

A Review on Advanced Automatic Transmission Methods Used in Automobiles

Dipraj G. Kadlag¹, Ashish M. Ekatpure²

¹Student, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering,
diprajkadlag@gmail.com

²Professor, Department of Mechanical Engineering, Smt. Kashibai Navale College of
Engineering,
ekatpureashishm@sinhgad.edu

ABSTRACT

The transmission system is the part of an automobile which transfers the engine power to the driving wheels through speed and torque change. The speed and torque change is done either manually or automatically according to the vehicle type. In a manual transmission, while shifting the gear, there is a discontinuity in power transmitted to the wheels of an automobile. The shocks are observed while pressing the clutch pedal, releasing it, and speed reduction during this period. The automatic transmission has several types which use a planetary gear set instead of a simple gear pair used in manual transmission and changes gears on behalf of the driver. Furthermore, it does not have a clutch pedal, so ease of driving. It allows the engine to run in the best efficiency RPM, resulting in fuel saving. Though most of the manual transmission vehicles consume a bit less fuel than a similar automatic transmission vehicle. This paper thus reveals about these new automatic transmission technologies used in automobiles and their relative comparison.

Keywords: Transmission system, automatic transmission, AT, DCT, CVT, driving comfort, manual transmission.

1. INTRODUCTION

The transmission system is an essential part of an automobile. The engine has usually rpm range of 600 to about 7000, while the wheels have 0 to 1800 rpm. It is so high because the engine cannot run below a specific speed efficiently. So, this drastic reduction in revolutions accomplished with the help of transmission system. Transmission system changes the speed and torque at the output according to the gear change. The reduction in speed and increase in torque output is done through the transmission system. Mostly, the transmission system has a number of gear ratios which can be obtained by it. The change in gear ratios is done either by manually by the driver or automatically. It also offers to move vehicle backward through reverse gear. The crankshaft of the engine having flywheel is connected to gearbox further. To connect engine crankshaft to the gearbox shaft, clutch or fluid coupling is used. The torque converter is mostly used as a fluid coupling when there is no clutch connecting the engine to the gearbox. Clutch is used when the driver has to change the gear and at braking mainly. It disconnects engine power which is transmitted to wheels when pressed. While in the case of torque converter we don't have to operate it manually.

There are types of gearbox according to transmission type used. Gearbox output is given to either to front wheels or to the rear wheels. Therefore, the cars are characterized as front and rear wheel drive cars. Also, the engine is mounted either at front of the car or at the rear. The gearbox output is given to the driving shaft through propeller shaft and differential when it is front engine rear wheel drive. There is no need of propeller shaft when front engine front wheel drive. In all-wheel drive, the power is given to all the wheels through two differentials and one propeller shaft. The all-wheel drive and front wheel drive are more popular.

There are mainly two types of transmission system used in today's automobile- manual and automatic transmission. An AT has mainly two types: dual clutch and continuously variable transmission.

2. MANUAL TRANSMISSION (MT)

In a manual transmission, the driver has to change the gear ratio manually. There are mainly 3 types of gearbox used in this. Namely sliding gearbox, constant mesh gear box, synchromesh gear box. The synchromesh type is used now. The sliding gear box is the simplest one. The engine shaft is connected to the clutch and then to the clutch gear. The clutch gear is always engaged with the lay shaft. All the gears on this layshaft is fixed to it and running when the engine is running and the clutch is engaged. Three direct gear ratios and a reverse one can be obtained by this with the help of selector mechanism. In constant mesh gear box, all the gears are always in mesh. the gears on the main shaft move freely on it and dog clutches are used to connect the power from main shaft gears to the main shaft. The dog clutches move with the main shaft. So, we can use helical gears in constant mesh gear box. Synchromesh gearbox is similar to constant mesh gearbox except for the synchromesh device. It is used to have frictional contact between the mating part, so as to match their speed before engaging.

Till date, MT vehicles give better fuel efficiency than any other automated transmission vehicles as the MT has clutch instead of a torque converter used in AT or the v-belt in continuously variable transmission. [1] Both torque converter and v-belt have power loss due to slip, thus the reduction in fuel economy. Also in an automatic transmission, a hydraulic pump is used causing more power requirements. But some new having locking torque converter improved the fuel economy. [2] Because of simplicity manual transmissions don't require active cooling, they weigh less than comparable automatic transmissions which can improve the economy. They are manufactured more easily, requires less maintenance and are less costly.

3. AUTOMATIC TRANSMISSION (AT)

Automatic transmission which is also called self-shifting transmission, or simply AT, is able to change the gear ratios as the vehicle moves. There is no clutch pedal in the automatic transmission. Also, there is no gear shift in it. Thus, the driver efforts are much reduced. There are several types of AT - Hydraulic AT, continuously variable transmission, semi-automatic transmission, dual clutch transmission. In this paper, hydraulic AT, CVT and DCT is explained.

3.1 Hydraulic Automatic Transmission

Hydraulic automatic transmission works on the planetary gear set. It has torque converter between engine output and gearbox input. [3]

3.1.1 Torque Converter

It has following components: impeller, stator and the turbine. The transmission pump fills the converter with the fluid.

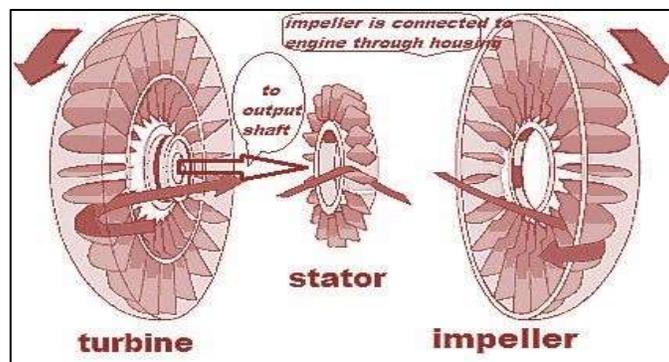


Fig-1: torque converter

The impeller is driven by the engine with respect to modes of driving i.e. park, neutral, reverse and drive. The turbine rotates due to the momentum of fluid in drive mode. Centrifugal force throws the fluid outwards in the impeller in the forward direction due to the shape of the casing and the curvature of the vanes. When the engine is idling and the vehicle is stationary little torque is transferred from the impeller to the turbine. When the engine accelerates fluid is transferred to the turbine due to the greater force occurred due to the centrifugal head. Fluid exits the impeller at high

velocity and impinges on the turbine blades. Here the energy is absorbed causing the turbine to rotate and thus the drive is transferred. The fluid leaving the turbine blades is in opposite direction to the rotation of the impeller. For this purpose, a stator is used to divert this fluid in the direction of impeller rotation. This is due to the curvature of the turbine blades. One way clutch is used to lock the stator. Thus, the fluid leaving the turbine blades due to stator strikes the impeller blades. Thus, there is torque multiplication in the torque converter.

3.1.2 Planetary Gearbox

It has two inputs and one output. The set has a sun gear and planet gears revolving around it. The ring gear is internally meshed with the planet gears. Planet carrier connects to all planet gears to the output. Sun gear and ring gets input. When the ring gear is stationary and rotation is given to sun gear. This will cause the carrier to spin giving output. Next speed ratios are obtained by fixing various combinations of inputs and giving revolutions to others. When the ring gear speed is less than, equal to and greater than sun gear, various speed outputs are obtained. Turning the sun gear in opposite direction will result in a reverse gear (ring gear is stationary). [4]

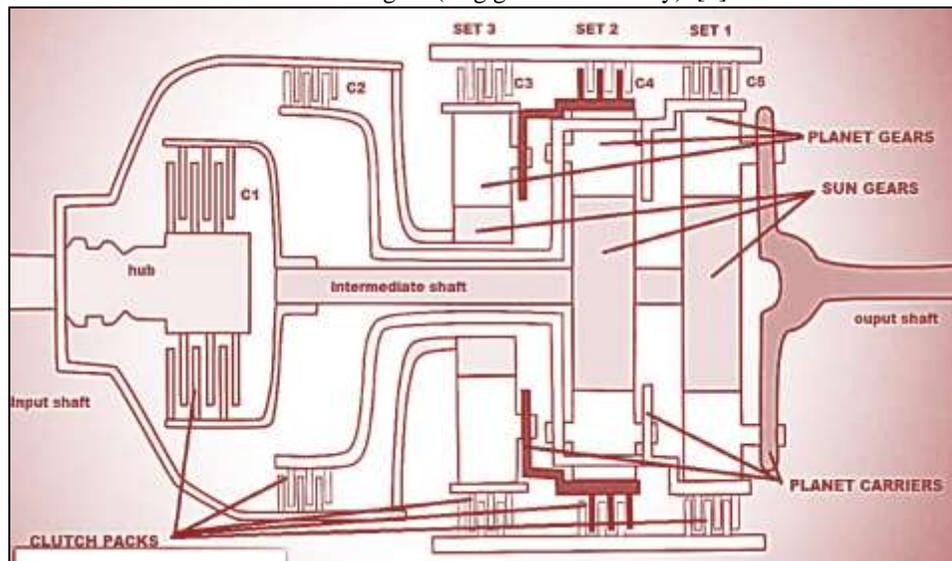


Fig-2: planetary gearbox in the hydraulic automatic transmission.

In hydraulic automatic transmission, there is no direct connection between the inputs and the output shafts. Rather there is an intermediate shaft between the two. Two clutch packs are used to transmit the power. Pressing the clutch pack locks the hub to the case. If the first clutch pack is applied, the input shaft will connect to the intermediate shaft. If the second clutch pack is applied, the ring gear will connect to the case, which will make the ring gear become stationary. In order to achieve the first gear, since just apply both the clutch packs together. Thus, input shaft will turn the sun since the ring gear is stationary, the output shaft will rotate with almost say one-third of the input speed. To achieve additional gear ratios, another planetary gear set 2 is added. Applying C1 will always rotate both the sun gears at the input shaft speed. If C4 is applied as well, the planet carrier of the second set will turn. This planet carrier is permanently linked to the ring gear of the first set. So when C1 and C4 are applied together the ring gear of the output set will turn. Thus, at the output set the situation is similar to that of the first gear except that the ring gear will rotate as well. The speed of the output planet carrier will increase. This is the second gear of the transmission. The planet carrier is also fitted with the hollow shaft. This shaft can be directly connected to the input shaft with the help of a rotating clutch module.

To get direct drive the ring and the sun gear of the output set should rotate at the speed of the input shaft. If C1 and C2 are applied the sun and ring gear will be directly connected to the input shaft. For the sixth gear, C1 is removed and C4 is applied. At the second set, input rotation is given to the carrier and the ring gear is stationary. Thus, overdrive at the output is achieved. A third planetary gear set is required to get the remaining gear ratios. The sun gear of this set is always connected to the input shaft. The output of this set is connected to the input of the next set. When C3 is applied, it will always turn the ring gear of the second set. For the remaining gear ratios, C3 is always applied. For the third gear, C1 is applied as well. For the fifth gear, C1 is removed and C2 is applied. In order to go reverse, C5 is

applied. Since the planet gear of the second set cannot revolve, they will spin. thus, the output will be reverse of the input speed. the torque converter is used in hydraulic automatic transmission. when the driver wants to apply brakes when the transmission is in gear, the torque converter allows braking without stoppage of the engine. It allows for the slip at braking. [5]

3.2 Continuously variable transmission (CVT):

As the name suggest, Unlike in MT, CVT continuously transmits the power from the engine to the wheels, without the aid of the gear change i.e. in descriptive steps. Newer vehicles are often having cvt, which gives the smooth driving experience. CVT provides infinite no of gear ratios making gear change operation a noticeable experience. [6]

3.2.1 Pulley Mechanism

Two conical pulleys and a steel belt make up a basic cvt. Input pulley turns the belt and the belt turns the output pulley. The gap between the cone determines the effective diameter of the pulleys. When the effective diameter of output pulley is more than the input pulley effective diameter, the output pulley will turn slower than the input pulley.as the gap decreases the effective diameter increases. When the right side of the input and left side of output is moved to the left, the overdrive is achieved due to the effective diameter of both pulleys is altered. Thus, we get countless gear ratios for the cvt. According to the driving conditions, a transmission control unit will adjust the width between the cones. As a result, unlike any other kind of transmission, the speed change will be smooth and noticeable. In order to get reverse gear ratio, planetary gear-set with two clutch packs is used. We can get various gear ratios in reverse direction also, even though it is not programmed to do so. [6]

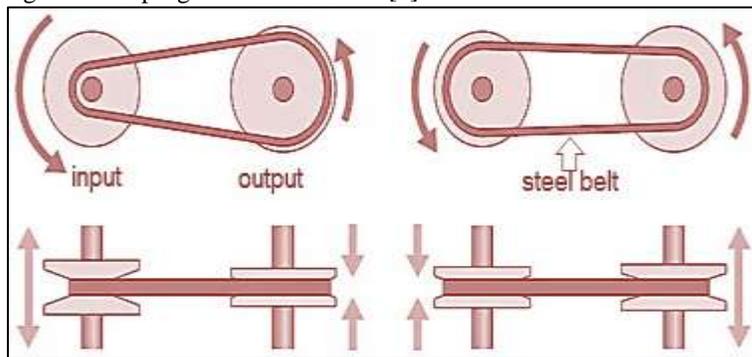


Fig-3: cvt pulley mechanism

3.2.2 Belt

Belt is the weakest part of the system.it limits the torque carrying capacity. Rubber v-belt was used so far. Now there is a new type of v-belt made from no of steel elements and several strips are used. These steel elements are held in place with several thin steel bands or strips that can bend easily. [6]

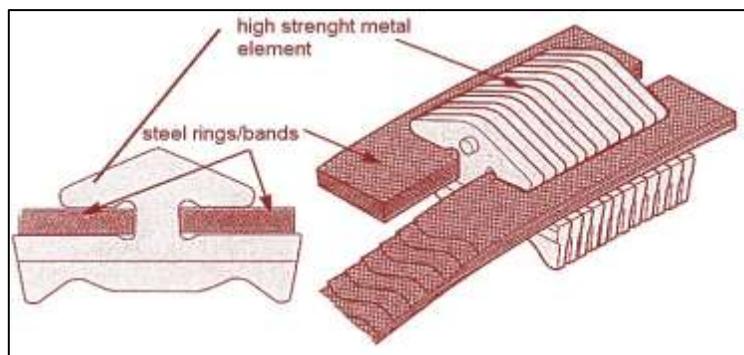


Fig-4: cvt steel belt

3.3 Dual-Clutch Transmission (DCT)

A dual-clutch transmission technology that offers advantages of a MT and hydraulic AT has made a revolutionary step in the automobile world. Since it is smooth as an AT and offers a better fuel efficiency, it has taken a good market share. [7]

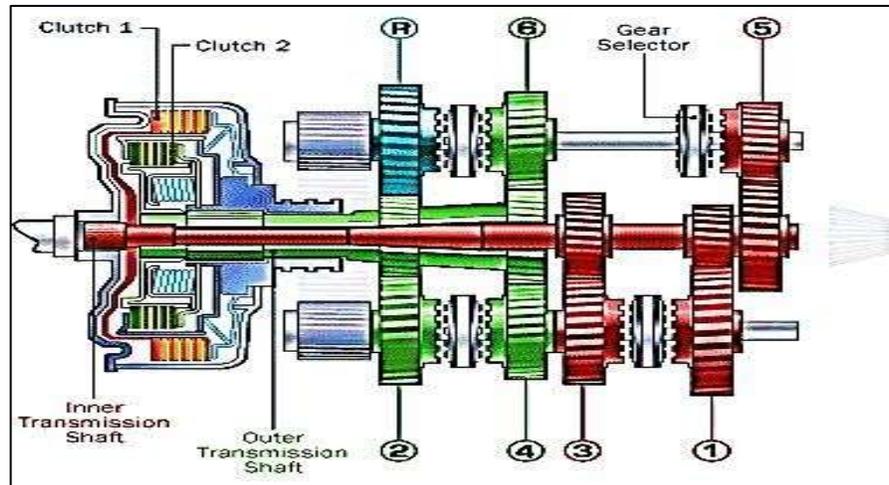


Fig-5: Dual-Clutch Transmission.

Actually, it is two independent MT controlled by a computer. In a manual transmission, while shifting the gear the clutch is to be pressed for smooth engagement of sleeve and the gear. So, there is a discontinuity in power flow reducing the traction and speed at the wheels. Shocks are observed and thus rough driving experience. So, in dct one more MT set is added with a separate clutch. The input shaft of the second set is inside the hollow shaft of the first set. From figure, if the clutch 1 is engaged the power flow will be to the red gear set and for clutch 2 the power flow will be to the green gear set. The odd gears are connected the red set and the even ones to the green gear set. To shift from first gear to the second gear, the sleeve of the second gear is connected to the gear in advance even when the first gear sleeve is already connected. Then simply the clutch 1(of the red set) is released and clutch 2(of the green set) is engaged. This preselection of gear gives constant power flow even during the transition phase. Thus, smooth driving experience as that of hydraulic automatic transmission. Depending upon the driving conditions the driving control module determines which gear will be preselected. Obviously, provision is made for reverse gear also. Unlike the regular manual transmission, the reverse gear of the dct has the synchroniser teeth arrangement. so, even if the vehicle is moving forward as long as the vehicle speed is low, the reverse gear can be engaged. This is not possible with a regular manual transmission. [7]

3.3 Comparison

In an automatic transmission, there is no abrupt of power flow, so smooth driving experience. Computer controlled operations of the AT makes the driving even simpler. It is clear that MT technology is much simpler than the AT technology. It has fewer components and is easier to repair. On the other hand, AT is a tightly packed arrangement. For heavy duty operation MT offer more durability. Due to this almost 80% of heavy duty trucks use MT's. the way of braking is different in both cases. In MT vehicle, before pressing the brake pedal, the clutch pedal must be pressed completely. However, there is no clutch pedal in AT car. So, to separate the engine rotation from the transmission a torque converter is used. It allows slippage; hence, it handles the condition of braking. However, the torque converter is a good heat generator which in turn reduces the efficiency of the vehicle. As a result, AT vehicles tend to become less fuel efficient than MT vehicles. However modern torque converters have overcome this problem. CVT provides the step-less transmission which no other transmission can provide. It allows the engine to run in its best efficiency area. So, there is better fuel consumption resulting better emission control. The belt is the weakest part in this CVT. It limits the transmission torque carrying capacity, even though the belt technology has been improved. There is high wear and also the CVT vehicles are costlier than MT vehicles. in a DCT gear shifting is done by computers, solenoids,

and hydraulics. The driver can also control these actions. DCT offers the most dynamic acceleration compared to any vehicle in the market. It gives the smooth acceleration reducing shocks as compared to MT. the most advantageous thing is it has improved fuel economy, as power flow don't interrupt while shifting gears as in MT. Some experts say that a six-speed DCT can deliver up to a 10 percent increase in relative fuel efficiency when compared to a conventional five-speed automatic. [6] Most manual transmissions can deliver better fuel economy and acceleration. But shift quality and fuel economy vary.

Model	Fuel economy (overall mpg)		Acceleration, sec. (0-60 mph)	
	Manual	Automatic	Manual	Automatic
Chevrolet Sonic LTZ/LT	30	28	8.9	9.3
Ford Fiesta SES/SE	32	33	10.7	10.9
Hyundai Accent SE/GLS	32	31	8.5	10.3
Mazda 3 i Grand Touring/ i Touring	32	33	8.2	8.3

Table-1: comparison of manual and automatic transmissions. [8]

3. CONCLUSION

Though many advanced transmission technologies are introduced, till date manual transmissions are more fuel efficient most of the times than AT's. but AT technology is upgrading faster and faster improving its disadvantages. For fuel economy, to feel driving experience, many sports enthusiasts should prefer MT and DCT's. those who wants smoother driving experience can afford the high money and don't want to get distracted by gear shifting while driving should prefer automats.

REFERENCES

- [1] Jamie Page Deaton "Which has better fuel economy: manual or automatic?" 8 July 2015. HowStuffWorks.com<<http://auto.howstuffworks.com/fuel-efficiency/fuel-economy/better-fuel-economy-manual-or-automatic.htm>> 02 May 2017
- [2] U.S. Department of Energy Vehicle fuel economy website". Fueleconomy.gov. Retrieved 2010-10-16.
- [3] Tracy, David. "This is how an automatic transmission works". Jalopnik. Gawker Media. Retrieved 6 October 2014.
- [4] Ofria, Charles. "A short course on automatic transmissions". CarParts.com. JC Whitney. Archived from the original on 6 October 2014. Retrieved 6 October 2014.
- [5] Karim Nice "How Automatic Transmissions Work" 29 November 2000. HowStuffWorks.com. <<http://auto.howstuffworks.com/automatic-transmission.htm>> 02 May 2017
- [6] William Harris "How CVTs Work" 27 April 2005. HowStuffWorks.com. <<http://auto.howstuffworks.com/cvt.htm>> 28 May 2017
- [7] William Harris "How Dual-clutch Transmissions Work" 6 April 2006. HowStuffWorks.com. <<http://auto.howstuffworks.com/dual-clutch-transmission.htm>> 02 May 2017
- [8] Consumer Reports. "Manual vs Automatic Transmission: Save Money." Consumer Reports. October 2014. (April22,2017) <http://www.consumerreports.org/cro/2012/01/save-gas-and-money-with-a-manual-transmission/index.htm>