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STUDY OF COST AND PERFORMANCE EFFECT OF GASOLINE AND ETHANOL BLENDING ON SI ENGINE

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ABSTRACT :

Petroleum products are expected to become more limited in the next decades due to current usage rates. Ethanol can reduce greenhouse gas emissions from cars and help meet fuel needs as a renewable alternative. Therefore, it is essential to design engines that can run on either pure ethanol or ethanol-gasoline combinations. This study aims to explore the effects of ethanol and its mixes on the performance and emissions of Spark Ignition (SI) engines. The primary objective is to analyse engine performance and emission characteristics when using gasoline-ethanol combinations. In this experimental investigation, a four-stroke, three-cylinder gasoline engine was tested under various operating conditions. Key performance indicators, including as efficiency, specific fuel consumption, and brake power, were evaluated for different ratios of ethanol to gasoline. These tests were conducted with varying coolant temperatures, loads, and engine speeds. The blend's ethanol component improves combustion efficiency by raising the air-fuel equivalency ratio and bringing it closer to the stoichiometric value. As a result, the engine may use fuel more effectively and generate greater power.

Keywords: Gasoline, Ethanol, SI Engine

1. Introduction :

Due to the world's diminishing oil sources and the impact of rising gas emissions on environmental deterioration, there is currently a critical need for alternative energy production, such as ethanol biodiesel. Vegetable oil is a potential alternative since it is flexible, renewable, environmentally benign, and easy to produce using electricity-all of which are much needed in modern rural regions. As a result, several studies have been carried out recently on the application of vegetable oil esters as biodiesel in machinery. Vegetable oil products may also encourage economic growth in rural regions since farmers benefit from the growing demand for vegetable oil. Many vegetable oils are used directly as fuel.

The automobile industry is the largest economy in the world, and using various fuels in cars provides a reliable and useful source of electricity for both passengers and transportation. Automobiles are made from fuel. Since the last century, gasoline has been widely utilized and has been based on diesel and gasoline. This liquid oil is made using crude oil in accordance with international norms. The daily demand for fossil fuels is rapidly increasing due to the rapid depletion of natural gas reserves and the increasing number of automobiles. The existing situation will make future energy emergencies more difficult. Actually, demand should increase in parallel with the number of cars worldwide and a growing economy.

The need for transportation fuels is mostly met by the demand for fossil fuels. However, utilizing fossil fuels could hurt the planet, their price will increase, and natural gas resources are running scarce. People are very reluctant to utilize power due to current social and economic situations, such as fuel shortages or political upheaval. The best designs and engines use less fuel. Renewable energy generated from agriculture can help address the aforementioned problems. Physical and chemical products, as well as some petroleum products, need to be replaced.

Using ethanol allows for an increase in the engine's oil compression ratio, which in turn increases the engine's power and thermal efficiency because it has a higher-octane number than gasoline. However, it's easy to run on original ethanol fuel, as the gasoline engine illustrates. It isn't. (2009); 2020; Sahoo, Sahoo, and Shah. Numerous publications have documented tests of various ethanol/gasoline mixes on the original gasoline engine. For example, Farhad et al. evaluated the effect of the ethanol content of the gasoline mixture on the electric generator. The results showed a 5% improvement in power output and octane levels using a 10% ethanol (E10) blend.

It can also reduce CO2 emissions by up to 30% (Salek et al., 2021). Adding ethanol to gasoline changes the fuel's properties, which affects how well a car performs in a number of ways. Performance (power), longevity, fuel economy, emissions, and evaporative emissions are all covered here. Performance may be affected differently by changing the oil composition depending on the vehicle. This will be influenced by exhaust control devices, fuel and control systems, and engine design. Ethanol is a clear, colorless liquid with an odor. Its latent heat of vaporization and oxygen content are related to how well it performs environmentally when used as an engline fuel for combustion, storage, and distribution.

Anhydrous ethanol and hydrated ethanol are the two processes used to produce ethanol. Hydrated ethanol, which is usually produced by fermenting and distilling biomass, is composed of 95% ethanol and the rest water. The Central Electricity Authority (CEA) predicts it will reach 122 GW. Despite a 15% increase from February 2022, this is still 30% less than the government's target of 175 GW by the end of 2022. It is flexible and aims to use 50%

non-fossil fuels in production. CEA is brought up. In February, 78.2 percent of the electricity generated came from thermal power plants that mostly burn coal.

Nuclear and hydropower, which are not considered renewable energy sources, account for 3% and 7% of total energy, respectively, while renewable energy only accounts for 12.3%, followed by wind (2.5%), biomass and bagasse (0.8%), and small hydropower (0.4%). In February, India's solar energy output increased by 31% over the same month the year before. Northern India now boasts the highest amount of solar energy in the country, with an annual increase of 50%. However, overall electricity production was lower than it was in February of previous year. The United States accounts for 70% of the country's green energy adoption from renewable energy sources. The three states with the slowest rates of renewable energy adoption are Manipur, Tripura, and Goa. According to a Mint study, 12% of India's total energy production is expected to come from renewable sources by February 2023. Fuels like ethanol are examples of renewable energy sources, and as India must import the majority of its fuel from abroad, it is looking for other fuel substitutes to help with its energy problems.

1.1. SI Engine Emission Comparison to Air Fuel Ratio

When there is enough air present for the fuel to burn entirely, the combination is said to be stoichiometric. The ratio that is affected by the molecular composition of the fuel is the stoichiometric air-fuel ratio. The stoichiometric air-fuel ratio for gasoline is 14.6:1. The ratio of the stoichiometric air-fuel ratio to the actual air-fuel ratio is known as the comparative or over-air coefficient. If Î´ is more than 1, the air mixture is said to be lean. The effects of the air-fuel ratio on CO, HC, NOx, and engine power in gasoline are depicted in Figure 1.1.

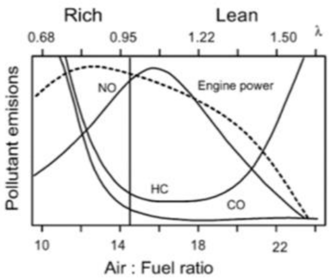

Figure 1.1 Variation of emissions and engine power with air-fuel ratio (Church et al. 1989)

The amount of CO generated increases significantly when the actual air-fuel ratio is lower than the stoichiometric value. During routine operation, such as cold starting, engine warm-up, and engine acceleration, the air-fuel combination is rich. One of the main causes of CO_2 emissions in this situation is engine operation. Increasing the combination above the crucial air-fuel ratio reduces the efficiency of the flame, which raises HC emissions. The rate at which HC emissions decrease is almost stoichiometry. Somewhat leaner blends have higher quantities of nitrogen oxides (NOx) due to the combination of higher combustion temperatures and oxygen availability. Even if the amount of oxygen increases, it decreases as the temperature drops and the mixture becomes worse. Because low mixture pressure leads to low cylinder pressure and, in turn, inadequate torque, the most powerful engines are built with minimum mixing. When you start reducing the temperature, you should look for both CO and HC emissions. Nitrogen oxides were taken into account in the current investigation to investigate the evolution of emissions, even though they were extremely low during the cold start-up of the S.I. Engine.

1.2. Engine Emission Norms in India

Table 1.1 SI Engine Emission Norms (ARAI)

SI Engine Emission Norms					
Grams Exhaust per km					
Stage	**Year**	**CO**	**HC**	**NOX**	**HC+NOX**
India Standard	1991	14.3 to 27.1	2.0 to 2.9		
India Standard	1996	8.68 to 12.74			3.0 to 2.18
India Standard	1998	4.34 to 6.20			1.5 to 2.18
India Standard	2000	2.78			0.97
BS II	2001	2.2 to 5.0			0.5 to 0.7
BS III	2005	2.3 to 5.22	0.2 to 0.9	0.15 to 2.1	
BS IV	2010	1 to 2.7	0.1 to .16	0.08 to .11	
BS VI	2021	1 to 2.7	0.1 to .16	0.06 to .082	

1.3. Gasoline-Ethanol Blends

Most of the energy utilized today comes from fossil fuels. As a result, other fuel sources are sought. Hydrogen, alcohol, vegetable oil and its esters, biogas, and gasoline are some of the most important fuels. Ethanol, one of the renewable energy sources made from biomass, is widely used in internal combustion engines. Here are a few advantages of ethanol:

- Ethanol works well with gasoline due to its high-octane number, high flammability temperature, and high evaporation number. Additionally, because of its low vapor pressure, ethanol can be stored and transported.

- Since the calorific value of ethanol is low, the fuel system requires more fuel.
- Since Ethanol have oxygen in its structure so it helps gasoline in combustion which finally good for environment

In order to look at approaches to replace carbon monoxide or specific market adjustments, the procedures must get or mix the gas, with a focus on studies evaluating the effects of ethanol. Previous studies aimed to determine the effects of various oil testing methods rather than using commercially recommended oil blends. The recommendations are based on a review of previous petroleum studies and literature, discussions with subject-matter experts, and consideration of the differences between industrial and other petroleum studies.

The project's objective is to determine how different percentages of ethanol blended with gasoline effect light automobiles and evaporative emissions, even though the method will be useful in investigating other fuels.

Because of differences in vehicle technology, driving time, and operation methods, previous study has produced a wide range of outcomes. The mileage difference is often only a small percentage of those lower numbers because modern automobiles create less pollution. In a multivariate study, research treatments included the Particulate Matter Index (PMI), ethanol concentration, aromatics content, and 50% and 90% distillation temperatures (T50 and T90). Although the findings of these studies are sparse or ambiguous, emissions from other fuel products are also affected.

There aren't many natural resources, and many studies require a lot of testing and fuel to be effective and resolve inconsistencies. Instead of looking directly at the composition of the oil market, these studies use interaction or additive models to evaluate the performance of assumed or measured oil products. Emissions compared to the same amount of gasoline. These studies do not represent a typical oil comparison on the current market. The only exception is the 15% ethanol blend (E15), which uses the same oxygenate blend (BOB) feedstock as E10. This hop mix reflects the present market. A careful review of the literature highlights how difficult it is to explain the effects of mixing ethanol with BOB.

Gasoline products are combined with favorable results as unexplained oil, even though the product does not always follow the coupling, coupling, and emissions production procedures. The distillate is still used to describe oil even if the amount of ethanol in it has changed. Because each car responds differently, it is difficult to draw conclusions. Depending on the vehicle's operating history, engine deposits, additional preliminary testing, and changes in engine speed and load, conclusions about the fuel composition may alter.

Finally, refinery heterogeneity is significant, and refinery mixes are influenced by economic factors. As gasoline's ethanol percentage increases, its aromatic concentration frequently decreases to maintain the same octane rating. BOB's actual composition often determines how ethanol affects it, and its composition can vary depending on the quality of production. Therefore, it is difficult to estimate the impact of global emissions using the available data.

Recommendations for future market fuel study practice represent a departure from prior practice:

To maximize the use of available resources, the consequences of changes in ethanol levels should only be evaluated for fuels with ethanol levels of interest. The hydrocarbon makeup of the market can also be flat. Each grade of ethanol should be represented by a fuel with an economically viable average hydrocarbon composition or a range of fuels with a hydrocarbon composition distribution that changes based on business needs.

In this way, measurements are not made to non-commercially available oil samples, and non-confounding effects can be immediately addressed by examining the oil. This approach focuses on a single goal rather than creating a general model of the effects of oil composition. It also provides results from in-depth examinations of various models.

It is better to measure oil composition than to use traditional methods to determine product qualities. The characteristics of the oil cannot be adequately described by a variety of attributes alone. The oil has a well-defined composition and might have the same qualities as several oils with different blends. Oil detailed hydrocarbon analysis (DHA) will be faster and more accurate if molecular kinds can be categorized into species, weights, or needs. Using mixers to mix and control oil products had little influence on the non-linear mixing effect on the study's findings.

Moreover, the process is not always subject to the same chemical, physical, or constant temporal laws as injection, combustion, catalysis, adsorption, and permeation processes in the real world. However, some fuel characteristics (such octane number) will continue to control fuel output at market pumps.

The equipment used in the investigation should not be viewed as a "black box"; rather, their control methods and power train technologies should be optimized. Explanations of how the engine power or power-to-weight ratio affects how the car reacts to gasoline at different speeds. Previous studies have validated important classifications, such as whether the engine is turbocharged or employs gasoline direct injection (GDI) or port fuel injection (PFI). The classification makes it easier to analyze differences between cars and how each vehicle's results relate to traffic. Data reporting and vehicle sensor monitoring are essential for testing and post-test emission impact analyses.

2. Literature Review :

Achim Kampker et al. (2019) studied low-cost production of large-scale parts in big area additive manufacturing (BAAM). They reviewed trends in material extrusion (ME) machine designs, from classic 3-axis structures to robotic systems with multidirectional kinematics, and evaluated existing designs through a case study, highlighting their strengths and weaknesses [1].

Andrej Basic et al. (2021) analyzed Fused Deposition Modeling (FDM), a widely used additive manufacturing (AM) technique capable of producing complex geometries with good properties. They developed mathematical models to predict ultimate tensile strength (UTS) and cost, analyzing the effects of process parameters like surface layers, fill spacing, and layer resolution [2].

Anish Raman et al. (2021) investigated the use of MTBE (Methyl tertiary butyl ether) as an oxygenated additive to improve IC engine efficiency and reduce incomplete combustion emissions. A four-cylinder, 1817 cc engine was tested using pure gasoline and MTBE-blended gasoline (M5, M10). MTBE blends showed increased BSFC and BTE, with reduced HC and CO emissions but higher CO_2 and NO_x emissions [3].

Balki Mustafa Kemal et al. (2014) examined the effects of ethanol and methanol on the performance, emissions, and combustion of a 2 kW single-cylinder engine. Tests at full-throttle and varying speeds showed that alcohol fuels increased torque, BSFC, thermal efficiency, and combustion efficiency. Cylinder gas pressure and heat release occurred earlier. CO_2 emissions rose, while HC, CO, and NOx emissions decreased compared to gasoline operation [4].

Bari, Saiful, and Idris Saad (2014) studied the use of guide vanes to enhance in-cylinder airflow in CI engines running on biodiesel, addressing lower performance and higher emissions compared to petro-diesel. Simulation optimized the number of guide vanes (3–12), with 4 vanes proving optimal for turbulence, velocity, vorticity, and swirling strength. Experiments confirmed that 4 vanes, with a 35° angle, a height of 0.2, and a length three times the intake runner radius, improved biodiesel combustion and performance [5].

Elfasakhany, Ashraf (2016) studied engine performance and emissions using neat gasoline and gasoline/n-butanol blends at speeds of 2600–3400 r/min without engine modifications. Results showed n-butanol blends slightly reduced torque, power, volumetric efficiency, exhaust temperature, and in-cylinder pressure due to a leaning effect. However, CO, CO_2, and UHC emissions significantly decreased, as n-butanol's extra oxygen improved combustion. Exhaust emissions were found to depend more on engine speed than n-butanol content. [12].

Elfasakhany, Ashraf (2014) investigated the effect of dual alcohol blends (n-butanol and iso-butanol) with gasoline on SI engine performance and emissions. Blends of 3%, 7%, and 10% alcohols were tested, alongside neat gasoline. Engine performance (brake power, torque, volumetric efficiency, cylinder pressure, exhaust temperature) and emissions (CO, UHC, CO_2) were measured at speeds of 2600–3400 r/min [13].

Elfasakhany, Ashraf (2015) examined the performance and emissions of a spark-ignition engine fueled with ethanol–methanol–gasoline blends. Test results from 3-10% ethanol–methanol blends were compared with ethanol–gasoline, methanol–gasoline, and pure gasoline. The study found that ethanol–methanol–gasoline blends significantly reduced CO and UHC emissions compared to gasoline, with methanol–gasoline blends showing the lowest emissions [14].

Irimescu et al. (2017) investigated the effect of n-butanol on combustion in a DISI engine using in-cylinder pressure and optical data. The study was conducted at 2000 rpm with partially open throttle conditions, close to stoichiometric air-fuel ratios. Optical diagnostics, including UV–visible imaging and natural emission spectroscopy, were used to analyze the combustion process from spark ignition to exhaust valve opening. Results showed that the use of n-butanol improved performance slightly compared to gasoline, with a significant reduction in NOx and soot emissions [20].

Ji, Changwei, and Shuofeng Wang (2013) studied the cold start characteristics of a hydrogen-fueled SI engine under rich combustion conditions, focusing on ignition timing (IT) control. They found that with an excess air ratio (λ) of 0.7, varying IT from 25 °CA BTDC to 10 °CA ATDC affected peak cylinder pressure and successful start time (SST), with the shortest SST and highest pressure at 15 °CA BTDC [21].

Larissa Cristina Sanchez et al. (2019) studied the impact of rheological properties on the 3D printing quality of poly(lactic acid) (PLA) and acrylonitrile-butadiene-styrene (ABS) using an additive manufacturing printer based on material extrusion [24].

Li J. et al. (2015) studied the use of gasoline/biodiesel blends in a reactivity-controlled compression ignition (RCCI) engine, which uses gasoline and biodiesel as low and high reactivity fuels, respectively. Numerical simulations using KIVA4–CHEMKIN were conducted to analyze the combustion process, focusing on the gasoline energy ratio and start of injection (SOI) timing [25].

Lianzhong Zhao et al. (2021) developed a strategy to enhance the formability of preceramic polymers for 3D structured ceramics through additive manufacturing. By adding a small amount of thermoplastic polymer (polypropylene, 5 wt.%) to preceramic polymers (e.g., polycarbazole), they improved the formability of the precursor while ensuring good compatibility for a homogeneous mixture [26].

Mack J. et al. (2016) studied the use of two butanol isomers (n-butanol and isobutanol) as fuels for Homogeneous Charge Compression Ignition (HCCI) engines, comparing them to ethanol and gasoline. The results showed that butanol required lower intake temperatures for a fixed combustion phasing, indicating higher reactivity. Both isomers exhibited single-stage ignition and similar combustion stability, with n-butanol slightly more stable, especially under lean conditions [27].

Raviteja S. and G.N. Kumar (2015) studied the performance of a 4-stroke, single-cylinder, EFI engine running on butanol blends (10%, 20%, 30%, and 100%) and hydrogen-enriched air (5% and 10%) [29].

Shane Terry et al. (2019) presented innovations in a new metal fabrication technique for Fused Filament Fabrication (FFF) in additive manufacturing. By using a PolyLactic Acid (PLA)-compliant metal powder composite filament, a part with about 90% metal composition is printed [30].

harudin Hazim et al. (2015) compared the fuel properties and engine performance of local gasoline (MU0) with two commercial fuel optimizers, MU1 (1/200 ratio of U1 additive) and MU2 (1/100 ratio of U2 additive), alongside a commercial enhanced gasoline (MU3). Performance tests were conducted in a single-cylinder, four-stroke spark ignition engine at engine speeds from 1200 to 2800 rpm with 100% throttle. Results showed that MU1 increased the octane number and viscosity by 3.49% and 16.92%, respectively, but reduced the heating value by 19.4%. MU2 increased heating value and viscosity by 1.68% and 22.31%. At 2800 rpm, MU2 and MU3 improved brake power by 4% and 16%, respectively, compared to MU0 [31].

Singh Suraj Bhan et al. (2015) discuss alternative fuels like biodiesel, alcohol, synthetic fuels, CNG, and HCNG in IC engines. The book covers fuel production methods, advanced combustion techniques, and explores hydrogen-fueled engines. It also addresses soot morphology in biodiesel and its toxicity [32].

Topgul, Tolga et al. (2015) studied the effects of oxygenated compounds like methyl tertiary butyl ether (MTBE) as additives in gasoline to improve fuel specifications. MTBE's high-octane number and oxygen content help reduce knocking and lower CO emissions. The study tested various MTBE blending rates (0, 5, 10, 20, and 30 vol.%) in a single-cylinder, four-stroke spark ignition engine. The results showed that engine torque remained similar to unleaded gasoline up to 10% MTBE content [34].

Wadea Ameen et al. (2019) explored the challenges associated with Fused Deposition Modelling (FDM), a widely used additive manufacturing process for producing prototypes and functional components. While FDM is efficient for building complex geometries, it faces challenges in printing overhang structures, which often require support structures to prevent failure. However, these support structures can lead to issues such as low printing efficiency, material wastage, longer build times, and post-processing needs [37].

Yusoff M.N.A.M. et al. (2015) discussed the significant role of machine learning (ML) in enhancing renewable energy systems by improving efficiency and production. ML is especially valuable in the renewable energy sector, where precise forecasts are crucial due to the intermittent nature of energy sources like solar, wind, and hydropower. It provides an overview of the most promising ML techniques for accurate energy forecasting and compares various performance metrics such as root mean square error and R-squared [38].

Zhang et al. (2015) investigated the combustion, performance, and emissions of a PFI SI engine fueled with methanol, ethanol, and butanol-gasoline blends. They found that alcohols advanced combustion phasing, reducing brake thermal efficiency (BTE) at gasoline's MBT, and requiring delayed spark timing [39].

Zhiyong Li et al. (2019) studied the impact of feed parameters on the blockage and quality of the color mixing nozzle in FDM 3D printers. They found that optimal feed parameters-triple torque extruder, 20 mm/s feed speed, and ABS material-improved printing quality by reducing vibration and blockages. Materials with a smaller flow behavior index caused less vibration during printing [40].

3. Research Methodology :

It is possible to ascertain the engine's performance characteristics through experimentation or by analyzing experimental data. Generally speaking, "efficiency" refers to how well an engine uses its power source or how effectively it produces power in comparison to other engines of a similar type. Engine's ideal operating temperature for maximum efficiency and reduced emissions. Ethanol and gasoline mixtures in various ratios (E0, E5, E10, E15, etc.) were made and tested on a computerized test bench equipped with a four-stroke, three-cylinder SI engine.

3.1. Gasoline-Ethanol

In the Bhopal area of Madhya Pradesh, crude ethanol is purchased locally from "Scientific system & Chemicals pvt. Ltd." as Extra Neutral Ethanol (ENA), which is composed of 95% ethanol and 5% water. A total of four fuel samples were examined. Four distinct combinations are made by mixing ethanol with unleaded gasoline; the ethanol level increases by 5%, from 10% to 15%. Before the experiment began, the fuel mixture was made to guarantee fuel mixing and avoid ethanol and water vapor interacting. The table below displays the distinctions between E0, E5, E10, and E15 fuels.

Table 3.1 Sample fuels

FUEL	% VOLUME
E0	0% ethanol 100% gasoline
E5	5% ethanol 95% gasoline
E10	10% ethanol 90% gasoline
E15	15% ethanol 85% gasoline
E20	20% ethanol 80% gasoline
E30	30% ethanol 70% gasoline

3.2. Properties of Ethanol and Gasoline

Since it is sustainable and would lessen reliance on fossil fuels, ethanol has drawn more attention than alternative fuels for gasoline (Szulczyk et al. 2010). According to Tangka et al. (2011), ethanol has several advantages over gasoline, including a lower molecular structure, a larger oxygen content, a higher latent heat of vaporization, a lower stoichiometric air-fuel ratio, a higher octane value, a faster flame, and a higher auto-ignition temperature. The table below lists the characteristics of pure gasoline and pure ethanol. To stop water vapor from building up in the gasoline tank, all combinations were ready before the experiment began.

3.3. Engine Heat Transfer and Cooling

Heat transfer processes are essential to the safety and effectiveness of internal combustion (I.C.) engines. The cylinder wall's temperature rises dramatically during combustion. By drawing heat from the cylinder wall and releasing it into the surrounding air, the coolant temperature in this situation is crucial in ensuring the engine runs within safe and ideal temperature ranges.

The automotive cooling system serves several crucial functions:

1. Dissipating excess heat from the engine to prevent overheating.
2. Facilitating proper combustion by maintaining optimal engine temperatures.
3. Ensuring mechanical operation and reliability by preventing components from reaching damaging heat levels.
4. Enhancing volumetric efficiency by regulating engine temperatures for optimal performance.
5. Sustaining a consistent engine temperature to support reliable operation under varying conditions.
6. Prolonging the lifespan of engine components by effectively managing heat and preventing excessive wear.

3.4. The Apparatuses and Procedures of Experiment

An investigation of the performance and emissions of a 4-stroke, single-cylinder gasoline engine running on ethanol blends mixed with gasoline was carried out. Brake-specific fuel consumption (BSFC), torque, power output, brake thermal efficiency (BTE), volumetric efficiency, and overall fuel consumption were among the metrics that were measured. Furthermore, CO, CO2, NOx, and HC exhaust emissions were tracked at various engine speeds and ethanol-gasoline blend ratios.

3.5. Experiment Set-Up

Without making any changes to the vehicles, this study assessed the impact of ethanol content on a subset of motorcycles. Because of this, the Hero CD100, an experimental carbureted motorbike, was selected for this investigation.

Because the heated air on the manifold wall evaporatively evaporates during the time that the air is drawn into the cylinder, the electric generator uses the energy of the air to transport the fuel to the air inlet, typically in the form of droplets. Heat addition, however, is typically restricted and has a direct impact on the fuel's evaporation quality. Ethanol has a lower calorific value than gasoline, as has been noted in numerous earlier investigations. Consequently, the vehicle test fuel needs to adapt the fuel supplied to the conditions using the fuel in order to use the ethanol-gasoline blend successfully.

It is extremely challenging for carburetor equipment to modify the gasoline to achieve the necessary power and fuel evaporation efficiency because of the fuel's evaporation characteristics, which might change based on the fuel's composition. It is advised that the oil's characteristics not significantly alter from those of the original oil. Consequently, the goal of this project is to produce gasoline that contains up to 30% ethanol.

Table 3.2 Test Engine Specification

Test Engine	
Max Speed	
Cooling Type	**Air Cooled**
Capacity	**97 cc**
Max. Power output	**7.5bhp@8000rpm**
Stroke	**49.5 mm**
Bore	**50 mm**
Injection Type	**Carburettor**

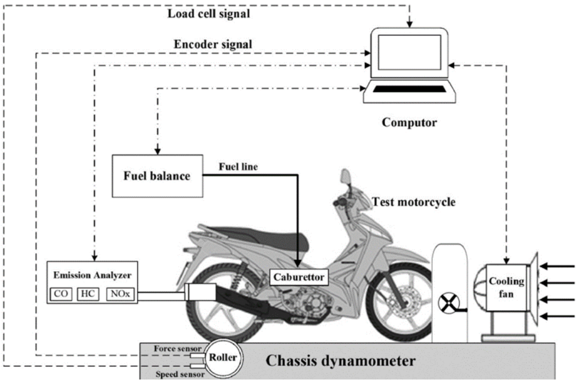

Figure 3.1 The schematic of the experimental system

Tachometer

The engine's crankshaft rotation speed is shown visually by tachometers or revolution counters mounted in automobiles, airplanes, and other vehicles. They frequently have marks that show a safe range of rotation rates, which helps drivers choose the right gear and throttle settings for the road conditions. Long-term high-speed running can cause a number of problems, including insufficient lubrication, overheating beyond the cooling system's capacity, or surpassing the speed capabilities of engine components, which may cause excessive wear or irreversible damage.

The phrase "redlining" refers to pushing an engine to its safe limit since analog tachometers usually display a red-colored area on the gauge to indicate speeds above the maximum safe operating range. A revolution limiter, an electrical device that limits engine speed to prevent damage, is found in the majority of contemporary automobiles. Vehicles and machines equipped with diesel engines that use conventional mechanical injector systems may not have redline indicators on their tachometers since these engines have an integrated governor that prevents over speeding.

Figure 3.2 Preparation of Blends using the magnetic stirrer

A common fixture in labs, the magnetic stirrer uses a revolving magnetic field to quickly move a submerged stirring bar through a liquid to create agitation. A spinning magnet or a set of fixed electromagnets placed underneath the liquid-containing vessel may be the source of this rotational force. Magnetic stirrers have the advantages of being quieter, more efficient, and having no exterior moving parts that can break or wear out (apart from the stirring bar magnet itself) when compared to motorized agitators driven by gears. These magnetic bars work especially well in glass containers that are commonly used for chemical reactions since they are unaffected by glass, guaranteeing reliable performance.

3.6. Experimental Procedure

First, 1L of gasoline and ethanol mixture should be mixed at different ethanol addition rates (10%, 20%, 30%, and 40%) and left for 30 minutes to ensure homogeneity and a steady state. We can only get this rank in this manner. When this mixture was moved to the tank, testing was scheduled to begin. The gasoline/ethanol mixture was put through four tests. The temperature of the primary air input is measured by a type K thermocouple, and the temperature of the exhaust air is measured by another thermocouple.

While the tachometer monitors the motor speed, the load cell device measures the motor torque. The PUC machine separates and analyzes the following exhaust gases: NOx, HC, CO, and CO2. Fuel consumption is determined by measuring the amount of time it takes for fuel to pass through the graded tube. The motor has a fixed ratio (8.5:1), variable speed (1500-2500 rpm), and a reading boost (250 rpm).

Dynamometer

The dynamometer's absorber (or absorber/driver) usually contains components for torque and rotational speed measurement. Vacuum machines have a certain type of rotor in their housing. Due to its attachment to the motor or other device under test, the rotor can spin at any speed required for the test. The rotor's braking power and the dynamometer housing's are increased by the equipment. Depending on the type of drive or suction, torque may be generated as electromagnetic, hydraulic, frictional, or in other ways. Few weapons are present. Free rotation is made possible by trunnions at either end supporting the housing with base-mounted trunnion bearings.

The torque arm is fastened to the dynamometer housing, and the weight indicator gauges the force generated as the dynamometer housing tries to rotate. Torque is the force expressed in units equal to the length of the torque arm as measured from the center of the dynamometer. An electrical signal equivalent to torque can be generated by converting a cell. The torque sensor provides an electrical signal proportional to the torque. In some cases, this method may be sufficient instead of using the file system, even though it is rarely used these days and is usually less accurate. Additionally, speed and torque indications can be recorded by a logger or plotter.

Typical components of an eddy current dynamometer include motors, housings, bearings, shafts, and bases. A working shaft holds the rotor in bearings in place. The housing in which the bearings rotate is supported by ball bearings that are part of the base plate of the apparatus. Inside the container, the field coils are connected one after the other. Since the cell provides DC power to the coils, the air differential between the rotor's two sides generates a magnetic field within the housing. The cooling air in the housing prevents the engine from overheating.

Water that enters the casing through the groove plates on either side of the rotor absorbs the heat produced. Because the outlet flange is attached at the base, hot water is expelled from the house. Eddy current dynamometers may measure the pressure per unit weight of the dynamometer. Because eddy current is easily created, the torque that the dynamometer measures is stable and constant regardless of the engine's operating conditions. The main advantages of using an eddy current dynamometer are increased torque variation at high speeds, activity, and smooth control.

The fundamental principle of the eddy current dynamometer is that the movement of the excitation current in the electromagnet controls the magnetic flux, while the rotor's rotation generates eddy current in the stator. Eddy current causes weight in the motor by preventing the rotor from moving. The electromagnet's current can be adjusted to alter the motor's weight. The key features of the eddy current dynamometer are its simple design, convenience of use, and ease of maintenance. High braking torque, exceptional accuracy, and outstanding efficiency define this system. A lower inertia period guarantees a rapid response to dynamic changes. Utilizing monitoring tools is essential for boosting output.

The operating principle of the eddy current dynamometer, including force measurement, speed monitoring, and brake action, is covered in great detail. The eddy current dynamometer's torque measurement direction is inverted, and the torque can be read by measuring the torque dynamometer in accordance with the concepts of equal torque and response torque. Because of the range of speeds and torques they provide, eddy current dynamometers are adaptable and suitable for engine research. Dynamometers are commonly used for this. A dynamometer can be used to measure the power of engines, electric motors, or hydraulic motors with any type of braking system.

Table 3.3 Eddy current dynamometer characteristics

Model	AG-10
Make	SAJ Test Plant Pvt.Ltd
End Flanges Bothe side	Carbon shaft Model 1260 type A
Water Inlet in bar	1.6
Maximum Pressure Kpa	160
Air Gap in mm	0.77/0.63
Torque in Nm	11.5
Hot Coll Voltage max	60
Continuous Current Empire	5
Cold Resistance in ahoms	9.8
Speed Max in rpm	10000
Load in Kgs	3.5
Bolt size	M12 x 1.75
Weight in kg	130
Arm Length in mm	185

Load cell

A load cell functions as a transducer, converting mechanical inputs like force into corresponding electrical impulses. This indirect conversion is divided into two phases. When force is applied, the mechanical structure first deforms a strain gauge. An electric wire strain gauge then electrically measures this deformation, altering the wire's overall electrical resistance. A load cell usually contains four strain gauges positioned in a Wheatstone bridge arrangement. An instrumentation amplifier is required to amplify the electrical signal output, which is normally a few millivolts, for practical use.

Algorithms are used to process the transducer's data and determine the applied force. Depending on their construction material and intended application-such as bending, voltage, compression, or alternation-the many types of load cells vary.

Force is converted into electrical signals that can be measured and described as torque, voltage, compression, or resistance via force transducers, sometimes referred to as load cells. The electrical signal output of the load cell varies in direct proportion to the amount of stress it encounters. Pneumatic and hydraulic load cells are also frequently utilized in industrial settings, despite strain gauge load cells' widespread use because to their precision, versatility, and cost.

These load cells' metal bodies, which are often made of stainless steel or aluminum alloy, offer strength and flexibility in addition to housing strain gauges. The "spring element," or elasticity, allows the load cell to slightly distort under stress and return to its original configuration when the load is released. The voltage variations that come from the ensuing changes in tension in the strain gauges serve as a representation of the applied force**.**

Make	Sensotronics
Model	60001
Type	S – Beam Universal
Capacity	0 – 50 kg
Mounting thread	M10 × 1.25 mm
Full scale output (mV/V)	3.00
Tolerance on output (FSO)	+/-0.25%
Zero balance (FSO)	+/-0.1mV/V
Non-linearity (FSO)	<+/-0.025%
Hysteresis (FSO)	<+/-0.020%
Non-repeatability	<+/-0.010%
Creep (FSO) in 30 min	<+/-0.020%
Operating temperature range	-20 ^{0}C to +70 ^{0}C
Rated excitation	10V AC/DC
Maximum excitation	15V AC/DC
Bridge resistance	350 Ohms (Nominal)
Insulation resistance	>1000 Meg ohm @ 50VDC
Span / ^{0}C (of load)	+/-0.001%
Zero / ^{0}C (of FSO)	+/-0.002%

Table 3.4 Load Cell Specifications

Non-linearity(FSO)	<+/-0.025%
Hysteresis (FSO)	<+/-0.020%
Non-repeatability	<+/-0.010%
Creep (FSO) in 30 Min	<+/-0.020%
Operating temperature range	-20 ^{o}C to +70 ^{o}C
Rated excitation	10V AC/DC
Maximum excitation	15V AC/DC
Bridge resistance	350 Ohms (Nominal)
Insulation resistance	>1000 Meg ohm @ 50VDC
Span/ ^{o}c(of load)	+/-0.001%
Zero/ ^{o}c(of FSO)	+/-0.002%
Combined error(FSO)	<+/-0.025%
Safe overload (FSO)	150%
Ultimate Overload (FSO)	300%
Protection class	IP 67
Overall dimensions	51 L x 20 w x 76 H mm
Weight	380 gm

The thin wire or foil used to make strain gauges is arranged in a grid. Changes in electrical resistance occur when the gauge deforms under stress. This deformation alters the shape of the wire and causes variations in resistance. Wheatstone bridge configurations commonly use sets of four strain gauges to boost sensitivity.

3.7. Dynamometer Loading Unit

To enable the dynamometer to determine the velocity of the direct flow, a dimmer stat regulates the loading unit, which operates on an ON/OFF basis. Current is drawn from the main power source to power the loading unit. In this experimental research engine, loading units such as Apex, AX-155, and Constant Speed Type are utilized. The trial used loading values ranging from 0 to 24 kg. It is easy to view and inspect the assembly because the loading device utilized in this inquiry is installed inside the engine panel box.

Software - Engine Soft

Apex Innovations Pvt. Ltd. developed Engine Soft, a lab software application that controls engine output. Among other engine testing requirements, it offers a comprehensive solution for tracking, data entering, data filing, and information recording.

This program evaluates engine strength, performance, fuel consumption, and heat release, and generates similar diagrams under different operating situations. During online engine testing in RUN mode, it scans, collects, and displays relevant signals for saved documents in graphical and tabular form.

Data can be exported from Engine Soft to Excel for further examination. It acts as a platform for online data collecting and engine performance monitoring, enabling configurable measurement results including pressure-crank angle charts and high-speed data collection. Experiments employ a variety of sensors to collect and store data, which is subsequently examined by a computerized data acquisition system (IC Engine soft). With a focus on Lab view, Engine Soft offers a customized software package for evaluating engine performance in real time. Analysis of Engine Performance.

3.8. Fuel System Modification Required

- Fuel Pump: Ethanol can be corrosive and may require a fuel pump that is compatible with ethanol or E85 and onwards (a common ethanol blend).
- Fuel Lines and Hoses: These should be made of materials that can handle ethanol's corrosive properties, as ethanol can degrade rubber and some plastics over time.
- Fuel Injectors: They may need to be replaced with ones designed for ethanol or higher ethanol blends, as ethanol has different lubrication properties compared to gasoline.
- Fuel Filter: Ethanol can loosen deposits in the fuel system, so a higher capacity or more efficient fuel filter might be needed to prevent clogging.
- Fuel Maps: Ethanol has a different energy content than gasoline, so the engine's fuel maps may need adjustment to compensate for the increased or decreased fuel volume needed.
- Ignition Timing: Ethanol has a higher-octane rating than gasoline, which may require adjustments to ignition timing for optimal performance.
- Air-Fuel Ratio: Ethanol typically requires a richer air-fuel mixture (more fuel relative to air) compared to gasoline, so the engine control unit (ECU) may need reprogramming to adjust the air-fuel ratio accordingly.

Engine Components

1. **Gaskets and Seals:** that gaskets and seals are ethanol-compatible to prevent leaks and degradation.
2. **Oxygen Sensors:** Ethanol can affect oxygen sensors, so they might need to be inspected or replaced if they become contaminated.

Cooling System

Ethanol burns cooler than gasoline, which can affect engine temperature.

Ethanol Blends Specifics

1. **E10 (10% Ethanol):** Most modern engines can handle E10 with no modifications.
2. **E80 (80% Ethanol):** This requires more significant modifications, including many of the changes listed above, and is generally used in flex-fuel vehicles designed specifically for it.

Carburetor

Jetting: Ethanol has a different energy content compared to gasoline, so it may need to adjust the carburetor's jets to accommodate a richer fuel mixture. This is particularly important for higher ethanol blends.

Ignition System

1. **Spark Plug:** Ethanol requires a different combustion temperature, so you may need to use a spark plug with a different heat range. Check the manufacturer's recommendations or consult with a mechanic.
2. **Ignition Timing:** Depending on the blend and its effects on combustion, you might need to adjust the ignition timing. Ethanol has a higher-octane rating, which can allow for more advanced timing.

Engine Tuning

Air-Fuel Ratio: Adjust the air-fuel mixture to ensure proper combustion. Ethanol requires a richer mixture than gasoline, so tuning the carburetor to handle this change is important for performance and fuel efficiency.

Cooling System

Temperature Monitoring: Ethanol burns cooler than gasoline, which could affect engine temperature. Ensure that the cooling system is functioning properly and monitor engine temperature to prevent overheating.

4. Results & Discussion :

The quest for more affordable and sustainable energy sources has led to a lot of interest in alternative fuels for internal combustion engines. Ethanol has become a viable option among these substitutes due to its renewable nature and its benefits in reducing greenhouse gas emissions. This study examines the effects of ethanol addition on the economy and efficiency of Spark Ignition (SI) engines, which are widely used in a range of applications, including cars and small machinery.

This findings section's primary objective is to present and analyze the data from experimental testing of SI engines operating on different gasoline and ethanol blends. In particular, the focus is on evaluating the engine's performance metrics, such as power output, fuel efficiency, and pollution levels, and doing a cost study to determine the financial impacts of using ethanol blends versus pure gasoline.

Performance indicators are assessed in this study using a variety of controlled engine tests. Understanding important features like engine power, torque, and thermal efficiency is necessary to comprehend how ethanol blending impacts engine performance. The results are compared across various ethanol-to-gasoline ratios in order to identify any significant changes or improvements in performance parameters. The sections that follow will present specific results from the experimental investigation. A detailed discussion of the financial ramifications and performance metrics will take place after the data is organized in accordance with the specific ethanol blend ratios that were tested. This will provide researchers studying alternative fuels and industry professionals with a thorough understanding of how ethanol blending affects SI engine performance and associated costs.

4.1. Brake Power

An analysis of brake power data for the SI engine operating with various ethanol blends shows that performance is much enhanced by higher ethanol concentration. As shown in Figure 4.1 and described in Table 4.1, the brake power progressively rises with the amount of ethanol in the mix. Specifically, when compared to pure gasoline, the E10 blend exhibits a modest gain in brake power. When a substantial increase in brake power is observed with the E20 blend, this trend becomes more apparent.

The E30 mix achieves the highest brake power and shows a discernible and consistent improvement over the E10 and E20 blends. This research suggests that a higher ethanol content has a positive impact on engine performance since ethanol has a higher-octane rating and increases combustion efficiency. These findings, which are displayed in tabular and graphical data formats, demonstrate the potential benefits of using ethanol blends to enhance engine performance.

Table 4.1 Brake Power

	BHP		
RPM	**E10**	**E20**	**E30**
1000	**2.07**	**2.17**	**2.28**
2000	**3.11**	**3.27**	**3.43**
3000	**4.82**	**5.06**	**5.31**

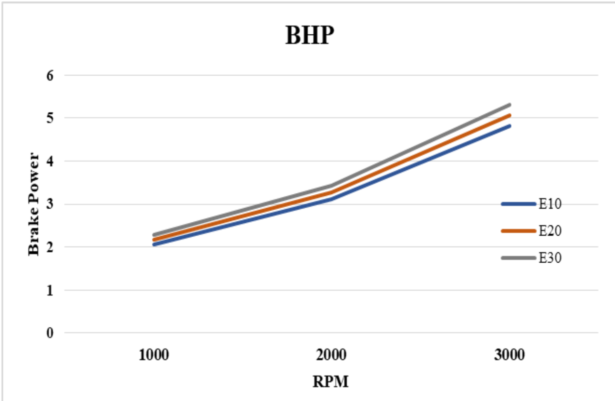

Figure 4.1 representation of brake power at various ethanol blend at various RPM

4.2. Thermal Efficiency

The E30 mix achieves the highest brake power and shows a discernible and consistent improvement over the E10 and E20 blends. This research suggests that a higher ethanol content has a positive impact on engine performance since ethanol has a higher-octane rating and increases combustion efficiency. These findings, which are displayed in tabular and graphical data formats, demonstrate the potential benefits of using ethanol blends to enhance engine performance.

This positive tendency continues with the E20 blend, where a more pronounced improvement is shown. Out of all the fuels that were studied, the E30 blend performs the best and increases thermal efficiency the most noticeably. This efficiency boost is most likely due to ethanol's higher octane rating and how it affects combustion dynamics. The advantages of using higher ethanol blends to achieve enhanced thermal efficiency in SI engines are highlighted by the graph and table's clear data illustrations.

Table 4.2 Thermal Efficiency

	Thermal Efficiency (%)		
RPM	E10	E20	E30
1000	20.7	21.7	22.8
2000	22.5	23.6	24.8
3000	31	32.5	33.1

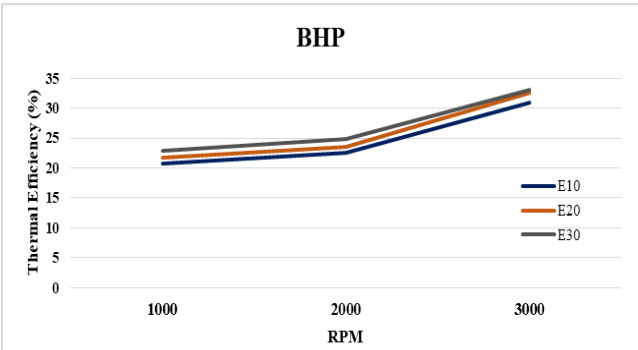

Figure 4.2 Thermal Efficiency at various ethanol blend at various RPM

4.3. Brake Specific fuel Consumption

Analyzing the Brake Specific Fuel Consumption (BSFC) of the SI engine operating on various ethanol mixes reveals an interesting trend. As shown in Figure 4.3 and described in Table 4.3, the BSFC decreases as the percentage of ethanol in the fuel blends increases. Specifically, the engine's BSFC is lower with the E10 blend than with pure gasoline, indicating improved fuel efficiency. This pattern is maintained with the E20 blend as the BSFC continues to decline, suggesting an even more efficient rate of fuel usage.

The engine uses the least amount of fuel per unit of power output while using the E30 blend, which leads to the most pronounced drop in BSFC. This decline in BSFC is caused by ethanol's increased energy content and its effect on combustion efficiency. The graphical and tabular figures show that higher ethanol blends improve fuel economy, highlighting their potential benefits in reducing fuel consumption in SI engines.

Table 4.3 BSFC

	BSFC		
RPM	E10	E20	E30
1000	0.42	0.38	0.35
2000	0.30	0.28	0.26
3000	0.27	0.26	0.25

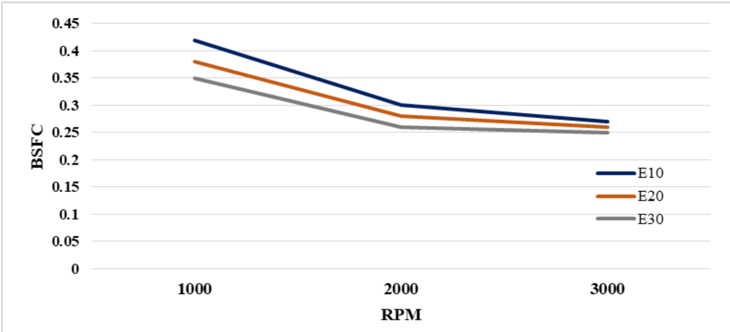

Figure 4.3 BSFC at various RPM

4.4. Cost Analysis

Beyond performance, the economic feasibility of using ethanol blends is assessed by looking at fuel consumption costs and overall operating expenses. This means calculating the cost per unit of power generated and comparing it to the cost of using solely gasoline. By examining these financial aspects, the study aims to provide light on the viability of ethanol as an affordable alternative fuel.

Table 4.4 Mileage

	Mileage (km/l)		
RPM	E10	E20	E30
3000	55.00	50.00	48.00

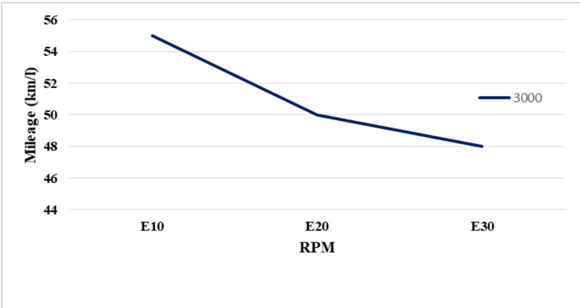

Figure 4.4 Comparison of mileage at various ethanol blends

Research on the mileage performance of the SI engine with various ethanol blends indicates a trend toward reduced fuel efficiency as the ethanol content increases. The distance traveled per unit of gasoline decreases as the mixes' ethanol percentage rises, as seen in Figure 4.4 and summarized in Table 4.4. Specifically, the E10 blend's mileage is slightly poorer than that of pure gasoline. This tendency becomes more apparent with the E20 blend as the engine's mileage keeps decreasing.

The engine achieves the shortest distance per unit of gasoline while using the E30 blend, which causes the most visible decrease in mileage. This decrease in mileage is caused by the fact that ethanol needs more fuel to provide the same amount of power than gasoline since it has a lower energy density. The data, which is clearly shown in the graph and discussed in the table, indicates that while ethanol blends may improve certain engine performance characteristics, they also decrease mileage, indicating a trade-off between fuel efficiency and other performance advantages.

5. Conclusion :

The cost-effectiveness and performance characteristics of a four-stroke, single-cylinder spark ignition (SI) engine powered by ethanol-gasoline blends at various volumetric ratios are investigated in this study. The primary objective was to assess how different ethanol-gasoline mixtures affected engine performance indicators.

The trials were designed to collect data on engine performance under practical operating conditions. By altering the load while keeping the engine speed constant, the study showed how ethanol-gasoline mixes impact engine performance.

This thesis examines in detail how gasoline and various ethanol blends affect the efficiency and economy of a Spark Ignition (SI) engine. Through a series of controlled testing at various rpms on a dynamometer, with engine temperature carefully maintained, this work has contributed significantly to our understanding of how different fuel compositions effect braking power (bp) and brake specific fuel consumption (BSFC). Furthermore, we have examined the cost-effectiveness of fuel that combines ethanol and gasoline.

Using a gasoline-ethanol mixture may alter the Honda CD 100 engine's performance in a number of ways. The degree to which these changes take place depends on the blend's ethanol percentage; blends with a higher ethanol content, like E80 (85% ethanol), will be more affected than E10 (10% ethanol). An outline of the possible impacts on performance measures is provided below.

Fuel Efficiency

Compared to gasoline, ethanol has less energy per unit volume. Therefore, while employing ethanol blends, we can see a drop in fuel economy (miles per gallon or kilometers per liter). The fuel efficiency drop with E10 could be negligible. The decrease may be more pronounced with higher ethanol blends, such as E80, necessitating more frequent refueling.

Power Output

Because ethanol has a greater octane rating than gasoline, it may be possible to ignite it more aggressively and produce more power. But this advantage can be outweighed by ethanol's decreased energy content. The power output change for E10 is often negligible. Unless the engine is specifically adjusted for such mixes, we may observe a minor decrease in power with greater ethanol blends because of the lower energy density of ethanol.

Engine Temperature

Compared to gasoline, ethanol burns cooler. Lower engine operating temperatures may result from this. Ethanol blends may cause the engine to run cooler, which could help with heat-related problems, but the cooling system may need to be modified to account for any changes.

Combustion Characteristics

Due to its higher octane rating, ethanol can withstand higher compression ratios and more sophisticated ignition timing without experiencing knocking. If the engine is adjusted to benefit from these characteristics, this can increase combustion efficiency. The effect on E10's combustion properties is often negligible. If the engine is set correctly, we might observe smoother operation and increased combustion efficiency with greater ethanol blends.

Throttle Response

Blends of ethanol can change the throttle response. The way the engine reacts to throttle input may be altered by the distinct combustion characteristics of ethanol. Changes in throttle response may be subtle with E10, but with higher ethanol blends, we might notice a different feel in throttle response and acceleration due to altered air-fuel mixtures

Engine Wear and Longevity

Over time, some engine parts may be impacted by ethanol's increased corrosiveness. Additionally, ethanol can absorb water, which might cause the fuel system to rust or corrode. If fuel system components are not ethanol-compatible, using ethanol blends could cause them to wear out more quickly. These effects can be lessened using ethanol-resistant parts and routine maintenance.

Idle Quality and Smoothness

Blends of ethanol may cause the engine to operate a little differently at idle. The air-fuel ratio and combustion properties can be changed by ethanol. Changes in idle quality for E10 are typically slight. If the engine is not correctly tuned, we may notice some roughness or vibration at idle while using higher blends.

REFERENCES :

1. Achim Kampker, Johannes Triebs, Sebastian Kawollek, Peter Ayvaz, Steffen Hohenstein, “Review on Machine Designs of Material Extrusion based Additive Manufacturing (AM) Systems Status-Quo and Potential Analysis for future AM systems,” Procedia, pp. 815-819, 2019.
2. Andrej Basic, Ivan Peko, Jure Krolo, Petra Bagavac, “Fuzzy logic modeling of ultimate tensile strength and cost in fused deposition modeling process of additive manufacturing,” international conference, Mechanical Technologies and Structural Materials, MTSM 2021.
3. Anish Raman, C., Varatharajan, K., Abinesh, P. & Venkatachalapathi, N. “Analysis of MTBE as an oxygenate additive to gasoline,” International Journal of Engineering Research and Applications, vol. 4, Issue 3, pp. 712-718, 2014.
4. Balki, Mustafa Kemal, Cenk Sayin, and Mustafa Canakci. “The effect of different alcohol fuels on the performance, emission and combustion characteristics of a gasoline engine,” pp. 901-906, 2014.
5. Bari, Saiful, and Idris Saad. “Effect of guide vane height on the performance and emissions of a compression ignition (CI) engine run with bio diesel through simulation and experiment,” Applied energy, vol. 136, pp. 431- 444, 2014.
6. Bari, Saiful, and Idris Saad. “Optimization of vane numbers through simulation and experiment, and investigation of the effect on the performance and emissions of a CI (compression ignition) engine run with biodiesel Energy,” vol. 79, pp. 248-263, 2015.
7. Bokhary, A.Y.F., et al. “Investigations on the utilization of ethanol-unleaded gasoline blends on SI engine performance and exhausts mission,” International Journal of Engineering &Technology, IJETIJENS, vol. 14, 2014.
8. Canakci, Mustafa, et al. "Impact of alcohol–gasoline fuel blends on the exhaust emission of an SI engine,” Renewable Energy, vol. 52, pp. 111-117, 2013.
9. Costagliola, M. A., et al. “Combustion efficiency and engine out emissions of a SI engine fueled with alcohol/gasoline blends,” Applied energy, vol. 111, pp. 1162-1171, 2013.
10. Deng, Banglin, et al. “The challenges and strategies of butanol application in conventional engines: the sensitivity study of ignition and valve timing,” Applied energy, vol. 108, pp. 248-260, 2013.
11. Dogan, Battal, Erol, D., Yaman, H., & Kodanli, “The effect of ethanol-gasoline blends nonperformance exhaust emissions of a spark ignition engine through exergy analysis,” Applied Thermal Engineering, vol. 120, pp. 433-443, 2017.
12. Elfasakhany, Ashraf. “Experimental study of dual n-butanol and iso-butanol additives on spark-ignition engine performance and emissions,” vol. 163, pp. 166-174, 2016.
13. Elfasakhany, Ashraf. “Experimental study on emissions and performance of an internal combustion engine fueled with gasoline and gasoline/n-butanol blends,” Energy conversion and management, vol. 88, pp. 277- 283, 2014.
14. Elfasakhany, Ashraf. “Investigations on the effects of ethanol methanol gasoline blends in a spark-ignition engine: performance and emissions analysis,” Engineering Science and Technology, an International Journal, vol. 18, Issue 4, pp. 713-719, 2015.

15. Erkus, Barış, M. Ihsan Karamangil, and AliSurmen. "Enhancing the heavy load performance of a gasoline engine converted for LP Guse by modifying the ignition timings," Applied thermal engineering, vol. 85, pp. 188-194, 2015.
16. Feng Renhua, et al. "Experimental study on SI engine fueled with butanol gasoline blend and H_2O addition," Energy Conversion and Management, vol. 74, pp. 192-200, 2013.
17. Gergo szemeti,Devarajan Ramanujan, "An Empirical Benchmark for Resource Use in Fused Deposition Modelling 3D Printing of Isovolumetric Mechanical Components," pp. 183 -191, 2022.
18. Gong, Jing, et al. "Emission characteristics of iso-propanol/gasoline blends in a spark-ignition engine combined with exhausts-circulation," Thermal science, vol. 18, Issue 1, pp. 269-277, 2014.
19. Gravalos, I., et al. "Emissions characteristics of sparking engine operating on lower–higher molecular mass alcohol blended gasolinefuels," Renewable Energy, vol. 50, pp. 27-32, 2013.
20. Irimescu, Adrian, Merola, S. S., Tornatore, C., & Valentino, G. "Effect of coolant temperature on air–fuel mixture formation and combustion in an optical direct injection spark ignition engine fueled with gasoline and butano," Journal of the Energy Institute, vol. 90, Issue 3 pp. 452-465, 2017.
21. Ji, Changwei, and Shuofeng Wang. "Combustion and emissions performance of a hydrogen engine at idle and lean conditions," International Journal of Energy Research, vol. 37, Issue 5, pp. 468-474, 2013.
22. Karsolia R.P. "Effect of Temperature on operating parameters of CI Engine with Diesel & Bio diesel blends. Ph.D. Thesis MANIT Bhopal," 2015.
23. Kumbhar, Shridhar, et al. "Environmental life cycle assessment of traditional bricks in western Maharashtra, India," Energy Procedia, vol. 54, pp. 260-269, 2014.
24. Larissa Cristina Sanchez, Cesar Augusto Gonçalves Beatrice, Cybele Lotti, Juliano Marini, Sílvia Helena Prado Bettini, Lidiane Cristina Costa, "Rheological approach for an additive manufacturing printer based on material extrusion," The International Journal of Advanced Manufacturing Technology, 2019.
25. Li, J. et al. "Effects of fuel ratio and injection timing on gasoline/biodiesel fueled RCCI engine: A modeling study," Applied Energy, vol. 155, pp. 59-67, 2015.
26. Lianzhong Zhao, Xiaofeng Wang, Huiwen Xiong, Kechao Zhou, Dou Zhang, "optimized preceramic polymer for 3D structured ceramics via fused deposition modeling," Journal of the European Ceramic Society, vol. 41, pp. 5066–5074, 2021.
27. Mack, J. Hunter, Schuler, D., Butt, R. H., & Dibble, R. W. "Experimental investigation of butanol isomer combustion inhomogeneous Charge Compression Ignition (HCCI) engines," Applied Energy, vol. 165 pp. 612-626, 2016.
28. Pal, Amit. "Blending of Ethanol in Gasoline: Impact on SI Engine Performance and Emissions," International Journal of Thermal Technologies, vol. 4, Issue 1, pp. 1-5, 2014.
29. Raviteja, S., and G.N. Kumar. "Effect of hydrogen addition on the performance and emission parameters of an SI engine fueled with butanol blends at stoichiometric conditions," International journal of hydrogen energy, vol. 40, Issue 30, pp. 9563-9569, 2015.
30. Shane Terry, Ismail Fidan,Khalid Tantaw, "Dimensional analysis of metal powder infused filament low-cost metal 3d printing," Solid Freeform Fabrication, Proceedings of the 30th Annual International, 2019.
31. Sharudin, Hazim, et al. "An overview of spark ignition engine operating on lower-higher molecular mass alcohol blended gasoline fuels," Journal Technology, vol. 76, 2015.
32. Singh, Suraj Bhan, Atul Dhar, and Avinash Kumar Agarwal. "Technical feasibility study of butanol gasoline blends for powering medium-duty transportation spark ignition engine," Renewable Energy, vol. 76, pp. 706 -716, 2015.
33. Soam, S., Kumar, R., Gupta, R. P., Sharma, P. K., Tuli, D. K., & Das, B "Life cycle assessment of fuel ethanol from sugarcane molasses in northern and western India and its impact on Indian biofuel programme," Energy, vol. 83, pp. 307-315, 2015.
34. Topgul, Tolga. "The effects of MTBE blends on engine performance and exhaust emissions in a spark ignition engine," Fuel Processing Technology, vol. 138, pp. 483-489, 2015.
35. Turkoz, Necati et al. "Experimental investigation of the effect of E85 on engine performance and emissions under various ignition timings," pp. 826-832, 2014.
36. Varol, Y, et al. "Comparison of methanol, ethanol, or-butanol blending with unleaded gasoline on exhaust emissions of an SI engine," Energy Sources, Part A: Recovery, Utilization and Environmental Effects, vol. 36, Issue 9, pp. 938-948, 2014.
37. Wadea Ameen, Syed Hammad Mian, Hisham Alkhalefah, "Design the support structures for fused deposition modeling 3D printing," Proceedings of the International Conference on Industrial Engineering and Operations Management Riyadh, Saudi Arabia, pp. 26-28, 2019.
38. Yusoff, M.N.A.M., et al. "Feasibility of bioethanol and bio butanol as transportation fuel in spark-ignition engine: a review," SC Advances, vol. 5, Issue 121, 2015.
39. Zhang, Jiaxiang, et al. "Comparative study of high-alcohol-content gasoline blends in an SI engine," SAE Technical Paper, 2015.
40. Zhiyong Li, Dawei Zhang, Liangchen Shao and Shanling Han, "Experimental investigation using vibration testing method to optimize feed parameters of color mixing nozzle for fused deposition modeling color 3 Dprinter," Advances in Mechanical Engineering, 2019, vol. 11, no. 12, pp. 1-12, 2019.