International Journal of Scientific & Engineering Research, Volume 5, Issue 9, September-2014

ISSN 2229-5518

A study on analysis of 2-stroke petrol engine using ethanol as an additive

Mr. Soumya Ranjan Nanda, Dr. Prof. Amitabh Biswas

Abstract— This study will consist of Introduction which is based on Literature and Review and also the effects and benefits of using ethanol. After Introduction comes the Planning of the study, the third one is Analysis of results and Discussion and the conclusion is drawn. The First part is Introduction. It consists of many topics which includes introduction to ethanol and why it is used, it's chemistry. As our study is based on using Ethanol, so there are various discussions about Ethanol, its production, its properties and benefits. The Second part is planning. This consists of Equipment setup, the various Apparatus required for the Experimentation, their specification and the procedure followed. The Third part is Analysis of Results and it's Discussion. Here various Experimental results are provided and discussed elaborately on basis of Performance and Exhaust Gas Analysis. This also includes the Experimentation with the ORSAT apparatus. Finally, after the study is completed the conclusion for the study is drawn.

Index Terms— Anti-knock Index, Brake thermal Efficiency, Carcinogens, Hydrocarbons, Oxygenate, PM (Particulate Matter), Research Octane number, Specific Fuel Consumption.

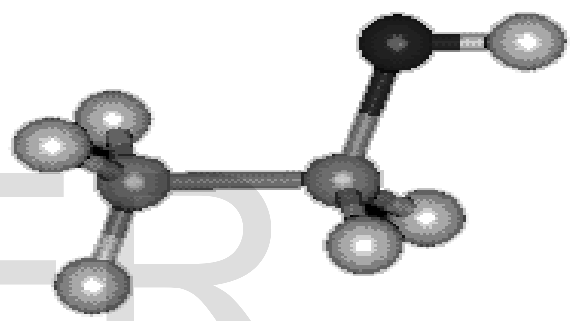
1. INTRODUCTION

Surveys show that People worldwide are concerned about the environment, global warming, and related issues. Yet many don't realize that the cars and trucks they drive are a major source of these problems, and that there are alternative choices they can make today.
Most of us drive or ride in vehicles that are powered by petroleum-based fossil fuels — gasoline or diesel. Some people, however, are choosing to drive vehicles that run on smaller amounts of fuel, and/or partially or completely on fuels other than diesel or gasoline. These advanced and alternative fuel vehicles (AFVs) help reduce our dependence on foreign oil imports, save us money on fuel costs, and improve our air quality. [1]

1.1 WHAT IS ETHANOL AND WHY IS IT USED AS AN AUTOMOTIVE FUEL?

Our whole project and experimentation includes the use of ethanol (Ethyl Alcohol), so it is essential to know more about this compound and why it is so popularly used as an Alternative Fuel, now a days for automotive purpose. We will have a detail look into this.

- *Mr. Soumya Ranjan Nanda is currently working with JINDAL SAW LTD, India, PH- +91 7698242163/9776868247. E-mail:soumya.213@rediffmail.com*
- *Dr. Prof. Amitabh Biswas is currently the Director of R&D in Rath Super Steel, India, PH-+91 8130562491. E-mail: amitabhabiswas@yahoo.com*

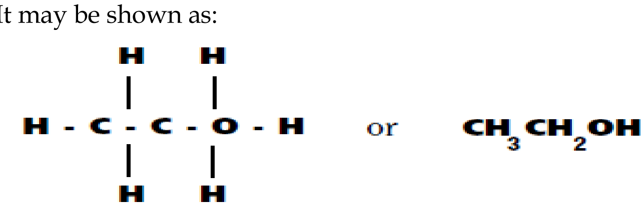


A molecular view of Ethanol
Fig. 1

- **Chemistry:**

Ethanol (ethyl alcohol) is a clear, colourless liquid with a faint odour. It has a high latent heat of vaporisation and contains oxygen, characteristics that are relevant to its environmental performance in combustion as a motor fuel, and in its storage and distribution. Ethanol is the most important member of a large group of organic compounds that are called alcohols. Alcohol is an organic compound that has one or more hydroxyl (OH) groups attached to a carbon atom. Alcohol is shown as: C-O-H or C-OH.

What is attached to the carbon at the three remaining bonds or locations determines the particular kind of alcohol. Ethanol has hydrogen present at two sites while the remaining site holds another carbon atom. This carbon atom, in turn, holds three more hydrogen atoms.
It may be shown as:



In its pure form, ethanol is a colourless clear liquid with a

ISSN 2229-5518

mild characteristic odour which boils at 78° C (172° F) and freezes at -112° C (-170° F). Ethanol has no basic or acidic properties. When burned, ethanol produces a pale blue flame with no residue and considerable energy, making it an ideal fuel. [5]
Ethanol mixes readily with water and with most organic solvents. It is also useful as a solvent and as an ingredient when making many other substances including perfumes, paints, lacquers, and explosives.
Let us have small comparison between Gasoline (petrol) and Ethanol.

Table 1

Property	Fuels	
	Gasoline	Ethanol
Molecular Formula	C_7H_{17}	C_2H_5OH
Molecular Weight (kg/kmol)	100-110	46
Octane Number	91-96	106-110
Lower Heating Value (MJ/kg)	44	26.9
Stoichiometric Fuel/Air Ratio	0.0685	0.1111
Density (g/cm^3)	0.72-0.78	0.785
Heat of Vaporization (KJ/kg)	305	840

How is ethanol made?

Ethanol is a product of fermentation. Fermentation is a sequence of reactions which release energy from organic molecules in the absence of oxygen. In this application of fermentation, energy is obtained when sugar is changed to ethanol and carbon dioxide.
Changing corn to ethanol by fermentation takes many steps. Starch in corn must be broken down into simple sugars before fermentation can occur. In earlier times, this was done by chewing the corn. This allowed the salivary enzymes to naturally break down the starch. Today, this is achieved by cooking the corn and adding the enzymes alpha amylase and gluco- amylase. These enzymes function as catalysts to speed up the chemical changes.
Once a simple sugar is obtained, yeast is added. Yeast is a single-celled fungus that feeds on the sugar and causes the fermentation. As the fungus feeds on the sugar, it produces alcohol (ethanol) and carbon dioxide. In fermentation, the ethanol retains much of the energy that was originally in the sugar, which explains why ethanol is an excellent fuel. [19]

Commercial production:

Most of the ethanol production in the United States is made in 60 production facilities in 20 different states. Most of these plants are located in the Midwest due to the ready availability of corn.
Changing the starch in kernels of corn to sugar and changing sugar to ethanol is a complex process requiring a mix of technologies that include microbiology, chemistry and engineering. Ethanol is produced from corn by using one of two standard processes: wet milling or dry milling. Dry milling plants cost less to build and produce higher yields of ethanol (2.7 gallons per bushel of corn), but the value of the co-products is less. [19]

Dry milling:

Most of the ethanol plants in the country utilize a dry milling process. The major steps of dry milling are outlined below:

- **Milling:** After the corn (or other grain or biomass) is cleaned, it passes first through hammer mills which grind it into a fine powder.
- **Liquefaction:** The meal is then mixed with water and an enzyme (alpha amylase), and passes through cookers where the starch is liquefied. A pH of 7 is maintained by adding sulphuric acid or sodium hydroxide. Heat is applied to enable liquefaction. Cookers with a high temperature stage (120°-150° C) and a lower temperature holding period (95° C) are used. The high temperatures reduce bacteria levels in the mash.
- **Saccharification:** The mash from the cookers is cooled and the enzyme gluco- amylase is added to convert starch molecules to fermentable sugars (dextrose).
- **Fermentation:** Yeast is added to the mash to ferment the sugars to ethanol and carbon dioxide. Using a continuous process, the fermenting mash flows through several fermenters until the mash is fully fermented and leaves the tank. In a batch fermentation process, the mash stays in one fermenter for about 48 hours.
- **Distillation:** The fermented mash, now called "beer," contains about 10 percent alcohol, as well as all the non-fermentable solids from the corn and the yeast cells. The mash is then pumped to the continuous flow, multi-column distillation system where the alcohol is removed from the solids and water. The alcohol leaves the top of the final column at about 96 percent strength, and the residue mash, called stillage, is transferred from the base of the column to the co-product processing area.
- **Dehydration:** The alcohol then passes through a dehydration system where the remaining water is removed. Most plants use a molecular sieve to capture the last bit of water in the ethanol. The alcohol at this stage is called anhydrous (pure, without water) ethanol and is approximately 200 proof.
- **Denaturing:** Ethanol that is used for fuel is then denatured with a small amount (2-5%) of some product, like gasoline, to make it unfit for human consumption.

Wet milling:

The wet-milling operation is more elaborate because the grain must be separated into its components. After milling, the corn is heated in a solution of water and sulphur dioxide for 24 to 48 hours to loosen the germ and the hull fibre. The germ is then removed from the kernel, and corn oil is extracted from the germ. The remaining germ meal is added to the hulls and fibre to form corn gluten feed. A high-protein portion of the kernel called gluten is separated and becomes corn gluten meal which is used for animal feed. In wet milling, only the starch is fermented, unlike dry milling, when the entire mash is fermented. [19]

- **Technology:**

The production of ethanol is an example of how science, technology, agriculture, and allied industries must work in harmony to change a farm product into a fuel. Ethanol plants receive the large quantities of corn they need by truck, rail, or barge. The corn is cleaned, ground, and blown into large tanks where it is mixed into slurry of cornmeal and water. Enzymes are added and exact acidity levels and temperatures are maintained, causing the starch in the corn to break down–first into complex sugars and then into simple sugars.

Plant scientists and geneticists are also involved. They have been successful in developing strains of yeast that can convert greater percentages of starch to ethanol. Scientists are also developing enzymes that will convert the complex sugars in biomass materials to ethanol. Cornstalks, wheat and rice straw, forestry wastes and switch-grass all show promise as future sources of ethanol. [11]

- **Production costs and price:**

Advances in ethanol production technology have substantially reduced costs. A shift to larger production plants along with improved yeast strains and enzymes have significantly reduced ethanol production costs. These innovations have lowered production costs from $1.40 per gallon in 1980 to less than $1.19 in 2000. Still newer plants and improved technologies have further reduced costs to an approximate current average of $1.10 to produce one gallon of ethanol. This trend is expected to continue. The cost of producing ethanol will also be affected by corn yields, corn costs, and markets for co-products. [13]

Consumer prices at the service station pump for E-10 Unleaded gasoline are usually near the same price per gallon as unblended fuel. This is also true for E-85 blends. These prices generally reflect applicable state or federal fuel tax incentives which are intended to make ethanol blends competitive with petroleum products.

Offsetting the cost of federal tax incentives is a reduction in farm subsidies and an increase in tax revenues. According to the U.S. Department of Agriculture, if ethanol use does not continue to grow, “deficiency payments for corn and other program crops will increase by $580 million for crop year 1998 and $740 million by the year 2000”—more than the cost of the tax incentives. The economic activity attributable to the ethanol industry will generate $3.5 billion in additional income tax revenue over the next five years – $1 billion more than the cost of tax exemptions. The U.S. ethanol industry will create a net gain to the taxpayers of almost $4 billion over the next five years.

The oil industry began receiving federal subsidies as early as 1916 to promote development of an energy industry. As the oil industry became more profitable, the subsidy payments continued. A recent study by the U.S. General Accounting Office found that since 1968, the oil industry has received approximately $150 billion in tax incentives. By contrast, the ethanol industry has received $11.2 billion through a partial exemption of the federal excise tax and $200 million in income tax credits. [19]

Ethanol can be produced in two forms: hydrated and anhydrous. Hydrated ethanol, usually produced by distillation from biomass fermentation, contains 95% ethanol with the balance being water. It is suitable for use as a straight spark ignition fuel in warm climates or for blending as a 15% emulsion in diesel. A further process of dehydration is required to produce anhydrous ethanol (100% ethanol) for blending with petrol. The most common uses are:

- 10% ethanol (E10); this is the blend available in Australia.
- 85% ethanol (E85); this blend is used in some states of the US and requires particular vehicle technology known as ‘Flexible Fuel Technology' (FFT). V8 super cars now use E85.
- 20-24% ethanol (E22); this blend, used in Brazil, requires specific vehicle optimisation.
- 100% ethanol (E100); this is also used in Brazil and requires vehicle technology dedicated to the fuel.

Ethanol is a known ‘octane enhancer’ and ‘oxygenate’. An octane enhancer increases the research octane number (RON) and reduces engine knock. An oxygenate is a fuel octane component containing hydrogen, carbon and oxygen in its molecular structure.

Oxygenates are often added to petrol to increase octane, extend petrol supplies and induce a lean-shift ('enleanment') in the engine's operation. Oxygenates 'enlean' the fuel by providing it with additional oxygen, effectively altering the air/ fuel ratio.

Ethanol blends tend to result in reduced emissions of carbon monoxide (CO), hydrocarbons (HCs), particulate matter, and certain known carcinogens. However, ethanol blends are likely to increase emissions of aldehydes, particularly acetaldehyde.

Several US studies conclude that the overall ozone forming potential of ethanol blends is the same or lower than that of petrol.

Ethanol can be considered as a renewable fuel when produced sustainably from agricultural sources and has potential for greenhouse gas emissions abatement. [13]

- **Need for fuel additives:**

In addition to AKI (Anti-Knock Index) and volatility, other fuel standards exist for copper corrosivity, stability in storage, sulphur content, metallic additives, and temperature for phase separation. It is important to note that gasoline retains its original “fresh” state for 90 days. It is usually 30 days old when it becomes available for consumer use. If gasoline is to be stored for longer than 60 days, a good gas stabilizer additive should be used by following the product directions. Other additives found in gasoline are detergents and deposit-control additives, anti-icers, fluidizer oils, corrosion inhibitors, anti-oxidants, metal deactivators, and lead substitute additives.

Detergents play an important role in preventing deposit build-up of port fuel injectors, intake valves, and combustion chamber deposits. Deposits on injectors and intake valves have been corrected by changes in detergents; however, some engines experience a build-up of deposits in the combustion chamber. Gas tank additives for injectors are designed to keep deposits from collecting. Special equipment and cleaning agents must be used to remove deposits. These special cleaning chemicals must not be used in the gas tank. [26]
Compatibility of materials is an issue, especially with certain brands of port fuel injectors. Causes of failure have not been verified, but a newly designed replacement injector prevents the problem from reoccurring.

Gasoline Additives

ADDITIVE	PURPOSE
Detergents/deposit control additives*	To eliminate or remove fuel system deposits
Anti-icers	To prevent fuel-line freeze up
Fluidizer oils	Used with deposit control additives to control intake valve deposits
Corrosion inhibitors	To minimize fuel system corrosion
Anti-oxidants	To minimize gum formation of stored gasoline
Metal deactivators	To minimize the effect of metal-based components that may occur in gasoline.
Lead replacement additives	To minimize exhaust valve seat recession

*Deposit control additives can also control/reduce intake valve deposits.

Purpose of Additives
Fig. 2

1.2 HOW DOES ETHANOL AFFECT ENGINE OPERATION?

1.2.1 Octane rating:

The octane number is a measure of the resistance 'knock'. As previously stated, ethanol in petrol is known to enhance the octane number of fuel.

The octane performance of a fuel is measured under two different operating conditions that provide the 'research' and 'motor' octane numbers (RON and MON) of the fuel. RON relates to low speed operation, and MON relates to high engine speed operation. [15]

The octane requirement of a particular engine results from a number of design factors such as compression ratio and combustion chamber design. Engines are designed to operate effectively on commercial fuel of specified octane numbers and fuel suppliers must ensure petrol octane meets these market needs.

Factors affecting the octane number requirement include:

- Compression ratio
- Barometric pressure/altitude
- Ignition timing
- Temperature
- Air/fuel ratio
- Humidity
- Combustion temperature (intake manifold heat, inlet air temperature, coolant temperature)
- Exhaust gas re-circulation rate
- Combustion chamber deposits
- Combustion chamber design

The difference between the RON and MON is called the 'sensitivity'. Petrol manufacturers try to maintain this at about 8 to 10 units to prevent high speed knock and possible engine damage. The sensitivity of E10 is about 14 units, although this may vary depending on the composition of the base petrol.

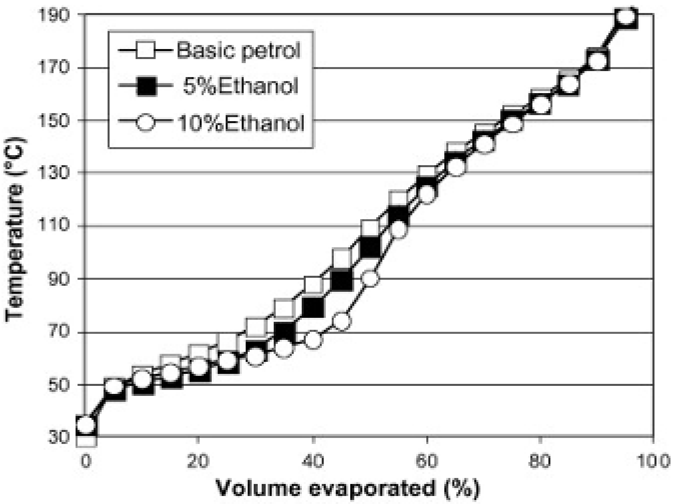
This change in sensitivity is unlikely to affect our older vehicles as we tend not to use them at continued high RPM & generally the compression tends to be low.

1.2.2 Volatility:

Volatility refers to a fuel's ability to change from liquid to vapour and is characterised by three measurements - vapour pressure, flexible volatility index and distillation curve.

Volatility is commonly measured by RVP (Reid Vapour Pressure), which is the fuel's vapour pressure at 37.8 degrees Celsius. This is a measure of the fuel's more volatile components, which vaporise first. RVP is largely governed by the fuel's butane content. [18]

Flexible Volatility Index (FVI) is a parameter used to ensure good hot weather operability of the fuel by limiting the fuel volatility so that vapour lock will not occur. It is the sum of the RVP and the percentage of fuel evaporated in a simple distillation test at 70C. The distillation test is used to determine the fuel's volatility across the entire boiling range of petrol and the plot of the evaporation temperature versus volume distilled is referred to as the distillation curve.



Evaporation of Various Ethanol Blends in reference to Tempreture

Fig. 3

Petrol that is too volatile may vaporise easily and boil in fuel pump lines or in carburettors at high operating temperatures. If too much vapour is formed, this could cause a decrease in fuel flow to the engine, resulting in symptoms of vapour lock, including loss of power, rough engine operation, or complete stoppage. Fuel economy could also deteriorate and evaporative emissions could increase. [21]

1.2.3 Fuel consumption:

Ethanol, like other alternative/renewable fuels, has a lower calorific value than petrol. Fuel consumption is influenced by a range of factors including, energy content of the fuel. Australian field trials have observed a fuel consumption increase of up to 2.8% with E10. This finding is consistent with theoretical energy losses of approximately 2-3%. [23]

So unless you are paying at least 3% less than standard unleaded costs you, you will get less Kms/dollar for E10 fuel.

1.2.4 Phase separation in storage tanks:

Ethanol blends are particularly sensitive to poor handling and storage practices because of the possibility of phase separation. Phase separation can occur when too much water is introduced into a storage tank. As ethanol has an affinity for water, ethanol blends are more likely to suspend moisture and carry it into the fuel system than non-oxygenated fuels. However, if too much water is introduced into an ethanol blend, the water and most of the ethanol (around 60% - 70%) will separate from the petrol and the remaining ethanol. The amount of water that can be absorbed by ethanol-blended petrol without phase separation varies from 0.3 to 0.5%, depending on temperature, aromatics and ethanol content.

Because ethanol is hygroscopic and absorbs water from the atmosphere (and any vessel containing water that it enters), it is prudent to ensure that water contamination does not occur in the distribution and storage of ethanol blends. [15]

If phase separation occurs in the storage tank, you can end up getting a very high concentration of both ethanol and water in your next tank full of E10.

1.2.5 Phase separation in vehicle’s tank:

Water in petrol can have dramatically different effects on an engine, depending on whether it is in solution or a separate phase. A small amount of water solution in a homogeneous ethanol/petrol blend has no adverse effect. Phase separation can occur in a vehicle's tank as a result of first fuelling with an ethanol blend then going out of the ethanol blend system. This situation arises if, for example, a quarter of a tank of ethanol blend is supplemented by three-quarters of a tank of petrol at refill, causing the concentration of ethanol in the blend to fall. It is therefore possible that in this situation, the presence of water normally contained within the ethanol blend will be sufficient to precipitate phase separation, giving you water in your fuel tank. [22]

But look on the bright side, water will cause the tank to rust and the holes in the tank will let the water out. Now who would have thought that just refilling your tank with proper petrol after using E10 would cause problems?

1.2.6 Emission outcomes for ethanol blends:

The study indicates that, for the majority of the vehicles, total hydrocarbons and carbon monoxide emissions, as well as fuel economy, decreased, while NOx and acetaldehyde emissions increased as the ethanol content in the test fuel increased. Formaldehyde and vehicle exhaust CO2 were largely unaffected.It seem using E10 will not do anything much to reduce our CO2 (global warming) emissions. Nitrous Oxide and acetaldehyde emissions are not a good thing. Remember all the environmental figures we hear about ethanol don’t take into account the environmental impact or growing the crop used to make the ethanol. [18]

After reading this report extract you may wish to drain your tank of ethanol “infected” petrol and tip it out however the full report warns that the BTEX plume is increased. [17]

The full report states “spills of ethanol blends result in more persistent BTEX (benzene, toluene, ethyl benzene and xylene) and cause the toxic BTEX compounds of petrol to travel up to 2.5 times farther than in the absence of ethanol.” So you can’t even get rid of the stuff.

Now let us talk about the various benefits that we will be getting by using as a fuel or Fuel Additive:

1.3 BENEFITS OF USING ETHANOL

➢ Consumer benefits:

- Consumers use more than 18 billion gallons of high performance, cleaner burning ethanol blended gasoline each year.
- Ethanol and ethyl tertiary butyl ether (ETBE) increase oxygenated supplies, reducing the need for methyl tertiary butyl ether (MTBE) imports and helping to reduce consumer costs.
- Ethanol is a high octane blending component used by many independent gasoline marketers – creating competition for the major oil companies.
- ETBE is a low volatility oxygenate which provides refiners a cost-effective means to meet Clean Air Amendment standards.
- Ethanol blends, such as E-10 unleaded, can be used in virtually all gas engines without any engine or mechanical revisions.
- Ethanol guards against gas line freeze by absorbing moisture that may get in the tank during cold weather. [14]

➢ Taxpayer benefits:

- The partial excise tax exemption for ethanol blends available to gasoline marketers saves money.
- A GAO study has shown that reduced farm program costs and increased income tax revenues offset the cost of the incentive.
- According to the USDA, if ethanol use does not continue to grow, "deficiency payments for corn and other program crops will increase by $580 million for crop year 1998 and $740 million by 2000" – more than the cost of the tax incentive.
- The economic activity caused by the ethanol industry will generate $3.5 billion in additional income tax revenue over the next five years – $1 billion more than the cost of the exemption.
- The U.S. ethanol industry will create a net gain to taxpayers of almost $4 billion over the next five years. [17]

➢ Economic benefits:

- More than $3 billion has been invested in 60 ethanol production facilities operating in 20 different states across the country.
- The ethanol industry is responsible for more than 40,000 direct and indirect jobs, creating more than $1.3 billion in increased household income annually, and more than $12.6 billion over the next five years.
- The ethanol industry directly and indirectly adds more than $6 billion to the American economy each year.
- As the economic activity created by the ethanol industry ripples through the economy, it will generate $30 billion in final demand between 1996 and 2000.
- Increases in ethanol production offer potential for economic growth in small rural communities. USDA has estimated that a 100 million gallon ethanol plant could create 2,250 local jobs, including grain production. [14]
- Each gallon of ethanol produced domestically displaces seven gallons of imported oil.

➢ Agricultural benefits:

- Industrial corn use, which includes ethanol and sweetener production, is now the third largest consumer of corn in America.
- Each $1 of up-stream and on-farm economic activity generates $3.20 in downstream economic stimulus attributable to ethanol processing, compared to just $0.31 when U.S. corn is exported.
- Ethanol production consumed nearly 535 million bushels of corn in 1994 (5.3 percent of the record 10 billion bushel corn crop).
- The demand for corn created by the ethanol industry increases crop values.
- If the market for ethanol did not exist, corn stocks would rise and net income to American corn farmers would be reduced by $6 billion over the next five years, or about 11 percent.
- One acre of corn can produce 300 gallons of ethanol – enough to fuel four cars for one year with a 10 percent ethanol blend. [19]

➢ Energy/trade benefits:

- Domestic ethanol and ETBE production reduces demand for imported oil and MTBE which drains our economy – oil and MTBE imports now represent almost 80 percent of the U.S. trade deficit.
- Currently, imported oil accounts for 54 percent of consumption.
- Today, ethanol reduces the demand for gasoline and MTBE imports by 98,000 barrels per day.
- Ethanol production generates exports of feed co-products, such as corn gluten in livestock feed, further decreasing our balance of trade. Corn gluten exports can top $800 million a year.
- Ethanol production is energy efficient, with a positive energy balance of 125 percent compared to 85 percent for gasoline.
- Ethanol production is the most efficient method of producing liquid transportation fuels. According to USDA, each BTU used to produce 1 BTU of gasoline could be used to produce 8 BTUs of ethanol. [29]

ISSN 2229-5518

➢ Environmental benefits:

- Ethanol blends reduce carbon monoxide better than any reformulated gasoline blend— more than 25 percent.
- Ethanol is low in reactivity and high in oxygen content, making it an effective tool in reducing ozone pollution.

2. PLANNING

2.1 EQUIPMENT SETUP:

The engine that we are going to use is a 2-stroke petrol engine that is available in our thermal laboratory of Mechanical Engineering Department.

This is the second time we are performing the Experiment on a 2-Stroke Petrol Engine so the setup remains the same, and this experiment is done using a blend of Ethanol (Rectified Spirit(90 % Ethyl Alcohol)) and Petrol , and the procedure followed is same as that in the Experiment "Load test on a 2-stroke petrol engine".
We have got the results and used them to plot graphs between various parameters of a 2-stroke petrol engine. The image of the setup is given below.

Fuel input and Fuel flow rate measuring setup
Fig. 4

In the Images above , we can see the general setup of our Experimental Setup on which our Experiment was performed. In the setup we can clearly see the fuel tank, fuel measuring equipment and the Engine set-up.

2.2 APPARATUS REQUIRED:

1) A single cylinder air cooled 2-stroke petrol engine set-up.
2) Belt brake Dynamometer.
3) Tachometer.
4) Rectified Spirit (90% Ethyl Alcohol).
5) A stop watch.
6) Fuel input measuring arrangement.
7) Orsat apparatus.

2.3 SPECIFICATION OF VARIOUS EQUIPMENT:

➢ Petrol engine:

The engine is single cylinder 2-stroke petrol engine. The engine is complete with air cleaner, carburettor exhaust silencer etc. Rated Horsepower: 1 HP at 3000 rpm. Cylinder Bore: 57 mm and Stroke: 57 mm.

Engine setup

Fig. 5

➢ Belt brake dynamometer:

The brake drum is of 200 mm diameter coupled to engine shaft through suitable pedestal with bearing, suitable dial type spring balance hand wheel screw rod and provided for control loading arrangement; piping arrangement for brake drum for flow of water to carry away the heat is also provided.

Belt Brake Dynamometer

Fig. 6

- **Fuel input measuring arrangement:**

It consists of a fuel tank of suitable capacity 100 c.c Burette each arrangement. And 400 and 200 ml Flasks to measure the Petrol, and a 100 ml vertical Flask to measure the Rectified Spirit (90% Ethyl Alcohol), for mixing them.

Fuel input measuring arrangement

Fig. 7

Equipments for blending ethanol into Petrol

Fig. 8

- **Stop watch:**

It is used to note down the time taken for 10 cc of fuel consumption.

- **Tachometer:**

It is used for measuring the RPM of the Engine, from which we can calculate the Torque and plot graphs accordingly.

Tachometer for measuring engine RPM
Fig. 9

ISSN 2229-5518

2.4 EXPERIMENTAL PROCEDURE:

1) Before starting make sure that the fuel tank and fuel line is cleaned by fuel oil and free from foreign matter. Fill the fuel tank and fuel mixture to required quantity.
2) Make the Spring Balance to zero reading.
3) Start the Engine with the kicker provided and run it for few minutes until the RPM reached the rated RPM of 3000.
4) Note down the first observation by running the engine at zero load condition.
5) At zero load condition note down the time taken for the 10cc consumption of fuel.
6) Now applying a minimum load on the engine and again noting down the time for 10cc consumption of fuel at the load condition.
7) Then we have to down the time taken by 10cc consumption of fuel by gradually increasing the load at constant RPM 3000.
8) Finally, the observation will help to find out the BTE (break Thermal Efficiency) of Engine at different load condition.

Fig. 10

3. ANALYSIS OF RESULTS AND DISCUSSION

This is the second time, we are performing the Experiment on the 2-stroke Petrol Engine, and this Experiment is done in two phases:

- In the first phase we have used a blend of Ethanol and Petrol, where Rectified Spirit was used, which consisted of about 90% Ethyl Alcohol. Here we have used about 5% Ethanol blended into Petrol. So for 1 litre of petrol, 50ml of Ethanol was blended into it. So it makes 950ml of Petrol and 50ml of Rectified Spirit.

- In the second phase we have used a blend of Ethanol, Petrol and some Water. Here Ethanol used was about 5% of the total mixture along with 1% of Water in Petrol. So For 1 litre of Petrol, 50ml of Ethanol and 10ml of Water was blended into it. So that makes it 940ml petrol and the rest a mixture of Ethanol and Water.
  The important thing is to mix the fuels; the measured quantity of water should be added to Ethanol instead of directly mixing it into petrol. Direct mixing of water into Petrol will cause insolubility, and the water will settle down at the bottom of the Fuel Tank causing difficulty in starting the Engine.

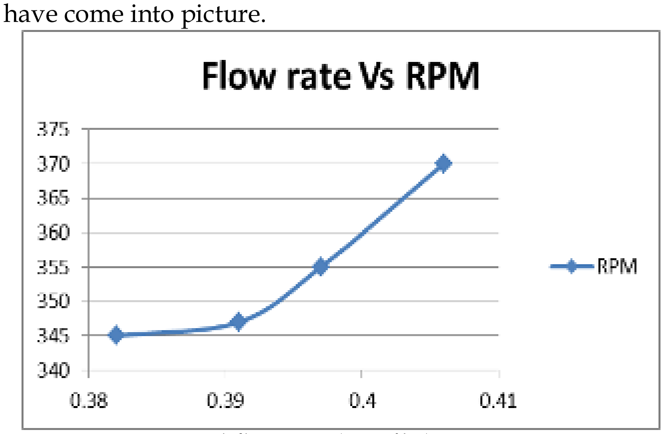
Now let me present the various data acquired after performing the Experiment on the 2-stroke Petrol Engine.

3.1 1st RUN: ONLY USING PETROL

Table 2

SL NO.	LOAD(L)	THROTTLE(T)	ENGINE SPEED(RPM)	FUEL FLOW RATE(KG/Hr)	INLET AIR TEMP.(C)
1.	L1	T1	370	0.40068	35
2.	L2	T2	345	0.4064	35
3.	L3	T3	347	0.3913	35
4.	L2	T1	345	0.3974	35
5.	L2	T3	355	0.3826	35

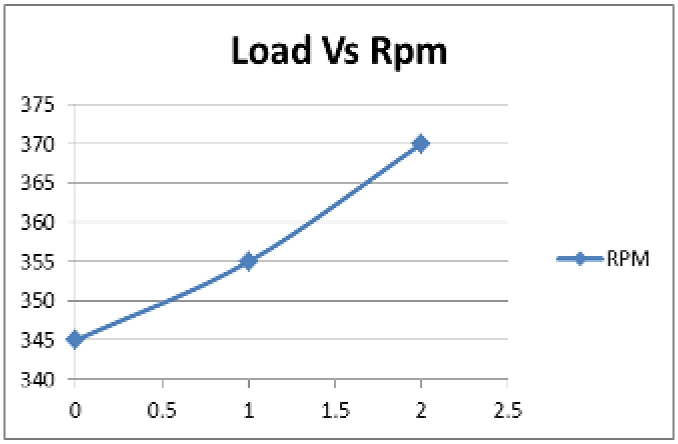
After performing this Experiment, graphs were plotted using various parameters such as Load, Engine speed (RPM), Fuel flow rate (Kgs/hr), and the following results have come into picture.



X-axis=Fuel flow rate(Kgs/hr), Y-axis=RPM

Fig. 11

It can be clearly seen that as the Fuel flow rate increases, more and more fuel enters the Engine giving it more power and thus increases it's Speed (RPM). Here RPM is in direct relation with brake Power (BP), so as RPM increases so does the BP.



X-axis=Load,Y-axis=RPM

Fig. 12

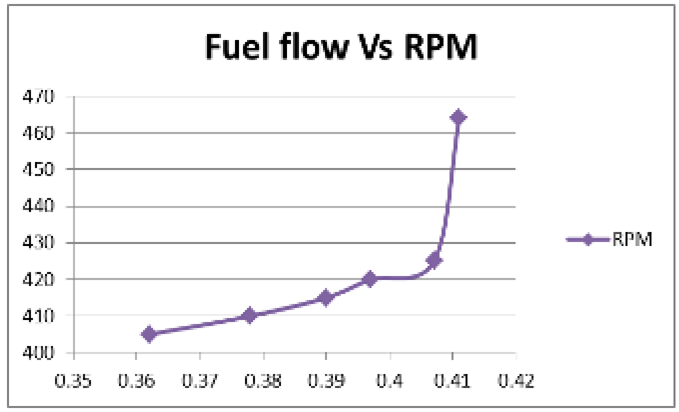
Here also it can be seen that with increasing Load the RPM continues to Increase.
this is because with increasing Load , the Throttle was also increased. If the Throttle had not been increased, the RPM would have gone down.
These readings and Graphs will act as reference for comparison of Results for other two Experiments , that is, Petrol with 5% Ethanol and Petrol with 5% Ethanol and 1% Water.

3.2 2nd RUN: USING 5% ETHANOL

Table 3

SL NO.	LOAD(L)	THROTTLE(T)	ENGINE SPEED(RPM)	FUEL FLOW RATE(KG/Hr)	INLET AIR TEMP.(C)
1.	L1	T1	410	0.4114	33
2.	L2	T2	415	0.390	33
3.	L3	T3	405	0.3621	33
4.	L2	T1	412	0.37764	33
5.	L2	T3	420	0.3974	33
6.	L1	T2	425	0.4075	33
7.	L1	T3	464	0.4093	33
8.	L3	T1	415	0.3695	33
9.	L3	T2	420	0.3788	33

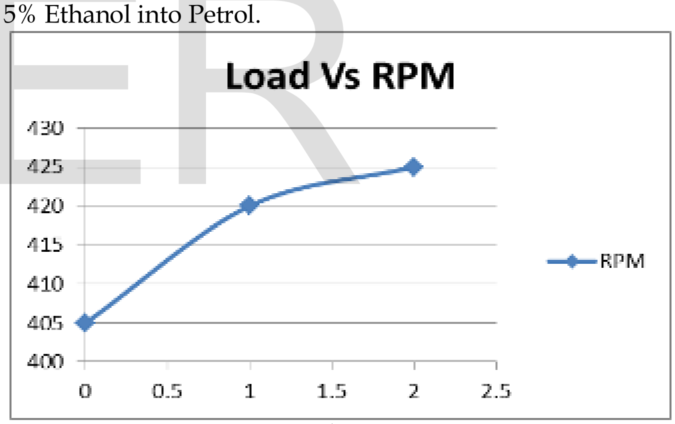
After performing the Experiment with 5% Ethanol the readings were noted in a Table mentioned above. Now to analyse them, they were plotted on a Graph against each other. The results can be seen on the Graphs mentioned below.



X-axis=Fuel flow rate(Kgs/hr), Y-axis=RPM

Fig. 13

From the above Graph, we can see that the RPM has increased values for the same Fuel flow rate, and also the rate of increase in RPM has increased.
So in comparison to the results for Petrol run, we can say that the Engine's performance has increased by blending 5% Ethanol into Petrol.



X-axis=Load, Y-axis=RPM

Fig. 14

As we have increased the Throttle along with the Load, the RPM doesn't come down.
But from this Graph we can see that with increasing Load the RPM increases upto certain level and then, the rate of increase in RPM will become constant. This result is due to the blending of Ethanol into Petrol.

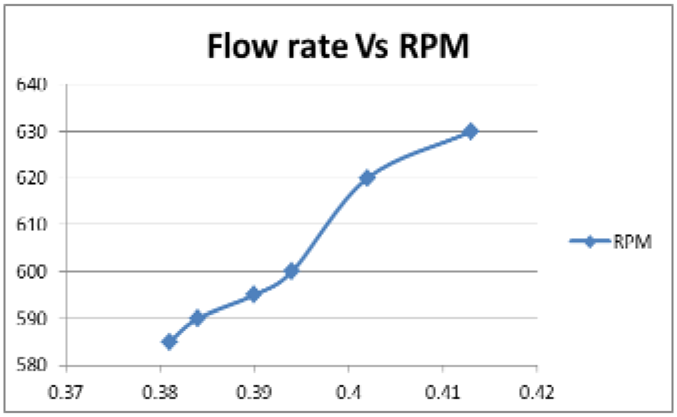
3.3 3rd RUN: USING 5% ETHANOL AND 1% WATER

Table 4

SL NO.	LOAD (L)	THROTTLE(T)	ENGINE SPEED(RPM)	FUEL FLOW RATE(KG/Hr)	INLET AIR TEMP. (C)
1.	L1	T1	585	0.38820	28

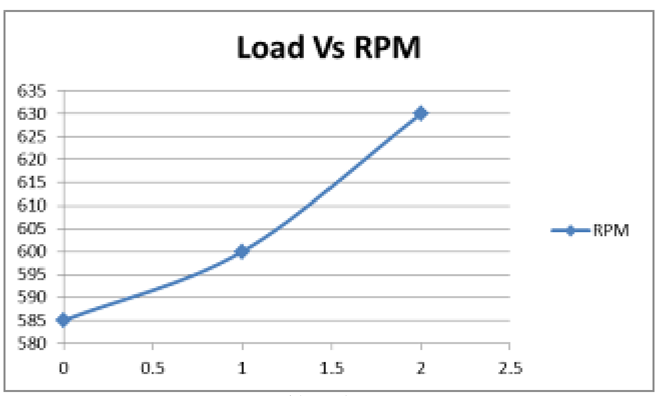
ISSN 2229-5518

2.	L2	T2	590	0.4021	28
3.	L3	T3	582	0.4136	28
4.	L2	T1	595	0.3921	28
5.	L2	T3	600	0.3942	28
6.	L1	T2	620	0.3848	28
7.	L1	T3	630	0.39068	28
8.	L3	T1	590	0.39011	28



X-axis=Fuel flow rate(Kgs/hr), Y-axis=RPM
Fig. 15

In this Experiment, we have added 1% water along with 5% Ethanol into Petrol.
The above Graph shows plot between Fuel flow rate and RPM. We can see that adding some Water into Petrol along with Ethanol has too increased the performance of the Engine. The RPMs are higher as compared to both of the former Experiments. As the rate of increase in RPM increases at the beginning and then tends to become constant afterwards.



X-axis=Load(Kgs), Y-axis=RPM

Fig. 16

In this Graph, we can see that load is plotted against RPM. Here it was found that for a blend of 5% Ethanol and 1% Water, the RPMs that we got are in a higher range as compared to both of the former Experiments. Also the rate in increase in RPM is also high.
Overall we can say that, the performance of the Engine has increased by using Ethanol and water as additive.
Where,

L1=0 kg, and T1=Throttle position 1
L2=1 kg, and T2=Throttle position 2
L3=2 kg, and T3=Throttle position 3

Below is provided an Image which shows the Throttle positions at various levels undertaken during our Experiment.

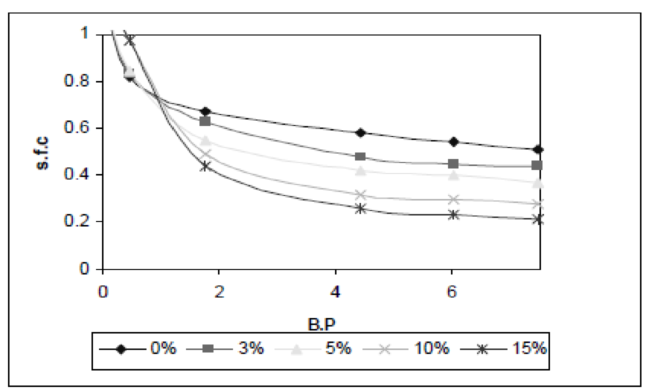
Fig. 17

Now we will be comparing the results of our findings of 2-Stroke Petrol Engine on which our Experiment was performed with the findings of another Experiment, which was done Professionally with the help of proper and accurate Equipments. We will be comparing the results on basis of analysis of Performance and Exhaust.

A. PERFORMANCE ANALYSYS

Here I have used the results from the Minor Project report to compare the results from my experiment. The results may vary distinctively as those Experiments were done under Professional supervision and Accurate Equipments.

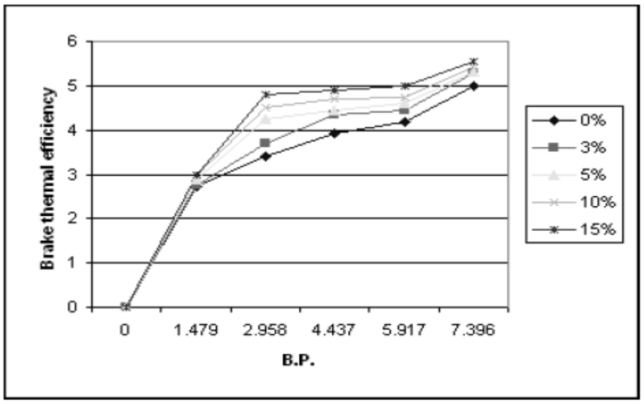
Specific fuel consumption (SFC):



X-axis=Brake power, Y-axis= Specific Fuel Consumption[29]
Fig. 18

The variation of SFC with brake power for different percentage of additives of Alcohol with the Petrol as shown in figure 18. The additive of Alcohol shows lower SFC compared to gasoline because of it has oxygen content so complete combustion takes place in combustion chamber. However SFC is lower for all the other additives. The SFC decreases with the increasing loads. It is inversely proportional to the thermal Efficiency of the engine.

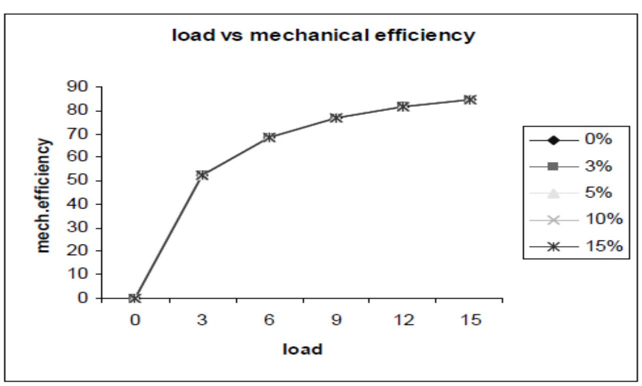
Brake thermal efficiency:



X-axis= Brake power, Y-axis=Brake thermal efficiency[29]
Fig. 19

The variation of BTE with brake power for different percentage of additives of Alcohol with the gasoline as shown in figure 32. The additive of alcohol shows the BTE is higher than the Petrol. The BTE is higher for various additives because of improve combustion efficiency. The brake thermal efficiency is based on B.P and calorific value of the engine. Brake thermal efficiency gradually increases with increase in percentage of additives. It is observed that brake thermal efficiency is low at low values of B.P and is increasing with increase of I.P for all additives of fuel. For an additive of 3% the brake thermal efficiency is high at higher power values when compared with other additives of fuel and is slightly higher than the petrol at high values of B.P.

Mechanical efficiency:



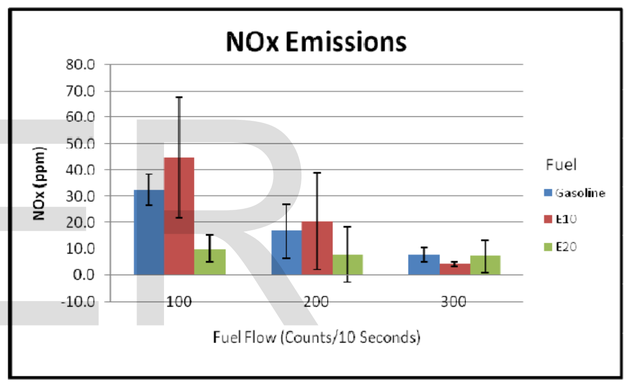
X-axis=Load(Kgs), Y-axis=mechanical efficiency[29]
Fig. 20

The variation of mechanical efficiency with brake power at different loads is shown in figure 33 .Mechanical efficiency of SI engine is constant. Because brake power and frictional powers are constant at various load conditions and additives of Alcohol why because speed of engine is set as constant.

B. EXHAUST GAS ANALYSYS

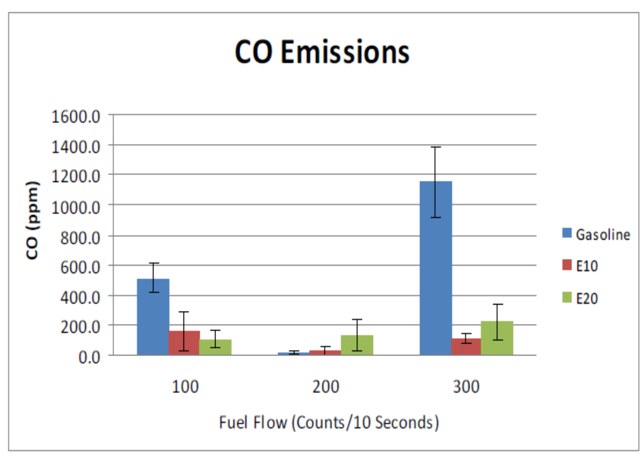
Nitrogen oxides:

The results for the NOx emissions are displayed in Figure 21. There are very few solid trends present in the data. The NOx emissions for 20% ethanol on average are smaller than those of pure gasoline. 10% ethanol blend produced the highest NOx emissions at the lower two fuel flow rates. The only responsible conclusion to be made based on the data is that NOx emissions are of a similar order for all 3 fuels, meaning that all the emissions were less than 50 ppm.



X-axis=Fuel flow rate,Y-axis=NOx(ppm) [29]
Fig. 21

Carbon monoxide:



X-axis=Fuel flow rate,Y-axis=CO(ppm) [29]

Fig. 22

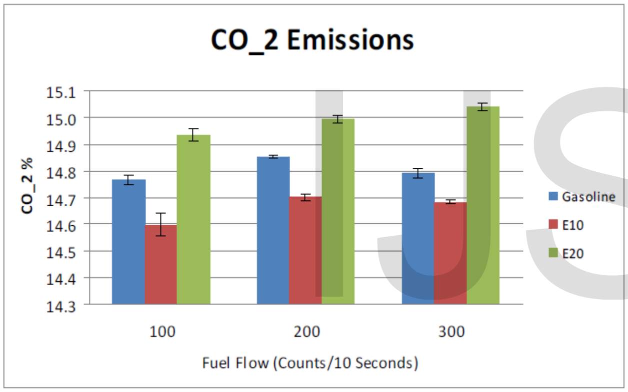
Figure 22 displays the Carbon Monoxide emissions for all 3 fuels. Although there is a large amount of variability in the

ISSN 2229-5518

data , it is safe to say that the gasoline emitted a lot more Carbon Monoxide than either of the ethanol blends. This is due to the fact that CO is formed when there is not enough oxygen for all of the carbon content of fuel to convert to Carbon Dioxide. Ethanol is an oxygenate; therefore, ethanol blends will have more oxygen in their chemical structure than pure gasoline, decreasing the chance that the carbon from the fuel will not be able to form CO2 during combustion.

Carbon dioxide:

The uncertainty for the CO2 emissions was very low in this study. Figure 36 displays the results for the CO2 emissions. It is clear the highest emissions were produced while operating on 20% ethanol blend. The 10% ethanol blend produced the lowest emissions. All of the results are within 0.5% of each other. It is important to remember that although the Carbon Dioxide emissions were highest for the 20% ethanol blend, a high percentage of the CO2 emitted by the ethanol blends will be recaptured as more ethanol is produced.



X-axis=Fuel flow rate,Y-axis=CO_2% [29]

Fig. 23

Due to some problem in the ORSAT Apparatus we were unable to conduct the Exhaust gas analysis by ourselves. So we have referred to the data of a journal based on the research topic "*Experimental work study on the effect of ethanol gasoline blends on the performance of two stroke petrol engine*"

3.4 THE ORSAT APPARATUS

The Orsat analyser is an apparatus which allows determining content of the four key flue gas components – nitrogen, oxygen, carbon monoxide and carbon dioxide – thanks to chemical reactions. An analyser of this type is shown in the figure below.

Fig. 24

The main components of the apparatus are:

- Burette used to measure volume of the flue gas sample.
- Bottle with coloured water, used as a driving medium by application of hydrostatic force.
- Two or three absorption bottles with capillary tubes where the individual components of the flue gas are absorbed.
- Block of valves providing access to individual absorption bottles.
- Three-way valve allowing connecting the burette to the incoming flue gas line or to the ambient air.

The general working principle is as follows:

- Certain amount of dry flue gas is delivered to the burette
- Flue gas is pumped to consecutive absorption bottles where individual flue gas components are absorbed. After absorption of each component, the volume of remaining gas mixture is verified, thus allowing determining volumes of individual components.
- Each apparatus at the Thermodynamics Laboratory has two absorption bottles:
- Bottle filled with potash lye (3), which absorbs carbon dioxide
- Bottle filled with pyro Gallic acid solution (4), which absorbs oxygen.

After CO2 and O2 are absorbed, CO content may be determined using an Ostwald's diagram for the specific fuel. It could also be determined using a third reagent.

4. CONCLUSION

We have successfully performed the Experiment on a 2-Stroke Petrol Engine using only Petrol, using a blend of Ethanol and Petrol where the Fuel mixture consisted of 5% Ethanol, and using a mixture of Ethanol and Water in Petrol where 5% Ethanol and 1% Water was used.
After completing the Experiment, the following points were concluded:

- As we can clearly see safety of Environment and Health has become an important factor for Government and for people. As Fossil Fuels creates pollution, damage Environment and affect people's health. It is now utmost necessary to take steps to avoid further detoriation of these factors, and use of Alternative Fuels is one of the steps that we need to take.
- Using ethanol as a fuel additive to unleaded Petrol causes an improvement in engine performance. Ethanol addition to Petrol results in an increase in brake power, brake thermal efficiency, volumetric efficiency, and fuel consumption respectively. The addition of 5% ethanol to the unleaded Petrol is achieved in our experiments without any problems during engine operation.
- From the exhaust gas analysis done using an ORSAT APPARATUS we can see that the percentage of Carbon dioxide, carbon monoxide and Hydrocarbon are likely to decreases but the amount of Nitrogen Oxide slightly goes up while using alcohol as an additive in petrol. This can be eliminated by using some advanced processes.

ACKNOWLEDGMENT

I would like to thank my friends Hemant, Ayush, Soumya and Ashrael for their efforts and patience in completing the project on time.

Also I would like to thank Dr. Prof. Amitabha Biswas for his esteem guidance .

REFERENCES

[1] Alternatives to Traditional Transportation Fuels: An Overview, by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels; U.S. Department of Energy, Washington, D.C., June, 1994.

[2] Green Guide to Cars and Trucks: Model Year 1999, by John DeCicco and Martin Thomas; American Council for an Energy-Efficient Economy, Washington, D.C., 1999.

[3] Paving the Way to Natural Gas Vehicles, by James S. Cannon; INFORM, New York, New York, New York, 1993.

[4] Renewable Energy: A Concise Guide to Green Alternatives, by Jennifer Carless; Walker Publishing Company, New York, New York, 1993.

[5] "Alcohol as Fuel, "Chemical Business, Jan. 1, 1997

[6] "Assessing the Hidden Cost of Fossil Fuels," A briefing Paper Prepared By the Union of Concerned Scientists, Jan. 1993

[7] Bechtold, Richard L., "Alternative Fuels Guidebook: Properties, Storage, Dispensing, and Vehicle Facility Modifications," 1997

[8] Bolson, J., "Gasoline of the Future," Mother Earth News, April 1996

[9] Cogan, R., "The Ethanol Fleet," Popular Science, Oct. 1997

[10] "Changes in Gasoline III, The Automotive Technician's Gasoline Quality Guide," Downstream Alternatives, 1996

[11] "Connecting the Pieces of a Growing Iowa Ethanol Industry," Proceedings from a one-day conference and five regional seminars, Iowa State University, May 1995

[12] Dunne, J., "A Ford in Your Future," Popular Mechanics, Mar. 1, 1996

[13] Ethanol and the Local Community," AUS Consultants and SJH & Company, June 2002.

[14] Evans, M., "Economic Impact of the Demand for Ethanol," Prepared for the Midwestern Governor's Conference, Feb. 1997

[15] "Everything You Wanted To Know About Ethanol But Were Afraid To Ask," Iowa Corn Promotion Board, 1994

[16] "85% Ethanol, An Alternative Fuel Concept for the Future," Iowa Corn Promotion Board, 1996

[17] Fuel Ethanol "Special Studies," A series of Six Reports Produced By Energetics, Inc. with support from Dept. of Energy, June 1994

[18] Gregor, H., "Gasohol," Colliers Encyclopedia CD-ROM, Feb. 28, 1996

[19] Hardin, B., "Improving Ethanol Yield From Corn," Agricultural Research, Oct. 1, 1996

[20] "Hauser, J., "Yeast In the Classroom," Carolina Tips, Oct. 1995

[21] "Iowa Auto Dealers Ethanol Survey," Iowa Corn Promotion Board, Sept. 1996

[22] "Iowa Independent Automotive Technician Ethanol Survey," Iowa Corn Promotion Board, Sept. 1997

[23] "Iowa Small Gas Engine and Recreational Service Centres Ethanol Survey," Iowa Corn Promotion Board, Sept. 1997

[24] Lorenz D., and Morris D., "How Much Energy Does It Take To Make a Gallon of Ethanol," The Institute for Local Self Reliance, Aug. 1995

[25] Lucht G. and Zinkand D., "Ethanol Industry Surviving Politics, High Corn Prices," Iowa Farmer Today, The Gazette Company, Cedar Rapids, Iowa

[26] Nakamura, D., "Ethanol, the Fuel That Wouldn't Die," Hydrocarbon Processing, Sept. 1, 1995

[27] Nissen, T., "Ford Launches Flexible Fuel Vehicle Program," Reuters Business Report", June 3, 1997

[28] Nussle J., "Help Fuel Independence," USA Today, June 19, 1997

[29] V.S. Kumbhar, D. G. Mali and P. H. Pandhare, "Effect of Ethanol Gasoline Blends on Performance and Emission Characteristics of the SI Engine: A Review", International Journal of innovations in Mechanical and Automobile Engineering, March: 2012