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Manufacturing of the Prototype for CVT using Spring & Application at Small Electric Vehicle

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Abstract

Global warming is causing abnormal climates such as floods, droughts, and typhoons all over the world. According to some scientists, carbon dioxide emitted from automobiles is the main cause of global warming. To cope with this, each country is making efforts to replace the existing fossil fuel-powered engine-driven cars with electric vehicles. In order to commercialize small electric vehicles in Korea, it is necessary to solve many problems such as improvement of hill climbing capacity and improvement of power performance. In this study, we propose a proprietary model for a continuously variable transmission(CVT) of a small electric vehicle that can be operated on hills, in which a spring is mounted on a driving pulley and a driven pulley. A prototype of the CVT model using a spring was manufactured and attached to a small electric vehicle body.

Keywords: *CVT(Continuously Variable Transmission), Spring, Small Electric Vehicle, Prototype, Pulley*

1. Introduction

Carbon neutrality means calculating the amount of carbon dioxide to absorb greenhouse gas emissions from the industry, planting trees as much as carbon, or investing in clean energy fields such as wind and solar power to offset pollution. For carbon neutrality, it is effective for automobiles to use electric energy instead of fossil fuels such as gasoline and diesel. China accounts for more than 95% of the world market for the motorcycle market and is actively promoting the electric motorcycle market to reduce smoke and air pollution. Japan is responding to technologically high added value, and is actively preparing activities to include electric motorcycles in ISO 26262 by forming a TF team centered on electric motorcycle manufacturers. As part of global warming and improving the atmospheric environment, converting fossil fuels used as power sources for automobiles into electrical energy is known to reduce greenhouse gas emissions by 20%. Currently, small electric vehicles are operated in many cities in China in line with the will of the Chinese authorities aiming at reducing soot. However, small electric vehicles operating in China are not commercialized in Korea due to hilly terrain problems [1-3]. In order for a small electric vehicle to run in the hilly terrain of Korea, it is necessary to improve the power performance including the ability of the vehicle to climb. As the performance

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of the motor improves, the weight of the motor becomes heavy and the price competitiveness is likely to decrease. In addition, the power consumption of the battery increases rapidly in order to drive a high performance motor. In order for small electric vehicles to be commercialized in Korea, many problems such as improvement of climbing ability and improvement of power performance should be solved [4-6]. In order to commercialize a small electric vehicle that does not emit harmful exhaust gases in hilly domestic terrain, it is effective to have a separate transmission system. In this study, considering the hilly terrain in Korea, a proprietary model for a CVT applicable to small electric vehicles that can be operated on hills is proposed, and the proposed CVT is equipped with a spring in the driving pulley and the driven pulley. In order to commercialize the proposed CVT, a prototype was manufactured and attached to a small electric vehicle body [8-10].

2. Model of a CVT using Spring

The model of the CVT proposed in this study is as shown in Figure 1. The CVT is divided into a driving pulley and a driven pulley, and a V-belt is used as a power transmission medium. In the spring installing is the driving process, the displacement is occurred about the load about hill. And the phenomenon that the power transmission medium V-belt is entangled can be prevented.

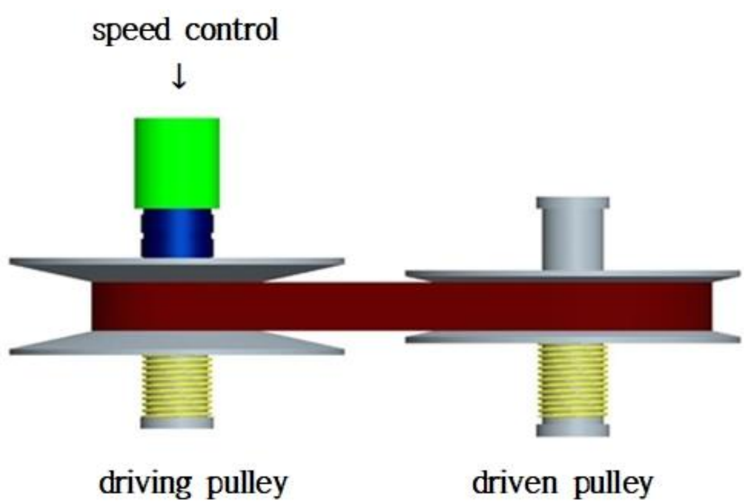

Figure 1. CVT model using spring

The proposed CVT model is applied to a small electric vehicle, with the drive pulley connected to the drive motor and the driven pulley connected to the wheels. Shifting can be proceed by using the speed regulator among the operation of electro-mobile with the will of operator [7, 11]. And in case the hill in which moreover, the load is increased is traveled, the spring displacement can be had the axial direction of pulley in order to multiply the torque. The tension T actuating on the power transmission medium V-belt is action on both sides of the V-belt. The reaction force R generates by the vertical direction of the V-belt side. The tensile force S by the spring mounted on pulley generates in the CVT and the power by the reaction force R and spring tensile force S is combined and the frictional force is occurred. The size of the frictional force actuating on the incline of the V-belt is as follows.

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

Where, μ is frictional coefficient, α is angle of groove. Moreover, from the equilibrium condition of the force, the relational expression of the spring tension S by the tension T, the reaction force R, and the belt tension can be obtained.

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

Equations (1) and (2) are equations that must be applied when assembling components of a CVT using a spring[1].

3. Manufacturing of Prototype

In order to commercialize a CVT using a spring, a prototype is manufactured. In order to mount the prototype of the CVT manufactured in a small electric vehicle, it is only possible to manufacture a vehicle body. For this reason, a prototype of a CVT using a spring together with the body of a small electric vehicle was manufactured.

3.1 Manufacturing of Vehicle Body

The body design considers the convenience of operation and the vehicles sold in the actual market. The front axle is connected to one wheel, and the rear axle is connected to two wheels. The basic design is Figure 2., and the manufactured results are as shown in Figure 3.

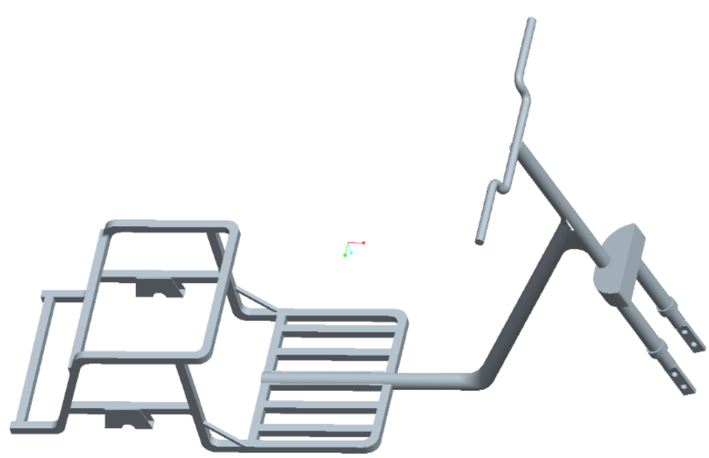

Figure 2. Diagram of a small electric vehicle body

Figure 3. Prototype of a small electric vehicle body

Steel was used for the bodywork, and steering, seats, etc. were arranged according to the drawings.

3.2 Manufacturing of CVT using Spring

The housing which can constitute the CVT using the spring by using the aluminum was manufactured. The spring was established in the driving pulley and follower. In addition, a motor was applied to the driving shaft, and a shaft connected to the wheel was installed on the driven shaft. 24V, 24A, 400W and 6.8 kg_f-cm motors were used in the prototype production. The constant of the spring mounted on the driving pulley and the driven pulley was 2.8kg_f/cm, the belt length was 530mm, the size of the driving pulley and the driven pulley was 110mm, and the groove angle between the driving pulley and the driven pulley was 10°. The first prototype of the CVT using spring is shown in Figure 4.

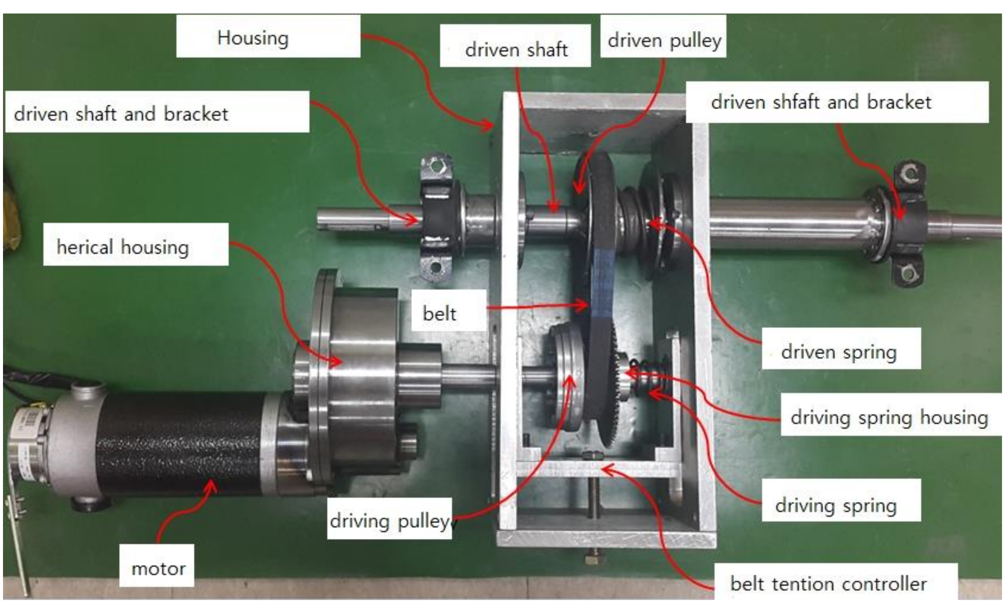

Figure 4. 1st prototype of CVT using spring

The figure of the small electric vehicle body equipped with the prototype of the first CVT manufactured is shown in Figure 5.

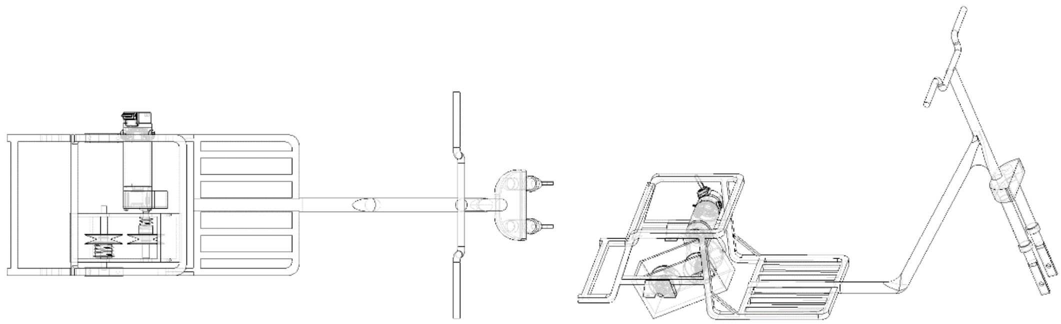

Figure 5. Diagram of a small electric vehicle equipped 1st prototype of CVT using spring

Figure 5 is the result of considering the actual dimensions of the parts used in the fabrication. As shown in the figure, the motor is out of the vehicle body. The manufactured result is shown in Figure 6.

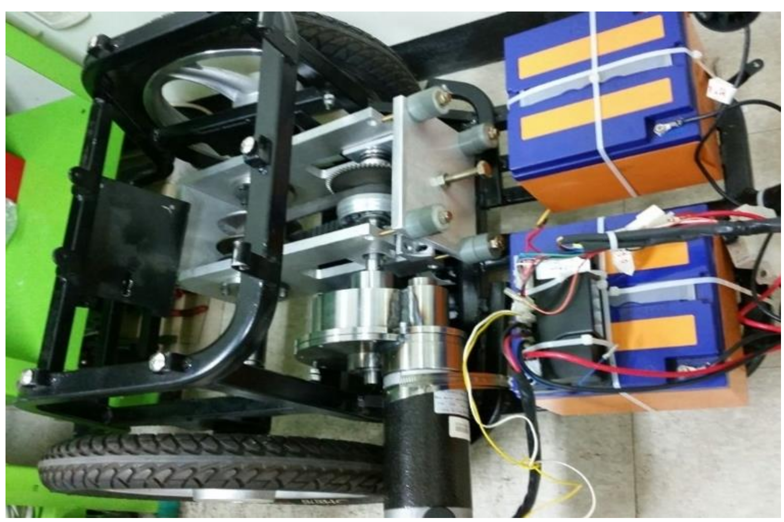

Figure 6. A small electric vehicle equipped 1st CVT using spring

As a result of attaching the first prototype of the CVT using spring the manufactured to the small electric vehicle body, the drive motor is out of the transmission housing and out of the rear wheel, which can be a problem in practical application. It is also possible to collide with other objects while driving, because the driving pulley and the driving motor are arranged in series. While the motor protrudes from the vehicle body and the vehicles revolves, the risk of collision is had. In order to solve the problem, the drive motor should be positioned at the top of the CVT to reduce the total length to the drive motor connected to the drive pulley. To this end, the driving motor is installed on the upper end of the CVT housing as shown in the following figure.

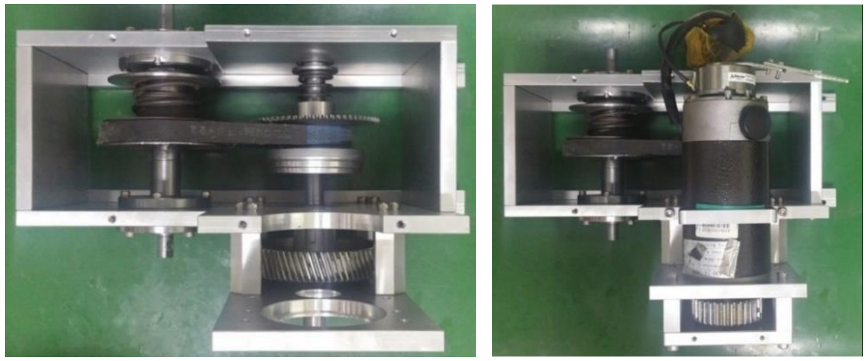

Figure 7. Prototype of the modified CVT using spring

The drawings attached to the small electric vehicle body with the modified CVT of Figure 7 are shown in Figure 8. The manufactured results are as shown in Figure 9.

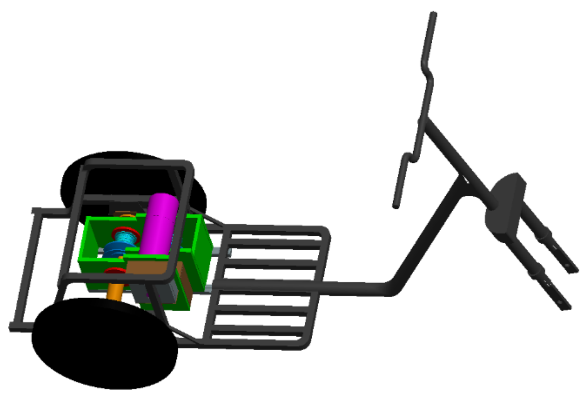

Figure 8. Diagram of a small electric vehicle equipped modified CVT using spring

Figure 9. A small electric vehicle equipped modified CVT using spring

A small electric vehicle equipped with a modified CVT has a front wheel and two rear wheels, and is comfortable to install a rear seat. The modified CVT is mounted between the rear wheels, which can be mounted on a real vehicle.

4. Conclusion

A CVT model with a spring installed in the driving pulley and the driven pulley is proposed. In order to commercialize the proposed model, a prototype was manufactured and a small electric vehicle body was also manufactured to attach the prototype of the CVT to a small electric vehicle. The proposed CVT and the vehicle body of the small electric vehicle were manufactured and the CVT was installed in the small electric vehicle. The following conclusions were obtained by manufacturing the prototype of the vehicle body of the proposed CVT and the small electric vehicle.

1) If the driving pulley and the driving device of the CVT are connected in series, the length of the driving device becomes large and the installation is restricted.

2) If the driving pulley and the driving device are connected in parallel, the CVT can be installed in a narrow space inside the vehicle body.

3) The spring is established in the same direction, it copes with the load added hill in the driving vehicles and shift can be proceed.

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