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Experimental study of the effect of wheel rim material and tire size on vehicle fuel consumption

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Extended Abstract

Introduction

In recent decades, pollution resulting from the combustion of fossil fuels, particularly in the transportation sector, has become a major environmental and public health concern. Vehicles are recognized as one of the primary sources of air pollutants such as CO, HC, and CO_2 , prompting extensive research on factors affecting fuel consumption and exhaust emissions. Previous studies have demonstrated that the use of alternative fuels such as CNG can significantly reduce pollutant emissions and the associated social costs of air pollution. Comparative investigations between gasoline-powered and gas-fueled vehicles indicate lower emissions of CO and HC in gas-fueled vehicles. Moreover, evaluations of different fuel supply systems reveal that vehicle design and applied technologies substantially influence emission levels. In addition, modifications to the intake air path and thermal insulation of the engine, particularly under hot and humid climatic conditions, have been shown to enhance volumetric efficiency and improve engine performance. Beyond engine optimization and control systems, vehicle weight and its related components, including tires and rims, have a direct impact on fuel consumption. Rolling resistance is a key parameter in tire design, where its reduction leads to lower resistance forces against motion, resulting in decreased fuel consumption and emissions. Rolling resistance is influenced by various factors such as tire inflation pressure, temperature, vehicle speed, tire structural design, material composition, and road conditions. Given that a tire is a complex fiber-reinforced polymer composite composed of elastomers, textiles, and steel cords, appropriate tire design and selection play a crucial role in overall vehicle efficiency.
Accordingly, the present study experimentally investigates the effect of wheel rim material (steel and aluminum) and tire size on the fuel consumption of a Peugeot Pars vehicle equipped with a TU5 engine. Different combinations of rims and tires were installed on the test vehicle, and fuel consumption was measured and compared under each condition.

Methodology

In this study, an experimental investigation was conducted to evaluate the effect of tire size and wheel rim material on fuel consumption using a Peugeot Pars vehicle with well-defined technical specifications. The test vehicle possessed a valid technical inspection certificate, and all components of the fuel supply and ignition systems, including injectors, spark plugs, ignition wires, and the fuel rail, were in proper operating condition during the experiments to minimize the influence of confounding factors. The experiments were carried out in four distinct stages. In each stage, different combinations of two tire sizes with widths of 185 mm and 205 mm, along with two types of wheel rims made of steel and aluminum, were installed on the vehicle. Tire specifications followed the conventional nomenclature (e.g., 205/60 R15), where the first number represents the tire width in millimeters, the second indicates the aspect ratio, the letter R denotes radial tire construction, and the final number corresponds to the rim diameter in inches. To ensure accurate measurement of fuel consumption, an auxiliary fuel supply system was designed and implemented to replace the original fuel tank during the tests. This system consisted of a graduated plastic tank calibrated in one-liter intervals to allow precise fuel measurement. An external fuel pump was used to transfer fuel from the tank to the fuel rail, while a return line was incorporated to redirect excess fuel back to the tank. This configuration enabled reliable and repeatable fuel consumption measurements under different experimental conditions.

Results and Discussions

To assess the effect of wheel rim material and tire size on vehicle fuel consumption, driving tests were conducted after installing the auxiliary fuel supply system on the test vehicle. Under each experimental condition, the vehicle

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was driven over a distance of 100 km at an average speed of 70 km/h, and the amount of fuel consumed was recorded. For each test stage, the corresponding combination of wheel rim material and tire size was mounted on the vehicle, and fuel consumption was measured accordingly. All experiments were carried out during early morning hours on a traffic-free road. Weather conditions, fuel quality, and other environmental parameters were maintained constant throughout the tests. To improve the reliability of the experimental results, each test was repeated four times, and the average fuel consumption value was used for further analysis. The findings reveal that both wheel rim material and tire size have a direct effect on vehicle fuel consumption. The use of aluminum rims led to noticeable reductions in fuel consumption compared to steel rims, with reductions of 7.7% and 5.6% observed when combined with tires of 185 mm and 205 mm width, respectively. This improvement is mainly attributed to the lower mass of aluminum rims. Furthermore, increasing the tire width from 185 mm to 205 mm resulted in additional fuel savings, with reductions of 2.6% and 0.45% observed for aluminum and steel rims, respectively.

Conclusion

Due to the depletion of fossil fuel resources and the increasing level of environmental pollution, investigating factors that contribute to reducing fuel consumption and emissions has become increasingly important. Vehicles are among the major sources of environmental pollutants, highlighting the need for optimization of their components. In the present study, the effects of wheel rim material and tire size on the fuel consumption of a Peugeot Pars LX equipped with a TU5 engine were experimentally investigated. Steel and aluminum rims, along with tires of different sizes, were installed on the test vehicle. To ensure accurate fuel consumption measurements, an external fuel supply system was designed and implemented. The experimental results demonstrated that both wheel rim material and tire size have a direct and significant impact on vehicle fuel consumption. The use of aluminum rims consistently resulted in lower fuel consumption compared to steel rims, which can be attributed to the reduced rotational mass of aluminum wheels. In addition, increasing tire size led to a further reduction in fuel consumption. Overall, the fuel consumption reduction ranged from 0.45% to 7.7% under different test conditions. Therefore, appropriate selection of wheel rim material and tire size can be considered an effective and practical approach to reducing vehicle fuel consumption, consequently contributing to lower emissions and a cleaner environment.

Key words: Experimental test, tire, wheel rim, environment, fuel consumption.

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