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Review Article

Impact of Biofuel in Petrol Engine-A Review

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Abstract

This review paper represents the recent development done in four stroke petrol engine using various blend of petrol and biofuel. Engine performance is increased by using ethanol as a blended fuel. Oxygen containing additives, such as methanol, ethanol, methyl tertiary butyl ether (MTBE) and diethyl carbonate (DMC), are used to improve engine performance. This review paper also present the experimental studies of engine performance and exhaust emission by using ethanol as a blended fuel in different ratio. With the help of these studies we observe that the mixture of ethanol and gasoline provide less ozone depletion potential and global warming potential than the pure gasoline. The mixture of ethanol and gasoline are best alternative fuel for spark ignition engine compare to other biofuel mixture.

Keywords: *Four stroke petrol engine, Ethanol, Unleaded gasoline*

1. Introduction

The increase in consumption of fossil fuels as economies grow and the nearing depletion of such fuels has prompted a search for their alternatives worldwide. Biofuels have emerged as a substitute for fuel oil, especially for oil-importing countries and serve a multitude of purposes. The most important advantage of these fuels is that they are renewable, and are being seen as sustainable sources of energy. Some studies have also pointed out that biofuels help reduce environmental emissions, apart from addressing the problem of the rising import cost of fuel oil. Among liquid fuels, there are several types of biofuel such as methanol, ethanol, diethyl carbonate (DMC) and methyl tertiary butyl ether, and they can be used either individually as fuels or for blending in petrol. While ethanol is produced from starch contained in crops such as corn and sorghum or through fermentation of sugarcane, molasses, and sugar-beet. In India, ethanol production is mainly done using sugarcane as feedstock. Transport has been identified as a major polluting sector and hence the use of biofuels is important in view of the tightening of emission norms.

2. Types of Oxygen containing fuel

Several oxygenates have been used as fuel additives, such as methanol, ethanol, diethyl carbonate (DMC) and methyl tertiary butyl ether. MTBE is the most common oxygenated fuel additive; it is always used to increase octane range and to reduce carbon monoxide and hydrocarbon emissions in engines.

2.1 The distribution of MTBE in the environment has broadened, causing concern because of its presence in drinking water. Due to its low taste and odor threshold, MTBE is not easily detected and thus could potentially impact human health. The Environmental Protection Agency (EPA) has classified MTBE as a potential human carcinogen therefore, it is necessary to find a substitute for MTBE.

2.2 Dim ethyl carbonate, often abbreviated DMC, is an oxygenated renewable fuel and is usually used as an oxygenated additive to blend with fossil fuels. Therefore, its production is non-toxic and environmentally friendly.

2.3 Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Feedstock for this fuel includes corn, barley and wheat. Ethanol can be produced from cellulose feedstock such as corn stalks, rice straw, and sugar cane which are examples of feedstock that contain sugar. As ethanol can be produced from agricultural crops, its cost can be lower in the states whose economy is largely based on agriculture and it can be used.

2.4 Methanol is one of the most promising and as experienced major research and development pure methanol and mixture of methanol and gasoline in various percentage have been extensively tested in engine and vehicle for number of years. The most common mixture are M85 (85% methanol and15% gasoline) M10 (10%

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methanol and 90% gasoline). Methanol can be obtained from many sources fossil and renewable. This includes coal, petroleum, natural gases, bio mass, wood, landfills and even the ocean.

3. Ethanol as an alternative fuel for SI engine

Ethanol was the first fuel among the alcohols to be used to power vehicles in the 1880s and 1890s. Presently, ethanol is prospective material for use in automobiles as an alternative to petroleum based fuels. The main reason for advocating ethanol is that it can be manufactured from natural products or waste materials, compared with gasoline, which is produced from non-renewable natural resources. In addition, ethanol shows good anti-knock characteristics. However, economic reasons still limit its usage on a large scale. At the present time and instead of pure ethanol, a blend of ethanol and gasoline is a more attractive fuel with good anti-knock characteristics. Due to the high evaporation heat, high octane number and high flammability temperature, ethyl alcohol has positive influence on the engine performance and increases the compression ratio. The low Reid evaporation pressure enable to storage and transportation safely.

Sustaining a clean environment is an important issue in an industrialized society. The air pollution caused by automobiles and motorcycles is one of the most important environmental problems to be tackled. Since using ethanol–gasoline blended fuels can ease off the air pollution and the depletion of the petroleum fuels simultaneously, much research has been devoted to study the effect of these alternative fuels on the performance and pollutant emission of an engine.

Table 1Property of ethanol

Fuel property	Gasoline	Ethanol
Formula	C8H18	C2H5OH
Latent heat value	44	26.9
Auto ignition temperature	257	425
Octane number	88 - 100	108.6
Freezing point	-40	-114
Boiling point	27 - 225	78
Density	765	785
Heat of vaporization	305	840

4. Ethanol blending program in India

Ethanol Blending Program (EBP) – 2002-2006

EBP initiated with the objective of energy security and GHG emission reduction.

1. The ministry of petroleum and natural gas (MPONG) issued in a notification in September 2002 for mandatory blended of 5% ethanol in 9 major sugar producing state and four union territories from 2003.
2. Report of committee on development and biofuel, under the auspices of the Planning Commission, recommended a phase-wise implementation program to blend Biofuels with petrol and diesel.
3. However, due to better prices offered by competitive usages, supply of fuel Ethanol remained short. The ethanol-blending mandate was made optional in October 2004, but it resumed in twenty states in October 2006.
4. Fuel Ethanol price was set at 14.50 per Ltr plus 75 paisa subsidy on the blended gasoline.

Ethanol Blending Program (EBP) – Year 2007

1. In October 2007, the Group of Ministers recommended to blend 5 % Ethanol in petrol across the country, with the exception of J&K, the Northeast and island territories. However, this was never implemented.
2. Uniform procurement price fixed at INR 21.50 / Liter (Ex-factory) for 3 years OMCs started procurement thro' tenders

Ethanol Blending Program (EBP) – Year 2008

1. In 2008, the Government of India announced its National Biofuels Policy mandating a phase-wise implementation of the program of ethanol blending in petrol in various states.
2. The blending level of bio-ethanol at 5% with petrol was proposed from October 2008, leading to a target of **20 %** blending of bio-ethanol by 2017.
3. This was taken up by the oil marketing companies (OMCs) in 20 states and 4 union territories
4. Industry witnessed drop in cane production and molasses during the season.
5. Ethanol Supply defaults as competitive usage – Potable sector offered better prices

Ethanol Blending Program (EBP) – 2010-12

Present Status

Season 2010-11 (Oct-Oct)-

1. The EBP demanded 1.04 billion Liters (10% blending for major sugarcane producing states and 5% blending for rest) The demand Excluded Tamil Nadu, Jharkhand, West Bengal, Odisha and Chhattisgarh
2. Indian sugar sector offered 703 Million Liters of Ethanol while actual supplied quantity in 12 states was 558.6 Million Liters at the rate of INR 27/Liter.
3. Key sugarcane producing states like UP and Maharashtra remained main defaulters

Season 2011-12 (Oct-Sept) –

1. Min. of Petroleum has agreed for a price of INR 34 - 35 / Ltr for fuel Ethanol, However, yet to be notified

2. Season 2011-12 (Oct – Sept) EBP requires 1.01 billion while offered quantity is 607.4million Liters till March 2012.

Benefits from the use of biofuels in India

1. Reduced emission of harmful pollutants

Ethanol and biodiesel are both oxygenated compounds containing no sulphur. These fuels do not produce sulphur oxides, which lead to acid rain formation. Sulphur is removed from petrol and diesel by a process called hydro-desulphurization. The hydro-desulphurization of diesel causes a loss in lubricity, which has to be rectified by introducing an additive. Biodiesel has natural lubricity, and thus no lubricity-enhancing additive is required. Since ethanol and biodiesel contain oxygen, the amount of carbon monoxide (CO) and unburnt hydrocarbons in the exhaust is reduced. With the introduction of ethanol in Brazil, CO emission from automobiles decreased from 50 g/km in 1980 to 5.8 g/km in 1995. The emission of nitrogen oxides (No_x) from biofuels is slightly greater when compared to petroleum, but this problem can be ameliorated by using de-No_x catalysts which work well with biofuels due to the absence of sulphur. One of the disadvantages in using pure ethanol is that aldehyde emissions are higher than those of gasoline, but it must be observed that these aldehyde emissions are predominantly acetaldehydes. Acetaldehydes emissions generate less adverse health effects when compared to formaldehydes emitted from gasoline engines

Table 2 Comparison of emission from 22% Ethanol E22 and 100% hydrated ethanol E100 with legal limits

Parameters	E22	E100	Legal Limits	Legal Limits
			Brazil	India(EuroIII/BharatIII
Carbon Doxide (g/km)	0.76	0.65	2	2.3
Unburned hydrocarbons(g/km)	0.13	0.15	0.3	0.2
Nox (g/km)	0.45	0.34	0.6	0.5
Aldehydes (g/km)	0.004	0.02	0.03	
Evaporatives (g/test)	0.86	1.6		
Partculate Matters (g/km)	0.08	0.002		
Sulphur Dioxide (g/km)	0.064	0		

2. Reduction in greenhouse gas emissions

The net CO_2 emission of burning a biofuel like ethanol is zero since the CO_2 emitted on combustion is equal to that absorbed from the atmosphere by photosynthesis during the growth of the plant (sugarcane) used to manufacture ethanol. This is illustrated by the following equations:

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6$ (plant sugar) + $6O_2$ (photosynthesis)
$C_6H_{12}O_6 + 3H_2O \rightarrow 3C_2H_5OH$ (ethanol) + $3O_2$ (hydrolysis and fermentation)
$3C_2H_5OH + 9O_2 \rightarrow 6CO_2 + 9H_2O$ (combustion of ethanol)

3. Energy security and decreased dependence on oil imports

India ranks sixth in the world in terms of energy demand, accounting for 3.5 per cent of the world commercial energy demand in 2001. But at 479 kg of oil equivalent, the per capita energy consumption is still very low, and the energy demand is expected to grow at the rate of 4.8 per cent per annum. India's domestic production of crude oil currently satisfies only about 25 per cent of this consumption. Dependence on imported fuels leaves many countries vulnerable to possible disruptions in supplies which may result in physical hardships and economic burdens. The volatility of oil prices poses great risks for the world's economic and political stability, with unusually dramatic effects on energy-importing developing nations. Renewable energy, including biofuels, can help diversify energy supply and increase energy security.

4. Improved social well-being

A large part of India's population, mostly in rural areas, does not have access to energy services. The enhanced use of renewable (mainly biofuels) in rural areas is closely linked to poverty reductions because greater access to energy services can:

• Improve access to pumped drinking water. Potable water can reduce hunger by allowing for cooked food (95 per cent of food needs cooking);

• Reduce the time spent by women and children on basic survival activities (gathering firewood, fetching water, cooking, etc.);

• Allow lighting which increases security and enables the night time use of educational media and communication at school and home; and

• Reduce indoor pollution caused by firewood use, together with a reduction in deforestation.

5. Good fuel properties

Ethanol has a research octane number of 120, much higher than that of petrol, which is between 87 and 98. Thus, ethanol blending increases the octane number without having to add a carcinogenic substance like benzene or a health-risk posing chemical like methyl tertiary butyl ether (MTBE). The energy content of ethanol is only 26.9 MJ/kg compared to 44.0 MJ/kg for petrol. This would suggest that the fuel economy (km/liter) of a petrol-powered engine would be 38.9 per cent higher than that of an ethanol-powered engine. In actuality, this difference is 30 per cent since ethanol engines can run more efficiently (at a higher compression ratio) because of the higher octane rating. For a 10 per cent ethanol blend the fuel economy advantage of a petrol engine is only 3 per cent. The flammability limit of ethanol (19 per cent in air) is higher than that of petrol (7.6 per cent), and likewise the auto-ignition temperature of ethanol is higher than that of petrol (366 versus 300^{o}C). Thus, ethanol is safer than petrol due to the lower likelihood of catching fire. Ethanol's higher latent heat of vaporization and greater propensity to absorb moisture may lead to engine starting and corrosion problems, respectively, but none of these problems have manifested in the millions of hours of running automobile engines in Brazil.

Table 3 Obstacles in implementation of EBP

Feedstock (Molasses) availability	Molasses is the only feedstock used for fuel Ethanol and it is available across 9 states only. While demand for fuel Ethanol is spread all over India
State policies and duties	Each state has its own policies and duty structure for Ethanol. This puts limitation on movement of fuel Ethanol across states
Competitive usage	Competitive use of Ethanol were not taken into account while going ahead with blending policy & deciding fuel Ethanol price
Price mechanism	The price offered for fuel Ethanol was fixed for a period and not linked in relation to competitive usage market price and gasoline prices. This policy de-motivated the fuel Ethanol producers
States Reluctance	Major sugar producing state - Tamil Nadu opposed the EBP to meet state's demand for potable alcohol and secure excise revenue

5. The ethanol industry in India

Ethanol is produced in India by the fermentation of molasses, a by-product in sugar manufacture. The yield of sugarcane in India varies from an average of 77 tons/ha in tropical states to about 52 tons /ha in subtropical states. The yield of sugar on average is approximately 105 kg per ton of cane. About 40 kg of molasses is produced per ton of cane from which about 10 liters of ethanol can be obtained. If the sugarcane is directly and fully used in ethanol manufacture, the yield of ethanol is 70 liters per ton.

Table shows the projected demand and supply of ethanol for blending in petrol (5 per cent ethanol – 95 per cent petrol).

Table 4 Projected demand and supply of ethanol for 5 % blending in petrol

Year	Petrol demand (Mt)	Ethanol demand (M L)	Molasses prodn. (Mt)	Ethanol production (M L)			Ethanol utilization (M L)		
				Molasses	Cane	Total	Potable	Industry	Balance
2001-2002	7.07	416.14	8.77	1775	0	1775	648	600	527
2006-2007	10.07	592.72	11.36	2300	1485	3785	765	711	2309
2011-2012	12.85	756.36	11.36	2300	1485	3785	887	844	2054
2016-2017	16.4	965.30	11.36	2300	1485	3785	1028	1003	1754

6. Literature review

Rong-Horng Chen et al: The effects of ethanol gasoline blended fuel on cold-start emissions of an SI engine were studied. During cold-start, the ECU controls fuel injection rate based on cooling water temperature and intake air temperature, which were carefully controlled during the experiment. More ethanol content in the blended fuel makes the air fuel mixture leaner and also affects the RVP value. The engine could be started stably with E5, E10, E20, and E30. The HC and CO emissions decreased significantly with more ethanol than 20% added. However, for E40 the engine idling became unstable because the air fuel mixture was too lean. Therefore, the ethanol content in gasoline for best cold-start emissions was determined to be at least 20 per cent but no greater than 30 percent.

Lan-bin et al: In this study, the effect of oxygen containing additives on gasoline blended fuels on exhaust emissions was investigated for different engine speeds in a single cylinder, four-stroke, and spark-ignition engine. The results indicate that CO and HC exhaust emissions are lower with the use of ethanol–gasoline and DMC–gasoline blended fuels as compared to the use of unleaded gasoline.

Mustafa Koç: In this study, the effects of unleaded gasoline (E0) and unleaded gasoline–ethanol blends (E50 and E85) on engine performance and pollutant emissions were investigated experimentally in a single cylinder four-stroke spark-ignition engine at two compression ratios (10:1 and 11:1). The engine speed was changed from 1500 to 5000 rpm at wide open throttle (WOT). The results of the engine test showed that ethanol addition to unleaded gasoline increase the engine torque, power and fuel consumption and reduce carbon monoxide (CO), nitrogen oxides (NOx) and hydrocarbon (HC) emissions. It was also found that ethanol–gasoline blendsallow increasing compression ratio (CR) without knock occurrence.

M. Bahattin Celik: In this study, ethanol was used as fuel at high compression ratio to improve performance and to reduce emissions in a small gasoline engine with low efficiency. Initially, the engine whose compression ratio was 6/1 was tested with gasoline, E25 (75% gasoline + 25% ethanol), E50, E75 and E100 fuels at a constant load and speed. It was determined from the experimental results that the most suitable fuel in terms of performance and emissions was E50.

Hu¨seyin Serdar Yu¨cesu: In this study, the effect of compression ratio on engine performance
and exhaust emissions was examined at stoichiometric air/fuel ratio, full load and minimum advanced timing for

the best torque MBT in a single cylinder, four stroke, with variable compression ratio and spark ignition engine.

Fikret Yu¨ ksel: In this study by using ethanol–gasoline blend, the availability analysis of a spark-ignition engine was experimentally investigated. Sixty percent ethanol and 40% gasoline blend was exploited to test the performance, the fuel consumption, and the exhaust emissions. As a result of this study, it is seen that a new dual fuel system could be serviceable by making simple modifications on the carburetor and these modifications would not cause Complications in the carburetor system.

M. Al-Hasan: In this study Performance tests were conducted for equivalence air–fuel ratio, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide (CO2) and unburned hydrocarbons (HC), using unleaded gasoline–ethanol blends with different percentages of fuel. The results showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and equivalence air–fuel ratio. The CO and HC emissions concentrations in the engine exhaust decrease, while the CO2 Concentration increases. The 20 vol. % ethanol in fuel blend gave the best results.

Conclusion

Internal combustion engine have taken continuously growth with its design, working fuel, efficiency and environmental issues. Ethanol was the best alternative fuel compared to gasoline having good thermal and chemical properties. The CO and HC emissions decreased dramatically as a result of the leaning effect caused by the ethanol addition, and the CO2 emission increased because of the improved combustion. Using oxygen containing additives increased fuel consumption. Reduction in NOx emissions was obtained with ethanol addition due to the high latent heat of vaporization of ethanol. The addition of Ethanol to gasoline increases the octane number. Hence, it enables the gasoline engine to operate at higher compression ratios. The use of ethanol gasoline blended fuels increase the brake power and brake torque, and decreases the BSFC.

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