Analysis Of The Transmission System In A 2010 Honda Beat Electric Motorcycle

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Abstract. With the advancement of technology and the growing awareness of environmental protection, electric motorcycles are becoming increasingly popular as eco-friendly alternatives to conventional motor vehicles. The modification of the 2010 Honda Beat is one such electric motorcycle model that has gained public attention due to its attractive design and reasonably good performance. However, despite the rising popularity of electric motorcycles, there are still some technical aspects that need further analysis to ensure optimal performance. One important component in a motorcycle is the transmission system. The transmission system functions to convert engine power into motion at the drive wheel. The cause of slipping that occurs in the 2010 Honda Beat electric motorcycle is overly loose tension. In the 2010 Honda Beat electric motorcycle, the transmission system has been changed from a belt drive transmission to a sprocket transmission system, with a ratio of 15 teeth on the front sprocket and 32 teeth on the rear sprocket, resulting in a sprocket ratio of 2.128. The chain speed is 7.7 m/s with 76 chain links or a length of 84.22 cm. The transmission system on this electric motorcycle uses a number 40 single-chain drive.

Keyword: Transmission, Honda Beat 2010, Electric Motorcycle, Transmission System, Slip, Belt Drive, Sprocket

INTRODUCTION

With the advancement of technology and the growing awareness of environmental protection, electric motorcycles are becoming increasingly popular as environmentally friendly alternatives to conventional motor vehicles. The 2010 Honda Beat is one such electric motorcycle model that has gained public attention due to its attractive design and reasonably good performance. However, despite the increasing popularity of electric motorcycles, there are still some technical aspects that need to be further analyzed to ensure optimal performance.
One of the crucial components of a motorcycle is the transmission system. The transmission system functions to convert power from the engine into motion at the drive wheels. In conventional fuel-powered motorcycles, manual or automatic transmissions with multiple gears are commonly used to provide maximum speed and acceleration that suit road conditions.

An electric motorcycle has been developed by the Mechanical Engineering Department of the Bengkalis State Polytechnic using a 2 kW BLDC electric motor, a 72-volt 25 AH LiFePO4 battery, and a controller with a current range of 100-500 Amps and a maximum power output of 3 kW. The issue faced by the 2010 Beat electric motorcycle lies in its transmission system. Initially, the electric motorcycle used the standard pulley and V-belt transmission of the 2010 Beat. However, after testing, the electric motorcycle did not move. The wheel could turn when lifted off the ground and not touching the ground, but when the motor was loaded or the wheel was lowered, there was slippage in the belt, both in the roller housing and the CVT section. Initial analysis indicated that the belt was too loose, and it was replaced with a 2011 Vario belt, but testing still showed slippage. [1] stated that the cause of slippage is the pulley on the shaft rotating at a speed based on the motor pulley through the belt and then experiencing a speed reduction when subjected to load on that shaft.

The transmission aims to transmit power from one source to another, ensuring the powered machine operates according to the desired needs. Various types of transmission systems include gear transmission systems, belt transmission systems, chain, and sprocket (chain drive) systems. The purpose of this research is to find a suitable transmission for electric motorcycles and to understand the effect of load on sprocket rotation.

This research will focus on the chain and sprocket transmission system. The research methods include literature study, direct observation of the 2010 Honda Beat electric motorcycle, and data collection through direct experiments on the 2010 Beat electric motorcycle by measuring actual RPM and theoretical RPM while varying the load on the electric motor. The collected data will be analyzed quantitatively to obtain accurate and useful results for the future development of electric motorcycle technology.

METHODS

The first step taken is to identify the problem that will be used as the research topic. The problem identified in the electric motorcycle is the slippage of the V-belt in the 2010 Beat electric motorcycle. After identifying the issue with the 2010 Beat electric motorcycle, it was found that the standard flat V-belt on the 2010 Beat motorcycle was slipping. Next, the author attempted to replace the standard V-belt on the 2010 Beat motorcycle with a notched V-belt from the 2011 Vario motorcycle. However, even after replacing it with the 2011 Vario V-belt, the electric motorcycle still experienced slippage when a load was applied. Following this, the transmission system was changed from a belt transmission system to a sprocket and chain transmission system. After switching to the sprocket and chain transmission system, the electric motorcycle operated as desired. The tools required for the sprocket rotation testing process on the 2010 Beat electric motorcycle were gathered. In this test, a tachometer was used to measure the sprocket's rotation speed. The location and time of the equipment testing were at Building B, Bengkalis State Polytechnic, Jalan Bathin Alam, Sungai Alam, Bengkalis, Riau

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Table 1. Components and Specifications of an Electric Motorcycle

Motor Listrik BLDC	2 Kw/72V
Controller	48-72V
Baterai	-
MCB	1 Pase 32A
Throtlle body Sensor TPS	-
Dioda	35A
DV coventer	48-60V/10A

The 2010 Beat Electric Motorcycle uses the 2010 Beat motorcycle body with a BLDC-type electric drive motor with a capacity of 2 kW. This electric motor is also equipped with supporting components such as a 72-volt 25 AH LiFePO4 battery and a controller with a maximum current of 500 Amps and a maximum power output of 3 kW. In general, the working principle of an electric motorcycle involves using a battery as the primary power source that stores electrical energy. The controller regulates the current flow from the battery to the electric motor, which then converts electrical energy into mechanical motion to rotate the drive wheels and power the vehicle. The throttle handle is used to control the amount of power released by the motor according to the rider's demand, while braking systems such as disc brakes or drum brakes are used to provide safe braking capability. The 2010 Beat electric motorcycle that has been developed is shown in Figure 1.

Figure 1. Motorcycle beat 2010

After the electric motorcycle was built and tested, several issues arose with the electric motorcycle. Initially, the electric motorcycle used the standard pulley and V-belt transmission from the 2010 Beat. However, the electric motorcycle would not move; the wheels would only turn when lifted off the ground, but when a load was applied to the motor or the wheels were lowered, the belt would slip, both in the roller housing and the CVT section. An initial analysis suggested that the belt was too loose, so it was replaced with a 2011 Vario belt. However, the test results still showed slippage. According to [1], the cause of the slip is that the pulley on the shaft rotates based on the speed of the motor pulley via the belt and then experiences a speed reduction when a load is applied to that shaft.

In this research, the pulley transmission system will be replaced with a sprocket transmission system. The sprocket to be used will have a size that fits the rear CVT housing, and the front part will use a smaller counterpart to achieve a higher ratio, providing greater torque to the rear wheels and thus increasing vehicle acceleration. In this research, a Honda Grand Strea sprocket will be used, with a rear gear diameter of 120 mm and a front gear diameter of 30 mm, having 32 teeth and 15 teeth, respectively. This sprocket will be installed in the transmission of the 2010 Beat electric motorcycle. The design of the electric motor vehicle can be seen in Figure 2.

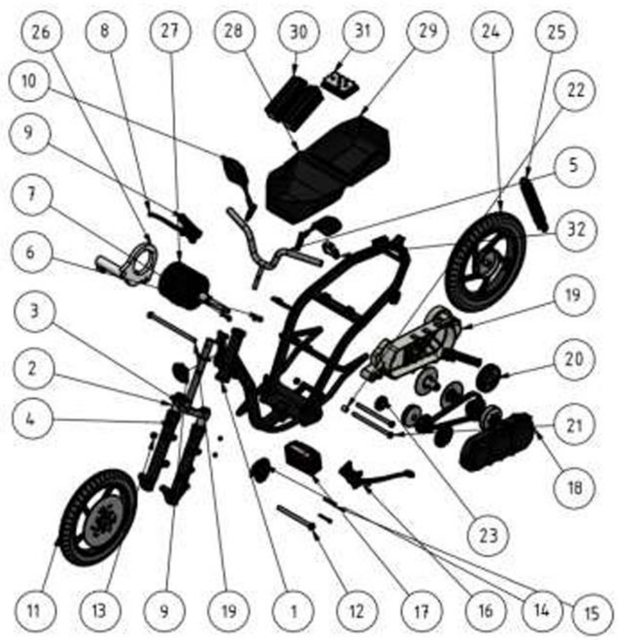

Figure 2, Design of eletectric motor conversion

RESULTS AND DISCUSSION

Slip on a motorcycle occurs when the rear wheel loses traction with the road surface. Slip can happen due to various factors, such as improper tire pressure or sudden acceleration. Slip on a motorcycle's belt occurs when the engine's power is not fully transmitted to the rear wheel through the drive belt (V-belt). This is caused by several factors, primarily the tension of the V-belt that is not optimal. If the tension is too loose, power transmission from the engine to the rear wheel will be less efficient and can easily slip during acceleration. On the other hand, if the tension is too tight, it can cause excessive pressure on the drive system components, accelerating wear and damage to the belt itself.

Slip on the motorcycle belt can significantly reduce its performance because the engine power is not fully utilized to drive the rear wheel. This can result in slow acceleration and a decrease in maximum speed. Various methods have been attempted to prevent the slip that occurred previously on this electric motorcycle, from using the standard V-belt of the 2010 Beat motorcycle to replacing it with the standard V-belt of the 2011 Vario, but slippage still occurred on the electric motorcycle.

The solution proposed by the author to prevent slip on the 2010 Beat electric motorcycle is to replace the transmission system from a belt drive to a chain and sprocket drive system. This is because chain and sprocket transmissions have high efficiency. Chains can efficiently transfer power from the engine to the rear wheel, resulting in more responsive acceleration.

Here are some factors to consider when choosing the sprocket gear ratio:

1. The difference in the number of teeth between the front and rear sprockets affects the acceleration of the electric motorcycle.
2. The gear ratio also impacts the top speed of the motorcycle; the lower the ratio, the higher the speed the vehicle can achieve.
3. The number of teeth on the sprocket also affects the torque and pulling power of the vehicle. A smaller sprocket ratio combination can provide more torque for pulling loads or navigating difficult terrain.
4. Changes in gear ratio also affect the efficiency of battery usage.

This sprocket testing was carried out by direct measurement using a tachometer. Measurements were taken on the drive sprocket (motor) and the driven sprocket (actual) in RPM units using different load variations. The results of the direct measurements can be seen in the table below.

Table 2. Motor and Actual Rotation Testing

Weight people (Kg)	Rotation Motor (Rpm)	Rotation Actual (Rpm)
0	2221	2114
45	2189	1231
50	1933	952,1
65	1575	728,1
70	1334	701,9
95	1200	653,2

Table 2 shows that the rider's load affects the motor's rotation; the greater the rider's load, the lower the resulting rotation. The graph of the rotation test can be seen in Figure 3.

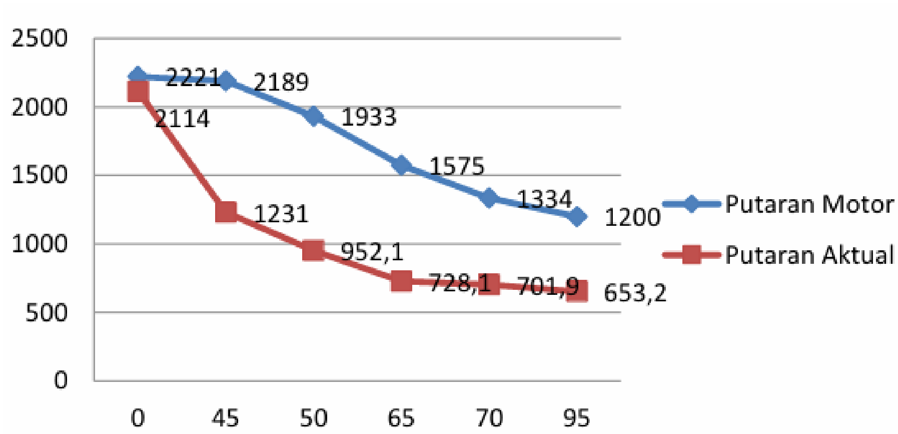

Figure 3: Graph of Motor and Actual Rotation Test Results

This figure shows the graphical results of the motor and actual rotation tests conducted during the experiment. It illustrates how the rotation speeds of both the driving sprocket (motor) and the driven sprocket (actual) change with varying loads. As observed in the graph, the motor rotation decreases as the load increases, confirming that the load affects the efficiency and torque of the electric motorcycle's transmission system. The graph provides a visual representation of the relationship between the rider's load and the rotational speed, indicating the system's performance under different conditions.

Figure 3 shows that the replacement from a belt transmission to a chain and sprocket transmission successfully made the motor move without slipping, even with a maximum load of 95 kg**.** Additionally, a downward trend in the rotations of both the driving sprocket and the driven sprocket can be observed. Overall, the effect of the rider's load on the sprocket rotation is inversely proportional—meaning the greater the rider's load, the lower the sprocket rotation value. The lowest rotations occurred with a 95 kg load, at 1200 RPM and 653 RPM, respectively. According to [2], the decrease in sprocket rotation is caused by a reduction in torque when a certain load is applied. Moreover, the advantage of this transmission compared to a belt and pulley transmission is its ability to transmit greater power with no slip. However, the drawback is that it cannot be used for high speeds and produces high vibrations [3].

Table 3. Theoretical Rotation Test Results

Beban Pengendara	Putaran Motor (rpm)	Putaran Aktual (rpm)	Putaran teoritis (rpm)
0	2221	2114	1041
45	2189	1231	1026
50	1933	952,1	906
65	1575	728,1	738
70	1334	701,9	625,
95	1200	653,2	562

This practical analysis is based on the existing test data, and a theoretical analysis will be conducted to compare and validate the theoretical values. The theoretical results are derived from the direct (actual) measurement results of the sprocket rotation tests, as follows. The rotation of the driven sprocket can be calculated based on the sprocket ratio. From the sprocket calculations above, using the established ratio, the theoretical sprocket rotation (T) is obtained, as shown in the table 3.

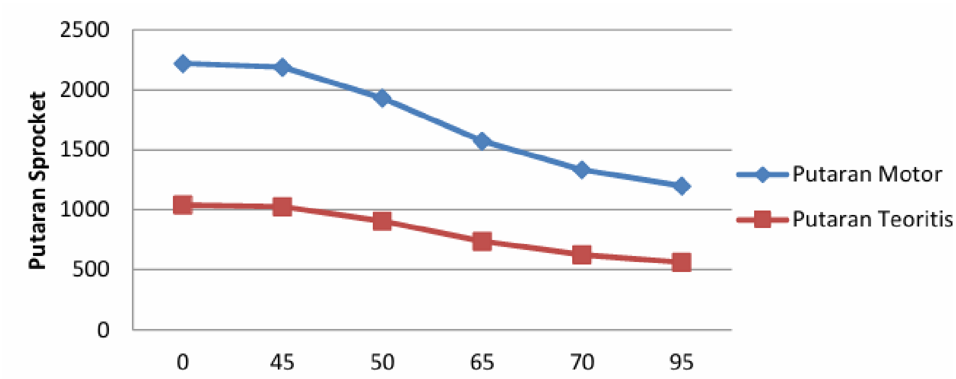

Figure 4. Theoretical Rotation Test Results

Figure 4 shows the theoretical rotation results by calculating the rotation of the driving sprocket divided by the sprocket ratio obtained from the rotations of the driving sprocket and the driven sprocket. Theoretically, the rotation of the sprocket is smaller than the actual rotation of the motor. In general, the decrease in rotation is influenced by the increasing weight of the load. The theoretical rotation of the sprocket provides an estimation of how the driven sprocket should behave under specific conditions based on the sprocket ratio. Here are some effects and implications of the theoretical rotation:

1. Comparison with Actual Rotation: The theoretical rotation helps in understanding the efficiency and performance of the transmission system by comparing it with the actual rotation measurements. If there is a significant difference between the theoretical and actual values, it may indicate energy losses due to friction, slip, or other mechanical inefficiencies.
2. Understanding Load Impact: As the theoretical rotation shows how the sprocket should perform ideally, any deviation from this value, especially under varying loads, highlights the impact of increased weight on the system. Generally, the rotation decreases as the load increases, revealing how the weight affects the system's torque and acceleration capabilities.
3. Optimization of Transmission Design: By analyzing the difference between theoretical and actual rotations, engineers can identify potential areas of improvement in the design and material of the transmission components. This helps in optimizing the gear ratios, reducing friction, or selecting better materials to enhance performance.
4. Efficiency Analysis: The theoretical rotation values are crucial for calculating the efficiency of power transmission from the motor to the wheels. Lower actual rotations compared to theoretical ones can indicate inefficiencies that need to be addressed to achieve optimal performance.
5. Predictive Maintenance: Regular comparison between theoretical and actual rotations can help predict wear and tear in the transmission system, enabling timely maintenance and reducing the risk of component failure.

Discussion

The transmission system in the 2010 Honda Beat electric motorcycle plays a critical role in converting power from the motor into motion at the rear wheel. Analyzing this system provides insights into its efficiency, performance, and potential areas for improvement. The key aspects of this analysis include understanding the causes of inefficiency, the impact of different transmission types, and the effect of load on the system's performance. The 2010 Honda Beat electric motorcycle originally used a belt transmission system (V-belt and pulley). However, significant issues arose with this setup:

- Slip Occurrence: One of the main problems identified was the slip in the V-belt transmission. This slip was primarily due to insufficient tension, which made the transmission of power from the BLDC motor to the rear wheel less efficient. When a load was applied to the motorcycle, the belt would slip, resulting in a loss of power and poor vehicle performance.
- Test Results with V-Belt Substitution: Attempts were made to replace the standard V-belt with a different type (e.g., Vario 2011 V-belt with teeth). However, even after this replacement, the slip persisted under

load conditions, indicating that the belt transmission system was fundamentally unsuitable for the power and torque requirements of the electric motor.

To address the inefficiencies and slip issues in the belt transmission system, the transmission was converted from a belt to a chain and sprocket system. The new system was configured as follows:

- Sprocket Configuration: A 15-tooth sprocket was used at the front (motor side), and a 32-tooth sprocket was used at the rear wheel, resulting in a sprocket ratio of 2.128.
- Chain Specifications: The system used a number 40 chain with a single configuration, providing a chain speed of 7.7 m/s with 76 links, equating to a chain length of 84.22 cm.

The transition to a chain and sprocket system provided several advantages:

- Higher Efficiency: The chain drive system proved to be more efficient than the belt drive, as it could transmit more power from the motor to the rear wheel without slipping, even under maximum load conditions.
- Improved Acceleration: Due to better torque transmission, the chain and sprocket system provided more responsive acceleration, which is crucial for an electric motorcycle where quick power delivery is often desired.
- Reduced Slip: Unlike the belt transmission, the chain and sprocket configuration eliminated slip issues, even when the motorcycle was loaded to its maximum capacity (95 kg).

The study compared the actual rotation of the sprockets (measured using a tachometer) with the theoretical values calculated based on the sprocket ratio:

- No-Load Conditions: Under no-load conditions, there was a significant difference between actual and theoretical rotations, with an average deviation of 973 RPM. This could be due to mechanical losses such as friction or inaccuracies in theoretical assumptions.
- Loaded Conditions: When a rider load was applied, the difference between actual and theoretical rotations was minimal, averaging around 83 RPM. This suggests that the chain and sprocket system performs reliably under typical operating conditions.

The analysis also demonstrated that the load significantly impacts sprocket rotation:

- Inverse Relationship: There is an inverse relationship between load and sprocket rotation speed. As the load increases, the rotational speed of the sprocket decreases. At a maximum load of 95 kg, the actual sprocket rotation was recorded at 653 RPM, while the theoretical was 632 RPM.
- Torque Considerations: The decrease in rotation speed under heavier loads indicates a drop in torque, which aligns with the expected behavior of a mechanical transmission system where greater torque is required to move larger loads.

While the chain and sprocket system provided notable improvements, it also has some limitations:

- Vibration and Noise: Chain drives tend to produce more noise and vibration compared to belt drives, which can affect rider comfort.
- Not Suitable for High Speeds: The chain and sprocket system is not ideal for high-speed applications, as it may introduce excessive wear and reduce overall efficiency

CONCLUSIONS

The cause of the slip in the 2010 electric Honda Beat motorcycle is due to too loose tension, making the power transmission from the BLDC motor to the rear wheel inefficient and prone to slipping even when the electric motorcycle is loaded.

1. The electric motorcycle's transmission system was changed from a belt transmission to a chain and sprocket transmission with a 15-tooth sprocket on the front and a 32-tooth sprocket on the rear, resulting in a sprocket ratio of 2.128, a chain speed of 7.7 m/s, with 76 chain links, or a length of 84.22 cm.
2. The transmission system on this electric motorcycle uses a number 40 chain with a single configuration.
3. The comparison between actual and theoretical rotations is generally the same, with differences only under no-load conditions. Under no-load conditions, the difference between actual and theoretical rotations is quite large, with an average of 973 RPM. However, when a rider load is applied, the average theoretical and actual rotations are the same, with a difference of 83 RPM.

4. The effect of load on sprocket rotation is very significant; the greater the load, the lower the sprocket rotation on the motor. At a maximum load of 95 kg, the sprocket rotation is 653 actual rotations and 632 theoretical rotations.

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