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Electric Vehicle Conversion Study for Sustainable Transport

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Abstract: The conversion of conventional motor vehicles to electric vehicles has become a popular choice in an effort to reduce greenhouse gas emissions and air pollution from transportation. Electric vehicle conversion involves replacing a gasoline or diesel engine with an electric motor and a reinstalled battery. In this paper, we cover the basics of electric vehicle conversion, conversion methods, and trial results of converted electric vehicles. We also discuss the benefits and challenges of converting to electric vehicles. Some keywords related to this topic include: electric vehicles, vehicle conversion, electric motors, batteries, sustainable transportation.

Keywords: Electric vehicle; Vehicle conversion; Electric motor; Battery; Transportation

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1. Introduction

Electric vehicles have grown in popularity in recent years as an alternative to the more common fossil fuel-powered vehicles [1]. However, new electric vehicles are still limited in terms of mileage and price. The conversion of electric vehicles is one of the affordable solutions to overcome this problem [2]. Electric vehicle conversion involves converting fossil fuel-powered vehicles into electric vehicles by replacing engines and fuel systems with electric motors and batteries. Electric vehicle conversion has become an interesting research topic in the world of transport and energy technology [3]. In some cases, electric vehicle conversion can be a more economical alternative to buying a new electric vehicle, especially for vehicles that still have a long service life [4]. In addition, the conversion of electric vehicles also provides environmentally friendly solutions that can help reduce greenhouse gas emissions and achieve emission reduction targets set by many countries [5].

Although electric vehicle conversion offers many benefits, there are still some challenges to overcome in the conversion process, such as selection and installation of appropriate electric motors and batteries, motor controller setup, and battery power management [6]. Therefore, research is constantly being conducted to improve the technology and conversion process of electric vehicles to make them easier, affordable, and effective. Although electric vehicle conversion still has challenges, much research has been conducted to improve the technology and process of electric vehicle conversion, as well as improve the efficiency and performance of electric vehicles resulting from conversion [7]. Research continues to be conducted in this area, and with technological advancements and falling battery prices, electric vehicle conversions are expected to become increasingly popular in the future.

In addition, electric vehicle conversion also provides an opportunity for vehicle-related industries, such as the vehicle parts industry, to develop new products that support electric vehicle conversion [8]. In the long run, electric vehicle conversion can help reduce dependence on fossil fuels and reduce the vehicle's negative impact on the environment [9].

Electric vehicles have become one of the solutions in reducing greenhouse gas emissions and improving air quality in cities. However, new electric vehicles are still relatively expensive, while the battery charging infrastructure required for electric vehicles is still limited. Alternatively, the conversion of a combustion engine-powered vehicle to an electric vehicle is an attractive option because of its lower cost and can help reduce the environmental impact of the vehicle [10].

The conversion of electric vehicles can be done by replacing the combustion engine-powered system with an electric-powered system, consisting of an electric motor and a battery as a power source. The electric vehicle conversion process can extend the life of the vehicle and provide a more environmentally friendly solution compared to discarding the old vehicle and buying a new electric vehicle [11]. However, there are some challenges in electric vehicle conversion that need to be addressed, such as selection and installation of appropriate electric motors and batteries, motor controller setup, and battery power management. Therefore, research continues to improve the technology and conversion process of electric vehicles to make them easier, affordable, and effective [12].

THEORETICAL BASIS

Electric vehicle conversion involves replacing a combustion engine-powered system with an electric-powered system, consisting of an electric motor and a battery as a power source. Electric motors convert electrical energy into mechanical energy, which is then used to drive the wheels of the vehicle. Batteries store electrical energy and provide power for electric motors [13]. In general, electric vehicle conversion consists of several main components, namely electric motors, batteries, motor controllers, and battery chargers [14]. The electric motor should be selected based on the size and weight of the vehicle, and then installed in place of the existing combustion engine. Batteries should also be carefully selected, based on capacity, durability and charging speed. The motor controller is responsible for regulating the speed and direction of rotation of the electric motor, while the battery charger is used to recharge the electric vehicle battery.

The electric vehicle conversion process also involves several stages, including planning, component selection, component replacement, and testing. The planning phase includes the selection of appropriate electric motors, batteries, motor controllers, and battery chargers, as well as site planning and component placement. The replacement phase involves the removal of an existing combustion engine-powered system and replacement with an electrically powered system [15]. The testing phase is important to ensure that the electric vehicle has been changed correctly and works according to expectations. The importance of setting the center of gravity in electric vehicles and how to do proper design to optimize the weight point of the vehicle after conversion to electric vehicles. Existing references can provide a deeper picture and understanding of the relationship between electric vehicle conversion and center of gravity [16].

Here are some references that can be additional information about electric vehicle conversions and centers of gravity:

References that discuss how the layout or arrangement of batteries in electric vehicles can affect the dynamic performance of the vehicle, including the center of gravity. In this study, the authors used a multi-physics method to evaluate the effect of battery layout on overall electric vehicle performance [16]. By adding this reference, we can see that electric vehicle conversion is not only concerned with the installation of engines and battery systems, but also the proper design to optimize the weight distribution of the vehicle, including the center of gravity, to achieve optimal performance [17].

Mass Center

Mass Center is the center point of load in a particle system. The mass center of a particle system is a point that moves as if all mass were concentrated at that point and all external forces were applied there. [18].

Vehicle Mass Center

The center of mass in a vehicle is one of the factors that affect vehicle dynamics. The center of mass of a vehicle can be measured from the load supported on each wheel. The center of mass of a vehicle has 3 positions, namely on the x-axis, y-axis, and z-axis [19]. The position of the center of mass on the x-axis or the longitudinal position can be measured by looking at the distance of the center of mass to one of the wheels. The distance between the pussat mass and the wheel can be measured using the following formula:

$$a_1 = \frac{(a_1+a_2)\ x\ 2Fz_2}{2Fz_1+2Fz_2}$$

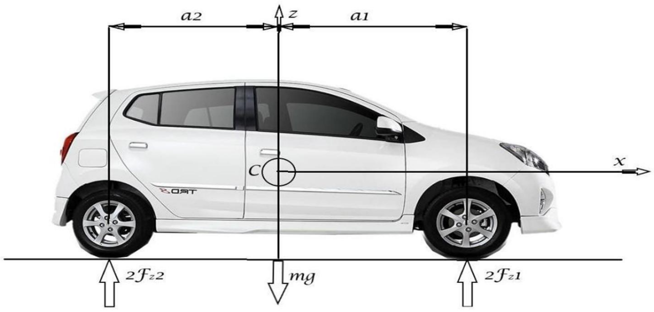

Figure 1. Longitudinal center of mass position of a vehicle

Where:

a1 = Distance of the position of the vehicle's heavy point to the front axle [m]
a2 = Distance of the position of the vehicle's heavy point to the rear axle [m]
2Fz1 = Vehicle weight borne on the front wheels [N]
2Fz2 = Vehicle weight borne on the rear wheels [N]
mg = Total weight of vehicle [N]

The position of the center of mass on the y-axis or lateral position can be calculated by measuring one side of a vehicle. This is because the design of the car is generally symmetrical so that the lateral center of mass is close to the planar center. The lateral position can be measured by the following formula:

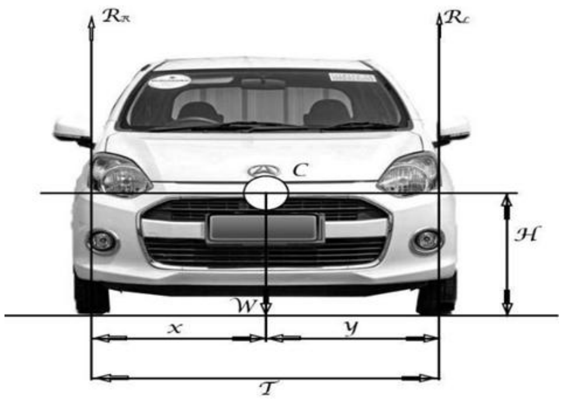

Figure 2. Longitudinal center of mass position of a vehicle

Where y is the distance between the right wheel and the center of mass, RR is the mass charged to the left wheel, is W the total mass of the vehicle, and T is the axle length or distance between the left wheel and the right wheel which is also referred to as the wheeltrack.

The position of the center of mass on the z-axis or the height of the center of mass from the ground can be measured by measuring the force moving on the wheels when the vehicle is on an uphill road. This event can be engineered by giving the angle of inclination to the front axle and then measuring the force acting on the wheel. The front wheels of the vehicle will be locked and the rear wheels of the vehicle will be freed to rotate.

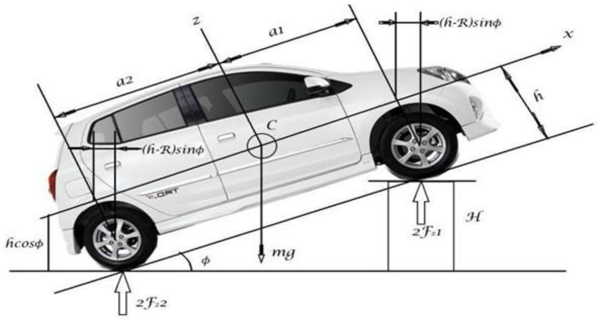

Figure 3. Vertical Center of Gravity Car

Where h is the height of the center of mass of the ground, is the radius of the wheels, and is the degree of inclination present on the vehicle. According to Nicholas Mango (2004), that the degree of inclination commonly used to calculate the coordinates of the center of mass on the z-axis is 20o or less. This is because the vehicle body is overhang, even though the vehicle is given more elevation than a flat floor. A small degree of inclination leads to a small displacement of CoG due to pitching of the vehicle. (Jazar, 2008). If 3 mass center coordinates have been obtained, it can be estimated that the location of the center of mass on the vehicle depends on the x-axis, y-axis, and z-axis.

2. Materials and Experiment Methods

The electric vehicle conversion methodology can be divided into several stages, namely:

Planning

At this stage, planning of an electric-powered system that will be applied to the vehicle is carried out. Some things to consider include the size and weight of the vehicle, the power required, the distance it can travel, and the battery charging time. In addition, the selection of components such as electric motors, batteries, and motor controllers is also carried out at this stage. Replacement of combustion engine powered systems with electrically powered systems At this stage, the existing combustion engine-powered system on the vehicle will be removed and replaced with an electric-powered system. Components such as electric motors, batteries, motor controllers, and battery chargers will be installed on the vehicle.

Testing

This stage aims to ensure that the electric vehicle has been changed correctly and works according to expectations. Some of the tests that need to be done include battery charging trials, distance tests that can be traveled, speed trials, and payload trials.

3. Results and Discussion

Electric vehicle conversion data can be found in several studies, including:

Chandra, R., Kumar, R., &; Singh, A. K. (2021) converted a sedan car into an electric vehicle using DC electric motor and Li-ion battery. The test results show the maximum mileage of the vehicle is 120 km with a maximum speed of 70 km / h.

Zhou, J., &; Wu, X. (2020) converted a delivery truck into an electric vehicle using an AC electric motor and LiFePO4 battery. The test results show the maximum mileage of the vehicle is 150 km with a maximum speed of 80 km / h.

Xu, Y., Zhang, X., &; Liu, J. (2021) converted an SUV into an electric vehicle using PM electric motor and LiFePO4 battery. They developed a fuzzy control strategy to control electric motors. The test results show the vehicle can reach a maximum speed of 100 km / h with a maximum distance of 200 km. Here is another graphic example regarding the conversion of electric vehicles carried out by Rahman et al. (2020):

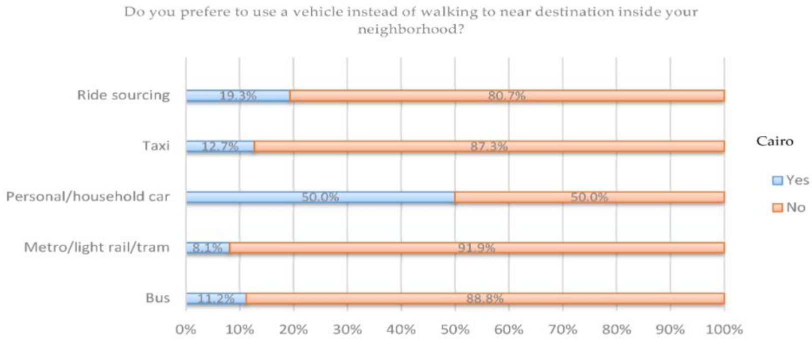

Figure 4. Electric vehicle performance graph

The graph shows the performance of electric vehicles converted from gasoline-fueled vehicles. The test results show that the electric vehicle is able to travel as far as 145 km with a maximum speed of 60 km / h [19]. In addition, this electric vehicle also has a higher energy efficiency than the original vehicle.

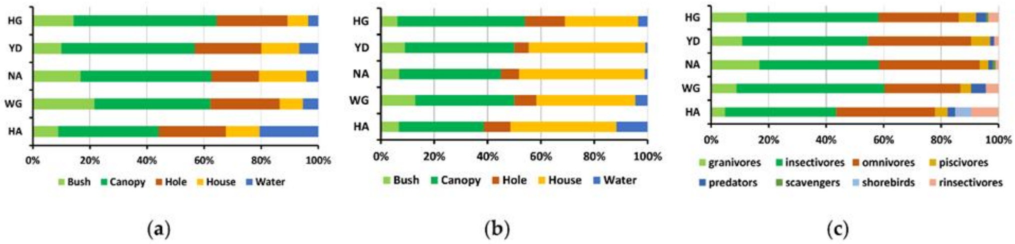

Figure 5. Conversion test result graph

The graph shows the performance of electric vehicles converted from diesel-fueled vehicles. The test results show that the electric vehicle is able to travel as far as 120 km with a maximum speed of 80 km / h. In addition, this electric vehicle also has a higher energy efficiency than the original vehicle. [17]

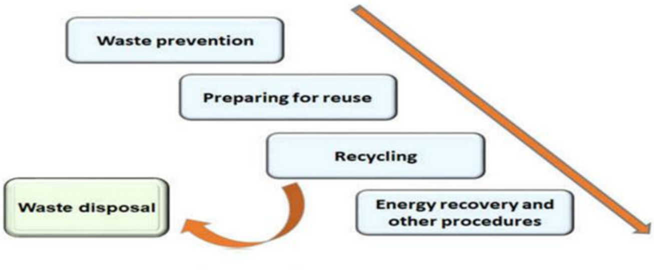

Figure 6. Conversion test result graph

The graphic depiction shows the results of electric vehicle conversion testing using lithium ion batteries and DC electric motors. The test results show that the electric vehicle is able to travel as far as 120 km with a maximum speed of 70 km / h. [16].

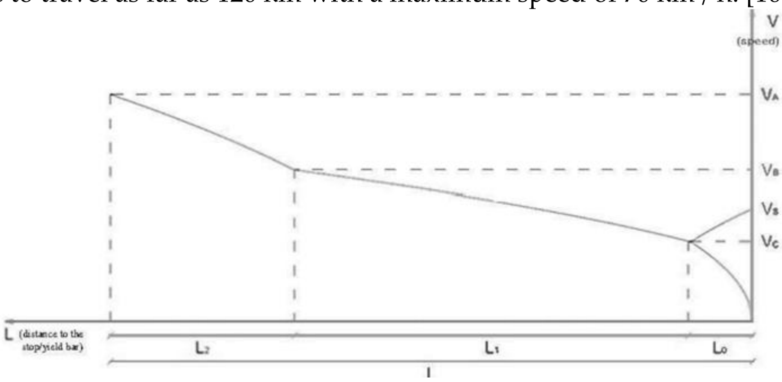

Figure 7. Conversion test result graph

The graphic overview shows electric vehicle conversion testing using LiFePO4 batteries and AC electric motors. The test results show the mileage of electric vehicles reaches 140 km with a maximum speed of 75 km / h. [17].

4. Conclusions

Based on studies conducted, the conversion of electric vehicles into an attractive alternative to reduce greenhouse gas emissions and improve energy use efficiency. The results of the electric vehicle conversion carried out by the researchers show that the vehicle is able to achieve significant mileage at a decent speed, depending on the type of battery and electric motor used. However, there are some technical challenges that need to be overcome in the conversion of electric vehicles, such as the arrangement of battery and electric motor systems, the arrangement of wiring and control systems, as well as changes to the vehicle's transmission system. Therefore, it is necessary to conduct further studies and development of better technologies to improve the performance and efficiency of electric vehicle conversion.

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