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Design and Modify Automatic Fuel (LPG + Petrol) Shifting System in Bike

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Abstract: *Dual-fuel systems are being investigated, especially for motorbikes, as a result of the rising need for environmentally friendly and efficient transportation. The design and development of an automatic fuel-shifting system for a dual-fuel (LPG + Petrol) bike is the main goal of this project. By smoothly transitioning between gasoline and LPG depending on engine conditions and fuel availability, the system seeks to maximize fuel consumption, lower emissions, and improve user convenience. To track engine performance and environmental factors in real time, the suggested system incorporates a number of sensors, such as those for engine load, temperature, speed, RPM, and fuel level. These inputs are processed by an Electronic Control Unit (ECU), which regulates solenoid valves to control the flow of LPG and gasoline. In order to guarantee enough combustion during cold weather, the system is made to start the engine with gasoline.*

Keywords: Dual Fuel System, LPG – Petrol Hybrid, Automatic Fuel Shifting, Emission Reduction, Fuel Efficiency Optimization, Sustainable Mobility, Global Warming

I. INTRODUCTION

With growing concerns about the environment and rising fuel prices, the automotive industry is looking for alternative energy sources and hybrid technologies. One promising solution is the **dual-fuel system** that uses both **Liquefied Petroleum Gas (LPG) and petrol**. This setup offers several benefits, such as **better fuel efficiency, lower emissions, and reduced running costs**. Since LPG burns cleaner than petrol, it is considered an eco-friendlier option for motorcycles. However, **manually switching between fuels can be inconvenient** and may not always provide the best engine performance.

This project focuses on designing and modifying an **automatic fuel-shifting system** for motorcycles with a **dual-fuel setup**. The system is designed to **automatically switch between petrol and LPG** based on real-time engine conditions. It uses an **Electronic Control Unit (ECU)** to monitor data from sensors that track **engine load, temperature, RPM, speed, and fuel levels**. To ensure smooth operation, the system **starts the engine with petrol during cold weather** and shifts to LPG once the engine reaches its optimal temperature.

This automatic system **enhances rider convenience, optimizes fuel consumption, and reduces emissions**. It is particularly useful in cities where emission regulations are becoming stricter, and people are looking for **cost-effective and environmentally friendly** mobility solutions. By integrating **mechanical, electrical, and software components**, this technology moves motorcycles toward a **more sustainable future**.

Currently, motorcycles are known for their **low maintenance and running costs**, and most use **petrol or diesel**, which comes from crude oil. However, crude oil reserves are **depleting**, leading to rising fuel prices. As vehicle numbers continue to grow, **petroleum consumption is increasing rapidly**, and the limited supply of fossil fuels may not be enough to meet future energy demands. Additionally, burning these fuels releases harmful emissions, contributing to the **greenhouse effect and air pollution**.

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Petrol and diesel engines emit pollutants like **carbon monoxide (CO) and hydrocarbons (HC)**, which negatively impact the environment. To address these issues, researchers are exploring **alternative fuels**, such as:

Synthetic fuels

Alcohol-based fuels

Gaseous fuels (like LPG, CNG, and hydrogen)

Among these options, **gaseous fuels are the most efficient for automobiles** because they offer **a higher-octane number, lower emissions, better combustion efficiency, and lower costs** compared to petrol and diesel. This makes LPG an ideal choice for **reducing pollution and improving fuel efficiency** in motorcycles.

II. LITERATURE SURVEY

As concerns about fuel shortages and pollution grow, researchers are looking for cleaner alternatives to petrol. LPG (Liquefied Petroleum Gas) has gained attention because it burns more cleanly and is cost-effective. This review summarizes studies on dual-fuel bikes that use both LPG and petrol, focusing on how they work, their performance, and their environmental impact.

In [1], Sudarshan et al. (2021) studied how petrol bikes can be modified to run on LPG. Their research showed that LPG-powered bikes produce less pollution, especially lower carbon monoxide (CO) and hydrocarbons (HC), while still maintaining good engine performance.

In [2], Barai Santosh (2015) looked into how LPG can be added to bikes. He discussed the need for special fuel injectors and carburetor adjustments to ensure smooth fuel mixing. He also pointed out that LPG can save money by increasing mileage and lowering fuel costs.

In [3], Dr. Sureshkumar K (2017) analyzed how LPG affects bike engines. He found that using LPG improves fuel efficiency and cuts down harmful emissions, making it a more sustainable choice.

In [4], Hemant Singh (2015) tested the emissions of LPG-powered bikes. His study confirmed that CO and HC emissions dropped significantly with LPG. However, there was a slight decrease in engine power, which could be improved with better fuel system tuning.

In [5], Syed Yousufuddin and Syed Nawazish Mehdi (2008) investigated the performance and emissions of a variable compression ratio SI engine running on LPG. Their study in the *Turkish Journal of Engineering and Environmental Sciences* found that varying the compression ratio significantly impacts engine efficiency and emissions. Higher compression ratios improved thermal efficiency but required careful optimization to prevent knocking. The research confirmed that LPG reduces CO and HC emissions compared to petrol, making it an eco-friendly alternative.

In [6], K.F. Mustafa and H.W. Gitano-Briggs (2004) examined the feasibility of LPG as an alternative fuel for spark ignition engines. Their study highlighted the benefits of LPG, including better combustion efficiency and lower emissions. They found that LPG engines exhibited reduced CO and HC emissions, making them more environmentally friendly. However, they also pointed out the need for adjustments in ignition timing and air-fuel ratio to optimize performance.

In [7], Hardik P (2016) explained the basics of dual-fuel engine operation. His research covered important aspects like ignition timing, air-fuel ratio control, and engine pressure changes when switching between fuels.

In [8], Ashish S. and Prof. M. J. Deshmukh (2012) explored blending LPG with ethanol to improve fuel efficiency and cut emissions even further. They suggested more research on mixing LPG with other fuels to enhance engine performance and durability.

In [9], Thirumal Mamidi and Dr. J.G. Suryawnshi (2012) studied how LPG performs in engines under different driving conditions. They found that LPG improves fuel economy and reduces emissions compared to petrol.

In [10], Chandan Kumar (2017) focused on LPG's properties, such as its chemical makeup and energy content, which influence how well it burns and how much pollution it produces. He also suggested modifications to improve engine performance.

In [11], M.A. Kalam and H.H. Masjuki (2011) investigated the effects of LPG as an alternative fuel in SI engines. Their study found that LPG combustion resulted in lower carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide

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(NOx) emissions compared to petrol. They also noted that LPG's high-octane rating allows for higher compression ratios, improving engine efficiency while reducing knocking risks.

In [12], J. Karthik and R. Mahalingam (2016) examined the energy efficiency of LPG-fueled two-wheeler engines. Their research indicated that LPG offers a cost-effective and eco-friendly solution for motorcycles, with improved mileage and reduced exhaust emissions. However, they pointed out that LPG storage and handling require additional safety measures.

In [13], S. Senthilkumar and A. Karthikeyan (2015) investigated the role of LPG in reducing engine knocking in SI engines. Their study found that LPG's high-octane number makes it a suitable alternative to petrol, reducing knocking tendencies and improving combustion stability. They also highlighted the need for spark plug adjustments to ensure complete combustion

In [14], H.S. Yadav and R.K. Maurya (2014) studied the effects of LPG on the wear and tear of engine components. Their findings suggested that LPG combustion leads to less carbon deposit formation, thereby reducing engine wear and increasing the lifespan of critical components. They also noted that proper lubrication is essential when using LPG to prevent dry combustion effects.

In [15], T.V. Mallikarjuna, K. Srinivasa Rao, and N. Rajagopal (2011) analyzed the combustion and performance characteristics of LPG-fueled SI engines. Their research found that LPG provides a more uniform air-fuel mixture, leading to better combustion efficiency and lower emissions. However, they emphasized the need for optimized fuel injectors to prevent lean mixture issues.

In [16], K.A. Subramanian (2013) explored the impact of using LPG in two-wheeler engines. His study showed that LPG-powered bikes exhibited higher brake thermal efficiency and lower emissions compared to petrol. He also recommended engine calibration adjustments to optimize fuel injection and improve power output.

III. PROPERTIES OF LPG AND PETROL

Properties	Gasoline	LPG
Chemical structure	C8H18+O2	C3+H6+O2
Density	780 (kg/m3)	570(kg/m3)
Octane number	82	110
Lower heating value (MJ/litre)	12.2	21.2
Higher heating value (MJ/litre)	20.2	25.5
Air fuel ratio	14:1	15.77:1
Calorific value	46.1	43.5

Table 3.1

IV. MATERIAL REQUIRED TO CONVERT LPG POWERED BIKE

Sr. No	Material
1	Bike
2	Regulator
3	Solenoid Valve
4	Gasifier
5	Switch
6	Tank
7	Nipple
8	Hoses Pipes
9	Gas Safety Device

Table 4.1

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Bike
Model Name: TVS Starcity 2006
Engine:
- Engine Type: Single-cylinder, 4-stroke, air-cooled
- Displacement: 109.7 cc
- Max Power: 8.2 bhp @ 7,500 rpm
- Max Torque: 8.1 Nm @ 5,000 rpm
- Fuel System: Carburetor
- Ignition Type: CDI (Capacitor Discharge Ignition)

Transmission:
- Gearbox: 4-speed manual
- Clutch: Multi Plate

Dimensions:
- Length: 1,980 mm
- Width: 725 mm
- Height: 1,080 mm
- Wheelbase: 1,265 mm

Fuel System:
- Fuel Capacity: 16 liters (including 2.5-liter reserve)

Fig. Bike

LPG Tank –
Capacity - 4Litre
Material – Carbon Steel
Manufacturer – Maharashtra Natural Gas Ltd
- **Fuel Storage:** It securely holds liquefied petroleum gas (LPG) under pressure, ensuring a reliable fuel supply for the engine.
- **Fuel Delivery:** The tank is connected to the bike's fuel system, allowing LPG to be delivered to the engine as needed for combustion.
- **Weight Distribution:** The placement of the LPG tank can help balance the weight of the bike, which can affect handling and stability.
- **Safety Features:** LPG tanks are designed with safety measures, such as pressure relief valves, to prevent overpressure and leaks.
- **Conversion Capability:** In dual-fuel systems, the tank enables the bike to switch between LPG and petrol, allowing for flexibility in fuel choice based on availability and cost.

Fig. Tank

LPG Regulator –

The primary function of this component is to regulate the pressure of the LPG gas from the storage tank and convert it into a form that the engine can use for combustion.

Key Functions:

- Pressure Regulation: It reduces the high-pressure LPG gas stored in the tank to a lower, more stable pressure that is suitable for the engine's fuel system.
- Automatic Choke: The device has an "Auto Choke" feature, which automatically controls the amount of fuel-air mixture required during cold starts, ensuring smoother ignition.
- Fuel Conversion: It plays a critical role in switching between LPG and petrol modes in dual-fuel systems, ensuring that the engine receives the correct type of fuel.

Fig. LPG Regulator

Solenoid Valve –

A solenoid valve is a key component in LPG-powered vehicles, including the dual-fuel (LPG + Petrol) systems. It is an electromechanical device used to control the flow of LPG within the system. In the case of the LPG reducer/regulator shown in the image, the solenoid valve is typically integrated to manage LPG flow efficiently and safely.

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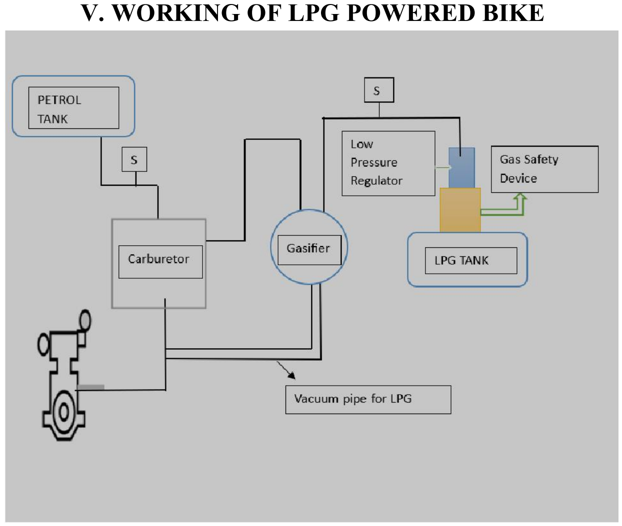
Fig. Solenoid Valve

Switch

To switch fuel LPG to petrol or vice versa button operated switch is used in this system which is connecting to ignition switch (main wire) and to both solenoid valve. It operated with the help of battery.

Fig. Switch

V. WORKING OF LPG POWERED BIKE



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Working Modes

1. Only Petrol Mode

Process:

The rider selects "Petrol Mode" via a switch.

The Arduino activates the **petrol solenoid**, allowing petrol to flow to the carburetor.

The **LPG solenoid valve is deactivated**, stopping LPG supply.

The **air filler solenoid opens**, enabling air to mix with petrol in the carburetor (as petrol combustion requires air).

Result: The bike runs entirely on petrol, with LPG flow and air filler for LPG closed.

2. Only LPG Mode

Process:

The rider selects "LPG Mode" via a switch.

The Arduino activates the **LPG solenoid**, allowing LPG to flow to the carburetor.

The **petrol solenoid is deactivated**, stopping petrol flow.

The **air filler solenoid closes**, as LPG does not require additional air for combustion.

Result: The bike runs entirely on LPG, with petrol flow and air filler for petrol combustion closed.

3. Hybrid Mode (Auto Shifting)

Process:

The Arduino automatically controls solenoid valves based on bike speed or power requirement.

At speeds **below 40 km/h**:

Petrol solenoid is activated, and the bike uses petrol.

Air filler opens for petrol combustion.

At speeds **above 40 km/h**:

LPG solenoid is activated, and the bike switches to LPG.

Air filler closes to match LPG combustion requirements. Switching happens seamlessly without manual intervention.

Switching happens seamlessly without manual intervention.

Result: The system optimizes fuel usage, using petrol for low-speed and LPG for high-speed performance.

VI. SIMULATION AND ANALYSIS

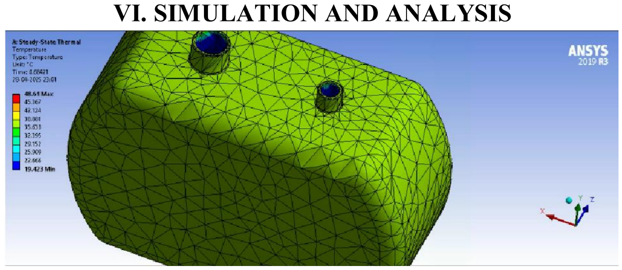

Fig. Simulation of LPG Tank

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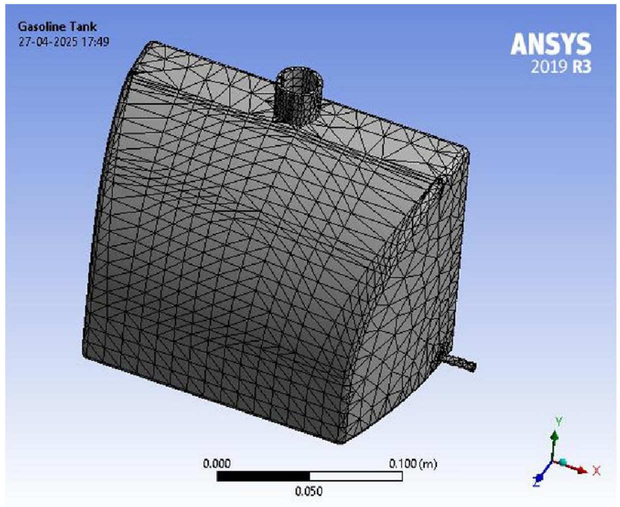
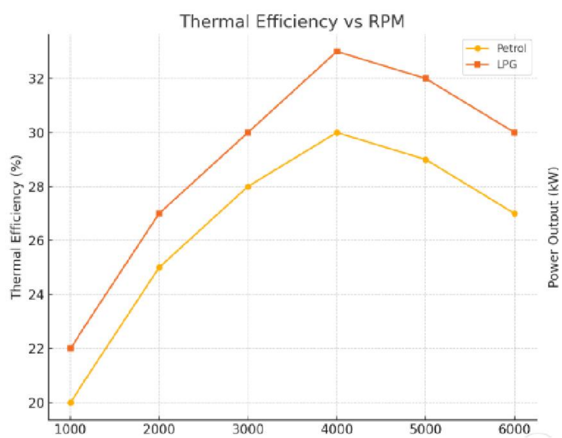


Fig. Simulation of Petrol Tank



The graph represents the variation of thermal efficiency with respect to engine speed (RPM) for both petrol and LPG fuels. The horizontal axis shows the engine RPM, ranging from 1000 to 6000, while the vertical axis shows thermal efficiency in percentage. It is observed that thermal efficiency increases with engine RPM for both fuels up to a certain point, after which it slightly decreases due to increased friction and heat losses at high speeds. LPG consistently shows higher thermal efficiency than petrol across all RPM levels. This is attributed to the more complete combustion of LPG and its higher hydrogen-to-carbon ratio. At 4000 RPM, LPG reaches its peak thermal efficiency of approximately 33%, compared to petrol's 30%. This trend highlights the potential of LPG as a more thermally efficient alternative in dual-fuel motorcycle engines.

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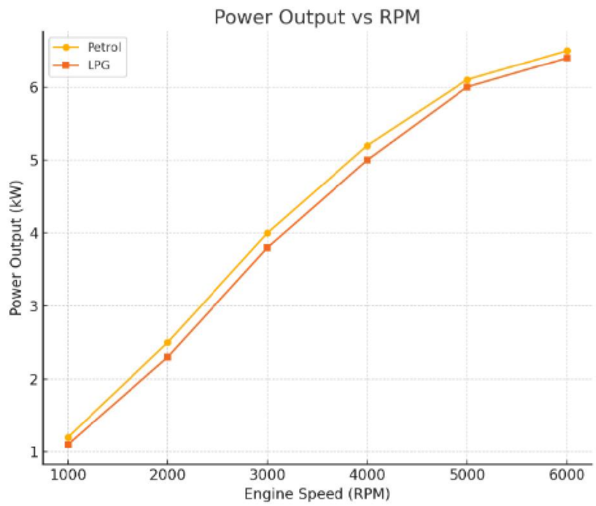

This graph illustrates the power output generated by the engine at different RPM levels using petrol and LPG. The x-axis denotes engine RPM, while the y-axis represents power output in kilowatts (kW).

Petrol exhibits a slightly higher power output than LPG at lower RPMs (1000–3000 RPM), likely due to its higher energy density and combustion characteristics. However, the power curves for both fuels converge at higher RPMs (4000–6000 RPM), indicating that LPG can deliver comparable performance under moderate to high engine loads.

The maximum power output observed is approximately 6.5 kW for petrol and 6.4 kW for LPG at 6000 RPM. This similarity in high-end power performance supports the suitability of LPG as a viable secondary fuel in a dual-fuel setup without compromising the riding experience.

VII. CALCULATIONS

Given Parameters:

- Density of Fuel: 0.75 Kg/lit
- Top Speed Approx: 95 Km/h
- Torque: 7.5 Nm
- RPM: 5000
- Mean Effective Pressure: 700 Kpa
- Total Displacement Volume per Second: 109.7 cc
- Heating Value of Gasoline: 47.30

Fuel Consumption Per Km:

$$= \frac{\mathbf{1}}{\boldsymbol{fuel\ eff(Km\ per\ liter)}}$$

Mass of fuel consumption per km -

$$= \frac{1}{65} \times 0.75$$

= **0.0125 kg/km**

Here 0.75 is the density of petrol.

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Mass Flow Rate –

= Mass of Fuel Consumption per km × Top speed
= 0.0125 × 95
= 1.09 Kg/h
= **0.000304 Kg/sec**

Brake Power –

$$B.P = \frac{2\pi NT}{60} \text{ Kw/h}$$

$$B.P = \frac{2\pi \times 5000 \times 7.5}{60}$$

B.P = 3926.99 Kw/h

Mechanical Efficiency –

$$\eta = \frac{B.P}{I.P}$$

Here,
B.P = Brake Power
I.P = indicated Power

$$\text{Indicated power} = \frac{Pm \times Vd \times N}{60 \times 1000}$$

Here,
Pm = Indicated mean effective pressure in Kpa
Vd = Total displacement Volume per cycle in cm^3
N = Number of Power Strokes Per Second

Vd = 109.7 cc
= 109.7 × 10^-6

Assume mean effective pressure (Pm) is 700 Kpa
N = 5000 rpm

$$I.P = \frac{700 \times 109.7 \times 10^{\wedge}{-6} \times 5000}{60 \times 1000}$$

I.P = 6.399×10^3

$$\text{Mechanical Efficiency } \eta = \frac{3.92699 \times 10^{\wedge}3}{6.399 \times 10^{\wedge}3} \times 100$$

η mech = 61.96 %

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Thermal Efficiency-

$$= \frac{B.P}{Fuel\ Energy(Q)}$$

Q = Mass Flow Rate × Heating Volume of Gasoline

Assume Heating Volume is 47.300

Q = 1.09×47.300

Q = 51.577 KJ/h

Thermal Efficiency = $\frac{3.92699\times10^{\wedge}3}{51.557}$

η thermal = 76.16%

VIII. CONCLUSION

The aim of this paper is to minimize overall running cost of the Bike and making it useful for daily use by reducing its cost. Also, we can to reduce the Harmful Emissions and decrease the danger of ozone depletion by utilizing a clean fuel in our bike engine.

There are also some features of the project, which are:

Low Emissions.

Decrease in maintenance.

Increase in engine life.

Low running Cost.

Calculating Running Cost Both Powered Bike

For Petrol Powered Bike

Price of 1 liter petrol is 120.83 INR Averageofpetrol-poweredbikeis55km 1 km = 2.19 INR

For LPG Powered Bike

Price of 1litre of LPG gas is 85 Indian rupees

Average of LPG powered Bike is 73 km

1Km =1.164 INR

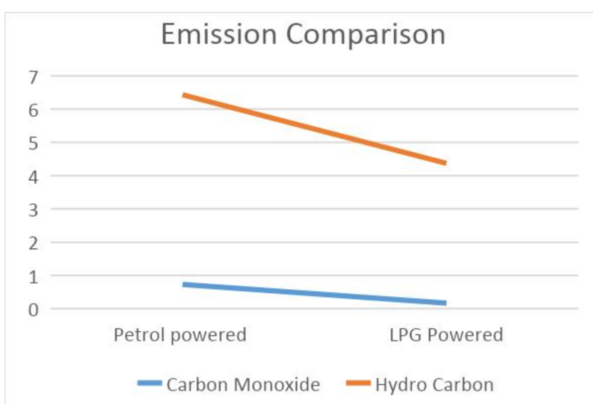

Fig. Emission Comparison

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IX. FUTURE SCOPE

Theresults obtained from this work will be useful insights for the further development ofLPG powered two-wheeler. Few improvements that could be made in future are as follows:

1) A battery can be added to the bike along with small electric motor this will allow the bike to run on electric power for short distance or during traffic or which saves a fuel and it can be a hybrid system that uses petrol, LPG as well as electricity as per need.

2) We can use microcontrollers (like Arduino) to control the switching between petrol and LPG automatically. Sensors can monitor engine temperature, load, and speed to decide the best time to switch fuel. This will make the bike more fuel-efficient and reduce emissions.

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