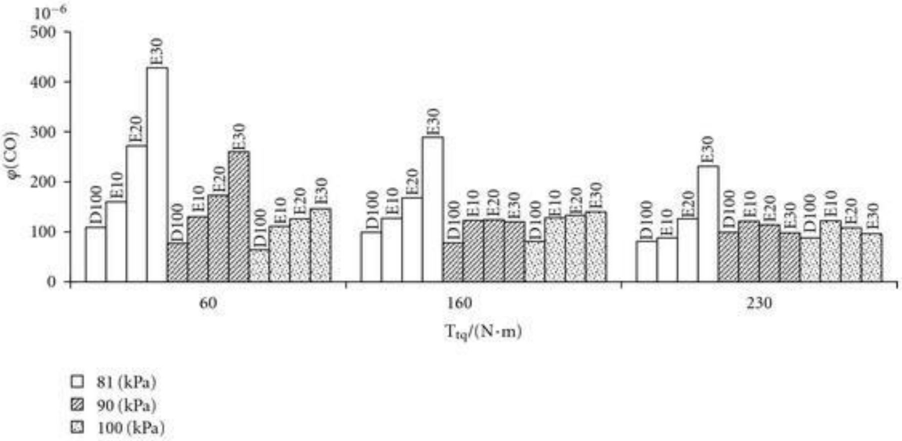


Fig (b): - Comparison of HC emissions of different atmospheric pressure and mix proportion at speed 2200 rpm

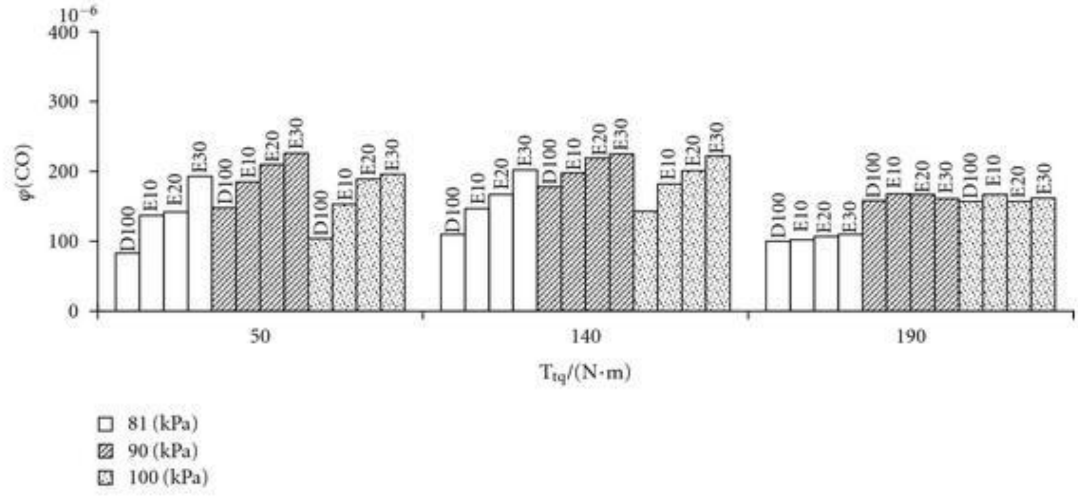


Fig (c): - Comparison of HC emissions of different atmospheric pressure and mix proportion at speed 3200 rpm

Emission Characteristics of CO: At 2200 r/min and low load (50 Nm), E10, E20, and E30 augmented the CO emissions by 20% ~ 250%, 33% ~ 301%, and 35% ~ 210%, respectively. With increasing engine speed and engine load, atmospheric pressure had litter influence on the CO emission. At low and middle loads, the higher proportion of ethanol increased the CO emission slightly. At full load, CO emissions of ethanol-diesel blends were lower than those of pure diesel, especially at 81 kPa. The experimental results indicated that the ethanol-diesel blends would not deteriorate the CO emissions except for 2200 r/min and low load.

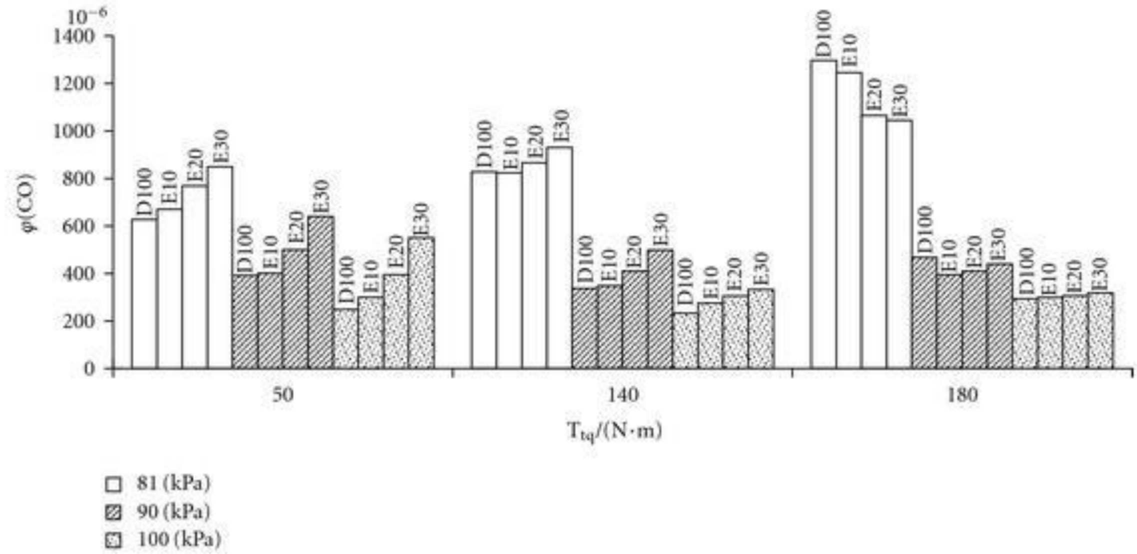
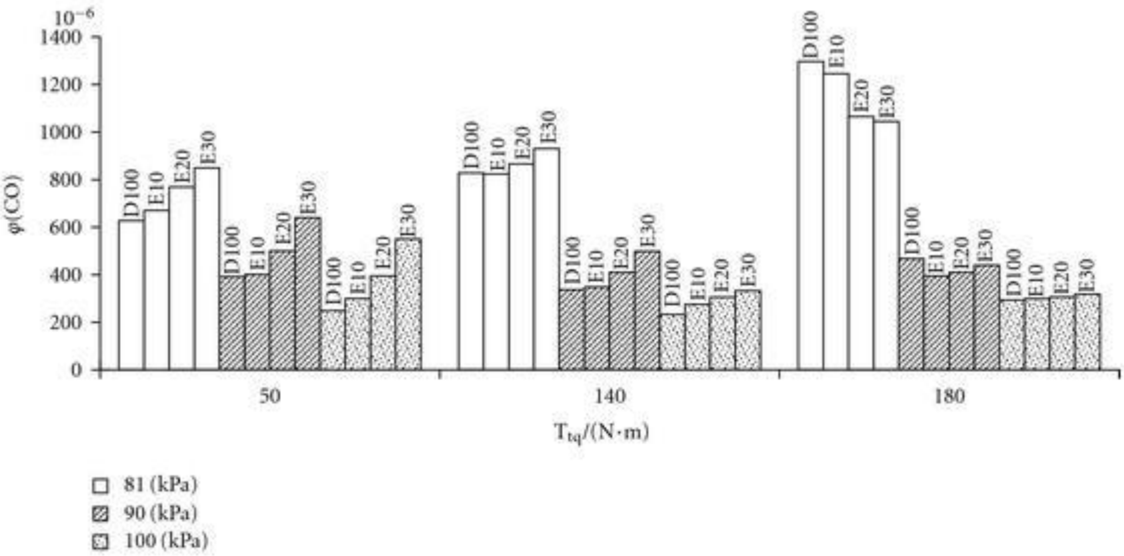


Fig (d): - Comparison of CO emissions of different atmospheric pressure and mix proportion at speed 1400 rpm.



Fig(e): -Comparison of CO emissions of different atmospheric pressure and mix proportion at speed 2200 rpm.

The addition of ethanol causes the reduction of gas temperature, which restrains the oxidation of CO, so CO emission goes up at low load. With the increase of engine speed and load, the increase of gas temperature, wall temperature, and oxygen content of ethanol promote the oxidation condition of CO, which decreases the negative effect of addition of ethanol. At full load, the excess air ratio is comparatively low, so the increasing proportion of ethanol decreases the CO emission greatly. With the increase of atmospheric pressure, the excess air ratio increases and the effect of ethanol is weakened, so the influence of atmospheric pressure on the CO emission is slight. Based on the above analysis, it can be said that CO emissions of ethanol-diesel blends are depended on the engine speed, load, and the mix proportion of ethanol.

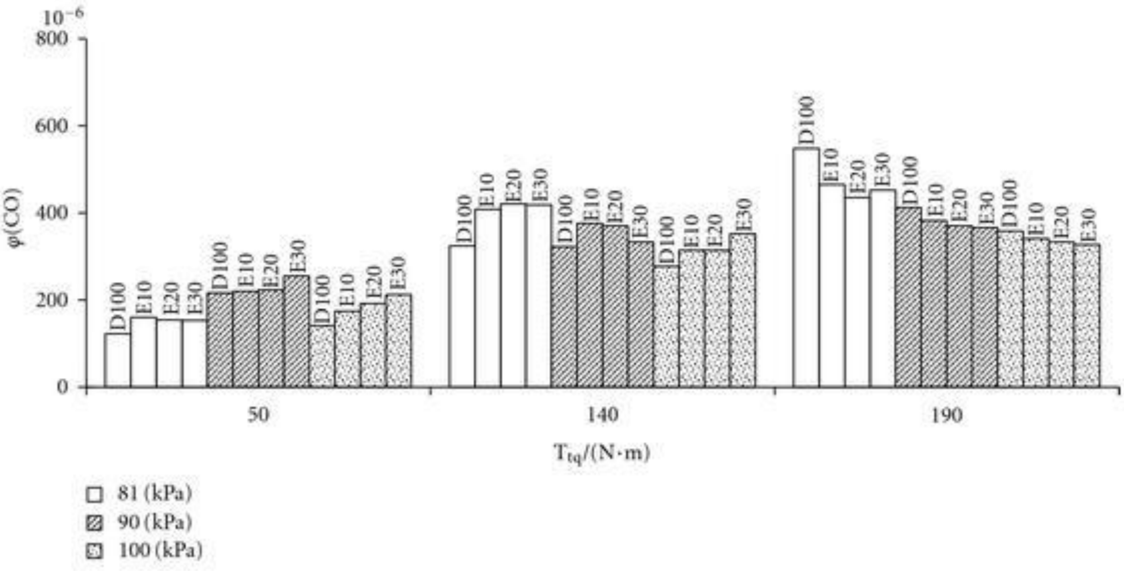
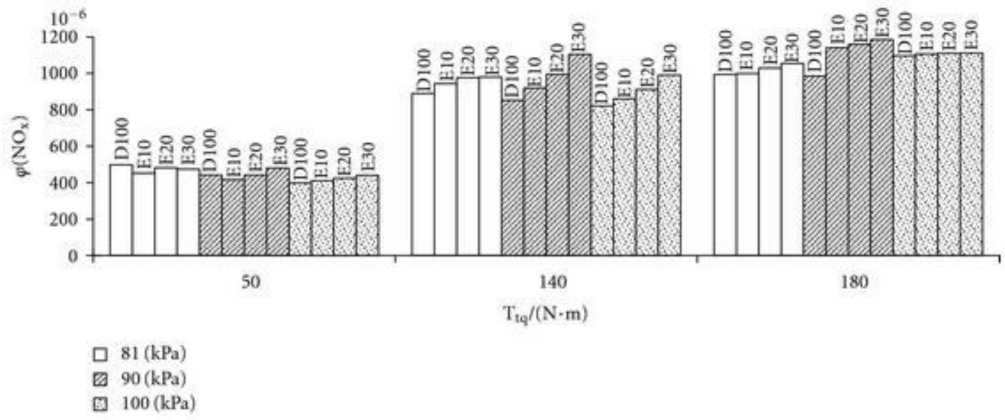
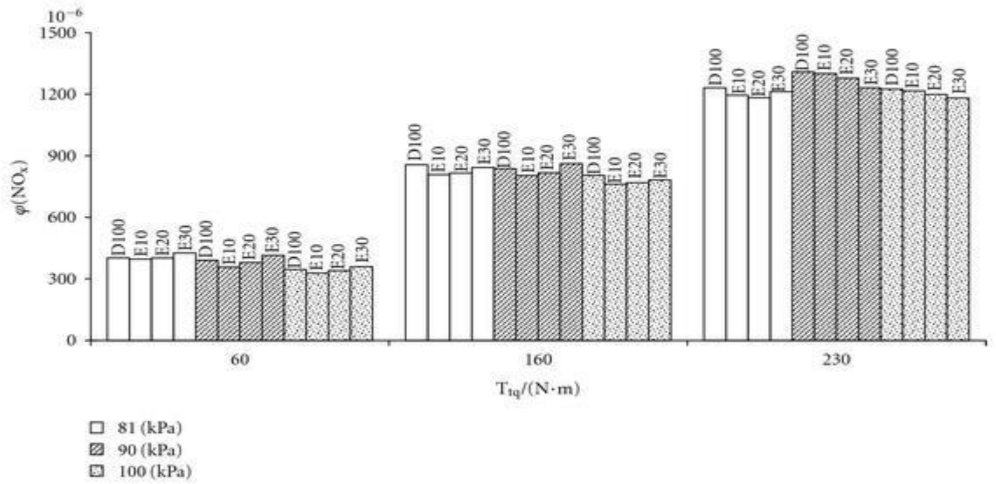


Fig (f): - Comparison of CO emissions of different atmospheric pressure and mix proportion at speed 2200 rpm.

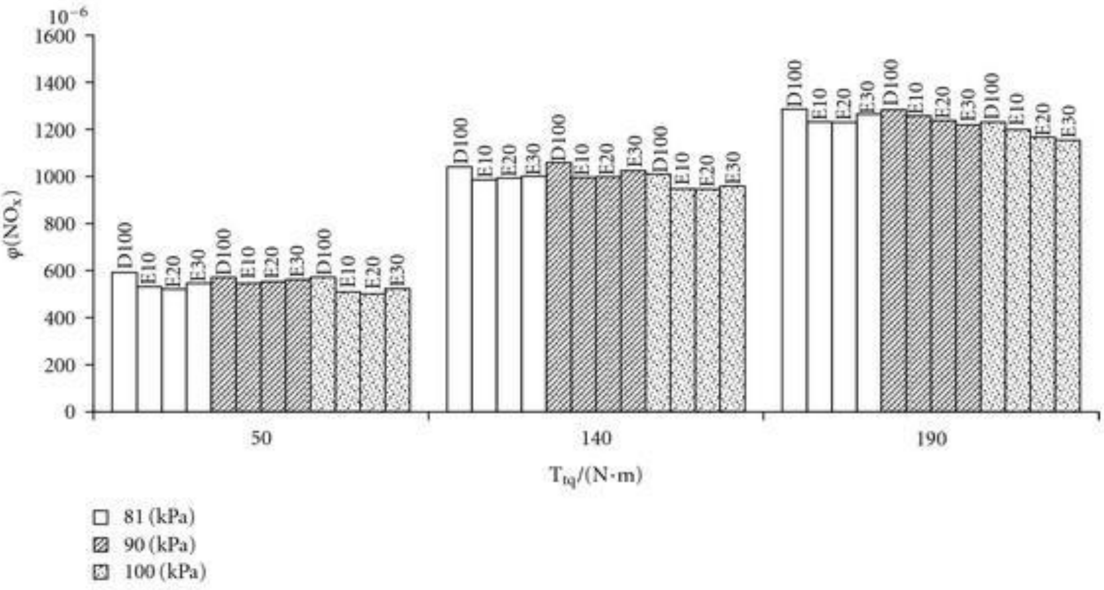
Emission Characteristics of NOx: At different atmospheric pressures and mix proportions, the NOx emissions showed the similar trend. The ethanol-diesel blends reduced the NOx emission at most modes. At 1400 and 2200 r/min and low load, the slight increase of NOx emission for E30 should be rendered by the bad emulsification at higher mix proportion. The increasing oxygen content can promote the formation of NOx; however, the maximum gas temperature is the most important factor of NOx formation, so the decreased gas temperature caused by higher latent heat of vaporization of ethanol can reduce the NOx emission.



Fig(g): - Comparison of NOx emissions of different atmospheric pressure and mix proportion at speed 1400 rpm



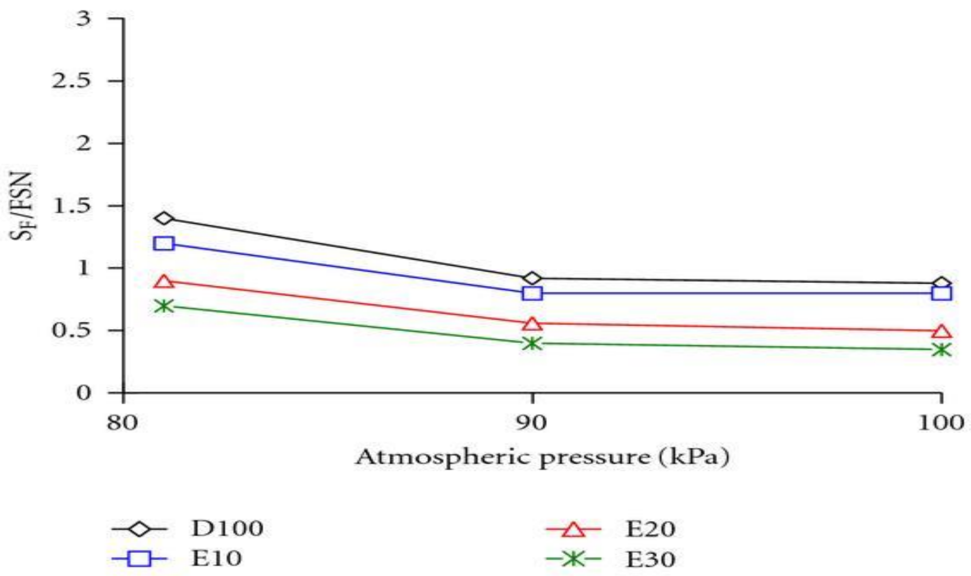
Fig(h): - Comparison of NOx emissions of different atmospheric pressure and mix proportion at speed 2200 rpm



Fig(i): - Comparison of NOx emissions of different atmospheric pressure and mix proportion at speed 3200 rpm.

Emission Characteristics of Smoke:

At different atmospheric pressures, the smoke emissions of ethanol-diesel blends had similar tendency as those of diesel. The smoke emissions of both blends and diesel were decreased with the increasing atmospheric pressures.

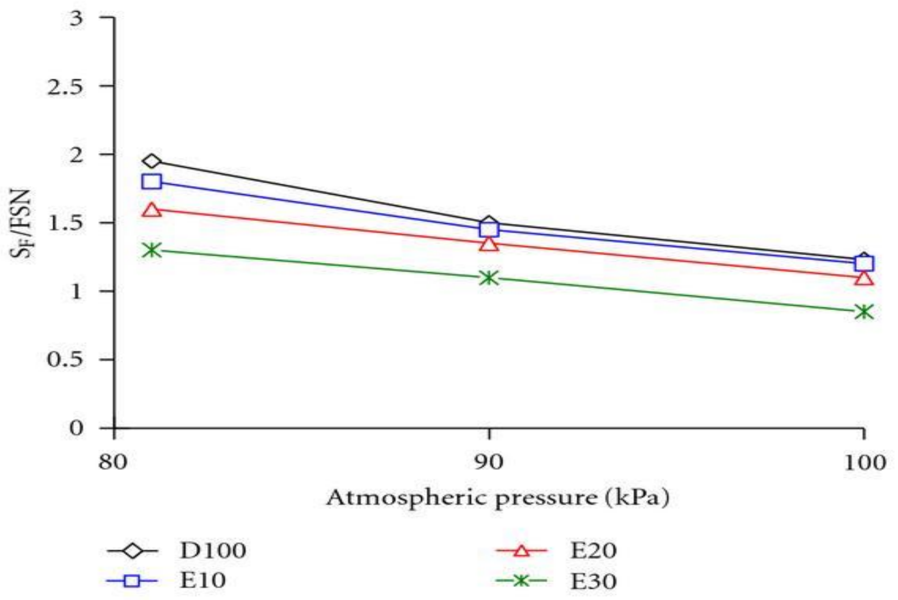


Fig(j): -At speed of 1400 r/min

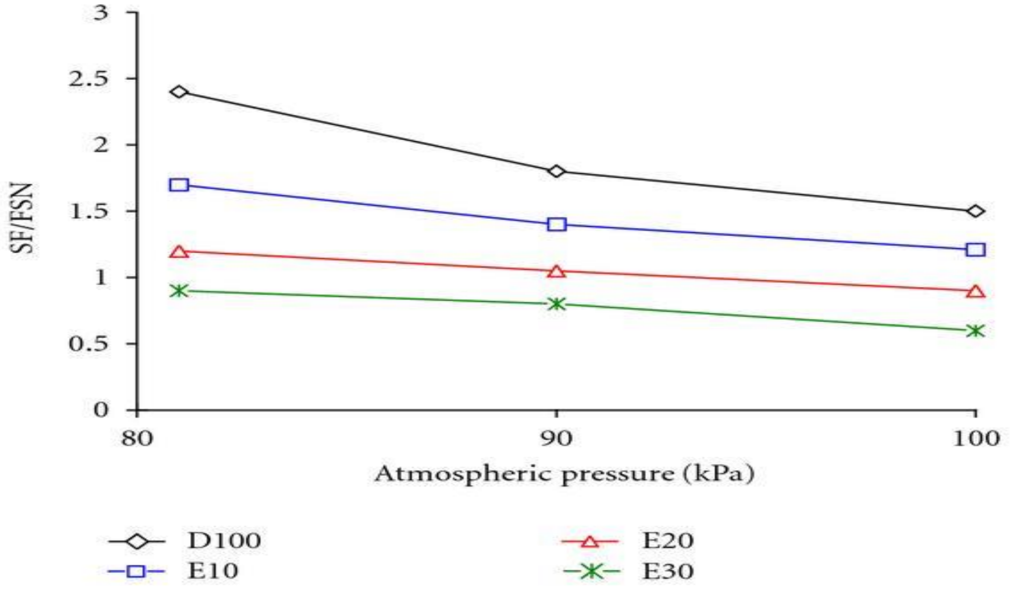
Compared with pure diesel, E10, E20, and E30 reduced the smoke emissions by 18%~26%, 36%~47%, and 50%~63%, respectively, at 81 kPa, by 18%~19%, 40%~38%, and 63%~59%, respectively at 90 kPa, and by 17%~19%, 34%~42%, and 58%~62%, respectively, at 100 kPa.

It showed that higher mix proportion of ethanol resulted in lower smoke emission at

the same atmospheric pressure and load. At 2200 r/min when atmospheric pressure ranged from 81 kPa to 90 kPa the smoke emissions of E10, E20, and E30 were reduced by 39%, 43%, and 55%, respectively. However, when atmospheric pressure ranged from 90 kPa to 100 kPa, the smoke emissions of E10, E20, and E30 were reduced by 14%, 6%, and 4%, respectively. It can be seen that atmospheric pressure has significant effect on the smoke emission when atmospheric pressure is lower than 90 kPa. The influence is weakened when it is above 90 kPa.



Fig(k): -At speed of 2200 r/min



Fig(l): -At speed of 3200 r/min

1.3. Hydrogen as Fuel:

Emission characteristics:

The major toxic pollutants present in the emissions of Internal combustion engines constitute of HC, CO, NOx and CO2.

HC Emissions:

- HC emission gradually decrease with increase in hydrogen fraction present in the mixture.
- Hydrogen addition in the fuel reduces unburnt hydrocarbons to the extent of 6 to 20% depending on the fuel consideration.

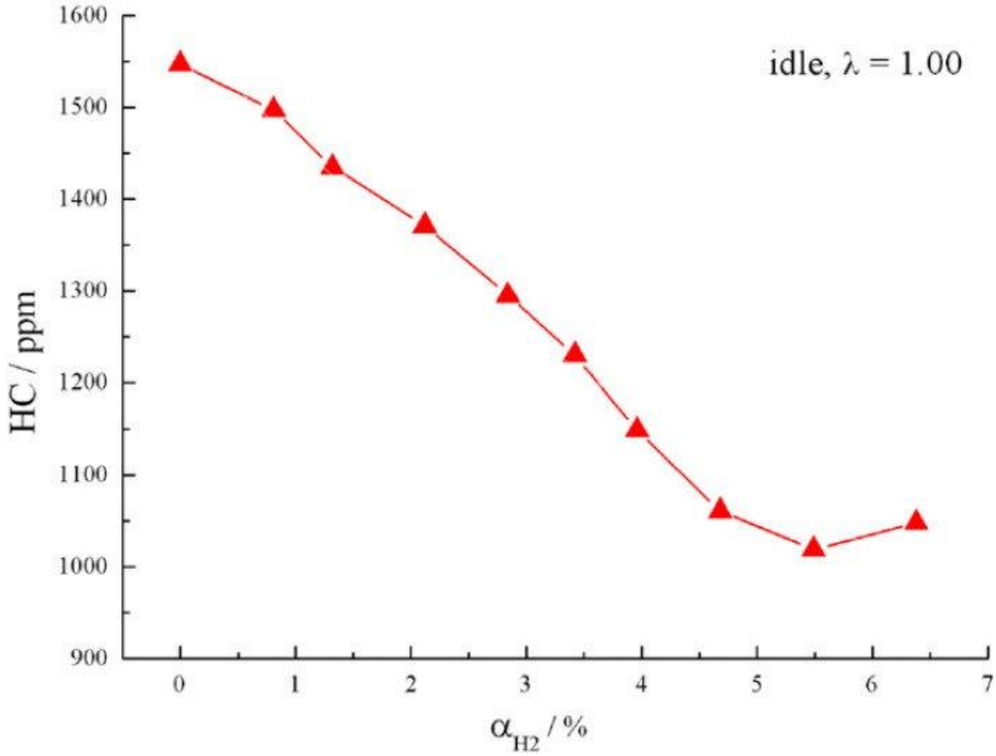


Fig1.3(a): - HC emission variation with hydrogen fraction for SI hydrogen-ethanol engine.

CO and CO2 emissions:

- Hydrogen has higher air-fuel ratio than petrol.
- If the engine runs under lean condition CO emissions are improved.
- The CO2 emission decrease with increase in hydrogen content.
- Hydrogen being carbonless fuel, its combustion generates no CO2.
- At specified excess air ratio, the carbon content in the petrol-hydrogen fuel mixture is reduced after hydrogen enrichment, causing lesser CO2 emission.
- CO2 emission can be further reduced in hydrogen-gasoline mixture fuelled engine by adapting large excess air ratios.

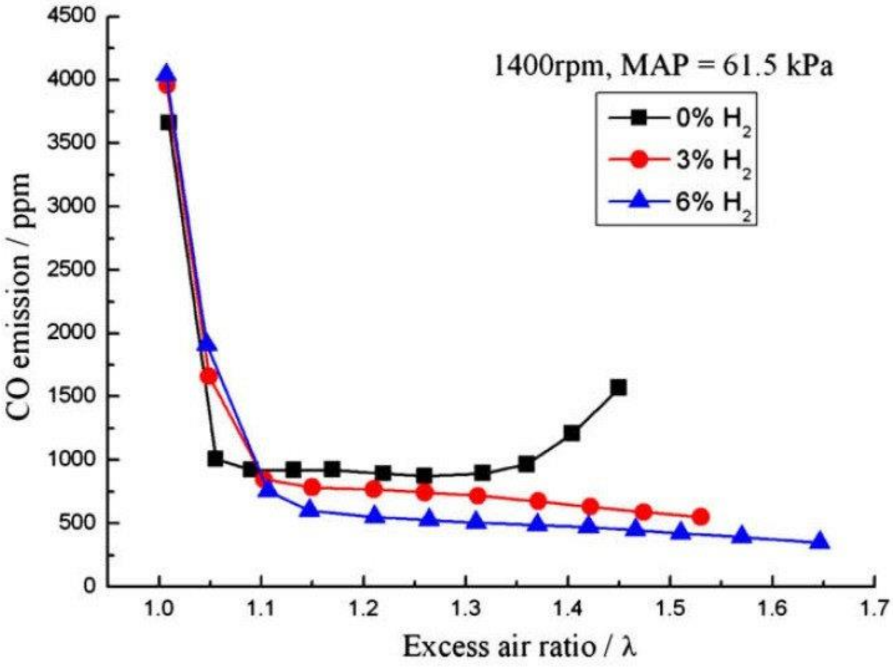
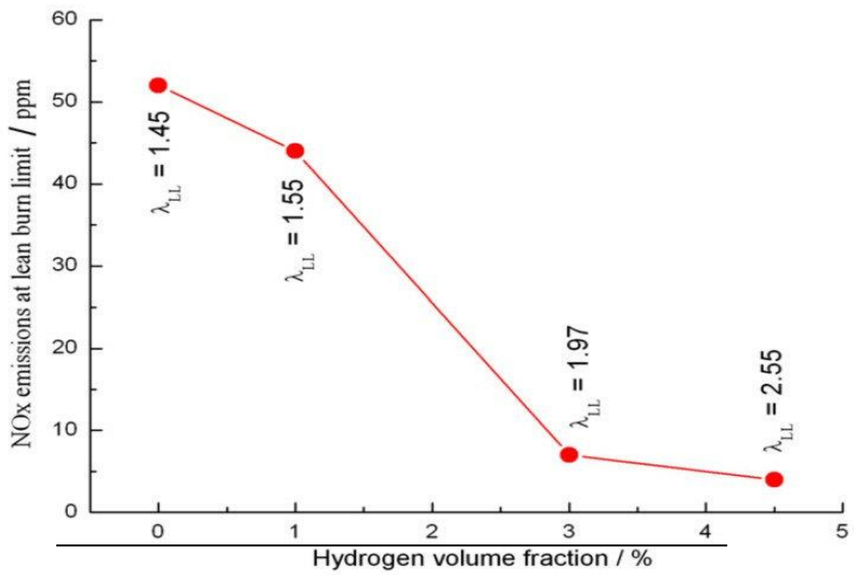


Fig 1.3(b): - CO emission variation vs. excess air ratio

NOx Emissions:

NOx emissions are found to increase with increase in hydrogen fractions in the mixture mainly in case of SI engines. NOx emissions mainly depend upon conditions like temperature and oxygen concentration present in the cylinder.



Fig(c): -NOx emission variation at lean burn limits vs hydrogen volume fraction at 1400rpm and 61.5KPA.

The peak in cylinder temperature increases with increase in percentage of hydrogen for the given excess air ratio and constant oxygen concentration, thus increasing NOx concentration. Although the hydrogen enriched ejects more NOx emissions when the excess of air ratio is around stoichiometric conditions, NOx emissions for all hydrogen enrichment levels drop to an acceptable value when the engine runs under high lean conditions. Thus, the total energy flow rate at the lean burn limit decreases with increase in hydrogen addition fraction, causing reduced in-cylinder temperature and thus NOx formation is constrained. The below figure shows the drop in NOx emissions from 52ppm at the original engine to a largely lower value at 4.5% of the hydrogen enriched gasoline engine.

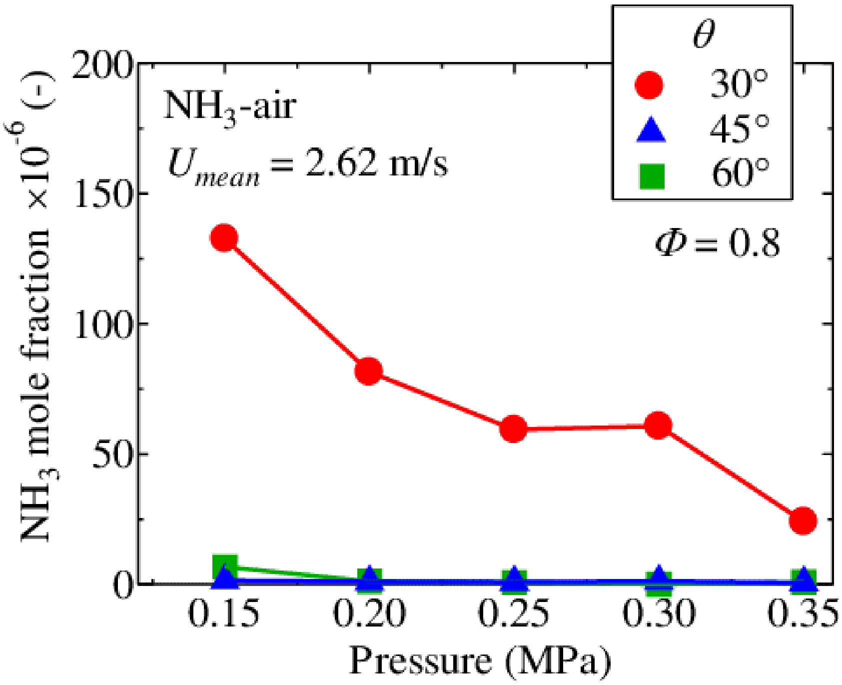
Greenhouse effect:

The emission of hydrogen to the troposphere leads to changes in the global distributions of methane and ozone, leading to increased radiative forcing. This prompts the questions whether a global hydrogen economy would have consequences for global warming and ultimately whether a hydrogen economy would be better or worse than the fossil-fuel economy that it replaces. It is estimated that the global hydrogen production capacity required to replace the entire current fossil-fuel based energy system would need to be of the order of about 2500 Tg H2 yr -1. If there was a leakage rate of the order of say 1%, then the global hydrogen economy would emit about 25 Tg H2 yr -1. Using the GWP of 5.8 described in Chapter 3 above, the global hydrogen economy would have the radiative forcing equivalent to 25 * 5.8 Tg CO2 yr -1, that is to say about 150 Tg CO2 yr -1. The fossil fuel system it would replace has a CO2 emission of 23,000 Tg CO2 yr -1. On this basis, the global hydrogen economy with a leakage rate of 1% has a climate impact of 0.6% of the fossil fuel system it replaces. If the leakage rate was 10%, then the climate impact would be 6% of that of the fossil fuel system.

1.4. Ammonia as fuel:

Emission characteristics:

Gas turbine combustors are operated at elevated pressures. The pressure ratio employed in the macro gas turbine plant. Therefore, the effect on combusts or ambient pressure on NH3 and NO emissions were investigated in the study at lean and rich conditions. The inlet velocity was kept constant in these experiments to ensure a constant fluid residence time with an increase in pressure. It was confirmed in the present study that the ambient pressure has significant effects on unburned NH3 and NO emissions from the combustor. NH3 pressure will be decreased with increase in pressure. This may be due to increased ammonia consumption resulting from faster burning rate. The mass consumption rate of fuels in turbulent combustion may increase with pressure owing to increased flame front wrinkling by turbulence, flame intensity and thermo diffusive effects.



Fig(a):- Variation of NH3 with ambident pressure

Global warming:

- Odour and ammonia are relevant pollutants from monogastric animals.
- The modification of the indoor climate due to global warming is considered.
- An increase of 0.16%/a of NH3 emission was determine for confined livestock.
- The increase of NH3 emission counteract the clean air efforts.
- No significant impact on the separation distances for odour was found.

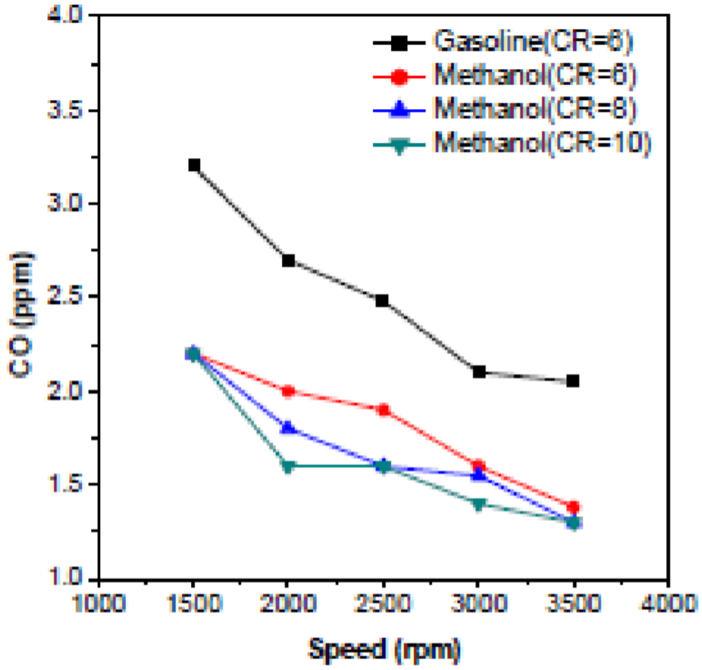
Ammonia and odour are the most relevant pollutants emitted from livestock buildings used for monogastric animal production. Whereas odour can cause annoyance in the close vicinity of the source, emission of ammonia is a precursor for the formation of particulate matter and acidification on a regional scale. Because of clean air regulation in Europe, total ammonia emissions reduced by 23% between 1990 and 2015 whilst, over the same period, anthropogenic warming became more and more evident. By a simulation of the indoor climate of a confined livestock building with a mechanical ventilation for 1800 fattening pigs, the modification of the odour and ammonia emission was calculated for the period between 1981 and 2017. For ammonia emission, a relative increase of 0.16% per year was determined. But following the clean air endeavour between 1990 and 2015 emissions over that period were reduced by 23%. The global warming signal counteracting this reduction in the range of 4% during over this period, which means that the overall reduction for the ammonia emission was only 19%. For Austria with a global warming increase of 1% from 1990 to 2015, this gives an increase in emissions of 5% instead. Odour emissions also increased by about 0.16% per year. The relative increase of the separation distances for the four cardinal directions was about 0.06% per year, the related increase for the separation area was 0.13% per year. This case study on the fattening pigs shows that the global warming signal has a negligible impact on separation distances.

1.5. Methanol as fuel:

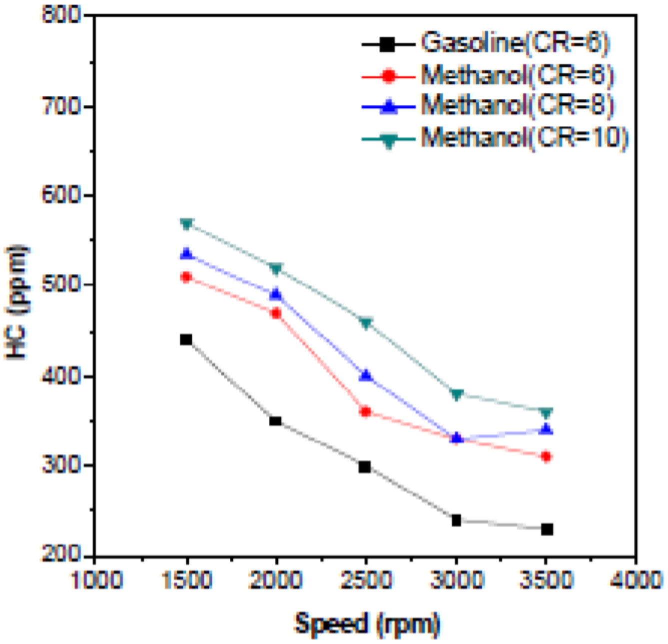
Emission Characteristics:

- Most of the emissions from the engines are carcigenous and harmful for environment as well as human health. Only four most important emissions considered under this study are CO, unburned hydrocarbon (UHC), NOx and CO2.
- The effect of methanol addition to petrol/gasoline on the pollutants emissions is briefly discussed in the following section. After several investigations They observed an improvement in the engine cold start and also the reduction in CO and HC emissions significantly due to more oxygen content of the blended fuels.
- As nitrogen oxides (NOx) emission is more with alcohol blended fuels, a three-way catalytic converter (TWC) was also been used for the treatment of the exhaust from the engine. The use of TWC reduces the NOx emissions and further improves HC and CO emissions.
- The non-regulated emissions like unburned methanol and formaldehyde increase with the fraction of methanol. On the other hand, from the study of the emission characteristics of methanol-gasoline blends made.
- It is reported that increase in CO emission and decrease in HC emission occur using methanol-gasoline blends. They also reported that CO2 emission increases with methanol addition to the gasoline fuel. Minimum CO2 emission was obtained when M5 blend is used. From the exhaust emissions results.
- It is reported that HC emissions during the rich combustion increases with increase in methanol into gasoline at relatively low temperature due to enhanced evaporation of the blended fuel. The emission data from the experimental study conducted.
- They reported that CO, NOx, CO2 emissions are decreased with methanol at higher compression ratio compared to gasoline. Only the HC emission is higher at any compression ratio compared to gasoline.
- For all compression ratios and all fuels, increasing the engine speed decreases CO emission and it is lower for methanol than that with gasoline. By increasing compression ratio from 6:1 to 10:1, CO emission decreases by almost 16%. From the graphs of CO2 emission vs speed, it is observed that at all the compression ratios with methanol, CO2 is lower than that with gasoline as alcohols have both lower carbon-hydrogen ratio and carbon con-tent than gasoline.
- By increasing compression ratio from 6:1 to 10:1, a 13% increase in CO2 was obtained when methanol was used. The effect of methanol addition to gasoline on HC emission at various compression ratios.
- It is reported that HC emission is higher for methanol than that with gasoline at all the compression ratios of 6, 8 and 10 considered in their study. Also, HC emission increases by about 12% with increasing the compression ratio from 6:1 to 10:1 for methanol.
- This is because as the compression ratios increase the combustion chamber surface/volume ratio increases also and the flame cools in the places near to surface and misfire occurs thereby increasing HC emission.

- The effect of both fuels on com-pression ratios and NOx emission and NOx emission increases by about 16% with increasing the compression ratio from 6:1 to 10:1 due to the increase in combustion temperature.



Fig(a): - comparison of methanol with gasoline with CO as emission



Fig(b): - comparison of methanol with gasoline with HC as emission

Global Warming:

Ten or more years ago, a typical methanol manufacturing plant would emit about 0.9—1.0 metric tonnes of carbon dioxide for every ton of methanol produced. In addition to the environmental concerns, large CO2 emissions represent operational inefficiencies in a methanol plant, since the carbon emitted as CO2 is not available for making methanol molecules. In fact, excess CO2 from other industrial facilities can also be captured and consumed to increase methanol production. Through the implementation of efficiency improvements and through replacing of older facilities with newer plants that use more efficient technologies, over the last decade methanol plants have been able to significantly reduce CO2 emissions by up to 40%. Some facilities report emissions as low as 0.54 tonnes of CO2 / tonne of methanol produced. This is equivalent to emitting 3.8 lbs of CO2 per gallon of methanol.

1.6. CNG as Fuel:

Emission Characteristics:

HC emissions: Hydrocarbon emissions were found to be higher throughout the load range for the injected biodiesel CNG dual fuel combinations compared to diesel-CNG (Figure 4). The overall HC emissions levels using DFC is higher due to the CNG charge, which causes lean, homogeneous, low-temperature combustion, resulting in less complete combustion. This is because small amount of pilot fuel cannot propagate fast and far enough to ignite the whole premixed fuel mixture. This is due to the increase of burnt gas temperature, which promotes the oxidation of unburned hydrocarbons. Under dual fuel operation, the filling of the crevice volumes with unburned mixture of air and gaseous fuel during compression and combustion is an important source dominating the formation of HC emissions [23]. HC emissions of JOME-CNG operation are found to be higher than HOME-CNG and diesel-CNG dual fuel operation. HC emission levels for diesel-CNG, HOME-CNG and JOME-CNG dual-fuel operation at 0.5 kg/h flow rate of CNG were found to be 61, 65 and 69 ppm respectively at 80% load.

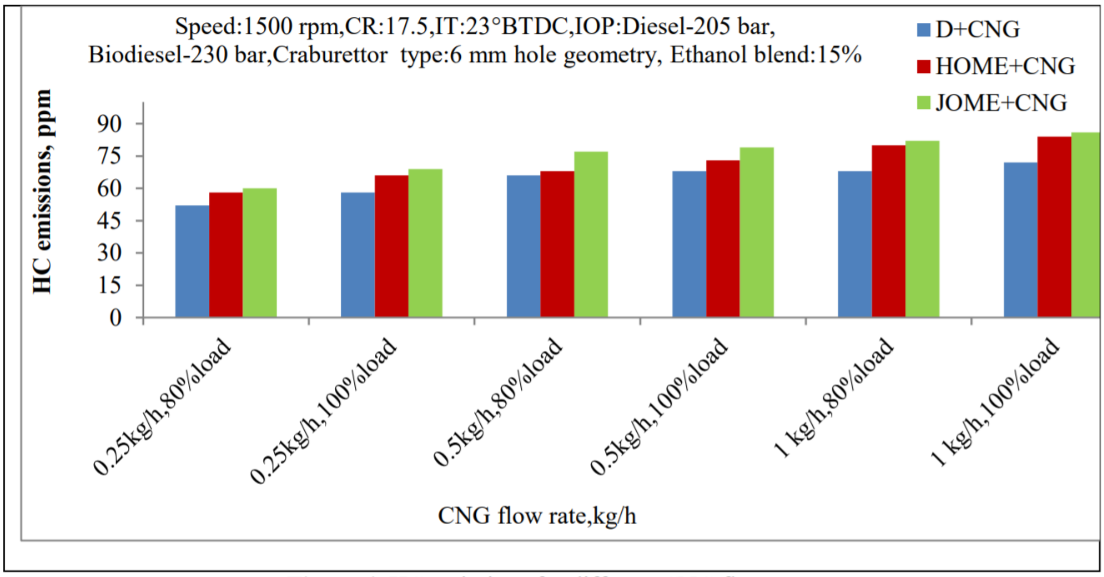


Figure 4. HC emissions for different CNG flow rates

Fig(a): - HC emissions for different CNG flow rates.

CO emissions: The carbon monoxide variation for various CNG flow rates are represented in figure 5. For CNG-diesel fuel combinations, the exhaust emissions of CO were lower compared to pilot fuels such as HOME and JOME along with CNG respectively. Higher heat release rate at premixed burning phase, resulted in lower CO for CNG-diesel mixture. The rich air-fuel ratio relative to stoichiometric invariably produces CO. The CO levels are observed to be minimum for lower CNG flow rate. As CNG flow rate increases CO emission and later on these begin to decrease. Poor engine performance was noticed as CNG flow rate is increased beyond 1 kg/h. The severe onset knock is encountered at higher CNG flow rate more than 1 kg/h. CO emission levels for diesel-CNG, HOME-CNG and JOME-CNG dual-fuel operation at 0.5 kg/h flow rate of CNG were found to be 0.13, 0.15 and 0.18% respectively at 80% load.

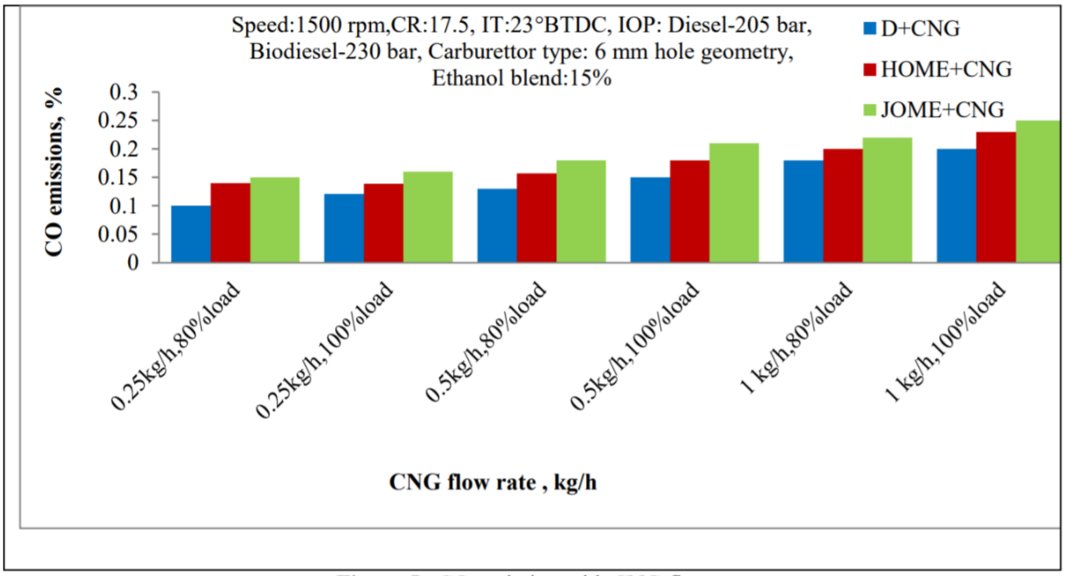


Figure 5. CO variation with CNG flow rates

Fig(b): - CO variation for different CNG flow rates.

NOx emissions: The NOx variation for different CNG flow rates is shown in figure 6. The NOx formation in CI engine is mainly because of more oxygen supply and higher charge temperature inside the cylinder. For CNG– diesel DFC operation, NOx emissions were higher followed by biodiesel-CNG fuel combination. The lower calorific value and heavier molecular structure of injected biodiesels in dual fuel operation leads to higher NOx emissions. As gas flow rate increased for all the DFC combinations the NOx emissions levels increased. NOx emission levels with diesel-CNG, HOME-CNG and JOME-CNG dual-fuel operation at 0.5 kg/h flow rate of CNG were found to be 910, 800 and 760ppm respectively at 80% load.

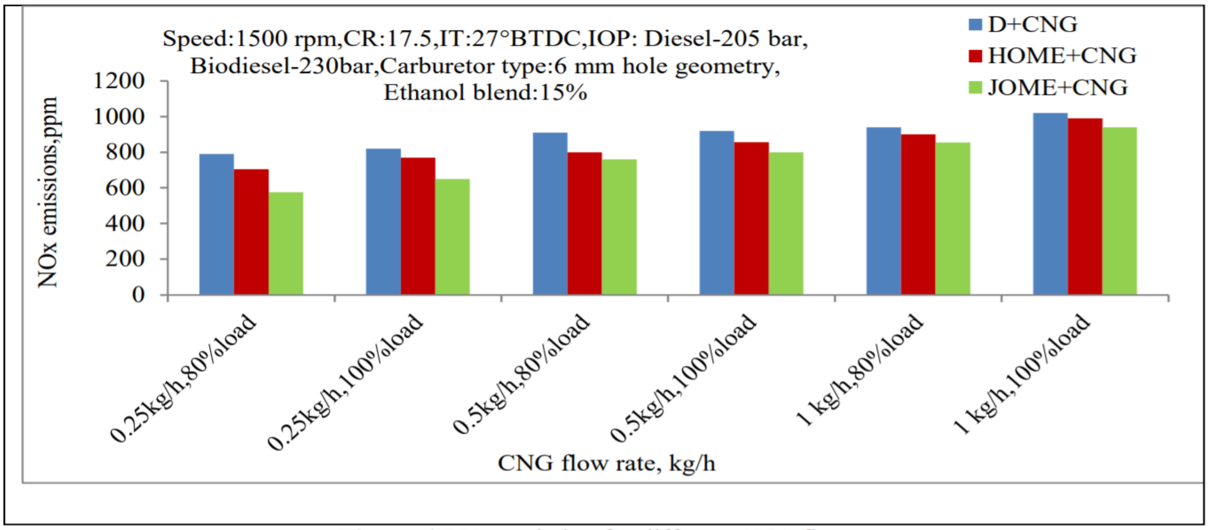


Figure 6. NO_x variation for different CNG flow rates

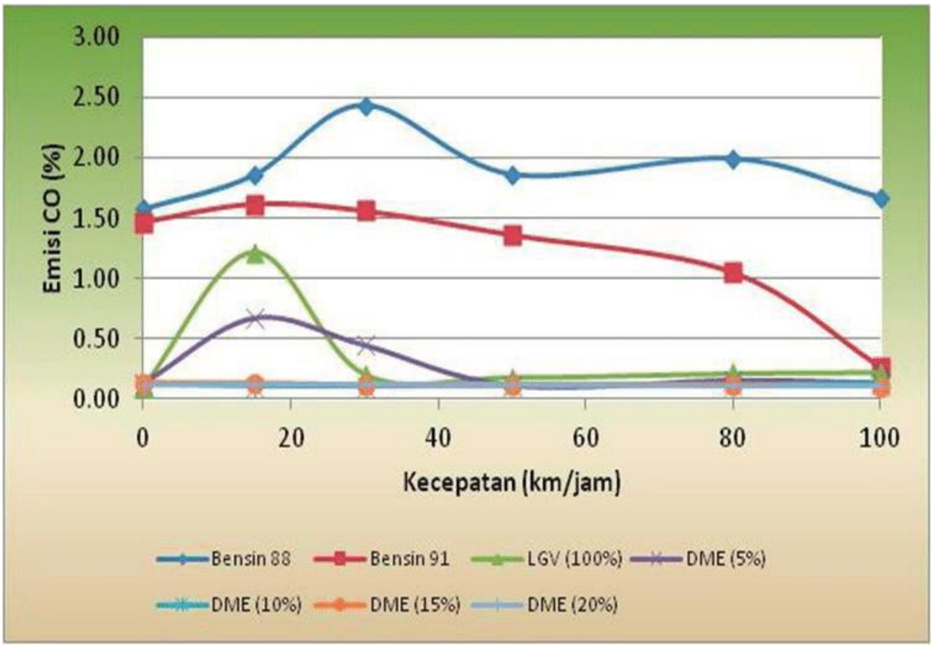
Fig(c): - NOx variation for different CNG flow rates

Emissions:

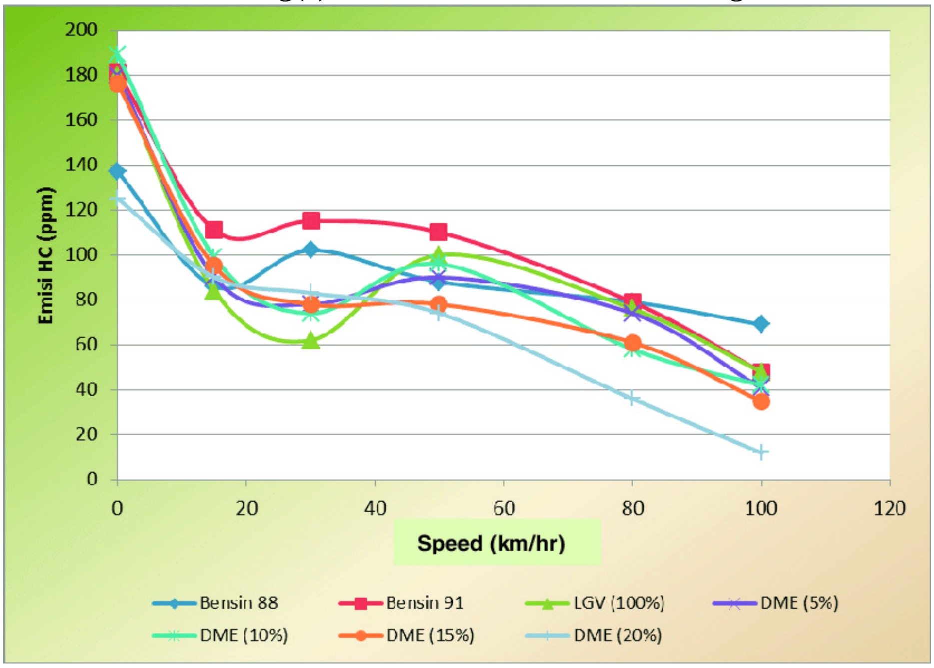
- CNG vehicles for one mile emits 20 per cent more greenhouse gases than a diesel vehicle for one mile. From the perspective of global warming, the decision to switch to CNG from diesel is a harmful one," the affidavit quoted the report.
- "CNG vehicle emits 80 per cent particulate matter and 35 per cent less hydrocarbons. However, the output of carbon monoxide is over five times more than diesel," stated the affidavit quoting the report.
- "If CNG is used, there will be a reduction in particulate matter. But other pollutants show a considerable increase. In fact, there is an increase in the emission of greenhouse gases with the increase in the age of CNG engine," argued the government quoting the report.

1.7. Dimethyl Ether as fuel: The emission level of the blended fuel was analysed using CO dan HC as parameters. It is commonly known that gaseous fuels produced lower CO than fossil fuel because tracking to their origin the carbon content inside the gaseous fuels is lower than fossil fuel.

it can be observed that the introduction of gaseous fuels into SI engine also lowering the HC emission compared to that produced by Gasoline 91. The good effects of blend the DME into LGV also can be observed in Fig.6, where the HC emission of all blends is lower than that of LGV. The value of decreased HC emission is 14.0 %, 15.2 %, 15.6 %, 21.4 %, and 40 % for DME 5 %, DME 10 %, DME 15 %, and DME 20 %, respectively. From the research done by Seokhwan et al. [11], it is also reported that in term of the emission level, NOx produced by DME and its blend with LPG is considered very low.



Fig(a): - CO emission level versus engine

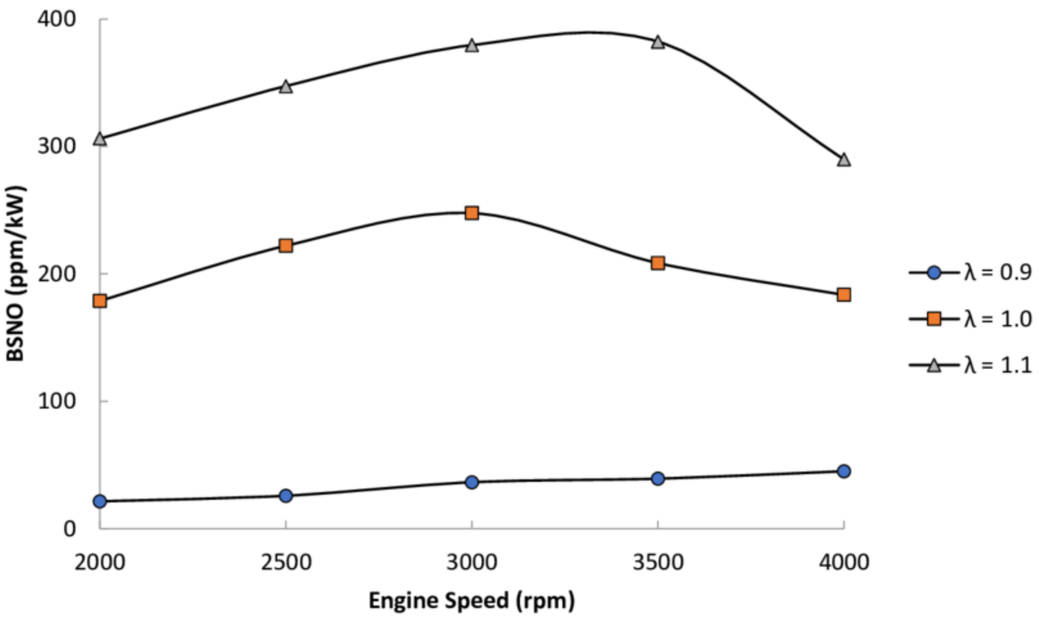


Fig(b): -HC emission level versus engine

1.8. Natural gas as fuel:

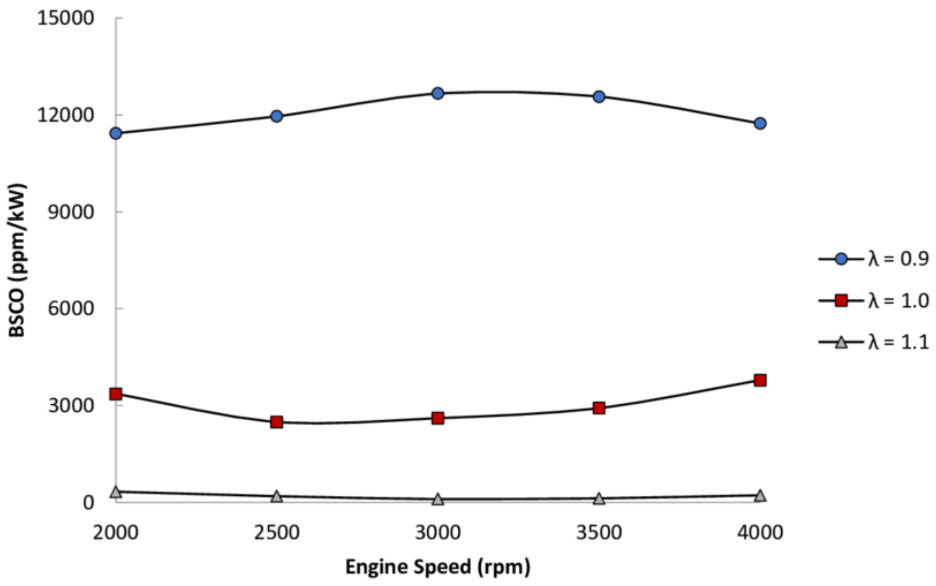
Emission Characteristics:

Brake Specific Nitric Oxide emission (BSNO): It is obvious from the graph, when engine speed increases, at early engine speed (from 2000 rpm to 3000 rpm), the nitric oxide emission also increases for all type of air fuel ratios under consideration. The nitric oxide emission is at lowest point before it increases moderately when engine speed is increased from 2000 rpm until 3000 rpm. This is so because, increase in engine speed, increase the turbulence within the engine cylinder and this also increases combustion temperatures. This formation of BSNO emission within the engine cylinder strongly depends on the combustion temperature; hence, the reason for increase in BSNO emission. In addition, the emission reduces from 3000 rpm until 4000 rpm because of reduction in oxygen concentration inside the combustion engine cylinder and this decreases the combustion temperature and thus BSNO reduces. Moreover, highest nitric of oxide emission trend occurs at excess air fuel ratio of λ = 1.1(Slightly Lean). This is largely due to the fact that oxygen concentration at slightly lean mixtures results in higher BSNO emission concentration as compare with the other mixtures. Further, increases in excess air ratio will remarkably decreases the cylinder gas temperature and this decrease the BSNO emission concentration. The lowest BSNO emission, occurs at λ = 0.9 due to excessive deterioration of the combustion quality engine.



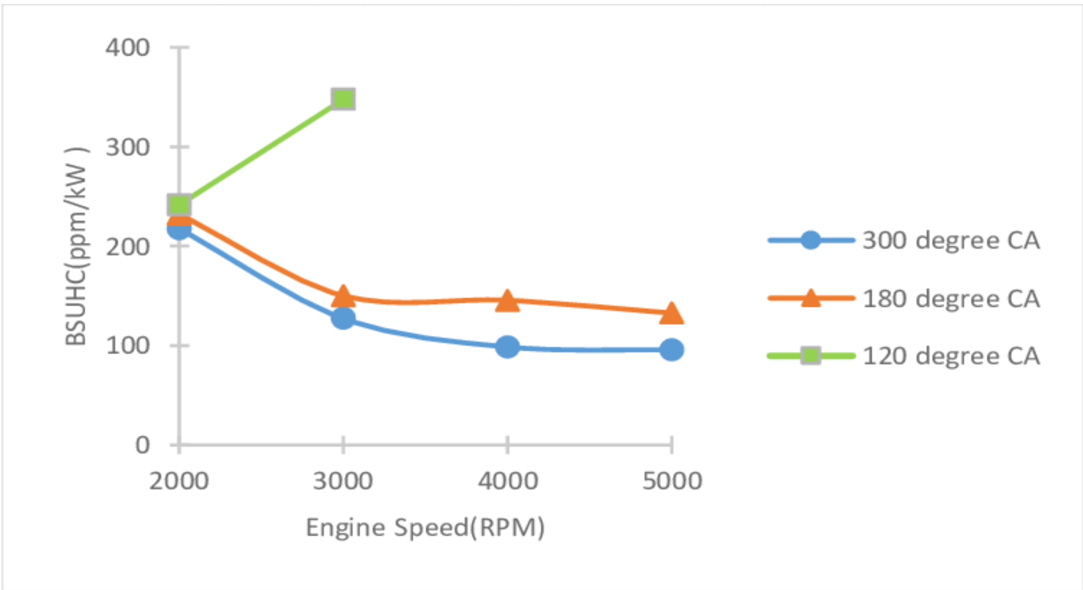
Fig(a): - BSNO against Engine Speed at Various Air Fuel Ratios

Brake Specific Carbon Monoxide (BSCO): The trend of the graph shows the approximately linearly constant graph. Based on the trend of the graph obtained, there is no significant effect on BSCO emission for all the mixtures under consideration λ = 0.9 (Rich Combustion), λ = 1.0 (Stoichiometric Combustion) and λ = 1.1(Slightly Lean Combustion). The graph on BSCO emission, shows that the highest BSCO occurs at rich mixtures (λ = 0.9) compared with stoichiometric mixtures (λ = 1.0). The reason being that, complete oxidation of the fuel carbon to carbon dioxide is not possible due to insufficient oxygen (incomplete combustion). For lean mixtures, CO levels are approximately constant at a low level of about 0.5 percent or less. Good agreement achieved with this experiment result.



Fig(b): -BSCO against Engine Speed at Various Air Fuel Ratios

Brake Specific Unburned Hydrocarbon (BSUHC): For a rich mixture λ = 0.9, the trend of the graph showed decrement in the BSUHC emission when the engine speed is increases from 2000 rpm to 3000 rpm. This is largely due to the lower expansion and exhaust stokes temperatures. As the speed increases from 3000 rpm upward, the BSUHC increases. This might be so because of slow combustion, partial burning and even misfire in turn occurs with increasing frequency. In addition, the highest BSUHC occurs at rich mixture. This is because of lack of oxygen for after burning of any unburnt hydrocarbon that escape the primary combustion process within the engine cylinder and exhaust system. For the other mixture (i.e., Stoichiometric and slightly lean mixture), BSUHC emission varies little with excess air ratio due to lower combustion efficiency.



Fig(c): -BSUHC against Engine Speed at Various Air Fuel Ratios