PERFORMANCE EVALUATION AND TESTING OF GASSOLINE – ETHANOL BLENDS

A Project Report submitted in partial fulfillment of the requirements for the award of degree of

Bachelor of Technology

in

Mechanical Engineering

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CERTIFICATE

This is to certified that **Alok Kumar, Deepak Singh, Shashank Dixit & Vaibhav Upadhyaya** of B.Tech. Final year have successfully completed their project report on **"Performance Evaluation and Testing of Gasoline-Ethanol Blends"** for partial fulfillment of requirement for the award of degree of **Bachelor of Technology** in **Mechanical Engineering** from **Kamla Nehru Institute of technology, Sultanpur** during the academic year 2018-19 under my guidance and supervision.

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ACKNOWLEDGEMENT

We have immense pleasure to present this Project Report on **"PERFORMANCE EVALUATION AND TESTING OF GASOLINE-ETHANOL BLENDS".** We want to take this opportunity to express our profound gratitude and deepest regards to our project guide **Prof. Ambuj Kumar (Deptt. of Mechanical Engg.)** for his exemplary valuable information and guidance, monitoring and constant encouragement throughout all the time of completion of our project work along with preparation of this report.

We want to also sincerely express our gratitude to all other teachers and faculty members of this institution for their cordial support, valuable information and guidance which helped us in completion of our project.

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DECLARATION

We hereby declare that this submission is our own work and that, to the rest of our knowledge and belief, it contains no material previously or written by another person nor material which to a substantial extent has been accepted for the award of any other degree of the university or other institute of higher learning, except where due acknowledgement has been made in text.

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ABSTRACT

Automotive sector is the biggest sector in the world which used various fuels as well as automobiles are the easy and reliable source for transportation and power generation. The power developed by an automobile is basically depends upon the fuel used for combustion. Gasoline and Diesel are basic fuels in liquid form which are extensively used in the world from last century. These fuels are derived from crude oil, which is available in limited quantity in the world. The increasing demand of these fuels will create a problem for energy crises in the future. Transport fuel demand is generally satisfied by the fossil fuel demand. However, resources of these fuels are decreasing, prices of fossil fuels are expected to rise and the combustion of fossil fuels has adverse effect on the climate.

Hence due to lack of crude oil reserves and increasing price of petrol alternative fuels are coming to picture. The researchers are looking for the substitution of the hydrocarbon fuels with some alternative fuels like alcohols, ethers etc due to their compatible properties with hydrocarbons. Today Most of the alternative fuels are biomass derived and easily available. Many alternative fuels blends have been introduced in past and they gave very satisfying results. Therefore, in this project the ethanol which is high octane biomass derived fuel is blended with petrol and tested at different blend ratios. The performance and emission characteristics of the engine were studied. The results show the reduction in consumption of fuel as the brake specific fuel consumption was found to decrease. The improvement in mechanical efficiency is also observed. While the emission parameters were also improved, both HC and CO emissions were significantly reducing as the load was increasing.

At last the problems related to limited blending of ethanol are discussed along with the future ideas to solving these problems and scope related to increasing the blend proportion in India as a conclusion of our report.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols/Abbreviation	Description
ºC	Degree Celsius
BSFC	Brake specific fuel consumption
Cal	Calories
CR	Compression Ratio
GDP	Gross Domestic Product
CO	Carbon monoxide
HC	Hydrocarbon
NO_x	Oxides of nitrogen
CO_2	Carbon dioxide
CV	Calorific Value
m_f	Mass of fuel
K	Kelvin
kCal	Kilocalories
EBP	Ethanol blended petrol
kJ	Kilo Joule
kW/hr	Kilo Watt per hour
ppm	Parts per million
rpm	Revolution per minute
S.I.	Spark ignition
DMC	Dimethyl Carbonate
IC	Internal Combustion
MTBE	methyl tert butyl ether
IP	Indicated Power
BP	Brake Power
FP	Frictional Power
Q	Heat Released/Absorbed

1. INTRODUCTION

Energy has always been a key player in the survival of human beings or any other species in the world. From the time of ancient civilisation humans have been very keen to understand the nature of different forms of energy present in the surroundings. But the first breakthrough in this field came by the invention of steam power plant which was the centre stage of the industrial revolution in Europe and then the whole world. In this the steam was formed by conversion of chemical energy of coal or wood into mechanical energy. The next energy revolution for human being came as the ability of human being to generate and transmit electricity. The coal remain the major source of energy until the mid of 20th century when it was dominated by oil.

Although hydropower, largely in the form of water wheels, has been in use by human society for centuries, hydroelectricity is a more recent phenomenon. The first hydroelectric power plants were built at the end of the 19th century and by the middle of the 20th century were a major source of electricity. As of 2010 hydropower produced more than 15% of the world's electricity.

In the 20th century, Einstein's Theories of relativity and the new science of quantum mechanics brought with them an understanding of the nature of matter and energy that gave rise to countless new technologies. Among these technologies were the nuclear power plant and the solar or photovoltaic cell both of these technologies emerged as practical sources of electricity in the 1950s. Nuclear energy quickly caught on as a means of generating electricity. Today, nuclear energy generates almost 15% of the world's electricity. Solar energy provides less than 1% of the world's electricity. Solar is the only primary energy source that can generate electricity without relying on Faraday's Law. Particles of light can provide the energy for the flow of electrons directly.

Humans have also managed to harness the geothermal energy of Earth to produce electricity. The first commercial geothermal power plant was built in 1911 in Larderello, Italy. geothermal energy is a result of the continuous radioactive decay of unstable elements beneath Earth's surface and the gravitational energy associated with Earth's mass. The radioactive decay and gravitational energy produce thermal energy that makes its way to the surface of Earth, often in the form of hot water or steam.

Although humans have found many different sources of energy to power their endeavors, fossil fuels remain the major source by a wide margin. The three fossil fuel sources are coal, oil, and natural gas. Oil has been the major fuel supply for industrialized society since the middle of the 20th century and provides more of the energy used by humans than any other source. Coal is second on this list, followed closely by natural gas. Together they accounted for more than 80% of the world's energy use in 2010.

As the time passes, it is believed that the petroleum products and crude oil will be not enough and will be costly. Various researches are going on for the improvement of fuel economy of engines. However as the demand and availability for petrol and diesel is somewhat unbalanced and there is a need to balance since that is mainly happened due to enormous increase in number of vehicles. If the same situation continues then the scenario will be more disastrous and petrol and diesel will be more costly and limited. With increased use and the depletion of fossil fuels, today more emphasis is given on the alternate fuels.

There is an essential need of alternate fuels in a way or other. Today intensive search for the alternative fuels for both spark ignition (SI) and compression ignition (CI) engines and it has been found out that the biomass derived fuels are suited for the alternate fuels. In spark ignition engines fuels like eucalyptus oil and orange oil are the suitable substituent for the petrol. They can be blended with petrol over a wide range of percentage according to the requirement. Another reason for the need of alternate fuels for IC engines is the emission problems. Combined with other air polluting factors, the large number of automobiles is a major contributor to the air quality problems of the world. As these fuels cannot be run directly in the engines therefore these are blended with gasoline at various percentage. One of the main reasons for selecting these fuels is the similarity in the properties of these with gasoline and they are miscible with gasoline without any phase separation. The engines used for these blending or for alternate fuels are modified engines which were originally designed for gasoline fuelling. The ethanol can be used in spark-ignition engines with very little engine modification as a blend with gasoline. Since the octane number of ethanol is more than gasoline, so it enhances the octane value of the fuel when it is blended with low octane gasoline. At the same time the compression ratio (CR) which is dependent on knock can be increased when these fuels are blended with gasoline.

Hence we can say that as with any human endeavor, the use of energy resources and the production of electricity have had and will continue to have impacts and consequences, both good and bad. Awareness of the energy used to grow, process, package, and transport food, along with the energy used to treat water supplies and wastewater, is important if society is to minimize waste and maximize efficiency. These are just a few examples of the many energy issues people can become informed about. Human society has and will continue to develop rules and regulations to help minimize negative consequences. As new information comes to light and new technologies are developed, energy policies are reevaluated, requiring individuals and communities to make decisions. This guide outlines the understandings necessary for these decisions to be informed.

2. GLOBAL AND INDIAN ENERGY SCENARIO

2.1. GLOBAL SCENARIO

As per the information received from Department of Chemicals & Petrochemicals, in India ethanol is produced mainly from molasses which is a by-product during production of sugar from sugar cane as compared to production of ethanol in USA which is mainly from corn and in Brazil, it is from sugar cane juice/molasses. The current practices in countries like Brazil & USA, are as follows:

Brazil is one of the major Bio-ethanol (from sugarcane) producers and the exporter. The sugar and Ethanol industry in Brazil contributes about 2.3% of the GDP[1]. In Brazil, few facilities are dedicated to produce exclusively Ethanol from sugar cane juice and no sugar. Some units are using sugar cane juice and molasses mixed in different proportions for production of ethanol. The ethanol production in Brazil is about 14 times of the Indian production.

USA is the major producer of ethanol from corn due to abundance production of corn in the country. Ethanol from sugar cane juice is not being produced in USA. The ethanol production in USA is about 26 times of the Indian production.

Global bio-fuel consumption and production increased to a total of 116.6 billion litres in 2013, following a slight decline in 2012. World fuel ethanol volumes were up by around 5% to 87.2 billion litres. Global ethanol production was dominated by the United States and Brazil, which retained their top spots and accounted for 87% of the global total. U.S. ethanol production in 2013, at around 50 billion litres and almost all of this was made from corn feedstock. Ethanol displaced about 10% of U.S. gasoline transport demand during the year. Besides, nearly 2.4 billion litres was exported to Canada (54%) and the Philippines (9%); the United Arab Emirates, Brazil, Mexico and Peru.

Brazil increased its sugarcane ethanol production by 18% in 2013, to reach around 25.5 billion litres. Argentina nearly doubled its ethanol production to almost 0.5 million litres, with the opening of a large corn ethanol plant. The expansion was driven by Argentina‟s 5% ethanol fuel blend mandate. Other significant producers of ethanol included China (2 billion litres) and Canada (1.8 billion litres).

World energy consumption is the total energy used by the entire human beings typically measured per year, it involves all energy harnessed from every source of energy applied towards humanity's endeavours across every single industrial and technological sector, across every country .It does not include energy from food, and the extent to which direct biomass burning has been accounted for is poorly documented. Being the power source metric of civilization, World Energy Consumption has deep implications for humanity's socio-economic-political sphere.

Institutions such as the International Energy agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency (EEA) record and publish energy data periodically. Improved data and understanding of World Energy Consumption may reveal systemic trends and patterns, which could help frame current energy issues and encourage movement towards collectively useful solutions.

So as per the report of "International Energy Agency" in 2015 the world's total energy consumption has came very close to 500 exajoules compared to less than 10 exajoules in 1960's.

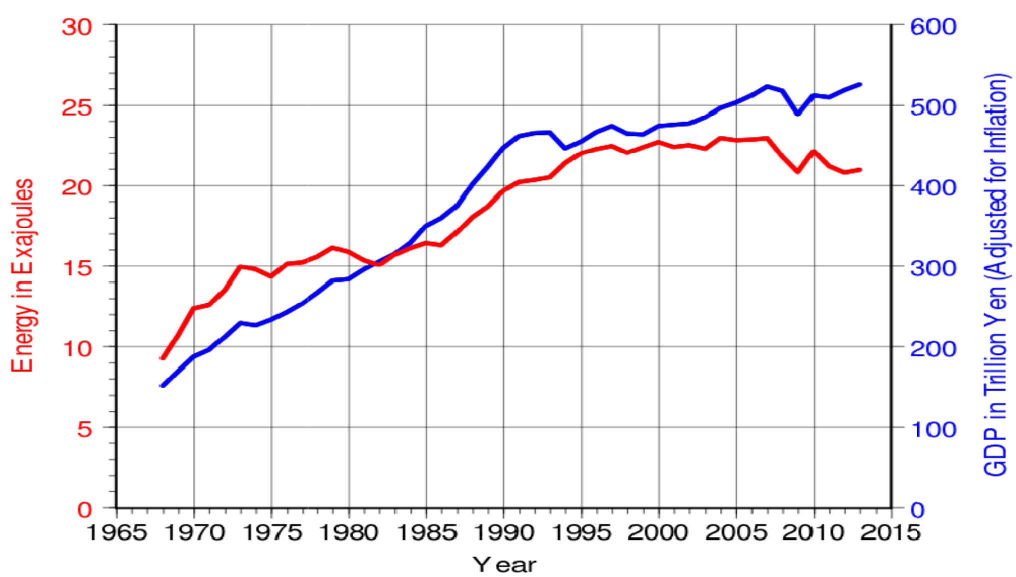

Fig 1. Graph showing the change in GDP and energy consumption of the world per year[2]

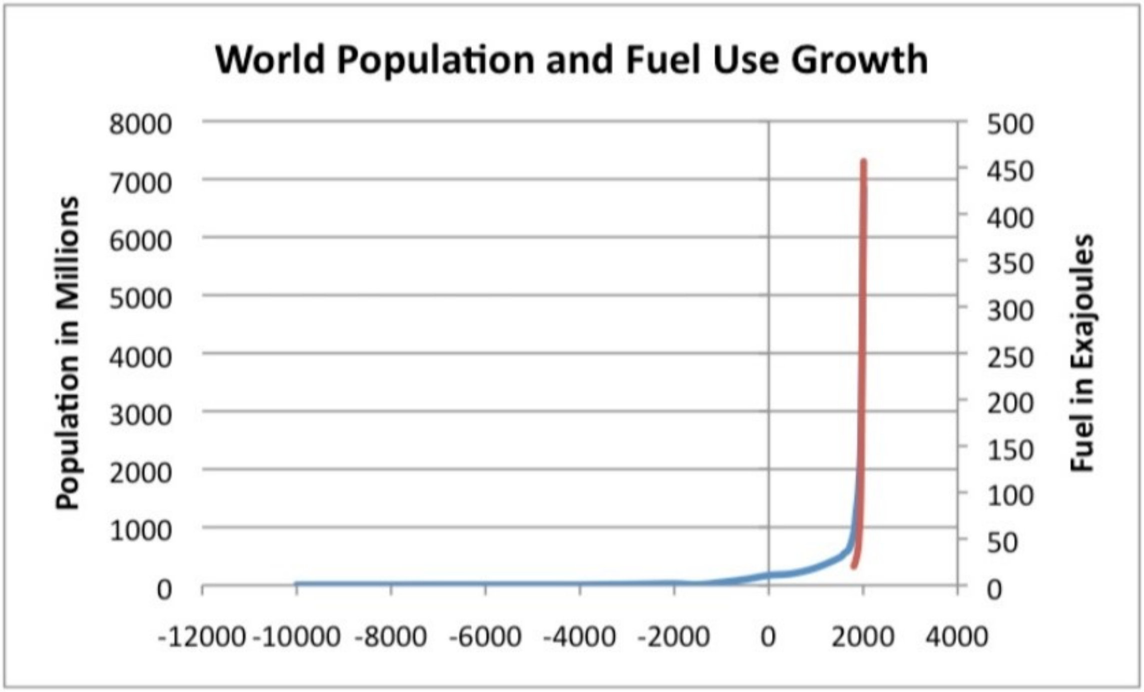

Fig 2. Graph showing variation of population with energy consumption[3]

Further "International energy agency "also published data regarding the source of this total energy consumed by the world and it found that fossil fuel consists of nearly 85% of the total energy production which constitutes 32.89% petroleum,23.4% natural gas,29.16% coal.

Here we need to understand that all of these fossil fuel are limited natural resources and hence they will get exhausted after a certain period of time. According to an estimate by some scientist less than hundred years are left before all the fossil fuel reserves get exhausted. Hence it can be said that there is an urgent need to look towards other non conventional sources of energy.

2.2 INDIAN SCENARIO

According to "World Data Info" in 2015 the energy balance of India is total consumption of 1,137.00 billion kwh per year which is not a very huge number considering the total population of India and comparing it with countries like United States of America and China .

The primary energy consumption in India is the third biggest after China and USA with 5.6% global share in 2017. The total primary energy consumption from crude oil (221.1 M toe;

29.34%), natural gas (46.6 M toe; 6.18%), coal (424 M toe; 56.26%), nuclear energy (8.7 M toe; 1.15%), hydro electricity (30.7 M toe; 4.07%) and renewable power (21.8 M toe; 2.89%) is 753.7 M toe (excluding traditional biomass use) in the calendar year 2015.

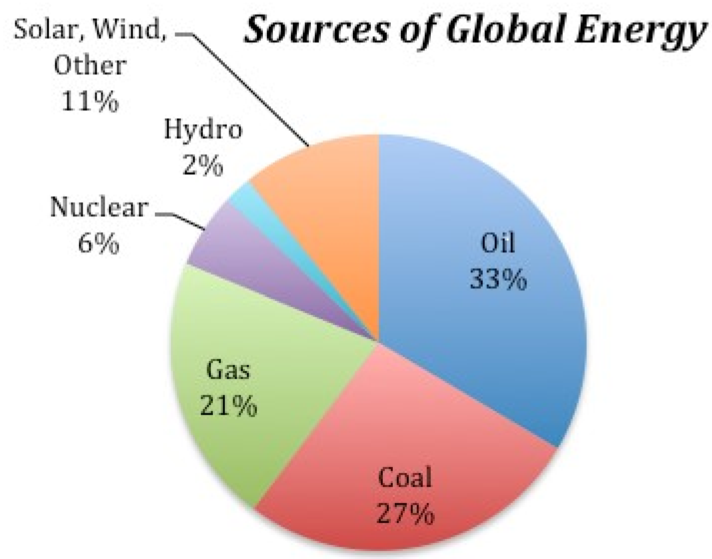

Fig.3.pie chart showing contribution of various sources of energy in world[3]

India relies very heavily Arabic countries like Iran and Saudi Arabia for fulfilling its energy needs with 82.8% dependence for crude oil and 45.3% for natural gas . The net foreign exchange outgo is 63.305 billion US$ in the financial year 2017-18 on account of crude oil imports which is a huge percentage from the GDP of India which is very harmful for our country as it leads to the outflow of the foreign exchange reserves from the country which weakens the economy and hence decreases the cost of rupees in the international market.

Further the dependence of India on Arabic countries like Saudi Arabia and Iran for oil and gas puts India at back foot at several diplomatic and geopolitical levels.

3. NEED OF BLENDING GASOLINE WITH ETHANOL

Energy is a critical input for the socio-economic development of any country. In India, fossil fuels i.e. Crude Oil and Natural Gas play a dominant role as primary energy resources . Since the domestic production of these fossil fuel based hydrocarbon resources is inadequate to meet the rapidly increasing energy demand, India imports 80% of its Energy requirements from the international market causing substantial outflow of precious resources in fuel import bill of the country. Though, India is able to receive supplies of fuel resources at present, its dependence on imports in the changing world scenario and geo-political instability can lead to crude oil supply disruptions at any time posing a threat to the energy security of the country. The growing environmental concern have also raised uncertainty over the use of fossil fuel resources in meeting the future energy demands and has necessitated the search for alternate sources of energy

We all know that fossil fuels are exhaustible energy resource and their availability is decreasing day by day. On the other hand due to several reasons involved internationally the price of the oil keep on changing and it is for sure that it will eventually become quite high. This high price or high demand of oil of the country have very adverse effect on the economy of the country like recently due to sanctions imposed by USA on Iran ,India was forced to stop its purchase of Iranian oil and now India have to buy oil from other countries like Saudi Arabia even if their price is comparatively higher than that of Iranian oil. So we need to look for some alternative solutions so as to meet the ever increasing demand of fuel for both industrial as well as transportation purpose as the number of vehicles and industries are continuously increasing day by day.

In order to gain control over the situation various researches are being performed so as to replace petrol and diesel as fuel with some potential fuels like ethanol, ecucalyptus oil and several others.

Right now a lot of focus is being given to ethanol as fuel or more precisely ethanol as blending fuel with gasoline. The government of India has also passed several legislation regarding the use if ethanol as a blending agent with gasoline. A lot of research is also taking place in this field in the country so as to develop new and more efficient ways to for the production of ethanol at industrial level.

3.1 POSITIVE IMPACTS OF ETHANOL

(i) Since ethanol contains 35 percent oxygen[4], this requirement of the act could be met by using an ethanol-containing blend as it result in improving the engine output up to a limit.

(ii) Reduces vehicle emissions (CO, HC), Green house gases (CO_2) & protects environment from climate change effects.

(iii) Less dependence on petroleum & reduces imports of crude oil.

(iv) Greater use of biofuels brings oil market into balance & reduces oil prices.

(v) Increases National energy security.

(vi) Locally produced biofuels can provide energy for local agricultural, industrial & household uses at less than the cost of fossil fuels.

(vii) Replaces bad gasoline additives (MTBE & lead) which are sources of surface & ground water contamination & dangerous to human health.

(viii) Substantial increase in employment opportunities in the rural sector.

(ix) Increases net farm income & strengthens rural & agricultural economies.

(x) Greening of wastelands & regeneration of forest lands.

4. PROPERTIES OF ETHANOL

4.1 BASIC CHEMISTRY

The chemical formula for ethanol is C_2H_5OH. It is a known under the names ethyl alcohol or hydroxyethane and is the type of alcohol found in alcoholic beverages. Ethanol is a rather simple organic molecule consisting of a group of carbon and hydrogen atoms, with a hydroxyl group (an oxygen and a hydrogen atom) attached. Compared to most gasoline components, the ethanol molecule is small and light, having a molecular weight of just 46 g/mol.

The fact that the ethanol molecule has both a polar and a nonpolar end makes ethanol soluble in both polar and nonpolar substances. The polar end makes ethanol miscible with water (and other polar substances), and the nonpolar end makes it miscible with many nonpolar organic substances, such as gasoline and, to a lesser extent, diesel fuel. The hydrogen bonding in ethanol also causes the substance to have a rather low volatility for a molecule of such relatively small molecular weight. Under atmospheric conditions ethanol is a liquid, although it will gradually evaporate if exposed to the atmosphere. It is colorless, has a distinct taste and smell, and is categorized as a mildly toxic substance.

Because of the production method, improper storage, and accidental contamination, ethanol often contains a small amount of water. Water contamination of pure ethanol can occur easily because ethanol is hygroscopic; that is, it will absorb water from the atmosphere if stored in an open container. Ethanol, as a fuel, is generally produced in either of two purities: anhydrous, meaning that the water content is less than 1 percent, or hydrous, generally referring to a water content between 5 and 10 percent.

Anhydrous ethanol is also called pure, dry, or absolute alcohol. Ethanol purities above 95.6 percent by mass (designated the azeotrope concentration) cannot be produced by traditional distillation methods, but require separate dehydration equipment, a fact that makes anhydrous ethanol approximately 20–25 percent more energy-demanding to produce than the ethanol/water azeotrope . To avoid the heavy taxation levied on spirits for consumption, it is normally required that fuel ethanol be made undrinkable. To accomplish this, a measure of a foul-tasting or toxic substance (normally less than 10 percent) is added to ethanol after distillation, and it is then called denatured alcohol. The denaturant used is sometimes been methanol, propanol, or acetone, but with fuel ethanol an obvious choice is often gasoline.

4.2. SIGNIFICANT PROPERTIES OF ETHANOL FOR BLENDING PURPOSE

PROPERTIES	**ETHANOL**	**GASOLINE**	**DIESEL**
Chemical formula	C2H5OH	C4 TO C14	C3 TO C25
Molecular weight [gm/mol]	46.07	100-105	200
Carbon%	52.2	83 TO 85	84 TO 87
Hydrogen%	13.1	12-15	33-36
Oxygen%	34.7	0	0
Liquid density at 293k [kg/lt]	0.792	0.72-.78	0.81 -0.88
Viscosity [cST]	1.52	0.4-0.9	2-6
Boiling temperature[k]	351.37	308-473	633
Vapour pressure[kpa]	16	50-100	0.1-0.15
Flammability limit[volume %]	3.3-19	1-8	0.6-5.5
Stoichiometric A/F ratio	9	14.5-14.7	14.6-15
Flash point temperature[k]	285	231	347
Autoignition temperature[k]	696	530	588
Heat of vapuorisation [kj/kg]	910	330-400	225-600
Heat of combustion per kg	26900	42000-44000	42800-45300
Heat of combustion per litre	21300	32000	37200
Research octane number	108	90-100	N/A
Motor octane number	92	81-90	N/A
(R+M)/2	100	86-94	N/A
Cetane number	N/A	5-20	40-55
Water tolerance	miscible	negligible	Negligible
Carbon dioxide emission[kg/kg fuel]	1.91	3.98	3.2
Energy per co2 emission [MJ fuel energy/ Kg carbon dioxide emitted]	14.1	13.5	13.8

Table no. 1: comparison between the properties of ethanol, gasoline and diesel[5].

The properties of ethanol related to blended compound with other basic fuels can be explained in the following main points as described below.

i. Octane number
ii. Volatility and distillation
iii. Heat of vaporization
iv. Flame temperature
v. Energy content
vi. Oxygen content
vii. Olefins and aromatics
viii. Water tolerance and ternary phase diagrams
ix. Acidity and trace elements
x. Bio-content measurement

4.2.1. OCTANE NUMBER

Octane numbers of low-molecular mass alcohols are high, and therefore they have been even used as octane boosters. Alcohols tend to increase the research octane number (RON) more than the motor octane number (MON). The blending RON of ethanol is about 120-135, and the blending MON 100-106. The sensitivity (RON-MON) is typically 8-10 units for gasoline, but 14 units for ethanol. The high octane numbers of ethanol could enable optimization of engine to increase the thermal efficiency. However, even special cars for ethanol use (FFVs) are still being a compromise to dedicated ethanol cars. Kalghatgi 2005 observed that knock sensor equipped cars performed better when using fuels with lower MON for a given RON. Ethanol increases octane numbers of the front-end distillation range of gasoline. When adjusting the octane number of ethanol/gasoline blend, octane numbers in the other distillation ranges of gasoline may need consideration.

4.2.2. VOLATILITY AND DISTILLATION

Ethanol forms azeotropes with hydrocarbons of gasoline, which impacts volatility. In particular, the vapor pressure and distillation characteristics of ethanol/gasoline blends are non-linear. Blending vapor pressures for alcohols are significantly higher than their nominal vapor pressures. Vapor pressure of neat ethanol is low at only 16 kPa (Owen and Coley 1995). When ethanol is added into gasoline, vapor pressure increases with blending ratios of 5-10%, but then gradually declines. With ethanol content of some 30-50%, vapor pressure is at the same level as for gasoline without oxygenates (Environment Australia 2002, Furey 1985).

Vapor pressure of blends can be adjusted by using base fuel with low vapor pressure. If strict fuel specifications are to be met, this rules out the possibility of so-called splash-blending of ethanol. In some regions, higher vapor pressures are allowed for gasoline-ethanol blends, if they contain ethanol.One notable point regarding the vapor pressure of ethanol blend is its tendency to increase more quickly than that of gasoline with increasing temperature.

The distillation “front-end” increases more than predicted when ethanol is blended with gasoline due to azeotropic behavior of the blend. When ethanol up to 20 vol-% is blended into a hydrocarbon gasoline, the increase in volume evaporated at 70 °C (E70) is as much as 30%. The effect of ethanol on the other parts of distillation curve is smaller. With 10 vol-% ethanol-containing blend, there changes in the E70 value and a flat part of distillation may be challenging.

4.2.3. HEAT OF VAPOURISATION

Heat of vaporization is higher for ethanol than for gasoline, which means that more energy is required to evaporate the fuel thus lowering the engine temperatures. This can improve knock resistance as auto ignition is less likely to occur with a cooler engine. Cooling of the intake air may increase engine efficiency, because higher air density allows more fuel to be injected and internal and exhaust gas heat losses are lower.

And high heat of vaporization aggrevates the start-up with a cold engine due to cooling effect of the air/fuel mixture. The startability limit of neat ethanol is around +12 °C. This problem can be reduced by using at least 15% gasoline in the fuel. The high latent heat of vaporization of ethanol leads to high emissions of organic gases, whereas the low combustion temperature of ethanol may lead to a reduction in engine-out NO_x emissions compared with gasoline. High latent heat of evaporation may even lead to frostbite in handling of ethanol in cold weather.

4.2.4. FLAME TEMPERATURE

Flame temperatures of alcohols are lower than flame temperatures of aromatics, for example.

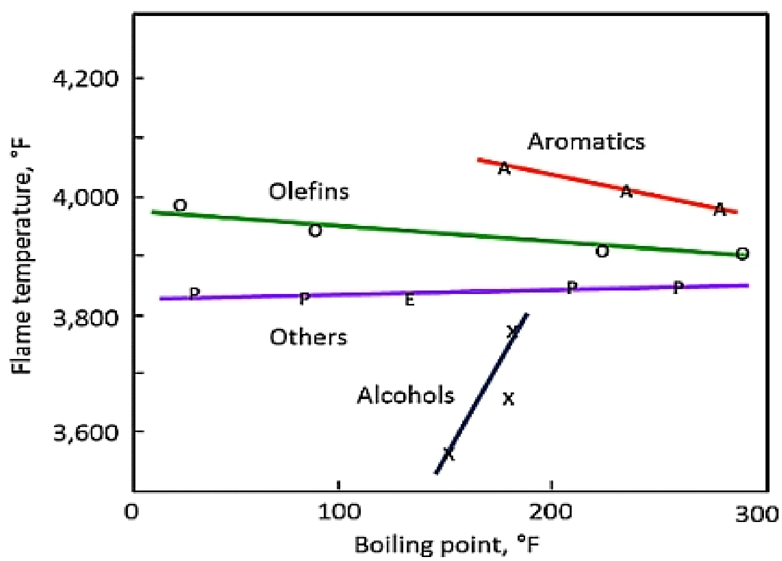

Fig 4. Flame temperature of alcohols (X), olefins (O), aromatics (A), paraffins (P), and ethers (E) (Piel and Thomas 1990)[6].

4.2.5. ENERGY CONTENT

The energy content of ethanol is lower than that of gasoline. The heating value of ethanol is around 27 MJ/kg, in volumetric terms around 21 MJ/l, which is only 65% of the volumetric energy content of gasoline. This leads to higher volumetric fuel consumption with ethanol compared to gasoline. Theoretically, increase in volumetric fuel consumption is about 3.5% when a 10% ethanol blend is compared with non oxygenated gasoline. Density of ethanol is 0.79 kg/l, which is slightly higher than that of gasoline. Higher density improves volumetric fuel economy to some extent.

4.2.6. OXYGEN CONTENT

The oxygen content of ethanol is 35%. The oxygen content of fuel determines the stoichiometric air/fuel ratio, which is 9 kg air/kg fuel for ethanol, whereas it is 14.6 kg/kg for gasoline. Closed-loop fuel control system can compensate the leaning effect of fuel, but even the modern cars can tolerate oxygenates only up to certain concentrations. This is reflected in legislation and standards of gasoline[6].

4.2.7. OLEFINS AND AEROMATICS

Ethanol may reduce the olefins and aromatics contents of the gasoline pool by a dilution effect, depending on the properties of the base gasoline.

4.2.8. WATER TOLERENCE

The storage and stability of ethanol blends are special issued due to ethanol's affinity for water and the risk of phase separation, which is harmful for cars and infrastructure. With the higher ethanol content, the greater amount of water can be absorbed in gasoline blend without phase separation. Filho (2008) published ternary phase diagrams of ethanol, gasoline and water at different temperatures. Larsen et al. (2009) determined the ternary phase diagrams of ethanol with Danish winter-grade gasoline at -2°C and -25 °C (lower diagram).

4.2.9. ACIDITY AND TRACE ELEMENTS

Ethanol has limits for weak acidity (as acetic acid) and strong acidity (pHe). Weak acidity may affect long-term durability, whereas strong acidity may generate rapid corrosion. Electrical conductivity reflects for example metallic ions, such as chloride, sulfate, sodium and iron. Inorganic chlorides are corrosive towards metals. Sulfates are also corrosive, and form deposits for example in fuel injectors. Copper induces gum formation and promote injector deposits. Phosphorus may accumulate in the exhaust catalyst.

4.2.10. MEASURING BIO CONTENT IN THE FUEL

Ethanol can be manufactured from fossil or bio-origin feedstocks. Bio-content of a blend can be based on the seller's declaration and bookkeeping, and ratio can be estimated by calculation. If required, bio-content in a fuel blend can be determined by $_{14}C$ isotope methods, which are also used for example for archeological studies. CO_2in the atmosphere contains unstable ^{14}C and stable ^{12}C carbon isotopes in a fixed ratio, and the same ratio is found from living plants and animals. Half-life of ^{14}C is 5730 years, which can be used to differentiate fossil and renewable carbon. Principles can be found from the standard ASTM D 6866.

5. INDUSTRIAL METHODS OF PRODUCTION OF ETHANOL

World ethanol production rose to nearly 13.5 billion gallon in 2006. Ethanol produced by fermentation, called bioethanol, accounts for approximately 95% of the ethanol production. Corn in the Unites States and sugarcane in Brazil are widely used as raw materials to produce bioethanol. Cellulosic materials are expected to be the ultimate major source of ethanol and also represent a value-adding technology for agricultural coproducts. European countries produce ethanol from beet. Also, intensive studies are going on ethanol production from lignocellulosic biomass (plant dry matter). Ethanol production from lignocellulosic biomass could find a way to utilize agricultural waste for ethanol production.
There are essentially three methods used to produce ethanol:

- Manufacture from ethylene using steam(Synthetic Route)
- Production from sugars and starches by fermentation using yeasts
- Production from biomass waste using bacteria

5.1 ETHYLENE HYDRATION

Ethanol for use as an industrial feedstock or solvent (sometimes referred to as synthetic ethanol) is made from petrochemical feed stocks, primarily by the acid catalysed hydration of ethylene:

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

The catalyst is most commonly phosphoric acid, adsorbed onto a porous support such as silica. The reaction is carried out in the presence of high pressure steam at 300 °C (572 °F) where a 5:3 ethylene to steam ratio is maintained.

5.2 ETHANOL FERMENTATION

Ethanol Fermentation, also called alcoholic fermentation, is a biological process which converts sugars such as glucose, fructose and sucrose into cellular energy, producing ethanol and carbon dioxide as by-products. Because yeasts perform this conversion in the absence of oxygen, alcoholic fermentation is considered an aerobic process. Most ethanol is produced by fermentation.The dominant ethanol feedstock in warmer regions is sugarcane. In temperate regions, corn or sugar beets are used.

During ethanol fermentation, glucose and other sugars in the corn (or sugarcane or other crops) are converted into ethanol and carbon dioxide.

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

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4\ CH_3CH_2OH + 4\ CO_2$$

Ethanol fermentation is not 100% selective with side products such as acetic acid and glycols. They are mostly removed during ethanol purification. Fermentation takes place in an aqueous solution. The resulting solution has an ethanol content of around 15%. Ethanol is subsequently isolated and purified by a combination of adsorption and distillation.

5.3 ETHANOL FROM BIOMASS

Cellulosic biomass is a complex mixture of carbohydrate polymers from plant cell walls known as cellulose and hemicellulose, plus lignin and a smaller amount of other compounds generally known as extractives. To produce ethanol from biomass feedstocks, a pretreatment process is used to reduce the feedstock size, break down the hemicellulose to sugars, and open up the structure of the cellulose component. The cellulose portion is broken down (hydrolysed) by enzymes into glucose sugar that is fermented to ethanol. The sugars from the hemicellulose are also fermented to ethanol. The lignin is burned as fuel to power the process.

Lignocellulose which is the principal component of plant cell walls is mainly composed of cellulose(40-60% of total dry weight) , hemicelluose(20-40%) and lignin(10-25%). Typical sources of lignocellulosic biomass are agricultural and forestry residues,industrial wastes and woody crops. Ethanol from lignocellulosic biomass is produced mainly via biochemical routes. The three major steps involved are pretreatment, enzymatic hydrolysis, and fermentation. Biomass is pretreated to improve the accessibility of enzymes. After pretreatment, biomass undergoes enzymatic hydrolysis for conversion of polysaccharides into monomer sugars, such as glucose and xylose. Subsequently, sugars are fermented to ethanol by the use of different microorganisms.Pretreated biomass can directly be converted to ethanol by using the process called simultaneous saccharification and cofermentation (SSCF). Pretreatment is a critical step which enhances the enzymatic hydrolysis of biomass.

6.BIOFUEL POLICY OF INDIA

6.1. SHORTAGE OF ETHANOL SUPPLY FOR BLENDING

During the year 2003-2004, the total ethanol production of 1280 million litre was achieved in India, whereas, the consumption figure was recorded as 1283 million litre. Out of the total consumption, 51% is preferably used for potable purpose mainly because of high revenue generation by ethanol producing states. The second major share of consumption i.e. 43 % is used for industrial purposes. In chemical industries, it is used as the basic raw material for the synthesis of acetic acid, acid anhydride, acetaldehyde and the highly versatile and value added chemical called ethylene oxide which is utilized for the production of awhole range of products called surfactants. Besides, ethanol is an industrially important solvent and base material for various other organic chemicals. The balance 6% of ethanol produced for the year (about 76million litre) was used for Ethanol Blending Program (EBP) and the rest 120 million litre of ethanol was made available by the distilleries as a carryover quantity of previous year. In view of the shortage in supply of ethanol from distilleries for Ethanol Blending Program (EBP) for transport fuel, the Government of India decided to implement 5% ethanol blending only in four states - Andhra Pradesh, Maharashtra, Uttar Pradesh from January 2003. The other five states -Gujarat, Haryana, Goa, Karnataka and Tamil Nadu and four union territories- Daman and Diu, Chandigarh, Dadra and Nagar Haveli and Pondicherry were to be covered in future depending on the availability of the ethanol for 5% blending in petrol.

During the present study, the data were collected from various distilleries located in different parts of the country. Almost 90% of the ethanol producer were covered by having first hand opinion about the subject, in addition to compile the data base about the production capacities (Installed as well as operational) in the country. The present requirement of ethanol in various sectors of applications like potable, industrial and transport was worked out, by having the interactions with the user industries as well as with various associations. From the study, certain interesting facts have emerged as follows:

(i) The data about the availability of the resources i.e. molasses for the production of ethanol vary drastically depending upon the mandate and the interests of the agencies having such data.

(ii) The figures on available quantities of ethanol for various outlets is also not as straight forward as one would expect it to be; Different stakeholders like producers of molasses, ethanol and ethanol based chemicals have different sectors depending upon the interest of a given sector.

(iii) The two essential players for success of EBP i.e. suppliers of ethanol and the producers of petrol appear to have poor co-ordination and claim differently about ethanol demand and supply gap. This should be taken as the point of reference to correct the wrongs in the path of EBP in India.

(iv) Due to cyclic nature of sugarcane production, sugar availability varies and in almost every third or fourth year shortfall is experienced. In meeting demand of domestic sugar consumption during the seven years, the surplus sugarcane would not be available for direct conversion of sugarcane juice to ethanol by distilleries. This is one of the most critical aspects which, policy makers must keep in mind while making any decision concerning direct ethanol production from sugarcane juice. All the above findings would require to be reviewed thoroughly to identify the success or risk factors of EBP.

6.2. FALL IN SUGARCANE PRODUCTION

In India, ethanol is mainly produced by the fermentation of molasses, which is a by-product of sugar producing industries using sugarcane as a raw material and hence the availability of molasses is directly linked to the production of sugarcane crop and thus to ethanol.
During early years in 20th century, there was a significant drop in the sugarcane production, which affected directly the availability of molasses required to produce ethanol. Therefore, to fulfill the domestic needs, India had to import molasses and ethanol during these years and thus due to the non-availability of feed stock resulting in variation in ethanol price and thus, the ethanol-blending program could not be implemented successfully and finally suspended.

6.3. PRICING OF ETHANOL

Pricing became a major constraint in selling of bio-ethanol blended petrol in India. The ethanol industry originally claimed that it could provide ethanol at Rs. 19 per litre, which was less than that of MTBE, which was costing Rs. 24-26 per litre[7]. The oil marketing companies (OMCs), however, were seeking parity between the price of ethanol and petrol on an ex-refinery basis. Implementation of the Central Excise duty exemption for ethanol was delayed until February 2003 due to the opposition from the chemical industry in the fear of higher prices and shortage of ethanol. So in June 2003, issue of ethanol pricing got complicated due to differences in excise duty and sales tax across different states, which still persists. Moreover, ethanol production cost in a particular year depends on the availability of molasses. During present study, while interacting with various stakeholders who would be responsible for the success of EBP in India, following facts emerged:

(i) The price of ethanol is determined by the degree of value addition for the user industries of ethanol for example, if the industrial chemicals derived from the petroleum resources become expensive, then the industries would be eager to adopt the ethanol-route for producing these chemicals. The use of ethanol to produce ethylene oxide followed by a whole range of surfactants demonstrates one of the most appropriate cases of industrial application of ethanol. The rise in the prices of crude oil has changed the scenario more in favour of ethanol route of production of industrial chemicals. As a result, the industrial uses of ethanol have been growing up that is leading to the rise in the ethanol prices. The EBP would thus be affected adversely because the higher ethanol price would not be acceptable to the petrol marketing companies.

(ii) Sugar industries and the distilleries have their own issues related to the pricing policy of ethanol as well as molasses. The competition between the potable use and industrial use of ethanol further complicates the situation related to the availability of ethanol at an acceptable price.

(ii) Sugar industries and the distilleries have their own issues related to the pricing policy of ethanol as well as molasses. The competition between the potable use and industrial use of ethanol further complicates the situation related to the availability of ethanol at an acceptable price. Thus, the main issue is the acceptable price; what is acceptable to the suppliers of the petrol must also be amenable to the ethanol producers.

(iii) Unless factors affecting the pricing of ethanol are not sorted out jointly and in an amicable manner to ensure sustainable supply season after season. The EBP in India would always be a doubtful starter. Thus, for any policy to be framed for EBP, this must be kept in mind.

6.4. CURRENT STATUS OF BLENDING IN INDIA

India is set to close in on the highest ever of 7.2 per cent of ethanol blending with petrol in the current season in some states in India (December 2018 – November 2019).

The current consumption of fuel sets 3300 million litres of ethanol requirement to achieve 10 % of blending target by 2022 for the entire country excluding J&K, North Eastern States and island territories. For the current season itself i.e. 2018-19, however, sugar mills in India have contracted for supply of 2370 million litres which works out to 7.2 per cent of the petrol consumption in India. Average all India ethanol blending ratio for year 2017-2018 was 4.22 %.

Steady rise in ethanol blending is set not only to save import of crude oil thus saving of precious foreign currency reserves, but encourage use of additional cane juice and other raw materials efficiently in addition to protect environment from release of motor vehicle obnoxious gas.

"Against a requirement of 3300 million litres of ethanol for 10 per cent ethanol blending in the country, ethanol supply contracts have been signed for 2370 million litres for the ethanol supply period 2018-19. If quantity as contracted is successfully blended, about 7.2 per cent of petrol consumption will get substituted by this environment friendly bio-ethanol," said The Director General, Indian Sugar Mills Association[8].

This is the highest ethanol supply contracts Indian distilleries have ever achieved. The best ever achieved was last year when contracts for 1600 million[9] litres were signed and 1500 million litres of ethanol were supplied in 2017-18 ethanol supply period.

The achievement is significant as the new Bio-fuel Policy, 2018 has fixed a target of achieving 20 per cent ethanol blending with petrol by 2030. Internally, the government is targeting to achieve the first milestone of 10 per cent of ethanol blending with petrol by 2022.

7. PERFORMANCE AND EMISSION CHARACTERISTICS

7.1. EXPERIMENTAL SETUP

Experiments were conducted on a single cylinder, four stroke, air cooled, GREAVES make MK 25 non road spark ignition) engine with different gasoline-ethanol blends (E0, E5, E10, E15 and E20).

Non-road gasoline engines differ from automotive engines in several technical specifications. Because of these design differences, the effects of alcohol/gasoline blended fuel changes on performance and emission characteristics from non-road gasoline engines are quite different from the effects of alcohol/gasoline blended fuel changes on performance and emissions from automotive gasoline engines. The engine Is coupled to a hydraulic dynamometer. Exhaust gases were sampled from the outlet and then were measured on line by an exhaust analyzer Bosch.

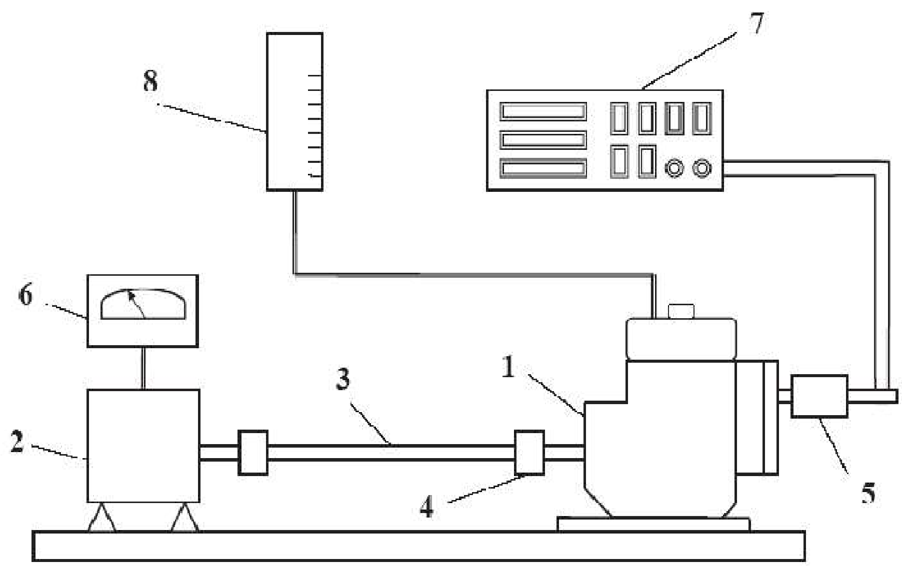

Fig no.5. Block diagram performance and emission characteristics testing machine

1- Engine	5- Computer screen
2- Dynamometer	6- Exhaust pipe
3- Shaft	7- Exhaust gas analyser
4- Flywheel	8- Sensors

7.1.1. ENGINE

In modern usage, the term *engine* typically describes devices, like steam engines and internal combustion engines, that burn or otherwise consume fuel to perform mechanical work by exerting a torque or linear force (usually in the form of thrust). Devices converting heat energy into motion are commonly referred to simply as *engines*. Examples of engines which exert a torque include the familiar automobile gasoline and diesel engines, as well as turboshafts. Examples of engines which produce thrust include turbofans and rockets. Engine is a device that burns or otherwise consumes fuel, changing its chemical composition.

A motor or engine is a machine designed to convert one form of energy into mechanical energy. Heat engines, like the internal combustion engine, burn a fuel to create heat which is then used to do work. Electric motors convert electrical energy into mechanical motion, pneumatic motors use compressed air, and clockwork motors in wind-up toys use elastic energy.

7.1.2 DYNAMOMETER

A dynamometer, or "dyno" for short, is a device for measuring force, moment of force (torque), or power. For example, the power produced by an engine, motor or other rotating prime mover can be calculated by simultaneously measuring torque and rotational speed (rpm). A dynamometer can also be used to determine the torque and power required to operate a driven machine such as a pump. In that case, a motoring or driving dynamometer is used. A dynamometer that is designed to be driven is called an absorption or passive dynamometer. A dynamometer that can either drive or absorb is called a universal or active dynamometer.

In an engine dynamometer, water flow, proportional to the desired applied load, creates resistance to the engine. A controlled water flow through the inlet manifold is directed at the center of the rotor in each absorption section. This water is then expelled to the outer dynamometer body by centrifugal force. As it is directed outward, the water is accelerated into pockets on the stationary stator plates where it is decelerated. The continual acceleration and deceleration causes the dynamometer to absorb the power produced by the engine. Through this transfer of energy the water is heated and discharged.

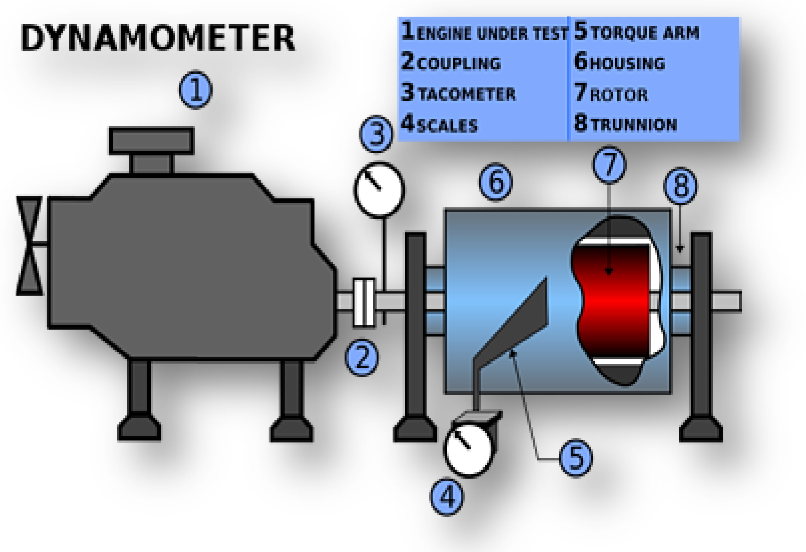

Fig. no. 6 schematic diagram of dynamometer

7.1.3 SHAFT

A drive shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. A drive shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.

7.1.4 FLYWHEEL

Flywheel is a mechanical device specifically designed to efficiently store rotational energy. Flywheels resist changes in rotational speed by their moment of inertia. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. The way to change a flywheel's stored energy is by increasing or decreasing its rotational speed by applying a torque aligned with its axis of symmetry. Since flywheels act as mechanical energy storage devices, they are the kinetic-energy-storage analogue to electrical capacitors, for example, which are a type of accumulator.

Common uses of a flywheel include:

- Smoothing the power output of an energy source. For example, flywheels are used in reciprocating engines because the active torque from the individual pistons is intermittent.
- Energy storage systems
- Delivering energy at rates beyond the ability of an energy source. This is achieved by collecting energy in a flywheel over time and then releasing it quickly, at rates that exceed the abilities of the energy source.
- Controlling the orientation of a mechanical system, gyroscope and reaction wheel

7.1.5 EXHAUST PIPE

Exhaust gasses are rejected in the atmosphere via these pipes.

7.1.6 COMPUTER SCREEN

IC engine software is installed in the computer. Here all the initial parameters like engine parameters, fuel parameters, setup parameters and constant parameters of the engine are being feed. It is very necessary to feed these parameters accurately without much error as the final characteristics of the fuel will be very much dependent on them.

Here final report from the IC engine software is also being generated which gives the observation table and the characteristic curves of the fuel.

7.1.7 EXHAUST GAS ANALYSER

An exhaust gas analyser is an instrument for the measurement of carbon monoxide among other gases in the exhaust, caused by an incorrect combustion, the Lambda coefficient measurement is the most common. The principles used for CO sensors (and other types of gas) are infrared gas sensors (NDIR) and chemical gas sensors. Carbon monoxide used to assess the CO amount during an MOT test In order to be used for such test it must be approved as suitable for use in the scheme.

Modern auto-body shops depend on exhaust gas analyser as an affordable and essential way to verify the functionality of the vehicles in their shop. In their most simple form, exhaust gas analyzers effectively sample and measure the various gasses present and provide the operator with an end reading. When it comes to exhaust pipe systems, exhaust gas analyzers can locate carbon monoxide and identify sources that may lead to fire if fuel is inadvertently released. More complex models can also play a key role in determining engine efficiency.

In terms of size and range of functions, exhaust gas analyzers are available in very simple and affordable forms as well as more expensive and complex. When selecting an exhaust gas analyzer, making sure its specifications meet your needs is essential—a more expensive and complicate analyzer may not be the best choice in all cases.

7.1.8 SENSORS

These sensors are used to sense parameters like indicated power, friction power, exhaust gas temperature and various other parameters.

7.2 STEPS INVOLVED IN THE TESTING OF THE FUEL

7.2.1 ACQUISITION OF FUEL

This is the first step involved in the steps of testing of our fuel. In this step we need to collect samples of pure gasoline and ethanol blended gasoline at various blending ratio. Here we will be performing our testing at 5%, 10%, 15% and 20% blending in the gasoline known as E05, E10, E15 and E20 respectively.

Here we need to take care that the fuel must be stored in a airtight container so that no moisture or anything else can react with it otherwise its composition may change and we may not get proper test results after the testing.

Here we have taken 1litre of sample of each fuel.

7.2.2 FINDING DENSITY AND CALORIFIC VALUE OF THE FUEL

7.2.2.1 CALORIFIC VALUE OF THE FUEL

Finding the calorific value is also one of the very important steps of the whole testing process. It is being found by the use of a prominent device called “BOMB CALORIMETER”. It is a device which is being used to find the calorific value of the fuel. It has got a record of giving very accurate value of the calorific value of the fuel.

Finding it involves various steps that need to be followed by the person performing the test. The following are the steps to be followed :

(i) Take 1.5gm of fuel and put it in the cup inside the bomb. A bomb is a stainless steel cylinder where fuel is being burnt.

(ii) Now attach a thread of known mass and calorific value just above the cup of the fuel so that it is dipped in the fuel.

(iii) On the top of the thread attach a fuse magnesium wire of known weight and calorific value. This wire will be connected to a 6V battery so that when key is closed, electric spark will be generated which will burn the thread and eventually burn the fuel. This whole assembly is being places inside the bomb.

(iv) Close the bomb and fill oxygen in it so that proper burning of the fuel, thread and wire takes place. Now this bomb is being placed in the calorimeter (outer shell) made up of copper. Inside the calorimeter bomb is surrounded by water.

(v) Start the calorimeter (battery will start working). Electric spark will be generated and will lead to the burning of the fuel, wire and thread. This will lead to increase in the temperature of the water inside the calorimeter.

(vi) Now the rise in temperature of the water inside the calorimeter is recorded by the electronic temperature sensor.

(vii) Using the value of rise in temperature of the water calculate the calorific value of the fuel. The calculations will be as follows:

Q_1 = heat generated by burning of fuel

Q_2 = heat generated by burning of wire

Q_3 = heat generated by burning of thread

Q_4 = heat absorbed by the water in the calorimeter

$$Q_1 + Q_2 + Q_3 = Q_4 \quad \text{[Energy Balance]} \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Fig no.7 Bomb calorimeter

$Q_1 = m_{f*}cv_f$ (KJ)

$Q_2 = m_{w*}cv_w$ (KJ)

$Q_3 = m_{th*}cv_{th}$ (KJ)

$Q_4 = m_{water*}cv_{water*}$ change in temperature of water

Using this formula for energy conservation i.e. equation number one , we can find the value of calorific value of fuel. The following are the values of mass and calorific value of wire, thread and water:

Mass of water = 2 kg

Mass of thread = 0.0235 gm

Mass of wire = 0.0103 gm

Mass of fuel = 1.5 gm

Calorific value of water = 4.186 KJ/KG

Calorific value of thread = 17489.12 KJ/KG

Calorific value of wire = 1401.64 KJ/KG

Putting these values and the value of temperature rise in equation one, we can find the value of calorific value of the fuel.

Type of fuel	Rise in temperature (K)	Calorific value (KJ/KG)
Pure gasoline	8.291	$4.64 * 10^4$
E05	8.183	$4.54 * 10^4$
E10	7.896	$4.38 * 10^4$
E15	7.699	$4.27 * 10^4$
E20	7.538	$4.18 * 10^4$

Table no. 2: Calorific values of pure gasoline and its blends

In this way we find the calorific value of the test fuel.

7.2.2.2 DENSITY OF FUEL

For the purpose of finding the density of the fuel, we pour fuel into a beaker of known mass with volume marking on it. Now we find measure mass of the beaker filled with fuel. Now we check the volume of fuel filled in the beaker and separate the mass of empty beaker with the mass of filled beaker which will be equal to the mass of the fuel in the beaker.

Use formula for density (density = mass/ volume) to get the density of the fuel.

Type of fuel	Mass (kg)	Volume(m^3)	Density(kg/m^3)
Pure Gasoline	357.5	0.5	715.0
E05	370.0	0.5	740.0
E10	375.0	0.5	750.0
E15	375.7	0.5	751.4
E20	376.0	0.5	752.0

Table no.3: density of pure gasoline and its blends

In this way we have found the density of the gasoline and ethanol blended gasoline at 5%, 10%, 15% and 20% known as E05, E10, E15, E20 respectively.

7.2.3 POURING FUEL INTO THE MACHINE

In this step we pour our test fuel into the machine via inlet duct and keep an eye on the fuel level indicator. Here we record the level of fuel which is equal to 1 liter.

Care is needed while pouring and taking the reading of the fuel poured in the engine as this reading will have to be taken manually. After that we also need to set the compression ratio of the engine. This is being done a changing the level of a screw like structure present on the engine.

Fig. no.8 Experimental setup used for testing of the fuel

7.2.4 TURN THE COMPUTER AND ENTER INITIAL PARAMETERS

7.2.4.1 ENGINE PARAMETERS

Engine type- GREAVES make MK 25 **Fuel type-** Ethanol blended gasoline

Rated speed- 3000rpm **Speed type-** constant

Number of cylinders- 1 **Stroke type-** 4

Cylinder bore- 87.5mm

Stroke length- 110mm

Connecting rod length- 234mm

Compression ratio- 7 or 8

Swept volume- 661.5mm^3

Fig no. 9 IC engine software running on screen

7.2.4.2 FUEL PARAMETERS

Fuel pipe diameter- 12.4mm

Fuel measuring interval- 60 sec

Calorific value of fuel- Depends on fuel

Fuel density- depends on fuel

7.2.4.3 SETUP PARAMETERS

Orifice diameter- 20mm

Orifice coefficient of discharge- 0.6

Dynamometer arm length- 185mm

7.2.5 STARTING OF ENGINE

In this step firstly we turn on the engine and wait for one minute so that the engine gains its constant speed. Then we turn on the “fuel supply cock” to “measuring” position by the help of IC engine software.

Now the engine is let free for one minute but unlike the last one minute, all the data is being recorded for this one minute like brake power, indicated power, friction power, mechanical efficiency and specific fuel consumption. Now this practice is being repeated at different blending ratio and different compression ratio.

7.3 PERFORMANCE ANALYSIS

7.3.1 REPORT GENERATION BY IC ENGINE SOFTWARE

This test report is being generated by ICENGINE software after performing complete test in it.

ICENGINESOFT TEST REPORT

Report month: April, Time: 3:30 pm
Organization: organization , operator: operator
Data file: fuel testing
Configuration file: GREAVES make MK 25 engine.xls

Engine Details :

ICEngine set up under test is GREAVES make MK 25 having power 4 kW @ 3000 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, petrol Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Swept volume 661.45 (cc)

Combustion Parameters :

Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m^3) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.26, Number Of Cycles : 10, Cylinder Pressure Referance : 7, Smoothing 2, TDC Reference : 0

Performance Parameters :

Orifice Diameter (mm) : 20.00, Orifice Coeff. Of Discharge : 0.60, Dynamometer Arm Legnth (mm) : 185, Fuel Pipe dia (mm) : 12.40, Ambient Temp. (Deg C) : 40, Pulses Per revolution : 360, Fuel Type : ethanol blended gasoline.

Tables for IP, BP, FP, Mech.eff. , BSFC & m_f at CR 7:1

Compression ratio: 7:1

Fuel type: pure gasoline

Speed(rpm)	Load(kg)	IP(KW)	BP(KW)	FP(KW)	Mech. eff.(%)
3002.000	2.000	4.811	2.742	2.069	57.011
2986.000	2.500	3.912	2.230	1.682	56.903
3122.000	3.500	5.223	2.938	2.285	57.521
2966.000	3.500	6.002	3.499	2.503	58.103
3100.000	4.000	6.561	3.776	2.785	58.232
3056.000	4.500	7.002	4.099	2.903	58.546
3033.000	5.000	7.463	4.419	3.044	59.223
3267.000	5.500	7.942	4.738	3.204	59.67
3000.000	6.000	8.341	4.990	3.351	60.03

Table no.4: Mechanical efficiency of pure gasoline (CR 7:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP (KW)	BSFC (kg/kwh)
3002.000	2.000	2.363	2.742	0.862
2986.000	2.500	1.917	2.230	0.860
3222.000	3.000	2.514	2.938	0.856
2966.000	3.500	2.977	3.499	0.851
3100.000	4.000	3.202	3.776	0.848
3056.000	4.500	3.439	4.099	0.839
3133.000	5.000	3.676	4.419	0.832
3267.000	5.500	3.899	4.738	0.823
3000.000	6.000	4.086	4.990	0.819

Table no.5: BSFC of pure gasoline (CR 7:1) at different loads

Compression ratio: 7:1

Fuel type: 5% ethanol blended gasoline (E05)

Speed (rpm)	Load(kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3006.000	2.000	5.120	2.918	2.202	57.000
3021.000	2.500	5.644	3.226	2.418	57.211
3033.000	3.000	5.940	3.415	2.525	57.501
2086.000	3.500	6.152	3.556	2.596	57.822
2999.000	4.000	6.501	3.790	2.711	58.312
2992.000	4.500	7.000	4.060	2.940	58.800
3066.000	5.000	7.962	4.697	3.265	59.012
3011.000	5.500	8.361	4.975	3.386	59.511
3077.000	6.000	8.920	5.441	3.479	61.000

Table no.6: Mechanical efficiency of E05 blend (CR 7:1) at different loads

Speed (rpm)	Load(kg)	m_f (kg/h)	BP (KW)	BSFC (kg/kwh)
3006.000	2.000	2.530	2.918	0.867
3021.000	2.500	2.775	3.226	0.862
3033.000	3.000	2.933	3.415	0.859
2086.000	3.500	3.045	3.556	0.857
2999.000	4.000	3.228	3.790	0.854
2992.000	4.500	3.456	4.060	0.841
3066.000	5.000	3.928	4.697	0.834
3011.000	5.500	4.070	4.975	0.824
3077.000	6.000	4.466	5.441	0.821

Table no.7: BSFC of E05 blend (CR 7:1) at different loads

Compression ratio: 7:1

Fuel type: 10% ethanol blended gasoline (E10)

Speed (rpm)	Load(kg)	IP(KW)	BP(KW)	FP(KW)	Mech. eff.(%)
3022.000	2.000	5.921	3.493	2.428	59.000
3056.000	2.500	6.142	3.636	2.506	59.200
3232.000	3.000	6.540	3.892	2.648	59.512
3054.000	3.500	6.735	4.020	2.715	59.701
3156.000	4.000	7.151	4.290	2.861	60.000
3032.000	4.500	7.855	4.769	3.086	60.721
3132.000	5.000	8.230	5.103	3.127	62.009
3122.000	5.500	8.783	5.580	3.203	63.534
3111.000	6.000	9.124	5.931	3.193	65.012

Table no.8: Mechanical efficiency of E10 blend (CR 7:1) at different loads

Speed(rpm)	Load(kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3122.000	2.000	2.967	3.493	0.851
3056.000	2.500	3.064	3.636	0.843
3032.000	3.000	3.233	3.892	0.831
3054.000	3.500	3.290	4.020	0.819
3156.000	4.000	3.453	4.290	0.805
3132.000	4.500	3.783	4.769	0.794
3132.000	5.000	4.010	5.103	0.786
3222.000	5.500	4.343	5.580	0.779
3111.000	6.000	4.570	5.931	0.771

Table no.9: BSFC of E10 blend (CR 7:1) at different loads

Compression ratio: 7:1

Fuel type: 15% ethanol blended gasoline (E15)

Speed(rpm)	Load(kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3024.000	2.000	6.151	3.845	2.306	62.511
3145.000	2.500	6.672	4.204	2.468	63.012
3026.000	3.000	6.920	4.408	2.512	63.700
3132.000	3.500	7.435	4.783	2.652	64.343
3044.000	4.000	7.742	5.026	2.716	64.923
3055.000	4.500	8.325	5.437	2.888	65.311
3022.000	5.000	8.791	5.813	2.978	66.133
3022.000	5.500	9.328	6.240	3.088	66.900
2934.000	6.000	9.782	6.583	3.199	67.301

Table no.10: Mechanical efficiency of E15 blend (CR 7:1) at different loads

Speed(rpm)	Load(kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3124.000	2.000	3.217	3.845	0.837
3145.000	2.500	3.479	4.204	0.828
3026.000	3.000	3.618	4.408	0.821
3032.000	3.500	3.879	4.783	0.812
3044.000	4.000	4.023	5.026	0.801
3055.000	4.500	4.313	5.437	0.794
3022.000	5.000	4.559	5.813	0.786
3022.000	5.500	4.819	6.240	0.773
2934.000	6.000	5.028	6.583	0.764

Table no.11: BSFC of E15 blend (CR 7:1) at different loads

Compression ratio: 7:1

Fuel type: 20% ethanol blended gasoline (E20)

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3024.000	2.000	6.922	3.980	2.942	57.512
3022.000	2.500	7.341	4.266	3.075	58.121
3044.000	3.000	7.545	4.428	3.117	58.700
3044.000	3.500	7.930	4.705	3.225	59.332
3044.000	4.000	8.291	5.024	3.267	60.600
3055.000	4.500	8.774	5.352	3.422	61.000
3044.000	5.000	9.349	5.771	3.578	61.732
3055.000	5.500	9.761	6.052	3.709	62.011
2955.000	6.000	10.230	6.393	3.837	62.502

Table no.12: Mechanical efficiency of E20 blend (CR 7:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3024.000	2.000	3.506	3.980	0.881
3022.000	2.500	3.707	4.266	0.869
3044.000	3.000	3.799	4.428	0.858
3044.000	3.500	3.994	4.705	0.849
3044.000	4.000	4.205	5.024	0.837
3055.000	4.500	4.468	5.352	0.835
3044.000	5.000	4.801	5.771	0.832
3055.000	5.500	4.992	6.052	0.825
2955.000	6.000	5.299	6.393	0.829

Table no.13: BSFC of E20 blend (CR 7:1) at different loads

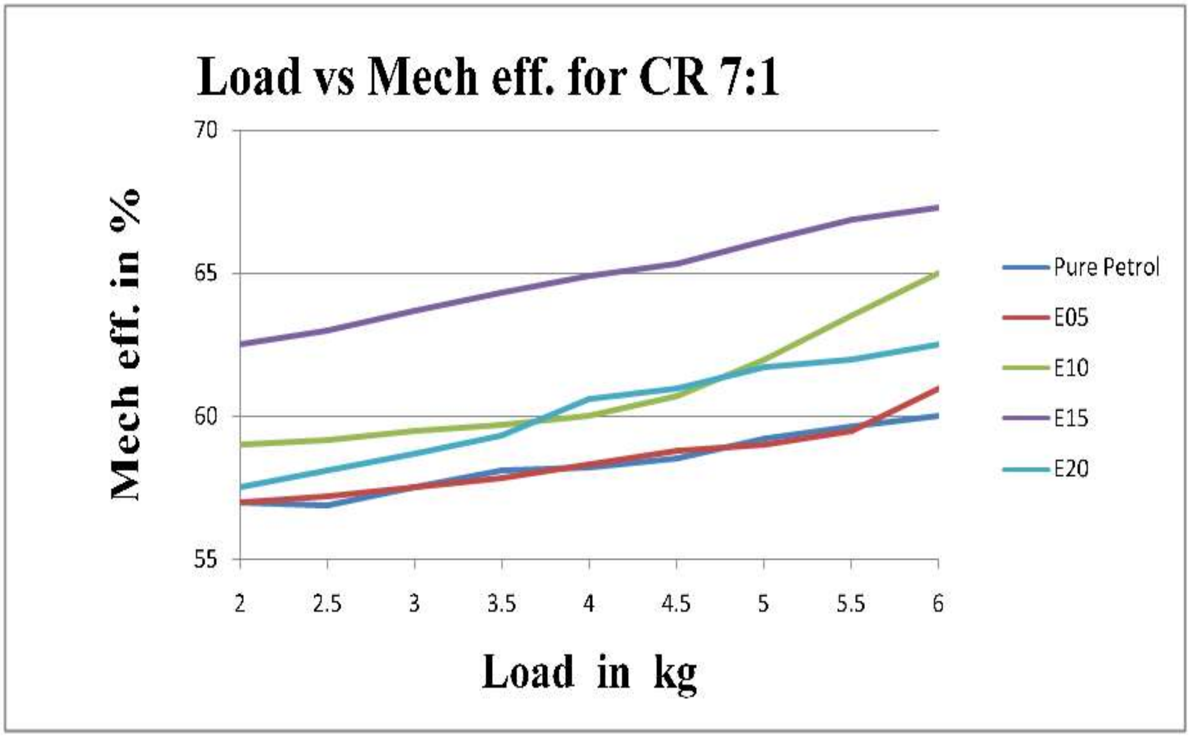

Fig 10 Variation of Mechanical Efficiency with Load for Pure Petrol and Various Ethanol Blends.

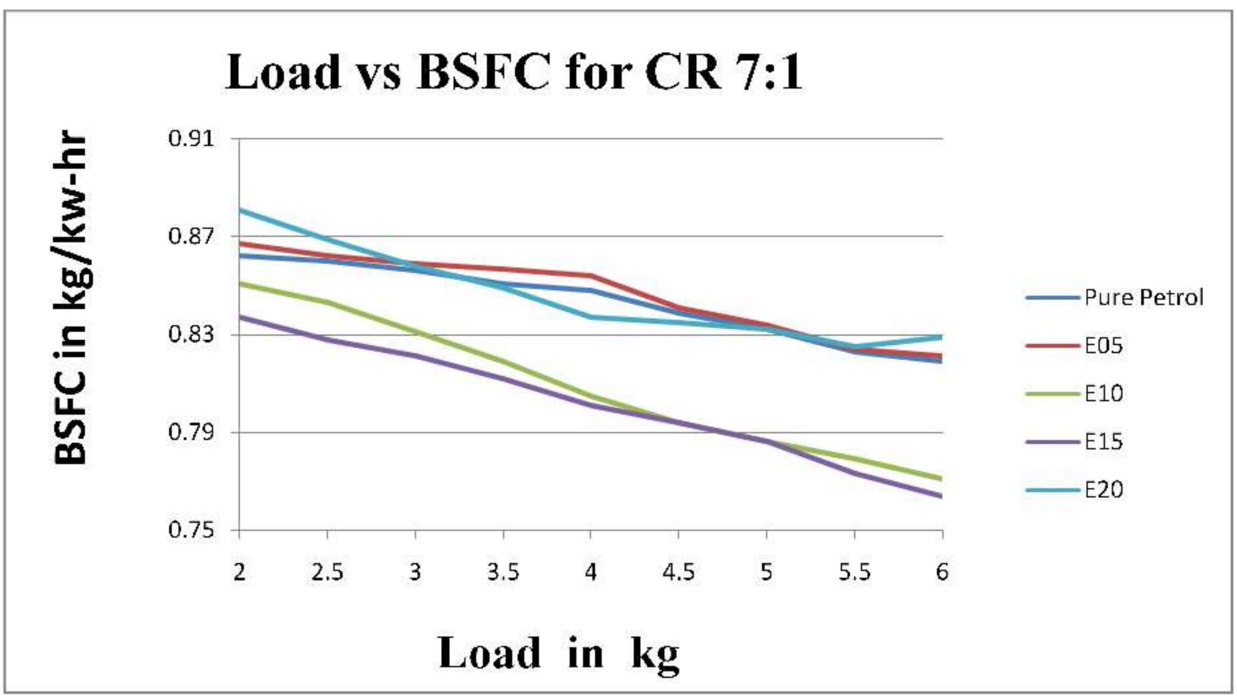

Fig 11 Variation of BSFC with Load for Pure Petrol and Various Ethanol Blends.

Tables for IP, BP, FP, Mech.eff. , BSFC & m_f at CR 8:1

Compression ratio: 8:1

Fuel type: pure gasoline

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3023.000	2.000	4.500	2.587	1.913	59.488
3034.000	2.500	4.845	2.805	2.040	59.894
3114.000	3.500	5.101	3.126	1.975	61.282
3122.000	3.500	5.650	3.492	2.158	61.805
3111.000	4.000	6.011	3.732	2.279	62.086
3033.000	4.500	6.451	4.057	2.394	62.889
3011.000	5.000	7.255	4.592	2.663	63.294
2978.000	5.500	7.871	5.005	2.866	63.587
2999.000	6.000	8.432	5.388	3.044	63.899

Table no.14: Mechanical efficiency of pure gasoline (CR 8:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3023.000	2.000	2.167	2.587	0.838
3034.000	2.500	2.330	2.805	0.831
3114.000	3.000	2.569	3.126	0.822
3122.000	3.500	2.842	3.492	0.814
3111.000	4.000	3.026	3.732	0.811
3033.000	4.500	3.253	4.057	0.802
3011.000	5.000	3.636	4.592	0.792
2978.000	5.500	3.948	5.005	0.789
2999.000	6.000	4.240	5.388	0.787

Table no.15: BSFC of pure gasoline (CR 8:1) at different loads

Compression ratio: 8:1

Fuel type : 5% ethanol blended gasoline (E05)

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3022.000	2.000	5.010	3.006	2.004	60.000
3014.000	2.500	5.121	3.108	2.013	60.691
2988.000	3.000	5.342	3.285	2.057	61.493
2965.000	3.500	5.951	3.683	2.268	61.888
2945.000	4.000	6.380	3.974	2.406	62.288
2999.000	4.500	6.940	4.351	2.589	62.694
3018.000	5.000	7.333	4.619	2.714	62.989
3091.000	5.500	7.891	4.987	2.904	63.198
3000.000	6.000	8.572	5.468	3.104	63.789

Table no.16: Mechanical efficiency of E05 blend (CR 8:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3022.000	2.000	2.497	3.006	0.831
3014.000	2.500	2.582	3.108	0.820
2988.000	3.000	2.683	3.285	0.817
2965.000	3.500	2.979	3.683	0.809
2945.000	4.000	3.171	3.974	0.798
2999.000	4.500	3.441	4.351	0.791
3018.000	5.000	3.630	4.619	0.786
3091.000	5.500	3.904	4.987	0.783
3000.000	6.000	4.270	5.468	0.781

Table no.17: BSFC of E05 blend (CR 8:1) at different loads

Compression ratio: 8:1

Fuel type: 10% ethanol blended gasoline (E10)

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3033.000	2.000	5.852	3.657	2.195	62.500
3122.000	2.500	5.900	3.711	2.189	62.910
2999.000	3.000	5.943	3.762	2.181	63.311
2987.000	3.500	5.990	3.822	2.168	63.809
2944.000	4.000	6.771	4.355	2.416	64.321
2956.000	4.500	7.922	5.142	2.780	64.911
3066.000	5.000	8.230	5.399	2.831	65.609
3076.000	5.500	8.788	5.854	2.934	66.618
3013.000	6.000	9.351	6.285	3.066	67.220

Table no.18: Mechanical efficiency of E10 blend (CR 8:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3033.000	2.000	2.958	3.657	0.809
3122.000	2.500	2.976	3.711	0.802
2999.000	3.000	2.987	3.762	0.794
2987.000	3.500	3.019	3.822	0.790
2944.000	4.000	3.409	4.355	0.783
2956.000	4.500	3.959	5.142	0.770
3066.000	5.000	4.108	5.399	0.761
3076.000	5.500	4.431	5.854	0.757
3013.000	6.000	4.707	6.285	0.749

Table no.19: BSFC of E10 blend (CR 8:1) at different loads

Compression ratio: 8:1

Fuel type: 15% ethanol blended gasoline (E15)

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3011.000	2.000	6.190	3.900	2.290	63.011
3081.000	2.500	6.220	3.963	2,257	63.721
3011.000	3.000	6.471	4.186	2.285	64.700
3001.000	3.500	6.562	4.286	2.276	65.322
3094.000	4.000	7.381	4.882	2.499	66.143
2934.000	4.500	7.944	5.316	2.628	66.921
2909.000	5.000	8.565	5.790	2.775	67.611
2988.000	5.500	8.971	6.163	2.808	68.701
2966.000	6.000	9.580	6.658	2.922	69.500

Table no.20: Mechanical efficiency of E15 blend (CR 8:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3011.000	2.000	3.174	3.900	0.814
3081.000	2.500	3.181	3.963	0.803
3011.000	3.000	3.305	4.186	0.792
3001.000	3.500	3.366	4.286	0.786
3094.000	4.000	3.795	4.882	0.778
2934.000	4.500	4.047	5.316	0.762
2909.000	5.000	4.351	5.790	0.752
2988.000	5.500	4.584	6.163	0.744
2966.000	6.000	4.926	6.658	0.740

Table no.21: BSFC of E15 blend (CR 8:1) at different loads

Compression ratio: 8;1

Fuel type : 20% ethanol blended gasoline (E20)

Speed (rpm)	Load (kg)	IP(KW)	BP(KW)	FP(KW)	Mech.eff.(%)
3022.000	2.000	6.950	4.364	2.586	62.800
3076.000	2.500	7.411	4.678	2.733	63.123
3043.000	3.000	7.622	4.833	2.789	63.421
2976.000	3.500	7.870	5.007	2.863	63.622
2997.000	4.000	8.372	5.351	3.021	63.923
2919.000	4.500	8.890	5.700	3.190	64.127
3076.000	5.000	9.544	6.152	3.392	64.467
3067.000	5.500	9.971	6.452	3.519	64.711
2999.000	6.000	10.34	6.710	3.630	64.900

Table no.22: Mechanical efficiency of E20 blend (CR 8:1) at different loads

Speed (rpm)	Load (kg)	m_f (kg/h)	BP(KW)	BSFC(kg/kwh)
3022.000	2.000	3.648	4.364	0.836
3076.000	2.500	3.878	4.678	0.829
3043.000	3.000	3.963	4.833	0.820
2976.000	3.500	4.070	5.007	0.813
2997.000	4.000	4.323	5.351	0.808
2919.000	4.500	4.577	5.700	0.803
3076.000	5.000	4.909	6.152	0.798
3067.000	5.500	5.142	6.452	0.797
2999.000	6.000	5.327	6.710	0.794

Table no.23: BSFC of E20 blend (CR 8:1) at different loads

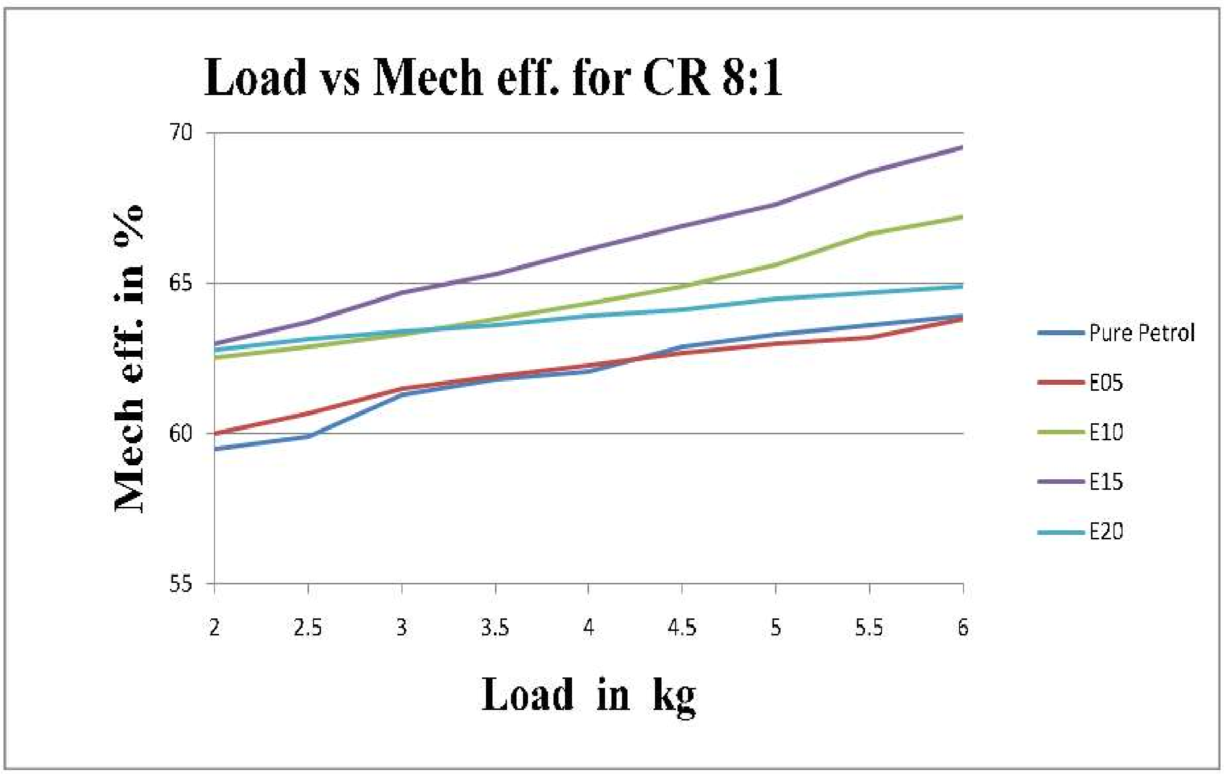

Fig 12 Variation of Mechanical Efficiency with Load for Pure Petrol and Various Ethanol Blends.

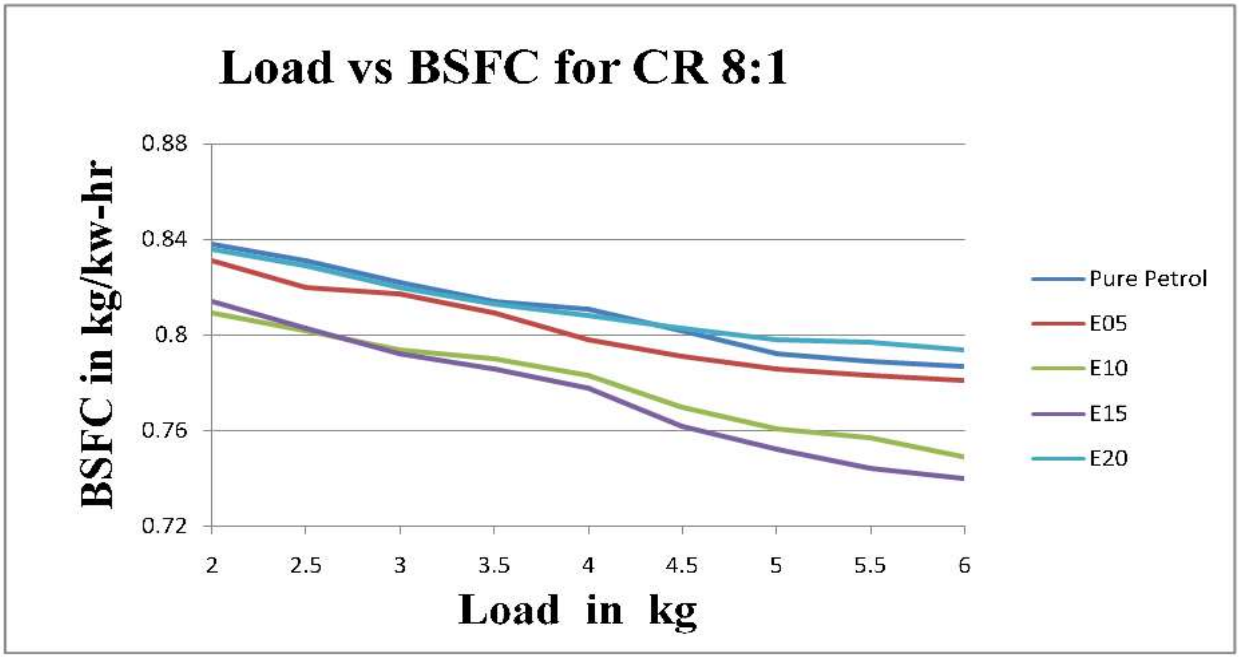

Fig 13 Variation of BSFC with Load for Pure Petrol and Various Ethanol Blends.

7.4 EMISSION ANALYSIS

While running any internal combustion undesirable emissions are generated during the combustion process emphasis is given on reducing the emission coming out of an engine. The emissions which are exhausted into the surrounding pollute the atmosphere and causes various problems like global warming, acid rain, smog, odours and respiratory hazards. Usually running an engine with petrol as fuel emission parameters are not specifically ideal that results in more emission of unburnt hydrocarbon HC and carbon monoxide CO and oxide of nitrogen NOx .

Engine emissions are classified into two categories:

(1) Exhaust emissions and (2) Non exhaust emissions

The above emissions are common to both SI and CI engines. The exhaust emissions are unburnt hydrocarbon, oxides of carbon, oxides of nitrogen and the main non exhaust emissions are the unburnt hydrocarbons from fuel tank and crankcase .

7.3.1 HYDROCARBON EMISSION

It is observed from figure, at all speeds the concentration of Hydrocarbon decreases for all the ethanol blends when compared over engine run on petrol. Since, hydrocarbons emissions are produced due to incomplete combustion or in other words due to insufficient oxygen supply complete combustion not occurs inside the engine cylinder. Ethanol contains 35% of oxygen so, ethanol blends shows reduction in hydrocarbons emission due sufficient supply of air by which helps complete burning of fuel. Among all ethanol blends, E15 DMC blend shows 84.37% maximum reduction in HC emission over engine run on petrol at full throttle condition.

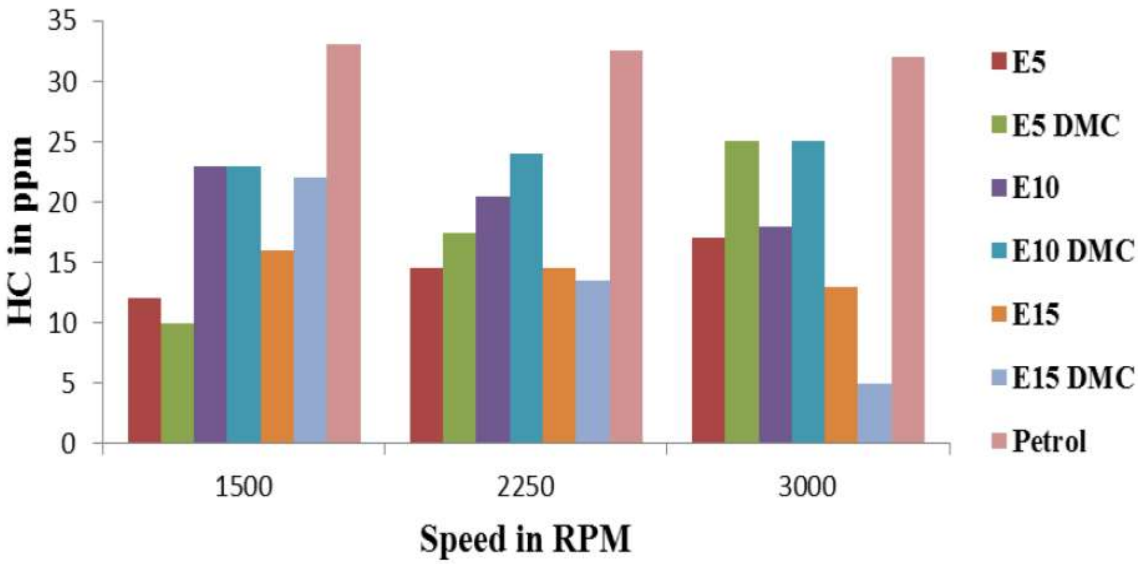

Fig 14 The effect of speed on Hydrocarbon Emission when petrol engine has run with ethanol blends and petrol

7.3.2 CARBON DIOXIDE EMISSION

It is observed from figure, that concentration of carbon dioxide decreases for all the ethanol blends when compared over engine run on petrol. The reason for reduction in carbon dioxide for ethanol blends, when hydrocarbon burns in presence of sufficient oxygen then it produces heat generating carbon dioxide and water as final product of reaction. So that sufficient oxygen is supplied by ethanol blended fuel. Among ethanol blends, E15 DMC blend gives 65.79% reduction in CO2 emission as compared with engine run on petrol at full throttle condition.

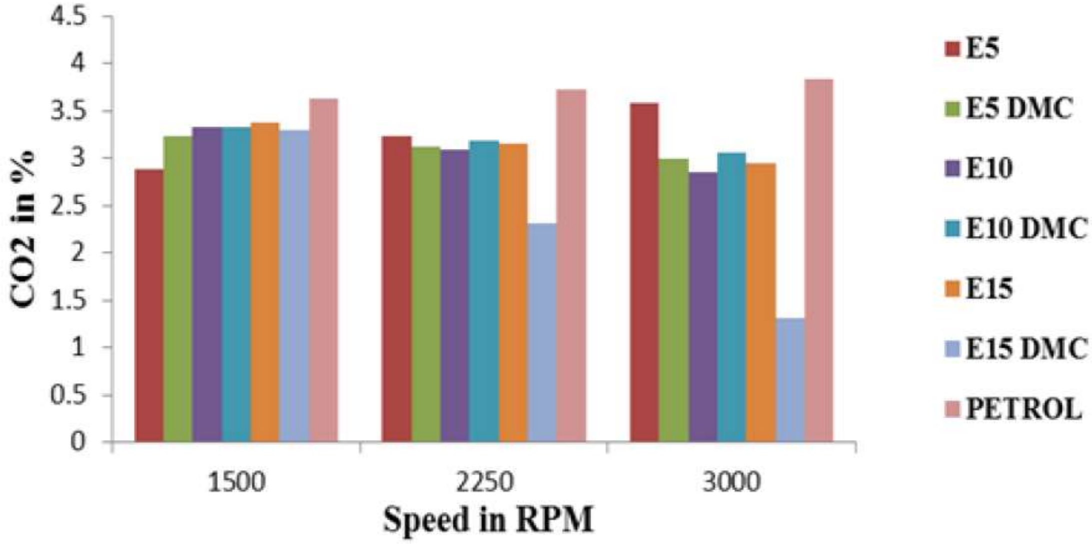

Fig 15 The effect of speed on Carbon Dioxide Emission when petrol engine has run with ethanol blends and petrol

7.3.3 CARBON MONO OXIDE EMISSION

Fig shows the effect of speed on Carbon monoxide at constant loading of 1 kW. In this figure shows that concentration of carbon monoxide decreases with increasing the ethanol blending ratios. And also all ethanol blends shows decrease in CO emission compared over engine run on petrol. This is mainly due to the decrease in carbon atoms concentration in the ethanol blended fuel and also because of high molecular diffusivity and higher flammability limits which improves mixing process and hence combustion efficiency. It can easily see from Fig. that there will be considerable decrease in CO emission for dimethyl carbonate (DMC) added ethanol blends because, DMC contains 53.3% of oxygen so this may provide additional oxygen for combustion process and leads to cleaner combustion of fuel finally reduced in CO emissions. Among ethanol blends, E15 DMC blend shows maximum reduction of 87.10% in CO emission over engine run on petrol at full throttle condition (3000 RPM).[10]

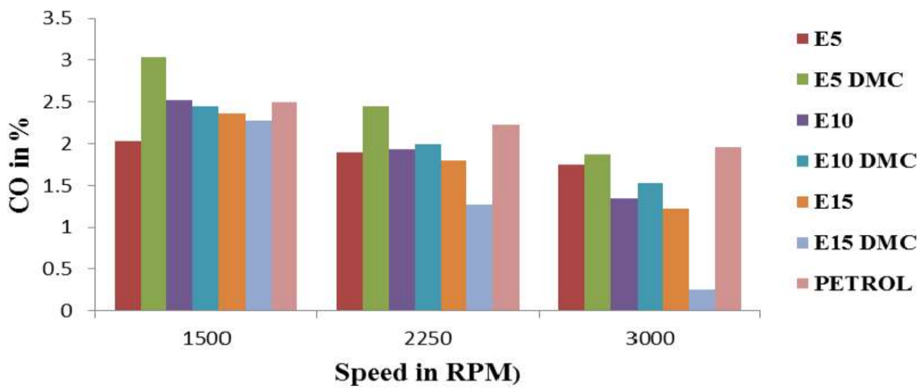

Fig 16 The effect of speed on Carbon Monoxide Emission when petrol engine has run with ethanol blends and petrol

7.3.4 NO_x EMISSION

It is observed from the figure, for all ethanol blends shows decrease in NOx when compared with engine run on petrol at three different speeds. This is because of the reason that lower heating value of ethanol than petrol resulting in reduction in the combustion heat energy and reducing the combustion temperature in the cylinder. And flame temperature for ethanol is lower than petrol, hence NOx emission are usually lesser than engine run on petrol. Among ethanol blends, Dimethyl carbonate (DMC) added ethanol blends gives still more reduction. Because, DMC additive still more decreases the ethanol flame temperature than petrol. Hence, it finally still more reduce in the NOx is obtained.

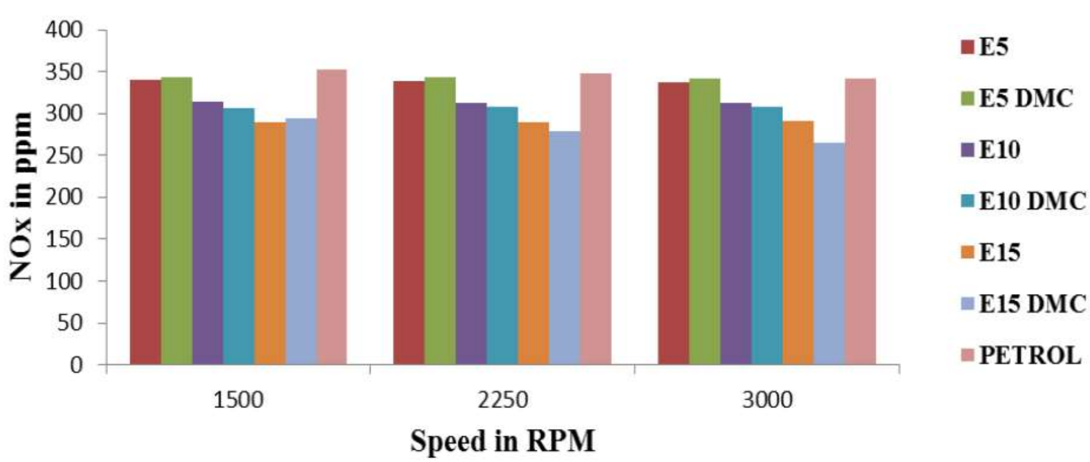

Fig 17 The effect of speed on Oxides of Nitrogen Emission when petrol engine has run with ethanol blends and petrol

In this study of emission analysis, performance parameters and emissions characteristics of a single cylinder spark ignition engine were measured on the utilization of the ethanol-petrol blends, and with adding Dimethyl carbonate (DMC) under different engine speed at the constant load of 1kW.

8. RESULTS

During the whole testing process we have analyzed pure gasoline and ethanol blended gasoline at various blend ratio (E05, E10, E15, E20). During this we have done both performance analysis and emission analysis. In this process we have got following results:

8.1 PERFORMANCE CHARACTERISTCS RESULTS

(i) As per the Performance of the engine 15% blended ethanol is best for use as it has got better mechanical efficiency than gasoline and any other blended gasoline at all the load value.

(ii) The break specific fuel consumption is minimum for 15% ethanol blended gasoline i.e. it's lower than all the blend ratio and pure gasoline.

Hence on the basis of the above observations we can say that E15(15% ethanol blended gasoline) is better performing fuel than pure gasoline and other ethanol blended gasoline.

8.2 EMISSION CHARACTERISTICS RESULTS

(i) Ethanol blended fuels gives best performances over engine run on petrol. Among ethanol blends, an E15 blend shows 14.45% decrease in brake specific fuel consumption.

(ii) Ethanol blended fuels shows reduction in emissions over engine run on petrol. It can be seen that major reduction in emissions for DMC added ethanol blends. At 3000 RPM, E15 DMC blend shows about 87.10%, 65.79%, 84.37% reduction in CO, CO2, HC emissions. Therefore, ethanol blended fuels shows a positive response on performance and emission characteristics over engine run on petrol. It can be concluded that E10 blend is a best suitable fuel for running petrol (spark ignition) engine without any engine modifications. DMC added ethanol blends are showing best results towards emissions but not performances. While studying the emission characteristics maximum improvement is seen. At low power outputs the HC emission is considerably more but as the load increases the reduction in HC emissions can be seen.

(iii) From the graph it can be seen that at medium and low loads CO emissions of the blend is not much impressive, but CO emission of the blend significantly decreases at full load. The lowest value obtained for CO emission is 0.12 % volume at full load.

(iv) At the same time when HC and CO emissions are reduced the CO_2 and NOx emissions are found to be increasing as the load increases. The reason for increase in these two parameters may be because of presence of oxygen in eucalyptus oil and the oxygenated fuel blends usually causes an increase in NOx emission. During complete combustion of the fuel high combustion temperature is achieved which results in higher NO_x and CO_2 formation.

9. CONCLUSION

9.1 REASONS FOR LIMITED USE OF ETHANOL AS A BLEND

(i) India is a country where we have a huge population to feed and if we have to increase our ethanol production we have to devote more farm land for it. The following are some stats associated with it:

Change in ethanol blend percentage(%)	Total Farm area to be devoted to it(%)
3 to 10	7
3 to 20	10

Table no. 24:.Relation between ethanol blend and farm area devoted to it .[12]

Hence if we increase our ethanol production then fuel vs food conflict will take place and stress on land resource will increase.

(ii) Water footprint is water required to produce a litre of ethanol, includes rainwater at the root zone used by ethanol-producing plants such as sugarcane, and surface, ground water, and fresh water required to wash away pollutants. Estimates of water footprints are available from the Water Footprint Network .

India's water footprint is not only high in overall terms, but India also uses more surface and ground water than the US and Brazil. Most of our daily uses of water come from this source. India has the least internal surface and ground water compared with Brazil and USA.

(iii) According to the Union Ministry of Petroleum and Natural Gas, the approximate ethanol availability in India is 300 crore litres. Of this, about 130 crore litres goes into making liquor, which is non-negotiable for states as liquor is a major revenue source for them. That leaves around 170 crore litres, out of which about 60 to 80 crore litres goes into making chemicals. That leaves about 100 to 120 crore litres for blending. From December 1, 2015 to November 30, 2016, 111 crore litres of ethanol was procured by the Oil Marketing Companies (OMCs) which would be sufficient for blending of only 3.5 per cent. During 2016-17, because of drought in Karnataka and Maharashtra, overall sugarcane and ethanol production reduced considerably and only 66.5 crore litres could be procured from suppliers. According to the Indian Sugar Mills Association (ISMA), sugar mills are set to more than double the supply of ethanol to fuel retailers for blending with gasoline in 2017-18. Ethanol manufactures and OMCs finalised supply contracts for a record 1.4 billion litres during 2017-18 (to realise 4 per cent blending), compared with 665 million litres a year ago.

(iv) It is very hard to locally procure the sugar by-product at the government-fixed rates as state governments have imposed heavy taxes on ethanol, widely used in the liquor industry. Sugar mills also prefer to sell ethanol to distilleries, where they get a better price and quicker deals.

(v) In India, sugarcane molasses are the major resource for bio-ethanol production and inconsistency of raw material supply is the major cause behind the sluggish response to blending targets. Since sugarcane production is cyclical, ethanol production also varies accordingly and does not assure optimum supply levels needed to meet the demand at any given time. The blending targets are partially successful in the years of surplus sugar production but unfulfilled when it declines. Drastic fluctuation in the pricing of sugar cane farming and sugar milling has resulted in mill owners being hugely indebted to farmers. Currently, Uttar Pradesh (UP)'s sugar mills have unpaid cane arrears owing to falling prices and a market glut and are saddled with huge quantities of molasses. It is reported that currently, UP sugar mills have unsold molasses of more than 2.62 million tonnes (MT) which have not been procured by liquor manufacturers. Permission is required for transferring molasses intending to produce ethanol and such applications are pending with the state excise department, which need to be processed urgently. As the domestic sourcing of ethanol is continuously failing to achieve the target, there is a need to look at other alternatives.

(vi) Ethanol has affinity to water. If water enters the fuel tank, it dilutes ethanol, reducing its value as a fuel. It causes problems of phase separation in fuel. Ethanol may also absorb dirt & carry inside the fuel lines and fuel tank, thus contaminating the engine system.

(vii) Due to material compatibility, engine wear & life. Rubber swelling & metal corrosion increases In-use vehicles may not be compatible with E15 fuel. So to use E15 level in blending some of the modifications may required for better performance of the engine.

9.2 WAYS TO INCREASE USE OF ETHANOL AS A BLEND

However, the current biofuel policy 2018 notified in June 2018 allows for procurement of ethanol produced directly from B-heavy molasses, sugarcane juice, and damaged food grains such as wheat and broken rice. During the agriculture crop year (July-June), when the Ministry of Agriculture & Farmers Welfare projects over-supply of food grains, the policy will allow conversion of these surplus quantities of food grains to ethanol, based on the approval of the National Biofuel Coordination Committee. In addition, using first generation fully developed technologies other alternative raw materials for production of ethanol will be promoted, such as sugar containing sugar beet or sweet sorghum, and starch-containing materials such as corn, cassava, or rotten potatoes. Opening of this route for ethanol production will not only help in utilizing the current capacities of grain-based distilleries but also will cover all the raw materials from which ethanol can be produced and help to harness fully developed 1-G technologies with minimum investment.

Push for Research and Development: The policy would encourage innovation and provide a push for research & development (R&D), and utilizing developed and emerging technologies.

Identified areas of intensive R&D work include: (1): Biofuel feedstock production (2): Advanced conversion technologies from identified feedstock (3): Technologies for end-use applications including modifications for biofuels (4): Utilization of bi-products of biofuels.

9.2.1 FUTURE PROGRAMME

India will triple its ethanol production over the next 4 years till 2023 and this will save rs. 12000 crore in the countries oil import bill, government has planned 12 biofuel refineries in the country at an investment of rs. 10000 crore. Now we will produce 450 crore litres of ethanol in the next 4 years from the existing 141 crore litres. By this the government will achieve 10% ethanol blending and is aiming to increase it further. There is a plan to setup 12 modern refineries for generating advanced biofuel.[13]

Under the Ethanol Blending Programme, the Centre has asked oil marketing companies (OMCs) to target 10 per cent blending of ethanol with petrol by 2022. According to data compiled by the Indian Sugar Manufacturers Association (ISMA), the nationwide average for ethanol blending stands at 4.02 per cent as on October 1.On June 4, 2018, the Ministry of Petroleum and Natural Gas (MoPNG), of the GOI notified the National Policy on Biofuels 2018, which came into effect on May 16, 2018 with approval from the Union Cabinet. The policy seeks to achieve 20 percent blending of ethanol with gasoline and 5 percent blending of biodiesel with diesel by 2030.

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