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THE EFFECT OF DRIVE PULLEY INCLINE ANGLE AND ROLLER WEIGHT VARIATION ON THE ACCELERATION PERFORMANCE OF HONDA SCOOPY 110 AUTOMATIC MOTORCYCLE USING FACTORIAL EXPERIMENTAL DESIGN

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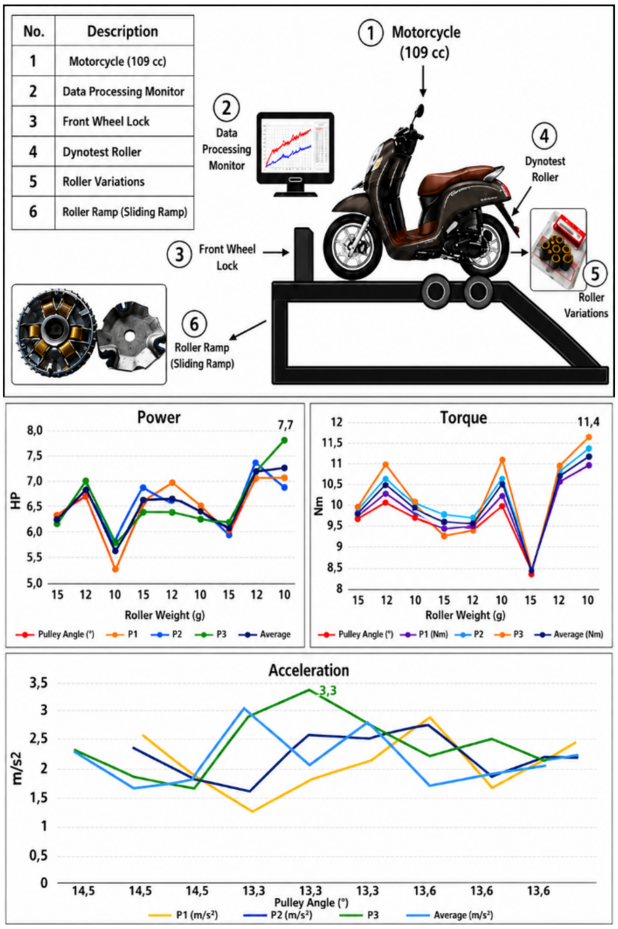
Abstract graphic



Abstract

The widespread use of automatic motorcycles has increased the application of Continuously Variable Transmission (CVT) systems due to their ability to provide smooth power delivery and riding comfort. However, the standard CVT configuration does not always provide optimal acceleration performance, especially during initial acceleration, overtaking, and uphill riding conditions. Previous studies mostly analyzed CVT component modifications separately, while the interaction between drive pulley inclination angle and roller weight using a factorial experimental approach is still limited. Therefore, this study aims to analyze the effect of drive pulley inclination angle and roller weight variation on the acceleration performance of a Honda Scoopy 110 automatic motorcycle.

This research used an experimental method with a 3 × 3 factorial design. The independent variables consisted of three drive pulley inclination angles (13.3°, 13.6°, and 14.5°) and three roller weight variations (10 g, 12 g, and 15 g). Acceleration testing was performed using a chassis dynamometer under controlled conditions, and each treatment combination was repeated three times. The obtained data were analyzed using Two-Way Analysis of Variance (ANOVA) and Tukey HSD test with a significance level of 5%.

The results showed that the combination of a 13.3° drive pulley angle and a 10 g roller produced the highest acceleration value of 2.73 m/s^2. The ANOVA results indicated that the drive pulley angle had a significant effect on acceleration performance ($F = 7.975$; $p = 0.003$), while roller weight individually did not show a significant effect ($F = 0.194$; $p = 0.825$). However, the interaction between drive pulley angle and roller weight significantly influenced acceleration performance ($F = 3.207$; $p = 0.037$). These findings indicate that optimizing CVT performance requires proper compatibility between pulley geometry and roller weight. This study provides practical recommendations for improving automatic motorcycle acceleration through appropriate CVT component configuration.

Keywords: CVT, drive pulley, roller weight, acceleration, Honda Scoopy 110.

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1. Introduction

The rapid development of land transportation in the globalization era has led to the increasing use of motor vehicles as the primary mode of transportation in Indonesia. This phenomenon is driven by the ability of motor vehicles to provide comfort and mobility convenience in supporting daily activities [1].Technological advancements have also significantly influenced the automotive sector, particularly the motorcycle industry. One of these developments is the implementation of automatic transmission systems commonly used in motorcycles and cars. This system utilizes pulleys and V-belts to transmit power from the engine to the rear wheel [2].

Automatic transmission systems, especially Continuously Variable Transmission (CVT), are designed to provide smoother acceleration and better fuel efficiency, which are important considerations for consumers in choosing automatic motorcycles. Optimization of CVT components such as pulley angle and roller mass has been reported to significantly affect acceleration response, particularly under loaded conditions or when traveling on inclined roads [3].This indicates the importance of research regarding the influence of CVT design on vehicle acceleration and overall performance.

Acceleration is one of the essential aspects of motorcycle performance, especially for vehicles used as daily transportation. Based on data from Cermati.com, a standard automatic motorcycle is capable of covering a distance of 200 meters in 12.98 seconds at a speed of 91.6 km/h[4]. Good acceleration enables vehicles to respond optimally to speed changes, both when carrying heavy loads and when passing uphill roads. However, some users report that acceleration performance is not always optimal, particularly when the motorcycle carries additional loads or is operated on inclined terrain. This condition indicates a gap between user expectations and the actual performance of the vehicle.

The CVT system plays an important role in determining acceleration performance. This transmission system consists of a primary pulley and a secondary pulley connected by a V-belt, allowing automatic ratio changes without manual gear shifting. The drive pulley functions to regulate transmission ratio changes, while the roller determines system responsiveness based on its mass. Variations in drive pulley angle and roller weight are known to significantly affect the resulting engine torque and power [5].

Recent studies have shown that optimization of Continuously Variable Transmission (CVT) systems plays an important role in improving transmission efficiency and vehicle performance. Han et al. [6] explained that CVT optimization is strongly related to transmission ratio characteristics and power transfer efficiency. Furthermore, Kim et al. [7] stated that appropriate transmission ratio adjustment allows the drivetrain system to operate more efficiently and improves vehicle dynamic performance.

Several previous studies have shown that variations in drive pulley angle and roller weight significantly influence the acceleration characteristics of automatic motorcycles. Widiyatmoko et al. [5] reported that modifications to pulley angle and roller mass affect torque, acceleration, engine power, and maximum speed. Similarly, Mi'radj [2] found that pulley angle and roller weight influence transmission efficiency and overall engine performance. Nurwanto and Hadi [8] demonstrated that these variations also affect torque characteristics in automatic motorcycles.

Further studies by Pahlevi [9] and Nugroho et al. [10] revealed that the optimal combination of pulley angle and roller weight can improve fuel efficiency and acceleration response without increasing fuel consumption. Additional findings from Anugrah [11] as well as Harsanta and Parta [12] showed that appropriate variations in pulley angle and roller weight can improve transmission ratio performance and extend component lifespan. Syaifullah [13] and Susena et al. [14] also rtheeported that certain combinations of pulley angle and roller weight can enhance acceleration, fuel efficiency, torque, and maximum engine speed, thereby providing better riding comfort.

However, despite the large number of studies conducted, many users still modify CVT systems using a trial-and-error approach without adequate technical data, resulting in inconsistent outcomes. In some cases, improper modifications may even increase fuel consumption or shorten component lifespan. In addition, most previous studies focused only on analyzing variables separately or used different types of motorcycles, such as Honda Beat or 150 cc automatic motorcycles. The use of performance testing equipment such as dynamometers has also not been widely applied in analyzing the combined effects of these variables.

However, previous studies generally focused on evaluating the influence of roller weight or drive pulley modification separately. Limited research has investigated the interaction between drive pulley geometry and roller weight using a factorial experimental design supported by statistical analysis. In addition, previous investigations have not extensively discussed how the combination of pulley inclination angle and roller centrifugal characteristics affects CVT ratio changes and acceleration performance. Therefore, further research is required to determine the optimal CVT configuration based on measurable acceleration data.

Therefore, this study aims to analyze the interaction effect between drive pulley inclination angle and roller weight on the initial acceleration performance of the Honda Scoopy 110 automatic motorcycle using dynamometer testing in order to obtain objective and measurable data.

2. Material and Method

2.1. Material

The materials and equipment used in this study are as follows:

1. Drive Pulley

   The drive pulley was used as the main variable in this study. Several variations of drive pulley inclination angles were applied, namely 13.3°, 13.6°, and 14.5°. The drive pulley functions to regulate transmission ratio changes in the CVT system and has a significant influence on acceleration performance[8], The modification of the drive pulley angle was carried out through a machining process by adjusting the pulley surface inclination to obtain angles of 13.3°, 13.6°, and 14.5°. The machining process was performed gradually to maintain the accuracy of the pulley surface geometry. The pulley angle was measured using a digital angle measuring instrument to ensure that each variation met the predetermined specifications before testing. All modified drive pulleys were tested under the same CVT installation conditions to maintain consistency and minimize experimental errors.

Figure 1. Drive Pulley Inclination Angle 13.3°, 13.6°, and 14.5°

2. **Roller**

   Rollers with weight variations of 10 g, 12 g, and 15 g were used in this study. The roller functions to generate centrifugal force in the CVT system, which affects pulley movement and transmission response [15]

Figure 2. Roller weight 10 grams,12 grams,15 grams

3.Honda Scoopy 110cc

Table 1. Spesification of Honda Scoopy 110cc

Specification	Information
Engine Type	4 Stroke, SOHC, Air Cooled
Engine Capacity	108,2 cc
Maximum Power	9,1 PS / 7.500 rpm
Maximum Torque	9,4 Nm / 6.000 rpm
Fuel System	PGM-FI (Fuel Injection)
Transmision	Automatic (V-Matic)
Fuel Tank Capacity	4 liters
Empty Weight	99 kg
Tire Size	Front: 100/90-12, Rear: 110/90-12
Brake	Front: Disc, Rear: Drum

2.2 Method

This study employed an experimental method to analyze the effect of drive pulley inclination angle and roller weight on the acceleration performance of a Honda Scoopy 110 automatic motorcycle. The research design used was a factorial experimental design involving two independent variables, namely the drive pulley inclination angle and roller weight[16].

The experimental procedure was carried out by modifying the CVT system using various combinations of drive pulley angles and roller weights according to the predetermined treatment variations. The motorcycle was tested under controlled conditions to minimize the influence of external factors such as engine temperature, environmental conditions, and operational inconsistencies [6]. Each treatment combination was repeated several times to obtain accurate and reliable data.

Acceleration testing was conducted using a chassis dynamometer to obtain objective and measurable performance data [17].The parameter observed in this study was acceleration (m/s^2), which indicates the motorcycle's ability to increase speed over time and represents the dynamic performance characteristics of the vehicle [3].

The data obtained from the acceleration tests were statistically analyzed using Two-Way Analysis of Variance (Two-Way ANOVA) to determine the effects of drive pulley inclination angle, roller weight, and their interaction on acceleration performance[18]. If significant differences were found, further analysis was conducted using the Tukey HSD test to determine the most influential treatment combination. All statistical analyses were performed at a significance level of 5% to ensure the validity of the research conclusions [14].

2.3 Experimental Setup

The experimental setup in this study consisted of a Honda Scoopy 110 automatic motorcycle equipped with several variations of drive pulley inclination angles and roller weights. The testing was conducted using a chassis dynamometer under controlled operating conditions. Each treatment combination was tested three times to ensure the consistency and reliability of the obtained data.

The motorcycle acceleration test was carried out from the initial condition until reaching a speed of 60 km/h. The acceleration data obtained from the dynamometer were recorded and used for statistical analysis. The experimental setup of the acceleration testing process is shown in Figure 3.

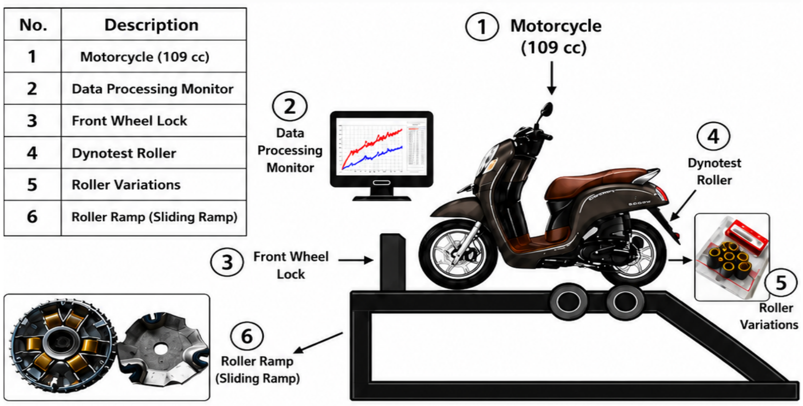

Figure 3. Experimental setup of acceleration testing

2.4 Exsperimental Method

The experimental method used in this study was a quantitative experimental method with a 3 × 3 factorial design. The study was conducted to determine the effect of variations in drive pulley inclination angle and roller weight on the acceleration performance of a Honda Scoopy 110 automatic motorcycle. The independent variables consisted of three variations of drive pulley inclination angles, namely 13.3°, 13.6°, and 14.5°, as well as three variations of roller weights, namely 10 g, 12 g, and 15 g. The dependent variable in this study was the motorcycle's acceleration performance, while the control variables included the type of fuel, engine condition, testing track, and the type of vehicle used during the research.

The experiment was conducted using a dynotest (chassis dynamometer) to obtain objective and measurable acceleration data. Each treatment combination between the drive pulley angle and roller weight was tested three times to obtain more accurate and consistent data. The testing procedure was carried out by operating the motorcycle from a stationary condition until reaching a certain speed on the dynotest, after which the acceleration data were recorded through the Sports Device Dynamometer application.

The experimental data obtained were then analyzed using descriptive statistical methods and Two-Way Analysis of Variance (Two-Way ANOVA) with the assistance of SPSS version 27 software. This analysis aimed to determine the effect of each independent variable as well as the interaction between drive pulley inclination angle and roller weight on the acceleration performance of the Honda Scoopy 110 motorcycle.

2.5 Method Factorial Design 3 x 3

This study employed a 3 × 3 factorial experimental design involving two independent variables, namely the drive pulley inclination angle and roller weight. Each factor consisted of three levels. The drive pulley inclination angles used were 13.3°, 13.6°, and 14.5°, while the roller weight variations used were 10 g, 12 g, and 15 g.

The factorial design method allows simultaneous analysis of the individual effects of each factor as well as the interaction effects between the two variables on the acceleration performance of the motorcycle.

Table 2. Factorial design combinations of drive pulley inclination angle and roller weight

Treatment	Drive Pulley Angle (°)	Roller Weight (g)
A1B1	13.3	10
A1B2	13.3	12
A1B3	13.3	15
A2B1	13.6	10
A2B2	13.6	12
A2B3	13.6	15
A3B1	14.5	10
A3B2	14.5	12
A3B3	14.5	15

This study employed a 3 × 3 factorial experimental design involving two independent variables, namely the drive pulley inclination angle and roller weight. Each factor consisted of three levels. The drive pulley

inclination angles used were 13.3°, 13.6°, and 14.5°, while the roller weight variations used were 10 g, 12 g, and 15 g.
The factorial design method allows simultaneous analysis of the individual effects of each factor as well as the interaction effects between the two variables on the acceleration performance of the motorcycle.

2.6 Analysis of variance (ANOVA)

Analysis of Variance (ANOVA) is a statistical method used to determine whether independent variables have a significant effect on the response variable. In this study, Two-Way ANOVA was used to analyze the effects of drive pulley inclination angle, roller weight, and their interaction on the acceleration performance of the Honda Scoopy 110 automatic motorcycle.

The independent variables used in this study consisted of three levels of drive pulley inclination angles (13.3°, 13.6°, and 14.5°) and three levels of roller weights (10 g, 12 g, and 15 g). Therefore, the experimental design applied was a 3 × 3 factorial design with repetitions for each treatment combination.

The ANOVA calculation was carried out by determining the total variation, the variation caused by factor A (drive pulley angle), the variation caused by factor B (roller weight), the interaction variation between factor A and factor B, and the experimental error variation. The mathematical model of Two-Way ANOVA can be expressed as follows:

$$Yijk = \pi + \alpha \mathrm{i} + \beta j + (\alpha\beta ij + \epsilon ij\mathcal{K} \tag{1}$$

Description:

Y_{ijk} = observed value
μ = grand mean
α_i = effect of the drive pulley angle factor
β_j = effect of the roller weight factor
$(\alpha\beta)_{ij}$ = interaction effect between the two factors
ε_{ijk} = experimental error

The calculation of the sum of squares (Sum of Squares) is done using the following equation:

$$SS_T = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}\left(Y_{ijk} - \bar{Y}\right)^2 \tag{2}$$
$$SS_A = bn\sum_{i=1}^{a}(\overline{Y_{i..}} - \bar{Y})^2 \tag{3}$$
$$SS_B = an\sum_{j=1}^{b}\left(\overline{Y_{.j.}} - \bar{Y}\right)^2 \tag{4}$$
$$SS_{AB} = n\sum_{i=1}^{a}\sum_{j=1}^{b}\left(\overline{Y_{ij.}} - \overline{Y_{i..}} - \overline{Y_{.j.}} + \bar{Y}\right)^2 \tag{5}$$
$$SS_E = SS_T - SS_A - SS_B - SS_{AB} \tag{6}$$

Table 3. Two-Way ANOVA Table for 3×3 Factorial Design

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (DF)	Mean Square (MS)	F-value
Drive Pulley Angle (A)	SS_A	a − 1	$MS_A = \frac{SS_A}{a-1}$	$\frac{MS_A}{MSE}$
Roller Weight (B)	SS_B	b − 1	$MS_B = \frac{SS_B}{b-1}$	$\frac{MS_B}{MSE}$
Interaction (AB)	SS_{AB}	(a−1)(b−1)	$MS_{AB} = \frac{SS_{AB}}{(a-1)(b-1)}$	$\frac{MS_{AB}}{MSE}$
Error	SS_E	ab(n−1)	$MSE = \frac{SSE}{ab(n-1)}$	
Total	SS_T	abn − 1		

3. Result and Discussion

The acceleration test results showed that variations in drive pulley inclination angle and roller weight affected the acceleration characteristics of the Honda Scoopy 110 automatic motorcycle. The highest average acceleration value of 2.73 m/s² was obtained using a 13.3° drive pulley angle combined with a 10 g roller weight. Meanwhile, the lowest acceleration value of 1.65 m/s² was obtained using a 14.5° drive pulley angle combined with a 10 g roller weight.

These results indicate that a smaller drive pulley angle tends to improve initial acceleration performance. This occurs because a smaller pulley angle is able to maintain a lower transmission ratio for a longer period, resulting in greater torque being transmitted to the rear wheel during initial acceleration. Consequently, the motorcycle is able to produce a faster acceleration response.

In addition, the use of lighter roller weights produced better acceleration characteristics compared to heavier rollers. Lighter rollers require higher engine speed before generating sufficient centrifugal force to shift the pulley system. As a result, the engine operates at higher RPM for a longer duration, thereby increasing torque output and acceleration performance.

Conversely, heavier rollers tend to accelerate the pulley shifting process at lower RPM, resulting in a smoother transmission response but reduced initial acceleration. This explains why the use of 15 g rollers generally produced lower acceleration values compared to the 10 g roller configuration.

The results of this study are consistent with the findings of Widiyatmoko et al. [6], who reported that variations in drive pulley angle and roller weight significantly affect acceleration and transmission characteristics in automatic motorcycles. Similar findings were also reported by Nugroho et al. [10], who stated that optimization of CVT component geometry can improve acceleration response and transmission efficiency.

Furthermore, the results of the Two-Way ANOVA analysis showed that the drive pulley inclination angle had a significant effect on acceleration performance, whereas roller weight individually did not show a statistically significant effect. However, the interaction between the two variables had a significant effect on acceleration performance. This indicates that the performance of the CVT system is strongly influenced by the compatibility between pulley angle and roller weight combinations.

The interaction effect demonstrates that roller weight cannot be evaluated separately from the drive pulley angle because both components work simultaneously in regulating transmission ratio changes and torque distribution within the CVT system. Therefore, proper optimization of both components is essential to achieve better motorcycle acceleration performance.

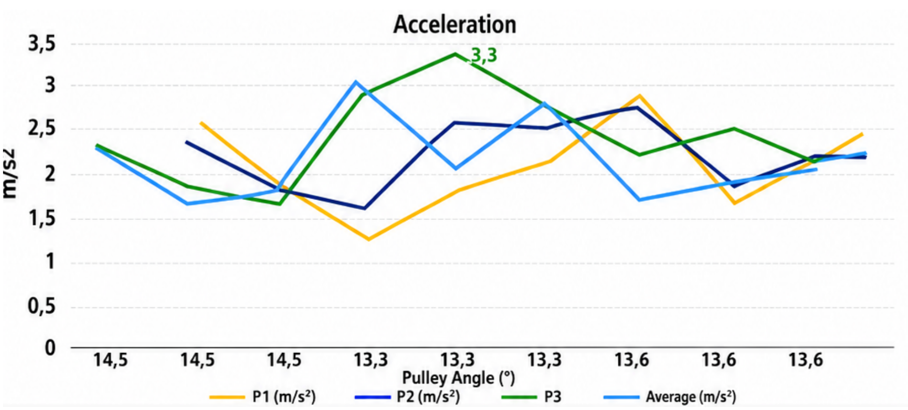

Figure 4. Acceleration test results of Honda Scoopy 110 under variations of drive pulley angle and roller weight

Based on the acceleration test results, variations in drive pulley inclination angle and roller weight affected the acceleration characteristics of the motorcycle. The highest acceleration value was obtained using a 13.3° drive pulley angle combined with a 10 g roller, with an average acceleration value of 2.73 m/s². Meanwhile, the lowest acceleration value was produced by the 14.5° drive pulley angle combined with a 10 g roller, with an average value of 1.65 m/s². These results indicate that the combination of CVT components has a significant effect on transmission response and engine performance.

The use of lighter rollers generally produced better acceleration because lighter rollers require less centrifugal force to move the pulley mechanism. As a result, engine speed increases more rapidly, leading to improved acceleration response. Conversely, heavier rollers tend to slow down pulley movement, resulting in slower acceleration characteristics. In addition, variations in the drive pulley inclination angle also affect the transmission ratio shifting mechanism. Smaller pulley angles allow the transmission system to maintain a lower gear ratio for a longer period, thereby producing greater torque during initial acceleration.

These findings are consistent with previous research conducted by Widiyatmoko et al. [6], which stated that variations in drive pulley angle and roller weight affect acceleration and engine performance. Similar results were also reported by Nugroho et al. [10], who found that optimization of the CVT pulley angle can improve acceleration response without significantly affecting fuel consumption.

Table 4. Average acceleration test result

No	Angle Pulley (°)	Roller Weight (grams)	P 1 (m/s^2)	P2 (m/s^2)	P3 (m/s^2)	Average (m/s^2)
1	14,5	15	2,55	2,28	2,29	2.37
2	14,5	12	1.92	1.75	1.93	1.87
3	14,5	10	1.41	1.83	1.72	1.65
4	13,3	15	1.87	2,88	2.77	2.51
5	13,3	12	2.13	2.05	3.3	2.49
6	13,3	10	2.77	2.72	2.70	2.73
7	13,6	15	1.71	1.75	2.23	1.90
8	13,6	12	2.18	1.95	2.47	2.20
9	13,6	10	2.39	2.08	2.13	2.20

Normality test

The normality test was conducted after obtaining the acceleration response data to determine whether the experimental data followed a normal distribution. This analysis was performed using the Shapiro-Wilk test. The normality test is important to ensure that the acceleration data meet the assumptions required for further statistical analysis using Two-Way ANOVA.

Table 5. *Normality test with shapiro wilk*

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Angle	Statistic	df	Sig.	Statistic	df	Sig.
Acceleration	13.3	.272	9	.053	.910	9	.315
	13.6	.138	9	.200*	.955	9	.745
	14.5	.206	9	.200*	.958	9	.780

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on Table 5, the acceleration data did not show any significant deviation from the normal distribution curve. The obtained Shapiro–Wilk significance value was greater than 0.05, indicating that the data were normally distributed. Therefore, the acceleration data met the assumptions required for further parametric statistical analysis using the Two-Way ANOVA test.

The normal distribution of the data indicates that the experimental measurement results were sufficiently consistent and reliable. Thus, the acceleration test results could be used for further analysis to determine the effect of drive pulley inclination angle and roller weight on motorcycle acceleration performance.

Table 6. *Homogenity test*

Dependent Variable	Testing Basics	Levene Statistic	df1	df2	Sig.
Acceleration	Based on Mean	4.219	8	18	0.755
Acceleration	Based on Median	0.449	8	18	0.876
Acceleration	Based on Median and with adjusted df	0.449	8	7.370	0.859

The homogeneity of variance test was conducted as a prerequisite before performing the Two-Way ANOVA analysis. This test aimed to determine whether the acceleration data from each treatment group had homogeneous variances. The test was carried out using Levene's Test with a significance level of 5% (α = 0.05).

Based on the results of Levene's Test, the significance value obtained from the Based on Mean analysis was 0.755. Since the significance value was greater than 0.05 (Sig. > 0.05), the acceleration data were considered to have homogeneous variances. In addition, the significance values obtained from the median, adjusted median, and trimmed mean analyses were 0.876, 0.859, and 0.812, respectively, all of which were also greater than 0.05.

These results indicate that there were no significant differences in variance among the treatment groups consisting of variations in drive pulley inclination angle and roller weight. Therefore, the assumption of homogeneity of variance was fulfilled, and the acceleration data were suitable for further statistical analysis using Two-Way ANOVA.

Analysis Variance

Two-Way Analysis of Variance (Two-Way ANOVA) was used to determine the effects of drive pulley inclination angle, roller weight, and their interaction on the acceleration performance of the Honda Scoopy 110 automatic motorcycle. Statistical analysis was conducted using a significance level of 5% (α = 0.05).
The ANOVA method was used to evaluate the variation in acceleration data by separating the total variation into variations caused by the main factors, interaction effects, and experimental error. In this study, factor A represented the drive pulley inclination angle, while factor B represented the variation in roller weight.
The acceleration data obtained from each treatment combination were analyzed using Minitab software to determine whether the independent variables had a significant effect on motorcycle acceleration performance. The ANOVA results included calculations of Sum of Squares (SS), Degrees of Freedom (DF), Mean Square (MS), F-value, and significance value (p-value).

Table 7. Two-way ANOVA analysis Acceleration

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	0.120	8	0.015	3.646	0.011
Intercept	3.070	1	3.070	748.168	<0.001
Angle	0.065	2	0.033	7.975	0.003
Roller	0.002	2	0.001	0.194	0.825
Angle * *Roller*	0.053	4	0.013	3.207	0.037
Error	0.074	18	0.004		
Total	3.264	27			
Corrected Total	0.194	26			

Based on Table 7, the hypotheses and decision-making criteria used in the Two-Way Analysis of Variance (ANOVA) are as follows:

The results of the Two-Way ANOVA analysis showed that the overall research model had a significant effect on acceleration performance (F = 3.646; p = 0.011). The R-square value of 0.618 (Adjusted R-square = 0.449) indicates that 61.8% of the variation in acceleration could be explained by the drive pulley inclination angle, roller weight, and their interaction, while the remaining variation was influenced by other factors outside the research model.

Based on the main effect analysis, the drive pulley inclination angle had a significant effect on acceleration performance (F = 7.975; p = 0.003). These results indicate that variations in the drive pulley angle produced significant differences in motorcycle acceleration. Meanwhile, the roller weight variable did not have a significant effect on acceleration performance (F = 0.194; p = 0.825), indicating that variations in roller weight independently did not produce significant differences in acceleration.

Furthermore, the interaction analysis showed a significant interaction effect between drive pulley inclination angle and roller weight on acceleration performance (F = 3.207; p = 0.037). These findings indicate that the effect of drive pulley angle on acceleration depends on the roller weight used. Therefore, the effects of each variable cannot be interpreted separately because both variables work simultaneously in determining the performance characteristics of the CVT system.

Although the 10 g roller produced the highest average acceleration, ANOVA results showed that roller weight alone did not have a significant effect. This phenomenon occurs because acceleration performance in a CVT system depends not only on centrifugal force generated by the roller but also on the movement characteristics of the drive pulley.

The significant interaction between pulley angle and roller weight indicates that both components work simultaneously in controlling CVT ratio changes. Therefore, the correct combination of pulley geometry and roller mass is more important than changing only one component.

Table 8.Post Hoc test (Multiple comparison)

(I) Angle	(J) Angle	Mean Difference (I-J)	Std. Errors	Sig.	Lower Bound	Upper Bound
13.3	13.6	0.0856*	0.03020	0.028	0.0085	0.1627
	14.5	0.1164*	0.03020	0.003	0.0393	0.1934
13.6	13.3	-0.0856*	0.03020	0.028	0.1627	0.0085
	14.5	0.0308	0.03020	0.575	0.0463	0.1078
14.5	13.3	-0.1164*	0.03020	0.003	0.1934	0.0393
	13.6	-0.0308	0.03020	0.575	0.1078	0.0463

Based on the results of the post hoc test using the Tukey HSD method, significant differences in acceleration were found between the 13.3° drive pulley angle and the 13.6° angle (p = 0.028), as well as between the 13.3° angle and the 14.5° angle (p = 0.003). These results indicate that changing the drive pulley angle from 13.3° to larger angles produced statistically significant changes in acceleration characteristics. Meanwhile, the comparison between the 13.6° and 14.5° angles did not show a significant difference, with a significance value of 0.575 (p > 0.05). This indicates that both angle variations produced relatively similar acceleration characteristics.

The Tukey HSD test results showed that the 13.3° drive pulley angle had the most distinct effect on acceleration performance compared to the other angle variations. This condition indicates that a smaller pulley angle is able to maintain a lower transmission ratio for a longer period, resulting in greater initial torque and improved acceleration response.

Therefore, the results of the Tukey HSD post hoc test strengthen the findings of the Two-Way ANOVA analysis, which demonstrated that the drive pulley inclination angle had a significant effect on the acceleration performance of the Honda Scoopy 110 motorcycle, particularly at the 13.3° angle variation.

4.Conclusion

Based on the results of this study, it can be concluded that variations in drive pulley inclination angle and roller weight affect the acceleration performance of the Honda Scoopy 110 automatic motorcycle. The best acceleration performance was obtained using a 13.3° drive pulley inclination angle combined with a 10 g roller weight, resulting in an average acceleration value of 2.73 m/s². Meanwhile, the lowest acceleration performance was obtained using a 14.5° drive pulley angle combined with a 10 g roller weight, with an average acceleration value of 1.65 m/s².

The results of the Two-Way ANOVA analysis showed that the drive pulley inclination angle had a significant effect on motorcycle acceleration performance. In contrast, roller weight individually did not show a statistically significant effect. However, the interaction between drive pulley inclination angle and roller weight had a significant effect on acceleration characteristics.

These findings indicate that the optimization of CVT components cannot be achieved by considering only a single variable. Instead, the compatibility between the drive pulley angle and roller weight must be properly adjusted to obtain optimal acceleration performance.

Overall, this study proves that proper modification of CVT transmission components can improve acceleration response and motorcycle riding performance. Therefore, optimization of drive pulley geometry and roller weight can be considered an effective alternative for improving the acceleration characteristics of automatic motorcycles, particularly the Honda Scoopy 110.

This study was limited to one motorcycle type and focused only on acceleration performance. Further research is recommended to analyze other performance parameters such as torque, power output, fuel consumption, and different engine capacities to obtain a more comprehensive evaluation of CVT optimization.

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