Subject:

Design and operation of dual-clutch transmissions

Essential Reading:

- ☑ Rebuilder
- ☐ Shop Owner
- ☐ Center Manager
- ☑ Diagnostician
- ☐ R & R

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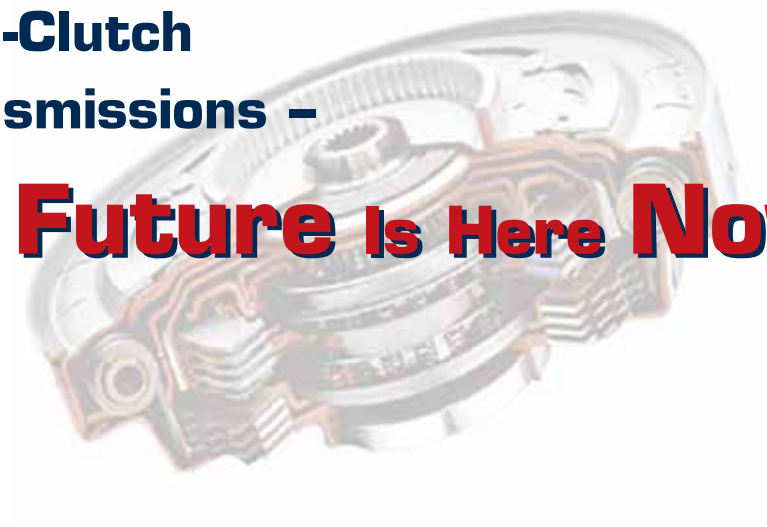
Dual-Clutch Transmissions – the Future Is Here Now



Technology marches on, and we are continually fighting to keep up with the advances found in new-model cars. The rising cost of fuel and the state of our economy have the general public worried. This, of course, is promoted by the never-ending doom-and-gloom hysteria by the mainstream press in their push to sell advertising. "Just the facts, sir" is a thing of the past, with every kind of media pushing the end of the world on TV and in the press.

The great body of corruption we call Congress has continued to act as irresponsibly as ever and never learns about the "law of unintended consequences." This law states that when you act without scientific research and facts, the outcome will be negative for us poor taxpayers. I have been hearing about a national "energy policy" since the last gas crisis in the 1970s, and we still do not have one. Congress enacted laws promoting "ethanol and flex fuels," which is basically a big cash cow for the farmers and a disaster for the driving public.

Ethanol at best produces about 14 miles per gallon as opposed to 25 for gasoline, and the production of corn-based ethanol uses as much fuel per gallon as what it would take to manufacture gasoline, so no savings there. Of course, the increased price of corn has raised every consumer's food bills substantially with no gains on the energy side.

Hybrid vehicles are an attempt to obtain better fuel economy, but the battery technology is still not where it needs to be. The increased cost of buying a hybrid vehicle means that, on average, it will take the car owner seven to 12 years to realize the cost savings in fuel. By that time batteries and other components will wear out, and we have yet to see the expense of repairs to these vehicles factored in.

Hydrogen fuel-cell technology is clean and fairly efficient, but building the infrastructure to supply hydrogen as a fuel on the same availability level as gasoline will cost huge dollars.

With regard to what is available now, we need to look at current new technology with reasonable cost factors. Dual-clutch transmissions may provide that answer in the short term.

The automatic transmission equipped with a torque converter has been the mainstay of conventional drivelines since World War II. A great deal of research, improved designs and advanced transmission technology have brought us excellent five-, six- and seven-speed automatics that perform extremely well. Manual transmissions are still more efficient from the fuel-economy standpoint but depend on the driver's skill and ability to drive in a fuel-efficient manner.

"The DCT (dual-clutch transmission) works just like a manual transmission, with speed gears and a counter gear providing five or six forward speeds. Bolted to the crankshaft is a dual wet clutch, very similar to an automatic-transmission clutch pack."

The EPA does not like manual transmissions because they shift at closed throttle. Automatics shift at open throttle and make control of emission levels much easier.

The torque-converter-driven planetary transmissions have limitations also, based on the inherent slippage of the torque converter until lockup is achieved and the extra weight of a large rotating mass attached to the engine crankshaft.

Dual-clutch transmissions (DCTs) may be the answer. A compact design that is lighter in weight, has no torque converter and does not need a clutch pedal is now in use in a number of makes, and that number can only grow as the design advances.

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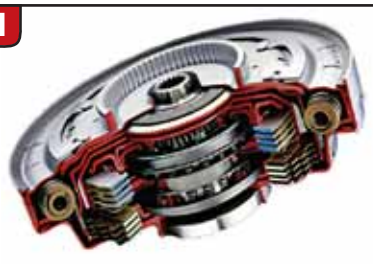

Courtesy of BorgWarner Corp.

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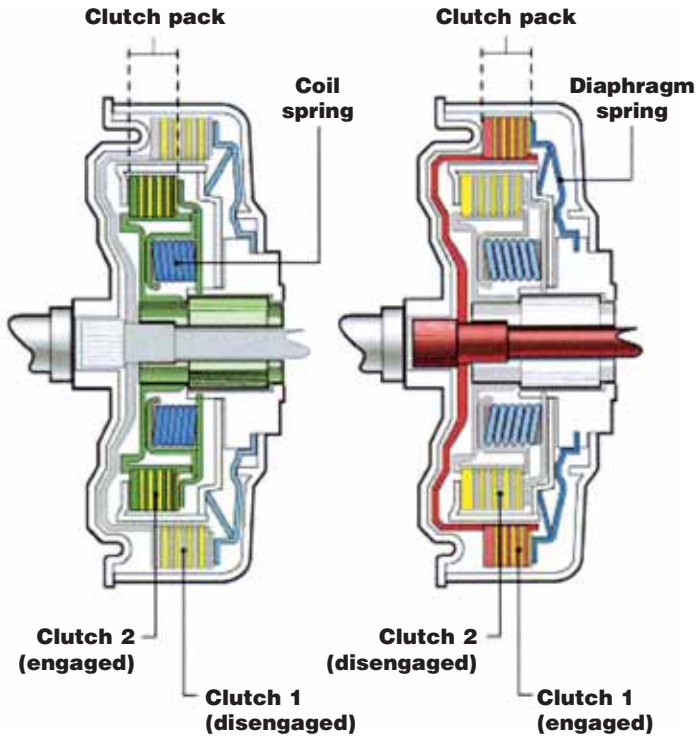

The DCT works just like a manual transmission, with speed gears and a counter gear providing five or six forward speeds. Bolted to the crankshaft is a dual wet clutch, very similar to an automatic-transmission clutch pack. The input shaft of the manual transmissions we know must have the ability to interrupt engine torque to allow the transmission to be shifted, and this occurs when the clutch is depressed (disengaged). At this point the drive wheels are turning the output shaft, there is no power flow from the engine to the input shaft, and another gear is selected. This continues every time a shift is made.

The DCT operates with two input shafts that are driven by the dual "automatic" clutch (see Figure 1). One input shaft sits inside another, with one shaft driving first, third and fifth gears and the second shaft driving the even-numbered gears – second, fourth and sixth. The hydraulic clutch has two sets of clutch plates, one of which is splined to the inner input shaft and one splined to the outer input shaft. Figure 2 shows operation of the dual-clutch pack, and Figure 3 on page 28 illustrates power flow through the inner shaft.

A control system that is nothing more than a valve body and a transmission-management computer operates the clutch applica-

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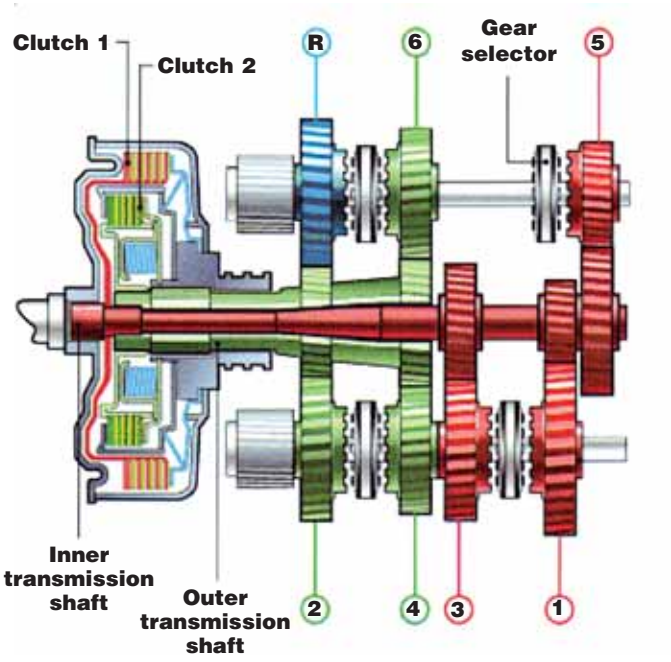

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Courtesy of BorgWarner Corp.

tions. This modular component (see Figure 4) contains a hydraulic valve body with proportional, on/off and PWM solenoids; a transmission-control microprocessor; speed, position, temperature and pressure sensors; and a circuit assembly with integrated connectors.

In operation, the driver selects a gear with no clutch pedal necessary and proceeds to drive as normal. The unit will shift automatically to the next gear as road speed and engine speed meet the computer program seamlessly, with the computer selecting which of the two clutches is used to select the next gear, and downshifts are made the same way.

The driver has the option of selecting each gear manually without using a clutch pedal. Shifts occur in milliseconds, with the dual clutches providing the necessary power transfer to the input shaft driving the gear selected. The dual-clutch unit also houses a sophisticated damper assembly to prevent shift shock and engine harmonics from entering the drivetrain.

This is not new technology. The dual-clutch gearbox was first conceived in 1939 by French military engineer Adolphe Kégresse, who developed the halftrack vehicle. The dual-clutch design lingered for many years until advances in computer technology made it easier to use.

Audi and Porsche were the first manufacturers to capitalize on the DCT technology, which first appeared in their race cars. The Porsche 956 and 962C race cars were equipped with the Porsche Dual Klutch, which is DCT technology, and the Audi S1 Rallye car that won the Pikes Peak hill climb in 1985 was similarly equipped.

BorgWarner Corp. has invested very heavily in the development and manufacture of its DCT, which it calls the DualTronic. Fuel prices in Europe have been the driving force for developing new technology for many years, and European-produced vehicles that are now using the BW DualTronic DCT include the Volkswagen Beetle, Golf, Jetta and Routan; Audi TT and A3; Seat Altea, Toledo and Leon; and Skoda Octavia. Most of these brands are not imported to the United States, but every manufacturer ultimately will take advantage of the weight savings, compact design and 10% increase in fuel economy. Ford is working with Getrag to develop its version of the DCT, which is called the PowerShift System and is expected to be in production within the next two years.

There is much to be gained by taking an immediate common-sense approach to a growing problem, using and perfecting already-available technology. These units, although new to us, will provide the basis for our vehicles to service in the future. It is obvious that fuel costs will heavily influence the next group of models that the manufacturers will produce. The DCT, direct-injection diesel engines and driveline technology without differentials will be implemented way before the more-complex hydrogen fuel cells and other more-exotic solutions will hit the roads in significant numbers. TD