BI-Fuel Ice Concept using Petrol and Hydrogen

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Abstract- **In this project, we are delving into the realm of alternative fuel sources by exploring the integration of hydrogen obtained through electrolysis into traditional petrol engines. Our objective is to design and implement a system that blends hydrogen with petrol to create a hybrid fuel mixture for combustion engines. Through electrolysis, we will generate hydrogen gas from water, which will then be introduced into the engine's intake system alongside petrol. By studying the combustion characteristics and performance effects of this blended fuel mixture, we aim to assess its viability as a cleaner and more efficient alternative to pure petrol combustion. This project not only contributes to the pursuit of sustainable energy solutions but also offers insights into the potential for hydrogen as a supplementary fuel in conventional internal combustion engines, paving the way for greener transportation technologies.**

Keywords- **Alternative fuels, Butane, combustion characteristics, Carbon dioxide (CO_2), Carbon monoxide (CO), emissions, fuel efficiency, hydrogen, Hydrocarbon (HC), internal combustion engines, NOx emissions, oxyhydrogen (HHO), petrol, pre-ignition, Renewable hydrogen production, sustainability, Tailpipe emissions.**

I. INTRODUCTION

The researchers and engineers are exploring alternative fuels to promote sustainable and eco-friendly transportation, with hydrogen-petrol mixtures gaining significant interest. Hydrogen, known for its fast flame speed and clean combustion properties, can enhance engine efficiency and reduce CO2 emissions when blended with petrol. However, challenges like pre-ignition, knocking, and increased NOx emissions require precise engine calibration. This study examines the impact of hydrogen-petrol mixtures on combustion characteristics, emissions, and fuel efficiency while addressing practical challenges such as storage, distribution, and safety. The goal is to assess the viability of this dual-fuel approach for internal combustion engines and its potential for widespread adoption.

Hydrogen Petrol Blend in ICE- Fossil fuels like petrol and diesel have long been the primary source of power for internal combustion engines, or IC engines. However, scientists and engineers are looking into alternative fuels due to growing worries about greenhouse gas emissions, environmental degradation, and depletion of fossil fuel supplies. Using hydrogen in combination with regular petrol is one such potential idea.

Combining the advantages of both fuels while reducing the disadvantages of each one is the idea behind the idea of combining hydrogen and petrol. As a clean and sustainable energy source, hydrogen has the potential to drastically lower emissions. It can increase fuel economy, improve combustion efficiency, and contribute to a more environmentally friendly transportation system when combined with petrol. The project studies the science underlying hydrogen-petrol blends and their effects on emissions, engine performance, and real-world applications. We look at the benefits, drawbacks, and requirements of using this dual fuel strategy. We also look at the potential uses, practical applications, and experimental research of hydrogen-petrol mixes in internal combustion engines.

II. OBJECTIVES

Hydrogen presents a promising solution for achieving clean combustion, significantly reducing tailpipe emissions, improving air quality, and contributing to climate change mitigation. When combined with petrol, hydrogen can enhance overall fuel efficiency, promoting better fuel economy. It also diversifies energy sources, reducing reliance on fossil fuels and strengthening energy security. However, developing an efficient network for hydrogen distribution, storage, and generation is critical to its widespread adoption. Retrofitting existing internal combustion engines enables the use of hydrogen in current vehicles, facilitating the transition to cleaner fuels. Real-world testing and data collection are essential to evaluate the performance of hydrogen-powered vehicles and encourage industry acceptance. Additionally, using renewable energy for hydrogen production supports the growth of green hydrogen, making it more economically viable and environmentally sustainable.

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III. COMPONENTS USED

The comparative emissions experiment uses a 100cc single-cylinder, 4-stroke engine with optimized specifications, including a 9:1 compression ratio for petrol and 12:1 for hydrogen, air cooling, and dual-spark ignition to handle hydrogen's faster combustion. The petrol setup uses a carburetor and 5-liter tank, while the hydrogen system features a high-pressure tank, regulator, specialized injectors, and safety measures like flame arrestors and non-return valves.

Hydrogen Tank- The hydrogen tank stores hydrogen gas at high pressure, providing a consistent supply to the engine. Constructed from high-strength materials, it is designed to withstand extreme pressures and ensure safety during operation. Advanced insulation and safety valves prevent leaks and regulate gas flow to the piping system.

Figure 3.1: Hydrogen Tank

Hydrogen Piping- To offer controlled and efficient flow, piping is used for transferring hydrogen gas from the tank to various components of the engine system. To prevent leaks and deterioration, the pipes must be made of materials that are chemically compatible with hydrogen. Ensuring performance and safety at high pressure demands proper sealing and insulation.

Figure 3.2: Hydrogen Piping

Distributer Valve- The distributor valve regulates and directs the flow of hydrogen gas to the engine's intake system based on demand. It plays a key role in controlling pressure and maintaining an optimal air-fuel ratio for combustion. Designed with precision, the valve ensures safe and efficient operation by preventing backflow or leaks.

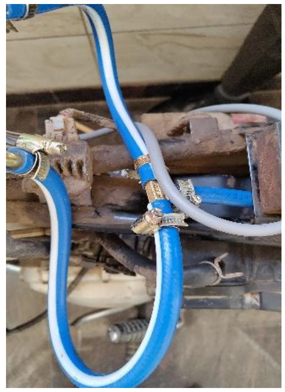


Figure 3.3: Distributer Valve

Carburetor- The carburetor is adapted in hydrogen engines to mix hydrogen gas with air in the correct ratio for efficient combustion. Unlike traditional carburetors for liquid fuels, it must be modified to handle gaseous fuel safely and prevent flashback. It ensures a consistent mixture, crucial for stable engine performance and emissions control.

Figure 3.4: Carburetor

IV. EXPERIMENT METHODOLOGY

Emissions are monitored using advanced gas analyzers capable of measuring CO_2, CO, HC, NO_x, and O_2, alongside a particulate matter (PM) sensor for fine particles and a humidity sensor for water vapor content in hydrogen combustion. The engine is mounted on a dynamometer with a load capacity suitable for engines up to 10 kW (approximately 13.4 HP). This dynamometer simulates real-world conditions like idling, acceleration, and steady cruising, while an integrated data acquisition system records parameters such as engine speed (RPM), torque, and power output in real-time. Environmental conditions are controlled, maintaining ambient temperatures between 20–25°C, atmospheric pressure at 1 atm, and humidity at 50–60%, ensuring consistency across tests. This configuration provides a robust setup for accurately comparing emissions from petrol and hydrogen-fueled engines under identical operating conditions.

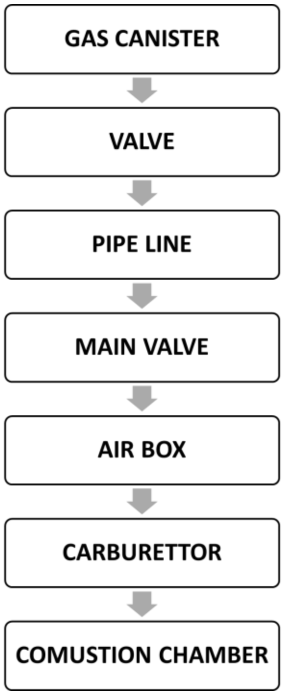


Figure 4.1: Methodology Flow Chart

V. FABRICATION

A robust housing unit was fabricated using high-quality sheet metal to securely accommodate the canisters containing the hydrogen and butane mixture. The design prioritizes structural integrity, ensuring durability and resistance to environmental factors such as heat and vibrations. The housing is ergonomically designed to provide adequate spacing for the canisters, allowing proper ventilation and minimizing the risk of overheating. To further enhance safety and functionality, a custom-fitted tank cover was fabricated and installed on top of the housing. This cover shields the canisters from external impacts, contaminants, and weather conditions, while also providing ease of access for regular maintenance, refilling, and inspections. The overall design ensures the system is both efficient and reliable for operation in various environments.

Figure 5.1: Canister Housing

VI. RESULT AND DISCUSSION

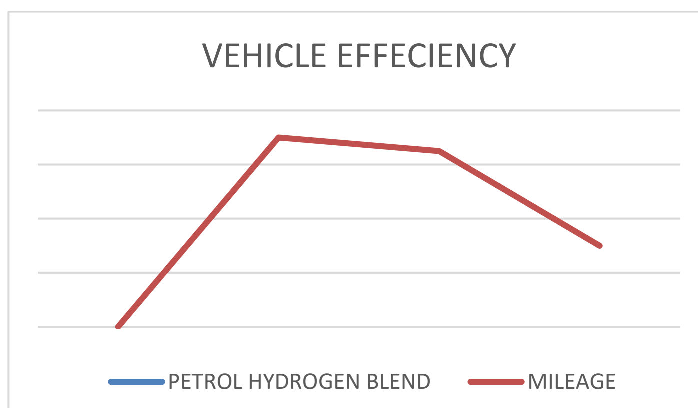
A comparison of emissions between a 100cc single-cylinder motorcycle engine running on petrol and one running on hydrogen reveals significant differences due to the distinct properties of the fuels. A petrol engine emits considerable amounts of carbon dioxide (CO_2), approximately 60–70 kg per 100 km, due to the carbon content in the fuel. It also produces moderate levels of carbon monoxide (CO) and unburned hydrocarbons (HC) from incomplete combustion. Nitrogen oxides (NO_x) emissions range between 1–3 g per 100 km due to high combustion temperatures and trace particulate matter (PM) is present due to impurities in the fuel. Conversely, a hydrogen engine emits no CO_2, CO, HC, or PM, as hydrogen is a carbon-free fuel. Its primary emission is water vapor (H_2O), approximately 15–20 g per 100 km. However, hydrogen combustion at high temperatures may lead to slightly higher NO_x emissions (2–4 g per 100 km) unless mitigated with advanced techniques like lean-burning or exhaust gas recirculation. This analysis highlights hydrogen's potential as an environmentally cleaner alternative, with near-zero harmful emissions except for manageable NO_x levels.

Tested results:

*With petrol :*100 ml of petrol equals engine runs 5 kilometers

With petrol and hydrogen: 100 ml petrol equals engine runs 4 kilometers.

Petrol used	Hydrogen blend	Efficiency
1 Liter	0%	50
1 Liter	5%	45
1 Liter	10%	40
1 Liter	15%	35
1 Liter	20%	25



Note- To enhance safety in the hydrogen-powered internal combustion engine project, 25% butane has been added to the hydrogen fuel (HHO). This addition leverages butane's distinctive odor, which aids in the early detection of any potential leaks, ensuring safer handling and operation of the system.5.1 Comparative Analysis of Emissions: 100cc Single-Cylinder Petrol vs. Hydrogen Engine.

Reason of failure- The experiment revealed that HHO, being an unstable element, causes significant fluctuations in the

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stoichiometric air-fuel ratio. As a result, the engine was unable to maintain an adequate air-fuel mixture for proper operation. Additionally, it was observed that HHO engines are not suitable for low-compression engines such as petrol engines. Further studies suggest that HHO engines perform more effectively in high-compression engine configurations. The global emphasis on reducing greenhouse gas emissions and combating air pollution has propelled the exploration of alternative fuels, including hydrogen, for internal combustion engines (ICEs). To understand the environmental implications of using hydrogen as a fuel, this analysis compares the emissions of a 100cc single-cylinder motorcycle engine operating on petrol with the same engine running on hydrogen. Although both engines use similar combustion principles, the chemical composition and combustion characteristics of the fuels result in markedly different emissions profiles.

Emissions from a petrol engine- Petrol, a hydrocarbon fuel, powers internal combustion engines due to its high energy density and ease of use but contributes to pollution and climate change. Key emissions include carbon dioxide (CO_2), a major greenhouse gas, at 60–70 kg per 100 km for a 100cc engine, directly contributing to global warming. Incomplete combustion produces carbon monoxide (CO), averaging 5–10 g per 100 km, a toxic gas reducing blood oxygen levels. Unburned hydrocarbons (HC) at 2–5 g per 100 km lead to smog and ozone formation. Nitrogen oxides (NO_x), formed at high temperatures, contribute to acid rain and respiratory issues, emitting 1–3 g per 100 km. Particulate matter (PM) emissions are minimal but can still impact health, particularly in urban areas.

Emissions from a Hydrogen (HHO) Engine- Hydrogen is among the cleanest fuels for internal combustion engines due to its carbon-free composition and simple molecular structure. Its combustion eliminates CO_2, CO, and unburned hydrocarbons (HC), making it a highly sustainable and environmentally friendly option. A 100cc hydrogen engine produces zero CO_2, CO, or HC emissions per 100 km, significantly reducing pollutants. While nitrogen oxides (NO_x) may form at high combustion temperatures, emissions are limited to 2–4 g per 100 km and can be minimized with advanced technologies like lean burn, water injection, or exhaust gas recirculation. Unlike hydrocarbon fuels, hydrogen combustion generates no particulate matter, reducing air pollution and associated health risks. The primary byproduct is water vapor (15–20 g per 100 km), which has minimal climate impact due to its rapid natural atmospheric cycling. Hydrogen offers a cleaner, more sustainable alternative to traditional fuels, aiding in the fight against climate change and air pollution.

Speed Analysis- When traveling at a steady speed of 30 km/h, the vehicle demonstrates a remarkable fuel efficiency of 60 km/l using pure petrol. However, this efficiency declines to 50 km/l when operating on a blended fuel comprising 90% petrol and 10% hydrogen. At a slightly higher speed of 40 km/h, the mileage drops for both fuel types, with pure petrol achieving 50 km/l and the blended fuel providing 40 km/l. As the speed increases to 50 km/h, the mileage experiences a sharper decline, with pure petrol yielding 42 km/l and the blend delivering only 34 km/l. At 60 km/h, the vehicle's fuel efficiency reaches its lowest recorded values, offering 35 km/l with pure petrol and 28 km/l with the blended fuel.

Load Impact- When the vehicle operates without any additional load, the mileage stands at 50 km/l for pure petrol and 40 km/l for the petrol-hydrogen blend. As a 50 kg load is introduced, a slight reduction in efficiency occurs, with pure petrol dropping to 48 km/l and the blend to 38 km/l. Adding more weight amplifies the reduction; at 100 kg, the vehicle achieves 45 km/l with pure petrol and 35 km/l with the blend. With a substantial load of 150 kg, the fuel efficiency diminishes significantly, offering only 40 km/l for pure petrol and 30 km/l for the blend.

This data highlights a clear trend where both speed and load substantially impact fuel efficiency. The drop in mileage with the blended fuel compared to pure petrol suggests that the hydrogen addition might reduce combustion efficiency or require engine modifications for optimal performance. Furthermore, increasing speed and load exacerbate this disparity, underlining the importance of optimizing vehicle design and fuel composition to balance performance and efficiency.

Table 6.1: Emission Data

Emission Type	Petrol Engine (100cc)	Hydrogen Engine (100cc)
Carbon Dioxide (CO_2)	60–70 kg per 100 km	3 kg per 100 km
Carbon Monoxide (CO)	5–10 g per 100 km	1 g per 100 km
Unburned Hydrocarbons (HC)	2–5 g per 100 km	0.3 g per 100 km
Nitrogen Oxides (NO_x)	1–3 g per 100 km	2–4 g per 100 km
Particulate Matter (PM)	Trace amounts	0 g per 100 km
15–20 g per 100 km	15–20 g per 100 km	15–20 g per 100 km

VII. KEY OBSERVATIONS AND IMPLICATIONS

The most notable advantage of hydrogen is the elimination of carbon-based emissions, including CO_2, CO, and HC. This makes hydrogen a powerful tool for addressing climate change and improving air quality. While hydrogen combustion reduces most pollutants, the potential for higher NO_x emissions remains a challenge. However, employing advanced combustion strategies can effectively mitigate these emissions, making hydrogen engines viable for widespread use. Hydrogen combustion eliminates particulate matter, offering significant health and environmental benefits, particularly in urban areas where air quality is a concern. Hydrogen combustion produces slightly higher water vapor emissions than petrol engines. However, this is a byproduct and poses no significant environmental harm.

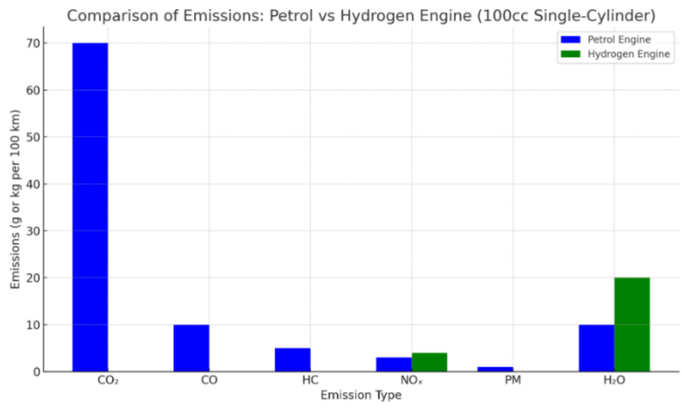

Figure 7.1: Emission Data Graph

The graph provides a comparative analysis of emissions from a 100cc single-cylinder motorcycle engine running on petrol and hydrogen. Carbon dioxide (CO_2) emissions are significantly high for the petrol engine, around 70 kg per 100 km, while the hydrogen engine emits none, as it is a carbon-free fuel. Carbon monoxide (CO) and unburned hydrocarbons (HC) are present in trace amounts for the petrol engine but are completely absent in the hydrogen engine due to the absence of carbon in the fuel. Nitrogen oxides (NO_x), resulting from high combustion temperatures, are slightly higher in the hydrogen engine (around 4 g per 100 km) compared to the petrol engine (3 g per 100 km). However, advanced NO_x mitigation technologies can reduce these emissions. Particulate matter (PM) is negligible for both, although hydrogen completely eliminates it. The hydrogen engine also produces more water vapor (H_2O), around 20 g per 100 km, as a byproduct of combustion, highlighting its clean-burning characteristics. This comparison underscores hydrogen's environmental benefits, provided NO_x emissions are effectively managed.

VIII. SCOPE OF FUTURE WORK

Hybrid vehicle- Since hydrogen is a waste product and can be found in water, it appears to be a viable alternative for use as a fuel in automobiles in the future, when fossil fuels are no longer the only main source needed to run them.

Challenges- Using a BS 6 engine with hydrogen fuel injectors is a wonderful viable alternative for future purposes as it appears to be inefficient to put the hydrogen cylinders and lines into a carburated engine. Additionally, improved spark ignition and fuel injector management are provided by the electronic control unit (ECU) found in current engines.

Hydrogen in internal combustion engines- There is possibility of running hydrogen and petrol combination by adapting current internal combustion engines.

Infrastructure- The existing petrol infrastructure is well-established globally. There are challenges for hydrogen gas as fuel where infrastructure is lacking.

IX. CONCLUSION

An important step toward greener and more sustainable automobile solutions is the use of a 100cc single-cylinder engine running on hydrogen. This experiment demonstrates how hydrogen has the ability to significantly cut emissions while just creating water vapor as a result and removing dangerous contaminants such as unburned hydrocarbons, CO_2, and CO. The technology guarantees safety, effectiveness, and performance on par with conventional gasoline engines thanks to the careful design of parts including the hydrogen tank, distributor valve, piping, and an adaptable carburetor. Although there are still issues with infrastructure, engine changes, and hydrogen storage, the experiment shows that hydrogen can be a competitive fuel substitute with the right engineering and design. This study emphasizes how hydrogen contributes to the development of environmentally friendly technologies and paves the way for its broader application in small engines and beyond, contributing to a cleaner and greener future.

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