Review the Effect of using Bioetanol Fuel in Internal Combustion Engine to Reduce Toxic Gas Emissions

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Abstract. The increasingly restrictive worldwide emission law necessitates significant efforts to achieve emission quality criteria while increasing combustion efficiency. Fuel ethanol combined with gasoline is one promising approach. Since it can be produced without the use of fossil fuels and has a high octane rating, ethanol is often utilized as an alternative fuel or a valuable additive to gasoline. Therefore, much study has been done on the effects on emissions and engine performance. Rather than using agricultural or woody biomass, many researchers now make bioethanol from industrial, municipal, and herbaceous wastes. The majority of the engine test results demonstrated a notable increase in engine performance and improved combustion properties for bioethanol fuel. Additionally, there was a decrease in the emissions of carbon monoxide and unburned hydrocarbons. On the other hand, there was no significantly appreciable decrease in carbon dioxide or nitrogen oxide emissions. Additionally, unregulated emissions like those of aromatics, acetaldehyde, and carbonyls did not significantly decline.

Keywords: Bioethanol, Emission, Spark Ignition Engine.

1 Introduction

The two leading causes of the energy consumption trend are (1) changing lifestyles and (2) the population's rapid expansion. Nowadays, the bulk of energy comes from fossil fuels, which have a petroleum base. On Earth, however, these fuels are limited. In the 20th century, research focused on building refineries that used fossil fuels like natural gas and crude oil as feedstock. This was done to address the requirements of the growing population while using easily accessible fossil fuels [1]. The burning of fossil fuels produces large amounts of carbon dioxide emissions, which directly cause global warming. Anthropogenic activities worldwide create around 25 billion tons of CO2 a year [2]. As a result, the current study focuses on alternate energy sources for the economy and society's sustainable growth [1]. While biofuels only make up 1% of the entire energy supply, fossil fuels still account for 80% of it [3].

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The possibility of ethanol as a vehicle fuel substitute has piqued curiosity worldwide [4]. The idea of using ethanol as gasoline is not new. Samuel Morey created an ethanol-powered engine in 1826 [5]. In the 1980s, studies on the usage of ethanol combined with diesel fuel were conducted. It was demonstrated at the time that ethanol mixtures were technically adequate for use as engine fuel. However, at the time, the comparatively expensive cost of producing ethanol prevented it from being used regularly. Instead, it required it to be used during periods of shortage. The prices of producing ethanol have improved significantly, and it can now be conventional gasoline [6].

Ethanol are becoming more and more critical as a CO2 sink, which lowers greenhouse gas emissions [7]. Because of its high octane and clean burning characteristics, ethanol is a fuel additive or alternative fuel that has been employed in diesel and spark ignition engines lately [8,9]. Even though utilizing bioethanol in spark ignition engines decreases emissions of carbon monoxide, hydrocarbons and other pollutants, there are still some differences in emissions, as several studies have shown. One of the major contaminants that the Environmental Protection Agency states may affect the respiratory system. With its widespread usage, emissions might pose a significant challenge to the industry's expansion in ethanol production.

The primary goals of this work are to present a comprehensive overview of the literature and make recommendations for future research on ethanol-based emissions reduction approaches. Many researchers have previously studied the manufacturing of ethanol [3,4,10–12] as well as its application in gasoline engines [13–15]. Many review papers are available about the influence of emissions on different types of biofuels [16–20]. This article solely discusses ethanol usage in gasoline engines and the emissions that occur. The following section will combine published research to show how emissions may vary when using these fuels. The explanations, however, contain a great deal of contradictions, which prevent thorough comprehension.

2 Method

The method for reviewing scientific journals involves the steps of reading articles carefully, assessing research methodology, analyzing results, checking references, identifying weaknesses, providing suggestions, and compiling a review report. The aim is to assess the quality, reliability and relevance of articles before publication, maintaining high scientific standards.

3 Results and Discussion

This aligns with the study's goals, which include determining the degree to which the performance of four-stroke motorbikes is impacted by using bioethanol derived from corncob waste mixed with RON 92. The study was conducted at three different engine speeds: 1400, 2400, and 3400 engine speeds. The test was run three times at each engine's speed. The following will discuss the impact of using bioethanol as a fuel combination for RON 90.

3.1 As a substitute for Bioethanol fuel

Ethanol is a green fuel as it is made from renewable energy sources. It is an oxygenated liquid hydrocarbon that is colorless, transparent, inert, volatile, and flammable. It also has an unpleasant burning taste and odor [4]. However, today's automobiles with fuel injection engines utilize gasoline and bioethanol more often. Ethanol and bioethanol are essentially the same substance. They are made of the same meaning. It is typically made from a variety of feedstocks, including sugarcane, sugar beets, corn, wheat, turf, oats, cannabis, bananas, sweet potatoes, cassava, potato, sunflower seeds, berries, maple syrup, grain, combustion, flour, cereal grains, sorghum, fiber, and other plant matter.

Fuels that include hydrocarbons, such as gasoline, are often less reactive than ethanol or bioethanol [21]. It dissolves readily in polar and non-polar substances because it contains both non-polar carbon chains and polar hydroxyl radicals [21]. Ethanol is currently employed as an alternative fuel worldwide due to its regenerative and biodegradable qualities. Worldwide encouragement to use gasoline with 3–10 vol% bioethanol has existed since a few years ago [22]. The benefits and drawbacks of utilizing ethanol instead of gasoline are presented in Tables 1 and 2.

Three main kinds of feedstocks may be distinguished among the world's ethanol production [23]:

1. Ethanol derived from biomass (beets, cane, and sweet sorghum) that includes sucrose.
2. Ethanol derived from biomass containing starchy components such as barley, maize, rice, wheat and milo.

Bioethanol is created by fermenting glucose, which is present in sugars and starchy biomass. According to equations, the two basic processes that might result in the production of ethanol are the production of alcohol and the interaction between ethane and steam. (1)-(3) [25,26].

The process of fermentation of alcohol [21]:

$$\underset{\text{(Glucose)}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow x\underset{\text{(Glucose)}}{C_2H_{12}O_6} + (2\text{-}x)\underset{\text{(Fructose)}}{C_6H_{12}O_6} \tag{1}$$

$$\underset{\text{(Fructose)}}{C_6H_{12}O_6} \rightarrow 2\underset{\text{(Ethanol)}}{C_2H_5OH} + 2CO_2 \tag{2}$$

Reaction of ethane with steam :

$$\underset{\text{(Ethane)}}{C_2H_4} + \underset{\text{(Steam)}}{H_2O} \rightarrow \underset{\text{(Ethanol)}}{C_2H_5OH} \tag{3}$$

Fig. 1 shows that global ethanol fuel production expanded steadily during the previous ten years. Fuel ethanol production has skyrocketed as a result of various countries' continued efforts to reduce their dependency on imported oil, and stimulate. Them tackle ethanol consumption in two ways: first, requiring ethanol petrol mixtures; second, the growing market for flex-fuel automobiles. In Brazil, flex-fuel engines power at least 90% of newly marketed cars, and 20–25% of petrol supplied there is anhydrous ethanol [29]. For adding ethanol to gasoline, several countries either already have mechanisms in place or are in the process of putting them in place—table Three. Most cars can run on ethanol mixtures up to 10%. Car manufacturers also design their vehicles with more excellent ethanol mixes in mind [30].

3.2 Physicochemical Characteristic Comparisons

The physical and chemical characteristics of the fuel indicate its suitability for burning in an engine. They impact the efficiency, quality, and attributes of engine emissions. Table 4 compares certain combustion-related characteristics of ethanol with gasoline. The following list compares the characteristics of ethanol to gasoline:

1. Ethanol has a heating value that is about one-third that of gasoline. Therefore, more gasoline is needed for ethanol to produce the same amount of engine power.
2. Ethanol's 34.7 weight percent oxygen concentration encourages high combustion temperature and combustion efficiency.
3. Fuel vaporizes at a lower temperature than ethanol. Consequently, more heat from the cylinder's interior is required for the charge to evaporate. As a consequence, the engine's volumetric efficiency increases.
4. Due to its somewhat lower density than gasoline, ethanol is injected at a lower mass via volumetric fuel pumps than gasoline.
5. Ethanol contains neither mono- nor poly-aromatic hydrocarbons.
6. The temperature of the adiabatic flame decreases with increasing ethanol because of its lower C/H atom ratio.
7. Ethanol has a higher ON octane rating than petrol.
8. Fuel combustion is finished earlier with ethanol due to its quicker laminar flame propagation rate than petrol, which improves the engine's thermal efficiency.
9. Manufacturing inferior quality fuel with lower ON Fuel blends using ethanol allows petroleum refineries to run more economically.

3.3 Blend Concentration's Impact

In SI engines, fuel blends with ethanol contents ranging from 5 vol% to 100 vol%, or pure ethanol, have been studied by researchers. The researchers used a variety of testing methodologies to get these findings. Table 5 shows that adding ethanol to petrol decreases its heating value while concurrently increasing its density, octane rating, and latent heat of vaporization. Many studies have been conducted to ascertain these alterations' effects on emission characteristics, specifically on emissions resulting from fluctuations in ethanol concentrations.

Table 1. Properties of different ethanol–gasoline blended fuels.

Property	E0	E5	E10	E15	E20	E25	E30	E40	E50	E60	E85
Density (kg/m^3)	757.5	759.1	760.8	776	764.5	775	768.2	780.6	751	789.5	
RVP (kPa)	53.7	59.3	59.6	58.8	58.3		56.8	63	45.3	57.4	37.85
RON	95.4	96.7	98.1	98.5	100.7	100	102.4	90.9	101.2	92.7	101.7
Sulfur (wt%)	0.0061	0.0059	0.0055	0.0063	0.0049	0.0246	0.0045	0.026	<0.001	0.032	<0.001
Distillation temperature (°C)											
(a) Initial boiling point	35.5–38.8	36.5	37.8	37.9	36.7–38.6		37.2–39.5	39.6	328.3		
(b) 10 vol%	54.5–56.1	49.7	50.8–52.9	51.7	51.3–52.8	58.1	52.1–54.8	53.4			73.9
(c) 50 vol%	94.4–109.6	88	71.1–95.8	72.6	70.3–73.8	71.7	72.4–74.6	72.5	521		78.0
(d) 90 vol%	167.3–206.3	167.7	157–166.4	165.3	165.2–163		154.6–159.3	152.7	547		78.7
(e) End point	197.0	202.5	197.5–208.4	198.1	198.6–203.6	177.9	198.3–205.1	204.1			79.9
Heating value (MJ/kg)	42.58–42.7	40.55–41.78	39.79–41	41.61	38.98–39.5	38.2	36.32–37.8	33.34–36.2	33.34	26.74	29.2

RVP = Reid vapor pressure, RON = Research Octane Number.

4 Conclusion

Due to the depleting fossil fuel sources and environmental concerns, alternative fuels are becoming more and more crucial for cars. Ethanol is one of the alternative fuels utilized for many years in many countries since it is produced from renewable resources and has better emissions. However, using ethanol in SI engines causes specific abnormalities in the emissions, as several studies have shown. The key conclusions are described below after thoroughly analysing the current literature on ethanol emission.

a. Using petrol and ethanol as fuel, several studies have theorized that heat.
b. In SI engines, ethanol-blend fuels may utilize a greater CR because of their higher octane number. With a more excellent ethanol mix %, a higher CR may be used without causing an increase in emissions.
c. Engine cold starts are not recommended for pure ethanol fuel. When using ethanol-blend gasoline instead of straight gasoline, an engine can start up quickly in a cold environment with less HC, CO, and pollution. However, a heated air-fuel mixture performs better during a cold start.
d. Premixed water and ethanol are more successful in reducing emissions than separate water injection, even though water content has a significant impact.
e. TBC is used to recover energy as workable work and decrease heat rejection to the coolant; nevertheless, its usage results in increased emission. Since ethanol is an oxygenated fuel, TBC accelerates combustion and formation in a mix at low concentrations. On the other hand, TBC may be sprayed with more excellent ethanol-gasoline blends without boosting emissions further because of the blend's decreased heating value.

Bioethanol and petrol are a technically sound alternative fuel for Spark Ignition engines. Ethanol's reduced heating value is an issue. Using butanol might address this issue. However, economic considerations will always support the usage of ethanol. As a result, investigating methods to lower the manufacturing costs of alternative solutions can be beneficial.

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