Study of Manual Transmission System

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Abstract— Almost everyone in this world has at least once used the conventional manual transmission system and knows its logic of working. Everyone knows that the dock gear gets engaged to the selected gear and the power is transmitted through this gear. But not many know about what exactly happens inside the transmission gearbox. All the moving parts we know of are the engine, clutch, the selected gear and the output shaft of the transmission gearbox. But there is more movement than that is thought to be, the counter shaft or the lay shaft moves constantly and it has all the gears on it which are moving too, these gears eventually give motion to the non-engaged gears on the output shaft. There are several different conditions here too, such as when the clutch is engaged or disengaged, whether the vehicle is static or is in motion and whether the transmission gearbox is set at some gear or is in the neutral condition. Once all these various actions taking place in the vehicle transmission are identified, we can move ahead to point out the advantages and disadvantages of this conventional manual transmission system. Through this we can discuss about the clutch present in this transmission system and how it proves to be very helpful in this system. Thus, through this paper we all come to know that this world is full of endless possibilities; there are still a lot of methods to modify and improve this transmission system.

Keywords: Manual Transmission System

I. INTRODUCTION

The conventional manual transmission system had been the backbone of the automobile industry since the very beginning. As years passed many innovations came, but the concept of the manual transmission remained the same. The manual transmission is being used even today as it is very simple, easy to use and cost effective all at the same time. One of the most important key features in this manual transmission system is that it uses the speed of the wheels of the vehicle as the feedback while shifting from one gear to another. The manual transmission system uses the clutch assembly to bring about ease and comfort during the shifting of gears. The following paper discusses about all the motions taking place inside the vehicle from the engine to the output shaft of the transmission gearbox. [1] We know that the docking gear holds the selected gear and the power is transferred through that specific gear, but there is a motion taking place in the other gear sets too. This paper determines these motions and actions and their effect. To sum it up into a simple statement we can say that while the gear is being shifted the running wheels drive the engine of the vehicle for an instant.

II. DECRIPTION

A. Let us consider a schematic diagram of the conventional manual transmission system as shown:

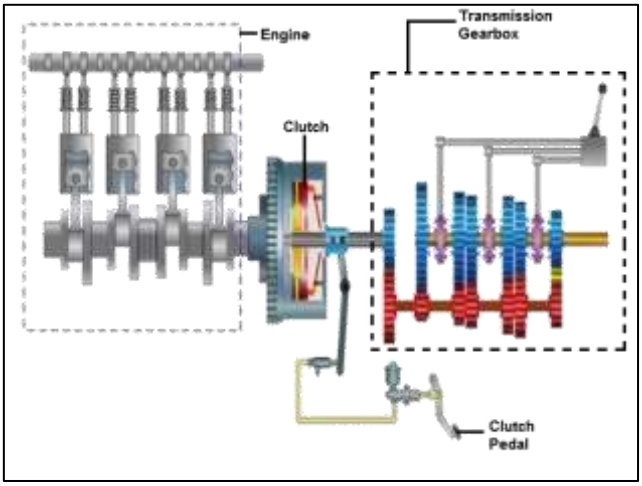

Fig. 1: Schematic diagram of a conventional manual transmission system [2]

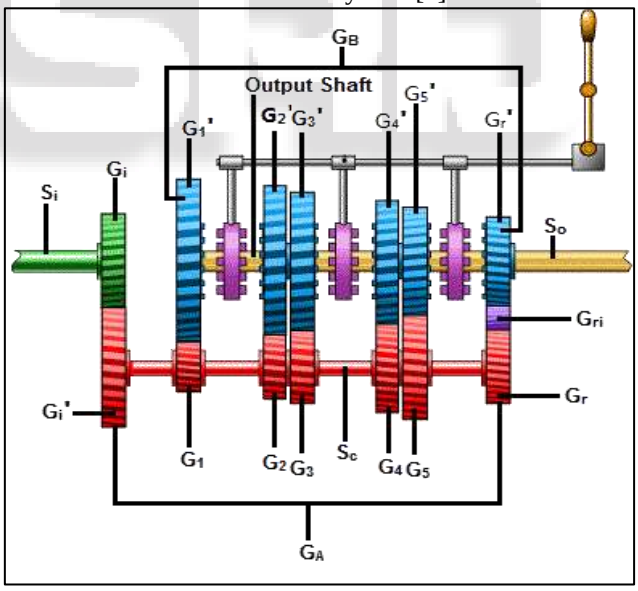

Fig. 2: Transmission gearbox parts [3]

Here, the various parts labeled are defined as;
E: Engine
C: Clutch, it is engaged to the input shaft of the transmission gearbox.
S_i: Input shaft, it has only a single gear on it, which is meshed with the first gear on the counter shaft.
S_c: Counter shaft
S_o: Output shaft
G_i: Gear on the input shaft
G_A: Gear set on counter shaft
G_B: Gear set on output shaft
G_1, G_2, G_3, G_4, G_5 and G_r: Gears in gear set 'A'

G_1', G_2', G_3', G_4', G_5' and G_r': Gears in gear set 'B'
G_i': Gear on counter shaft coupled to G_i
G_{ri}: Idler gear for reverse
G_n: The selected gear on the output shaft when the vehicle is moving at 'x' speed.
G_n': The gear meshed with 'G_n' on counter shaft.
G_m: The gear into which the transmission will be shifted.

B. Well aware about the working of this type of transmission system, we know a few points:

1) The gear set 'A' and the counter shaft is one single body, all the gears on this shaft move at the same speed that of the counter shaft.
2) The counter shaft has one extra gear as compared to the gears on the output shaft. This gear couples the counter shaft to the input shaft coming from the clutch.
3) When the clutch is in its defined state i.e. the clutch is engaged to the engine, the clutch runs at the speed of the engine. Hence the input shaft moves at the same speed of the clutch. At the same instant, the gears on the counter shaft rotate at the speed with respect to the gear ratio of the gear on the input shaft and the G_i' gear on the counter shaft. [4]
4) The gear set 'B' is just placed on the output shaft and are not fixed on it as a single body. The shaft and the gears move individually. It is the selector fork that couples the output shaft and the gear set 'B'. This is the reason why the gears in this type of manual transmission are in a constant mesh. Hence its name.
5) When the clutch is disengaged from the engine and the vehicle is in some motion on a gear, the output shaft is turned by the wheels whose are moving. The output shaft in turn rotates the gear on the output shaft with the help of the selector fork. This gear then rotates the entire counter shaft which in turn rotates the input shaft and the clutch mounted on it.
6) When the shifting is initiated the dock gear first releases the n^{th} gear, moves into the neutral for a fraction of second and then gets engaged into the m^{th} gear. [5]

C. Now let us consider different static and dynamic conditions of the vehicle to identify the various processes occurring in the transmission system:

1) In the neutral gear:

a) Clutch engaged:
- C, S_i and G_i revolve at engine speed.
- S_c and G_B revolve at speed w.r.t. gear ratio of G_i and G_i'.
- G_1', G_2', G_3', G_4', G_5' and Gr ' revolve at speed w.r.t. individual gear ratios with G_A.
- S_o does not move because there is no gear selected.

b) Clutch disengaged:
- No motion is transferred ahead of the flywheel, hence nothing moves in the transmission system.
- For n^{th} gear, vehicle running at x speed:

c) Clutch engaged:
- C, S_i and G_i revolve at engine speed.
- S_c and G_B revolve at speed w.r.t. gear ratio of G_i and G_i'.
- G_1', G_2', G_3', G_4', G_5' and Gr ' revolve at speed w.r.t. individual gear ratios with G_A.
- S_o rotates at the speed at which G_n rotates.

d) Clutch Disengaged:
- S_o rotate w.r.t. speed coming from the wheels of the vehicle running at x speed due to inertia.
- S_o turns G_n selected from G_B.
- G_n turns G_n' with respective gear ratio.
- G_n' turns S_c, G_A and G_i' at the same speed.
- G_A except for G_n' turns G_B at speed w.r.t. gear ratios.
- G_i' turns G_i with the respective gear ratio.
- G_i and C turn at same speed.

2) Now for shifting from n^{th} gear to m^{th} gear:

Here in case of m^{th} gear the vehicle will be running at y speed for the constant E speed and the processes taking place will be just like that for the n^{th} gear only with different gear speeds.

a) Clutch Disengaged:
- S_o rotate w.r.t. speed coming from the wheels of the vehicle running at x speed due to inertia.
- S_o turns G_n selected from G_B.
- G_n turns G_n' with respective gear ratio.
- G_n' turns S_c, G_A and G_i' at the same speed.
- Dock gear releases G_n and gets engaged with G_m.
- S_o rotate w.r.t. speed coming from the wheels of the vehicle running at y speed due to inertia.
- S_o turns G_m selected from G_B.
- G_m turns G_m' with respective gear ratio.
- G_m' turns S_c, G_A and G_i' at the same speed.
- G_i' turns G_i with respective gear ratio.
- G_i turns C at the same speed.

b) Clutch Engaged:

In a conventional manual transmission system if the clutch is not disengaged while shifting the gear the following incidents occur:
- Now while shifting if the throttle is bought to zero, the engine runs at a speed according to the inertia of the vehicle. When the gear is shifted in this condition, the difference in the gear ratios of the two gears forced to shift from a certain speed to a different speed very suddenly. The clutch here doesn't give slippage because of the axial force holding the plates together tight. Hence the primary load of shifting does directly on the engine, causing various damages to it.
- In the second situation if the throttle is held at a certain extent, at first the engine is giving power to the wheels in the loaded condition. As we know, when the shifting is initiated the dock gear first releases the n^{th} gear, moves into the neutral for a fraction of second and then gets engaged into the m^{th} gear. Here due to the throttle being held at a certain extent, when the dock gear goes into the neutral region the engine is relived from the load and hence the engine speed increases suddenly. But this is for a faction of a second and the dock gear gets engaged with the m^{th} gear. After the engine take a sudden peak in the speed and the m^{th} gear gets engaged, the engine supplies high power to the wheels giving a jerk to the vehicle. This sudden change in load also damages the engine parts.

c) The last situation to be taken into consideration is clutch working in traffic:

While driving in traffic there is a lot of random disengagement and engagement of clutch at constantly changing speeds. In this situation when there comes a gear shifting there generally is a lot of difference in torque and power requirement. Hence the driver opts for the optimum gear at that moment; this is in practice determined depending on the engine speed at the particular gear. While reengaging the clutch the clutch lever needs to be released quit smoothly to let the engine speed come up to the required speed. This is the best example to discuss about the feedback from the wheels of the moving vehicle to alter the engine speed. When the clutch is disengaged the general practice is to release the throttle so that the engine speed falls to ideal speed. And later when the clutch is reengaged there is the need to bring the engine speed back to a certain speed so that it matches the speed w.r.t. the speed of the vehicle at that particular gear. There are two methods to match the engine speed; first it to manually throttle the engine and then reengage the clutch, second is to smoothly let the clutch reengage so that the wheels of the vehicle force the engine to come to the required speed. The second method is quiet simple and less time consuming, and mostly used in traffic.

D. After identifying various actions taking place in a conventional manual transmission system, let us discuss the advantages of having such a type of transmission system:

1) The clutch in this transmission type helps in the free decision whether to provide power to the wheels or not.
2) Gear shifting becomes easy and free to the decision of the driver.
3) The clutch makes the transmission system cheap, light weight and easy to make.
4) There is no complication in understanding the working and construction of this system.
5) When the shifting takes place by disengaging clutch, there is no damage to any of the engine parts or the transmission system. The only wear taking place is at the clutch while engaging and disengaging, which is very less and does not cause a lot of maintenance expenses.
6) The gears in motion while shifting helps the engine come to a proper speed after the clutch is released, causing less loading due to complete engagement. The clutch proves to be very helpful in this situation too, by proving the ability of partial loading of the engine.

E. The disadvantages of the conventional manual transmission system are as follows:

1) The driver needs to take utmost care to make proper use of the clutch while the vehicle is in motion.
2) One must have the proper information of the usage of gear number for a particular speed.
3) Driving the vehicle at lower gear at high speed revs up the engine to higher RPMs, causing excessive fuel usage and heating of the engine. Whereas driving at lower speeds at higher gears puts the engine at loads which may cause engine damage.
4) A proper clutch working is required when driving on slopes or in traffic.

F. Improvisations those have already been made in the conventional manual transmission system are as follows:

1) We see some improved versions of the conventional manual transmission system in usage, some of those are:
– Dual Clutch Transmission (DCT),
– Automatic Manual Transmission (AMT),

These variations are a result of some basic modifications in the gear arrangements of the conventional type manual transmission system.

2) A few minor modifications in the conventional transmission system itself those are seen in use are:
– Synchromesh manual transmission system,
– Dog Clutch Gearbox,
– Sliding Mesh Gearbox,
– Sequential Gearbox.

These modifications are done by specialized improvements in the convention manual transmission gearbox itself. But those prove to be of a very good comfort to bring about ease in the usage of manual transmission system.

The most important modification and improvement that have been done on the manual transmission system are of the automation of the use of clutch, as seen in the DCT and AMT. [6]

III. Conclusion

Having discussed about the actions taking place inside the convention manual transmission system and identifying its advantages, disadvantages and improvisation those have already been made to it, we come to a simple conclusion; when the gears are being shifted, the docking gear doesn't simply disengage and engage two different gears but the wheels of the vehicle for an instant use the inertial speed of the vehicle to keep the gears inside the transmission gearbox in a certain motion so that the reengagement with the engine using the clutch is smooth. There are various different situations such as when the vehicle is static or in a motion, or the clutch is engaged or disengaged, or whether the vehicle is in a certain gear at a particular speed or in the neutral gear. We have discussed all the motions occurring inside the transmission gearbox with respect to all the situations mentioned above. Considering all the topics and outcomes of all the situations we finally come to a simple conclusion; while clutch working, the motion of the wheels provides a lot of help to rev match the engine.

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