Manual transmissions and automatic transmission engineering essay

This report will analyse and compare the features between manual transmissions and automatic transmission. It will also include the comparison based on advantages and disadvantages in each system. Furthermore, it will analyse the limitations and drawbacks on both systems.

Introduction

One of the main functions of the transmission is to effectively and safely transmit the power from the engine to the wheels, subsequently to the ground. The most powerful engine in the world will be useless without a transmission. Transmission also functions as a control over power output. By means, transmissions is needed to be able to regulate both power output and the speed range of the engine relative to vehicle speed required at any given time (Garrett, Newton & Steeds, 2001).

All transmission has the same basic purposes; regardless they are manual or automatic.

They are used to transmit power from the engine to the drive wheel when required.

Its functioned to disconnect the drive wheels from the running engine during gear changes or when the vehicle in stationary.

In the event of reversing the vehicle, transmission is used to reverse the direction of power flow.

Its also functioned as a torque multiplier as needed.

(Johansen and Duffy, 2005)

Gears in Transmission

There are many types of gears and most of them can be found in cars transmission. Several common types of gears are listed below; See Figure 1.

1

Straight tooth spur gears.

Because of high impact stress and noise while meshing, most of the transmissions have replaced it with helical gears. However, this type of gears are able to transmit high torque and cheaper to manufacture. Typical applications of spur gears include manual and automatic transmissions.

Helical spur gears.

This type of gears reduced noise and impact load, but it generates trust load that requires strong bearing to absorb it at the end of the shaft. They are common in all types of parallel shaft application (Childs, 2003).

Straight-tooth bevel gears.

This type of gears used to transmit power between intersect shaft, which are not parallel to one another. They are noisy as straight tooth spur gears. They are suitable for differentials.

Spiral bevel gears.

This type of gears is used in final drive to connect the intersecting shafts.

(a)

(c)

(d)

(e)

(b)

(d)Figure 1. 1 - (a) straight tooth spur gear, (b) Helical spur gear, (c) Straight tooth bevel gear, (d) Spiral bevel gear, (e) Hypoid gear ; (Purdue University, 2011)

(a)Automatic Transmission

Some of the automatic transmissions components were developed earlier before the development of the automobile itself. For example, the planetary gear principles were used to drive machinery in 19th century mills. The first automatic transmission that similar to modern transmission was design by Borg-Warner and Ford back in 1950. The first two speeds type was invented with used of torque converter and hydraulic control system that change gears automatically (Johansen and Duffy, 2005). Automatic transmission consists of many separate components and systems. See Figure 2. 1,

Figure 2. 1. Typical automatic transmission basics component (Pacificdriveline. com, 2011)

They are vast component in automatic transmissions and there huge explanation for each and every component, but it is beyond this scope of report to be covered. The major mechanical parts in automatic transmission include:

Fluid Coupling/Torque converter

Fluid coupling and torque converter are component that installed between transmission and engine. They are fluid filled units consist of two sets of blades. One side of the blade connected to the engine (impeller) and the other one connected to the transmission's input shaft (turbine). See Figure 2. 2.

Figure 2. 2 (Pacificdriveline. com, 2011)

The fluid from the hydraulic pump will be forced into converter. Inside converter the impeller blades spun the fluid and strike the turbine blades, cause the turbine blade to spin the input shaft. That is how the power is transmitted to transmission.

Planetary Gear sets

Figure 2. 3. Diagram of planetary gear set (Mistertransmission, 2011)

As shown in figure 2. 3, planetary gear set consists of ring gear, sun gear and two or more planer gears. They are mechanical system that provides forward gears and reverse gear as well.

Clutch Packs

Packs of clutch in the clutch drums fit alternately with steel disk and disk with friction material on the surfaces. Piston inside the drum, which is activated by oil pressure at the appropriate time, will squeeze to lock the clutch pack together so it will turn as one.

Hydraulic System

The Hydraulic System uses transmission fluid pumped by an oil pump through the Valve Body to control the bands and clutches to control the planetary gear sets.

Governor and Modulator/ Computer Controls

The Governor and the Modulator monitor speed and throttle position in order to determine when to shift. The computer controls uses sensors on the engine and transmission to detect parameters such as throttle position, vehicle speed, engine speed, engine load etc.. It is to control shift points and how soft or firm the shift should be

Automatic Transmission Operation

When engine is running and the transmission is in Park (P) or Neutral (N), the hydraulic pump is pumping the fluid into torque converter, impeller turns the turbine but no power reaches the planetary gears.

When transmission is shifted to Drive (D), fluids will flows through the manual valve to holding members. Once the holding members applied, planetary gears will connect input and output shafts. At this stage, power flow from engine through converter, impeller, turbine and input shaft, and to the planetary gears. Fluid exits the planetary gears and tries to turn output shaft. When the vehicle in stationary with brakes applies, turbine blade, input shaft and gears will stop while fluid from impeller continues to strike turbine. It creates friction and heat, which will be removed by the oil cooler.

The property of the fluid will allow enough slippage to keep impeller running to prevent engine stalling (Johansen and Duffy, 2005).

To get the vehicle moving, planetary gears increase torque and reduce the input shaft speed. When the vehicle speed increases, the hydraulic control system actuates valves to shift between holding members. This changes the planetary gears rotation and shift transmission into higher gear (Johansen and Duffy, 2005). Control system continues actuate various valve as vehicle speed increase until the higher gear ratio. The control system work same way with valves to lower the gear ratio as vehicle slowing down to stop. It will match engine load and vehicle speed.

At some point, the lockup clutch applies to increase the efficiency. In this situation the impeller and turbine turn at same speed (Johansen and Duffy, 2005). The lockup clutch releases when vehicle approaches complete stopped position.

Operational Limitations in Automatic transmission

With the great convenience offers by automatic transmissions, there are limitations in its operational behaviour. When operating the automatic transmissions, driver controls over transmissions are very minimal. Even with the Tiptronic transmissions, computer system will still override the manual selection under certain circumstance.

The automatic transmissions are not very responsive relatively to manual transmissions, which reduced the driving pleasure as well as overtaking capabilities. Furthermore, with the hydraulic torque converter operation in automatic transmissions, it needs the efficient cooling to cool down the

transmission system. In addition, automatic transmissions are not as robust as manual transmissions.

Apart from limitations mentioned, automatic transmissions also have less fuel efficiency compared to its manual counterparts.

Overall Performance

How automatic transmission with torque converter performance should be match the engine performance depends on the type of the vehicle. For example, in a family saloon manufacturer might emphasis on attaining top speed, whereas in sport car high torque at low speed.

In general, beyond the torque converter coupling point, the power transmission efficiency is at 80% to 90%, with the vehicle accelerating modestly at constant engine speed. While below the coupling point, as loads increase and speeds fall off, converter slip increases and efficiency declines (Garrett et al., 2001). This is the reason why lock-up clutch is installed in the torque converter. With the lock-up clutch engaged, overall fuel consumption is improved. Without lock-up clutch optimum fuel consumption is depends on engine and converter efficiency.

All automatic transmission systems are controlled with reference to vehicle speed and engine load. However, with electronic control additional factor may be introduced in order for automatic transmission to act in any kind of scenario.

Overall performance in automatic transmissions are non comparable to manual transmissions fitted into the same power plant. The attribute factors,

such as friction losses in multi plate clutches, losses in hydraulic control system, converter losses and friction losses in the gears has contribute to the performance of the transmissions as well to the fuel consumption.

Manual Transmission

Manual transmission is a transmission that allow driver to change ratio between one and another, as required. This type of transmission have different ratio that able to be shifted according to relative speeds between engine and road wheels (Smith and Julian, 2000). Manual transmission generally used a manual operated clutch system. There are two distinct type of manual transmission, 'transverse' or 'transaxle' used for front wheel drive gearbox, while rear and four wheels drive vehicles used inline gearbox (Smith and Julian, 2000).

Inline type gearboxes are normally found in wide range of vehicle from passenger cars up to large trucks, while most of transverse type of gearboxes is used in passenger cars and vans (Smith and Julian, 2000).

The engine maximum horsepower and torque are produce at certain RPM ranges. Manual transmissions only have a few combination of gears ratio that allow engine to operate at its best performance at certain vehicle speed.

Nowadays, manual transmission become less popular in passenger cars market compares to the pass where majority of passenger vehicle and trucks used manual transmissions. These changes are particularly related to the market situation that is becoming dominated by automatic transmission.

Figure 3. 1. (Renault. com, 2011)

Figure 3. 1 is an image of a 'typical' front wheel drive transmission. Its features are typically found in most of gearboxes. The essential components are the three shafts that take the drive from the engine to the output of the gearbox. From there, the drive shafts connect the gearbox to the drive axle. This configuration of gearbox can also be used in rear wheel drive, 'mid engine' vehicles, the installations being very similar. Two main features of this gearbox are the integral differential and the final drive gear pair.

Because of the final drive, the overall ratio of the front wheel drive gearbox has typical reduction ratios of around 12: 1 in 1st gear and around 3: 1 in top gear. In comparison, the typical rear wheel drive gearbox will have a reduction of 3 or 4: 1 in 1st and an overdrive ratio of around 0. 8 in top (Smith and Julian, 2000).

While in rear wheel drive car the final drive reduction gear pair will be found in differential unit. The 4th gear is normally a direct drive from input to output and will gives a ratio of 1: 1. In some gearboxes, the direct drive is in 5th gear in order to give more efficient drive in 5th gear (Smith and Julian, 2000).

Manual Gearbox Operation

Power from the engine transmitted, via the clutch to the input shaft. The various gear pairs then transmit torque to the intermediate shaft. The final drive pinion is part of this shaft will drives the final drive wheel. The final drive wheel is part of the differential assembly. Each of the drive shafts is connected by a spline to the side gears in the differential. This allows both

wheels, through drive shafts to rotate at difference speeds to each other although the average speed will always be the same as the final drive wheel.

Drive is only engaged between the input and intermediate shafts using one set of gears at any time. For example, when 1st gear is engaged, only that particular gear pair carries the drive between the two shafts. This is achieved using the synchromesh assemblies.

Operational Limitations in Manual Transmissions

With the robust characteristic in manual transmission, a relatively cheaper maintenance and high torque efficiency are some of the advantages that manual transmission can offers. However, there are limitations for the system especially if it is compared to all the latest technology developed in automatic transmission technology.

First, there is a complexity in the learning curves for the driver to adapt with the gears shifting timing and smoothness. Manual transmission also requires drivers to decide the best gear ratio to use at different speed to match the maximum power output from the engines. It is wholly depend on driver experience and skills.

The other obvious limitation in operating manual transmission is the slow shifting speed, as time required for driver to push the clutch pedal and move the gear lever from one to another gears. Even thought manual transmission is fun to drive along with a powerful engine, still it is tiring and requires more concentration especially in heavy traffic situations. In addition, manual transmissions are not possible to be cooperated with the auto cruise features.

Overall performance

Because of space availability in manual transmission, generally manual transmissions offer more selection of gear ratio compared to automatic transmissions. Nowadays, many manufacturers offer 5 or 6 speed manual transmissions. Currently, only cars with fully manual transmission would be able to exploit engine power at low to medium engine speed. It is noticeable during uphill climbing, where cars with manual transmission are able to maintain the speed while climbing. Whereas cars with automatic transmissions need to slowdown to avoid forced downshift controlled by computer system.

In manual transmissions, drivers are able to shift the gear down earlier before making a rapid acceleration in the event of overtaking. Overall, in manual transmissions, driver will totally have a direct control over transmissions according to the intentions, exactly and instantly. However, it is difficult for drivers to always maintain the correct gear ratio with the changing of the vehicle speeds in order to run the engine at its optimum performance. In addition, manual transmissions also have a good engine braking compared to automatic transmission

Comparison Between Manual and Automatic Clutch System

Two main functions of clutch system are to take up the drive smoothly, as well as disengage the drive when required (Hillier & Pittuck, 1983).

As been discussed in the earlier subtopics, in term of features and the nature of operation of both manual and automatic clutch systems has shown a

significant differences. Based on that we will discuss the advantages and disadvantages on both systems.

Advantages of manual clutch system

Manual clutch or friction clutch system is considered to have high mechanical efficiency. Hence, it is most effective and efficient relatively to hydraulic clutch in automatic systems (Hillier & Pittuck, 1983). Manual clutch also relatively simple and cheap to produce compare to torque converter in automatic clutch system. It is smaller in size and hence usually easier to package in the vehicle.

Manual clutch system does not requires active cooling, thus contribute to lighter vehicle weight. We might find manual clutch system handy in the event the engine can be started, where it could be started with push start.

Disadvantages of manual clutch system

There are few disadvantages in manual clutch system can be discussed. First, it depends on driver skills and experience to operate, especially when starting forward on a steep road or when parking on an incline. The other drawback in manual clutch system is the clutch operation and changing gears can be tiring, especially when in heavy traffic. Manual clutch systems are not suitable for all drivers. Furthermore, controls on larger vehicles can be heavy and most require some dexterity during operation.

Advantages of automatic clutch system

The bigger advantage in automatic clutch system is the clutches are applies with the control of computer system by measuring the engine load and road

speed, the computer regulates which clutch to apply and when to apply. Thus it is more efficient shifting applied relative to the engine load. Besides that, the gears shift ratio can be accomplished faster compare to manual clutch system.

Disadvantage of automatic clutch system

There are disadvantages in automatic clutch system. Fuel consumption for a car with automatic transmission that embodying a torque converter, is relatively higher than the equivalent manual clutch control transmission. This is the attributable to factors such as friction losses in multiple plate clutches, losses in hydraulic control system as well as losses to the heat in torque converter (Garrett et al., 2001).

Torque converter also creates lot of heat. The efficient cooling is required as the fluid temperature has to be kept below 135 ËšC, else it will damage the clutches and bands (Johansen and Duffy, 2005). Torque converter require hydraulic pump to run torque converter, disadvantage on parasitic power consumption to the engine.

Analysis of the Limitations and Drawbacks

This section discusses and analyse the limitation and drawbacks, which were highlighted in previous sections. We will analyse and discuss the limitations and drawbacks in commons for both automatic and manual transmissions.

Driving is always tiring, even worst in heavy traffic conditions. That is the main idea why peoples move from manual to automatic transmissions. At the same time demands for efficiency and fuel economy still desired. Even

thought the conventional automatic transmission has overcome some of these drawbacks, still there are areas where improvement could be made such as losses at torque converter as well as size and weight of the transmission itself.

As for electronically shifted manual transmission, some improvement criteria had been achieved besides the size and weight remains similar as conventional manual transmissions. This type of manual transmission shift automatically, without a clutch pedal. But, still there is a delay and harsh in shifting, unlike the manually operated manual transmission. This small factor is still creating imperfection to the type of transmission that everybody would want.

The ideal transmissions criteria that people are looking are; smaller in size and weight, high efficiency thus contribute to fuel economy, comfort and smooth shifting as well as cheap and easy maintenance.

As we are aware, the transmission technology is always advancing. Some developments are involving the new entire concept of transmissions.

The best ever solutions to compromise most the above limitations and drawbacks in both manual and automatic transmissions are semi-automatic transmissions, such as DSG (Direct Shift Gearbox) which was developed by BorgWarner Inc. and licensed to Volkswagen group.

DSG has overcome some major drawbacks in conventional transmissions, such as Fuel consumption, torque efficiency, fastest shifting and smoother shifting. With all those advantages that DSG could offer, still there are some

minor limitation and drawbacks in the system. The main limitation of the DSG is similar to other geared transmissions, where the transmission is unable to keep engine at optimum power and fuel economy due to fixed number of gears. However, because of its dual shaft characteristic DSG transmission is far heavier than other transmissions.

Transmission manufacturer should consider enhancing and improving more on DSG type of transmissions development, as it is at the moment have almost all the required criteria for the ideal transmission. Furthermore, they should develop the hollow type of transmissions shaft in order to reduce the weight as well as to increase the mechanical efficiency in the transmissions.

Conclusions

In this case study, there are many facts that I have learned and explored as summarized below;

Learned and understand the purpose of the transmission in motor vehicles, the major component in the transmission as well as the operation of both manual and automatic transmission.

Learned and explored the limitations in both systems.

Learned more about constant mesh and synchromesh gearbox mechanism.

Learned and understand the operating principle of epicyclic gearing in automatic transmissions.

Learned about the transmissions development and how the development has affected the limitations and drawbacks on conventional systems.

It is clear that both manual and automatic transmissions system has its own limitations and drawbacks. It is apparent that the advantages in one type of transmission appear to be disadvantages for the other. It seems very hard to achieve a perfect transmissions characteristic that consist of all the desired features and characteristics.

Years to come, we can see there are more development on the transmission technology going to come out.