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CVT system applied pulley consisting of the basic disk and rotational disk

Dong-Gu Sien

Student, Department of Automotive Engineering, Seoul National University of Science and Technology, Graduate School, Korea z7743321@naver.com

Abstract

Automobile manufacturers in each country are spurring the development of electric vehicles that use electric energy, an eco-friendly energy, as a futuristic vehicle. Electric vehicles have the advantage of no harmful gas or environmental pollution and low noise. Unlike automobiles using existing internal combustion engines using fossil fuels, electric vehicles use the electricity of batteries to cause rotational motion of motors. In the electric vehicle driven by the motor, it is indispensable to develop a controller for controlling the motor. One of the areas where automobile manufacturers are concentrating is the development of small electric vehicles as a personal transportation means. Small electric vehicles such as electric motorcycles, one-seat electric vehicles and two-seat electric vehicles are expanding the market as a means of operating throughout the city. In the domestic road conditions with many hills, it is effective to have a separate transmission system for small electric vehicles to drive smoothly. In this study, we propose a new type of continuously variable transmission(CVT) system to ensure that small electric vehicles can be driven smoothly in hilly domestic terrain. The proposed CVT system is equipped with a basic disk and a rotational disk in the driving pulley and the driven pulley, respectively, and is applied with a sloping spline to rotate the rotational disk. To commercialize the proposed CVT system, an experimental device was developed to examine the power transmission efficiency and the configuration of the CVT system was proposed.

Keywords: *CVT, Basic Disk, Rotational Disk, Pulley, Spline, Auxiliary Disk*

1. Introduction

In order to cope with the global climate change crisis, each country is taking measures at the government level. Automobile manufacturers around the world are making efforts to convert vehicles using fossil fuels into electrical energy as part of a countermeasure to the climate change crisis [1, 2, 3]. Automobile manufacturers are developing technologies for batteries, motors and controllers needed for electric vehicles. Also, personal transportation is being developed with the emergence of the term 'personal mobility' as a means of transportation in the city [4, 5, 6]. In China, electric bicycles, electric motorcycles, and electric drive small vehicles are commercialized mainly in large cities, and they are often seen in the city center [7, 8]. However, Korea is required to be able to climb electric-powered small cars due to the topographical problems of many

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Corresponding Author: z7743321@naver.com
Tel:*** - **** - ****
Student, Department of Automotive Engineering, Seoul National University of Science and Technology, Graduate School, Korea

hills [9, 10]. In this study, we propose a model of the CVT system for small electric vehicles that can be applied to hilly domestic terrain. In addition to the basic role of transmission, we propose a model that can be applied to small electric vehicles. The proposed model consists of a spline on the driving shaft and the driven shaft. In addition, the present invention has a structure for performing a shift by installing a basic disk and a rotary disk on a driving shaft and a driven shaft. The first model of the proposed CVT system is the same as Figure 1 with a pulley consisting of a basic disk and a rotational disk. Figure 1 (a) is an example of the basic components of the proposed CVT system pulley, consisting of a basic disk, a rotational disk, and a sliding pin with a loosening slot. The chain or the timing belt etc. are set up on the sliding pin and the power transmission is performed. The Figure 1 (b) shows the spline which is the central axis of the rotational disk and basic disk.

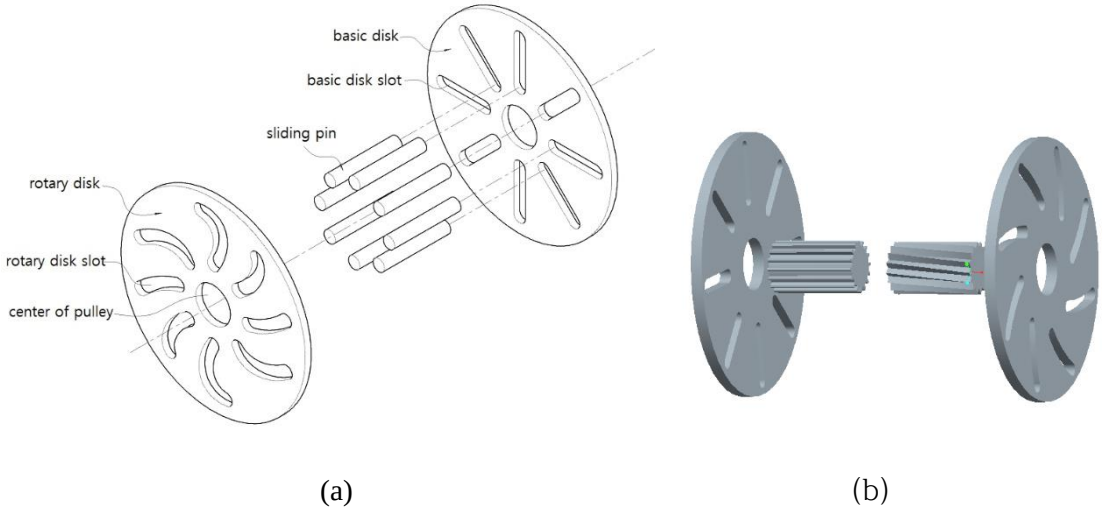


Figure 1. Pulley diagram of proposed CVT system

The basic disk leaves on the spline shaft of the linear type. The rotational disk puts on the inclined spline shaft position. The pitch radius of the power transmission media rotating the rotational disk at the clockwise direction or the counter clock-wise and moves the sliding pin to the center of circle direction and protects the sliding pin can be diversified. That is, the rotation plate placed on the inclined spline is moved and shift can be performed.

The second form of the proposed CVT system is a linear shape of the slots of the basic disk and the rotational disk, which are composed of pulleys, and a hinge joint of the auxiliary disk interlocking with the rotational disk between the basic disk and the rotational disk and a link connected to the slot. The auxiliary disk connected with the rotational disk and the form in which link is connected to the rotational disk are same as those of Figure 2. The auxiliary disk and the link are attached to the rotational disk and connect to the end of the link to the sliding pin, and both sides of the sliding pin can move along the basic disk and the rotational disk slot. It is a structure that encloses sliding pins and delivers power by a moving chain or timing belt, which can induce stable movement of the sliding pin moving along the slot.

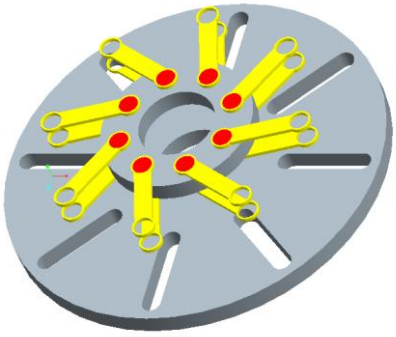
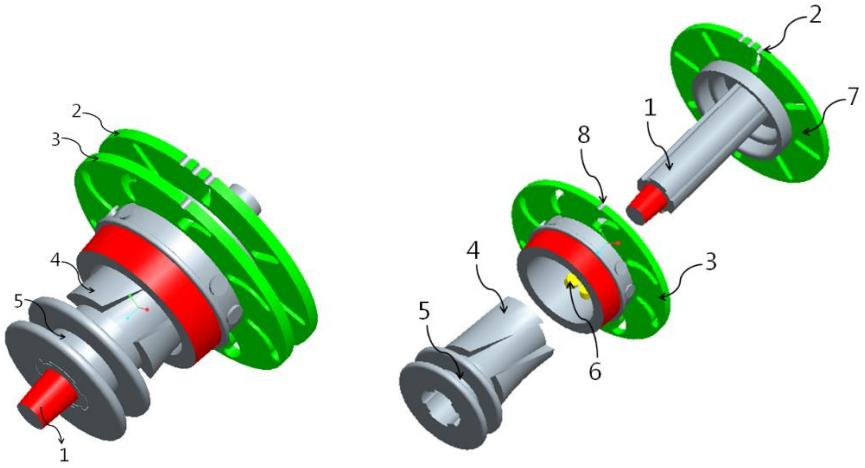


Figure 2. Rotational disk attached auxiliary disk and link

2. A pulley structure composed of a basic disk and a rotational disk

The practical configuration of pulley for commercialization of the proposed CVT system can be expressed in Figure 3. In Figure 3 the spline of the linear form is the basic axis at the innermost part of the axis, and the shift fork of the helical spline form is moved on the basic axis having the spline of the linear form. The inside of the shift fork digs the helical spline groove in order to rotate the rotational disk, or bearing is installed in the direction in which the helical spline can move and the shift fork is pushed axially or it pulls and the rotational disk can be moved to the clockwise direction or the counterclockwise direction. Sleeves are placed at the end to move the helical spline axially.



1: center shaft of pulley 2: basic disk slot 3: rotary disk 4: herical spline
5: shift pork sleeve 6: bearing 7: basic disk 8: rotary disk slot

Figure 3. Pulley of the CVT system using spline

The structure of the pulley when using the timing belt in which groove is dug the power transmission medium by using the described pulley structure is the same as Figure 5. The width of the sliding pin having sprocket shape is the variation according to the size of the applied timing belt. And the structure of improving the power transmission efficiency.

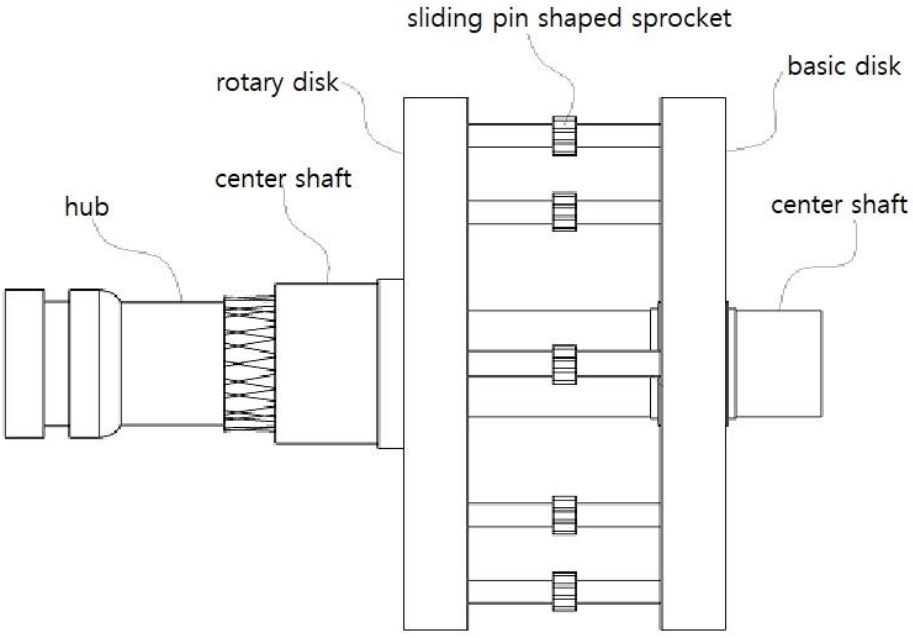


Figure 4. Pulley structure for timing belt

3. A CVT system consisting of a basic disk and a rotational disk

The proposed system consists of a basic disk and a rotational disk which are released. The auxiliary disk is introduced in the structure of the pulley to have different types of pulley structures. This section describes the contents of the CVT system according to whether or not the auxiliary disk is introduced.

3.1 Pulley composed of a basic disk and a rotational disk

The overall configuration of the CVT system consisting of a linear slot on the basic disk, a pulley with a slot in the arc shape on the rotational disk, and a driving pulley and a dirven pulley is the same as Figure 6..

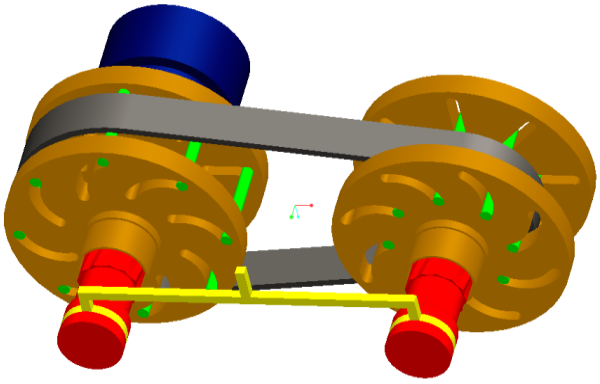


Figure 5. Assembly diagram of CVT system using pulley equipped basic disk and rotational disk

The driving pulley can apply the motor to the driving source. And by using the shift fork for shift, it pushes or it pulls and shift is proceed. If the pitch radius of the driving pulley is large, the pitch radius of the driven pulley should be small. To do this, the shapes of the helical spline in the shift fork should be crossed, and the shapes of the rotational disk should be crossed. The power transmission medium is equipped with a timing belt and a sleeve should be placed at the end of the center axis to mount a shift fork. The slots of the basic plate are linear in the center direction and the slots of the rotational disk are arc-shaped. The rotational disk slots of the driving pulley and the driven pulley are composed of the opposite direction. The reason for the reverse position is to make the radius change of the sliding pin in the opposite direction according to the shift operation mounted on the driving pulley and driven pulley. It moves about the basic disk plate to the clockwise direction to the counterclockwise direction in rotation according to the limited slot region and it diversifies the radius of pulley and the sliding pin connecting the slot of the rotational disk and moves can be shift.

3.2 Pulley using the auxiliary disk and link

The assembly drawing and resolution of the CVT system attaching to the auxiliary disk and link the basic disk and rotational disk as to the configuration of pulley are as follows. In case the auxiliary disk and link are used, the slot of the linear type possible.

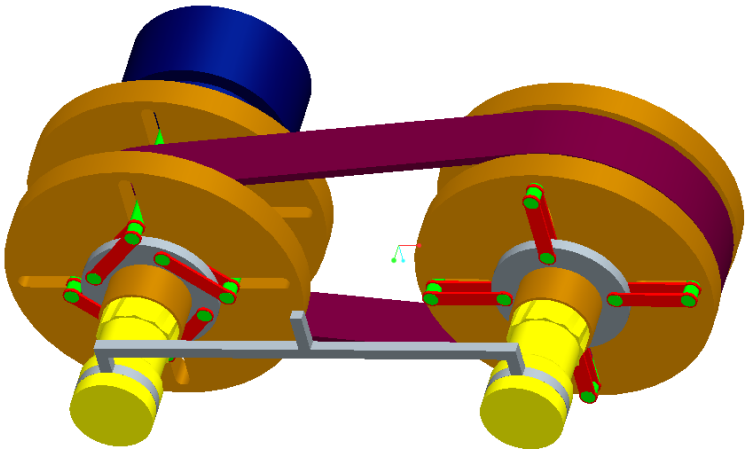


Figure 6. Assembly diagram of CVT system using spline equipped auxiliary disk and link

The end of the sliding pin is connected to the link and the end of the link must be hinge-jointed. The shift lever using the shift fork is used for shifting or it pushes or it pulls and shift is performed. If the pitch radius of the driving pulley is large, the pitch radius of the driven pulley should be small. To do this, the shapes of the helical spline in the shift fork should be crossed, and the shapes of the rotational disk should be crossed.

4. Experiment

The prototype of the proposed spline-based CVT system using spline was fabricated and a dedicated dynamometer was fabricated to measure the power transmission efficiency.

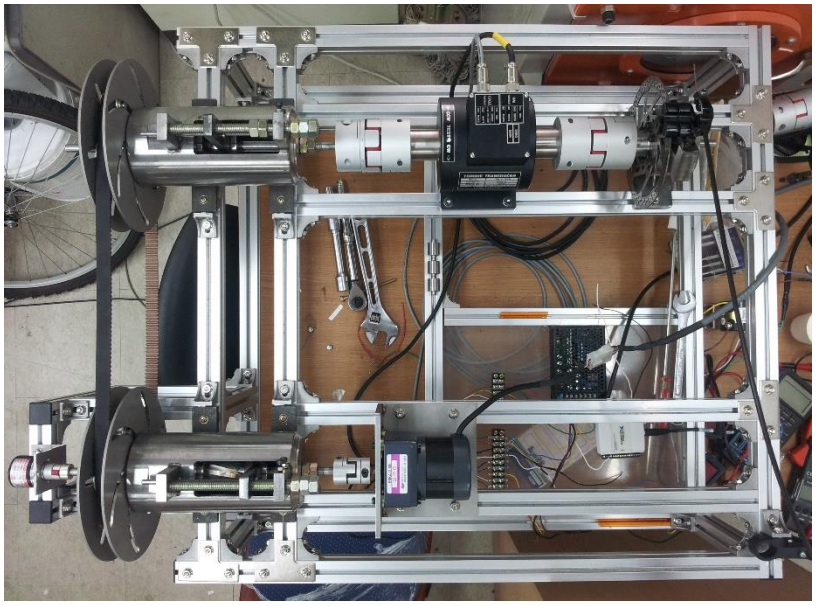


Figure 7. Experimental apparatus

The parts used in the experimental device configuration are the same as Table 1.

Table 1. Parts list of experiment

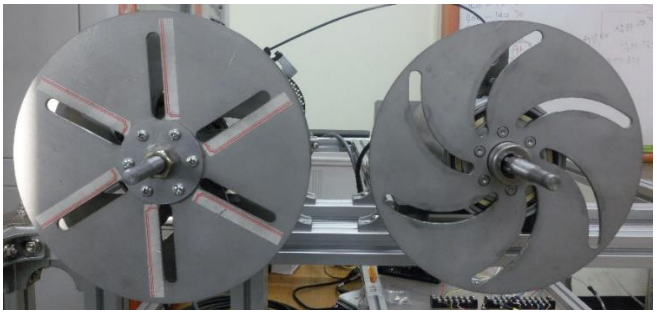
No.	Parts list/Specification
1	Driving pulley / ST φ210
2	Driven pulley / ST φ210
3	Timing belt / S5M 1250
4	Helical Spline / S45C
5	Motor / 220V, 100W, 3000rpm
6	Anchoder / HE40B.6-600-3-N-24
7	Torque sensor & rpm meter / 20kgf·m, pulse No.60
8	Load disk / Shimano disk

The torque, voltage, and current of the motor which is the driving source are measured. The number of rotation is measured in the encoder installed at the driving pulley front and the power inputted by using these values can be calculated. And the voltage of the torque sensor of the follower connected to the timing belt, current and number of rotation are measured and the output power can be obtained. In order to change the gear ratio, the helical spline connected to the driving pulley and the follower was moved axially to change the pitch radius of the driving pulley and the follower wrapped in the timing belt. The load device is basically manufactured by using a brake device, and the rotatable disk is used to hold the disk using push metal using coil spring. The spring constant of the coil spring embedded in the load device was calculated using the valve spring tester. The load torque was obtained by measuring the change length of the coil spring and the load torque values were confirmed using the torque sensor to verify the change length.

Figure 8. Load apparatus

The practical application of the proposed CVT system can be applied to small electric driving vehicles such as bicycles, electric bicycles, and electric scooters. For this purpose, the most basic and traditional bicycle power transmission device and power transmission efficiency were compared. The type of power transmission device used in the comparative experiment was examined by applying two types of rotation disk applied to the pulley of the CVT system proposed in this study in the form of straight lines and arcs and chains and sprockets, which are power transmission devices of bicycles. In Figure 9. (a) is a power transmission device using a chain and sprocket of a bicycle, (b) is a CVT system using a pulley consisting of a basic disk with a linear slot and a rotary disk with an arc slot, and (c) is a CVT system using a pulley consisting of a basic disk with a linear slot and a rotary disk with a linear slot.

(a) chain



(b) arc

(c) linear

Figure 9. Power transmissions equipped to dynamometer

The experimental results of power transmission efficiency according to the type of power transmission device are the same as Figure 10. The gear ratio applied to the experiment was 0.8~1.7 considering the range of shift between the conventional chain and sprocket mounted on the existing bicycle, and the power transmission efficiency was shown according to the shape of each power transmission device. The load torque is 0.2 $kg_f \cdot m$ and the number of rotations of the drive motor is 1125rpm, 2062.5rpm, and 3000rpm. The driving pulley is rotated using a reducer of 12.5:1, and the torque and the number of rotations are measured while changing the transmission ratio. The center of the driving pulley and the distance between the shafts of the follower are 402mm. The measurements were repeated five times and the average values were taken.

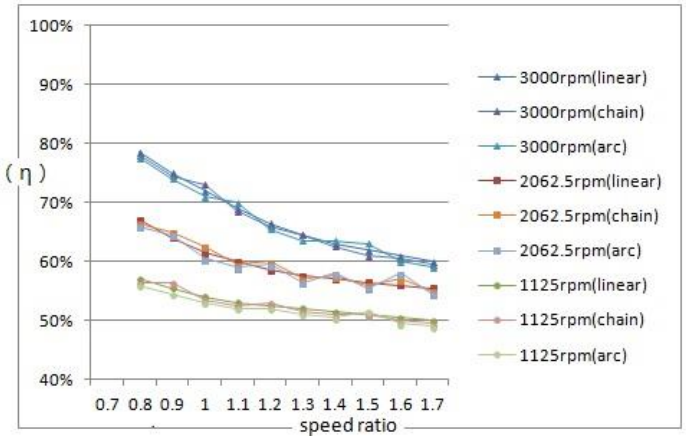


Figure 10. Power efficiency according to different transmission

In Figure 10 the x-axis represents the speed ratio between the driving pulley and the driven pulley, and the y-axis shows the power transmission efficiency. The transmission ratio and the power transmission efficiency are as follows.

$$r = \frac{r_d}{r_n} = \frac{D_d}{D_n} \tag{1}$$

$$\eta = \frac{P_{input}}{P_{output}} \tag{2}$$

It was confirmed that the CVT system using radius change pulley and the existing power transmission system, chain and sprocket, delivered power at almost the same efficiency under limited transmission ratio and load conditions. In the power transmission system of all kinds of the forms applied to experiment, efficiency is demoralized as the shift ratio increases.

5. Conclusion

In this study, we propose a model of a CVT system using a basic disk and a rotational disk in the configuration of a pulley of the CVT system. The proposed model can be commercialized in two types according to whether the auxiliary disk is applied or not. As to the application of the power transmission media connecting the driving pulley and driven pulley, the belt can be applied and application possible in the small electro-mobile or the electric scooter etc. The results of the study on the proposed independent model for the CVT system that constitutes the pulley using the basic disk and the rotational disk were as follows.

1) When the pulley is constructed using only the basic disk and the rotational disk, the shape of the helical spline in the shift fork should be crossed and the shape of the rotational disk should be crossed.

2) In case of using the auxiliary disk and link in the configuration of pulley, the end of the sliding pin is connected to link and the end of link should be hinge joint.

3) In case the auxiliary disk and link are used as to the configuration of pulley, the slot of the linear type is possible in both the rotational disk and basic disk. The slot of the linear type is facilitated than the slot of the arc type.

4) According to the experiment of the proposed CVT system, the efficiency is lowered as the transmission ratio increases.

References

[1] Sien Dong Gu, “A Proprietary Model of Continuously Variable Transmission System using Spline,” International Journal of Advanced Smart Convergence Vol.11 No.1 87-93, http://doi.org/10.7236/IJASC.2022.11.1.87, 2022

[2] Y. W. Kwon and S. C. Park, “Proposal and Manufacturing of Prototype of the CVT Model using Spring,” International Journal of Advanced Smart Convergence Vol.10 No.4 256-262, http://doi.org/10.7236/IJASC.2021.10.4.256, 2021

[3] Y. W. Kwon and S. H. Ham, “Manufacturing of the Portable Electric Scooter Prototype According to Variation of Wheel Number,” International Journal of Internet, Broadcasting and Communication Vol.12 No.2 51-58, DOI: http://doi.org/10.7236/IJIBC.2020.12.2.51, 2020

[4] Y. W. Kwon and H. S. Eu, “Proposal of a Portable Folding Electric Scooter Model and Manufacturing of the Prototype,” International Journal of Advanced Smart Convergence Vol.8 No.1 pp.58-64. DOI: http://doi.org/10.7236/IJASC.2019.8.1.58, 2019

[5] Choi, Hyun Seok, “Study on selection methods according to specifications of domestic electric scooters,” master’ thesis of Daegu university, 2018

[6] Wang. Tianyang, “Design and research of urban sharing electric scooter,” master’ thesis of Ewha university, 2018

[7] V. Tran Tuan, et al. 3, “Low Cost Motor Drive Technologies for ASEAN Electric Scooter,” J. of the Electrical Engineering & Technol. 13(4): 1578-1585, DOI:http://doi.org/10.5370/JEET.2018.13.4.1578, 2018

[8] Y. W. Kwon and M. J. Kim, “Travelling Performance Test of a Small Electric Vehicle equipped the Gradient Response CVT,” J. of KSMT, Vol.17 No.5, pp.1116-1120, 2015. 10

[9] Y. W. Kwon et al. 4, “Development of a Portable and Foldable Electric Scooter,” Proceeding of KSPSE, pp.145-146, 2015. 12

[10] G. S. Kim and Y. W. Kwon, “The Development of Gradient Response CVT for a Small Size Electric Vehicle,” J. of the KSPSE, Vol.19, No.6, pp.33-38, 2015. 12