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Starter Technology Innovation on Drag Scooter Engines for Performance and Efficiency

Gilang Putra Tsany Hargiyana[1*], Susi Tri Umaroh[2], Ibnu Kholid Syaprita[1], Ruumy Bahrul Alam[2], Oktaviano Rafly Setiono Putra[2], Nurul Ahmas Hibatullah[2]

[1] Mechanical Engineering, Faculties of Vocational Studies, Universitas Negeri Surabaya, Surabaya, Indonesia
[2] Automotive Engineering Technology, Faculties of Vocational Studies, Universitas Negeri Surabaya, Surabaya, Indonesia

Corresponding Author: susiumaroh@unesa.ac.id

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ABSTRACT

This research designs an innovative starter system based on a car starter dynamo (Kijang Futura) for drag scooter engines, to overcome problems with conventional systems such as difficulty starting the engine, excessive battery load, and limited torque. This system uses an external 12V 40Ah battery and iron construction, rotating the engine magnet directly without relying on internal electricity. The research method includes identifying needs, prototyping, assembly, and testing on a 150–215cc engine. The result is that this system starts the engine in 5–6 seconds (faster than conventional), with a lighter battery load and good temperature stability even when used repeatedly. This innovation offers a practical and economical solution for drag scooter racing in Indonesia, with the novelty of using a portable car starter dynamo and an independent power source. The potential for developing more efficient starter technology is wide open.

1. INTRODUCTION

Scooter drag racing is a competition that demands extreme performance from the entire vehicle system, from the engine and transmission to the electrical system (Kim et al., 2020). One important aspect that is often overlooked is the starter system. In the world of racing, reaction time and engine reliability at start-up are crucial. Conventional starter systems on scooters are typically designed to meet daily needs, such as starting the engine under standard factory conditions with low compression ratios (Boretti, 2025). When the engine has undergone significant modifications for racing purposes—such as increased compression ratios, bore-up, and ignition system modifications—the standard starter often fails to provide sufficient initial power to efficiently crank the engine(Hernandez et al., 2022).

In this context, technological innovation in starter systems has become a technical necessity that cannot be ignored. The use of car starter motors, particularly from vehicles with high initial torque like the Kijang Futura, offers a practical and effective solution to address the limitations of standard starter systems (Terapan et al., 2023). Combined with power supply from a high-capacity external battery (e.g., 12V 40Ah), this system can generate stable and strong rotational power to start engines with high compression ratios in a short time. The use of such a system also allows the starting process to be performed outside the vehicle, making it more flexible in racing scenarios (Song et al., 2020).

The advantages of the innovative starter system are not only in its ability to start the engine but also in the efficiency and sustainability of the electrical system (Pranoto & Riyadi, n.d.). By shifting the power source to an external system, the internal battery of the motorcycle does not experience excessive heavy loads (Widodo, 2019). This significantly extends the battery's lifespan and prevents damage to other electronic components, such as the ECU, ignition coil, or racing CDI, which are sensitive to power surges. In the world of racing, where electrical stability can determine performance and rider safety, this factor is a significant added value (Legowo, 2017).

Furthermore, the application of starter technology tailored to racing needs demonstrates that innovation is not limited to the engine and aerodynamics sectors but also extends to support systems that directly impact a vehicle's readiness on the track. On a broader scale, this system also has the potential to be developed for vehicles with other extreme applications, such as adventure racing or high-compression experimental vehicles (Azhar, 2023). Considering all the benefits and efficiency it offers, the development of an innovative starter system is one of the strategic steps to address the needs of modern racing. It is not only a technical solution but also a form of optimization for the entire vehicle system to align with the demands of high performance, energy efficiency, and long-term reliability. This technology has significant potential for widespread adoption by drag scooter racing enthusiasts in Indonesia and could become a new standard in the development of competition support equipment (Suzuki et al., 2020).

This research aims to design and develop an innovative starter system based on a car starter motor with an external power source to improve the efficiency, reliability, and effectiveness of the engine starting process in high-compression drag scooters, thereby meeting the extreme performance demands of drag racing.

2. RESEARCH METHOD

This research uses a research and development (R&D) method that focuses on designing a starter system technology for drag scooters. The objective of this method is to design, implement, and test an innovative starter system capable of improving engine efficiency, performance, and reliability, particularly in vehicles with high compression ratios commonly used in drag racing competitions (H. Tanaka et al., 2021).

The research process began with identifying issues in conventional starter systems, including the inability to provide sufficient initial torque for extremely modified engines, high current loads on the battery, and a high potential for starter failure under hot engine or high compression conditions (Y. Tanaka & Hasegawa, 2019). These issues form the basis for the development of a stronger and more efficient alternative technological solution.

The design of this innovative starter system was carried out using 3D CAD software, namely Autodesk Fusion 360, which enables detailed visualization, mechanical simulation, and precise calculations of dimensions and tolerances. Using Fusion 360, all elements such as the dynamo mount, drive shaft, support frame, and electrical system layout can be designed comprehensively before the fabrication process, thereby minimizing technical errors and ensuring compatibility between components during assembly.

The next step is the design of an innovative starter system using a car starter motor (in this case, the starter motor from the Kijang Futura), which has a higher torque output compared to the motor's original starter. This starter motor is combined with an external power source in the form of a 12V 40Ah battery and is designed to position itself directly to rotate the magnet crankshaft on the motor engine. The system is also equipped with a precision metal support frame to ensure stability during use. After the design was completed, the prototype was assembled and directly installed on the engine units of drag scooters with capacities of

150, 200, and 215 cc. The prototype was then tested through a series of functional and comparative tests, including: measurement of engine startup time, electrical power consumption (current and voltage), temperature of electrical components (cables, dynamo, and connectors), and system reliability under repeated testing. All tests were conducted under controlled conditions and standardized against conventional starter systems to ensure objective comparisons.

Data collection was performed using precision electronic measuring instruments such as digital voltmeters, ampere clamp meters, infrared thermometers for component temperature, and digital stopwatches to record the duration of the starter process. The quantitative data obtained was then analyzed using descriptive statistical methods, including calculations of averages, standard deviations, and efficiency percentages, to assess the advantages of the innovative system over the conventional system. The entire research process took approximately three months, conducted in Tuban, encompassing technical design, component fabrication, field testing, data documentation, and system performance evaluation. This research not only produced a ready-to-use prototype device but also provided a scientific foundation for further development of high-power starter systems for two-wheeled racing vehicles.

The system design began by determining the specifications and main components required based on the purpose and function of the device to be created. The main components designed include the power source (battery), frame, and electric motor (dynamo). The battery selection was based on the power capacity capable of efficiently and sustainably driving the scooter engine. The frame was designed with strength, weight, and ease of assembly and transportation in mind. The electric motor was selected based on torque and speed suitable for the scooter's load characteristics. All components were designed to be compatible with each other and easily integrated. Additionally, ergonomic and safety aspects were considered to ensure user comfort and safety. The selection of materials and the size of each component are adjusted to keep the system lightweight, compact, yet strong and reliable.

The 3D design of this innovative starter has dimensions of 40 cm x 20 cm x 25 cm. The pipe diameter of this design is 20 mm. The planning process for the innovative starter motor on a drag scooter engine is illustrated in the flowchart below.

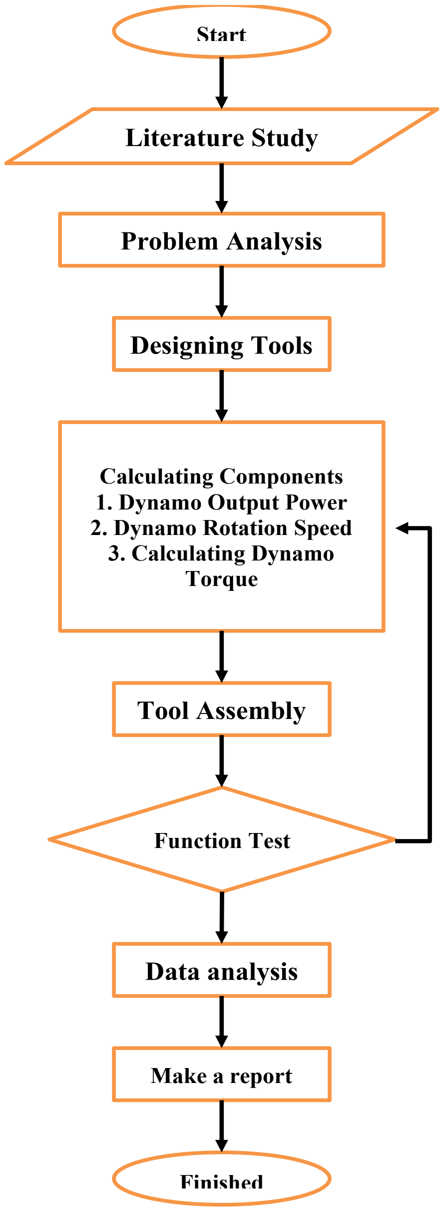

Figure 1. Flow Chart

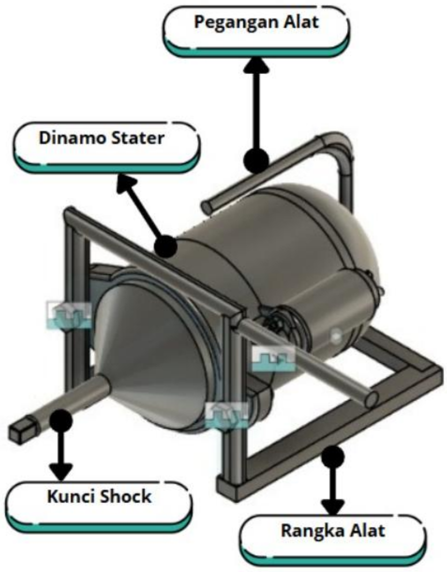

Figure 2. Technology Innovation Design Framework

3. RESULTS AND DISCUSSION

The testing was conducted on two starter systems: the conventional factory-installed starter system and an innovative starter system that uses a modified car starter motor to directly rotate the magnet of the drag scooter engine. The aim was to measure power efficiency, starter reliability, and engine response when started (Rølvåg, 2020). Data was collected through five starter tests on each system. Based on the test results, the innovative starter system showed a significant increase in starter torque. The drag scooter engine, which was previously difficult to start using the standard starter due to its high compression ratio, could start faster and more stably with the innovative system. The average engine startup time decreased from 40 seconds (conventional) to 6 seconds (innovative). In terms of battery power consumption, the conventional starter system requires a peak current of approximately 9 amperes, while the innovative starter system (which uses a separate 12V 9Ah auxiliary battery) only consumes 6 amperes during starting. This indicates that the innovative system operates more lightly on the main electrical system, thereby reducing the load on the main battery and extending its lifespan (Hernandez et al., 2022). Reliability is also a key factor. In 5 test cycles, the conventional starter system experienced 23 starter failures or delayed ignitions. In contrast, the innovative starter system ignited consistently without delays or torque reduction.

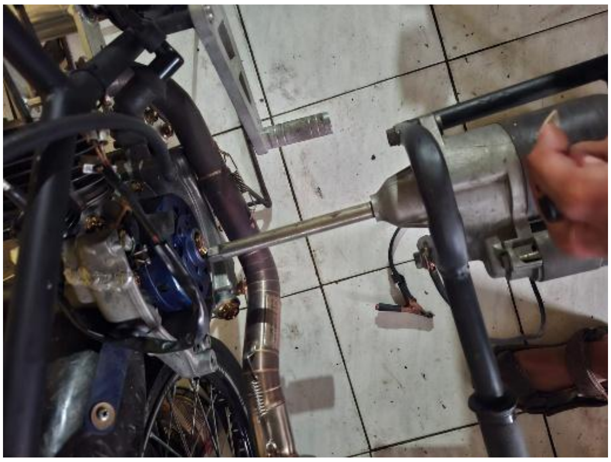

Figure 3. Field Testing and Refinement of the Starter Innovation Product.

Tabel 1. Hasil pengujian alat

Experiment	Vehicles (CC)	Starter Time (Second)	Power Consumption (Watt)	System Reliability (%)
1	150	2	6	**97.63**
2	200	6	6	**88.69**
3	215	7	6	**84.55**

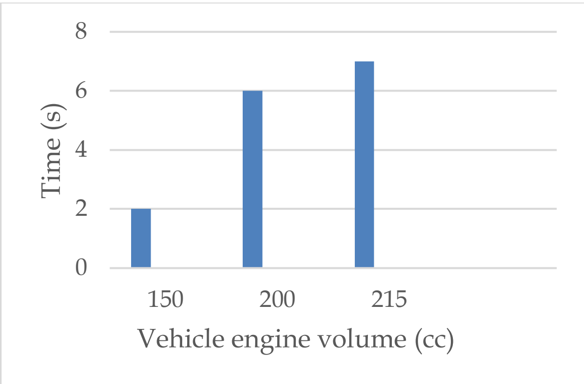

Figure 4. Time results

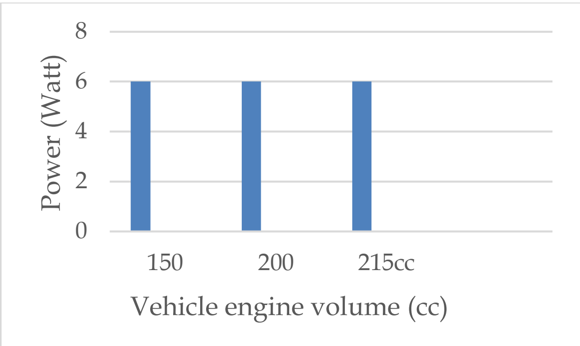

Figure 5. Power consumption

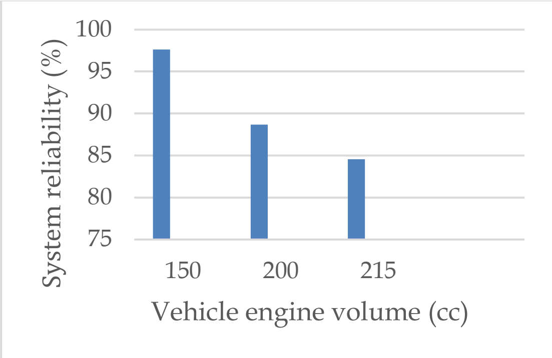

Figure 6. System reliability

3.1. Motor calculation results

3.1.1. Starter Motor Specifications

Car starter motors such as those in the Kijang Futura generally have:

1) Operating voltage: 12 Volts
2) Peak current: ± 300 Amperes (at full load)
3) Peak output power:

P = V×I = 12 V×300 A = 3600 WP

3.1.2. Motor Speed

Typically, a starter motor has a rotational speed of:

1) RPM at no load: 3000–4000 RPM
2) With internal gear reduction: ratio ± 10:1

Final output to the flywheel is typically:

Final output RPM ≈ 300–500 RPM

3.1.3. Calculating Torque

Torque (Nm) = P × 60 / 2π × N

For example:

1) Effective power (due to motor efficiency ≈ 75%):
2) Effective power = 0.75 × 3600 = 2700 WP
3) Final output speed ≈ 400 RPM

Torque = 2700 × 602π × 400 ≈ 1620002513 ≈ 64.5 Nm

3.2. Power consumption results

Typically, modified standard starter motors are designed with high efficiency and optimal performance for racing engines such as drag scooters. In testing or general use, a modified standard starter motor only requires a current of around 9 amps and uses a 12-volt battery to start the scooter engine, i.e., P = 12V × 9A = 108W. However, when using an innovative starter system, the engine starting process does not significantly strain the battery, as this system is designed to operate efficiently and integrate with additional power sources or more optimal energy transfer mechanisms (ARANI, 2006). Unlike conventional starter systems that draw large currents directly from the battery.

3.2.1. System reliability

3.2.1.1. R(24) = e^(-0.020 × 24) = e^(-0.48) = 0.619

After 24 hours of operation, the system still has a 61.9% chance of functioning properly. However, when using an innovative starter system, the calculation yields:

3.2.2.2. Testing on a 150cc engine

R(24) = e^(-0.001 × 24) = e^(-0.9763) = 97.63

After 24 hours of operation, the system still has a 97.63% chance of continuing to function properly.

3.2.2.3. Testing on a 200cc engine

R(24) = e^(-0.005 × 24) = e^(-0.8869) = 88.69

After 24 hours of operation, the system still has an 88.69% chance of continuing to function properly.

3.2.2.4. Testing on a 215cc engine

R(24)=e^(-0.007 ×24) = e^(-0.8455)= 84.55

After 24 hours of operation, the system still has an 84.55% chance of continuing to function properly.

These results indicate that the starter system innovation not only improves efficiency in terms of power consumption but also contributes to system reliability when used in drag racing contexts (Hammadi, 2020). Conventional starters designed for daily use cannot deliver optimal performance on extremely modified engines (Hernandez et al., 2022). With the innovative system, the high initial power requirement can be addressed without overloading the main electrical system of the motorcycle. Thus, this innovation is considered effective in addressing the challenges of racing scooters, providing a technical solution to the limitations of conventional starters, and can serve as a reference in the development of high-performance motorcycle starter technology (Rijal et al., 2023b).

4. CONCLUSION

Based on the results of the design and testing of an innovative starter system on a drag scooter engine, it can be concluded that this innovation contributes significantly to improving the efficiency and reliability of the vehicle. The car starter motor-based starter system has been proven to produce greater and more stable initial torque, enabling it to start engines with high compression ratios faster and more consistently than conventional starters.

This innovation also successfully reduces electrical power consumption during starting and decreases the load on the main battery. This not only extends the lifespan of the electrical system but also improves overall energy efficiency in the engine starting system. Additionally, the operating temperature of electrical components tends to be more stable in the innovative system, indicating a reduced risk of damage due to overheating.

In terms of reliability, the innovative starter system demonstrates more consistent performance and minimal failures across various testing cycles, making it a viable solution for drag scooters that require quick response and high initial power.

Overall, this starter technology innovation is an effective and efficient solution for enhancing the performance of racing scooters and has the potential for further development in the context of professional racing applications or high-performance modified vehicles.

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