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Ethanol as an Oxygenator for IC Engines: A Review

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Abstract: **It is seen that there has been a gradual increase in conventional fuel consumption, in spite of its limited availability, due to increase in vehicular population. Also they form the main source of environmental pollution. The transportation sector consumes approximately 65 percentage of the petroleum products in India. Thus, transportation facilities pose a threat to the environment as they emit major pollutants in large concentrations. Hence, a need arises for an alternate fuel, to reduce pollution and its effects. Some of the most commonly available alternate fuels are alcohol based fuels, Liquefied Petroleum Gas (LPG), Compressed Natural gas, Hydrogen and Biodiesel. This paper focuses on ethanol being used as a fuel additive in Internal Combustion (IC) engines and describes the engine performance in terms of efficiency and pollutants being emitted. Ethanol is mainly used as a blend with the conventional fuels to enhance the existing properties.**

Keywords: **Internal Combustion engine, Conventional fuel, Alternate fuel, Emissions, Ethanol, biodiesel.**

1. INTRODUCTION

Ethanol (C_2H_5OH) is a cost effective, non-petroleum based fuel (alcohol fuel). E-85 (85% ethanol and 15% gasoline), is the most commonly used alternate fuel. Ethanol happens to be one of the most promising alternate fuels, which can substitute gasoline and diesel with its benefits such as renewability, higher octane rating and high laminar flame velocity [1]. Its setback is that, it may corrode the metal and rubber parts that it may come in contact, in the engine. Ethanol is basically produced by fermentation process of vegetables and plants. In India, its main source is molasses and it is done in three stages-extraction, fermentation and distillation.

Ethanol is recognized as a fuel which has the potential to cater to the wide requirements of transportation sector in the near future.

Although, 100% ethanol cannot be used in Internal Combustion (IC) engines [2], due to its low evaporative pressure and cold starting problems. As a result of which ethanol-gasoline blend is used.

Apart from using ethanol as a fuel in IC engines, it can also be used in Homogeneous Charge Compression Ignition (HCCI) engines [18], in which the air-fuel mixture (charge) is made homogeneous to obtain better engine performance and low emissions.

2. ETHANOL BLENDS

E10

E10 contains 10% ethanol and 90% gasoline. This is very much suitable for light duty automobiles and can be used directly without modifying the engine. The octane rating is higher by 2 or 3 numbers.E10 reduces the emission of Carbon monoxide (CO) by 20-30% [15] and Carbon dioxide (CO_2) by 2% compared to gasoline, however it emits evaporative pollutants that arises due to age of the vehicle and weather conditions.

E15

E15 contains 15% ethanol and 85% gasoline. This is the highest ratio of ethanol to gasoline and prescribed by only few automotive manufacturers [16].

E20, E25

E20 contains 20% ethanol and 80% gasoline and E25 contains 25% ethanol and 75% gasoline. E20 and E25 have been extensively used in Brazil. The vehicles used in Brazil run on these fuels as they are specifically designed to run on them.

E70, E75

E70 is a mixture of 70% ethanol and 30% gasoline. E75 is a mixture of 75% ethanol and 25% gasoline. Both of them are used in large scales in the United States.

E85

E85 contains 85% ethanol and 15% gasoline. It has an octane rating of 95(approx) .The limit was set at 85% ethanol to decrease the ethanol emissions and cold starting problems.

E100

E100 is nothing but 100% ethanol. Due to lower evaporative pressures E100 imposes limitation on normal engine operation. Also the engines fuelled with E100 face cold starting problems at temperatures below 15^0C.For this reason ethanol is blended with gasoline [17].

3. PROPERTIES

The efficiency and the power output of an IC engine are greatly dependent on the type of fuel used which in turn depends upon the fuel properties. These properties have to be taken into account in order to study the overall performance of the fuel in an engine. The properties which define the performance of an engine have been discussed in the following paragraphs.

Heating Value

If the heating value of the fuel is high, the power output of the engine is high [3].Although the heating value of ethanol is lower compared to gasoline, its other properties such as high heat of vaporization of ethanol lowers the effect of its low heating value.

Octane Number

Knocking reduces the efficiency of the engine and results in engine wear [4]. Fuels with higher octane number are less susceptible to knock. Thus octane number can be defined as a measure of the ability of a fuel to resist knock. Ethanol has a higher octane number compared to gasoline.

Laminar Flame Velocity

It is the velocity at which the laminar flame propagates through the charge [3]. It is a measure of the rate at which the air-fuel mixture burns. Higher flame velocity, reduces the combustion temperature which results in lowering the NO_x (oxides of nitrogen) emissions and knocking tendency of the engine [4] and provides higher engine efficiency.

Heat of Vaporization

It is defined as the amount of heat required to transform a substance from its liquid phase to gaseous phase at constant temperature. High heat of vaporization of ethanol results in high volumetric efficiency of its blends, resulting in high power output [1],[5] . It has been observed that ethanol – gasoline blends results in high brake power and lower brake specific fuel consumption [1, 6, 7].

TABLE 1: Ethanol Properties

Properties	Value
Octane Rating	106-110
Lower Calorific Value (MJ/kg)	26.9
Chemically correct Fuel/Air Ratio	0.1111
Density (kg/m^3)	785
Heat of Vaporization (kJ/kg)	840

4. ENGINE PERFORMANCE

The major benefit of ethanol is its high octane rating, as a result of which its tendency to knock is reduced. This property allows it to withstand higher compression ratio which results in high efficiency. In particular, using E85 as a fuel, the efficiency can be increased by 9% compared to the conventional gasoline fuelled engine [8].

Ethanol has a low cetane rating, because it has a low capacity to combust under pressure, as a result of which ethanol-diesel blends are not common. In some cases, 95% ethanol is combined with 5% diesel (E95) and used in Compression Ignition (CI) engines. In these cases, cetane number enhancer is used to improve the engine combustion.

CI engines using ethanol as a fuel have 30% higher efficiency compared to spark ignition (SI) engines running on ethanol. However, CI engine efficiency is the highest initially compared to SI engine efficiency [9]. E95 which is a blend of ignition enhancer and hydrous ethanol is used in third generation buses.

Brake Power

Brake Power (BP) of E10 is similar to that of gasoline engine or in some cases it may increase. In case of E20, the power output is again same or it can even decrease but the decrease is not more than 9%. E30 has a higher percentage of ethanol (30%) and BP is found to considerably decrease compared to E10 and E20.

Brake Specific Fuel Consumption (BSFC)

BSFC [14] is maximum for E30 and minimum for E20 at lower loads. It is approximately equal to gasoline for E10.

Brake Thermal Efficiency (BTE)

Higher BTE [14] is obtained for E10 at 1200 rpm and E20 at 1400 and 1500 rpm. Maximum BTE of 23.7% is obtained for E20 at 1500 rpm.

5. EMISSIONS

An engineer's aspect is to derive more power output from an engine. Along with it, steps to reduce undesirable emissions have to be followed. Factors that influence exhaust emissions are composition of fuel, fuel-air ratio, conditions at which the engine operates, oxygen content and the chemical structure of additives [10]. These emissions have adverse effects on the ecosystem and human life [2]. Several emission control methods have been developed which are efficient enough to reduce the pollutants. However, the steep rise in the number of vehicles and the quantity of pollutants emitted by them overrule such control methods [11]. Thus, emissions from vehicles continue to pose an impact on human health.

Nitrogen Oxides

Oxides of Nitrogen (NO_x) react with air to form ozone and are one of the main reasons for the formation of photochemical smog. At the ground-level they pose a great threat to the lungs and cause other biological impacts [2]. Few studies have proved that E30 when used in SI engines has reduced NO_x emissions considerably [4]. NO_x emissions from E10 and gasoline are almost the same [11].

Carbon Monoxide (CO)

When engine operates with fuel rich equivalence ratio CO is formed. Formation of CO is an inference of loss of thermal energy during the process of combustion [2]. Therefore, the operating time of an engine under fuel rich conditions must be reduced in order to reduce CO emissions. Early start-up condition prone to less oxygen availability in cylinder helps in the formation of CO [3]. Ethanol blends containing oxygen also decreases CO emissions in comparison to engines which run on gasoline [11].

Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) emissions of gasoline engines and engines running on ethanol fuel blends are almost same. Although these emissions do not have a direct impact on the human health but it affects the climatic conditions [11]. If engines operate on ethanol blends, CO_2 emission from these engines can in turn be utilized by the ethanol producing plants itself for their photosynthesis process [10]. However, it cannot be said that the entire CO_2 emissions can be eliminated in such a manner, but it is believed to reduce a part of the emissions.

Drawbacks

The main obstacle of using ethanol as a fuel is that, they are corrosive, due to which storing them also becomes a problem. The problems observed as a result of fleet tests are:

(1) Due to the solvent nature of ethanol [9], it is found to damage plastic and rubber materials (softening and swelling).

(2) Due to the acidic nature of ethanol, metals are prone to degradation. Anhydrous ethanol being corrosive makes water pollution inevitable [12].

(3) Fuel clogging problems occurs along the fuel lines [12].

(4) Cold start problems and increased fuel emissions due to evaporation occurs for blends E10 and above [13].

6. CONCLUSION

Our dependence on energy is central to our economy. Economically, we need to utilize new and renewable types of fuels, as the supply of petroleum based fuels have become very limited. Scientifically, the burning of fossil fuels leads to the emission of harmful pollutants which in turn have adverse effects on the environment.

On the other hand engines which operate on bio-fuels such as ethanol has 40% (approximately) lesser smog forming rate compared to gasoline engine .Air toxics are also reduced by 50% than a gasoline engine. Engines running on ethanol produce minor amount of aldehydes, however their release to the atmosphere can be minimized by means of a catalytic converter.

Thus, it is required to adapt to an alternate fuel such as ethanol in place of fossil fuels as it is very advantageous in many aspects.

REFERENCES

[1] A.Y.F.Bokhary, Majed Alhazmy, Nafis Ahmad, Abdulrahman Albahkali, "Investigations on the utilization of ethanol-unleaded gasoline blends on si engine performance and exhaust gas emission" IJET-IJENS Vol:14 No:02

[2] Pulkrabek, W. W., 1997, Engineering fundamentals of the internal combustion engine, prentice-hall, upper saddle river, p. 154.

[3] Ferguson, C. R. and Kirkpatrick, A. T., 2001, Internal combustion engines – applied thermosciences, john wiley & sons, New York, pp. 1-28, 328.

[4] Baghdadi-Al, M., 2008, "Measurement and prediction study of the effect of ethanol blending on the performance and pollutants emission of a four-stroke spark ignition engine," IMechE, 222(D), pp. 859-873.

[5] Lynd, L. R., 1996, "Overview and evaluation of fuel ethanol from cellulosic biomass: technology, economics, the environment, and policy," Annual Energy Review, 21, pp. 403-406.

[6] Al-Hasan, M., 2003, "Effect of ethanol-unleaded gasoline blends on engine performance and exhaust emission," Energy Conversion and Management, 44, pp. 1547-1561.

[7] Abdel-Rahman, A., A. and Osman, M. M., 1997, "Experimental investigation on varying the compression ratio of si engine working under different ethanol-gasoline fuel blends," International Journal of Energy Research, 21, pp. 31-40.

[8] "Alcohol-based fuels in high-performance engines," Turner. JW.G. (Lotus Engineering) et al., SAE 2007-01-0056, 2007.

[9] Ethanol as a Fuel for Road Transportation, IEA Implementing Agreement on Advanced Motor Fuels, Technical University of Denmark, May 2009.

[10] He, B., Wang, J., Hao, J., Yan, X., and Xiao, J., 2003, "A Study on emission characteristics of an efi engine with ethanol blended gasoline fuels," Atmospheric Environment, 37, pp. 949-957.

[11] Karman, D., 2003, "Ethanol fuelled motor vehicle emissions: a literature review," Health Canada, Carleton University.

[12] Dumont, 2007. "Controlling induction system deposits in flexible fuel vehicles, (ffv) operating on e85," SAE tech paper 2007-01-4071, 2007.

[13] "Biofuels for transport," Fulton. L., and Howes, T., IEA, 2004.

[14] Yash Menon, Vishal More, Varun Mohan, Nilesh Yenganti, Girish Dalvi: "Investigation of effect of ethanol blends on performance parameters of i.c. engine", IJERT ISSN: 2278-0181.

[15] Low-Level Ethanol Fuel Blends, Clean Cities Fact Sheet,April 2005.

[16] "Moving to E15 would help extend the fuel supply in the wake of hurricanes", American Coalition of Ethanol.2008-09-16.

[17] Ron Kotrba (March 2008)."Cold start 101".Ethanol Producer Magazine.

[18] B.Bahri, A.A.Aziz, M.Shahbakthi, M.F.Muhamad Said, "Ethanol fuelled hcci engine:A Review", World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering Vol:7, No:7, 2013.