A REVIEW ON THE PRODUCTION AND OPTIMAL USE OF ETHYL ALCOHOL AS A SURROGATE FUEL IN IC ENGINES EXTRACTED FROMORGANIC MATERIALS

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ABSTRACT

Depleting fossil fuel reserves and increasing cost of petroleum products become a big challenge of modern world. It has been adumbrated that by year 2032, there will be a surge of 62% of the current consumption of the fossil fuel like Petrol, Diesel, etc. Ethyl Alcohol or Ethanol (C_2H_6O) may be considered as a suitable alternative fuel by replacing fossil fuel resulting reduce in environmental emissions. The objective of this paper to enumerate Ethanol, produced by the process of fermentation and distillation from organic material suitably blended with gasoline or diesel to be used as a standard alternate fuel for IC engines. Ethanol emerges a good fuel property of high octane number, better volatility, viscosity and thermal conductivity to be used as a substitute for fossil fuel.

KEYWORDS: Ethanol, IC Engines, Antiknock, Fermentation, Distillation.

Ethanol (C_2H_6O) is a renewable fuel. It can be produced from agricultural feedstock, such as sugarcane, corn, potatoes, cassava, cellulose materials and also from forestry wood wastes and agricultural residues. Ethanol has a simple molecular structure with well-defined physical and chemical properties. Ethanol can be employed as a transportation fuel even in its original form and can also be easily blended with other fuels, such as gasoline (Petrol and Diesel). Currently, there is a lot of interest in ethanol production from organic materials, to minimize the emissions of Carbon dioxide (CO_2), Hydrocarbons (HC) which is a greenhouse gas that contributes to global warming. The addition of ethanol to gasoline results in the enhancement of the octane number in blended fuels and changes the distillation temperature, as well as reducing CO_2emissions.

Today, the reserves of petroleum based fuels are being rapidly depleted. Alcohols, such as ethanol, are colourless liquids with mild characteristic odours that can be produced by fermentation of biomass crops, such as sugarcane, wheat and wood. Using alcohols as fuel for I.C engine have some advantages over gasoline. Ethanol has better anti-knock characteristics and the engine's thermal efficiency improves with the increase in compression ratio. Ethanol burns with lower flame temperature and luminosity owing to the decrease of the peak temperature inside the cylinder so that the heat loss and NOx emissions are lowered. Ethanol has high latent heat of vaporization. The latent heat cools the intake air and hence increases the density and volumetric efficiency. However, the oxygen content in ethanol reduces the heating value more than gasoline does. It is evident that ethanol can be used as a fuel in I.C Engines.

PRODUCTION OF ETHANOL

Raw Materials

Ethyl Alcohol can be produced by the fermentation process from three basic types of raw materials called as feedstock.

The three basic types of feedstock are:

Saccharine

Sugar containing materials in which the carbohydrate (the actual substance from which the alcohol is made) is present in the form of simple, directly fermentable six and twelve carbon sugar molecules such as glucose, fructose, and maltose. Such materials include sugar cane, sugar beets, fruit (fresh or dried), citrus molasses, cane sorghum, potato, corn whey and skim milk.

Starchy Materials

That contains more complex carbohydrates such as starch and insulin that can be broken down into the simpler six and twelve carbon sugars by hydrolysis with acid or by the action of enzymes in a process called malting. Such materials include corn, grain sorghum, barley, wheat, potatoes, sweet potatoes, Jerusalem artichokes, cacti, manioc, arrowroot, and so on.

Cellulose Materials

Such as wood, wood waste, paper, straw, corn stalks, corn cobs, cotton, etc., which contain material that can be hydrolyzed with acid, enzymes or otherwise converted into fermentable sugars called glucose.

Methods of Production of Ethanol

-Fermentation

-Distillation

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-Dehydration

Fermentation is a metabolic process that converts sugar to acids, gases, or alcohol. It occurs in yeast and bacteria, and also in oxygen-starved muscle cells, as in the case of lactic acid fermentation.

Ethanol is produced by microbial fermentation of the sugar. Two major components of plants, stratch and cellulose, are both made of sugars and can, in principle, be converted to sugars for fermentation. Currently, only the sugar (e.g., sugar cane) and starch (e.g., corn) portions can be economically converted. There is much activity in the area of cellulosic ethanol, where the cellulose part of a plant is broken down to sugars and subsequently converted to ethanol.

Distillation is a process of separating the component or substances from a liquid mixture by selective evaporation and condensation.

For ethanol to be usable as a fuel, the majority of the water must be removed. Most of the water is removed by distillation, but the purity is limited to 95–96% due to the formation of a low-boiling water-ethanol azeotrope with maximum (95.6% m/m (96.5% v/v) ethanol and 4.4% m/m (3.5% v/v) water). This mixture is called hydrous ethanol and can be used as a fuel alone, but unlike anhydrous ethanol, hydrous ethanol is not miscible in all ratios with gasoline, so the water fraction is typically removed in further treatment to burn in combination with gasoline in gasoline engines.

Dehydration process is to remove the water from an azeotropic ethanol/water mixture. The first process, used in many early fuel ethanol plants, is called azeotropic distillation and consists of adding benzene or cyclohexane to the mixture. When these components are added to the mixture, it forms a heterogeneous azeotropic mixture in vapour–liquid-liquid equilibrium, which when distilled produces anhydrous ethanol in the column bottom, and a vapour mixture of water, ethanol, and cyclohexane/benzene.

When condensed, this becomes a two-phase liquid mixture. The heavier phase, poor in the entrainer (benzene or cyclohexane), is stripped of the entrainer and recycled to the feed—while the lighter phase, with condensate from the stripping, is recycled to the second column. Another early method, called extractive distillation, consists of adding a ternary component that increases ethanol's relative volatility. When the ternary mixture is distilled, it produces anhydrous ethanol on the top stream of the column.

As Ethanol is hygroscopic, means it absorbs water vapour directly from the atmosphere. Because absorbed water dilutes the fuel value of the ethanol and may cause phase separation of ethanol-gasoline blends (which causes engine stall), containers of ethanol fuels must be kept tightly sealed. This high miscibility with water means that ethanol cannot be efficiently shipped through modern pipelines, like liquid hydrocarbons, over long distances.The fraction of water that an ethanol-gasoline fuel can contain without phase separation increases with the percentage of ethanol.

From the above table we see that Ethanol is similar in nature with gasoline with high octane number. Both are liquid in nature thus storage and transportation are much similar. Both can be mixed easily and burnt. Ethanol has small molecular weight, large oxygen content and high H/C ratio. Octane number for ethanol is 100.Ethanol is oxygenated fuel with small molecules; it can burn fast and fully with oxygen inside. These characters can help to improve thermal efficiency

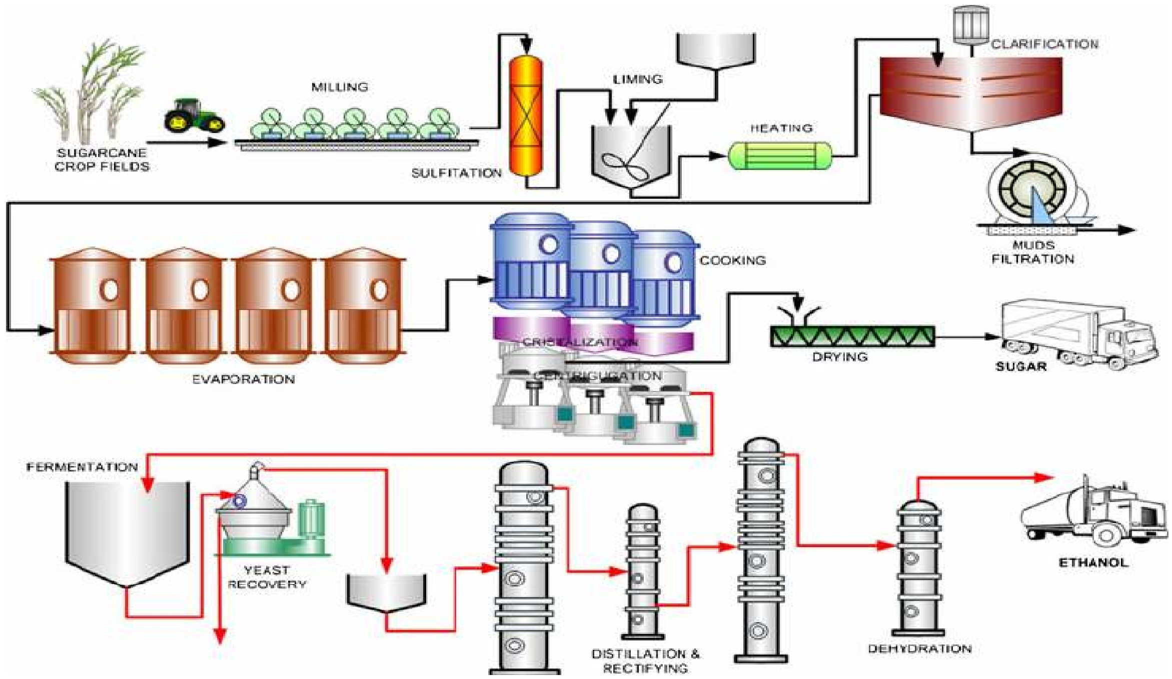


Figure 1: Schematic diagram of Ethanol Production

Table 1: Fuel Characteristic of Ethanol and Gasoline Fuel

Sl. No.	Character	Ethanol	Gasoline
01	Molecular Weight	46.14	102-106
02	Composition	C=52% H=13% O=35%	C=85% O=15%
03	Specific Gravity	0.797	0.72-0.85
04	Density (Kg/m^3)	791	711-781
05	Boiling Temperature (^{0}C)	78.5-80	27-256
06	Freezing Point (^{0}C)	-114	-57
07	Ignition Temperature (^{0}C)	423	390-421
08	Air Fuel (a/f) Ratio	9.1	14.7
09	Octane Number	100	80-99
10	Cetane Number	8	0-10

as well as to achieve the cleanliness inside the engine and to reduce exhaust. With low boiling point ethanol is easy to burn and form the mixture gas which is conducive for gasoline to burn completely. Latent heat of vaporization of ethanol is three times bigger than that of petrol. So when ethanol is vaporizing, it absorbs a large amount of heat, at the same time the temperature of the mixed gas is lowered down. Although calorific value of ethanol is low, the heat, which the mixed gas of ethanol and gasoline produces under theoretical air fuel ratio, is roughly the same as that of petrol.

USE OF ETHANOL IN FUEL SYSTEM

Gasoline is composed of C_4–C_{12}hydrocarbons and it has wide transitional properties. On the other hand, alcohol such as ethanol contains OH group that has oxygen atom and it is viewed as a partially oxidized hydrocarbon that would under-go complete combustion.

As for the combustion characteristics, the auto-ignition temperature and flashpoint of alcohol are higher than gasoline, which makes it safer for transportation and storage. The latent heat of evaporation of alcohol is 3–5 times higher than gasoline. Thus, it lowers the temperature of the intake manifold and increases the volumetric efficiency.

The enthalpy of alcohol is lower than gasoline. Therefore, more alcohol fuel is required to achieve the same energy output, which is an approximately1.5–1.8 times of gasoline fuel. The stocheometric air to fuel ratio of alcohol is about 1/2–2/3 of the gasoline, so the amount of air required for complete combustion is lesser for alcohol.

ETHANOL-RESEARCH OCTANE NUMBER (RON) GASOLINE BLENDED FUEL

RON plays a crucial role for combustion in IC engines. According to the past studies, the research octane number (RON) of the gasoline has been changed due to the addition of ethanol. The more ethanol is added, the higher RON get obtained. Increasing octane number of the fuel leads to decreases in CO and HC emissions.

The combustion duration also becomes longer with increase in the octane number. Longer combustion duration may result in lower thermal efficiency and increased the consumption. Moreover, gasoline with a high octane number is suitable for vehicles with a high compression ratio. The compression ratios of motorcycles (8–10:1) are less than gasoline cars (9–12:1). Thus, highethanol content gasoline (>15%) may not be suitable for motorcycles due to high octane number.

EMISSIONS OF ETHANOL BLENDED GASOLINE

Bata et al. (1989) studied different blend rates of ethanol blended with gasoline fuel for combustion in the engine and found that adding ethanol had reduced the CO and HC emissions to some degree. The reduction of CO emission is attributed by the wide flammability and oxygenated characteristic of ethanol. The study done by Palmer (1986) indicated that addition of 10% ethanol to gasoline could reduce the concentration of CO emission up to 30%. Alexandrian and Schwalm (1992) showed that the air fuel ratio (A/F) has great influence on the CO emission.

Using ethanol-gasoline blended fuel instead of gasoline alone, especially under fuel-rich conditions, it has lower CO and NOx emissions. However, studies by Chao et al. (2000) has pointed out that using ethanol-gasoline blended fuel, it increases the emission of formaldehyde, acetaldehyde and acetone, 5–14 times higher than from gasoline. Even though the emission of aldehyde will be increased when ethanol blended gasoline is used as a fuel, the damage to the environment by the emitted aldehyde is far less than by the poly-nuclear aromatics emitted from burning gasoline. Therefore, using higher percentage of Ethyl Alcohol in blended fuel can make the air quality better in comparison with burning of gasoline.

Pang et al. (2007) found that CO emission was slightly reduced (1.5–6%) from 10% (E10) ethanol blended gasoline in comparison with gasoline (RN95 -E0). The oxygenated agents (ethanol) blended with gasoline can effectively deliver oxygen to the pyrolysis zone of the burning gasoline resulting in less CO generation. In engine-out exhaust, THC emission from E10was lowerthan E0 at the torque of 3 Nm, but higher than from E0 by 2–17% under other operating conditions.

PERFORMANCE OF AN IC ENGINE USING ETHANOL BLENDED GASOLINE

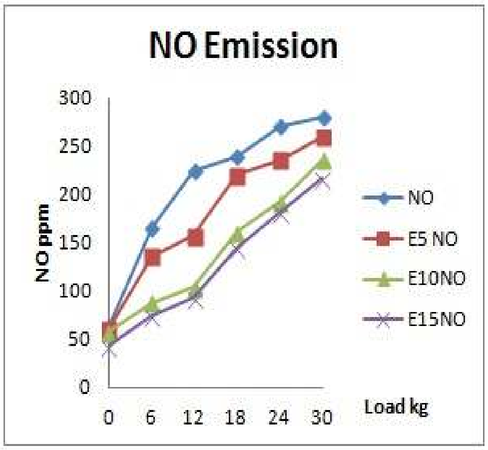
In 1986, Palmer investigated the effect of various blend percent by volume for ethanol and gasoline fuels in engine tests. Results indicated that adding 10% ethanol increases the engine power output by 5% and the octane number can be increased by 5% for each 10% ethanol added.

Abdel-Rahman and Osman (1997) had tested 10%, 20%, 30% and 40% ethanol of blended fuels in a variable-compression-ratio engine. They found that the increase in ethanol content increases the octane number, but decreases the heating value. The 10% addition of ethanol had the most observable effect in increasing the octane number. Under various compression ratios of engine, the optimum blend rate was found to be 10% ethanol with 90% gasoline.

Hsieh et al. (2002) determined the brake specific fuel consumption (bsfc) to demonstrate the variations of fuel consumption in the test engine using different ethanol gasoline blended fuels. The theoretical air-fuel ratio (A/F) of gasoline is 1.6 times of ethanol. Therefore the bsfc should be increasing with increase of ethanol content.

However, the fuel injection strategy tends to operate the engine at fuel rich condition. Thus, the ethanol addition produces leaning effect to enhance the combustion of fuel. Therefore, this factor makes no difference on the bsfc between using pure gasoline and using ethanol-gasoline blended fuels.

The influence of different ethanol-gasoline blended fuels on the torque output has also been investigated by performing engine test at 3,000 rpm with throttle valve opening of 40%, 60%, 80%,and 100%.It was observed that at lower throttle valve opening, the torque output is either increased or decreased by adding ethanol. However, at higher throttle valve openings (60%, 80%, 100%), the torque output increaseswith the ethanol content, which rangefrom 2% to 4%.



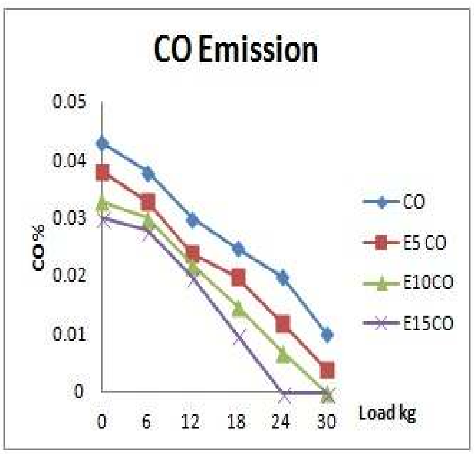


Figure 2: NOx & CO emission by using different percentage of Ethanol blend

As the percentage of ethanol increases, there was a reduction in CO and NOx emissions. The overall consumption of ethanol-gasoline blended fuel (E5, E10, E15, and E20) was lesser as compared with gasoline (RON 95).

CO and NOx are emitted from exhaust system due to the incomplete combustion in the combustion chamber. Therefore, lower CO and NOx emissions indicate that higher degree of combustion is achieved. By using ethanol-gasoline blended fuel, there is significant reduction in CO and THC emissions as compared with gasoline (RON 95).

It can be observed that the reduction of CO and NOx emissions become more significantas theethanol content increase. Ethanol which contains OH groups used as an oxygenate compound to raise the oxygen content of gasoline.

With additional oxygen molecule, the current air to fuel (A/F) ratio is increased and allowed the combustion occur at stoichiometric burning. In this case, the engine tends to operate in leaner conditions where combustion process of fuel is more complete. Therefore, the concentration of CO and THC emissions decreases as the fuel burning is more efficient(Wei-Dong et al., 2001).Decrease of CO and THC concentration is also due to the lower carbon content of ethanol in comparison with gasoline.

Based on the research by Zervas et al. (2003), addition of ethanol dilutes the fuel. Hence, it enhances the combustion of CO and HC in the cylinder. Ethanol reduces the high boiling point hydrocarbon chain by increasing the number of methyl branches. This results in more completely fuel combustion in the cylinders without generated accumulation of un-burned hydrocarbon in combustion chamber emitting into the environment through the exhaust system.

American PetroleumInstitute (2010) stated that octane number of unleaded gasoline like RON 95will increase up to certain degree by adding in ethanol as an octane booster.Thus, ethanol blended with RON 95 will increase the octane number of the fuel to that of RON 97 or even higheras the content of ethanol increases. It is observed that the fuel consumption per kilometre is reduced up to 6.5% for E20.

ADVANTAGES & DIS-ADVANTAGES OF USING ETHANOL AS A FUEL

Advantages

- Unlike petroleum, ethanol is a renewable resource.
- Ethanol burns more cleanly in air than petroleum, producing less carbon (soot) and carbon monoxide
- The use of ethanol as opposed to petroleum could reduce carbon dioxide emissions, provided that a renewable energy resource was used to produce crops required to obtain ethanol and to distil fermented ethanol

- Exhaust gases of ethanol are much cleaner.
- The use of Ethanol blended fuel such as E85
- Can reduce the net emissions of green house
- gases by as much as 38%, which is a significant
- amount.

Dis-Advantages

- Ethanol has a lower heat of combustion (per mole, per unit of volume, and per unit of mass) that petroleum
- Large amounts of arable land are required to produce the crops required to obtain ethanol, leading to problems such as soil erosion, deforestation, fertiliser run-off and salinity
- Major environmental problems would arise out of the disposal of waste fermentation liquors.
- Typical current engines would require modification to use high concentrations of ethanol.

CONCLUSION

Ethanol-gasoline blended fuel (E5, E10, E15, and E20) has reduced CO and THC emission up to 72.1 % and 58.1% respectively as compared to gasoline. There is also a reduction of fuel consumption up to 6.5%. Lesser emissions of green house effect gases into environment can be achieved by burning ethanol blended gasoline. It is viable alternative for reducing the rate of depletion of fossil fuel and a better fuel to reduce harmful gases emission into atmosphere. The results of this study can be used as the basis to determine the optimum blending proportion in future study.

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