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The Enhancement of Hybrid Transmission System of EV on Low Power Driving

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A B S T R A C T

Electric Vehicle (EV) is electric power based of vehicle with concern to environment safety and energy conservation through electric motor. The development of this vehicle is predicted faster. The design of various type of EV also existed. The transmission system is one of the vital part of EV. There are many variety of transmission system available nowadays in the market. That the smoothness of EV motion is influenced by the transmission system. In general, the EV has a direct transmission system to transmit energy from electric motor to the wheels. This condition makes the convenient while driving EV. Nevertheless, the availability of power source also varied. It effects the design of transmission system. The using of low electric power source is inevitable because of low cost. That it has low transmission efficiency such as inconstant torque at low speed. In order to reach the ideal characteristic where it has constant torque at low speed and constant power at high speed. This research aims to find a better driver requirement. This study applies additional component mounted in transmission system. That it can run convenient in condition overload and hiking routes. The use of a continuous variable transmission (CVT) system can support existing direct transmission system. The design and implementation of this additional transmission generates the high efficiency transmission of EV. The experiment shows that EV has constant torque at low speed and constant power at high speed.

Keywords: EV, additional transmission system, smoothness, CVT

Introduction

In recent years, there has been growing request of Electric Vehicle (EV), because it has lot of advantages regarding to environmental issues, such as zero emission, and renewable energy sources[1]. However, the electric mileage is still lower driving range compared to internal combustion engine vehicle. It is about twenty to thirty percent of ICE vehicle[2]. So, the improvement of overall EV efficiency is a serious challenging. The use of Permanent Magnet Synchronous Motor (PMSM) is very common use in EV. However, this motor has characters to generate back EMF at high speed. That it needs an inverter to generate high output voltage while high speed operation. Although the produced flux can solve the back EMF problem, but this flux also decrease efficiency of PMSM. EV which uses PSMS tends to have narrower driving range than ICE vehicle. The acceptable solution to handle this problem is employing a transmission to EV. The excellent driving range of ICE vehicle is absolutely supported by sophisticated transmission system. Besides EV also have many varieties of transmission system too. But most of them have two or three speeds. It is enough to secure target speed range. But not to extending electric mileage.

Furthermore, almost all EVs have a fixed gear ratio[3]. Although it decrease the capital cost but it may not offer efficient energy consumption. The increase of recharge cost is possible to be happened. While the accelerating and cruising, the EV consumes more energy than needed. While breaking, it may cause underutilization of the regenerative breaking potential. The deployment transmission system in principle influence the energy efficiency of EV. The structure of transmission system is as shown in Fig.1 below.

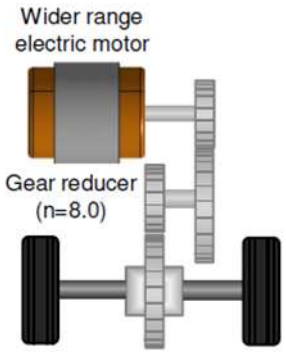

Fig. 1 The structure of transmission system with single ration transmission[1]

Fig. 1 shows the output of motor shaft is connected to transmission. Thus, energy flow diagram of the EV is as shown in Fig.2

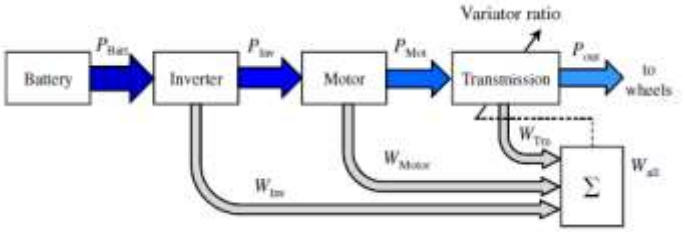

Fig.2 Energy flow diagram of EV

Fig.2 shows energy flows of EV from battery to wheels. This energy flow measures the losses and consumed energy of EV. In order to increase the transmission efficiency, the employment of continues variable transmission (CVT) is reasonable. The CVT deployment in transmission system of EV is as shown in Fig. 3 below.

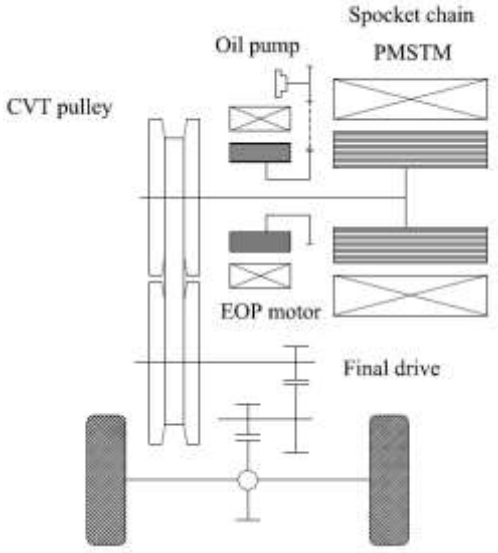

Fig.3 CVT deployment in the vehicle[2]

Fig. 3 shows schematic diagram of electric CVT (ECVT) with PMSTM

The ECVT is derived from traditional CVT by removing clutch and hydraulic torque converter. The forward and reverse rotation of Permanent Magnet Synchronous Traction Motor (PMSTM) and output large torque at low speed. That the PMSTM of EV can work at zero speed.

The variation of transmission system in EV become a common modification in driving EV to obtain high efficiency, especially the transmission system efficiency[4]. Besides using electric CVT, the deployment of programming devices to CVT parts possible to be implemented. The purpose of this programming device is to decrease the cost of ownership. The integration CVT with electric machine (EM) such as generator become feasible. The integration is term as EM-CVT. The block diagram of EM-CVT is as shown in Fig. 4 below.

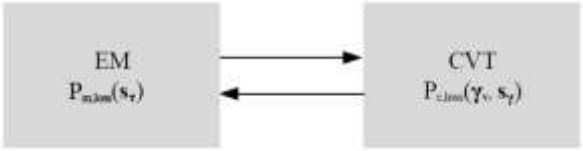

Fig. 4 Schematic diagram of coupling EM-CVT

Fig. 4 shows the schematic diagram of coupling EM-CVT, where CVT speed ratio, CVT size, EM size , CVT power losses and EM power losses become important factors to design integration and efficiency of transmission system.

Electronic CVT is a smart transmission that has unlimited gear ratios. The ECVT can be chosen as the most efficient gear ratio. Commonly, ECVT needs Planetary Gear Set (PGS) as a power splitter[5]. The architecture of the ECVT is as shown Fig. 5 below.

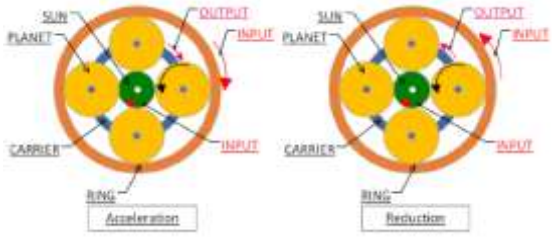

Fig. 5 Variable gear ratio[5]

Fig. 5 shows the PGS uses two motors as a driving force to function as a variable ratio. Maximum and minimum traction force can be generated through the Eq.1 and Eq.2 below.

$$F_{tmax} = \frac{I_{tn} \cdot I_g \cdot T_{m\ max}}{r} \eta_t \quad (1)$$

$$F_{tmin} = \frac{I_{tn} \cdot I_g \cdot T_{m\ min}}{r} \eta_t \quad (2)$$

The force that occurs on the vehicle can be seen from the Eq.2. The Planetary Gear Set(PGS) generated power splitter from the obtained data. In order to increase torque at the input ring gear, the modification of PGS become a new architecture. It is as shown in Fig. 6 below.

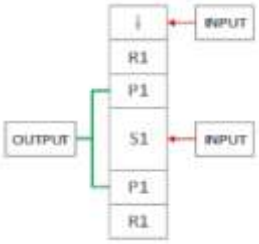

Fig. 6 The modified configuration of PGS

Thus, the output of new configuration on the carrier is as shown in Fig.7 below.

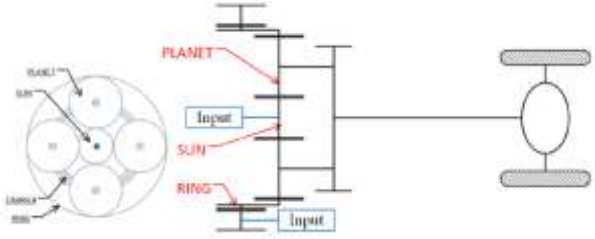

Fig. 8 Configuration with output

In order to keep continue improving vehicle efficiency, there were many transmission system with various speed available. This strategy is to escalate the average of working efficiency of motor and improve the driving capability. The implementation of two-speed automatic transmission was useful to apply to truck vehicle[6]. The various structure of transmission is as shown in Fig. 9 . It implemented in many purposes vehicle in the last decade.

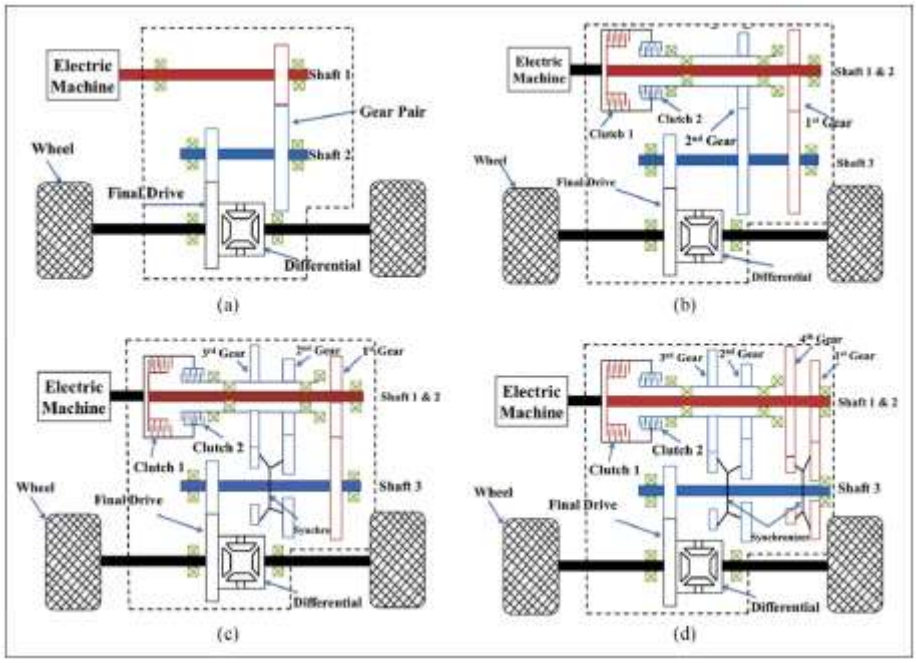

Fig. 9 The structure of powertrain (a) One speed; (b) two speed; (c) three speed; (d) four Speed;

Fig. 9 shows the control strategy and motor power in transmission of EV. The single speed of transmission such in 9(a) is uses in many EV car like BMWi3, Nissan Leaf, etc. The above structure generate traction curve as shown in Fig. 10 below.

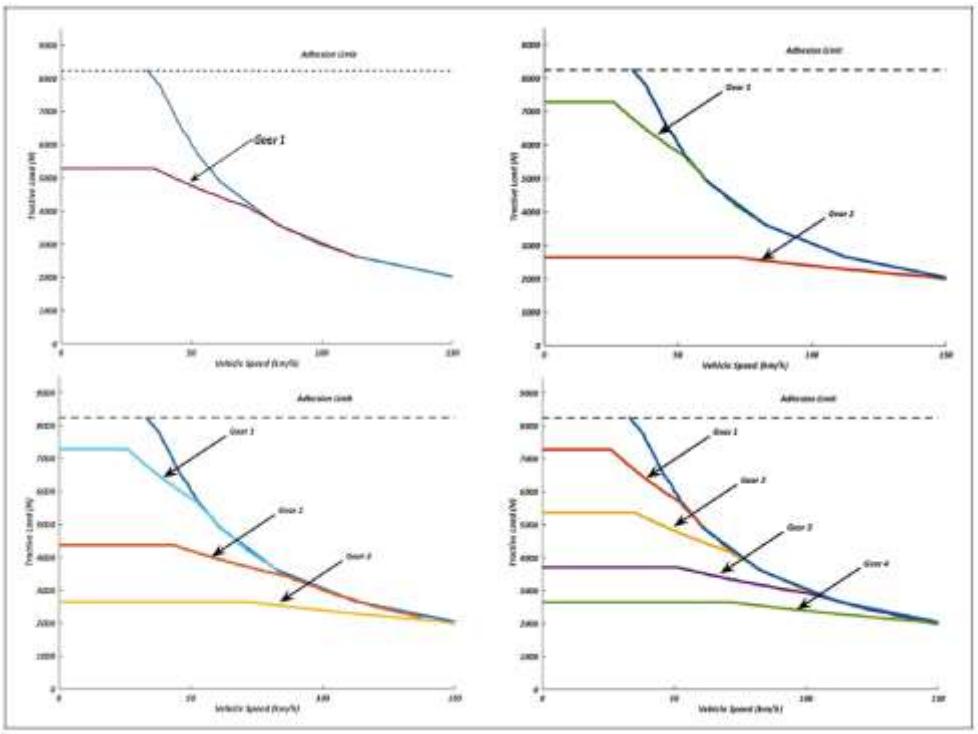

Fig. 10 Traction curve of one, two, three and four speed of transmission.

Method

In order to handle the low power driver, the proposed method combine CVT and direct transmission. That the power and torque can be formulated as in Eq.3 below.

$$Pd = Fc * P \quad (3)$$

Where Pd is target power, P is transmissed power(kW) and Fc is chain factor. That the generated torque is ratio between motor power output and generated angular speed of motor according to T = 974000* Pd/n. Where n is the motor rotation (rpm), T is torque (kgf.mm). Thus chain speed is defined as long chain (m) that work in sprocket in 9s) that

$$V= (\mu.d.n)/60 \quad (4)$$

Where d is sprocket diameter (m); v is speed (m/s).

The design of transmission is as shown in Fig. 11 below.

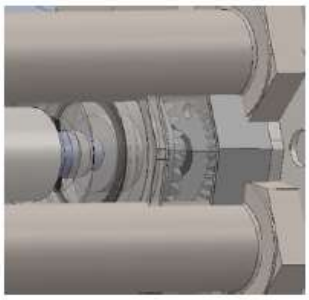

Fig. 11 The transmission design

3. Result

Based on transmission design system as in Fig. 11, the target power obtained is as shown in Fig. 12 below.

Fig. 12 The target power of transmission system

Fig.12 shows the relation between Designed Power and Correction factor of the chain . The rise of power correction steps up the designed power gradually. The speed of chain generated is as shown in Fig.13 below.

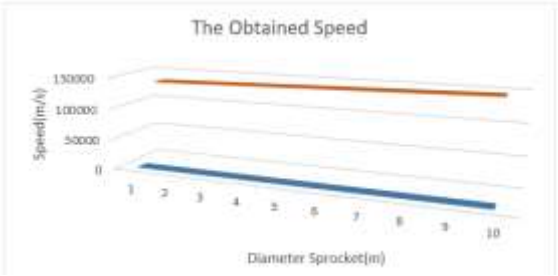

Fig. 13 The obtained speed of chain

Fig. 13 shows the speed of chain increase as the sprocket diameter larger. The suitable diameter determine target speed of chain.

4. Conclusion

As the development of EV rise in the recent years, the new methods exist in various sub section of EV. One of the most common improvement is transmission system. The EV transmission system have evolved from time to time to discover the better one. The configuration of transmission from single speed to multiple speeds. The ratio of transmission gear started with the countable ration up to uncountable ratio. The using of CVT is one of very efficient technology to reach long range driving and high efficiency. The proposed method uses the twin CVT completed with single direct transmission system. This configuration is used for EV with low power sources. The result shows the high speed can be reached through combination of gear ration. That the convenient and high efficiency performance of EV suitable with the target costumer.

References

[1] D.Gunji andH.Fujimoto, "Efficiency analysis of powertrain with toroidal continuously variable transmission for Electric Vehicles," IECON Proc. (Industrial Electron. Conf., pp. 6614–6619, 2013.

[2] Y.Liu et al., "Study on the Design and Speed Ratio Control Strategy of Continuously Variable Transmission for Electric Vehicle," IEEE Access, vol. 11, no. August, pp. 107880–107891, 2023.

[3] A. K.Madhusudhanan andM.Corno, "Effect of a Nu Vinci type CVT based Energy Efficient Cruise Control on an Electric Vehicle's Energy Consumption," 2022 Eur. Control Conf. ECC 2022, pp. 1722–1727, 2022.

[4] C.Wei andT.Hofman, "Co-Design of CVT-Based Electric Vehicles," pp. 1–33, 2021.

[5] H. S.Maulana andI. N.Sutantra, "Design and Analysis of ECVT on Electric Powered Vehicles for Determining the Speed Ratio," vol. 5, no. 2, pp. 55–66, 2021.

[6] J.Ruan, P. D.Walker, J.Wu, N.Zhang, andB.Zhang, "Development of continuously variable transmission and multi-speed dual-clutch transmission for pure electric vehicle," Adv. Mech. Eng., vol. 10, no. 2, pp. 1–15, 2018.