A COMPREHENSIVE STUDY ON ETHANOL BLENDED S.I ENGINE

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Abstract:
Ethanol fuel has been utilized as an alternative to petrol in internal combustion engines for decades, presenting the potential to mitigate carbon monoxide emissions from traditional petrol engines. Conversely, the transition to bio-petrol is a complex challenge requiring in-depth understanding by researchers, driven by escalating petroleum prices and impending environmental regulations. Successful tests of ethanol-petrol blends in spark ignition engines indicate a slight increase in engine power without the need for modifications. The results demonstrate decreased CO2 emissions at high engine speeds, albeit with an increase in CO emissions. This leads to improved combustion processes, enhanced stability, and a 15% boost in engine efficiency with ethanol comprising 15% of the fuel blend. In the context of India's petroleum imports, amounting to 185 million metric tons at a cost of US $551 billion in 2020-21, with a significant portion dedicated to transportation, implementing a viable E20 program could potentially save the country $4 billion annually (approximately Rs. 30,000 crores). Ethanol, being a less polluting and cost-effective fuel compared to petrol, coupled with the abundance of cultivable land, increasing food-grain and sugarcane production, available technology for ethanol production from plant-based sources, and the feasibility of adapting vehicles to ethanol-blended petrol, positions E20 not only as a national necessity but also as a crucial strategic initiative for India.

Keywords :Ethanol , Ethanol blending,Anhydrous ethanol , S.I Engine

Introduction:

[1-2] The continual release of harmful gases from car exhausts significantly impacts both the environment and society. Despite industrial emissions, the quantity of car exhaust is on the rise, containing detrimental substances like carbon monoxide, nitrogen oxide, and hydrocarbons. These gases— (CO), (NO), and (HC)—are present in automobile exhaust systems. Ethanol, derived from renewable sources, serves as an environmentally friendly fuel, reducing CO2 emissions through photosynthesis. In Brazil, sugar cane is used to produce both anhydrous and hydrous ethanol. Anhydrous ethanol, containing no more than 0.7% water, functions as an anti-knock supplement in standard gasoline. On the other hand, hydrous ethanol, with a water content of up to 7.4%, is utilized to power cars and light commercial vehicles. In Brazil, the predominant vehicles in terms of sales are flexible fuel vehicles, which can operate on either ethanol or gasoline. The objective of this study is to evaluate the performance of the engine when utilizing hydrous ethanol (ethanol containing 6.8% water) or conventional gasoline (with 22% v/v anhydrous ethanol) as the fuel source. [3-4] In the 2021-22 season, India utilized its sugarcane molasses to manufacture edible sugar, yielding 5000 lakh metric tonnes of sugarcane. During this period, sugar mills processed 3574 metric tonnes of sugarcane, resulting in the production of 394 metric tonnes of sugar. Looking ahead to 2022, a total of 35LMT of sugar is earmarked for the production of 113 crore liters of ethanol, projecting a 12.68% increase in ethanol production in the upcoming years. The use of ethanol holds the potential to reduce reliance on oil imports, generate employment opportunities, and potentially double the income of sugarcane farmers in the future.

Literature review

T.Beer et al.[5] investigated the use of ethanol-gasoline mixtures with an ethanol volume ratio greater than 10% in light commercial vehicles .Such a blend could potentially reduce his CO2 emissions, but the reductions would be small and likely be overshadowed by his CO2 emissions from ethanol production. With an ethanol content of 20% by volume, fuel consumption is expected to be reduced by approximately 7% due to the lower energy content .As the amount of ethanol mixture increases, evaporative emissions are also expected to increase.

Using a 20% ethanol mixture can reduce vehicle performance, especially on older vehicles with lean carburetors Through experimental studies of butanol and gasoline mixtures with different butanol ratios under stoichiometric conditions,

Wallner et al[6].was found to have a long, advanced combustion phase. The decline in Brake Thermal Efficiency (BTE) resulted from the introduction of butanol. This was attributed to the engine running at gasoline MBT ignition timing. The enhanced combustion quality, stemming from the oxygen content in the fuel, counteracted the decrease in BTE caused by the improper combustion stage of butanol. Gasoline blends were unable to compensate for this effect. B30 outperforms G100, showcasing comparable BTE and lower CO (8.7%), UHC (15.3%), and NOX (6.4%) emissions compared to other blends of butanol and gasoline.

Yecesu et al [7] In this research, we explored how the performance and emissions, both gas and particulate, of a turbocharged gasoline engine fueled by port injection at 3000 rpm and high engine load are affected by the E85 injection mode. Two E85 injection methods were compared: Dual Fuel, where ethanol and gasoline are separately injected into the intake manifold, and Blending, where ethanol and gasoline are mixed to form E85, which is then injected. The primary benefit of dual fuel injection lies in the system's flexibility, enabling the easy delivery of varying ethanol percentages to the engine. Conversely, injection systems are more complex as they require two separate circuits and tanks

H.SerdarYu¨cesu [8] The examinations indicated negligible fluctuations in the MBT timing of the engine when running on unleaded gasoline and blends of unleaded gasoline and ethanol. Nevertheless, retarding the ignition timing resulted in the ethanol blend producing greater engine braking torque compared to unleaded gasoline. The peak torque was consistently reached at a 0.9 RAFR for all test fuels at both 8:1 and 10:1 compression ratios. Notably, the torque of the ethanol-blended fuel surpassed that of E0, particularly in a richer operational range than the stoichiometric air-fuel ratio, especially at a compression ratio of 10:1. The operational range has been expanded, and the engine torque has risen in correlation with the ethanol content. He Bang-Quan,

WangJian-Xin [9] From this result, it can be concluded that ethanol blends can very well replace pure gasoline in gasoline engines.This result clearly shows that ethanol has a lower calorific value compared to gasoline, which increases fuel consumption and mechanical efficiency.

Hence, the curve makes it evident that opting for gasoline mixed with 10% ethanol is the optimal selection for operating in current gasoline engines, requiring no adjustments to enhance efficiency. Mixing increases the maximum pressure in the cylinder, so consideration must be given to the materials used. Blending ethanol and gasoline uses more fuel, so accommodating blend users requires a balance between fuel consumption and efficiency**.**

Pidol L et Al [10] This study investigated the blending of biodiesel and ethanol with diesel to enhance engine performance . Consequently, substituting ethanol with biodiesel in the mixture adequately balances varied fuel characteristics, yielding a composition of 15% biodiesel, 5% ethanol, and 80% diesel with minimal fuel consumption. It appears to be achievable.

Labeckas G et Al[11] This research explores the viability of mixing biodiesel and ethanol with diesel at varying concentrations, with a specific emphasis on studying heating and evaporation properties, cetane number (CN), viscosity, and calorific value. These attributes play a crucial role in fine-tuning engine performance and design. The findings indicate that incorporating biodiesel along with ethanol helps offset the reduction in droplet lifetime, surface temperature, cetane number, viscosity, and calorific value.

As an illustration, a blend comprising 15% biodiesel, 5% ethanol, and 80% diesel exhibited marginal decreases in droplet lifetime, cetane number (CN), viscosity, and calorific value, each amounting to less than 1.2%, 0.2%, 2%, and 2.2%, respectively. Comparison with genuine diesel.

In general, the findings indicate that integrating an additional 20% of biofuel into diesel is feasible for engines initially intended for pure diesel use, necessitating minimal or no modifications.

M.Al-Hasan et Al[12] In this study, the noise emissions of five used and new motorcycle models, both zero and full throttle, in idle mode The level was characterized: muffler, no silencer. The study found that different models of motorcycles emit different levels of noise. The different modes of operation that affect the noise emission level of motorcycles include , age condition (new and used), idle mode (throttle and full throttle), and speed rating of the motorcycle being ridden (At speeds of 30 km/h, 40 km/h, and 50 km/h) and the effect of load (with or without load) .Results of a descriptive statistical analysis conducted on the noise emission level of a new motorcycle during idling at zero and full throttle using the average value of the muffler, Jincheng was shown to emit the highest noise level with an average of 74.00 dB(A) (SD = 2.62 at zero throttle) and 80.00 dB(A) (SD=2.54) at full throttle.

MA Ceviz et al [13] According to the findings of the study, ethanol has proven to be a viable substitute for traditional fuel in gasoline engines. Blending ethanol and gasoline improves engine performance, improves combustion efficiency, and reduces NOx, CO, and CO2 emissions. The research revealed a 10.91% enhancement in thermal braking efficiency (BTE) with E20 in contrast to regular gasoline, leading to improved performance. While the addition of ethanol elevated the brake specific fuel consumption (BSFC), the total fuel consumption (TFC) rose due to the lower calorific value of ethanol. As ethanol boasts a high octane rating, blending it contributes to an overall increase in the gasoline's octane rating. Additionally, the ethanol blend exhibited superior volumetric efficiency. In summary, ethanol blending is an efficient way to reduce emissions and represents a promising alternative to gasoline .

Wei-Dong Hsieh et Al[14] Examined the impact of a blend of ethanol and gasoline in a conventional gasoline engine, revealing a modest rise in torque and fuel consumption. Notably, there was a substantial increase in CO and HC emissions attributable to fuel lean effects, which decreased with improved combustion resulting from ethanol use. While CO and HC emissions could be reduced by 10-90% and 20-80%, respectively, CO2 emissions increased by 5-25%, contingent on engine conditions. It was observed that NOx emissions were more closely tied to the equivalence ratio and engine operating conditions rather than the ethanol content. Subsequent investigations will focus on the open-loop control of fuel injection and the management of aldehyde emissions.

Performance Of I.C Engines

Jitendra Kumar et Al[15] The optimal mixture of fuel and air in an engine holds significant importance for combustion and overall engine efficiency. This ratio is denoted by the mass of fuel to the mass of air and vice versa.:

Ratio of air to fuel :

A / F = ratio of air flow to fuel flow

Fuel consumption rate specific to a given parameter : Brake-Specific Fuel Consumption (BSFC) and Indicated Specific Fuel Consumption (ISFC) represent fuel consumption associated with braking force and indicated power, respectively.

Fuel consumption specific to braking (Kg/kwh):

B.S.F.C = Flow of fuel in kilograms per hour per brake horsepower.

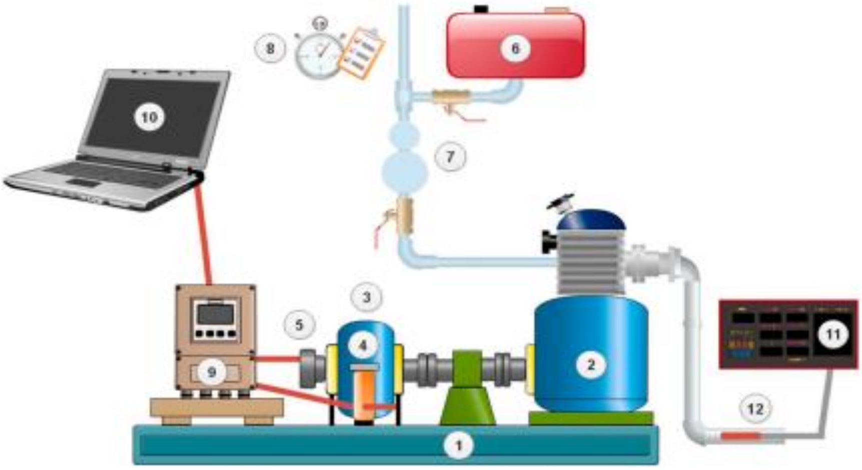
Efficiency in mechanical processes (ηm) : "Mechanical efficiency is the relationship between the braking force (supplied power) and the designated power (power delivered to piston)."

η= Ratio of power from braking compared to power indicated.

The arrangement for the experiment

In experiments, 2 L of ethanol and gasoline mixtures were mixed with different ethanol addition The experiment commenced by introducing the mixture at rates of 10%, 20%, 30%, and 40% to attain steady state and uniformity in the engine tank. The ultrasonic bath employed was a CT BRAND 5L. Each session was configured for a duration of 30 minutes with zero energy to avoid fuel evaporation.

The initial trial involved using pure gasoline, followed by four additional tests using a prepared mixture of ethanol and gasoline. A K-type thermocouple measured the initial intake air temperature, while another thermocouple gauged the exhaust gas temperature. The motor speed was determined through optical sensor pulses, and a force measuring instrument recorded the motor torque. Exhaust gases were identified and analyzed using a Techno exhaust gas analyzer. Fuel consumption was assessed by recording the time it took to pass through a scaled tube. The experiment utilized a TD 200 engine with a fixed compression ratio and variable speed. The collected signals were captured and transferred to a computer for display. A hydraulic dynamometer was used to dissipate energy and measure braking torque.



1. Engine chassis 2. Test engine 3. Dynamometer 4. Load cell 5. Tachometer 6. Fuel tank 7. Fuel burette
8. Stop watch 9. Data acquisition 10. Computer 11. Exhaust gas analyzer 12. Exhaust gas analyzing probe

Specification of test engine used during the experiment (TD-200).

Element	Specification
Maximum Speed	2500 (r.p.m)
Refrigeration	Capacity cooled by air 172 (cc)
Peak power capacity	4.39 (K.W)
Manufacturing	TecQuipment
Strokes	49.0 (mm)
Opening(cavity)	66.9 (mm)
Ratio of compression	8.50 : 1.0
Infusion category	Carbureto

Table 1

Characteristics of various fuel types.

Element	Petrol	E(10%)	E(20%)	E(30%)	E(40%)
(RVP) at 38 ?C (kPa)	53.7	55.2	56.8	58.3	59.6
(RON)	93.00	92.30	92.30	91.80	91.40
(MON)	83.12	83.72	84.29	84.58	84.79
Chemical ratio at the stoichiometric level.	15.05	14.399	13.82	13.21	12.59
Lower heating value (MJ/kg)	43.8	42.11	40.42	38.73	37.04
Density (at 15 ?C) (kg/m3)	754	758	764	768	771

Table 2

The indecisiveness of measuring apparatus.

Element	Number	Errors
CO	1.0	±0.01%
CO2	1.0	±0.09%
HC	1.0	±9.90 p.p.m
NOX	1.0	±9.90 p.p.m
Thermocouple	2.0	± 2.19 ◦C
Optical sensor	1.0	±99 R.P.M
Cell for measuring load.	1.0	± 0.024% *(load cell output)

Table 3

Performance(SI engine)

Brake power (pb)

The study found that brake power peak at 2499.9 r.p.m in above all the experimental tests. Brake power increases rapidly with engine speed, with maximum percentages of 14.67%, 13.3%, 12.23%, 10.63%, and 6.76% reported for alternative fuel compared to gasoline fuel. Blended ethanol improved the ratio of air to fuel equivalence and led to better combustion and higher power output. The braking capability is a function (it is function of speed , torque), and mixing ethanol was beneficial in improving the the output of the engine .

The efficiency of braking thermal system (ηth)

The research investigates how brake thermal efficiency is influenced by engine speed and blending ratio. The maximum efficiency is achieved at 2500 rpm, with a range of 20.21% for gasoline engines to 38.88% for engines using E40(fuel) The inclusion of ethanol substantially enhances thermal efficiency, demonstrating an increase of up to 31.12% when using an E40 blend. This arises from the characteristics of fuel blending , which increase engine heat compared to pure gasoline due to improved combustion speed and smaller combustion duration. As the combustion duration decreases, less fuel is burned and heat transfer losses decrease, thereby increasing brake thermal efficiency. The higher H/C ratio of ethanol ensures that oxygen molecules can burn carbon completely for thermal conversion, further improving engine thermal efficiency. The increased rate of fuel consumption, along with the fuel-to-air ratio, also enhances the combustion rate of the engine.

volumetric efficiency (ηv)

The study showed that as the engine speed increases, the volumetric efficiency also increases, reaching its peak at 1500 rpm. At 2000 rpm, the most significant difference between gasoline and E40 was 6.33%. Volumetric efficiency exhibits a similar trend both under no load and load conditions, decreasing as engine speed rises due to a reduction in induction stroke time. However, it slightly increases with increased load. The study highlights the importance of blending ratios in determining volumetric efficiency.

Exhaust emission

Carbon monoxide (CO)

Carbon monoxide emissions demonstrate fluctuations based on engine speed and blending ratio within a test engine. As engine speed rises, CO emissions decline, and the emissions from blended fuel remain consistently lower across all engine speeds when compared to petrol fuel . At a blending ratio of E30 and 2500 rpm, the maximum percentage deviation of CO in gasoline fuel, as compared to blended fuel, peaks at 26.33%. Mixing fuels in a layered fashion keeps a leaner ratio close to the cooler cylinder wall and in proximity to the spark plug. This arrangement makes it easier to extinguish and ignite the blend. This wider lean burn limit enhances flame propagation, elevates combustion temperature, increases the heat release rate, and consequently, diminishes CO emissions.

Carbon dioxide (CO2)

The study demonstrates that using blending fuel in a test engine reduces CO2 emissions due to its lower carbon-to-hydrogen ratio and efficient combustion. The fuel undergoes a transformation of its carbon content into CO2, with a decrease in CO2 emissions as the engine speed rises.

Combining a fuel with lower carbon content than gasoline results in reduced CO2 production, thereby mitigating its contribution to global warming during combustion .When contrasting the CO2 content in gasoline fuel with another fuel, the highest percentage variance occurs, reaching 42.5% for E40 at 1500 rpm. This discrepancy is attributed to the low carbon-to-hydrogen ratio and efficient combustion, leading to decreased CO2 emissions compared to pure gasoline.

Emissions of hydrocarbons (CxHy).

The research investigates the release of carbon monoxide (CxHy) from test engines under various engine speeds and blending ratios. The occurrence of CxHy in exhaust emissions suggests inadequate combustion, and its levels decrease as engine speed increases. Incomplete combustion and the formation of CxHy are influenced by factors such as inadequate oxygen, low temperatures, and heterogeneous mixtures. At 2500 rpm, the largest difference in CxHy content between gasoline fuel and blended fuel occurs in E40, reaching a maximum disparity of 31.05%. As ethanol levels rise, CxHy emissions decrease, resulting in a more homogeneous mixture and improved combustion. Blended fuel contributes to achieving complete combustion and reducing hydrocarbon emissions by employing wall quenching. The decrease in hydrocarbon levels is noticeable with an increase in engine speed under a consistent load, with the extended valve overlap periods significantly affecting this pattern, particularly at higher speeds.. The variation in hydrocarbon emissions is influenced by brake mean effective pressure, with an increase leading to reduced hydrocarbons and enhanced combustion.

Nitrogen oxides (NOx)

The study reveals that as engine speed increases, so does NOx emissionsGasoline fuel produces elevated NOx emissions across all engine speeds compared to blended fuel, a result of heightened fuel consumption and combustion temperatures.

The introduction of blended fuel brings about a cooling energy flow effect, reducing cylinder gas pressure and shortening the combustion duration. Delaying the ignition timing can assist in attaining lower NOx emissions without sacrificing thermal efficiency. The most significant percentage difference in NOx content between gasoline fuel and another fuel is 20.91%, as observed with E40 at 2500 rpm.

Conclusion

The results suggest that Ethanol blends can efficiently replace pure Gasoline in Spark Ignition Engines. The findings unmistakably show an increase in Specific Fuel Consumption due to the lower calorific value of Ethanol compared to Gasoline, accompanied by a rise in mechanical efficiency. Analysis of the curves indicates that a 10% ethanol blend with gasoline stands out as the optimal selection for current Spark Ignition Engines, without the need for any modifications to improve efficiency. However, it is important to consider the materials used, as blending increases the maximum pressure inside the cylinder. Striking a balance between Specific Fuel Consumption and efficiency is crucial, considering that users of the blend will experience higher fuel consumption due to the addition of ethanol to gasoline.

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