

## AN INSIGHT TO THE CONSTRUCTION AND WORKING OF DUAL CLUTCH TRANSMISSION

\*Rashmi V N, \*\*Varun Kumar G, \*\*\*Rashmi S,

\* Student, Dept. of Industrial Engg. & Management JSS Academy of Technical Education, Bengaluru - 560060

\*\*Student, Global Academy of Technology, Dept. of Mechanical Engineering, Bengaluru – 560098

\*\*\*Assistant Professor, JSS Academy of Technical Education, Dept. of Industrial Engg. & Management, Bengaluru

### Abstract

A dual clutch transmission (DCT) is a type of automatic transmission featured with a dual-clutch module and two input shafts. A DCT is able to provide a high-quality gear shifting with a gear pre-selection procedure and overlapping of clutch engagement. The gear pre-selection procedure means that the synchronization of the oncoming gear has been completed before the actual gear shifting procedure starts. And due to the overlapping mechanism of the two clutches, torque is transferred from the engine to the driving wheels without interruption during gear shifting. Therefore, it provides a rapid gear shifting without sacrificing fuel efficiency and riding comfort. In addition, with a precisely computed and accurately controlled slippage of the dual-clutch module, the DCT is able to provide a fast and smooth gear shifting. The performance of a DCT during gear shifting relies on a well-designed clutch engagement controller which should be able to achieve fast clutch-to-clutch shifting and smooth gear shifting without noticeable torque disturbance.

**Keywords**— Dual, Clutch, Transmission, Synchronizer, clutch to clutch shift, paddle

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### 1. INTRODUCTION:

Engine known as heart of automobile system produces the power required to drive the automobile. But every time the complete power generated by the engine cannot be utilized to the fullest to run the automobile at a constant speed. If so were to be used then the automobile should be driven at a constant speed from the start, which is a contradictory situation. While driving an automobile lot of power (torque) is required to initiate from rest. Hence it starts at low speed and when the Speed from the start, which is a contradictory situation. While driving an automobile lot of power (torque) is required to initiate from rest. Hence it starts at low speed and when the Vehicle attains sustainable momentum the speed of the vehicle increases without requirement of much torque. This can be analysed from Eq. 1,

$$\text{Power} = \text{Torque} \times \text{Speed} \quad (1)$$

Hence to control the application of power from engine rotating at thousands of RPM in order to control the speed available at the vehicle wheels and to transmit power through right angle drive, because the crankshaft and rear axle are normally at right angles to each other the transmission system plays a vital role. [1]

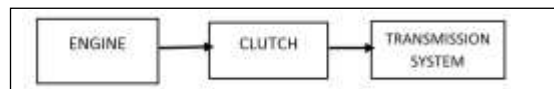
A clutch is a mechanical device which engages and disengages the transmission of power from the engine to the transmission, system.

## 2. CLASSIFICATION OF TRANSMISSION SYSTEM

Basically the transmission system is of three types:

- Manual transmission
- Semi-automatic transmission
- Automatic transmission

**2.1 Manual transmission:** Manual transmission is the most widely used system in automobiles. The major reasons for this are- it is cheaper, can be easily manufactured, flexible, faults can be detected and rectified easily etc. comparatively to other systems. In this system a clutch pedal is facilitated for the driver in order to change the speed of the vehicle by disengaging the transmission system from the engine and shifting among various gears in order to achieve various gear ratios. During the shifting of gears there is an interruption of power (torque gap) from the engine causing uncomfortable in the drive. The typical block diagram of manual power transmission system is as shown below.



**Fig. 1. Manual transmission**

The transmission system in brief is a speed varying mechanism, which is a compact arrangement of combinational gears mounted on several shafts coupled with clutch.

**2.2 Automatic transmission system:** Automatic transmission system is the most advanced transmission system in automobile field. In this system unlike manual transmission there is no clutch pedal. The shifting of the gears takes place automatically according to the speed and torque controlled by sensors, actuators, hydraulic systems. Unlike manual transmission system in automatic transmission system the same set of gears produces all of the different gear ratios. The planetary gear set is the device that makes this possible in an automatic transmission. The block diagram of automatic transmission system is shown below



**Fig. 2. Automatic transmission**

**2.3 Dual Clutch Transmission (DCT):**DCT is also termed as semi-automatic / automated manual / clutch less manual transmission. The credit of inventing dual clutch transmission goes to Adolphe KEGRESSE. This is the type of transmission intermediate between automatic and manual transmission system. The problem of power interruption (torque gap) is overcome in this system. Typically this system consists of two clutches either dry or wet, one controlling odd gears and the other even gears with the idler. In addition to this the clutch pedal is eliminated whose job is done by electro-hydraulic actuator system. The main advantage of this system is the synchronization of the upcoming gear before changing and thereby transmitting continuous power to the drive system. The block diagram of dual clutch transmission is shown below. [2]

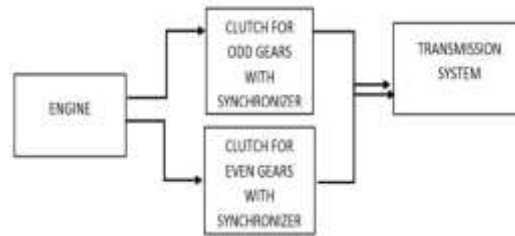


Fig. 3. Dual Clutch Transmission

### 3. PARTS OF A DUAL CLUTCH TRANSMISSION SYSTEM:

A dual clutch transmission system consists of the following main parts

#### 3.1 Multi plate clutches:

Similar to the manual transmission system the DCT also consists of clutch plates. They are two in number which are either dry or wet in a single housing coupled to driven shafts. DCTs currently on the market use wet multi-plate clutches. A "wet" clutch is one that bathes the clutch components in lubricating fluid to reduce friction and limit the production of heat.

#### 3.2 Drive shafts :

Unlike other transmission which consists of single solid shaft connecting the transmission system and wheel axle the DCT system holds two shafts from the transmission system to the wheel axle concentrically. Among the two shafts one being solid (inner shaft) and the other being hollow (outer shaft). The solid shaft transmits power from engine to the odd gears and the hollow shaft transmits to the even gears or vice versa according to the design of the clutch and gear housing.

#### 3.3 Gear arrangement :

Gears being the most useful component of transmission system are required in order to extract high torque from high speed engine to overcome gradient resistance and during starting even though they are performed at low speeds. When the vehicle is running at high speed it does not require much torque because of the momentum gained from inertia.

This mechanism of controlling the speed and torque according to the road conditions is done by gear arrangements by maintaining the suitable gear ratios. The basic relation used in designing the gears and maintain the appropriate ratio is given in Eq. 2.

$$N_2/N_1 = T_1/T_2 \quad (2)$$

If  $N_1$  and  $N_2$  are the speed of driver and driven respectively and  $T_1$  and  $T_2$  are the number of teeth on driver and driven respectively, to obtain a specific speed at the driven (wheels) from the engine (driver) rotating at high speed the driver gear is designed with a less number teeth compared to the driven gear in order maintain  $T_1/T_2$  ratio less than unity.

#### 3.4 Synchronizers:

Synchronizers are the key elements and centralized components in the Double Clutch Transmission systems featuring interfaces to the output. In common to synchronize means to adjust the speed of shaft and gear wheel. The

synchronization process always follows a predefined sequence of instructions. While shifting the gear the sleeve on the shaft is moved by the shift fork towards the gear to be engaged. As long as there is a speed difference between the sleeve and the gear wheel the sleeve is blocked by the blocker ring and the synchronizer rings create a friction torque. Once the speeds are synchronized the sleeve moves further and engages into the next gear train. This whole mechanism is controlled by electro-hydraulic actuator system. However, the shifting of gear can be made completely automated or manual by including paddle shifts according to convenience. [3]

#### 4. CONSTRUCTION OF A DUAL CLUTCH TRANSMISSION SYSTEM:

The dual clutch transmission is mounted between the engine and the final drive. The dual clutch transmission transfers power from the engine to the driving wheel while providing desired gear ratios.

A 6-speed Dual Clutch Transmission (DCT) is as shown in Figure-1. There are two power transfer path formed by two clutches and corresponding shafts, synchronizers and gears.

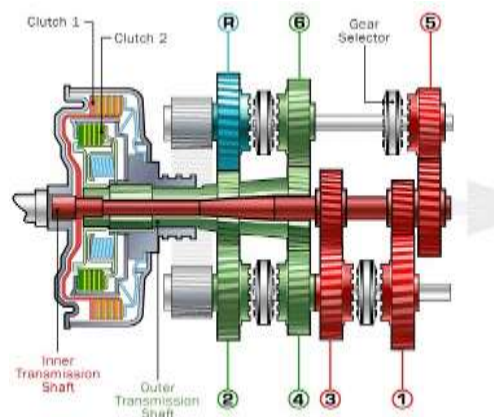


Fig. 4.6 Speed DCT. [7]

When the dual clutch transmission is working in a specific gear, only one of the clutches and corresponding synchronizers are engaged. Therefore only one power path transfers power in that working condition. While in gear shifting transients, the oncoming clutch starts to engage and the off-going clutch begins to disengage. So before the gear shifting is completed, the power paths both transferring power at the same time. As a unique feature of a dual clutch transmission, the next gear is preselected and the corresponding synchronizers are engaged before the actual gear shifting starts. In this way dual clutch transmission is able to perform a fast gear shifting.

The dual-clutch module, that gives name to the transmission, is mounted between the engine flywheel and the two coaxial input shafts of the transmission, one for odd gears and one for even gears. Therefore, the dual-clutch module in the DCT provides the powertrain with two routes from the engine to the driving wheels. The dual-clutch module can be single disk or multi-disk, dry or wet type, depending mainly on the amount of power needed to be transferred and the available speed. A dual clutch transmission as typically implemented on an automobile is as shown in figure-2. The coaxial input shafts consist of a solid shaft and a hollow shaft. The solid shaft carries the 2nd gear, the 4th gear and the reverse gear. The hollow shaft carries the 1st gear, the 3rd gear and the 5th gear. Synchronizers are located in a way similar to a traditional manual transmission. The synchronizers are located on the two intermediate shafts. The synchronization is completed before gear shifting starts, and this leads to a faster gear shifting operation. [4]

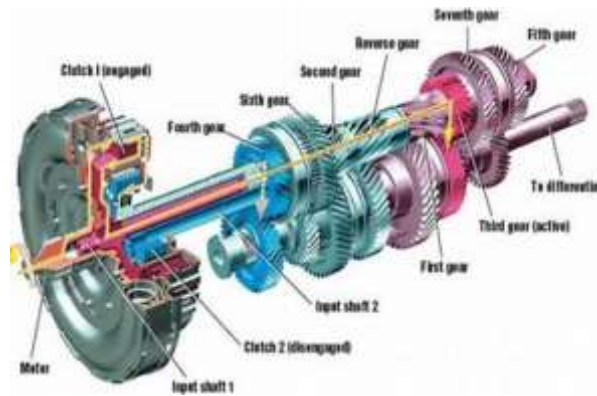


Fig. 5.DCT implemented on an Automobile [7]

### 5.WORKING OF A DUAL CLUTCH TRANSMISSION SYSTEM:

When in a specific gear, the corresponding clutch and synchronizer are engaged and torque is transferred from the engine to the driving wheels through a particular path. Meanwhile, the other clutch is disengaged and the remaining gears freewheel (rotate freely on the splined shaft). In the gear shifting process, there is a period that both clutches are transferring torque from the engine to the gearbox. This clutch overlapping process involves the engagement of the oncoming clutch and the disengagement of the off-going clutch. This mechanism is shown in figure3. The clutch overlapping mechanism ensures no interruption of the power transmission occurs between the engine and the driving wheels during gear shifting procedure. To achieve a fast and smooth clutch-to clutch shifting, a sophisticated control of clutch slippage is performed.

The clutch-to-clutch control of gear shifting between two consecutive gears is described as following. Consider the gear shifting from even gear to odd gear as shown in figure 3. The clutch-to-clutch shift is automatically controlled by the Electrical Control Unit (ECU) and implemented by the relevant actuators.

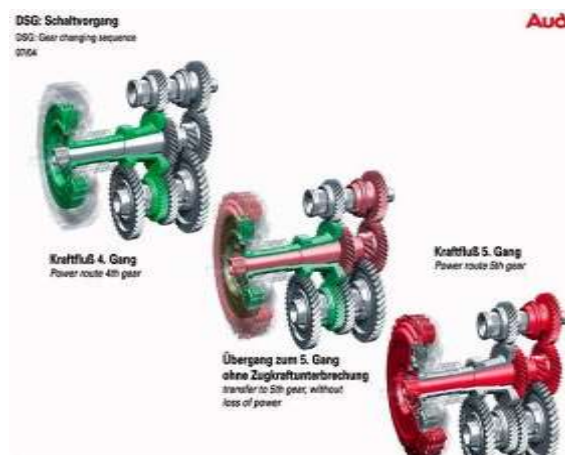


Fig. 6.Shifting from 4th to 5th gear in a DCT [7]

Before the slippage of the two clutches starts to change, the clutch pressures in the two clutches are changed to meet the pressure threshold when the torque capacity of the oncoming clutch starts to be positive and the torque capacity of the off-going clutch decreases to the critical level that the off-going clutch begins to slip. This procedure eliminates the time delay that could bring an undesirable impact to the clutch-to-clutch shift quality. After that, the torque capacity of the oncoming clutch continuous to increase in a pre-programmed manner and the torque capacity of the off going clutch is controlled to decrease at a rate that ensures the output torque of the transmission tracks the demanded level. The torque capacity is controlled by the clutch pressure applied by the related actuators. This

concurrent process eliminates the power transmission interruption that happens in manual transmissions, automated manual transmissions and classic automatic transmissions during gear shifting. Therefore, the clutch-to-clutch control process allows both rapid gear shifting accomplishment and continuous torque transfer to the driving wheels. A similar process is repeated whenever gear shifting between another two consecutive gears occurs. [5]

## **6. COMPARISON OF DUAL CLUTCH TRANSMISSION WITH OTHER TRANSMISSION SYSTEMS:**

A dual clutch transmission shows different dynamic characteristic from an automatic transmission. The distinctive feature of a dual clutch transmission system is to allow torque transferring from engine to the drive wheel without interruption. But, this phenomenon can be achieved in Continuously Variable Transmission also. And the manual transmission remains inferior to the former ones'.

In automatic transmissions to achieve this uninterrupted flow of power, torque converters are used. Whereas in dual clutch transmission no such torque converter setup is used that dampens the shift transient. The absence of torque converter makes dual clutch transmission more sensitive to input torque indifference.

Here, torque difference is the difference between the desired output torque and the actual output torque. Hence, in order to minimize the gear shifting time and reduce the output torque difference of a dual clutch transmission an advanced control law for dual clutch module during clutch to clutch shift controller is needed. This unique mechanism is performed by the combined operation of dual clutches, electro-hydraulic unit and synchronizers. The two clutches are engaged alternatively in different gears (odd and even). A typical gear shifting involves the engagement of oncoming clutch and disengagement of off going clutch. Thus, the clutch-clutch shifting enables fast gear shifting without power interruption. [6]

## **7. SALIENT FEATURES OF DUAL CLUTCH TRANSMISSION OVER OTHER TYPES**

- In dual clutch transmission the clutch pedal is replaced by computers, solenoids and hydraulics. But, even without a clutch pedal, the driver can still instruct the computer to take action through paddles, buttons or a gearshift.
- DCT offers the most dynamic acceleration of any vehicle on the market which is approximately 8 milliseconds for upshift of gear.
- It certainly offers smooth acceleration by eliminating the shift shock that accompanies gearshifts in manual transmissions and even some automatics.
- The most compelling advantage is that, the power flow from engine to transmission is not interrupted which subsequently improves the fuel efficiency. According to experts six-speed DCT can deliver up to a 10 percent increase in relative fuel efficiency when compared to a conventional five-speed automatic.
- Dual clutch transmission systems are lighter and fit easily into spaces engineered for a common manual transmission.

## **8. APPLICATION OF DUAL CLUTCH TRANSMISSION**

The various applications of DCT are listed in Table 1.

Table 1 Application of DCT in Automobiles [8]

| Sl. No | Applications |            |               |
|--------|--------------|------------|---------------|
|        | Manufacturer | Model      | Specification |
| 1      | Porsche      | 956 & 962C | 6-speed       |
| 2      | Audi sport   | Quattro    | 6-speed       |
| 3      | lamborghini  | huracan    | 6-speed       |
| 4      | BMW          | M3         | 5-speed       |
| 5      | Volkswagen   | Golf , Mk4 | 5-speed       |
| 6      | Ford         | fiesta     | 5-speed       |

## 9. RESULTS:

We have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

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