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The Effect of Camshaft Modification on Fuel Consumption and AFR Value on The Honda Supra X 125 Motorcycle

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Abstract

This study investigated the effects of camshaft modification and fuel variation on fuel consumption and air–fuel ratio (AFR) in a Honda Supra X 125 motorcycle. An experimental design was employed using three camshaft configurations standard, touring, and racing and two fuels: pure Pertamax and Pertamax blended with an octane booster. Fuel consumption was measured at idle and 5000 rpm based on the time required to consume 20 mL of fuel, while AFR was measured under idle conditions. Each test was repeated three times, and the results were expressed as mean ± standard deviation. At idle, the standard camshaft produced the longest fuel-consumption time, reaching 8.14 ± 0.09 min/20 mL with pure Pertamax and 9.22 ± 0.06 min/20 mL with the blended fuel. At 5000 rpm, the touring camshaft with the blended fuel produced the longest consumption time at 3.20 ± 0.05 min/20 mL. The racing camshaft consumed fuel more rapidly, with the lowest idle value of 6.57 ± 0.35 min/20 mL using pure Pertamax. AFR values decreased from 14.02 ± 0.06 for the standard camshaft with pure Pertamax to 13.45 ± 0.06 for the racing camshaft with the blended fuel. These findings indicate that camshaft geometry and fuel composition influence fuel-consumption characteristics and mixture richness. The standard camshaft was most efficient at idle, the touring camshaft performed best at 5000 rpm, and the racing camshaft produced the richest mixture.

1. INTRODUCTION

Transportation plays an important role in supporting daily human activities, particularly motorcycles, which are widely used due to their efficiency and practicality. However, motorcycles that have been used for a long period, especially more than five years, tend to experience a decrease in engine performance caused by wear and suboptimal combustion processes (Naryanto et al., 2026).

One effort to improve engine performance without increasing engine capacity is through optimization of engine components, particularly the camshaft. The camshaft is a critical component in a four-stroke engine that functions to regulate the opening and closing timing of intake and exhaust valves, which directly affects the air-fuel mixture entering the combustion chamber and the exhaust gas release process. Therefore, modifications to camshaft parameters such as duration, lift, and lobe separation angle (LSA) can significantly influence engine performance, fuel consumption, and combustion efficiency (Rahmat et al., 2024).

Previous studies have shown that modifications in the air-fuel flow system, including valve timing, can improve engine performance and efficiency. Research on intake manifold modification demonstrated that changes in airflow angle can increase torque by up to 25.28% and power by 23.9%, while also reducing fuel consumption by 15.65%, indicating improved volumetric efficiency (Rohman & Adiwibowo, 2017). Furthermore, studies on camshaft duration show that increasing duration can improve engine power up to 7.5 HP and torque to 8.56 Nm, but at the cost of increased fuel consumption and reduced thermal efficiency (Halim et al., 2021). Other studies have also emphasized the importance of lobe separation angle (LSA), where appropriate adjustments can improve engine performance while maintaining fuel efficiency (Muhajir et al., 2018).

In addition, variations in camshaft geometry such as intake lift, exhaust lift, and valve clearance have been proven to significantly affect fuel consumption. A study by Wijanata and Muhaji (2014) showed that certain valve configurations can produce more efficient combustion, resulting in lower fuel consumption where 20 ml of fuel can run the engine for nearly 6 minutes. Small variations in LSA have also been shown to significantly improve engine performance, with optimal results achieved at 103° LSA, producing increases in torque and power along with better fuel efficiency (Pangeran et al., 2020). Moreover, increasing camshaft lift can enhance volumetric efficiency and combustion quality, leading to improved torque and power output (Ramadhani et al., 2025).

Another important factor affecting engine performance is the air-fuel mixture quality, which is commonly represented by the Air-Fuel Ratio (AFR). AFR indicates the proportion of air to fuel in the combustion process, where the ideal stoichiometric ratio for gasoline engines is approximately 14.7:1. Deviations from this value can result in either a lean or rich mixture, both of which can negatively affect combustion efficiency and emissions. Research by Khalwani et al. (2025) showed that camshaft modification can reduce AFR values from 14.7 to around 13.8, indicating a richer mixture that improves engine performance. In addition, fuel characteristics such as octane number, benzene content, and aromatic compounds significantly affect AFR, fuel consumption, and combustion efficiency (Al-Arkawazi, 2019). Furthermore, variations in valve timing influence volumetric efficiency and AFR, as shown in studies on intake valve timing and combustion characteristics (Rimkus et al., 2022).

Despite numerous studies on camshaft modification and fuel characteristics, most research has been conducted separately, focusing either on mechanical modification or fuel composition. There is still limited research that integrates both aspects simultaneously, particularly in small-displacement motorcycles such as the Honda Supra X 125. Therefore, this study aims to analyze the combined effect of camshaft modification (standard, touring, and racing) and fuel composition (pure Pertamax and Pertamax mixed with additives) on fuel consumption and AFR. This integrated approach is expected to provide more comprehensive insights into optimizing engine performance, improving fuel efficiency, and maintaining stable combustion for practical daily use.

2. RESEARCH METHODS

This study employed an experimental method to analyze the effect of camshaft modification and fuel variation on fuel consumption and Air-Fuel Ratio (AFR) in a four-stroke motorcycle engine. The experiment was conducted by directly testing the performance of a Honda Supra X 125 under controlled conditions.

2.1 Research Object

The research object used in this study was a Honda Supra X 125 motorcycle with a standard engine condition. This motorcycle was selected due to its widespread use in Indonesia and its suitability as a representative of small-displacement four-stroke engines. The detailed specifications of the motorcycle are presented in Table 1.

Table 1. Specifications of Honda Supra X 125

No.	Type	Specification
1.	Engine	4 Stroke, SOHC, Single Cylinder,124.89 Cubic Centimeters.
2.	Fuel System	PGM-FI (Fuel Injection)
3.	Bore	52.4 mm
4.	Stroke	57.9 mm
5.	Compression Ratio	9.3 : 1
6.	Power	7.40 kW (10.1 PS) at 8000 rpm
7.	Torsi	9.30 Nm at 4000 rpm
8.	Transmission	4 speed rotary
9.	Vehicle Dimensions (L x W x H) mm	1,918x 709 x 1101
10.	Wheelbase	1,235 mm
11.	Ground clearance	136.5 mm
13.	Fuel Tank Capacity	4 liters
14.	Fuel Consumption	57.2 km/l

Figure 1. Honda Supra X 125 Motorcycle

2.2 Materials and Equipment

The materials used in this study consisted of two types of fuel, namely pure Pertamax and Pertamax mixed with an octane booster additive. The equipment used included three types of camshafts (standard, touring, and racing), fuel measuring instruments, and an AFR measuring device. Supporting tools such as tachometer, stopwatch, and measuring cylinder were also used to ensure accurate data collection.

Table 2. Specifications of Camshaft Standard

Camshaft Standard		Specification
Lift	Intake	6.22 mm
	Exhaust	5.9 mm
Duration	Intake	203°
	Exhaust	214°
LSA		103. 75°
Valve Clearance	Intake	0.93 mm
	Exhaust	0.82 mm
Overlap	Intake	6.22 mm
	Exhaust	5.9 mm
Intake Valve	Open	0° Before TDC
	Close	23° After BDC
Exhaust Valve	Open	33° After BDC
	Close	1° After TDC

Table 3. Specifications of Camshaft Touring

Camshaft Touring		Specification
Lift	Intake	6.29 mm
	Exhaust	5.89 mm
Duration	Intake	225°
	Exhaust	215°
LSA		105.5°
Valve Clearance	Intake	0.05 mm
	Exhaust	0.05 mm
Overlap	Intake	1.11 mm
	Exhaust	1.20 mm
Intake Valve	Open	5° Before TDC
	Close	40° After BDC
Exhaust Valve	Open	31° After BDC
	Close	4° After TDC

Table 4. Specifications of Camshaft Racing

Camshaft Racing		Specification
Lift	Intake	6.50 mm
	Exhaust	6.49 mm
Duration	Intake	228°
	Exhaust	234°
LSA		99.5°
Valve Clearance	Intake	0.05 mm
	Exhaust	0.05 mm
Overlap	Intake	1.51 mm
	Exhaust	1.78 mm
Intake Valve	Open	15° Before TDC
	Close	33° After BDC
Exhaust Valve	Open	37° After BDC
	Close	17° After TDC

2.3 Research Variables

The variables in this study were divided into three categories, namely independent variables, dependent variables, and controlled variables. The independent variables consisted of the camshaft type (standard, touring, and racing) and the fuel type (pure Pertamax and Pertamax with octane booster). The dependent variables were fuel consumption and Air-Fuel Ratio (AFR). Meanwhile, the controlled variables included engine condition, testing environment, engine temperature, and measurement procedures.

2.4 Experimental Procedure

The experiment was carried out by installing each type of camshaft on the test motorcycle and conducting fuel consumption and AFR measurements under two operating conditions, namely idle and 5000 rpm. For each test, the engine was allowed to stabilize before measurements were taken. Fuel consumption was measured based on the time required to consume a fixed volume of fuel (20 ml), while AFR values were recorded using a scanner
Each test was repeated three times to ensure data reliability, and the average values were used for analysis. The same procedure was applied to all variations of camshaft and fuel to maintain consistency in the experiment.

2.5 Data Analysis Technique

The collected data were analyzed using a descriptive quantitative approach. Fuel consumption data were compared based on the time required to consume a fixed fuel volume, while AFR values were analyzed to determine combustion characteristics. The results were presented in the form of tables and graphs to facilitate interpretation and discussion.

The data were statistically analyzed using the Kruskal–Wallis test to determine whether there were significant differences among the camshaft variations. The Kruskal–Wallis test is calculated using the following formula:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1)$$

Description:

H = Kruskal–Wallis test statistic,
N = total number of observations,
k = number of groups,
R_i = sum of ranks in group i, and
n_i = number of observations in group *i*.

The decision criterion used in this study was a significance level of 0.05. If the p-value was less than 0.05, the result was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Fuel Consumption Analysis

The results of fuel consumption testing were obtained under two operating conditions, namely idle and 5000 rpm, using different camshaft variations (standard, touring, and racing) and fuel types (pure Pertamax and Pertamax mixed with octane booster). The complete results of the fuel consumption test are presented in Table 5.

Table 5. Fuel Consumption at Idle Speed

Type Camshaft	Fuel Type	Testing (min/20 ml)				SD
		1	2	3	Average	
Standard	Pertamax	8.03	8.19	8.19	8.14	± 0.09
	Pertamax + octane booster	9.27	9.23	9.15	9.22	± 0.06
Touring	Pertamax	7.38	7.45	7.38	7.40	± 0.04
	Pertamax + octane booster	8.36	8.46	8.27	8.36	± 0.10
Racing	Pertamax	6.51	7.06	6.55	6.57	± 0.35
	Pertamax + octane booster	741	7.42	8.28	7.57	± 0.50

Table 6. Fuel Consumption at 5000 RPM

Type Camshaft	Fuel Type	Testing (min/20 ml)				SD
		1	2	3	Average	
Standard	Pertamax	2.54	2.58	2.52	2.55	± 0,03
	Pertamax + octane booster	2.54	2.59	2.58	2.57	± 0,03
Touring	Pertamax	3.14	2.57	2.57	2.76	± 0,33
	Pertamax + octane booster	3.26	3.17	3.18	3.20	± 0,05
Racing	Pertamax	2.27	2.43	2.33	2.32	±0,08
	Pertamax + octane booster	2.43	2.22	2.36	2.34	± 0,11

Based on the results, it can be observed that camshaft variation significantly affects fuel consumption characteristics. At idle conditions, the standard camshaft tends to produce the most efficient fuel consumption compared to the touring and racing camshafts. This is because the standard camshaft is designed with valve timing that is optimized for daily use, resulting in a more stable and efficient combustion process.

In contrast, the racing camshaft shows higher fuel consumption due to its longer duration and higher lift, which allow more air-fuel mixture to enter the combustion chamber. Although this improves engine performance, it also leads to a richer mixture and increased fuel usage. Meanwhile, the touring camshaft provides a balance between efficiency and performance, with fuel consumption values that are generally between the standard and racing camshafts.

At 5000 rpm conditions, similar trends were observed. The touring camshaft tends to show better efficiency at medium engine speeds, indicating that its design is more suitable for cruising conditions. The comparison of fuel consumption at different engine speeds is illustrated in Figure 2.

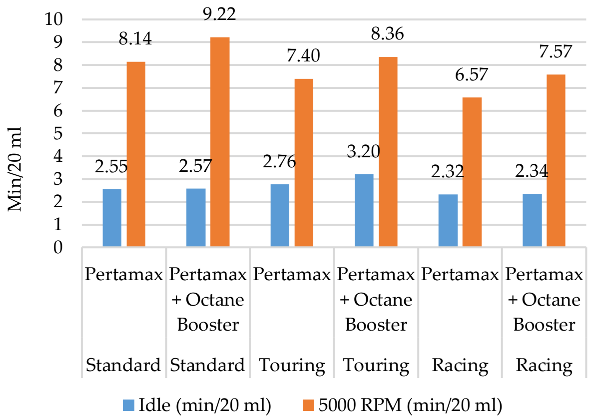

Figure 2. Fuel Consumption at Idle Condition

Furthermore, the experimental results show a clear quantitative difference in fuel consumption between camshaft variations. At idle condition, the standard camshaft combined with octane booster achieved the highest efficiency, reaching 9.22 minutes per 20 ml, while the racing camshaft with pure Pertamax showed the lowest efficiency at 6.57 minutes per 20 ml. This indicates that camshaft geometry significantly influences fuel usage, especially at low engine speed where combustion stability plays a crucial role (Wijanata & Muhaji, 2014).

The higher efficiency of the standard camshaft is attributed to its valve timing characteristics, which produce a more optimal air-fuel mixture and stable combustion. In contrast, the racing camshaft increases fuel consumption due to excessive valve overlap and longer duration, which leads to incomplete combustion and fuel losses. This finding is in line with previous research stating that increasing camshaft duration can improve engine performance but may reduce efficiency at low engine speeds (Halim et al., 2021).

At 5000 rpm, the results indicate a shift in performance characteristics, where the touring camshaft combined with octane booster achieved the best efficiency at 3.20 minutes per 20 ml. This suggests that the touring camshaft is designed to operate more effectively at medium engine speeds, where increased volumetric efficiency improves the combustion process (Rohman & Adiwibowo, 2017). The improved performance at this speed is influenced by better air-fuel mixing and more optimal cylinder filling.

In addition, the differences in fuel consumption between camshaft types are closely related to volumetric efficiency and valve timing optimization. As engine speed increases, the need for faster air-fuel flow becomes more critical, which explains why the touring camshaft performs better at higher rpm compared to the standard camshaft (Pangeran et al., 2020).

These results are consistent with previous studies which state that camshaft parameters such as duration, lift, and lobe separation angle (LSA) directly affect engine efficiency and fuel consumption. Increasing duration and lift improves air intake but may also increase fuel consumption if not balanced with combustion conditions (Prasetyo et al., 2020).

Table 7. Kruskal–Wallis Test Results for Fuel Consumptions

Fuel Type	Kruskal-Wallis H	df	p-value	Conclusion
Pertamax	2.898	2	0.235	Not Significant
Pertamax + Octane Booster	2.538	2	0.281	Not Significant

Based on the Kruskal–Wallis test results for the fuel consumption parameter, a value of H = 2.898 with df = 2 and Sig. = 0.235 (> 0.05) was obtained for pure Pertamax fuel. Meanwhile, for Pertamax with an octane booster, the result showed H = 2.538 with df = 2 and Sig. = 0.281 (> 0.05). These results indicate that the camshaft variations produced relatively small differences in fuel consumption and did not show consistent changes for both fuel types. This condition suggests that fuel consumption is more influenced by engine operating conditions and fuel characteristics than by the camshaft variations used.

3.2 Air-Fuel Ratio (AFR) Analysis

The Air-Fuel Ratio (AFR) measurements were conducted to evaluate the combustion quality of each camshaft and fuel variation. The results are presented in Table 7.

Table 8. AFR Measurement Results

Type Camshaft	Fuel Type	AFR 1	AFR 2	AFR 3	Average AFR	SD
Standard	Pertamax	13.98	13.98	14.1	14.02	± 0.06
	Pertamax + octane booster	13.87	13.87	13.98	1391	± 0.06
Touring	Pertamax	13.76	13.76	13.87	13.80	± 0.06
	Pertamax + octane booster	13.64	13.76	13.76	13.72	± 0.06
Racing	Pertamax	13.64	13.64	13.64	13.64	± 0
	Pertamax + octane booster	13.41	13.41	13.53	13.45	± 0.06

The results show that camshaft modification influences AFR values significantly. The standard camshaft generally produces AFR values closer to the stoichiometric ratio (approximately 14.7), indicating more complete combustion and better fuel efficiency. This condition is ideal for daily operation, as it ensures stable engine performance and lower fuel consumption.

On the other hand, the racing camshaft tends to produce lower AFR values, indicating a richer air-fuel mixture. This occurs because the increased valve opening duration allows more fuel to enter the combustion chamber. Although a richer mixture can enhance engine power, it also results in higher fuel consumption and less efficient combustion.

The use of octane booster also affects AFR values by altering the combustion characteristics of the fuel. In some cases, the addition of octane booster results in a slightly richer mixture, which can improve combustion stability but may reduce fuel efficiency.

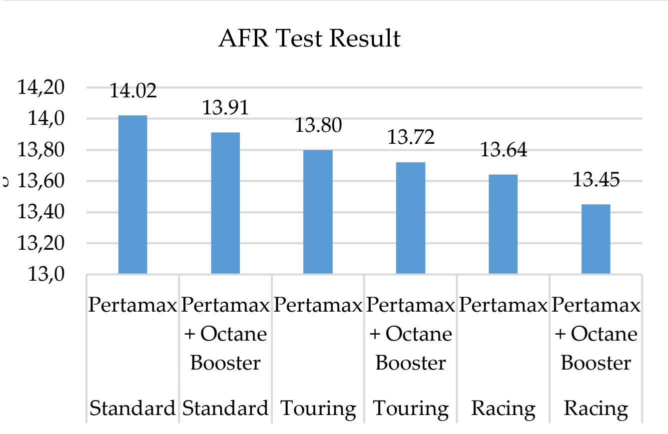

Figure 3. AFR Comparison Graph

Furthermore, the experimental results indicate a clear variation in AFR values for each camshaft and fuel combination. The highest AFR value was obtained using the standard camshaft with pure Pertamax, reaching 14.02, which is close to the ideal stoichiometric ratio. In contrast, the lowest AFR value was recorded in the racing camshaft combined with octane booster, at 13.45, indicating a richer air-fuel mixture. These results confirm that camshaft characteristics significantly influence combustion quality (Al-Arkawazi, 2019).

The standard camshaft produces AFR values closer to the ideal condition due to its optimized valve timing, which ensures a balanced air-fuel mixture and more complete combustion. This is particularly important for fuel efficiency and stable engine operation under normal conditions. On the other hand, the racing camshaft results in lower AFR values due to increased valve duration and lift, which allow more fuel to enter the combustion chamber. This leads to a richer mixture and higher fuel consumption, although it may improve engine power output (Khalwani et al., 2025).

In addition, the use of octane booster affects AFR values by modifying fuel combustion characteristics. The addition of octane booster tends to produce a slightly richer mixture, which can enhance combustion stability but may reduce fuel efficiency. This is consistent with studies showing that fuel composition, including octane number and chemical additives, has a direct impact on AFR and combustion performance (Rimkus et al., 2022).

Moreover, variations in AFR are closely related to volumetric efficiency and air-fuel mixing quality. Changes in camshaft parameters such as duration, lift, and lobe separation angle (LSA) influence the amount of air entering the combustion chamber, which directly affects AFR values. As a result, improper matching between camshaft characteristics and fuel type can lead to suboptimal combustion (Muhajir et al., 2018).

Table 9. Kruskal–Wallis Test Results for AFR

Fuel Type	Kruskal-Wallis H	df	p-value (Sig.)	Conclusion
Pure Pertamax	7.200	2	0.027	Significant
Pertamax + Octane Booster	7.270	2	0.026	Significant

Based on the Kruskal–Wallis test results for the Air-Fuel Ratio (AFR) parameter, camshaft variations showed a significant effect on both fuel types. For pure Pertamax fuel, the result obtained was H = 7.200 with Sig. = 0.027 (< 0.05), while for Pertamax with an octane booster, the result was H = 7.270 with Sig. = 0.026 (< 0.05). These results indicate that camshaft variations significantly affected the AFR values in both pure Pertamax and Pertamax mixed with an octane booster.

4. CONCLUSION

Based on the results of this study, it can be concluded that camshaft modification has a significant effect on fuel consumption and Air-Fuel Ratio (AFR) in the Honda Supra X 125 motorcycle. At idle condition, the standard camshaft combined with octane booster provides the best fuel efficiency, while the racing camshaft shows the highest fuel consumption due to its longer duration and higher lift characteristics. At 5000 rpm, the touring camshaft demonstrates the best performance in terms of fuel efficiency, indicating its suitability for medium engine speed operation. In terms of combustion characteristics, the standard camshaft produces AFR values closer to the ideal stoichiometric ratio, indicating more complete and efficient combustion. Meanwhile, the racing camshaft results in richer air-fuel mixtures, which may improve engine performance but lead to higher fuel consumption and reduced efficiency. The addition of octane booster also influences AFR by slightly enriching the mixture and improving combustion stability.

Overall, the selection of camshaft type should be adjusted according to the intended use of the motorcycle. The standard camshaft is more suitable for fuel efficiency and daily use, the touring camshaft offers a balance between performance and efficiency, and the racing camshaft is more appropriate for high-performance applications despite its higher fuel consumption.

5. DECLARATION/STATEMENT

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The author used a Generative AI tool (ChatGPT) in a limited capacity for language editing and structuring of the manuscript without influencing the scientific content.

5.2. Author Contribution

The author contributed as the primary researcher responsible for conducting the experiments, collecting and analyzing data, and preparing the manuscript. Abdurrahman contributed by supervising the research process, providing guidance during the experimental work, and offering valuable insights for improving the study. Ranu Iskandar and Rizqi Fitri Naryanto contributed by supervision.

5.3. Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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