GEARING UP

Gearboxes can be confusing so, given that they rarely cause problems, tend to get neglected. In the first of a two-part series, Brian Tinham talks to Scania's Keith Gallon about troubleshooting

From a technician's point of view, gearboxes are generally no big deal. Inspection and maintenance rarely extends beyond changing a filter and checking one or two transmission fluid levels – two if there's a PTO (power take off) – simply by releasing the filler plug(s) at the manufacturer's recommended intervals. There's a little more to it on increasingly common AMTs (automated manual transmissions), with electro-pneumatic damper fluid levels to check on the selector assembly and, if (as in Scania's case) automated clutch operation is electro-hydraulic, a fluid reservoir level to check. Nice and simple.

However, all that can change when it comes to troubleshooting – either in response to significant and unexpected falls in those fluid levels, or, more likely, due to driver-reported defects. Then it pays to understand not only how AMT selector mechanisms function, but also the detail behind the power path through each of the gears to the differential. Specifically, that means the arrangement of the transmission shafts and gears – including their associated splitter, range and overdrive mechanisms (where fitted) – as well as the mechanics of gear shifting, synchromesh operation and how the clutch assembly works.

It's not enough simply to know that an arrangement of solenoid valves fires off pneumatically-actuated lateral and longitudinal selector strokes to engage/disengage appropriate gears. Nor is it enough to understand that an electro-hydraulic clutch involves an electric motor spinning up and forcing fluid into a slave cylinder that, in turn, controls clutch movement.

You need to nail the engage and disengage sequences, including the relevant components and their interactions. You also need to get the detail of electrical, pneumatic and mechanical actuations, as well as the sensor types and their roles, and the relevant ECUs and associated communications.

Bear in mind that the driver will be unaware of any detail. Particularly with an AMT, all he or she sees is the gear numbers on the dashboard – usually one to 12. So when it comes to diagnosing problems, you need to be able to

mechanisms, as well as how they work. However, for now, to provide assistance with the role of troubleshooting, the following gives an initial insight into how gear shifting itself is achieved.

Just as in a manual gearbox, with an AMT, gears are kept engaged under torque by back-cut teeth on the selectors. When off torque, the detents

Gear shifting: how it works

Looking at Scania's GRSO 925 gearbox with Opticruise automation, this is a 16-speed tunnel style AMT (automated manual transmission) with range, split and overdrive. The unit has three main gears, which are doubled with the range change and doubled again with the splitter to provide 12 forward gears, including overdrive. It also has crawler gear (low and high) and reverse (also low and high). Note: the driver only sees selections of gear numbers one to 12 on the dashboard, along with crawler and reverse. He or she has no view of how the ratios are achieved.

Fitted with Scania's latest Opticruise 5, the gearbox offers three-pedal or fully automatic two-pedal operation (in line with most truck manufacturers).

However, in this company's case, the electronic clutch actuator (ECA) is controlled electro-hydraulically (as opposed to electro-pneumatically). In operation, an electric servomotor displaces fluid in the master cylinder to increase pressure in the clutch slave cylinder and actuate the clutch pushrod and fork. The ECA clutch assembly is fitted with an angle sensor for motor position and a Hall sensor for the slave cylinder, so enabling precision actuation under feedback control.

Note that, whether pneumatically- or hydraulically-actuated, on a two-pedal gearbox the accelerator (and brake pedal) becomes a virtual clutch – see next month for transmission shift strategies and detailed operation.

Next month we will also provide a full analysis of the gears, selector assemblies, range and shift

Keith Gallon, Scania

Photos: Donald MacLellan

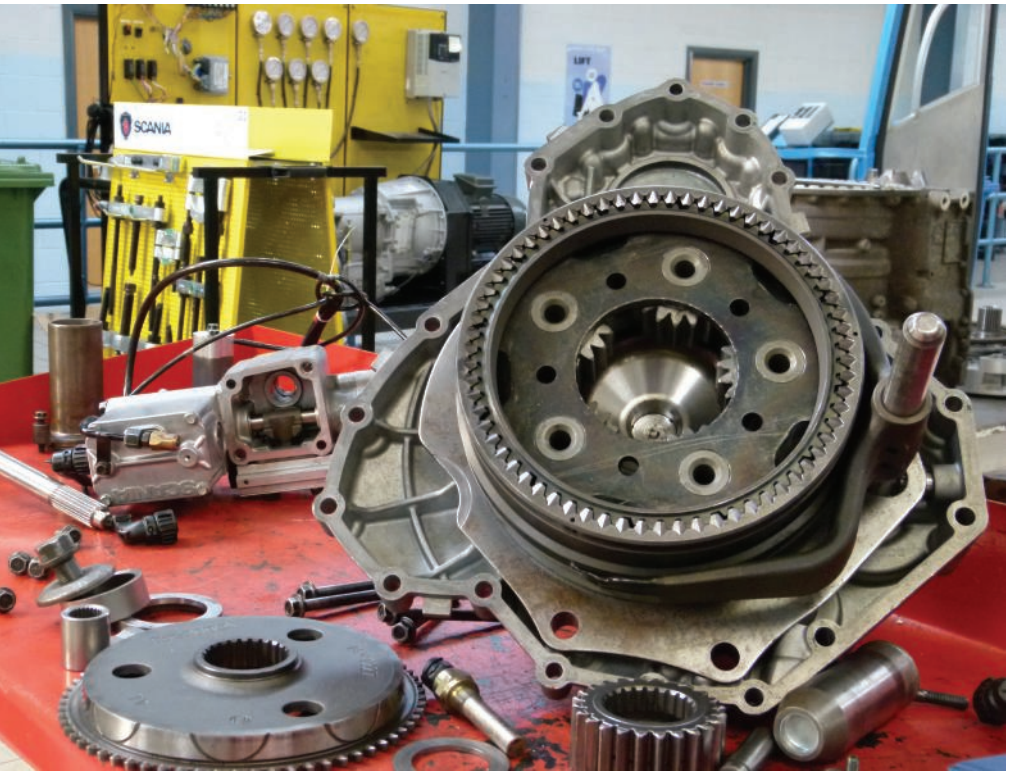
(ball and spring in the shaft recess) prevent gears from dropping out. Only when the pneumatically-actuated AMT selectors are fired up can the detent force be overcome and the gear released. Incidentally, Opticruise also sees any gearbox or engine PTO engaged and activates a 200Nm torque dispensation to ensure smooth gear changing and engagement.

So when the GMS (gearbox management system) triggers a gear change in response to vehicle speed, engine torque/power demand and/or vehicle inclination, it first instructs the EMS (engine management system) to ramp off torque. That relaxes the grip on the back-cut teeth. GMS then triggers the ECA, via a CAN sub-network, to open the clutch (amount depends on precise shift strategy). GMS then fires the relevant solenoid for air pressure to the selector to release the gear linkage longitudinally, so overcoming the detent. Next the laterally self-centring spring drops the box temporarily into neutral. The clutch is then closed.

EMS next syncs the engine speed to the gears (downshift demands increased engine revs while certain upshifts require exhaust brake activation – sensors provide feedback of main shaft, layshaft and engine speeds). GMS, while in neutral, then fires the solenoids for pneumatic actuation to drive the relevant selectors laterally and longitudinally, and engage the next appropriate gear (mating to the baulk ring and compressing the synchro on the way). On confirmation of gear engaged, GMS then communicates with EMS to ramp torque back up while simultaneously signalling the newly selected gear to the dash.

How rapidly that happens depends on the nature of the gear change. If it's a split shift – so not changing the main gear, but only shifting one selector mechanism forward or back for low- or high-shift – it's a small fraction of a second, using the ECA unit to rapidly reduce remaining torque in the gearbox with a partial clutch action.

Note: if driving off from stationary, GMS selects an appropriate gear while holding the clutch open before sending clutch position requirements to the ECA unit for a smooth and efficient take-up of drive. Speed of take-up is dependent on several parameters, including throttle demand, vehicle weight and inclination, working together with 'Hill Hold' on the braking system (if set) and monitoring engine torque so as not to over stress the driveline.



interpret what the driver tells you in terms that matter – considering selector movements, the ranges and splits, etc – and avoid jumping to potentially expensive conclusions.

WHAT IT MEANS

For example, when a driver tells you that all the odd numbered gears won't engage, what are you going to do? You should know that gears one, three, five, etc, are all low split, so you can conclude that it's not a range change or gear engagement problem, but an issue with the high shift. So that's where you might want to focus investigation.

Meanwhile, if the driver can't get anything below seventh, you will know that seventh to 12th gears on the dash are high range, so the starting point is some kind of low range problem. What about if he or she can't get first, second or third? In Scania tunnel gearboxes (such as GR and GRS series), that's everything on the left hand side internally – so we have a left-hand selector stroke or a synchromesh problem. But remember, those are not the only logical conclusions: it's also possible that the driver may be trying to engage drive before building up air pressure.

Then again, if the defect report indicates a grating noise between fifth and third, you should know that both are in low split and they're also low range (which covers one to six). So it can't be a split or range change issue. That leaves a physical problem in moving from third to second gear in the gearbox itself – so you might want to consider second gear synchromesh. But the astute among you may be thinking, why didn't the driver complain about 11th to ninth as well, given that it's the same gears and splits, but high range? The answer: probably because the gear speeds are higher and more closely matched to the engine, so it's an easier shift. The problem may be the same, just not noticed.

TECHNICIAN BEWARE

But there are other potential causes, including air leaks, damage to components such as the self-centring (neutral) spring, and even incorrect assembly. If there is an air leak to the selectors, then, when the solenoids fire, there may be pressure to drive longitudinal movement, but not enough to complete the lateral stroke left or right. That alone could account for gear selection problems – including grating sounds. If the leak is severe enough, it might also account for events such as gears pulling out on-torque. Equally, if the self-centring spring breaks, the selector won't return to the middle neutral position laterally. Attempted gear engagement may then result in the selector pushing on the edge of second and third, or reverse and crawler: look for burrs on the gear edges before you strip the box.

Scania's Keith Gallon recalls one operator's workshop that stripped an automatic gearbox in response to a defect report indicating graunching sounds. Finding nothing, technicians reassembled the box, but the problem remained. So they fitted a new control unit (£2,000), road tested it and still the same problem. Needing the vehicle back in service, they fitted a new gearbox – but to no avail. Why? Because a new box comes in its raw state, so the automatic selector assemblies had been taken off the 'faulty' gearbox and fitted to the new unit.

The problem was with the selectors – in fact the centring spring, which had been inserted incorrectly after an earlier strip down. It was getting the gear but also touching others. As Gallon says, you must question the driver carefully. Had they done so, they might have understood that the right selector stroke was fine, but the left side had problems – meaning it was unlikely to be a gearbox problem and much more likely to be an issue with the selector mechanism or its automation. Incidentally, with a manual box, technicians would have diagnosed the equivalent cause – worn or loose linkages.

Best advice is first listen very carefully to the driver. Use your AMT understanding to visualise potential problems that match the symptoms. Don't throw expensive stuff at a problem: be sure before you order new equipment or strip anything down. That also means checking the usual things – powers, earths, air pressure, and LINbus and CANbus communications.

Next month, we review gearbox internals in detail, and move on to modern fuel-saving AMT gearshift strategies and advances with crawler and manoeuvring modes.