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Comparative Study on the Kinematic Performance of Front Wheel Drive (FWD) and Rear Wheel Drive (RWD) Vehicles

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ABSTRACT

The automotive industry has continuously innovated drive systems. Among various types, Front Wheel Drive (FWD) and Rear Wheel Drive (RWD) systems are widely used. This research examines the influence of these systems on acceleration and deceleration performance through field tests conducted on public highways. Five speed variations—40, 60, 80, 100, and 110 km/h—were tested for acceleration and deceleration. Results indicate RWD vehicles outperform FWD vehicles in acceleration due to the rear location of the drive wheels, providing superior propulsion. Conversely, FWD vehicles demonstrate better deceleration performance, attributed to shorter braking distances and improved braking efficiency.

Keywords: *Drive system, acceleration, deceleration, FWD, RWD*

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ABSTRACT

Industri otomotif terus melakukan inovasi pada sistem penggerak kendaraan. Di antara berbagai jenis sistem penggerak, Front Wheel Drive (FWD) dan Rear Wheel Drive (RWD) merupakan yang paling banyak digunakan. Penelitian ini mengkaji pengaruh sistem penggerak tersebut terhadap performa akselerasi dan deselerasi melalui pengujian lapangan yang dilakukan di jalan raya umum. Lima variasi kecepatan—40, 60, 80, 100, dan 110 km/jam—diuji untuk akselerasi dan deselerasi. Hasil penelitian menunjukkan bahwa kendaraan RWD lebih unggul dalam akselerasi karena lokasi roda penggerak yang berada di belakang, sehingga menghasilkan daya dorong yang lebih baik. Sebaliknya, kendaraan FWD menunjukkan performa deselerasi yang lebih baik, berkat jarak pengereman yang lebih pendek dan efisiensi pengereman yang lebih tinggi.

Kata kunci: *Sistem penggerak, akselerasi, deselerasi, FWD, RWD*

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INTRODUCTION

Cars are land vehicles powered by engines, equipped with four or more wheels, and typically use petroleum-based fuels [1]. As one of the most popular modes of transportation, the development of automotive technology and innovations has become inseparable from increasing vehicle sales. Consequently, car manufacturers continuously conduct research and development to improve their products in terms of design, engine performance, fuel efficiency, and other aspects.One of the key components prioritized in automotive development is the drive system. The drive system in a car is a mechanism that transfers power generated by the engine to the wheels [2]. There are various types of drive systems, but the two most commonly found are Front Wheel Drive (FWD) and Rear Wheel Drive (RWD).

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The purpose of developing a car's drive system, apart from providing better comfort, is to optimize the traction achieved by the vehicle's wheels. Previous studies focusing on the analysis of traction characteristics in cars have highlighted the critical importance of traction, as it affects numerous factors related to vehicle performance [3]. Nevertheless, a deep study on the effect of vehicle drive systems on kinematic performance has not been conducted before, or on the other hand, it has been lacking in information. This study is indeed necessary as a further drive system design consideration.

This study, therefore, aims to compare the kinematic performance of vehicles equipped with Front Wheel Drive (FWD) and Rear Wheel Drive (RWD) systems. The kinematic performance being tested includes acceleration and deceleration. Acceleration is a key variable for evaluating engine performance, particularly in high-performance and racing cars. Deceleration, on the other hand, is used to assess braking effectiveness, which directly relates to driving safety.

METHOD

Front Wheel Drive (FWD)

The Front Wheel Drive (FWD) system as seen in Figure 1 uses the front wheels of a car to transmit engine power [2]. This system is commonly adopted in small cars because maximizing cabin space is essential in such vehicles. The operational mechanism of FWD involves transferring engine power to the transmission system located at the front of the car. The power then continues to the differential, which connects the right and left wheels, enabling forward rotation. The differential is also connected to the axle or Constant Velocity (CV) Joint, allowing power to be distributed to both wheels. A distinguishing feature of FWD cars is the transverse positioning of the engine.

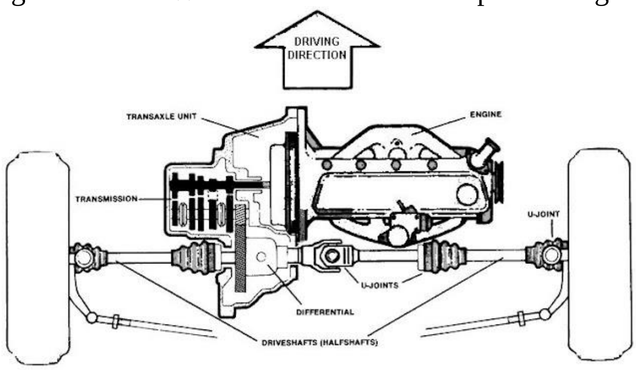

Figure 1. Front Wheel Drive System [3].

Rear Wheel Drive (RWD)

The Rear Wheel Drive (RWD) system as seen in Figure 2 transmits engine power to the rear wheels to propel the car. Known as Front Engine Rear Wheel Drive (FR) or RWD [2], this system was widely popular in the 1990s. Numerous cars, such as the Toyota Kijang, utilized this configuration. Unlike the transverse engine layout in FWD vehicles, RWD systems employ a longitudinal engine layout to direct power to the rear wheels.

The RWD system is more complex than FWD because it requires a Drive Shaft (commonly referred to as a propeller shaft) to connect the transmission to the rear differential. Consequently, cars with RWD systems often sacrifice some passenger cabin space to accommodate the Drive Shaft tunnel.

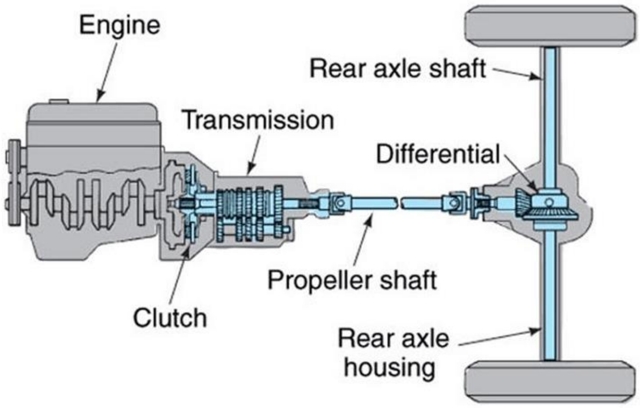

Figure 2. Rear Wheel Drive System [5].

Acceleration

Acceleration refers to a vehicle's ability to change its speed over time [6]. Positive acceleration indicates an increase in speed, while negative acceleration, or deceleration, involves a speed reductioncaused by braking activity. During driving, acceleration and deceleration occur alternately due to the dynamic nature of road conditions. Drivers frequently need to accelerate when increasing speed or decelerate when conditions require reduced speed.

Deceleration

Deceleration is the opposite of acceleration and involves a speed reduction. According to Pasila et al. (2019), deceleration can be defined as negative acceleration, resulting in a slowdown or deceleration [6]. The Indonesian Language Dictionary (KBBI) defines deceleration as the power to reduce speed [1]. Deceleration is a critical safety factor in vehicles due to its role in braking.

Deceleration in vehicles occurs through two mechanisms: braking systems and engine braking. Braking systems include various components, such as ABS (Anti-Lock Brake System), rotor brakes, and caliper brakes. Engine braking occurs when the vehicle slows due to the engine's residual rotational force after acceleration. Engine braking is directly linked to the vehicle's drive system and contributes to deceleration efficiency.

The research methodology is presented in the form of a flowchart in Figure 3. The process begins with a literature review of previous studies related to the current research topics of acceleration and deceleration. The next step involves preparing the tools and samples required for the testing process. Data collection is carried out using a field-testing method through direct tests conducted on a toll road. The acceleration tests measure the time taken for the vehicle to increase its speed from 0 km/h to 110 km/h using a stopwatch. The tests are conducted incrementally at the following speed intervals: 0–40 km/h, 0–60 km/h, 0–80 km/h, 0–100 km/h, and 0–110 km/h. The acceleration tests are performed under normal driving conditions.

Following the acceleration tests, deceleration tests are conducted. These measure the time taken for the vehicle to reduce its speed from the maximum test speed (110 km/h) to a complete stop (0 km/h). Similar to the acceleration tests, the deceleration tests are conducted incrementally at the following intervals: 110–0 km/h, 100–0 km/h, 80–0 km/h, 60–0 km/h, and 40–0 km/h. Both tests are performed on two vehicle samples: a Rear Wheel Drive (RWD) car (Daihatsu Terios) and a Front Wheel Drive (FWD) car (Toyota Avanza 2022). The testing location for both vehicles is the same, specifically the Gempol-Pandaan toll road, assumed that the road condition is unformly normal without any uneven matters or obstacles.

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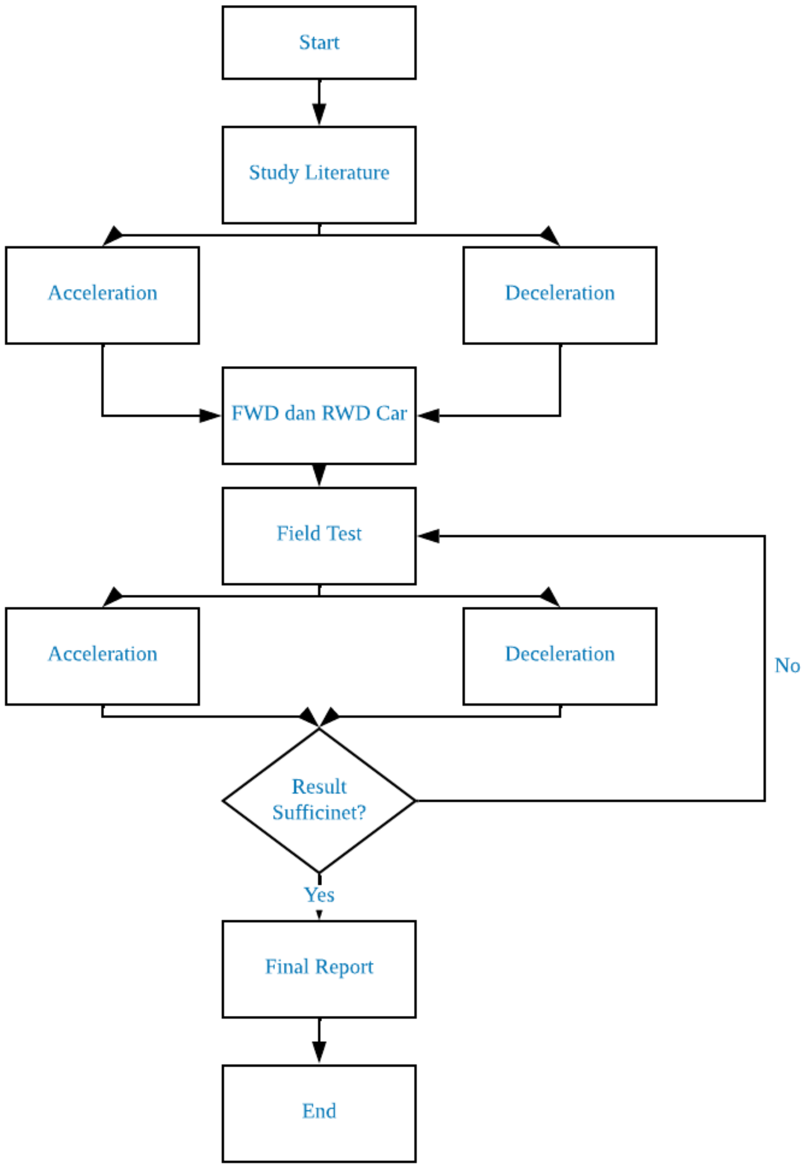

Figure 3. Research Flowchart.

Tools

The tools required to conduct the performance tests in this research include:

1. Timer/Stopwatch
2. Notebook and writing tools
3. Smartphone

Test Samples

The test samples used in this study are commercially available vehicles with two different drive types. Both vehicles share the same engine type and specifications. The detailed specifications are shown in Figures 4 and 5 below, along with their technical details.

(a) (b)

Figure 4. Rear Wheel Drive Vehicle: (a) Daihatsu Terios 2022 (MT) [7], and
(b) Front Wheel Drive Vehicle: Toyota Avanza 2022 (MT) [8]

Vehicle Specifications	**RWD Vehicle**	**FWD Vehicle**
Engine Type	2NR-VE DOHC Dual VVT-i	2NR-VE DOHC Dual VVT-i
Engine Capacity & Cylinders	1,469 cc & 4 Cylinders	1,469 cc & 4 Cylinders
Maximum Power	104 PS	106 PS
Maximum Torque	13.9 kg-m	14 kg-m

RESULTS AND DISCUSSION

Table 1. Acceleration Test Data

No	Acceleration (km/h)	Time Taken (seconds)
1	0 - 40	12.54
2	0 - 60	22.15
3	0 - 80	34.61
4	0 - 100	80.7
5	0 - 110	147.9

Table 2. Deceleration Test Data

No.	Deceleration (km/h)	Time Taken (seconds)
1	110 - 0	24.99
2	100 - 0	14.38
3	80 - 0	8.9
4	60 - 0	10.6
5	40 - 0	18.46

Tables 1 and 2 present the outcomes of acceleration and deceleration tests for rear-wheel drive (RWD) vehicles. A clear trend emerges from the data: higher target speeds require longer acceleration times. For instance, reaching 40 km/h from a stationary position took 12.54 seconds, whereas accelerating to 110 km/h required 147.9 seconds. This pattern reflects the increasing influence of factors such as aerodynamic drag and rolling resistance at higher velocities [11, 12].

Similarly, the deceleration results indicate a direct relationship between the initial speed and stopping duration. An anomaly was noted in the 80 km/h to 0 km/h test, which concluded in just 8.9 seconds—possibly influenced by external traffic factors during data recording. Despite this irregularity, the overall pattern remains consistent: higher initial speeds correspond to longer stopping times. For example, decelerating from 110 km/h to a complete stop took 24.99 seconds, whereas from 40 km/h, it was 18.46 seconds. These observations align with prior studies on acceleration and deceleration characteristics, which emphasize the influence of vehicle type, road conditions, and braking performance [13, 14].

Furthermore, these findings underscore the importance of advanced braking technologies and traction control systems in enhancing vehicle safety and performance. Recent studies on electric and hybrid vehicle dynamics have highlighted the role of regenerative braking and optimized transmission systems in improving both acceleration and deceleration efficiency [15, 16]. Future research could expand this analysis by incorporating variable conditions, such as road surface types, vehicle loads, and driver reaction times, to provide a more comprehensive understanding of vehicle dynamics [17, 18].

Table 3. Acceleration Test Data

No	Acceleration (km/h)	Time Taken (seconds)
1	0 - 40	23.20
2	0 - 60	29.49
3	0 - 80	38.60
4	0 - 100	117.2
5	0 - 110	129

Table 4. Deceleration Test Data

No	Acceleration (km/h)	Time Taken (seconds)
1	110 - 0	21.50
2	100 - 0	7.99
3	80 - 0	10.3
4	60 - 0	5.91
5	40 - 0	15.25

Tables 3 and 4 reveal the kinematic performance of FWD vehicles during acceleration and deceleration tests. Like RWD vehicles, the FWD data shows a linear relationship between target speed and time. The acceleration test results indicate that the longest time (129 seconds) was for 0–110 km/h, while the shortest (23.2 seconds) was for 0–40 km/h. For deceleration, the longest stopping time was recorded at 110 km/h (21.5 seconds), and the shortest was at 40 km/h (15.25 seconds).

Comparison Between RWD and FWD

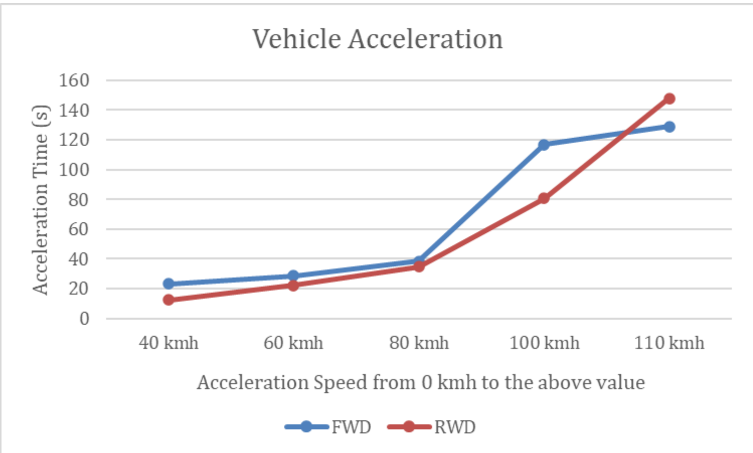

Figure 6. Comparison of acceleration test data for FWD and RWD

When comparing acceleration data between rear-wheel drive (RWD) and front-wheel drive (FWD) vehicles, a consistent linear relationship is observed. However, FWD vehicles generally take longer to reach target speeds than RWD vehicles. For instance, at 40 km/h, RWD vehicles took 12.54

seconds compared to FWD's 23.2 seconds—almost double. This trend continues at higher speeds, with RWD vehicles consistently outperforming FWD vehicles. The performance difference can be attributed to RWD's rear propulsion system, which efficiently distributes power to the rear wheels and improves traction during acceleration [19].

In deceleration, however, FWD vehicles demonstrated superior efficiency. This advantage arises from the shorter distance between the braking mechanism and the front wheels in FWD systems. The proximity reduces energy loss during braking compared to RWD vehicles, where braking energy must travel to the rear wheels [20]. Furthermore, the engine braking effect in FWD systems enhances deceleration performance, contributing to shorter stopping times [20].

These findings highlight the trade-offs between RWD and FWD systems. While RWD excels in acceleration due to better traction and weight distribution, FWD offers advantages in braking efficiency and control. Ultimately, the choice between RWD and FWD depends on the intended application, whether prioritizing performance or safety. Further research into hybrid systems and torque-vectoring technologies may help optimize the strengths of both designs to meet evolving vehicle dynamics and performance demands [19, 20].

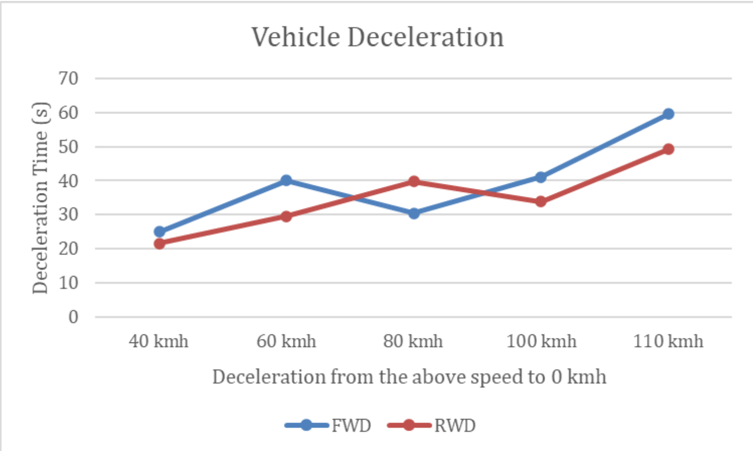

Figure 7. Comparison of Deceleration Test Data for FWD and RWD

CONCLUSION

Based on the test results, the following conclusions can be drawn:

1. Acceleration Performance:
   For speed ranges between 0 km/h and 100 km/h, the Rear Wheel Drive (RWD) vehicle outperforms the Front Wheel Drive (FWD) vehicle in overall acceleration. However, at speeds exceeding 100 km/h, the FWD vehicle demonstrates superior acceleration compared to the RWD vehicle.
2. Deceleration Performance:
   During deceleration tests, the FWD vehicle achieves shorter stopping times compared to the RWD vehicle, indicating better braking efficiency.
3. Implications for Vehicle Design:
   These findings provide valuable insights for automotive manufacturers and can be considered in designing future vehicle models to optimize performance for specific driving needs.

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