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ANALYSIS EFFECT OF THE PRIMARY PULLEY ANGLE OF SPORTY MOTORBIKE

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ABSTRACT

The research aims to analyze the effect of the primary pulley slope angle on engine torque and fuel consumption of the Mio Sporty 115 CC motorbike. The inclination angle of the primary pulley based on factory standards is 14º. Changing the slope angle of the primary pulley using a lathe for angles of 12º, 13º and 13.5º. Testing was carried out using a dyno test machine, 3 data for each slope angle. The dyno test results consist of engine speed, torque, and power. Fuel consumption is obtained using calculations based on test data. Based on the analysis of test results and calculations, it is known that the slope angle of the primary pulley affects engine torque and fuel consumption of the Mio Sporty 115 CC motorbike. The 14º slope angle produces 6.35 torque, the 13.5º slope angle produces 6.47, the 13º slope angle produces 6.29 and the 12º slope angle produces 6.02. Meanwhile, for fuel consumption, slope angle 12º and 14º require fuel consumption of 0.19 l/hour, slope angle 13º & 13.5º require fuel consumption of 0.18 l/hour. Based on the highest torque and the lowest fuel consumption results, a slope angle of 13.5º is recommended.

Keywords: *Primary Pulley, Slope Angle, Engine Torque, Fuel Consumption, Dyno Test*

INTRODUCTION

The primary pulley is an important component in the automatic transmission system, Continuous Variable Transmission (CVT) (Nobaveh, Herder, and Radaelli 2023)(Tsokanas, Pastorino, and Stojadinović 2022) , (Ardah et al. 2023), (Simoes et al. 2023) , (Mattetti et al. 2022), (Rossetti and Macor 2018). The CVT transmission ratio can be adjusted to match the required vehicle speed to the desired speed (Rossetti and Macor 2018). The automatic transmission system provides motorbike users with comfort when driving. As time goes by, drivers are less satisfied with the comfort and performance of the vehicles they use and want to improve them. Several modifications were made to increase comfort, including modifications to the primary pulley.

The Mio Sporty 115 CC motorbike is one of the motorbikes produced by Toyota that uses an automatic transmission. The inclination angle of the primary pulley based on factory standards is 14º. The primary pulley is the part of the motorbike engine that produces engine torque and power. Engine torque affects engine comfort and performance. Engine torque is influenced by speed and influences engine power. Machine characteristics influence engine performance (Komnos et al. 2022).

Simple modifications can be made with a lathe, namely by reducing the angle of inclination. It is hoped that by reducing the slope angle, the torque and power of the engine will increase. Apart from affecting torque and power, changes in the slope angle of the primary pulley are expected to affect the amount of fuel consumption. Torque and engine speed affect fuel consumption (Broekaert et al. 2021).

Found 18 articles when checking articles on ScienceDirect for period 2018-2023 with these terms ("Primary Pulley" AND "Slope Angle") AND ("Engine Torque" OR "Fuel Consumption")

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OR "Dyno Test". This means that research with these variables still has research opportunities or gaps. Research related to engine performance in fuel reduction and checking with dyno tests has been widely carried out. Of the 10 articles reviewed, 6 articles discussed fuel consumption and 9 articles discussed checking engine performance using a dyno test.

Based on the problems mentioned above, the aim of this research is to analyze the effect of the primary pulley slope angle on engine torque and fuel consumption of the Mio Sporty 115 CC motorbike.

LITERATURE REVIEW

Fuel consumption is one of the reasons modifications or improvement activities are carried out (Komnos et al. 2022). To test fuel use, it is carried out by ensuring the fuel volume for each condition is in accordance with the experimental plan by draining the fuel reservoir (Zhang et al. 2020). Measuring fuel consumption under actual operating conditions will provide more accurate results (Tsiakmakis et al. 2019), although it requires more time and effort. Much research has been carried out to reduce fuel consumption in vehicles (Komnos et al. 2022), (Broekaert et al. 2021), (du Plessis et al. 2023), (Weber, Sundvor, and Figenbaum 2019), (Tsiakmakis et al. 2019), (Yang et al. 2023) .

Engine performance is determined based on power, torque, speed, and fuel consumption (Broekaert et al. 2021). Accurate engine performance testing can be done using a dyno test or Dynamometer test (Komnos et al. 2022), (Zhang et al. 2020), (Broekaert et al. 2021), (du Plessis et al. 2023), (Weber et al. 2019), (Ilia et al. 2019), (Boger et al. 2022), (Dauphin et al. 2023), (Yang et al. 2023). Dyno test is credible in testing engine performance (du Plessis et al. 2023). Considering cost, engine performance testing with a dyno test is carried out only a few trials, for example 3 trials for each change in slope angle.

METHODOLOGY

Research was conducted on the Mio Sporty 115 CC motorbike (Figure 1). The inclination angle of the primary pulley based on factory standards for the Mio Sporty 115 CC motorbike is 14º (Figure 2). Changing the slope angle of the primary pulley using a lathe for angles of 12º, 13º (Figure 3) and 13.5º. To ensure the modification results of the lathe, the angle of the primary pulley is measured with an arc ruler (Figure 4). If the angle of the primary pulley does not match the target, then modify it again with a lathe until an appropriate result is obtained.

Testing was carried out using a dyno test machine (Figure 5), taking 3 data for each slope angle (12º, 13º, 13.5º and 14º). The dyno test results consist of engine speed, torque, and power. The average result of each slope angle is calculated to check the trend result. Fuel consumption is obtained using calculations based on test data (time for 10 ml fuel). The simulation was carried out with an empty vehicle due to fuel consumption in an empty vehicle and a loaded vehicle is different. Simulation results with a dyno test can predict fuel use (du Plessis et al. 2023).

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Figure 1. Mio Sporty 115 CC motorbike

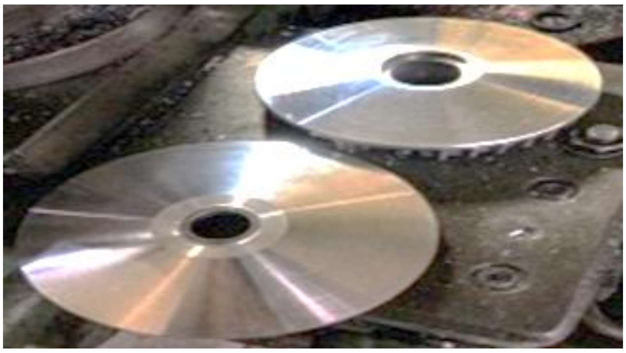

Figure 2. Primary pulley standards 14º (before modification)

Figure 3. Primary pulley standards 13º (after modification)

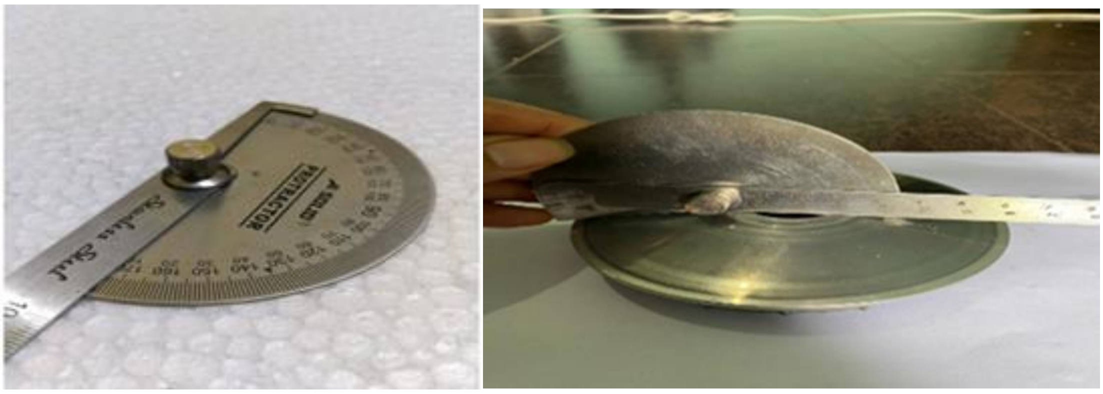

Figure 4. Arc Ruler & Method of Checking Angle

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Figure 5. Dyno Test

RESULT AND DISCUSSION

Test results with dyno test (Figure 6-9), dyno test shows speed, torque, and power results for 14º slope angle (Table 1), 13.5º slope angle (Table 2), 13º slope angle (Table 3) and 12º slope angle (Table 4). Testing fuel consumption with a dyno test was carried out by simulating 10 ml of fuel for each slope angle of primary pulley (Table 5).

Table 1. Summary of the Dyno Test Results for 14º

14º	**Speed (K-RPM)**	**Power Max (HP)**	**Speed (K-RPM)**	**Torque Max (Nm)**
1	6.79	8.26	6.68	6.44
2	6.76	8.08	6.68	6.30
3	6.75	7.99	6.55	6.30
Ave	6.77	8.11	6.637	6.35

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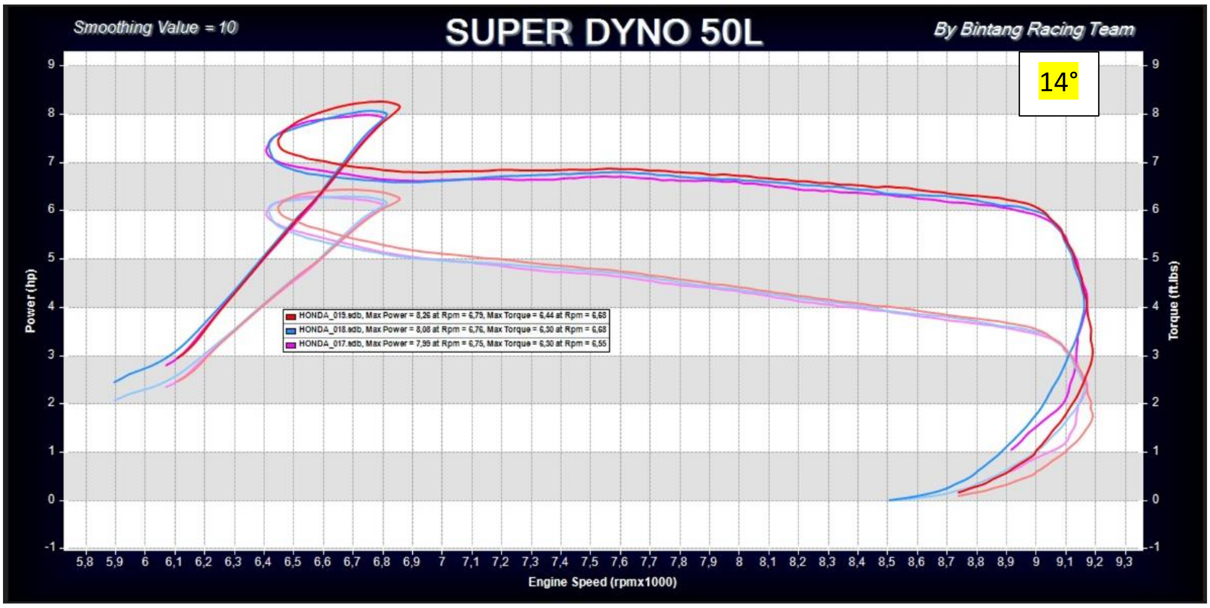

Figure 6. Result of Dyno Test for slope angle 14º

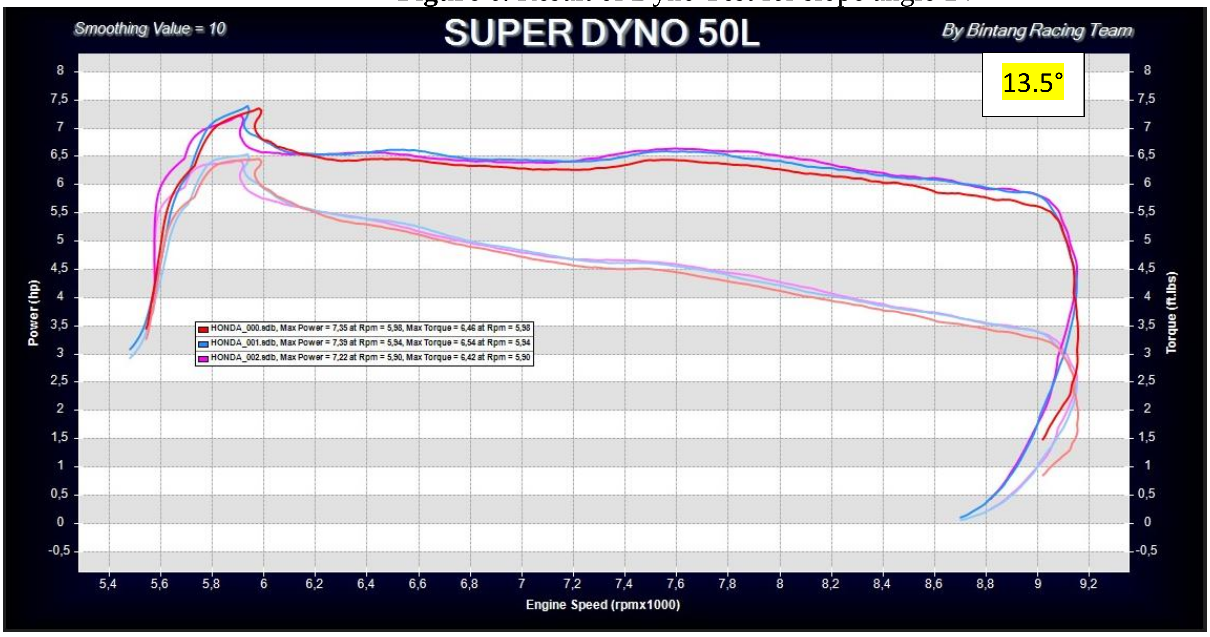

Figure 7. Result of Dyno Test for slope angle 13.5º

Table 2. Summary of the Dyno Test Results for 13.5º

13.5º	Speed (K-RPM)	Power Max (HP)	Speed (K-RPM)	Torque Max (Nm)
1	5.98	7.35	5.98	6.46
2	5.94	7.39	5.94	6.54
3	5.90	7.22	5.90	6.42
Ave	5.94	7.32	5.94	6.47

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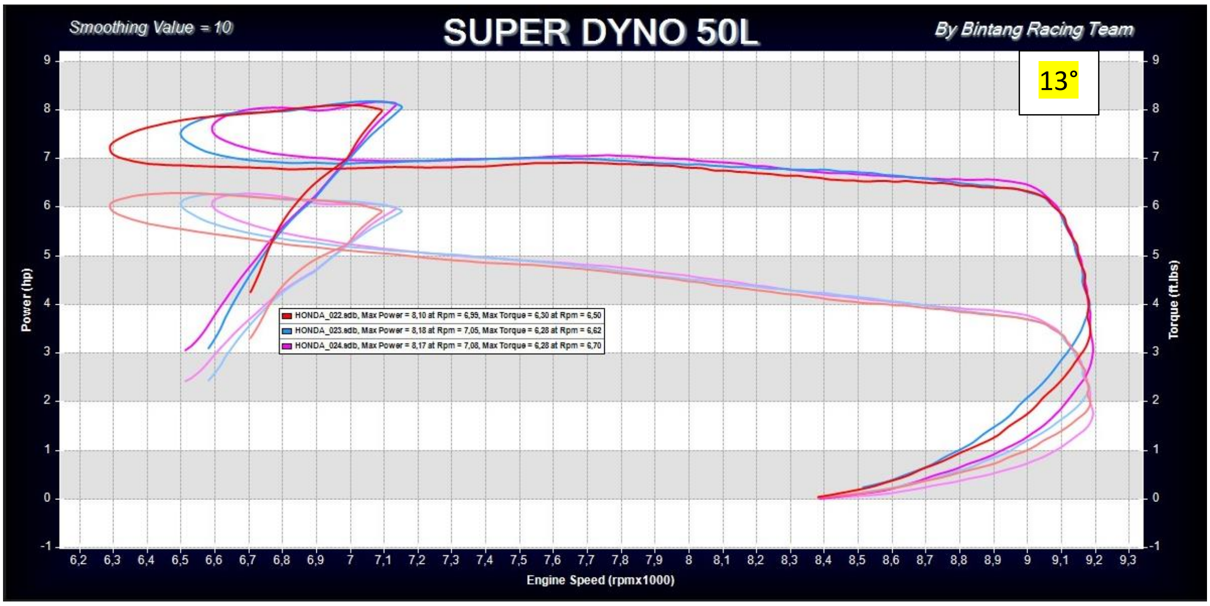

Figure 8. Result of Dyno Test for slope angle 13º

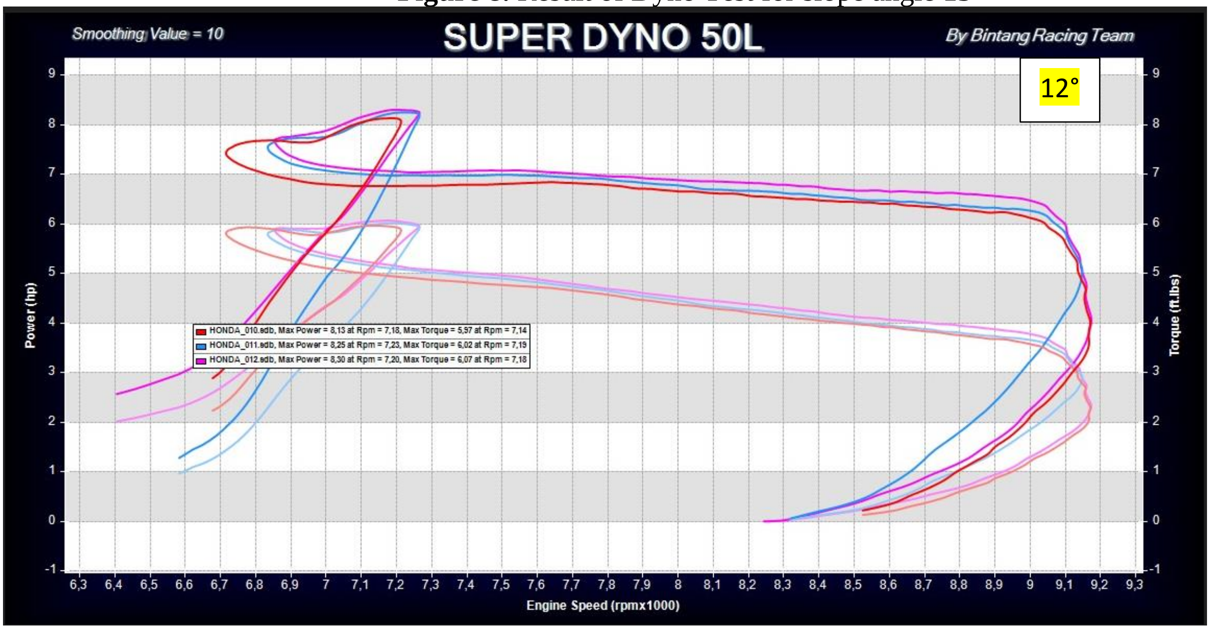

Figure 9. Result of Dyno Test for 12º

Table 3. Summary of the Dyno Test Results for 13º

13º	Speed (K-RPM)	Power Max (HP)	Speed (K-RPM)	Torque Max (Nm)
1	6.99	8.10	6.50	6.30
2	7.05	8.18	6.62	6.28
3	7.08	8.17	6.70	6.28
Ave	7.04	8.15	6.607	6.29

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Table 4. Summary of the Dyno Test Results for 12º

12º	Speed (K-RPM)	Power Max (HP)	Speed (K-RPM)	Torque Max (Nm)
1	7.18	8.13	7.14	5.97
2	7.23	8.25	7.19	6.02
3	7.20	8.30	7.18	6.07
Ave	7.20	8.23	7.17	6.02

Table 5. Fuel Consumption

Angle	Time (Sec)	Fuel Consumption (L/H)
14º	192.7	0.19
13.5	195.7	0.18
13	199.3	0.18
12	182.8	0.20

Table 6. Summary of Dyno Test for Torque & Power

Angle	Torque Max (Nm)	Power Max (HP)
14º	6.35	8,11
13.5	6.47	7.32
13	6.29	8.15
12	6.02	8.23

There is a relationship between power, torque, and speed. In theory, Torque is directly proportional to Power and inversely proportional to speed. However, in actual application it is not completely correct (Table 5) because there are losses, namely frictional losses between bearings and gears. Not all engine power is delivered to the wheels. Engine power (BHP) includes Power delivered at wheels (HP) and Losses (frictional losses between bearings and gears). Brake horsepower (BHP) is a measurement of the engine's power taken at the flywheel or crankshaft without the engine losing power due to drivetrain and gearbox resistance. It means that the BHP of an engine will always be higher than the HP of the engine. The difference between the engine torque and the measured wheel torque was calculated as the torque loss (Broekaert et al. 2021).

The data displayed by the dyno test is the maximum power and torque obtained in each test, where the speed recorded is different for each test. The same speed does not necessarily produce the same power or torque. Of the 4 types of angles tested, the 13.5º angle showed the most stable results where the maximum power and maximum torque for 3 trials were obtained at the same speed in each trial. In the 1st experiment, maximum power of 7.35 HP was obtained at a speed of 5.98K-RPM and maximum torque of 6.46 Nm was obtained at speed 5.98K-RPM too. Likewise for experiments 2 and 3, the speed for maximum power and maximum torque are the same (Table 2).

Based on table 6, the results from an angle of 13.5º give different results, which means that the size of the angle cannot be said to be directly proportional to the amount of power and torque. Although the overall research results show that the angle of inclination of the primary pulley influences the amount of torque produced, where an angle of 13.5º produces the largest torque, namely 6.47 Nm. Based on table 5, the fuel consumption of the 13.5º and 13º (18 Liter/Hour) corners is lower than when using the 14º (0.19 Liter/Hour) and 12º (0.20 Liter/Hour) corners.

Overall, it can be stated that the angle of the primary pulley affects torque and fuel consumption. The 13.5º angle is recommended based on the highest

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torque results and lower fuel consumption compared to other angles. The 13.5º angle also produces more stable maximum power and maximum torque at the same speed. Fuel consumption is directly affected by engine torque and speed (Broekaert et al. 2021), (Tsiakmakis et al. 2019).

CONCLUSION AND SUGGESTION

Based on the analysis of test results, the slope angle of the primary pulley affects engine torque and fuel consumption of the Mio Sporty 115 CC motorbike. The 14º slope angle produces 6.35 torque, the 13.5º slope angle produces 6.47, the 13º slope angle produces 6.29 and the 12º slope angle produces 6.02. Meanwhile, for fuel consumption, slope angle 12º and 14º require fuel consumption of 0.19 Liter/Hour, slope angle 13º & 13.5º require fuel consumption of 0.18 Liter/Hour. Based on the highest torque results and the lower fuel consumption results, a slope angle of 13.5º is recommended.

Suggestions for further research, it is necessary to carry out research on a slope angle of 13.5º in more detail so that the cause of maximum power and maximum torque results is more stable at the same speed.

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