

Proposal and Manufacturing of Prototype of the CVT Model using Spring

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Abstract

In order for small electric vehicles to drive on hilly roads in Korea, methods to improve the climbing ability and power performance of vehicles should be taken. In order to improve the power performance of small electric vehicles, the performance of motors mounted on electric vehicles should be improved. However, if the performance of the motor is improved to improve the power performance of the electric vehicle, it is possible to lower the price competitiveness accordingly. In addition, the power consumption of the battery is rapidly increased to drive the high-performance motor, so in order to introduce the small electric vehicle into the domestic market, various problems must be overcome. In order to commercialize small electric vehicles that do not emit harmful exhaust gases to the human body in the hilly domestic terrain, it is effective to introduce a separate continuously variable transmission system that can improve the climbing ability and power transmission ability. In this study, we propose a proprietary model of continuously variable transmissions that can be applied to small electric vehicles. The proposed continuously variable transmission is equipped with a spring in the driving pulley and the driven pulley, and has the advantage of performing a shift that increases torque in a situation where the vehicle needs to increase torque when driving on a hill. In addition, the basic design for commercialization of the proposed continuously variable transmission was carried out, and the prototype manufactured and attached to the body of a small electric vehicle.

Keywords: Spring, Small Electric Vehicle, Concept Drawing, Prototype, Pulley

1. Introduction

Korea's industrial structure is composed of over-consuming energy, and for this reason, it is the world's seventh largest greenhouse gas emitter. Therefore, in order to prevent global warming after 2020, emissions must be reduced in accordance with the World Convention. In order to respond to this, the government decided to invest 19 trillion won over the next five years to foster new energy industries [1, 2, 3].

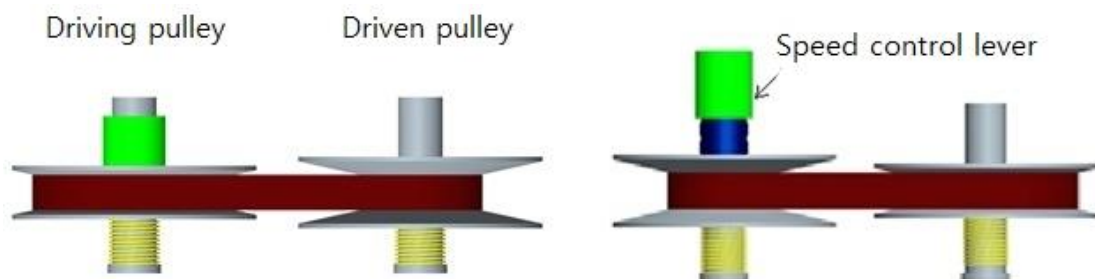
As part of global warming and improving the atmospheric environment, converting fuel used in automobiles into electricity is known to reduce greenhouse gas emissions by 20% because it does not emit carbon dioxide. Currently, small electric vehicles are commercialized in China and operated in many cities in China, but in Korea, there are many hills and terrain problems, and they are not commercialized yet. In order

for small electric vehicles to travel in many hills scattered in Korea, it is necessary to improve the power performance mounted on electric vehicles including the climbing ability of vehicle [4, 5]. To do this, the performance of motors used in small electric vehicles should be improved. If the performance of motors is improved, the weight of the motor will become heavy and the price competitiveness will be lowered [6, 7]. In addition, the power consumption of the battery increases sharply in order to drive the high performance motor. In order for small electric vehicles to enter the domestic market, many problems such as improvement of climbing ability and improvement of power performance should be solved [8, 9]. It is effective to have a separate transmission system in order to commercialize small electric vehicles that do not emit harmful exhaust gases in hilly domestic terrain [10].

In this study, we propose a continuously variable transmission model that can be applied to small electric vehicles. In order to commercialize the proposed continuously variable transmission model, the basic design and prototype were manufactured and mounted on the body of a small electric vehicle.

2. Proposal of the CVT Model

The proposed model of the continuously variable transmission for small electric vehicles using spring is like Figure 1. The power transmission medium of the proposed continuously variable transmission model is made of V belt, and the driving pulley is connected to the motor, and the driven pulley is connected to the driving wheel. In the proposed continuously variable transmission configuration, the spring is installed in the same direction as the driving pulley and the driven pulley, so that the transmission can be automatically performed to increase torque when the small electric vehicle climbs the hill. Figure 1(a) is the driving mode of plate road, and Figure 1(b) is the driving mode at gradient.



(a) Driving mode at plate

(b) Driving mode at gradient

Figure 1. CVT model using spring

The proposed continuously variable transmission allows spring displacement in the axial direction of the pulley to increase torque by itself when climbing the hill, and the structure of increasing the rotational force by changing the belt pitch radius when the vehicle climbs the hill. In addition, the speed control lever can be operated by the will of the driver to control the transmission ratio. The power transmission medium is based on the V belt, and the free body diagram of the force acting on the V belt is the same as Figure 2.

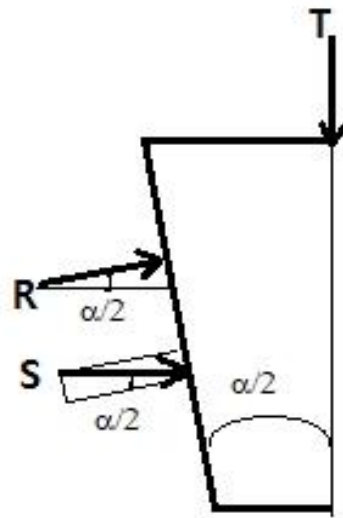


Figure 2. Free body diagram of V-belt at CVT model using spring

As seen in Figure 2. when the V belt is pushed in the radial direction of the pulley due to the belt tension, the tension T acts on both sides of the groove ; the reaction R occurs in the vertical direction of the V groove surface. The tensile force S by the spring mounted on pulley generates in the continuously variable transmission and the power by the reaction force R and spring tensile force S are combined and the frictional force is occurred. The size of the frictional force actuating on the incline of V belt is as follows.

$$F = 2\mu(R + S \cdot \cos \frac{\alpha}{2}) \quad (1)$$

Also, the relational expression of the spring tension S by the tension T , the reaction force R , and the belt tension can be obtained from the equilibrium of the force. μ is the friction coefficient.

$$T = 2(R \cdot \mu \cdot \cos \frac{\alpha}{2} + S \cdot \mu \cos^2 \frac{\alpha}{2} + R \cdot \sin \frac{\alpha}{2}) \quad (2)$$

The equations (1) and (2) are obtained in equilibrium for the components of the proposed continuously variable transmission, which is an equation that must be applied when assembling the components of the proposed continuously variable transmission.

3. Manufacturing of Prototype

The first form of the prototype of the continuously variable transmission proposed in this study is like Figure 3. The prototype is listed in series with housing and drive motor supporting the continuously variable transmission body. This type of driving motor is connected to the continuously variable transmission housing in series, so that the distance between the continuously variable transmission housing and the driving motor is distant.

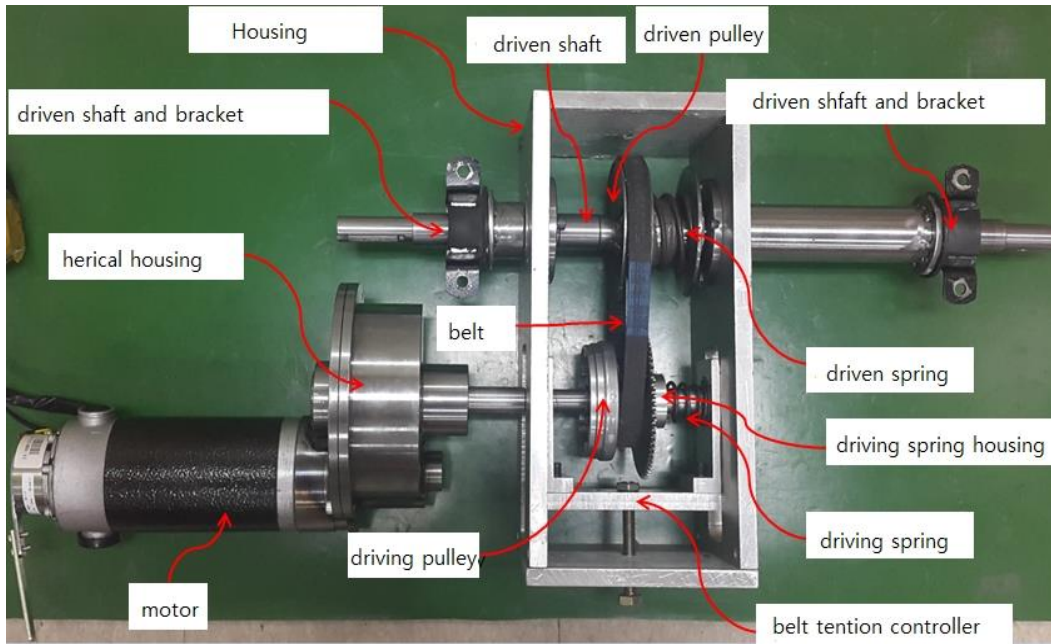


Figure 3. First type manufactured proposed CVT model

The first type of continuously variable transmission manufactured to be attached to a small electric vehicle body is like Figure 4. As a result of attaching the first continuously variable transmission prototype to a small electric vehicle, the drive motor is out of the transmission housing and out of the rear wheel. This form has a problem in the application of actual vehicle. That is, the motor protrudes out of the vehicle body and the vehicle runs, which is at risk of collision. To eliminate this risk, the drive motor was rebuilt by placing it on the top of the continuously variable transmission. In the basic design, a spring is placed on the driving pulley and the driven pulley, and the motor is placed on the transmission to place the driving motor inside the vehicle body. Based on these contents, the basic design contents were shown in Figure 5.



Figure 4. A small electric vehicle equipped with the first CVT model prototype

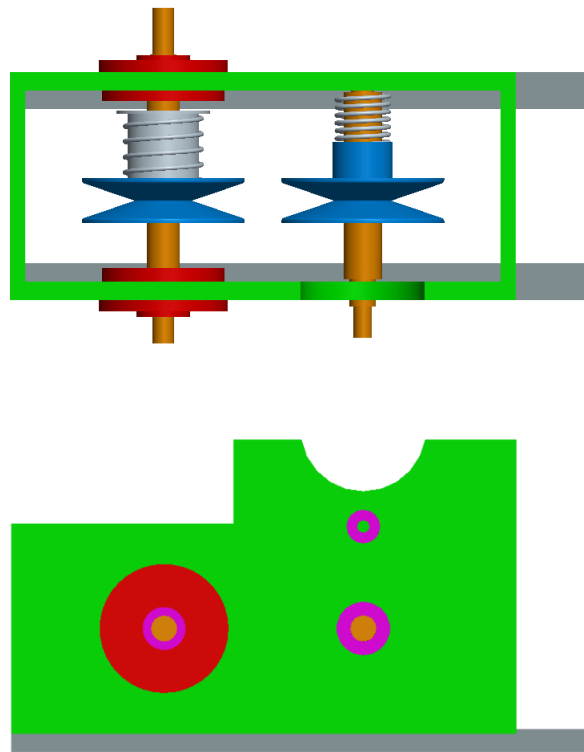


Figure 5. Modified housing design of CVT model

The continuously variable transmission, which was rebuilt based on the basic design of Figure 5, is like Figure 6. As seen in the picture, the drive motor is located on the continuously variable transmission housing.

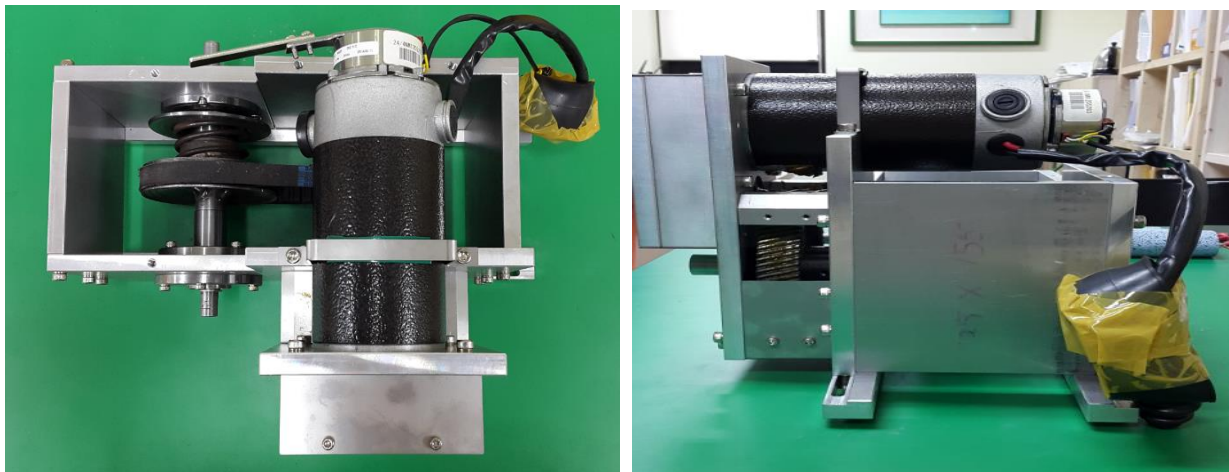


Figure 6. Modified CVT prototype with motor

The drawings and results for attaching the modified continuously variable transmission to the small electric vehicle body were shown in Figure 7.

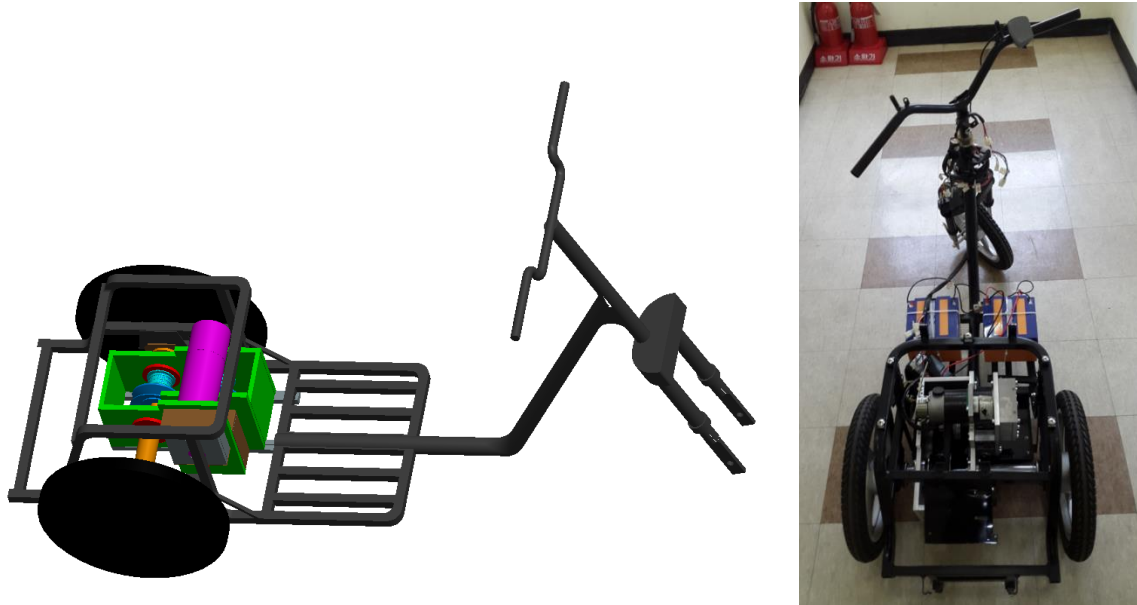


Figure 7. Small electric vehicle equipped with the modified CVT prototype

The proposed small electric vehicle with the prototype of the continuously variable transmission is in the form of two front and rear wheels, easy to steering and comfortable to install the rear seat. The modified continuously variable transmission is mounted between the rear wheels. This type is the form that can be mounted on the actual vehicle.

4. Conclusion

In this study, we propose a continuously variable transmission model that can be mounted on small electric vehicles that can be operated in hilly domestic terrain. The proposed continuously variable transmission model has a spring installed in the driving pulley and the driven pulley, and has a characteristic that the continuously variable transmission increases the torque by itself in a situation where the vehicle needs to increase the torque of the hill. The following results were obtained from the manufacturing of the prototype for the commercialization of the proposed continuously variable transmission and the attachment to the small electric vehicle body.

- (1) The proposed continuously variable transmission model is equipped with a spring in the same direction to the driving pulley and the driven pulley, and the vehicle increases the torque by itself when the vehicle goes up.
- (2) The power transmission medium of the proposed continuously variable transmission is made of V belt.
- (3) The driving pulley and driven pulley constituting the continuously variable transmission can make the housing and it can be compact.
- (4) The drive motor is installed on the drive pulley and driven pulley housing, the shift system can install in the small electric vehicle body.

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