Automatic Transmissions: What Makes Them Work

By Scott Memmer

In this month's Tech Center column we're going to take a look at the inner workings of the standard automatic transmission. Then we'll discuss some ways to keep your tranny healthy and give it long life.

What is an automatic transmission? What does it do, and why do we need it?

First, a little history.

The earliest automobiles offered only manual transmissions. Similar in principle to today's stick-shift vehicles, these cars, such as the Ford Model T, sported two forward gears and one reverse, coupled to the engine via a series of pedals. But as cars grew larger and traffic got worse, engineers began searching for a way to have the car "automatically" shift from one gear to another.

Designers spent decades perfecting the modern automatic transmission.
This was followed in close succession by Chrysler which in 1941 introduced "Fluid Drive" -- a semi-automatic transmission that still had a clutch pedal. Although Fluid Drive allowed you to start out without using the clutch and the electric overdrive kicked in automatically, you still had to employ the clutch to change between "low" and "high" gears.

The technology came along at a propitious time in American history. The United States, rife with victory from World War II and building up steam for the post-war boom, produced scads of babies and cars (not necessarily in that order). Into those cars they dropped thousands of automatic transmissions.

It could be fairly argued that the automatic transmission, with its simplicity and ease of use, offered up the automobile to the masses, fulfilling the promise of President Herbert Hoover, whom a generation earlier had promised "a car in every garage and a chicken in every pot." At the very least it widened the vistas of an increasingly mobile workforce, fed the flow of migration to the suburbs, and welcomed women back into the economy following the war effort.

The automatic transmission did this by offering a "no-muss, no-fuss" form of shifting. No more missed shift gates. No engine lugging or racing. No torn-stocking, high-heel clutch-pedaling dramas. None of that. Just press the gas and go.

Okay, enough with history. Let's take a look inside an automatic transmission.

The Torque Converter

The key to the modern automatic transmission is the torque converter. It takes the place of a clutch in a manual transmission.

A direct descendant of an earlier component called a fluid coupling, the torque converter offers the advantage of multiplying the turning power provided by the engine. It is connected to the motor by means of a metal rod known as the transmission shaft (sometimes called the input shaft), which fits next to but does not touch the engine crankshaft. *Repeat: there is no direct connection between the engine and the transmission.*

Instead, the engine turns the transmission by means of a process called hydraulic coupling.

Think of two electric fans in a room. Line them up a few feet apart, one in front of the other, both facing the same direction. Now turn on the rear fan. What happens? If you've turned the fan up high enough, and if the fans are close enough together, the front fan will begin to turn as well. In this same manner does the engine crankshaft influence the transmission shaft, causing it to rotate.

The identical process occurs in a torque converter, except that transmission fluid takes the place of air.

But there's more. Inside the torque converter are several components that help multiply the power.

These are the impeller (or pump), the turbine, and the stator (or guide wheel).

A torque converter is like a giant doughnut. The impeller and the turbine (the two fans in the analogy above) face one another inside the round metal casing. The impeller is on the engine side, the turbine on the tranny side. Both of these components have blades that catch the transmission fluid and cause them to spin.

Picture two halves of a chambered nautilus, and this will perhaps give you a better image.

As one fan begins to spin, the other will spin as well. Through centrifugal force, the fluid moves to the outside of the blades, where it is redirected by a third fan, called a stator, back to the turbine side. This continual flow of fluid is what causes the power to be multiplied.

The Lockup Torque Converter
Because the only connection between two sides of a torque converter is a fluid connection, there is always a little slippage, running from about 2-8%. To increase efficiency and gas mileage, most modern automatic transmissions also have something called a lockup clutch (aka, torque converter clutch).

It works like this. As the speed of the car nears 40 miles per hour, the highly pressurized transmission fluid is channeled through the transmission shaft and activates a clutch piston. This metal pin locks the turbine to the impeller, in effect bypassing the torque converter. It remains this way until the vehicle slows below 40 mph, at which point the clutch piston disengages and the torque converter kicks in again. Simple, right?

Planetary Gearsets
No, we're not talking Mars and Venus here. These are different-sized gears, just like the ones on the back of your mountain bike. They're called planetary because they're circular and revolve around a central gear known as a sun gear. If it sounds like our solar system, you're right -- it's designed on the same model.

A planetary gearset system has three major elements:

- Sun gear
- Planet carrier, drum, and pistons
- Ring gear and drum

Although there are different variations on the planetary gearset theme (for instance, some trannies have two sets of planetary gears, two sun gears, etc.), the essential design has remained unchanged for more than half a century.

One example is the Simpson geartrain. In this design, two sets of planetary gearsets mesh with two sun gears. The two sun gears are in turn connected together to form what is called a common sun gear.

The Simpson geartrain is an older, three-speed design no longer in popular use, but it will give us an idea of the way an automatic transmission works.

In neutral, with the exception of the free-turning input shaft, there is no motion within the transmission.

In first gear, the front planetary gear is engaged, locking onto the input shaft. Think of this as the low gear on your bicycle. The gear ratio here is 2.46:1. This gets the car moving.

Once the car is rolling, the transmission shifts into second. The intermediate band is applied, holding stationary the high clutch drum, the reverse clutch, and the sun gear. The forward clutch is applied, locking the input shaft to the ring gear. The gear ratio here is 1.46:1.

In high gear, the ratio goes to 1:1. All planetary gear members are locked to each other and to the output shaft.

In reverse mode, the reverse and high clutch is applied. The input shaft is locked to the reverse and high clutch drum, the input shell, and the sun gear. Gear ratio for reverse is 2.17:1.

These are the basic workings or a Simpson transmission.

Clutches, Bands, and Servo Pistons
Gear shifting in an automatic transmission is very similar to the action taken while riding your mountain bike -- except that a series of valves, sensors, and other components take the place of your brain, deciding when to upshift and downshift to a larger or smaller gear.

Some cars use a multiple-disc clutch operation. In this setup, a series of friction discs are placed between steel plates. The clutch also has a piston and return springs. This whole assembly is known as a clutch pack. When fluid pressure is applied to the clutch pack, the piston engages, locking the assembly together and driving the wheels. When pressure releases (for instance, the engine goes to idle), the piston disengages and the wheels stop turning.

Other cars use transmission bands. In this design, a flexible metal ring fits around the outside of the clutch housing. It tightens to engage the gears, and loosens to release them. This type of transmission also uses a servo piston to activate and deactivate the bands.

The transmission is connected to the wheels via an output shaft, which meshes to the axles in a variety of ways, depending on your car's design. The transmission turns the output shaft, which in turn spins the axles, which in turn make the wheels go. There are a myriad of ways to do this. Since you can have a front- or rear-wheel drive car, and since engines can be located in the front, rear, or even middle of the vehicle, the engineering choices are infinite. Suffice it to say, the axles drive the wheels.

Many modern front-wheel-drive cars use an assembly called a transaxle, which saves weight (thereby increasing mileage) and space. The transaxle houses the transmission *and* the axles in a single unit that weds to the engine.

In Closing...

Well, there you have it: an automatic transmission primer. We realize that this is a very generalized overview. Still, we wanted you to have a basic understanding of how your automatic transmission works. For other Edmunds.com articles on the ins and outs of transmissions, both manual and automatic, please click on the links below:

When Fact Meets Friction: The Basics of Clutch Operation
What Wheel Drive?

At the outset, we promised a few tips on maintaining your automatic tranny. Since it's a closed system, there's not a lot of work to be done. Still, here are a few things to watch for.

- **Look for leaks.** Most of us have been conditioned to look under our cars from time to time for leaking fluids. Transmission fluid is usually reddish-brown. If you find this color liquid spotting your driveway, trace it to its source and make sure it's coming from the tranny. If you're not sure, take the

car to your mechanic as soon as possible. Transmission repairs are not always expensive. A leaky gasket or bearing is sometimes the culprit. Regardless, get it fixed. A leaking transmission is a $2000 repair waiting to happen.

- **Check your dipstick.** While we're on the subject of leaks, check your dipstick. A lot of people don't know that their engine compartment has a dipstick to check transmission fluid level as well as engine oil. It will be located near the engine oil dipstick, but it's usually off to the side and located deeper in the engine. You'll note that it's typically longer than the oil dipstick, the better to reach the tranny below. (Note: the engine must be running to get an accurate transmission fluid level reading.) If you find the fluid level low, search for leaks and follow the procedure above. Return the fluid level to normal as soon as possible.

- **Come to a complete stop before shifting.** Be kind to your tranny, and it will give you many years of service. When shifting from forward to reverse and back, make sure the car has come to a complete stop. Also, don't race the engine in neutral and then drop the sucker into drive. Common sense, but you'd be amazed at the way some people treat their cars.

- **Change your transmission fluid regularly.** Look in your owner's manual for recommended service intervals. Most cars recommend changing it every 12-18,000 miles. It's a messy job requiring special tools, so you'll probably want to go a quik-lube place to have it done. Cost: $50-60.

On this last point, it should be noted that many newer cars (such as GM products) come with a 100,000-mile tranny fluid replacement policy. Some even have "zero service required" polices in place now (it's a sealed system, requiring no service). Again, check your owner's manual for the correct service interval for your specific vehicle.

Finally, automakers have been experimenting for decades with something called Continuously Variable Transmissions (CVT). This is another form of automatic transmission whose day may soon come.