SYNCHRONIZATION OF EPICYCLIC GEAR BOX WITH ITS SUBORDINATE FUNDAMENTAL COMPONENTS IN AUTOMATIC TRANSMISSION SYSTEM

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ABSTRACT: ***The modern automatic transmission is by far, the most complicated mechanical component in today's automobile. Automatic transmissions contain mechanical systems, hydraulic systems, electrical systems and computer controls, all working together in perfect harmony which goes virtually unnoticed until there is a problem. The transmission is a device that is connected to the output of the engine and sends the power from the engine to the drive wheels. An automobile engine runs at its best at a certain RPM range and it is the transmission's job to make sure that the power is delivered to the wheels while keeping the engine within that range. The automatic transmission is employed with the fundamental components such as torque converter, multi plate brakes and clutches, planetary gear set whose proper coordination and synchronization is ensured by electronic control unit (ECU) and electro hydraulic control unit in order to facilitate various transmission gear ratios depending upon the sensed parameters such as speed, load, slope etc.***

KEYWORDS: ***Automatic transmission, epicyclic gear box, planetary gear set, electronic control unit, torque converter.***

I. INTRODUCTION:

Vehicles need a transmission to transfer the power from the engine to the drive shaft and the differential to let the wheels turn. The transmission varies the torque, the speed and the direction by changing the transmission ratios and enables the car to start with a high torque. An automatic gearbox, or automatic transmission system, is a gearbox in which gear is shifted automatically by sensing the load, speed and other parameters thus eliminating the need of clutch pedal, it does not require manual switching.

Automatic transmissions contain many gears in various combinations. In a manual transmission, gears slide along shafts as you move the shift lever from one position to another, engaging various sized gears as required in order to provide the correct gear ratio. In an automatic transmission, however, the gears are never physically moved and are always engaged to the same gears. This is accomplished through the use of planetary gear sets.

The most popular form found in automobiles is the hydraulic automatic transmission. Similar but larger devices are also used for heavy-duty commercial and industrial vehicles and equipment. This system uses a fluid coupling in place of a friction clutch, and accomplishes gear changes by hydraulically locking and unlocking a system of planetary gear. These systems have a defined set of gear ranges, often with a parking pawl that locks the output shaft of the transmission to keep the vehicle from rolling either forward or backward.

The main advantage of an automatic transmission to the driver is the lack of a clutch pedal and manual shift pattern in normal driving. This allows the driver to operate the car with as few as two limbs, allowing individuals with disabilities to drive. The lack of manual shifting also reduces the attention and workload required inside the cabin, such as monitoring the tachometer and taking a hand off the wheel to move the shifter, allowing the driver to ideally keep both hands on the wheel at all times and to focus more on the road. Control of the car at low speeds is often easier with an automatic than a manual, due to a side effect of the clutchless fluid-coupling design.

II. PRINCIPAL OF OPERATION:

This type of transmission system uses no sliding dogs or gears to engage but different gear speeds are obtained by merely tightening brake bands on gear drum. It consists of a sun gear, pinion or planet gear and the ring gear. The ring gear contains teeth on it inner circumference and it surrounded by a brake band. The brake band is operated by the hydraulic pressure exerted by the hydraulic oil. This is control by the electronic sensor or the movement to vehicle speed, load and the accelerator valve opening. The planet gears are in constant mesh with both thee sun gear and ring gear and are free to rotate on their axes carried by the carrier frame which in turn is connected to the driver shaft.

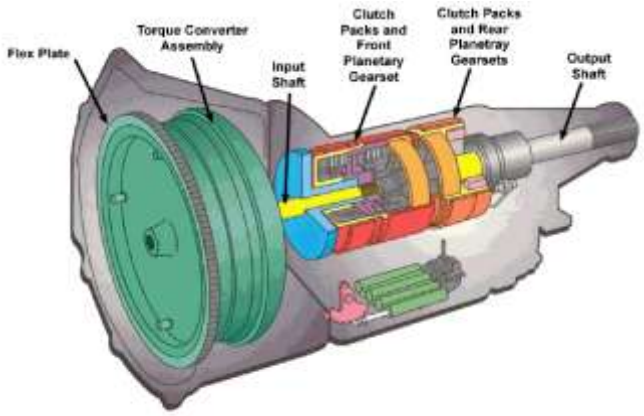

Fig.1 Automatic transmission system

When the ring gear is locked by the brake band, the rotating sun gear causes the planet gears to rotate. Since the ring gear cannot move. The planet gears are forced to climb over it. During this position, the ring gear acts as track for the planet gears to move over. The driven shaft which is connected to the planet gear carrier is thus rotate. When the ring gear is released, it is free to move in consequence to the rotation of planet gears which rotate around their axis. During this position, there is no movement of planet carries and hence the driven shaft remains stationary. A planetary gear box contains a numbers of such units to obtain various speed reductions.

In the automatic transmission the engine shaft is connected to the clutch and the further connected to the turbine of the torque converter. The torque converter drives the ring gear of first gear train through a free wheel. The drive of the ring gear of the second gear train is then taken form the planet carrier of the first gear train so that the two act in series. This arrangement gives three forward and one reverse speed by subsequently application of brake.

The selection of the particular gear and application of corresponding clutch and brake is done hydraulically. The hydraulic pressure I regulated by the car speed that control oil pressure on one side of the shift valve and the throttle opening controlled by the driver through the accelerator pedal which controls oil pressure on other side of the shift valve.

III. FUNDAMENTAL COMPONENTS:

The main component of the automatic transmission is the converter housing case, oil pan and the extension housing. The converter housing encloses the torque converter and the case contains epicyclical gear train while the extension housing encloses the output shaft. The oil pan is bolted to the case. The entire transmission unit is attached to the engine block by means of bolts through holes in the converter housing flange. The entire unit is synchronized to perform its task effectively, by multi plate brakes and clutches, hydraulic actuators, lockup clutch which are controlled by electronic control unit.

3.1 TORQUE CONVERTER:

The torque converter also called as fluid coupling is a device used to transfer mechanical rotational energy through fluid movement from one mechanical moving system to another. It can replace a clutch due to the fact that it allows the engine to rotate freely by vastly reducing the torque delivery from the powertrain to the transmission. It never fully disconnects, as you can feel through the 'creep' that occurs if you take your foot off the brake of an automatic car from standstill.

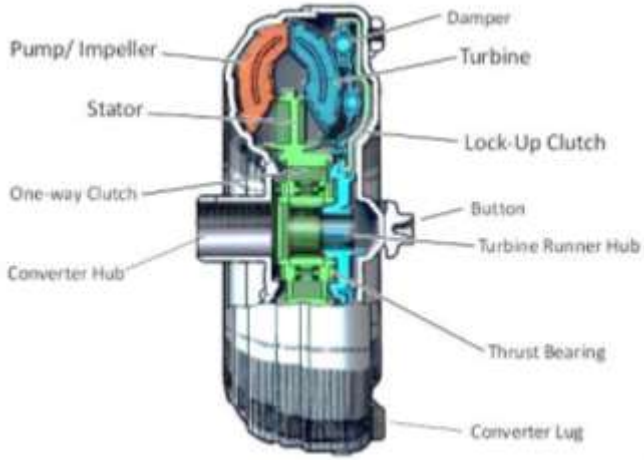

Fig.2 Torque converter

The torque control is achieved through the use of a pump that sends fluid around the torque converter depending on the rotation of the crankshaft. Within the torque converter is a turbine which is rotated as the pumped fluid comes into contact with the turbine's vanes, thus gauging the amount of torque that makes it to the transmission through the input shaft.

The casing of the torque converter is connected to the flywheel (which therefore spins at the same rate as the crankshaft) and within the housing is the turbine, the fluid centrifugal pump (or impeller) and a stator. The centrifugal pump effectively flings the transmission fluid into the fins of the turbine which in turn spins and transmits torque through to the transmission. The stator is there as a barrier to fling fluid straight back to the turbine instead of back to the pump, vastly increasing the efficiency of the system.

So at idle, the rate of fluid pumped to the turbine is very slow, which means very little torque is making its way from the engine through to the transmission. Then, as the crankshaft rotates faster with more throttle and in-turn rotates the flywheel, more fluid is propelled at a faster rate from the pump into the turbine.

The turbine then rotates faster, allowing more torque through to the transmission. Unfortunately, the transfer of energy from the pump through to the turbine can never be 100 per cent efficient - additional energy losses occur through this system which are amplified once the engine torque has also transferred through the gearbox and out of the differential.

3.1.1 TORQUE CONVERTER LOCKUP CLUTCH:

There is always a slight loss of energy between the pump and the turbine, which implies that the turbine always spins slightly slower than the pump, which is the main reason why automatics in general have lower fuel efficiency ratings than their manual counterparts. Lock-up clutch connects torque converter housing with transmission input shaft. i.e. The impeller and turbine are directly coupled to each other, such that speed ratio impeller to turbine is 1:1. It predefines low level of slip. Generally, torque converter lock up clutch engages when the vehicle runs in fourth or fifth gears.

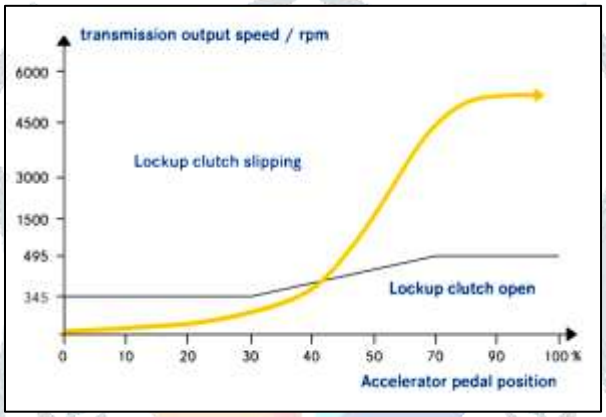

Fig.3 Operation of lockup clutch

3.2 SHIFT COMPONENTS:

The shift components include the multi plate brakes, multi plate clutches, oil pump and the hydraulic circuit. These shift components are controlled by electronic control unit so as to hold or connect various gears of planetary gear set to obtain desired transmission ratio.

3.2.1 MULTI PLATE BRAKES:

The function of Multi-Plate brake is to hold Transmission Components Stationary. Brakes are used to hold a component in the planetary gear set still. The brakes fitted in today's automatic transmissions are all multi-plate brakes, with one set of plates splined together with the transmission component and the other connected to the transmission casing. The multi-plate brake is actuated by a pressure piston and returned to its rest position by a disc spring (piston return spring).

Externally Toothed Plates are connected to transmission casing by external plate carrier. Internally toothed plates connected with Transmission component via internal plate carrier. Friction lining us provided on both sides of the external and internal plates.

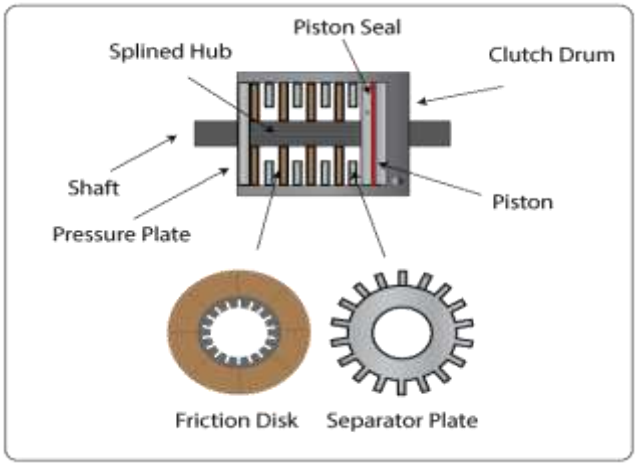

Fig.4 Multi plate brake and clutch

External Plate Carrier is held stationary. Externally toothed plates are fixed internally over the slots provided on the external plate carrier. The internal plate carrier rotates with the transmission shaft connected to the element which is to be stopped. Internally toothed plates are fixed externally over the slots of internal plate carrier.

3.2.2 MULTI PLATE CLUTCHS:

The main function of multi plate clutch is to connect or couple two transmission components of the planetary gear set. Their constructional and operational features are similar to the multi plate clutches. A clutch pack consists of alternating disks that fit inside a clutch drum. Half of the disks are steel and have splines that fit into groves on the inside of the drum. The other half have a friction material bonded to their surface and have splines on the inside edge that fit groves on the outer surface of the adjoining hub. There is a piston inside the drum that is activated by oil pressure at the appropriate time to squeeze the clutch pack together so that the two components become locked and turn as one.

3.2.3 OIL PUMP:

The transmission oil pump is responsible for producing all the oil pressure that is required in the transmission. The oil pump is mounted to the front of the transmission case and is directly connected to the hub of the torque converter housing. Since the torque converter housing is directly connected to the engine crankshaft, the pump will produce pressure whenever the engine is running as long as there is a sufficient amount of transmission fluid available. The oil enters the pump through a filter that is located at the bottom of the transmission oil pan and travels up a pickup tube directly to the oil pump. The oil is then sent under pressure to the pressure regulator, the valve body, and the rest of the components as required.

3.2.4 HYDRAULIC SYSTEM:

Transmission fluid serves a number of purposes including: shift control, general lubrication and transmission cooling. Unlike the engine, which uses oil primarily for lubrication, every aspect of a transmission's functions are dependent on a constant supply of fluid under pressure. This is not unlike the human circulatory system (the fluid is even red) where even a few minutes of operation when there is a lack of pressure can be harmful or even fatal to the life of the transmission. In order to keep the transmission at normal operating temperature, a portion of the fluid is sent through one of two steel tubes to a special chamber that is submerged in anti-freeze in the radiator. Fluid passing through this chamber is cooled and then returned to the transmission through the other steel tube. A typical transmission has an average of ten quarts of fluid between the transmission, torque converter, and cooler tank. In fact, most of the components of a transmission are constantly lubricated in fluid including the clutch packs and bands. The friction surfaces on these parts are designed to operate properly only when they are coated in oil.

IV. PLANETARY GEAR SET:

The epicyclic gear box consists of the planetary gear set unit. In planetary gear set all of the gears are in one plane, grouped around each other like the planets around the sun. The central gear is called the "sun gear". In mesh with it is a circular grouping of gears, called "planet gears", mounted on a rotating carrier. The planet gears also engage teeth on the inner periphery of the "ring gear". By holding any one of the three gear elements motionless, different ratios can be produced between the other two.

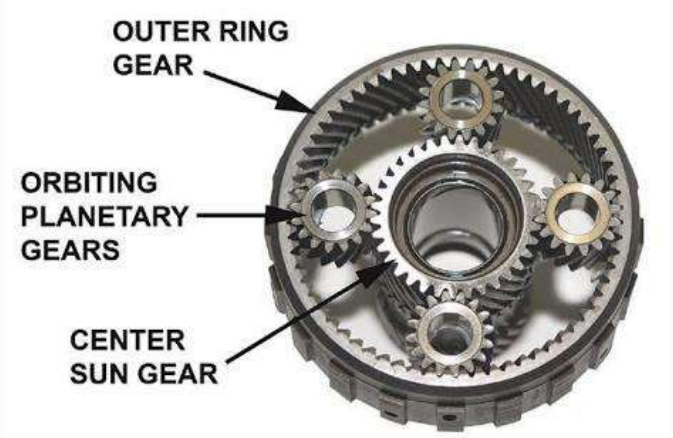

Fig.4 Planetary gear set

By holding any one of the three gear elements stationary, different ratios can be produced between the other two.

A. Sun gear locked, Ring gear driving, Planet gears driven, we get low step-down ratio.

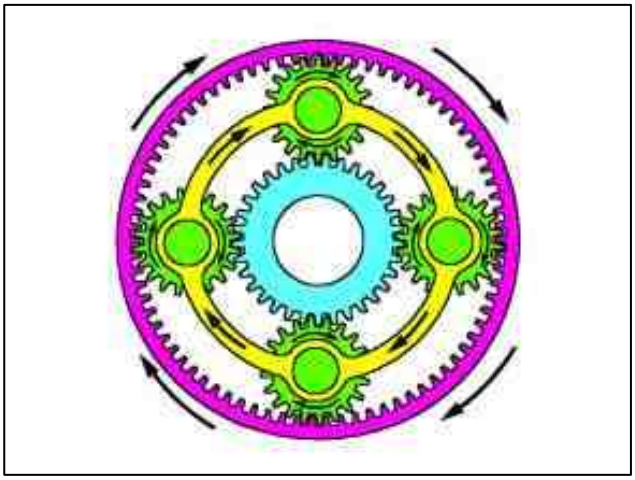

Fig.5 Low step down ratio

B. Hollow gear locked, Sun gear driving, Planet gears driven, we get high step-down ratio.

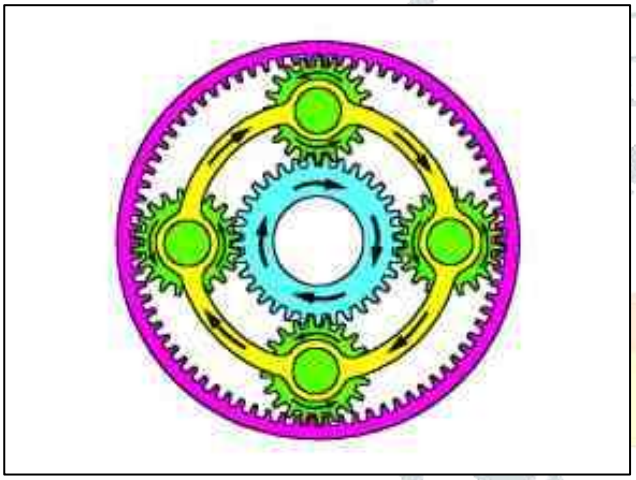

Fig.6 High step down ratio

C. Locking two elements together so that the planetary gear set turns as a unit, produces a direct power transmission (Transmission ratio = 1).

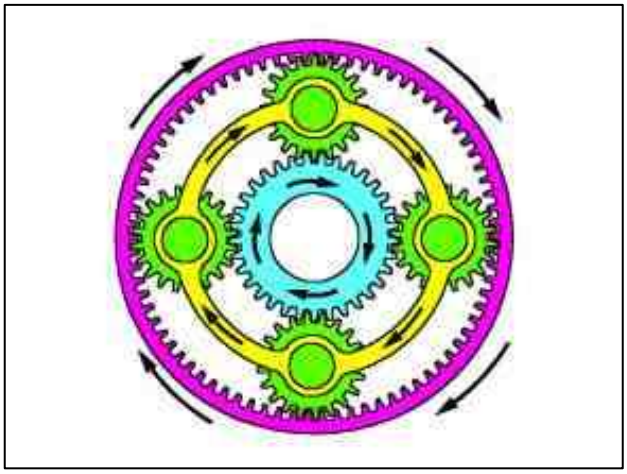

Fig.7 1:1 transmission

D. Planetary carrier locked, Sun gear driving, Ring gear driven, Direction reversal and step-down ratio.

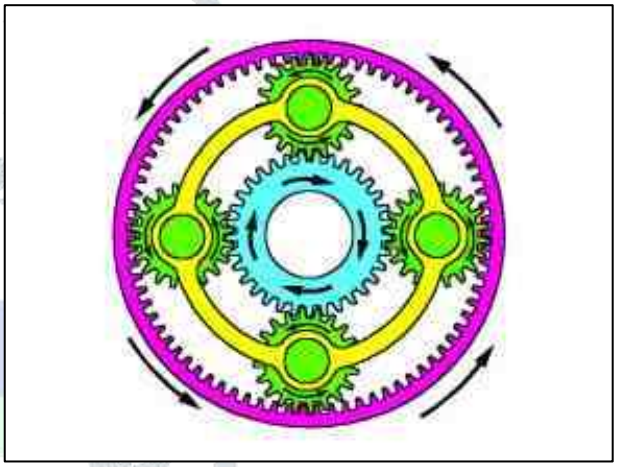

Fig.8 Reverse direction and low step down ratio

V. ELECTRO HYDRAULIC CONTROL UNIT

Electro Hydraulic Control Unit is the automatic transmission control Centre. When instructed by the Electronic control unit it builds up the required hydraulic pressure, and relays them to the hydraulic shift elements. It consists of solenoid operated hydraulic valves and pressure regulating valves. Electro Hydraulic control unit builds up pressure for shift elements (multi plate brakes and clutches), torque converter, torque converter lockup clutch.

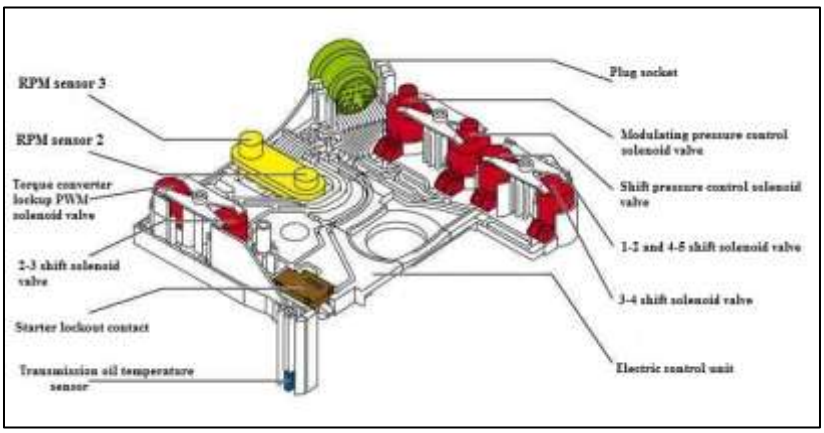

Fig.9 Electro hydraulic control unit

5.1 ELECTRONIC CONTROL UNIT (ECU):

Electronic control unit (ECU) is the heart of automatic transmission system. The Electronic Control Unit senses various parameters such as speed and accordingly sends signal to actuate solenoids in Electro Hydraulic Control Unit to engage the desired gear. It performs its operation in accordance with the signals received from various sensors such as taco sensors, position sensors, etc.

BASIC BLOCK STRUCTURE OF ECU:

INPUT:

- Speed of the vehicle.
- Temperature of automatic transmission fluid.
- Position of accelerator pedal.

PROCESSONG:

- To decide the optimum gear ratio at the given circumstances.
- Executing gear change.

OUTPUT:

- Send signal for actuating solenoid control valves.
- Display of shift mode and shift range / gear selection.

VI. COMPUTER CONTROL:

The computer uses sensors on the engine and transmission to detect such things as throttle position, vehicle speed, engine speed, engine load, stop light switch position, etc. to control exact shift points as well as how soft or firm the shift should be. Some computerized transmissions even learn driving style and constantly adapt to it so that every shift is timed precisely when you would need it.

Because of computer controls, sports models are coming out with the ability to take manual control of the transmission as though it were a stick shift, allowing the driver to select gears manually. This is accomplished on some cars by passing the shift lever through a special gate, then tapping it in one direction or the other in order to up-shift or down-shift at will. The computer monitors this activity to make sure that the driver does not select a gear that could over speed the engine and damage it.

VII. CONCLUSION:

The automatic transmission system contains mechanical systems, hydraulic systems, electrical systems and computer controls, all working together in perfect harmony and synchronization in order to assure the most optimum selection of gear ratios in accordance with varying circumstances and at the same time ensure proper and smooth transmission so as to offer abundant comfort. The electro hydraulic control unit plays the most crucial role in ensuring proper functioning by sensing sensor signals, synthesizing and processing data and accordingly functioning hydraulic actuators in form of multi plate brakes and clutches in order to hold various planetary gear element to obtain desired gear ratio.

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