A particular feature of the motor scooter is its final drive via the variator. This is an ingeniously simple continuously variable transmission, made up of just a few components, which transfers the engine power to the rear wheel. The variator is ideal for smaller engines and is a weight- and cost-saving replacement for the gearbox and shaft or chain drive used in the majority of motorcycles. The variator was first installed in a scooter in the late 1950s by the German manufacturer DKW, in the "DKW Hobby", a scooter with a 75 cc two-stroke engine that still enabled the scooter to reach an impressive top speed of nearly 40 mph.

Variator and clutch

1. First remove the airbox, then you can start ...
2. ... tie up the airbox
3. Remove the rubber sleeve
4. You can now remove the variator cover
5. Do not lose the adapter sleeves of the cover
6. Block the variator and undo the central nut ...
When it comes to the maintenance and tuning of your scooter, you'll find that the variator is pretty much at the top of the agenda. This is because, on the one hand, its components are subject to a certain degree of wear and tear, and on the other, a badly tuned variator can cause sluggish engine performance. To understand the workings of your variator, think of the transmission of a bicycle with derailleur gears (such as a mountain bike), which most of us are familiar with. When you move off, you use a small sprocket at the front and a large one at the back. Then, as your speed increases and you have to overcome less resistance (e.g., on a downhill stretch), you shift the chain to a larger sprocket at the front and a smaller one at the back.

The variator works in a similar way except that it uses a drive belt instead of a chain, is continuously variable and is automatically controlled via centrifugal force adjustment, depending on the speed of rotation. The drive belt runs in a V-shaped gap between two V-pulley halves at the front and back. The two pulley halves are a variable distance apart on their shaft. The front inner pulley half also acts as the housing for the variator roller centrifugal weights, which run along precisely calculated curved paths. A contra spring presses the V-pulley halves against each other at the rear. As you start up your scooter, the drive belt runs close to the shaft at the front and at the top of the pulley at the rear. When you open the throttle, the rotational speed of the variator increases and the centrifugal force pushes the roller weights outwards. They in turn press the movable pulley half outwards along the shaft. The gap between the two pulley halves becomes smaller, and the drive belt is forced out to a larger radius. Because the drive belt cannot stretch, it is also forced downwards at the back against the spring force. The end position of the belt is ultimately the exact opposite to its starting position, so you now have a high (speed-increasing) gear ratio instead of a low (speed-reducing) ratio.

However, the variator scooter must also be able to idle. An automatic centrifugal clutch has the job of separating the rear wheel from the engine at low speed, and connecting it as soon as you twist the throttle and the engine speed increases to a certain level. This action is enabled by a clutch bell housing on the drive of the rear wheel. Inside this clutch bell housing are rotating spring-loaded centrifugal weights that are fitted with friction linings. The point in time at which the centrifugal weights with their friction linings “grab” the clutch bell housing depends on the strength of the springs – weak springs engage at quite a low speed, while stronger springs offer more resistance to the centrifugal force and the engagement is delayed until a somewhat higher engine speed. So it is important for the springs to match the engine characteristics if the scooter is to move off at optimal engine speed. If they are too strong, the engine would stall; if they are too weak, your scooter would only be able to set off with the engine howling.

Maintenance
The drive belt of your scooter is a wearing part that must be replaced at regular intervals. Failure to do so may cause the belt to break without warning – which would certainly bring you to a sudden standstill. And if you’re unlucky, the belt might catch in the housing, which could result in further damage. For precise maintenance intervals, please refer to your vehicle manual – these will depend largely on the engine size, and are usually between 12,000 and 25,000 miles.

Over time, the V-pulleys will develop grooves caused by the movement of the belt, which can impair the functionality of the variator and reduce the service life of the drive belt. So it is important to replace any grooved pulleys.

The variator rollers will also wear with time and develop flat spots – at which point they must also be replaced. Worn rollers will adversely affect performance and cause jerky acceleration. A rattling sound coming from your scooter is also often a sign that they need replacing.

On the clutch, the linings are also subject to regular wear and tear from friction. Over time, this will cause the clutch bell housing to become worn and grooved – at the latest, these parts will need to be replaced when the clutch starts slipping, i.e. it cannot deliver power to the wheels. Because they stretch, the clutch springs become worn out, which can cause the clutch linings to start rattling and the scooter will move off at too low an engine rpm, which is why it’s always best to replace the springs at the same time as you are servicing the clutch.

Checking and replacing components
Before dismantling the variator, find a clean, dry place to work – if possible, one where the scooter can remain undisturbed should it turn out you need to get new parts. Before you start, make sure you have the following tools to hand: a good socket wrench set, a mini torque wrench (1/4",...
Fit the bush and any spacers. Put on all washers and the central nut. This may be a two-man job.
A large quantity of rubber abrasion in the housing may indicate that the belt is not running correctly in the variator (investigate the cause!) – or may just be due to the fact that the maintenance interval is long overdue. Premature wear of the drive belt may also be due to incorrectly installed or worn V-pulleys. If the V-pulleys are grooved, they must be replaced (see above). If they have turned blue due to heat, this means they have warped or were incorrectly installed. If the drive belt does not yet need replacing, wipe it clean with brake cleaner and mark the correct running direction on it before continuing.

Removing the variator rollers
To check the variator rollers, or to replace them, pull the front inner V-pulley half with the variator housing off the shaft as a unit (see Fig. 13 and 14). The housing may be fixed to the pulley or loose – so to make sure the components don’t all fall apart, and to keep the variator weights in place, hold the unit very firmly together as you remove it.

Now dismantle the housing of the variator rollers – make a note of the position of the individual parts. Clean them with brake cleaner. Check the variator rollers for wear and tear – if they are worn, display flat spots or angular wear, or are irregular in diameter, replace them as a set (see Fig. 15 and 16).

Installing the variator rollers
When assembling the variator housing, the variator rollers and tracks have to be installed either lightly greased with Castrol LMX or dry (check with your local retailer). If the variator housing is fitted with an O-ring, this will need to be replaced with a new one. When fitting the unit on the shaft (see Fig. 17), take care to ensure that the variator rollers stay in position in the housing, otherwise you will have to remove it again and reposition the rollers. Press the rear V-pulley halves apart (see Fig. 18) so that the belt can slide deep between the two halves and has more space at the front. Now install the front outer V-pulley half of the variator with all its components – lightly grease the shaft with Castrol LMX before fitting the bush (see Fig. 19). Make sure the drive belt is running smoothly between the pulleys and do not jam it. Before putting on the nut, double-check that all components are in their original position (see Fig. 20). Use the locking tool again (see Fig. 21) and a torque wrench to tighten and torque the nut in accordance with manufacturer specifications. If it makes it easier, get someone to hold the locking tool for you again while you work! Check again that the V-pulleys of the variator are running straight in relation to the sealing surface of the housing when your rotate the variator. If they are wobbling, check that you have mounted everything correctly! Tauten the drive belt by pulling it slightly out from between the rear pulley halves.

Removing the clutch
You can check the clutch without having to remove the drive belt. Remove the clutch bell housing from the shaft so that you can check its inner running surface and the linings of the centrifugal weights (see Fig. 22). Check with your local retailer for wear limits – linings that are less than 2 mm thick or have worn unevenly need to be replaced immediately.

If you are changing the clutch linings and springs, it is better to pull the entire rear V-pulley unit complete with clutch off the shaft, as it has to be screwed on and this is made more difficult by a spring inside. To do this, first remove the drive belt. To undo the central nut on the shaft, hold the clutch bell housing firmly, with a special tool that grips in the openings of the bell housing, or hold the exterior of the bell with a strap wrench. Once again, it may be helpful to get someone to hold the locking tool in place while you undo the lock nut. If the nut is located on the outside, you can undo it before removing the variator cover – in which case, you will already have carried out this step, as in our example. When you have unscrewed the nut, remove the clutch bell housing and, as mentioned in the previous section, check for signs of wear and tear (grooves). If the clutch linings are worn or the springs of the centrifugal weights have become stretched, you will need to pull the V-pulley unit complete with clutch off the shaft as described in the previous section. This unit is held together by a large central nut. To loosen this nut, grip the clutch with a suitable tool, such as a metal strap wrench, and use a special wrench of the correct size to loosen the nut – water pump pliers are not a suitable tool (see Fig. 23)! Because the V-pulley halves are pushed together by an inner contra spring, the unit will fly apart when you loosen the nut – so bear this in mind and press against the unit in order to remove the nut gradually from the shaft. Be aware that if your scooter’s engine is bigger than 100 cc, the spring tension is pretty strong. In order hold down the spring, we strongly recommend holding all the components together from the outside using a spindle, which gradually slackens after you have removed the nut (see Fig. 24 - 28). This spindle also helps to control the spring during reassembly so that it is easier to put on the nut.

Once you have detached the clutch from the V-pulley (see Fig. 29), you can replace the springs and the lin-
ings. Always use new circlips (see Fig. 30) when changing the linings and make sure that they are securely seated.

Care of the clutch bearings
The bushing of the V-pulley unit generally contains needle bearings – it is crucial not to allow any dirt to get into the bearing and to make sure that it is running smoothly and easily. If necessary, clean by spraying out with Procycle brake cleaner and re-grease with Castrol LMX. Check the bearing for leaks – because any grease landing on the drive belt may cause it to slip.

Installing the clutch
To install the clutch proceed in the reverse order. Tighten the outer central nut using a 1/4", 3-15 Nm torque wrench – check with your local retailer for the correct torque. Before closing the variator housing again, double-check that all the components are correctly installed and then re-mount all external components back in their original position.

Tuning
In order to ensure optimum road performance, the weight of the variator rollers must be optimally matched to the engine’s rpm range. If the variator rollers are too heavy, the high centrifugal force will push the belt upwards between the V-pulley halves at the front before the engine reaches its ideal rpm range – the engine struggles and you will not get good acceleration. If the weights are too light, the transmission ratio will be constantly too short, the engine overrevs, and you lose power. For example, many standard 50 cc engines with their original exhaust have an ideal rpm of approx. 6000 rpm, i.e. this is the level where the engine power is at its highest. You then tune your variator to this speed – i.e. the “gear shift” will occur at approx. 6000 rpm. However, if you install an aftermarket exhaust which supports the cylinder charge in a different way, or if you are using other tuning parts, this ideal rpm will not be the same. The majority of performance exhaust systems will produce a higher ideal rpm and will require lighter variator rollers. These are often supplied with the exhaust. If you do not install these at the same time, your “performance” exhaust may well become more of a performance-reducer ...

You also need to bear in mind the weight of the rider when tuning. So if you are looking to get the most out of your scooter engine, it will take some trial and error to find out which variator roller weights are best for you. There are tuning kits available on the market for this purpose. Once you have determined your optimum roller weight, you replace the tuning rollers with the ideal rollers for long-term use.

Staying street-legal
Please be aware that if your tuning measures enable your 50 cc scooter to exceed the permitted top speed, it will no longer be street legal. Some variators are fitted with a throttle ring (limiter ring) in order to meet German approval guidelines – removal of this ring will also mean that your scooter is no longer street legal. And if you don’t yet have a driving license that permits you to drive faster vehicles, you may find yourself in a whole lot of trouble if the police catch you on a public road riding a such a tuned up scooter!

Please note!
These tips for DIY mechanics contain general recommendations that may not apply to all vehicles or all individual components. As local conditions may vary considerably, we are unable to guarantee the correctness of information in these tips for DIY mechanics. Thank you for your understanding.
We recommend:

**Precision Mini Torque Wrench, 1/4"**
Ininitely adjustable, handy and compact torque wrench for low torques of 3-15 Nm. Ideal for less sturdy bolts and up to 7 mm thread sizes. With 1/4 inch connection, reversible ratchet head. +/- 4% actuation accuracy. Comes in a sturdy plastic case.
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