International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Overview of transmission system for the electric vehicle

Prathamesh Joshi[1], Prof. A.S. Ugale[2]

[1]UG Student, Department of Mechanical Engineering, MIT School of Engineering, MIT ADT University, Pune, Maharashtra, India
[2]Assistant Professor, Department of Mechanical Engineering, MIT School of Engineering, MIT ADT University, Pune, Maharashtra, India

---

Abstract - *The automobile sector is changing fast and wide. There are many environment and fuel related problems due to automobile. Hence, the electric vehicles are coming into picture. These electric vehicles are playing vital role in automobile industry. Due to eco-friendly, fuel efficiency and various advantages various companies like Tesla, MG, Tata are looking positive towards the electric vehicles market. Electric vehicle consists of various parts like battery, motor, transmission system. This paper describes the overview of transmission system for the electric vehicle and also its advantages and limitations. Also, explains the transmission system which is efficient in case of electric vehicles.*

Key Words*: *Electric Vehicle, Transmission System, Fuel-Efficiency, Eco-Friendly

1.INTRODUCTION

As the 21st century is technologically advanced. So much advancements in technology and engineering are happening. Like in automobile the electric vehicles are acquiring the IC engine vehicles. As the technological advancements taking place. Transmission of the vehicles are also changing day by day. Basic types of transmissions can be Manual and Automatic Transmissions. But in electric vehicle only automatic transmission used as the speed variations in electric vehicle is less and also automatic transmission gives comfort to driving the vehicle. Single speed Transmission and Multi-speed Transmission are two types of transmission mostly used in electric vehicles. The key factors affecting on the transmission are fuel efficiency, motor efficiency, speed-torque variation, power, cost, weight etc. Based on the mentioned factors both transmission systems can be compared.

The transmission can be simply defined as the transfer of power generated from source to the wheels of the vehicle. As mentioned earlier, in electric vehicles has two types of transmission-1. Single Speed Transmission

2. Multi Speed Transmission (Two Speed Transmission)

1.1 Single Speed Transmission

In this type of gearboxes only one gear pair used for transmission and the speed of the vehicle is constant. Commonly, it consists of single reduction gear, reverted gear or a compound gear train. The reduction gear works on principle of reduction of RPM and increasing torque of high-speed motor or engine. In reverted gear train single speed transmission, the compound gears arranged in reverted order. Fig-1 given below shows the single speed transmission used in the electric vehicles. Single speed transmissions are used in several cars like Chevrolet Bolt, Tesla Model S etc. which are very popular models.

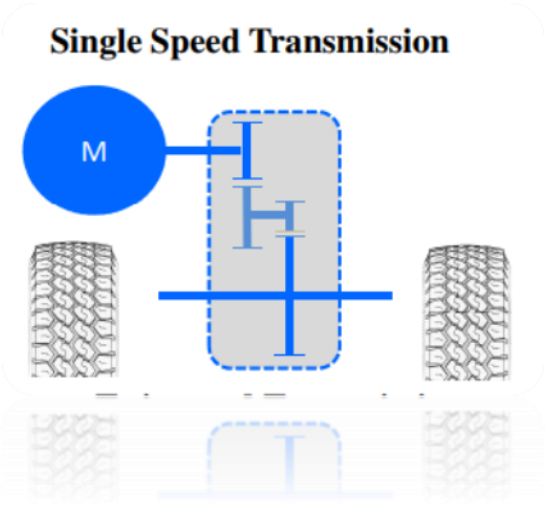

Fig -1: Single Speed Transmission in EV

Advantages-

1. It has direct drive.
2. Its operation is very smooth and also it generates instant torque when coupled with motor.
3. No complex gear system required.
4. It occupies less space.

Limitation-

1. It has a fixed gear ratio.

1.2 Two Speed Transmission

This is multi-speed transmission system used in electric vehicles. Mostly two speed transmission only is used. Due to the two degrees of freedom of the compound planetary gear system, two different gear ratios can be achieved. The transmission is comprised of a compound planetary gear system with a double pinion planetary gear set and a single pinion planetary gear set. Fig-2 given below represents the two-speed transmission used in the electric vehicles. These types of transmissions are used in Porsche Tycan and other cars.

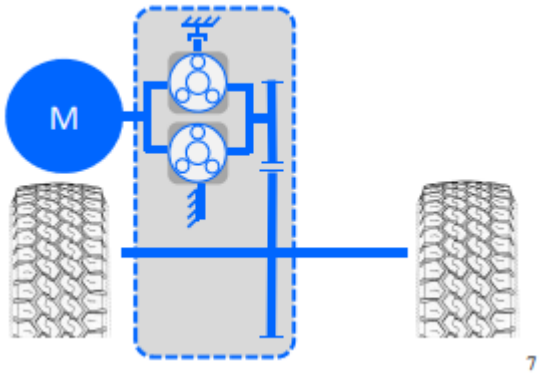

Fig -2: Two speed transmission in EV

Advantages-

1. Stall torque can be increased.
2. Efficiency can be optimized.
3. Top speed of vehicle can be achieved.

Limitations-

1. These transmissions are too heavy and large.
2. It has very high cost.

2. Comparison between Single speed and Multi-speed Transmission

As basically two types of transmission systems used in electric vehicles. But based on torque, speed, efficiency and other major factors these transmission systems can be compared.

2.1 Torque Vs Speed

For the comparison of two transmission systems based on torque vs. speed characteristics. We get following graphs which are based on experimentation on both of the transmission systems.

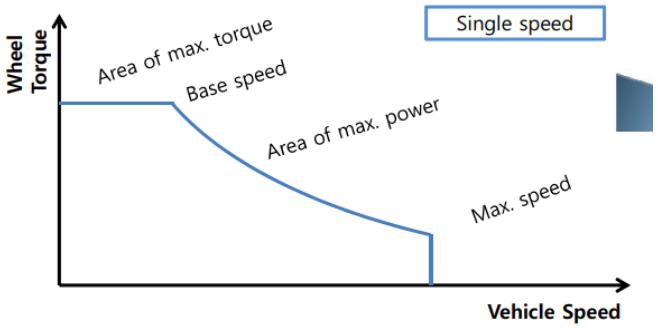

Fig -3: Torque Vs Speed of Single Speed Transmission in EV

From above fig.3, we can observe the characteristics of single speed gearbox for electric vehicle. Similarly, for two speed gearbox we have following graph.

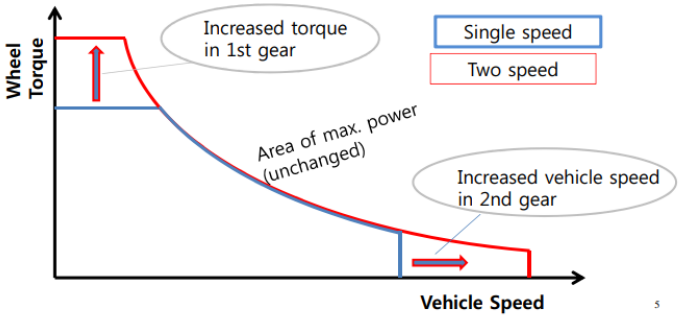

Fig -4: Torque Vs Speed of Two Speed Transmission in EV

From above Fig 3 and Fig 4, we get torque vs speed characteristics for single speed and two speed gearboxes. We can conclude following from above graphs:

Area of maximum power remains unchanged in both of the cases. However, torque capacity of first gear of two speed gearbox is more than single speed gearbox. Similarly, speed of two speed gearbox is way more than in single speed gearbox.

2.2 Efficiency

Optimum efficiency of electric vehicles is typically at high or medium speed and at high load. However, in real life the most frequently use in driving is at various speeds and at low load. Two speeds of the transmission can increase the effective area of high efficiency. Efficiency of two speed

transmission system can be optimized as speed and driving range can be increased.

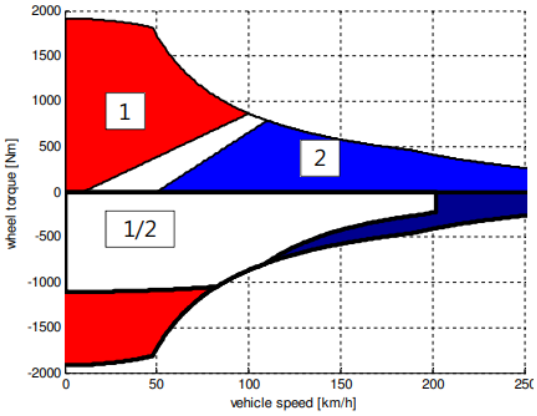

Fig -5: Efficiency at different speed of two speed gearbox in EV

3. DESIGN OF TWO SPEED TRANSMISSION SYSTEM

The design of two speed transmission system involves different steps as following:

1. Calculations of the gear specification

2. Mechanism of transmission

3. Transmission Clutch

3.1 Calculations of gear specification

For the commercial vehicles two speed transmission system Simpson type Sun-Planetary gear train is used. Fig-6 shown below shows the sun-planetary gear units.

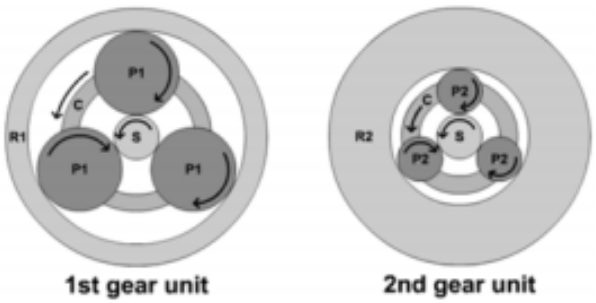

Fig -6: 1st and 2nd gear units

This type of transmission system has the interesting feature of changing gear ratios without having engage or disengage of individual gears. This allows for smooth gear changing even under high or low load. Thus, it is easy to change gears among 1st gear, 2nd gear, parking gear, reverse gear, and neutral gear.

Zs is the number of teeth on sun gear, Zp1, Zp2 are the number of teeth on 1st planet gear and 2nd planet gear, Zr1, Zr2 are the number teeth of 1st ring gear and 2nd ring gear. Assume that carrier is fixed and sun gear rotates at angular velocity ω1 and angular velocity of ring gear ωR can be defined as

$$\omega R = -(Zs/Zr1) * \omega 1 \quad \ldots\ldots (1)$$

The negative sign in above equation (1) indicates that the ring and sun gears rotate in the opposite direction. Calculations of gear ratio is shown in Table 1.

Table -1: Reduction Gear Ratios calculations

	S (Sun Gear)	R1(R2) (Ring Gear)	C (Carrier)
C is fixed and S rotating at ω1	ω1	-(Zs/Zr1) ω1	0
Rotate all +	(Zs/Zr1) ω1	(Zs/Zr1) ω1	(Zs/Zr1) ω1
R1(R2) is fixed	[1+(Zs/Zr1)] ω1	0	(Zs/Zr1) ω1

3.2 Mechanism of Transmission

For shifting movement of gears on this transmission system, each ring gear has clutch B1, B2 which is operated hydraulically to stop spinning of each ring gear. By shifting gear from neutral to 1st gear, 1st clutch B1 is operational, 1st ring gear R1 is fixed, input is provided to the sun gear which rotates planetary gear P1, and output rotations are produced from the carrier. There is no difference mechanism of gear shifting between 1st gear and 2nd gear, except which clutch is operated. Below Fig-7 shows the shifting movement of gears.

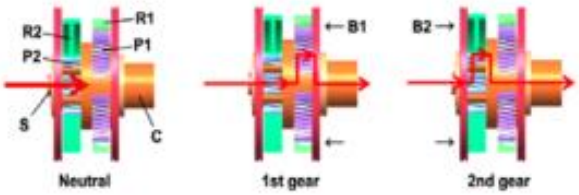

Fig -7: Shifting Movements of gears

3.3 Transmission Clutch

For the given transmission system in electric vehicle, two clutches (B1 and B2) are used for the smooth transmission of gears. Both of these clutches are operated through hydraulic circuit. This type of clutch has various driving components stacked with several driven components.

4. CONCLUSIONS

From all the comparisons between single speed transmission and two speed transmission. From comparisons it can be concluded that two speed transmission is more efficient than single speed transmission. Two speed is an effective solution to improve performance and efficiency. Two speed transmission allows system optimization which reduces the size of electric motor and inverter of the electric vehicle. Two speed transmission allows the various gear ratios and thus maximum speed of vehicle can be achieved. Design of the two-speed transmission is very easy but it has more cost. Though, cost of two speed transmission are high but it can be managed. Now a days two speed transmissions are used most commonly. In coming years, second generation two speed transmissions will be developed in which allow higher torque range for convenient drive of electric vehicles.

REFERENCES

[1] Ahmed Elmarakbi, Adrian Morris, Qinglian Ren and Mustafa Elkady, "Modelling and Analyzing Electric Vehicles with Geared Transmission Systems: Enhancement of Energy Consumption and Performance", International Journal of Engineering Research & Technology (IJERT), 2013

[2] Fuad Zainuri, Danardono A. Sumarsono, Muhammad Adhitya and Rolan Siregar, "Design of synchromesh mechanism to optimization manual transmission's electric vehicle", AIP Conference Proceedings, 2017

[3] Md Ragib Ahssan, Mehran Motamed Ektesabi, Saman Asghari Gorji, "Electric Vehicle with Multi-Speed Transmission: A Review on Performances and Complexities", SAE International Journal of Alternative Powertrains, 2018

[4] Yang Tian, Jiageng Ruan, Nong Zhang, Jinglai Wu, Paul Walker, "Modelling and control of a novel two-speed transmission for electric vehicles", Journal of Mechanism and Machine Theory, 2018

[5] Ren.Q.; Crolla, D.A.; Morris, A., "Effect of Transmission Design on Electric Vehicle (EV) Performance", 2009

[6] Fuad Un-Noor, Sanjeevikumar Padmanaban, Lucian Mihet-Popa, Mohammad Nurunnabi Mollah and Eklas Hossain, "A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development", *Energies* 2017

[7] Rony Argueta, "A Technical Research Report: The Electric Vehicle", University of California Santa Barbara College of Engineering, 2010

[8] Saphir Faid, "A Highly Efficient Two Speed Transmission for Electric Vehicles", EVS28, KINTEX, Korea, May 3-6, 2015

[9] J.W. Shin, J.O. Kim, J.Y. Choi and S.H. OH, "DESIGN OF 2-SPEED TRANSMISSION FOR ELECTRIC COMMERCIAL VEHICLE", International Journal of Automotive Technology, Vol. 15, No. 1, pp. 145−150 (2014)

[10] Sameer Shah, "Single Speed Transmission for electric vehicles", Mechanical Seminar Report, Visvesvaraya Technological University