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Analysis of The Effects of Oil and Fuel Type on Motorcycle Fuel Consumption Vario 125 CC ESP FI

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ABSTRACT

The efficiency of fuel consumption in motorcycles is determined by multiple factors, such as the type of oil and fuel utilized. The careful choice of these two elements is essential for enhancing engine performance and reducing operational expenses. This study examines the impact of various oil and fuel types on the fuel consumption of the Honda Vario 125 cc ESP FI motorcycle, with particular attention to the relationship between engine oil viscosity and fuel quality. The study involved conducting experiments with a range of engine oil combinations, specifically 10W-30 and 20W-40, alongside different fuels like Pertalite and Pertamax, each exhibiting distinct octane ratings and combustion properties. The methodology included systematic and thorough testing in controlled environments, where factors like distance and load were standardized to guarantee precision and consistency. The results indicated clear variations in fuel efficiency among the tested combinations. The application of 10W-30 oil in conjunction with Pertalite fuel resulted in a 0.76% enhancement in efficiency when compared to the use of 20W-40 oil with the same fuel type. In a comparable analysis, 10W-30 oil demonstrated a 3.87% increase in efficiency over 20W-40 oil when used with Pertamax fuel. In the analysis of fuel types, Pertamax demonstrated a 16% increase in efficiency compared to Pertalite when used with 10W-30 oil, and a 12.52% increase in efficiency with 20W-40 oil. The results highlight the benefits associated with the utilization of high-quality, low-viscosity oils and higher-octane fuels in achieving improved fuel economy. In summary, the most effective combination for achieving fuel efficiency and cost savings is the use of 10W-30 oil alongside Pertamax fuel. This pairing is advised for Honda Vario 125 cc ESP FI users aiming for improved performance and lower fuel costs.

1. Introduction

Fuel oil (BBM) in Indonesia is divided into two types: subsidized and non-subsidized fuel, each serving different segments of the population and catering to specific government policies. Subsidized fuel, such as Pertalite and Solar, is financially supported by the government to ensure affordability for the general public, particularly low-income groups [1]. These fuels are sold at a lower, fixed price regulated by the government, making them more accessible but often limited in supply to prevent misuse. In contrast, non-subsidized fuels, such as Pertamax and Pertamax Turbo, are sold at market-driven prices that are not regulated by the government. These prices tend to be higher and may vary across regions due to logistical costs, tax variations, and market competition. This fundamental distinction between subsidized and non-subsidized fuel directly influences consumer choices and market dynamics. Subsidized fuels are typically preferred by individuals and businesses looking to minimize operational costs, whereas non-subsidized fuels, which often have higher octane ratings and superior quality, are chosen by users prioritizing better engine performance and longevity. The pricing structure of both types also reflects broader government policies aimed at balancing economic growth, social equity, and environmental sustainability. For instance, the government encourages the gradual shift to non-subsidized fuels to reduce subsidy burdens and promote the use of cleaner, more efficient energy sources, aligning with Indonesia's commitments to environmental conservation and energy security. This pricing and policy framework significantly shapes the energy consumption patterns and fuel market in the country.

Fuel consumption is how much fuel an engine or vehicle uses over time, according to Mafruddin et al. [2]. Since it affects operating costs, energy use, and environmental sustainability, it is essential for vehicle economy and performance evaluation. The economic viability of operating a vehicle depends on fuel consumption, which also indicates emissions compliance. More fuel-efficient vehicles conserve energy and lessen environmental impact. Good engine maintenance and fuel compatibility with the vehicle's design can also affect fuel economy. gasoline economy depends on driving behavior, load, road conditions, and gasoline quality. With the global focus on lowering greenhouse gas emissions and fossil fuel dependency, vehicle manufacturers and authorities are prioritizing fuel consumption. Fuel efficiency is improved by modern fuel technologies, engine design, and alternative energy sources, promoting sustainable mobility and environmental protection.

The connecting rod force balances the combustion air pressure above the piston head, converting thermal energy into mechanical energy during engine running, according to Kirstianto [3]. Due to connecting rod angular movement, motor load, speed, and temperature cause sideways forces on the cylinder wall. The piston and cylinder wall friction from these sideways forces causes wear, efficiency loss, and heat loss. The piston wall's contact with the cylinder should be minimized and low-viscosity lubricants used to reduce friction. This method may increase wear at high temperatures and pressures because low-viscosity lubricants may not protect well. High engine speed increases friction owing to piston movement and connecting rod force, which stresses the lubricating system.

Higher activation energy makes high-octane fuels less likely to knock in the combustion chamber, according to Naryanto [4]. This lets high-octane fuels work well in high-compression engines, which maximize power and efficiency. Such engines operate smoothly, wear less, and fail less due to high-octane fuels' regulated combustion. When utilized in high-compression engines or under challenging conditions, low-octane fuels sometimes fail to achieve combustion criteria. Knocking, where fuel-air combinations ignite prematurely or unevenly, causes vibrations, lower power output, inefficient fuel use, and long-term damage to pistons and cylinder walls. High-octane fuels reduce detonation danger, but applying them to engines not intended for them can reduce combustion dynamics. Incomplete combustion from high-octane fuels' slower burn rate reduces power output and fuel efficiency. Optimizing engine performance requires matching fuel type to compression ratio and operational needs.

A vehicle's fuel consumption can be determined by comparing the total miles driven to the volume of fuel consumed during that distance, as explained by Danesvaran [5]. This correlation makes it easy to measure fuel economy, which is usually measured in miles per gallon (mpg) or kilometers per liter (km/L). Use this formula to figure out how much gas you'll need. This formula is essential for measuring the efficiency of a vehicle's fuel conversion, which in turn allows consumers to gauge the vehicle's overall performance. In order to minimize external factors and get accurate fuel consumption readings, it is important to keep the testing settings consistent. This includes things like constant driving speeds, defined load weights, and equivalent road surfaces.

Research on oil viscosity, fuel consumption, and engine performance explains how lubricants affect motorcycle efficiency. Sianturi [6] showed that SAE 10W-40 oil outperformed

15W-40 and 20W-40 oils in fuel efficiency at 1000–4000 rpm. SAE 10W-30 oil performed best at 4000 rpm, consuming just 0.9 ml/m, whereas SAE 10W-40 oil performed best at 2000 and 3000 rpm, consuming 0.35 and 0.65 ml/m, respectively. Surbakti [7] continued these findings by studying 125 CC motorbike fuel consumption and oil viscosity. SAE 10W-40 oil performed best at 1300 rpm, according to the study. As engine speed increased to 2000 and 3000 rpm, the difference in fuel consumption amongst lubricants of different viscosities decreased, demonstrating that viscosity was more important at lower engine speeds. Purba and Tarigan [8] found an inverse association between oil viscosity and fuel consumption in 150 CC bicycles. SAE 10W-30 oil had the maximum fuel efficiency at 5000 rpm but lower engine power than 10W-60. This shows that lower viscosity oils improve fuel efficiency and higher viscosity oils boost power.

In Semarang, Priangkoso et al. [9] examined how lubricant viscosity affects engine temperature and fuel consumption on specific routes. High-viscosity lubricants absorb more heat, raising engine temperatures. However, heat management increased fuel consumption, stressing the importance of lubricant selection in thermal performance and efficiency. Finally, Iswanto et al. [10] found that oil and gasoline type affected power and fuel consumption in Yamaha Jupiter Z 110 cc bikes. Highest power production of 9.03 HP was at 6000 rpm with single-grade oil and premium fuel; lowest was 3.07 HP at 3000 rpm. The most efficient fuel consumption rate was 0.14 kg/m^3 at 3000 rpm, while the wasteful rate was 0.06 kg/m^3 at 5000 rpm using single-grade oil and Pertalite gasoline. These studies emphasize the necessity of matching oil viscosity and type to engine specs and operating conditions to improve fuel efficiency, power output, and thermal performance. Motorcycle riders looking to improve performance and manufacturers looking to build more efficient and ecologically friendly engines need this knowledge.

This study uses Shell AX5 Matic oil with SAE 10W-30 and SAE 20W-40 standards because to its affordability and industry reputation. These lubricants are popular in the automotive industry for their reliable performance and low cost, making them a good choice for motorcycle owners. Their use reduces costs while preserving engine protection and efficiency. Despite benefits, some oils have drawbacks. Both varieties are mineral-based oils, which are adequate for regular use but lack synthetic or entirely synthetic characteristics. Semi-synthetic oils may be less resistant to thermal degradation, oxidation, and sludge formation than completely synthetic lubricants due to the lack of sophisticated additives. This may affect engine performance in harsh conditions like high temperatures or heavy loads and require more frequent oil changes.

2. Methodology

This research uses a quantitative approach with experimental methods. The research site refers to the location or object where a study is conducted. The research location is on Jalan Banyuurip-Purworejo, Banyuurip, Purworejo, Central Java. The coordinates of the road are as follows: 7°45'19.3 "S 109°58'24.1 "E. The implementation of this research was from August 2024 to September 2024.

This study analyzes the mileage variables resulting from the use of two types of fuel namely Pertalite and Pertamax, as well as two types of oil namely SAE 10W-30 and 20W40. The subject of observation was a 2016 Vario 125cc motorcycle, with a maximum speed limit of 60 km/h. Each experiment was carried out with a fuel volume of 200 ml for each type of fuel used, using Shell AX5 Matic oil, acceleration 0-60 km/h by 20 seconds.

Table 1. SAE 10W30 Fuel Consumption Calculation Results Instrument

Oil viscosity (SAE)	Fuel Type (Ron)	Fuel Rate (ml)	Distance (km)	Fuel consumption (km/L)
10W30	Pertalite (90)	200		
		200		
		200		
		200		
	Pertamax (92)	200		
		200		
		200		
		200		

Table 2. SAE 20W40 Fuel Consumption Calculation Results Instrument

Oil viscosity (SAE)	Fuel Type (Ron)	Fuel Rate (ml)	Distance (km)	Fuel consumption (km/L)
20W40	Pertalite (90)	200		
		200		
		200		
		200		
	Pertamax (92)	200		
		200		
		200		
		200		

This test will involve a process that is carried out sixteen times. First, fuel consumption using 10W-30 lubricant and Pertalite fuel for four tests. Second, fuel consumption using 10W-30 lubricant and Pertamax fuel for four times. Third, fuel consumption using 20W-40 lubricant and pertalite fuel for four tests. Finally, fuel consumption using 20W-40 lubricant and firstx fuel for four tests. Motorcycle mileage data was calculated using an odometer. Fuel volume measurements were taken using a measuring cup to ensure accuracy. Documentation of odometer changes was done using a smartphone, which was used to visually record the measurement results as additional evidence. The data obtained will be entered into a Table 1 and 2.

After completing the research and collecting the data, the next step involves analyzing the data obtained by processing any information collected. The technique used in this research is descriptive data analysis. The data obtained from the tests were analyzed to determine the extent of the effect of using the type of oil and fuel ron on the resulting fuel consumption.

3. Result and Discussion

3.1 Fuel consumption of SAE 10W-30

Fig. 1 shows that there were only small changes in fuel usage throughout all four tests, which means that the experimental methodology was consistent and reliable. The initial test showed fuel consumption of 48 km/L, while the second test showed a small improvement, measuring 49 km/L. There was very little change from the first two tests since the third one also indicated a consumption rate of 48.5 km/L. Optimal operational or environmental conditions probably had a role in the fourth and last test's greatest fuel efficiency, which reached 51.5 km/L. The overall efficiency of the motorbike under the provided experimental conditions was highlighted by the average fuel consumption of 49.25 km/L throughout all four tests. To compare how various fuel and oil types affect performance, this average is used as a standard. The uniformity between the tests proves that the experimental setup and testing protocol are reliable. Variations in driving habits, environmental variables including temperature and wind resistance, and variations in road conditions are all potential causes of the difference seen in the final test. Additional research could investigate these topics. Gaining a better grasp of these factors will help shed light on how to maximize fuel efficiency and make future research more reproducible.

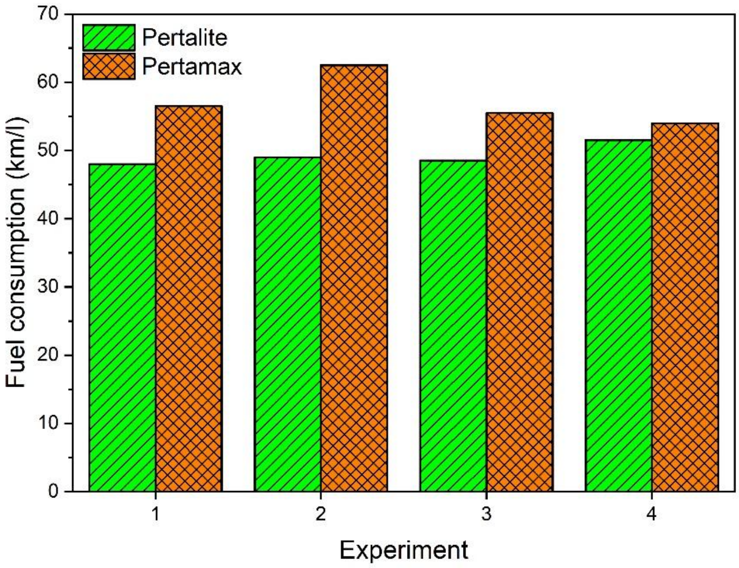

Figure 1. Fuel consumption of SAE 10W-30

Fuel consumption varied significantly from test five through test eight, as seen in Fig. 1, indicating that the testing environment and conditions were constantly changing. Fuel consumption was 56.5 km/L in the fifth test, indicating a reasonable level of economy. Perhaps impacted by advantageous operating circumstances like smoother driving patterns or optimized road conditions, the sixth test achieved the highest recorded consumption of 62.5 km/L, demonstrating a notable improvement. The economy of the vehicle declined in the seventh test, when fuel consumption dropped to 55.5 km/L. Engine performance variations, climatic circumstances, or higher mechanical resistance could be to blame for the persistent drop that was seen in the eighth and last test, which yielded a somewhat lower result of 54 km/L. Overall, the four tests resulted in an average fuel consumption of 57.13 km/L, which shows a rather efficient performance but also shows how different situations affected the variability. This average can be used to compare the effects of various operational factors or combinations of fuel and oil [11]. To learn what caused the performance to peak in the sixth test and then drop in the tests that followed, more research is needed. Future research might benefit from these findings by learning how to optimize experimental settings and keep fuel efficiency consistent.

3.2 Fuel consumption of SAE 20W-40

Results from the ninth through twelve tests show fuel consumption figures with moderate variability, which may be explained by both internal consistency and external influences (see Fig. 2). In particular, the ninth test had the group's best fuel economy at 46 km/L, which could indicate unfavorable circumstances such enhanced mechanical resistance, irregular driving patterns, or bad road conditions. Possible causes of this outcome include the effects of engine warming up or initial inefficiencies [12]. At 48.5 km/L, the results of the tenth and twelfth tests are somewhat better than those of the ninth test, suggesting that the circumstances were either more steady or improved over these trials. These two numbers are so comparable to one another that it makes you wonder if the testing conditions or driving techniques used in these experiments were consistent. Though the results were lower than the maximum usage in this category, they were nonetheless respectable.

Among these tests, the eleventh one stood out for its far higher efficiency than the others, clocking in at 52.5 km/L. Potential causes of this improvement include less engine friction, more relaxed driving habits, or optimum climatic circumstances [13] (such as temperature, wind speed, or road grades) during the test. The level of efficiency attained here highlights the possibility of improved fuel performance in an ideal setting. The average fuel consumption from the ninth to the twelfth test was 48.88 km/L, showing a dependable performance with little variation. Using this average as a starting point, we may examine how various testing circumstances, fuel types, or operational aspects affect overall efficiency.

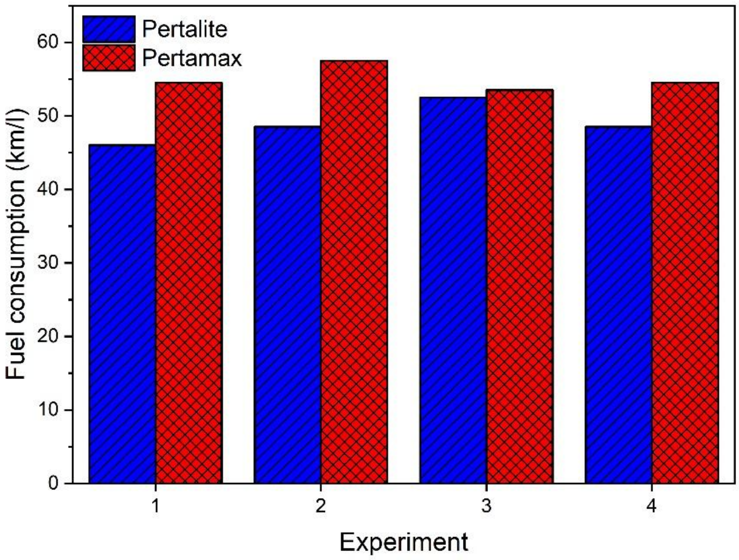

Figure 2. Fuel consumption of SAE 20W-40

The results from the twelfth through the sixteenth tests show that the fuel consumption remains relatively constant with only small fluctuations, indicating that the testing conditions and procedures used were dependable, according to Fig. 2. A solid benchmark for this set of testing was established in the thirteenth test, which showed fuel consumption of 54.5 km/L. Efficiency at this level indicates that all operational parameters, including driving habits, road conditions, and environmental factors, were within acceptable ranges [14]. The fourteenth test had the greatest fuel usage of the set, reaching 57.5 km/L. Possible optimum conditions that could explain this noticeable improvement include less mechanical resistance, more uniform driving speeds, or flatter roads. This result can be used as a standard for assessing how optimal conditions affect fuel consumption, as it shows how well the vehicle performs when all the circumstances are right. On the fifteenth run, fuel usage was 53.5 km/L, a little drop from the previous run. Variations in driving habits, higher engine load, or slight changes in external variables like wind resistance or temperature could be the cause of this minor decline [15]. The outcome is still within a narrow range, indicating consistent performance even with the reduction. Comparing the thirteenth and last test, the fuel consumption in the sixteenth and last test was 54.5 km/L. This efficiency return to baseline further supports the reliability of the experimental approach and provides more evidence that the differences between tests were probably caused by temporary outside influences. Fuel consumption averaged 55 km/L throughout all four tests, demonstrating the vehicle's remarkable efficiency even under constant load.

3.3 Average fuel consumption

Fuel economy of 49.25 km/liter can be achieved by using 10W-30 lubricant in conjunction with Pertalite fuel, as shown in Fig. 3. Under typical circumstances, this degree of efficiency suggests respectable performance. By combining the same lubricant with Pertamax fuel, the vehicle's performance is greatly enhanced, leading to an impressive fuel efficiency of 57.13 km/liter. The increased octane number of Pertamax fuel likely gives it better combustion qualities, leading to more effective energy conversion and fewer engine knocking, as this noticeable boost in efficiency demonstrates. Likewise, the vehicle achieves a fuel efficiency of 48.88 km/liter while using 20W-40 oil in conjunction with Pertalite fuel. It appears that the somewhat poorer performance compared to 10W-30 lubricant may be due to the greater friction and energy loss caused by the higher viscosity of 20W-40 oil. The vehicle achieves an impressive 55 km/liter when using 20W-40 oil in conjunction with Pertamax fuel. The efficiency of the mixture of 10W-30 lubricant with Pertamax fuel is still higher, but this is an improvement over using the same lubricant with Pertalite. In every case of lubricant type, the results demonstrate that Pertamax fuel outperforms Pertalite fuel in terms of efficiency. The increased performance and less waste caused by Pertamax fuel's better combustion efficiency is the reason behind this. When using 10W-30 lubricant, the disparity in fuel efficiency between Pertamax and Pertalite fuels becomes even more apparent. This lends credence to the theory that lubricants with lower viscosity work in tandem with high-octane fuels to optimize combustion conditions and reduce internal friction.

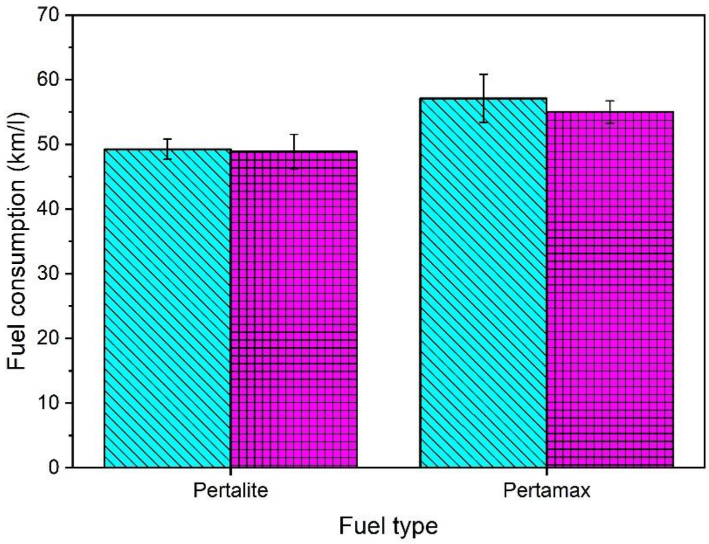

Figure 3. Average fuel consumption based on fuel type

Fig. 4 shows that the vehicle could achieve a fuel consumption of 49.25 km/L while using 10W-30 oil in conjunction with Pertalite fuel. With its reduced viscosity, which decreases engine friction and increases combustion efficiency, 10W-30 oil is able to optimize fuel utilization, resulting in relatively high efficiency. Using 20W-40 oil and Pertalite fuel resulted in marginally lower fuel use, measuring 48.88 km/L. This shows that the vehicle achieved 48.88 km/l, which is little worse than the efficiency of 10W-30 oil, but still respectable. The benefit of choosing a lighter oil, such as 10W-30, in obtaining higher fuel economy is highlighted by the modest difference of 0.37 km/L. Both kinds of oil saw even greater efficiency gains when fueled with Pertamax. The fuel consumption was measured at 57.13 km/L when using 10W-30 oil, which means that the vehicle could travel 57.13 kilometers on a single liter of fuel. Because of its higher octane rating, which improves combustion qualities and reduces the chance of knocking, especially in high-performance engines, Pertamax fuel is of exceptional quality, as is demonstrated by this substantial improvement. Fuel consumption was measured at 55 km/L when using 20W-40 oil and Pertamax fuel. Although it was still efficient, it was not as good as the results obtained with 10W-30 oil, which goes against the trend of using lubricants with a lower viscosity to maximize fuel efficiency [16].

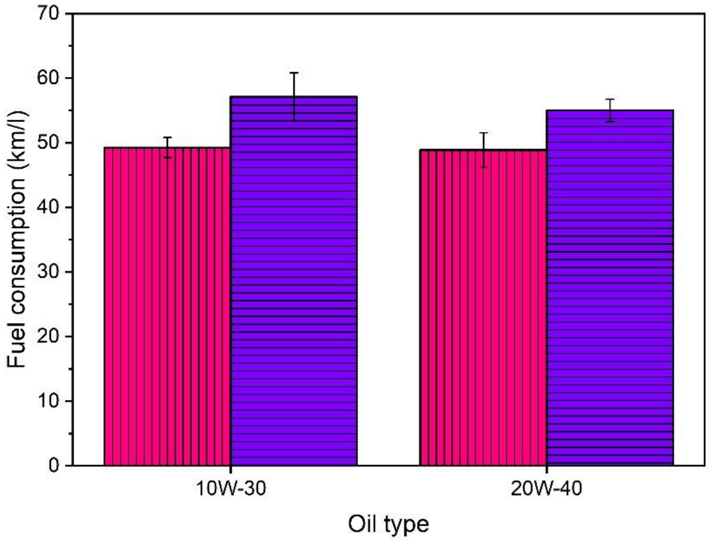

Figure 4. Average fuel consumption based on oil type

Regardless of the fuel type, these comparisons clearly show that 10W-30 oil routinely surpasses 20W-40 oil in terms of fuel efficiency. It is clear that oil viscosity affects engine efficiency, since there is a 0.37 km/L difference in Pertalite testing and a 2.13 km/L difference in Pertamax tests. Lighter 10W-30 oil improves combustion and decreases internal friction, enabling the engine to harness a greater amount of energy from fuel. The thicker 20W-40 oil, on the other hand, offers better protection in some situations, but it also increases engine resistance and somewhat decreases fuel economy [17]. The results indicate that the best option for consumers looking to get the highest gas mileage, especially on regular roads, is to use a mixture of 10W-30 oil and Pertamax fuel. It is crucial to choose the correct oil and fuel for the engine based on its needs and operating conditions, as this combination consistently performs better. To have a better grasp of their advantages, future studies could investigate how these oil types affect engine wear and performance over the long run.

4. Conclusion

Based on the research and discussion conducted regarding the analysis of the effects of oil and fuel types on the fuel consumption of Vario 125 CC motorbikes in 2016, several conclusions can be drawn. The study highlights that the type of oil used significantly impacts fuel efficiency. Specifically, the use of 10W-30 oil was found to be more efficient than 20W-40 oil. This efficiency is evident from the average fuel consumption results, with vehicles using 10W-30 oil achieving 57.13 KM/L with Pertamax fuel and 49.25 KM/L with Pertalite fuel. The research also identified differences in fuel consumption based on the type of fuel used. Pertamax fuel consistently provided better efficiency across all tests compared to Pertalite fuel. This superiority is demonstrated by the average fuel consumption of 57.13 KM/L when using Pertamax fuel with 10W-30 oil and 55 KM/L with 20W-40 oil. These findings underscore the importance of selecting the right fuel type to optimize vehicle performance and efficiency. In addition to efficiency, the combination of 10W-30 oil and Pertamax fuel offers economic advantages. This pairing not only enhances fuel consumption efficiency but also proves to be more cost-effective over time, making it a practical choice for users seeking to balance performance and expenses. The research highlights that careful selection of oil and fuel types can significantly influence both operational efficiency and financial savings. Overall, the study provides valuable insights into how oil and fuel types affect motorcycle fuel consumption. The findings emphasize the need for users to consider both the technical performance and economic implications of their choices to achieve optimal results. These conclusions can guide future research and inform practical strategies for improving fuel efficiency in motor vehicles.

Conflict of interest

The authors declare no conflict of interest.

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