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TECHNOLOGIES FOR IMPROVING THE EFFICIENCY OF FUEL SUPPLY SYSTEMS IN GAS-FUELED VEHICLES

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Abstract
This scientific article examines the technologies for improving the efficiency of fuel supply systems in gas-fueled vehicles. The study demonstrates that using compressed natural gas (CNG) and liquefied petroleum gas (LPG) not only reduces harmful emissions such as CO_2 and NOx by 20–35%, but also increases fuel efficiency, prolongs engine and mechanical component life, and lowers operational costs. Key technologies discussed include automatic fuel injector systems, digital monitoring and diagnostics, high-efficiency engine designs, and optimized fuel supply systems. The research concludes that a comprehensive approach combining these technologies ensures environmental safety, economic efficiency, and technical reliability of gas-fueled vehicles. The results have practical relevance for vehicle manufacturers, transport companies, and fuel system developers aiming to implement environmentally friendly and efficient transportation solutions.

Keywords gas-fueled vehicles, fuel supply system, efficiency improvement, automatic injector, digital monitoring, environmental safety.

Introduction

In the current era of globalization and industrial development, the transport sector plays a crucial role not only in ensuring economic stability but also in addressing social and environmental challenges. In particular, road transport is an integral part of the economy, serving as the foundation for population mobility, as well as the delivery of goods and services. At the same time, road transport has a significant impact on the environment. Emissions from vehicles, including carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), and other harmful gases, contribute to global warming, air pollution, and negative effects on human health. According to data from the World Health Organization, millions of people are affected by air pollution annually, with a significant portion directly linked to transport sources. In this context, gas-fueled vehicles (CNG – Compressed Natural Gas and LPG – Liquefied Petroleum Gas) are gaining wide recognition as environmentally safe transport options. Gas fuels significantly reduce the amount of harmful substances released into the atmosphere compared to conventional gasoline and diesel fuels and also provide opportunities to increase energy efficiency. Currently, in developed countries, gas-fueled vehicles are being adopted as an effective means of ensuring fuel efficiency and environmental sustainability.

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The fuel supply system in gas-fueled vehicles is one of the most critical systems, determining engine performance, fuel consumption, and emission levels. The efficiency of this system is closely linked to engine lifespan, maintenance costs, and operational convenience.

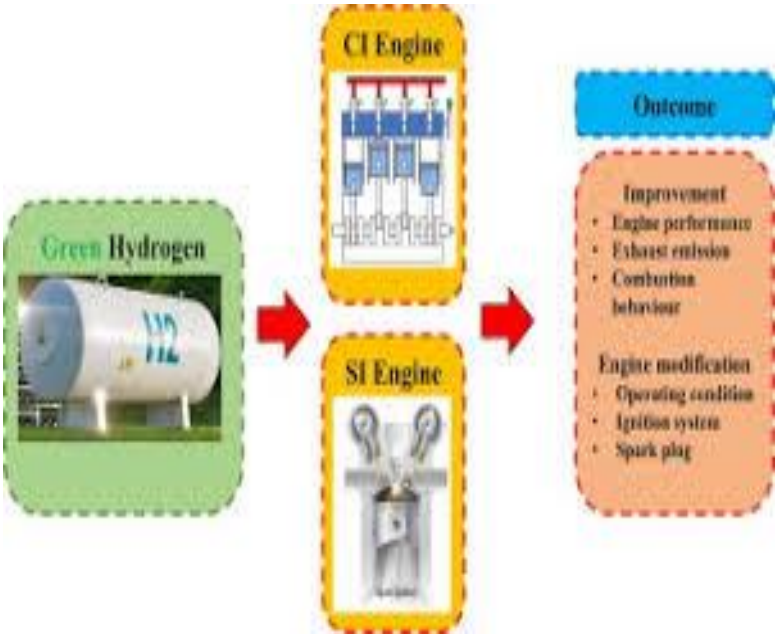

Figure1. The use of green hydrogen as fuel in both SI and CI engines.

Therefore, optimizing fuel supply systems in gas-fueled vehicles, implementing modern technologies, and monitoring system performance is a scientifically and practically relevant issue. In recent years, modern technologies such as automatic injector systems, digital monitoring, high-efficiency injectors, and turbocharged engines have played a key role in improving fuel efficiency in gas-fueled vehicles. At the same time, the implementation of systematic diagnostics and maintenance systems enhances engine performance, reduces emissions, and significantly lowers operational costs.

The purpose of this scientific article is to systematically study the technologies for improving the efficiency of fuel supply systems in gas-fueled vehicles, identify existing challenges, and develop practical recommendations. The research examines the process of using gas fuel in vehicle engines, modern injector systems, monitoring methods, and scientifically-based technologies to enhance energy efficiency.

RESEARCH METHODOLOGY

Advantages and Environmental Significance of Gas-Fueled Vehicles Gas-fueled vehicles (CNG – Compressed Natural Gas, LPG – Liquefied Petroleum Gas) have several advantages over conventional gasoline and diesel fuels: Reduces harmful emissions: CO_2 emissions decrease by 20–25%, while NOx and SOx emissions are reduced by 30–35%. This contributes to improved air quality and helps slow down climate change. Increases fuel efficiency: Gas fuels burn more efficiently and have higher octane ratings, converting more engine energy into usable power. Economically beneficial: Gas fuel is generally cheaper than conventional fuels,

reducing operational costs. Extends service life: Gas fuel causes less wear on engine components, increasing the overall lifespan of the engine. Globally, in countries such as Germany and the Netherlands, gas-fueled vehicles account for 10–15% of the fleet, contributing to the environmental sustainability of transport in these countries.

Fuel Supply System Components and Operating Principles in Gas-Fueled Vehicles The fuel supply system in gas-fueled vehicles consists of the following main components:

Fuel storage tanks: Store gas under high pressure and supply it to the engine. Pressure regulators: Ensure the gas is delivered to the engine at the correct operating pressure.

Injector system: Delivers precise amounts of gas into the engine combustion chamber.

Sensors and monitoring systems: Track gas flow, pressure, temperature, and fuel consumption in real time. The key requirement for the fuel supply system's operation is the injection of the optimal amount of fuel at the correct timing. This maximizes engine efficiency, reduces emissions, and optimizes fuel consumption.

Technologies to Improve Fuel Supply Efficiency in Gas-Fueled Vehicles Several modern technologies are used to enhance the efficiency of the fuel supply system in gas-fueled vehicles: Distribute gas according to engine operating conditions. Optimize the real-time injection volume, reduce fuel consumption by up to 10–15%.

Sensors monitor gas pressure, injector performance, engine temperature, and fuel consumption.

- Reduce emissions and increase maintenance efficiency.
- Enable real-time diagnostics to detect malfunctions.

Turbocharged engines and direct-injection systems ensure more efficient fuel combustion. Improve engine energy efficiency by 15–20%. Minimize fuel waste and emissions. Tank placement and pressure regulator configuration enhance engine efficiency. Fuel system components made from high-quality materials reduce malfunctions and extend service life. Practical Significance of Efficiency Improvements in Gas-Fueled Vehicles The application of these technologies in gas-fueled vehicles results in: Significant reduction in fuel consumption (10–15%).

- Decrease in atmospheric emissions by 20–35%.
- Increase in engine service life by 15–20%.
- Reduced operational costs for vehicles.

Additionally, modern technologies not only ensure environmental sustainability but also improve the economic efficiency of transport vehicles.

CONCLUSIONS AND RECOMMENDATIONS

This scientific study comprehensively examined technologies for improving the efficiency of fuel supply systems in gas-fueled vehicles. The research results indicate that the use of gas fuel in modern vehicles not only ensures environmental sustainability but also increases fuel efficiency, extends the service life of the engine and mechanical components, and reduces operating costs.

- Based on the analysis, the following conclusions were made:

The use of gas fuels (CNG, LPG) significantly reduces harmful emissions: CO_2 emissions decrease by 20–25%, while NOx and SOx emissions decrease by 30–35%. This contributes to improved air quality and mitigates the negative effects of climate change.

Automatic injector systems and digital monitoring ensure the optimal use of gas, reducing fuel consumption and lowering emission levels. High-efficiency engine designs and modern technologies maximize fuel combustion efficiency, increasing fuel efficiency by up to 10–15%

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