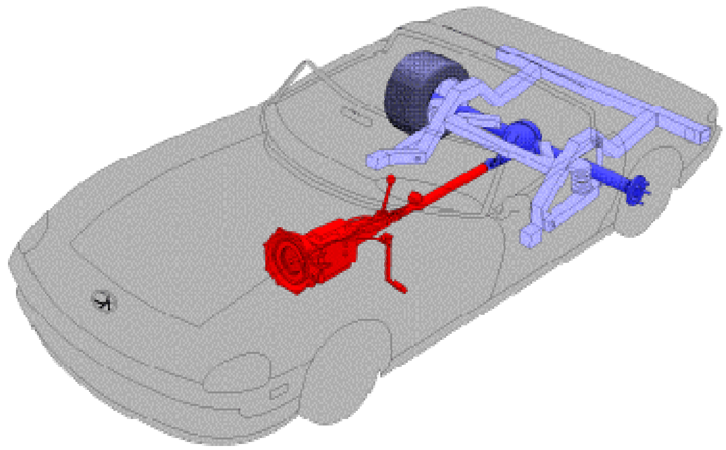
Automotive Driveline Overview



Below is an overview of auotmotive driveline operation

Drive Train (An Overview)

The drive train serves two functions: it transmits power from the engine to the drive wheels, and it varies the amount of torque. "Power" is the rate or speed at which work is performed. "Torque" is turning or twisting force. Multiple ratio gearboxes are necessary because the engine delivers its maximum power at certain speeds, or RPM (Rotations Per Minute). In order to use the same engine RPM's at different road speeds, it is necessary to change the "Gear Ratio" between the engine and the drive wheels. Just like a bicycle, the car has to switch gears in order to move at a wide range of speeds. Unlike your bicycle, the car's drivetrain also has to allow you to back up. (Well, you could push it backwards if you ate your Wheaties)

There are actually two sets of gears in the drive train; the transmission and the differential. The transmission allows the gear ratio to be adjusted, and the differential lets the drive wheels turn at different speeds.

Manual transmissions usually have four or five speeds, and often have "overdrive", which means that the output shaft can turn faster than the input shaft for fuel economy on the highway. Some use an electric clutch and a switch that controls whether the overdrive is engaged or not. An interesting development on a few cars is the "clutchless" manual transmission, which uses a stick shift and an automatic electric clutch. Speed and position sensors, mini computers, and throttle controls keep the engine from over-revving when the driver shifts gears. As with many automotive "inventions", this is an old idea which may now reach feasibility due to the computer revolution.

Automatic transmissions commonly use three forward gears to blend speed and torque. In the case of a three-speed transmission, first gear delivers maximum torque and minimum speed for starting. Second gear offers medium torque and speed for acceleration and hill climbing. Third gear allows maximum speed with minimum torque for highway travel. A reverse gear permits backward movement.

A transmission is a speed and power changing device installed at some point between the engine and driving wheels of a vehicle. It provides a means for changing the ratio between engine RPM (Revolutions Per Minute) and driving wheel RPM to best meet each particular driving situation.

Some types of drive train layouts use a "Transaxle", which is simply a combination of the transmission and the differential. These are usually found on front wheel drive cars, but are also used on mid- and rear-engine cars. Some exotic cars have their engine in the front, and a transaxle in the rear of the car for better weight balance.

Torque is derived from power. The amount of torque obtainable from a source of power is proportional to the distance from the center of rotation at which it is applied. It is logical, then, that if we have a shaft (in this case, the crankshaft) rotating at any given speed, we can put gears of different sizes on the shaft and obtain different results. If we put a large gear on the shaft, we will get more speed and less power at the rim than with a small gear. If we place another shaft parallel to our driving shaft and install gears on it in line with those on the driving shaft, we can obtain almost any desired combination of speed or power within the limits of the engine's ability. That is exactly what an automobile transmission does by means of gears and other devices.

There are two types of transmissions; manual and automatic. If you have a manual transmission, you have to shift the gears yourself, usually with a stick located on your console and the clutch pedal. If you have an automatic transmission, the mechanism changes without any help from you. This is accomplished through a system that works by oil pressure. Each shift of the gears is controlled by a shift valve; the gears shift change depending on speed, the road, and load conditions.

Another basic component of all drive trains is some form of a clutch. it allows the engine to continue rotating while the gears and wheels are stationary. Automatic transmission cars use a "torque converter" in lieu of a clutch.

From the back of the engine to where the rubber meets the road, the drivetrain encompasses one of the most complicated systems of your car. Some people say looking at a transmission "makes their brain hurt".

Manual Transmission

The manual transmission provides a means of varying the relationship between the speed of the engine and the speed of the wheels. Varying these gear ratios allows the right amount of engine power at many different speeds.

Manual transmissions require use of a clutch to apply and remove engine torque to the transmission input shaft. The clutch allows this to happen gradually that so that the car can be started from a complete stop.

Modern manual transmissions do not disengage any of the forward drive gears, they are simply connected to their shafts through the use of "synchronizers". Reverse is achieved through reverse idler gears, which are engaged to move the car backwards.

Some manual transmissions have an "overdrive." An overdrive is a mechanical unit bolted to the rear of the transmission. It is usually known as fifth gear. When you use it, it will reduce the engine speed by about one-third, while maintaining the same road speed.

Chrysler came out with the first overdrive transmission in 1934.

Transmission Gears

Most cars have from three to five forward gears, and one reverse gear. The transmission changes the ratio of the engine speed and the wheels by connecting gears in various combinations. If a gear with 10 teeth is driving a gear with 20 teeth, the drive would be said to have a 2:1 ratio.

First gear connects the engine power to the drive wheels via a pair of reduction gear sets, which gives increased power and reduced wheelspeed when the car is beginning to move. This means the engine is turning much faster than the output shaft, typically around a 4:1 ratio. Intermediate speeds are delivered by changing the gear ratio closer to 1:1. Final drive is usually accomplished by directly linking the input and output shafts, giving a 1:1 gear ratio. Using a moveable set of different sized gears, it's possible to get several degrees of torque output. The differential pinion, driven by the drive shaft, turns the ring gear, which acts like a single speed transmission. This further reduces RPM's and increases torque by a set ratio.

Gears work exactly like levers. A small gear driving a larger one gives an increase in torque, and a decrease in speed, and vise-versa.

Transmission gears are heat-treated, high quality steel. They have smooth, hard teeth, cut on precision machinery while red hot. There are many types of gear teeth, but most transmissions use spur and helical gears. Most of the gears are the helical type, because they last longer and are more quiet than spur gears. There has to be enough room (a few thousandths of an inch) between the gear teeth for lubrication, expansion, and any irregularities in size.

Transmission Oil

The transmission needs lubrication to keep all of the gears and shafts running smoothly. This is accomplished by partially filling the transmission housing with thick transmission gear oil. When the gear gears spin, they fling the fluid around and lubricate all of the parts. Oil seals at the front and rear stop the fluid from leaking out of the housing.

Fluid levels should be checked when you change your oil, or if you notice difficulties or differences in shifting. This can indicate that the level of fluid might be low.

Gear Shift Mechanism

What causes the transmission to shift? It's shifted by shifter forks, also known as sliding yokes. These resemble the oarlocks you find in a row boat. and they ride in a groove in the clutch sleeve and sliding gear. Shifter forks are connected to a cam and shaft assembly. The cam assembly is kept in the selected gear by spring loaded steel balls that jump through notches (in the cam assembly) and hold the shifter forks in that gear. The shafts (of the cam and shaft assembly) go through the housing and are fastened to shift levers.

The shifter forks move the synchronizers which engage the gears to the shafts they ride on.

The shift levers are connected to a control on the steering column or a shift stick located on the floor. Both of these are powered by -- you!

Speedometer Cable

The speedometer cable is connected to the gearbox output shaft, the transmission shaft, or differential. The rotation of these shafts is used to measure the speed and record mileage. This information is sent back through the cable where it is recorded on the speedometer.

The speedometer and odometer are driven by a cable housed in a flexible casing. This cable is connected to a gear in the transmission. Speedometer cables break as the result of age, lack of lubrication, or because the cable casing has sharp bends. It also breaks from too much friction in the speedometer head.

The Clutch

The clutch allows you to connect and disconnect the engine and the transmission, both starting up and during shifts. Friction plates route the rotation of the engine crankshaft to the gears, and then to the wheels. It takes the rotation up slowly, so that you aren't off to a screeching start. In a manual transmission, you disengage the clutch when you press the pedal down. The pedal works the thrust pad, and it presses levers in the middle of the clutch cover. Doing all this lifts the pressure plate away from the clutch plate. The flywheel (which is turned by the crankshaft from the transmission shaft) gets disconnected.

When you lift the clutch pedal, springs force the pressure plate and clutch plate against the flywheel. The clutch plate friction linings allow it to slide before becoming engaged. The sliding causes a smooth start instead of a jolt.

The Clutch Plate

The clutch plate is a thin, steel, disc. Its center is connected to the transmission input shaft by a grooved piece of metal, or hub. The disc is covered with material that is similar to the break linings. This material allows the clutch to slip smoothly and quietly.

The Flywheel

The flywheel is a fairly large wheel that is connected to the crankshaft. It provides the momentum to keep the crankshaft turning between piston firings.

The flywheel is the base for the entire clutch attachment. The side of the flywheel that the clutch is attached to is smooth, so that it provides a surface for friction. The clutch assembly is mounted to the flywheel, sandwiching the clutch plate in between. A bearing, called the "pilot bearing" is installed in a hole in the center of the flywheel. This lubricated bearing, either a ball bearing or a bronze bushing, is used to support one end of the clutch shaft, which is also the transmission input shaft. Around the flywheel is the ring gear, which the starter motor turns when the key is turned.

The Clutch Pedal, Cables and Levers

One way to activate the throw-out fork of the clutch is by using a system of levers and cables. These levers and cables are connected between the clutch pedal and the throw-out fork. When you press the clutch pedal with your foot, the pressure is transmitted to the fork through the cable and lever arrangement.

Hydraulic Clutch

Another method used to activate the clutch throw-out fork is the hydraulic clutch. This method is often used when the mechanical design of the car makes it difficult to use levers and cables. It is also used to multiply force, reducing driver fatigue.

With a hydraulic clutch, when you press the clutch pedal, it moves a small cylinder called the "master" cylinder. Pressure is created in the master cylinder which is, in turn, transmitted to the "slave" cylinder. The slave cylinder is attached to the throw-out fork by a small adjustable rod, so when pressure is exerted on the slave cylinder, it operates the fork. Both master and slave cylinders are designed in such an uncomplicated way that they are easy to attach with hydraulic tubing.

Front Wheel Drive

Many cars use a front drive axle. Most front-wheel drive axles are constructed the same way as rear-wheel drive axles, with one exception. A front-wheel axle assembly must provide a way to turn the wheels as well as drive them.

The clutch or torque converter sends the power on to the transmission input shaft. Next, the power is sent on to the differential by gears or chains (belts). It goes through the differential gears through the axle and CV Joints and finally to the front wheels.

Front wheel drive was not new in the eighties when it became popular. Front wheel drive was introduced by the Pennington Car Company in 1900. Before that, steamers and electric cars had used it for years.

2WD, 4WD and AWD

2-Wheel Drive

The engine, clutch and gearbox are usually mounted on the frame at the front of the vehicle. The rotating motion produced by the crankshaft at the front of the vehicle is transmitted either to the two wheels at the rear (rear wheel drive), or the two wheels at the front (front wheel drive). Some cars are manufactured with rear mounted engines that drive the rear wheels, and front mounted engines that drive the front wheels.

4 Wheel Drive

4-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle.

All Wheel Drive (AWD)

All-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle. An all-wheel drive vehicle has both axles live at all times without manually activating or deactivating axles.

Automatic Transmissions

An automatic transmission is much easier to drive than a manual transmission, because you don't have to use a clutch pedal or gearshift lever. An automatic transmission does the work all by itself. The first automatic transmission appeared in 1939.

Automatic transmissions automatically change to higher and lower gears with changes in the car's speed and the load on the engine. These transmissions are also aware of how far down you have pushed the gas pedal, and shift accordingly.

The system is operated by transmission fluid pressure; shift valves control the gear changes. A "governor" controls the shifting of the gears. It's linked to the output shaft and throttle valve and controls the transmission fluid supply, at different pressures, to the shift valve. Here's how it works: the output shaft turns the governor. The faster the car goes, the faster the governor turns. Oil is sent from the pump to the shift valves by centrifugal force from the governor. The shift valves move out, and send the transmission fluid to the gear shifting mechanisms in the transmission. When you slow down, the valves move in, and send the transmission fluid in the opposite direction. This action changes the gears.

By routing the pressure to the clutches and brake bands, the different gears are selected.

Torque Converter

The torque converter is a type of fluid coupling between the engine and the gearbox to even out speed changes. The torque converter also multiplies engine torque.

The torque converter is used as a clutch to send the power (torque) from the engine to the transmission input shaft. It has three parts; an impeller connected to the engine's crankshaft, a turbine to turn the turbine shaft which is connected to the gears, and a stator between the two. The torque converter is filled with transmission fluid that is moved by the impeller blades. The stator's vanes catch the oil thrown off from the impeller, and use it to move the turbine's blades. When the impeller spins above a certain speed, the turbine spins, driven by the impeller.

In some designs, the torque converter locks the impeller and the turbine together when at highway speeds, which increases efficiency.

Brake Bands

A brake band is made of steel, and has a friction lining. One end of the band is attached a servo actuating rod.

A servo actuating rod is a hydraulic piston (a cylinder with a piston inside it) that is open at one end to allow oil to flow in. The piston is normally in the released position because it's kept that way by a spring. However, when pressurized oil is sent to the cylinder, the oil forces the piston forward. This causes the brake band to tighten, and this locks the brake.

Transmission Fluid

Transmission fluid is a special kind of oil used only for transmissions. It circulates through and lubricates the gears. Check your car's owner's manual for the type to use. No other type of oil should ever be used in your transmission.

Automatic Gear shifting

Almost all automatic transmissions use a pair of gear groups called epicyclic, or planetary gears. Each group consists of; an outside "ring" gear, a shared "sun" gear in the center, and a set of "planet gears", which mesh in between the sun and the ring gear. Planet gears are so named because each one turns on its own axis as they orbit the sun gear, like planets do. Each group of planet gears is held in a "planet gear carrier". By clamping the ring gears, the sun gear, and the carriers together in various combinations, and by locking some of them in stationary positions, it is possible to achieve three forward gear ratios, and reverse as well.

To increase torque: When the ring gear is stopped, and the power is applied to the sun gear, the planet gears are forced to go around the sun gear. This makes the pinion gears revolve more slowly around the inside gears, and drive from the carrier will have lower speed and increased torque.

To reverse the torque's direction: If the planet gear carrier is stopped, and torque is applied to the sun gear, the planet gears are forced to turn by the sun gear. This makes the ring gear revolve, but more slowly than the ring gear, which increases the torque, and in the opposite direction as the sun gear, giving reverse.

If two members of the gear set are locked together, planetary action is stopped and the gear set turns as one unit. When this happens, there are no increases or decreases in torque transmission.

In order to have more than 2 forward speeds, two sets of epicyclic gears are needed. By changing the number of teeth (size) of one set of planetary gears, 4 forward speeds can be produced.

The clutches within the transmission are used to connect the input torque, and the brake bands are used to lock the sun gear or the rear planet carrier. One way bearings serve to allow power flow in certain directions only, working as clutches. All of the clutches and brake bands are powered by hydraulic pressure, and regulated by the logic circuit which is connected to the governor and/or directly to a computer-controlled valve assembly. The transmission senses gas pedal position and drive selector position, and engages the proper clutches and bands for you to "Get out of Dodge".

The details of automatic transmission functions are vast, and different designs are introduced by the many automakers with great regularity. Some common principles shared by virtually all automatics are: fluid clutches, brake bands, one way bearings (one way clutches), and epicyclic gears. This crazy diagram is a simplified version of but one design among many, and if you think it's hard to understand, don't feel bad. It is!

In this type of transmission, to give first gear, the forward drive clutch (C) locks the turbine shaft to the front ring gear. At the same time, the second planet carrier brake band (D) locks the rear planet carrier in place. The power from the turbine shaft flows through the front ring gear, which turns the front carrier, which turns the sun gear. This reduces the RPM's and increases torque one time. The second reduction/multiplication happens when the sun gear turns the rear planet gears, each of which rotate within their stationary carrier. This causes the second ring gear to turn. The second ring gear transfers its torque to the output shaft through the second one-way clutch. (Does your brain hurt yet?)

Second gear is accomplished by engaging the sun gear brake band (B) and the forward-drive clutch (C). This gives one reduction in RPM.

Third gear (Drive) is engaged by locking the reverse-high clutch (A) and the forward-drive clutch (C). This gives a 1:1 (direct) ratio between the input and output shafts.

When reverse is selected, the reverse-high clutch (A) and the second carrier brake band (D) are locked. This reverses the torque direction, and reduces the ratio (twice) for use in backing up the car.