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A Study on the Steering System of Electric Scooter

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Abstract

Recently, the popularization of personal mobility(PM) has made it possible to see many electric scooters. The energy source of personal transportation used by the general public and the disabled can be seen as environmentally friendly as electricity. Personal transportation means are divided into small electric vehicles because they use electric energy, and they are being treated as new models by automobile manufacturers in each country and spurring development. On the other hand, personal transportation means may cause various types of traffic accidents as they travel between roads and a human walk. In order to prevent such accidents, it is judged that the enactment of laws on the establishment of specifications for electric scooters, which are personal transportation means, and the method of restricting road operation should be given priority. The electric scooter is basically different from the conventional vehicle. The steering shaft of the steering system applied to the electric scooter one to two is possible. 1 to 2 the front-wheel under the steering column is used. It is classified according to the number of wheel installed at the electric scooter is the vehicle body into 2 wheel - electric scooter, and 3 wheel - electric scooter and 4 wheel - electric scooter. In this study, we propose a steering shaft design model that can be applied to an electric scooter, one of personal transportation means. A design model for 1-shaft steering and 2-shafts steering that can be applied to electric scooters is proposed. In addition, we have produced the prototypes for the commercialization of the proposed models, and reviewed the pros and cons of the manufactured prototypes and models.

Keywords: *Steering, Electric Scooter, Personal Mobility, Differential, Driving Wheel*

1. Introduction

Carbon neutrality means calculating the amount of carbon dioxide to absorb greenhouse gases emitted from the industry, planting trees as much as the amount of carbon, or investing in clean energy fields such as wind power and solar power generation to offset pollution. The Enforcement Decree of the Carbon Neutral and Green Growth Basic Act passed the Cabinet meeting on March 22, 2022. The government will set up a national carbon neutral basic plan every five years to implement the 2030 greenhouse gas reduction target (NDC) by 40%. It is effective to use electric energy instead of fossil fuels in automobiles for carbon neutrality [1, 2, 3].

Electric vehicles using electric energy have become an important research subject of manufacturers, and electric scooters and electric bicycles, which are small electric vehicles, are recognized as short-range means

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of transportation. The electric scooter is driven with the motor [4, 5, 6]. The motor is rotated by using the electricity of battery. The driving wheel connected to the motor is rotated and it is driven. The general matters to be considered in designing the electric scooter body are as follows. First, the front part of the electric scooter may be lift in the early stage of movement, and such front wheel lifting can be solved by lengthening the wheel base or putting the motor in the form of an in-wheel on the front wheel. Second, the consideration of the selection of the driving wheel is the installation of the differential device, which is applicable to the case where the number of wheels applied to the electric scooter is three or more. When two wheels are installed in the front or rear shaft of the electric scooter, the differential function according to the rotation of two wheels should be considered. If not considered, in vehicle, problem occurs in cornering, so the passenger becomes embarrassed or deviates from the vehicle body. In particular, if the left and right wheels are connected by a link or an shaft, the design should be made considering the differential function. In order not to install such a differential device, the left and right wheels of the shaft should not be connected to each other. Considering these contents, the steering system of the electric scooter should be designed [7, 8].

The general steering system applied to automobiles is a 1-shaft steering system using a gear system consisting of rack and pinion. If the gear system which is the steering system applied to vehicle is used for the electric scooter, the problem that the cost of the electric scooter product itself rises can be occurred. One to two steering shafts are possible to be applied to electric scooters. In this study, we propose applicable models by dividing the steering system applied to electric scooters into one and two shafts. Also, the composition and contents of the proposed models were examined, and the prototypes were produced for commercialization [9, 10].

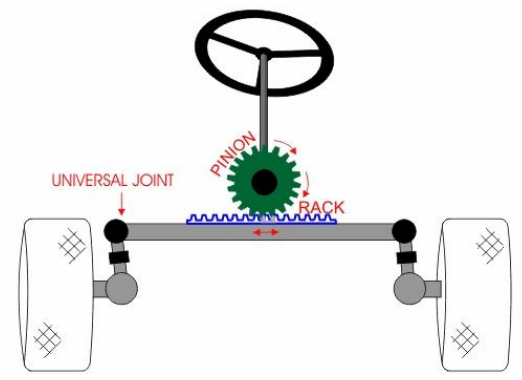


Figure 1. Steering system applied automotive

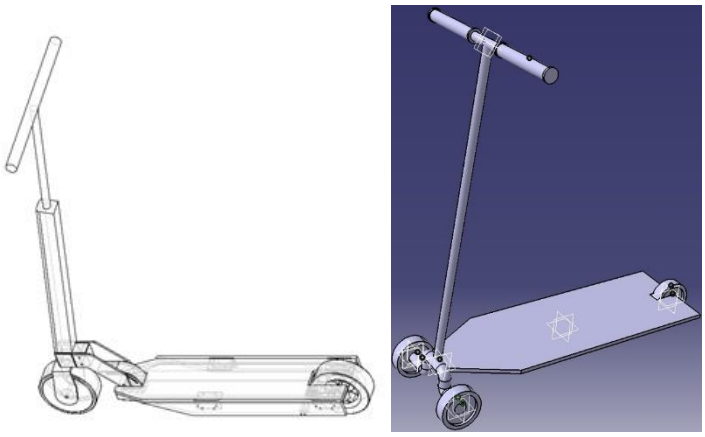
2. Steering shaft

Electric scooters are basically less vehicle body weight than automobiles, and size is smaller. In addition, unlike general vehicles that drive between cities and cities, it is common to be used as a personal transportation means for movement in the city center. One or two steering shafts are available for electric scooters with a small size and weight, and this section is described by classifying them into the contents according to the number of steering shafts applicable to electric scooters.

2.1 1-shaft steering system

In the steering system using one shaft in the electric scooter carrying the small vehicle body, one or two wheels connected to the steering shaft are possible. The steering system considering the above-mentioned contents is the same as Figure 2. Figure 2(a) shows one steering shaft, with one wheel under the steering shaft,

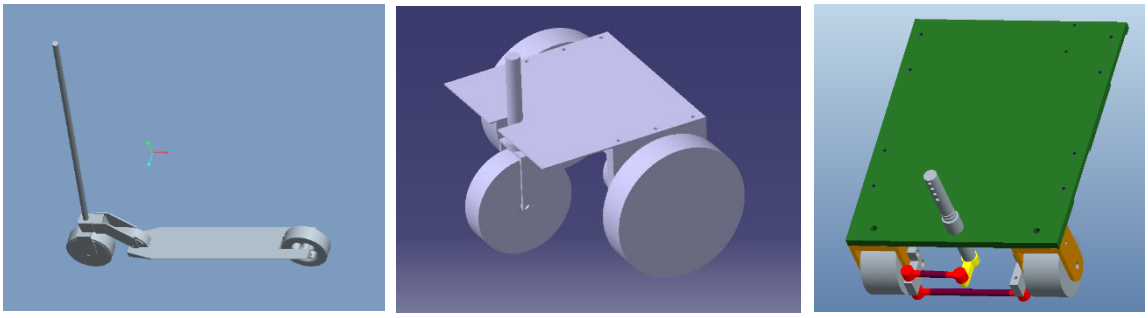
and (b) with two wheels under the steering shaft. There are two wheels in front wheels in Figure 2(b) but if two wheels are not connected by axis, no differential device is required. That is, when the vehicle body is turned by the will of the driver, the left wheel and the right wheel of the front wheel operate separately, so no differential device is required.



(a) (b)

Figure 2. 1-shaft steering systems of an electric scooter

Generally, the total number of wheels mounted on the electric scooter body is two, three and four; models for having one steering shaft on these electric scooters are the same as Figure 3. When the total number of wheels is two in the configuration of the electric scooter body, it consists of one front wheel and one rear wheel due to the arrangement structure of the wheel. This form is also called an electric board. If three wheels are employed on the body of an electric scooter, the left and right wheels may move separately on the front wheels, as in of Figure 2(b), but may have the same structure as Figure 3(b). In this case, the steering wheel is made up of one, so free steering is possible. However, the rear wheel has two wheels, so the differential should be considered. When four wheels are employed in the electric scooter body, the front wheel has two wheels. When two wheels are provided in the front wheel, the steering shaft can be made of one by using the link structure such as Figure 3(c). If the rear wheel is two, as in (b) and (c) in Figure 3., the differential function should be considered.[1]



(a) (b) (c)

Figure 3. 1-Shaft steering systems of a electric scooter according wheel number

2.2 2-shafts steering system

If the steering shaft of the electric scooter is two, the steering shaft must have a structure connected to the

front wheel. An example of a link structure is like Figure 4.. In Figure 4. the two wheels of the front wheel are connected to the steering shaft, respectively. This structure is connected to the steering shaft, but it is a structure that can operate the vehicle without the need for a differential device because two front wheels are not connected.[1]

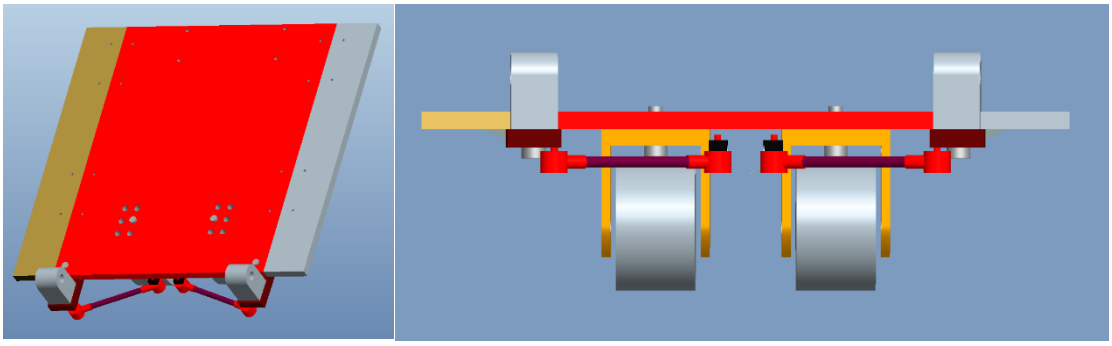


Figure 4. 2-Shafts steering system

If two front wheels are connected directly to the axis, the left wheel and the right wheel are linked to each other, so differential should be considered.

3. Manufacturing of the prototype

The contents of the prototype which is manufactured by applying the steering system of 1-shaft and 2-shafts to the electric scooter are described.

3.1 Prototype of 1-shaft steering system

In 1-shaft steering, the first was to produce a prototype with two wheels mounted on the electric scooter body; an in-wheel motor was inserted into the front wheel to make the driving wheel front-wheel. Battery and controller can be left in the steering shaft of front-wheel according to establish the in-wheel motor in front-wheel. The specification of the two-wheeled electric scooter prototype is the same as Table 1, and the production result is the same as Figure 5.

Table 1. Specification of manufactured 2-wheel electric scooter

Subjects	Specification
Capacity of motor	24V, 1.5kW
Location of motor	Front wheel
Location of battery	Steering shaft
Height of vehicle body	100cm
Weight of vehicle body	12.5kg
Driving method	In-wheel motor of front wheel
Number of steering shaft	1-Shaft

Total wheel number	2
Wheel size	15cm
Velocity control	Throtti1e
Material of foot plate	Engineering plastic

Figure 5. Prototype of a 2-wheel electric scooter

Electric scooters, which are composed of two wheels, are sometimes called electric boards. The structure of the electric scooters with two wheels is the most economical structure and is being launched on the market as a shared scooter. The two-wheel electric scooter is sufficient to allow the wheel-base to be lifted in the departure, so that the driving wheel selection can be freely arranged.

The prototype of a three-wheeled electric scooter with 1-shaft steering is the same as Figure 6. Figure 6.(a) is a three-wheel electric scooter, and (b) is a motor and differential device for rear-wheel drive applied to the three-wheel electric scooter.[1]

Figure 6. Prototype of 3-wheel electric scooter

To steer two front wheels with 1-shaft steering, a link structure connecting two wheels is required. The prototype of the four-wheeled electric scooter that reflects these contents is like Figure 7. The results of the 1-

shaft steering of the 4-wheel electric scooter are different from those of Figure 2. (b). Although the front wheel has two wheels, the figure connected by the link is Figure 7, and the left and right wheels are not connected, and the structure that each operates separately is Figure 2. (b).[1]

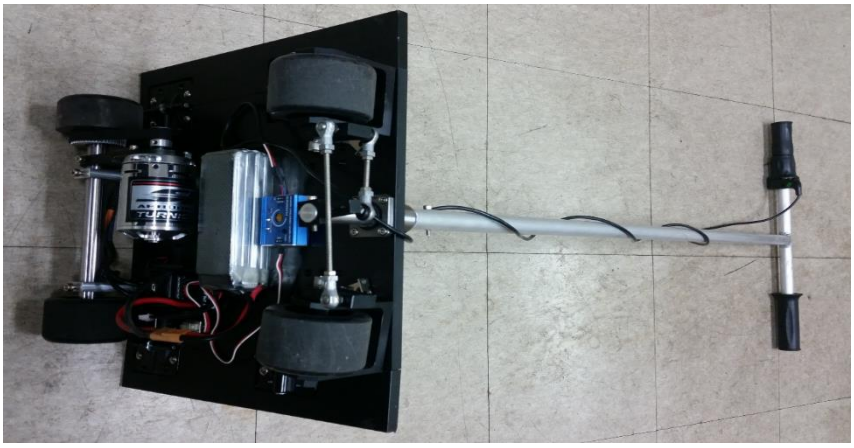


Figure 7. Prototype of 4-wheel electric scooter

3.2 Prototype of 2-shafts steering system

The form having 2-shafts steering is possible even when the front-wheel is one. In this case, two steering shafts are installed on the front-wheel. However, electric scooters have a simple structure and a low cost structure that can secure competitiveness. For this reason, 2-shaft steering is basically valid at two front wheel. The prototype for 2-shafts steering systems of the two front wheel is the same as Figure 8. In order to make two steering shaft with two front wheels, the structure of connecting the two wheels to the steering shaft using a link should be formed. However, a fixed reference point is required to form a rotating structure, and a steering shaft must be connected to each other by a different link to prevent a differential device.[1]

Figure 8. Prototype of 4-wheel electric scooter with 2-shafts steering system

In the steering system manufacturing process, the steering shaft and front wheel are connected to the link. The steering angle changes according to the location of the link. Also, the throttle of the handle part connected to the steering shaft was used for speed control.

Manufactured 2-shafts steering electric scooter is rear wheel drive, and rear wheel drive should consider the differential function in the four-wheel electric scooter. In order not to have differential devices, the shaft

of the drive motor is connected to only one wheel.

4. Conclusion

Electric scooters, which are in the spotlight as personal transportation, should be able to switch directions according to the will of the driver. The redirection of the electric scooter is made of the steering wheel held by the driver in his hand. This handle is connected to the steering shaft. One of the important decisions to consider when designing an electric scooter is the number of steering shafts. In this study, we reviewed the models of the steering shaft of the electric scooter with one or two steering shafts, and based on this, we produced the prototypes. The models of electric scooters were proposed considering the steering system, and the following conclusions were drawn through the production of the prototypes

1) It is advantageous to have 1-shaft steering in order to have a wide rotation angle of the steering wheel.

2) When two wheels are installed on the front or rear of the electric scooter, the differential function according to the rotation of two wheels should be considered.

3) If the front wheel is two, the front wheel must be connected to the steering shaft with different links so that the differential device is not required.

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