

# transmission

## TECHNOLOGY INTERNATIONAL

AN ENGINE TECHNOLOGY INTERNATIONAL PUBLICATION

SEPTEMBER 2015

# Final shift

As automatic transmissions go from strength to strength, is the end really nigh for the trusty manual?

**engine**  
technology international

### GEAR CHANGE

The time has come for high-tech EVs to move beyond rudimentary 1- and 2-speed architecture

### VIRTUAL REALITY

Will advances in computing power mean that one day soon there will be no need for real-world transmissions testing?

### EXCLUSIVE INTERVIEW

In one of his first media outings since leaving GM, FCA's new transmission VP, Jeff Lux, discusses future plans at Fiat-Chrysler

[www.enginetechnologyinternational.com](http://www.enginetechnologyinternational.com)



# DCT solenoid development

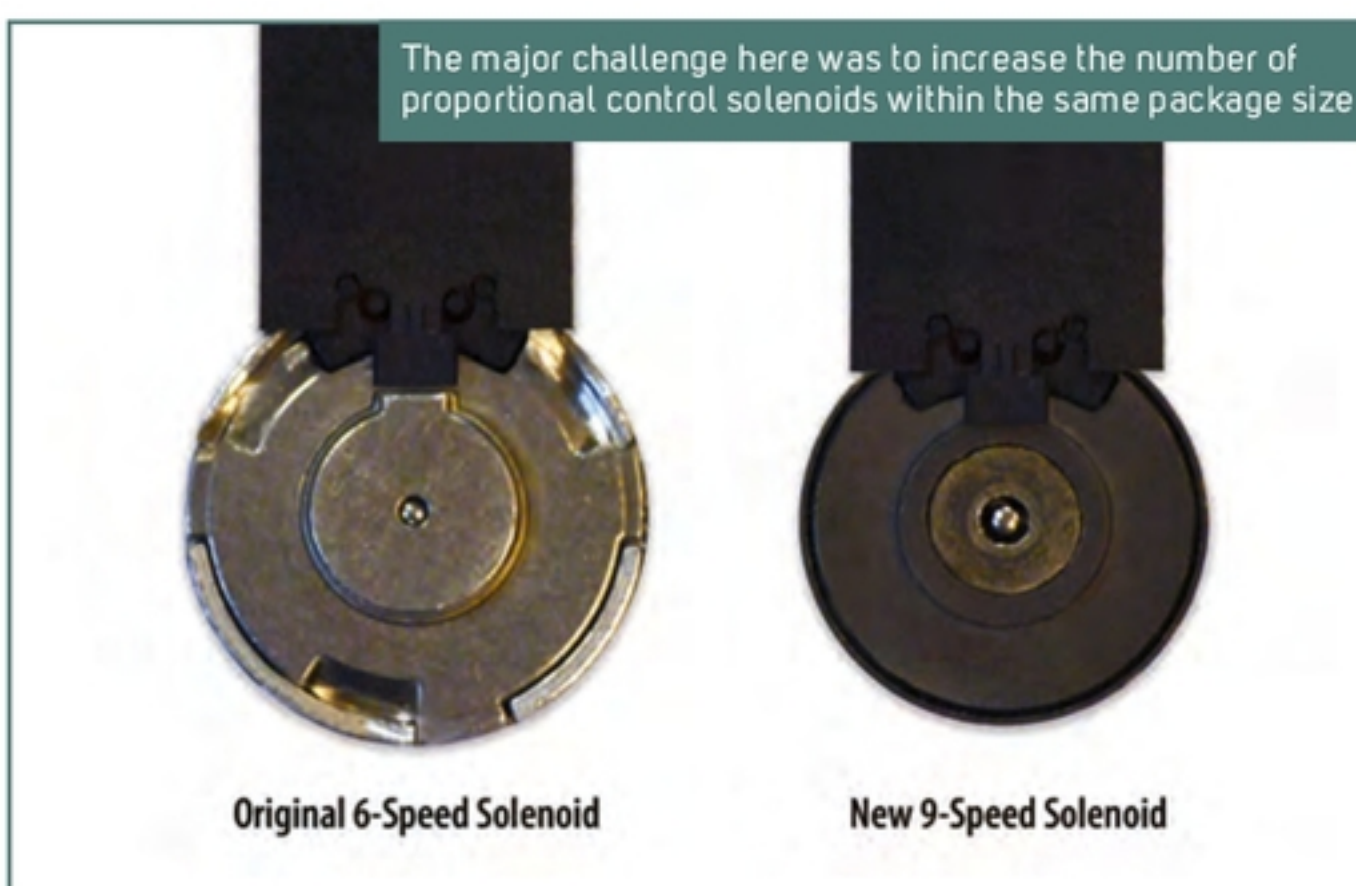
As more gears are added, the control solenoid package must shrink to fit the space formerly occupied by fewer solenoids, while operational requirements stay the same

► As CAFE sets ever-stricter standards to cut emissions and improve fuel economy for passenger vehicles, major OEMs are increasingly looking to bring in multispeed DCTs, which are essentially two separate manual transmissions working as one unit, where the shifting is done by electrohydraulic components inside the application.

Based in Pewaukee, Wisconsin, TLX Technologies has developed a proportional control solenoid for the electrohydraulic component in DCTs. These are used to operate spool valves in the hydraulics of DCTs during shifting. Proportional control of the spool valves is required for gear synchronization during a shift to reduce shift shock. TLX Technologies encountered a number of challenges during the development of these solenoids, which ultimately led to a more innovative and efficient design.

## Solenoid design

One major challenge encountered with the design of the proportional control solenoids for DCTs was the overall package size. As OEMs develop DCTs with more gears, the package must shrink to fit the space previously occupied by fewer control solenoids, while operational requirements remain the same. For example, increasing the number of gears in a DCT from six to nine reduces the maximum allowable outside diameter of the control solenoid by 30%, which means all of the force-producing elements within the solenoid are also reduced. Using magnetic FEA, TLX Technologies has been able to model and achieve sufficient magnetic force to shift the hydraulics and maintain proportional control in a small package size by using a combination of radial and conical magnetic designs. The radial part of the magnetic design is used to reach

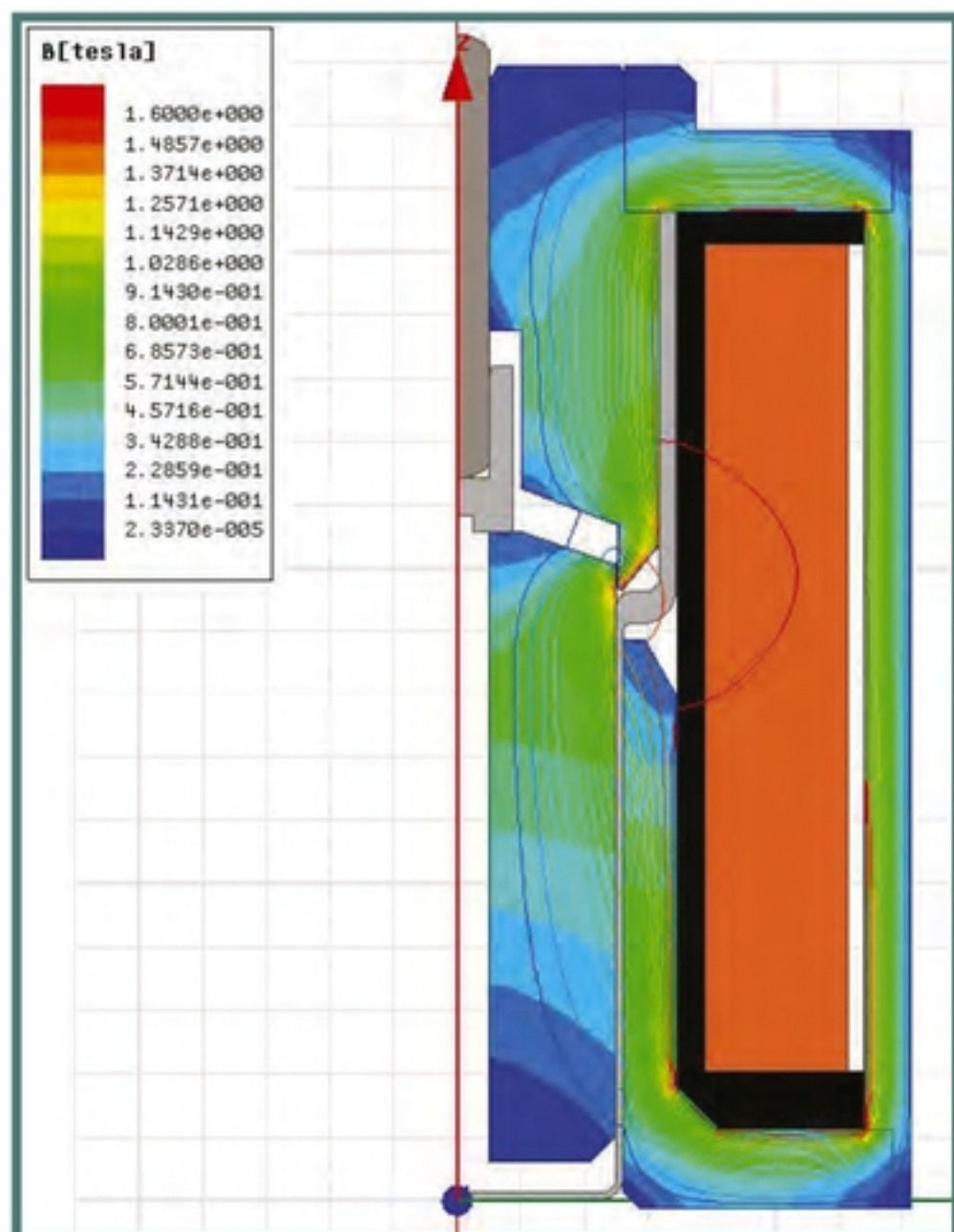


the high initial force requirement, and the conical part of the magnetic design is used to keep the force consistent as the solenoid moves throughout the working stroke of the hydraulics. TLX was able to achieve cycle-to-cycle repeatability of less than  $\pm 0.25\%$  and to improve the controllability of DCT hydraulics.

Another challenge encountered during the solenoid design was producing enough magnetic force in the smaller package size while addressing the force losses due to hysteresis. Hysteresis loss seen in magnetic design is due to both the friction between sliding components and the hysteresis properties of the magnetic material being used. To limit the effects of material hysteresis loss and maximize the saturation flux density, TLX Technologies used annealed silicon core iron. Annealing silicon core iron produces a fine-grained microstructure material that possesses low residual magnetism and minimum magnetic hysteresis. In order to reduce friction between the sliding solenoid components, TLX Technologies employed a mix of low-friction DLC coatings and Polytetrafluoroethylene fabric. The DLC coatings provide a low coefficient of friction and a high

micro-hardness, making it a perfect solution for cutting down friction in tribological applications. Another benefit to using DLCs is increased wear resistance – critical when using annealed soft magnetic materials. Since these proportional control solenoids are mounted in the transmission where there is not always lubrication available, the Polytetrafluoroethylene fabric maintains lubrication between sliding surfaces. The fabric also acts as a break between sliding magnetic components, reducing side loading seen in radial magnetic designs. Through these developments, overall hysteresis was reduced to less than 2.5% of the maximum force output from the control solenoid.

As a leading developer, TLX Technologies answers unique system demands with superior electromagnetic solutions, working with customers to design and develop solenoids and solenoid valves that meet the challenging requirements of their system applications. ©



Magnetic finite element analysis of proportional control solenoid using radial and conical magnetic design strategies to achieve force requirement in scaled down package size

FREE READER INQUIRY SERVICE

To learn about TLX, visit:

[www.ukipme.com/info/tr](http://www.ukipme.com/info/tr)

INQUIRY NO. 519