

LuK Clutch Course and Failure Diagnosis

Introduction to Clutch Technology –
Guidelines for Evaluating Clutch System
Malfunctions in Commercial Vehicles



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1 Clutch System

1.1 Functional Diagram

Internal combustion engines only provide useful output within a certain speed range. To be able to use this range for various driving conditions, vehicles must have a transmission. Today, the transmission is generally connected to the engine via a dry single-disc clutch. Dry twin-disc clutches are used whenever extremely high engine torques are transmitted at low actuation forces. They are therefore mainly used in sports cars and heavy-duty commercial vehicles.

Unlike “dry” clutches (i.e. clutches operating in air as the medium), wet clutches operate immersed in oil or oil mist. They are typically used as multi-disc clutches in automatic transmissions, building machinery and special vehicles but most often in motorcycles.

A clutch must satisfy the following requirements:

- Transmit engine torque
- Decoupling and coupling the power flow between the engine and transmission
- Allow fast gear shifting
- Provide smooth take off
- Dampen vibrations
- Protect the drive train against overload
- Remain maintenance-free over the entire service life
- Be durable and easy to replace

Dry single-disc clutch

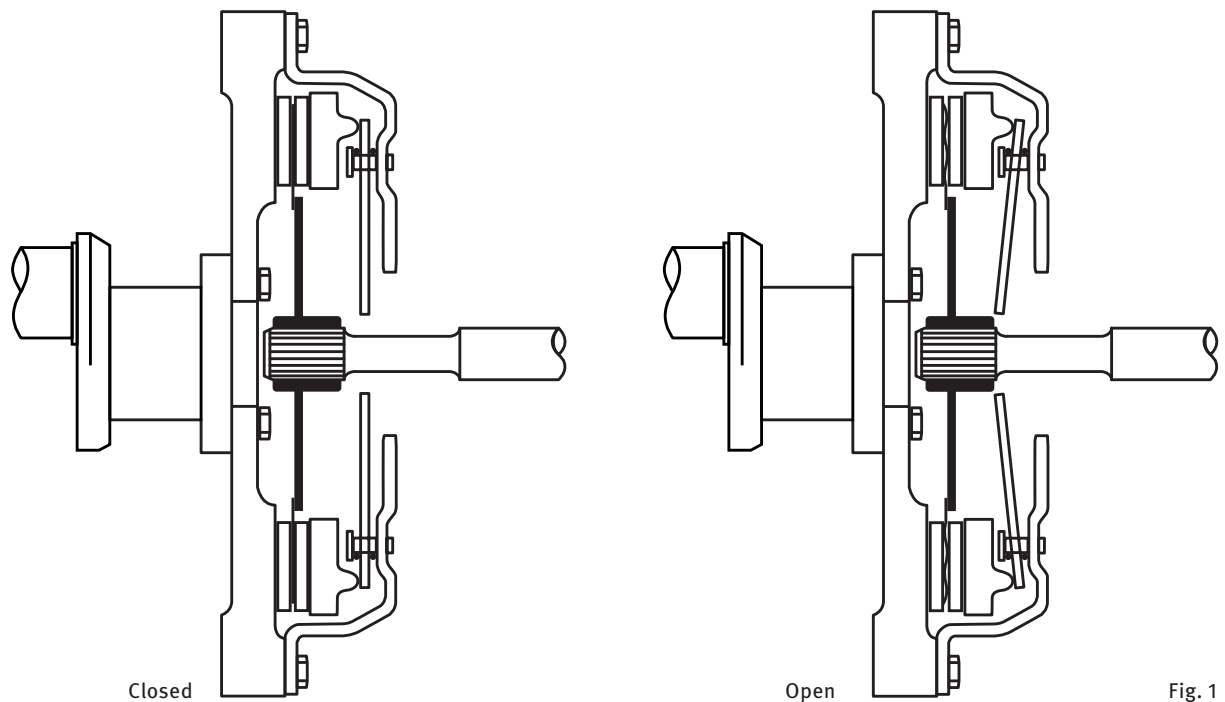


Fig. 1

1.2 Calculating the Transmittable Torque

One of the primary tasks of a clutch is to transmit the engine torque to the transmission input shaft. The transmittable torque of a clutch is calculated using the formula below:

$$M_d = r_m \cdot n \cdot \mu \cdot F_a$$

Where:

M_d	transmittable torque
r_m	mean friction radius of the clutch lining
n	number of friction surfaces
μ	frictional coefficient of the linings
F_a	clamp load of the diaphragm spring

Example:

Lining inside diameter $d_i = 242$ mm
Lining outside diameter $d_a = 430$ mm
Clamp load $F_a = 27,000$ N
Frictional coefficient $\mu = 0.27-0.32$ (organic linings)
 $0.36-0.40$ (inorganic linings)

Calculation of r_m

$$r_m = \frac{d_i + d_a}{4}$$
$$r_m = \frac{242 \text{ mm} + 430 \text{ mm}}{4}$$
$$r_m = 168 \text{ mm}$$

For the next calculation, the result is shown in meters.

$$168 \text{ mm} = 0.168 \text{ m}$$

$$M_d = 0.168 \text{ m} \times 2 \times 0.27 \times 27.000 \text{ N}$$

$$M_d = 2.450 \text{ Nm}$$

Clutches are essentially designed with a safety factor. As a result, the transmittable torque is always greater than the maximum engine torque.

Depiction of the calculation parameters

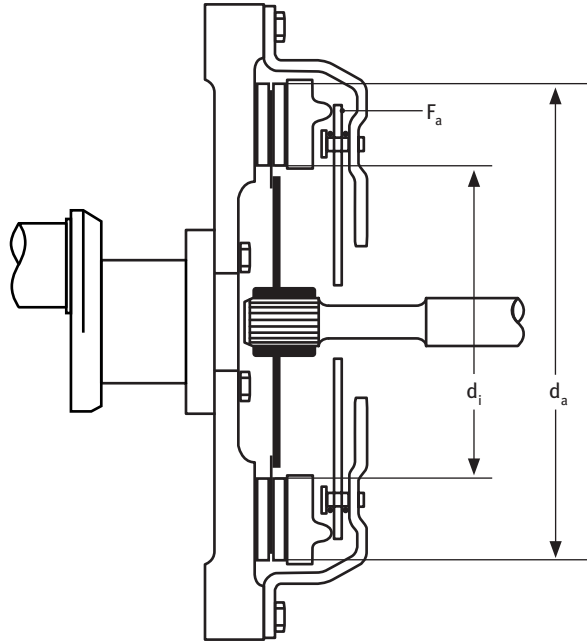


Fig. 2

1.3 Design

In the clutch cover, diaphragm springs, spacer bolts, support rings, tangential leaf springs and the pressure plate form a mechanism that permits a friction lock-up connection that can be modulated. The diaphragm spring generates the clamp load and forms the lever between release bearing and pressure plate. Support rings guided via spacer bolts act as the support point for the diaphragm spring. The pressure plate is centrally guided by several tangential leaf springs in the clutch cover. Power is transmitted by the clutch disc with the clutch linings. The clutch disc creates a friction lock-up connection with the engine via the linings, and a form-fit connection with the transmission input shaft through the hub.

- 1 Tangential leaf spring
- 2 Clutch housing/clutch cover
- 3 Pressure plate
- 4 Support ring (also pivot ring)
- 5 Diaphragm spring
- 6 Torsional damper
- 7 Hub
- 8 Guiding sleeve
- 9 Transmission input shaft
- 10 Release bearing
- 11 Pilot bearing (also guiding bearing)
- 12 Clutch disc
- 13 Spacer bolts
- 14 Segments for cushion deflection
- 15 Friction lining
- 16 Flywheel

Dry single-disc clutch (closed), components

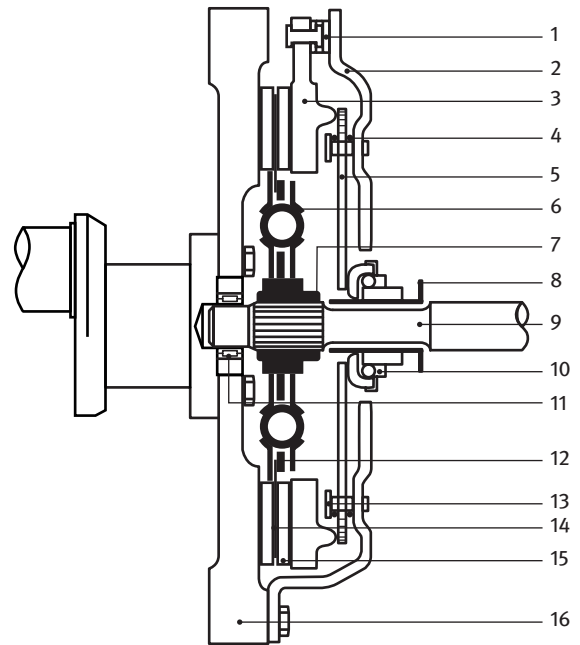


Fig. 3

1.4 Function

Clutch closed (Figure 3)

In the engaged state, the force of the diaphragm spring acts on the pressure plate. This pushes the axially movable clutch disc against the flywheel. A friction lock-up connection is created. This allows the engine torque to be directed via the flywheel and the pressure plate to the transmission input shaft.

Clutch open (Figure 4)

When the clutch pedal is pressed, the release bearing is moved against the diaphragm spring load in the direction of the engine. At the same time, the diaphragm springs are deflected over the support rings, and the force on the pressure plate is reduced. This force is now so low that the tangential leaf springs are able to move the pressure plate against the diaphragm spring load. This creates play between the friction surfaces, allowing the clutch disc to move freely between the flywheel and the pressure plate. As a result, the power flow between the engine and transmission is interrupted.

Dry single-disc clutch (open)

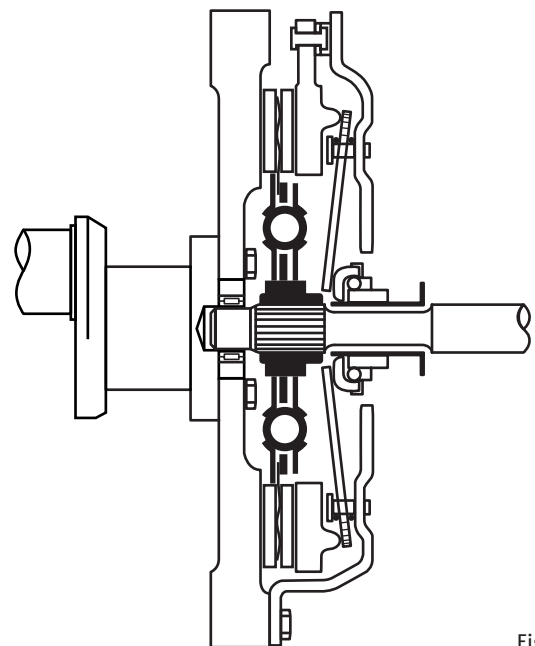


Fig. 4

2 Clutch Pressure Plate

2.1 Tasks

The clutch pressure plate together with the flywheel and clutch disc form a friction system. It is connected to the flywheel and induces the transmission of the engine torque via the clutch disc to the transmission input shaft.

The diaphragm spring

The core component of the clutch pressure plate is the diaphragm spring. Unlike the coil springs used in earlier commercial vehicle clutches, it has the advantage that it can have a much flatter and lighter design. Especially important is the characteristic curve of the diaphragm spring, which differs substantially from the linear characteristic curve of a coil spring.

Precise modeling of the thickness, rise angle and material hardness as well as the diaphragm spring's outside and inside diameters allows a characteristic curve to be produced, as shown by the continuous curve in the first diagram in Figure 5. While the clamp load with a coil spring clutch decreases linearly as the lining thickness decreases as a result of wear, here it increases initially and then drops again. This force profile is perceptibly more comfortable than the version with coil springs. The clutch is designed to begin to slip before the wear limit of the lining is reached. The necessity of a clutch replacement is thus signaled in due time, so that further damage, e.g. by the scoring of the lining rivets, is avoided. Moreover, because of the diaphragm spring characteristic curve, the requisite actuation forces are lower than with coil spring clutches.

2.2 Clutch Characteristic Curves and Force Diagrams

Figures 5 to 7 show some examples of clutch characteristic curves and force diagrams. They do not directly refer to the following designs but apply generally.

The vertical axes on the left represent the forces. The release travel and, in Figure 5, the release bearing travel are shown at the bottom on the horizontal axes. The lift of the pressure plate is clearly shown on the vertical axes on the right.

The solid line in Figure 5 shows the development of the clamp load. With a newly installed clutch disc, the position of maximum spring force of the diaphragm spring is exerted (point of operation of new clutch).

As the lining thickness begins to decrease, the clamp load of the diaphragm spring first increases to the peak load, then gradually drops again to around the load level of the newly installed clutch when the lining is worn to the wear limit.

The clutch disc thickness decreases by approx. 1.5–2 mm during its service life. The clamp loads are calculated in such a way that the clutch begins to slip shortly before the rivets of the clutch lining score the pressure plate or flywheel and would cause additional damage.

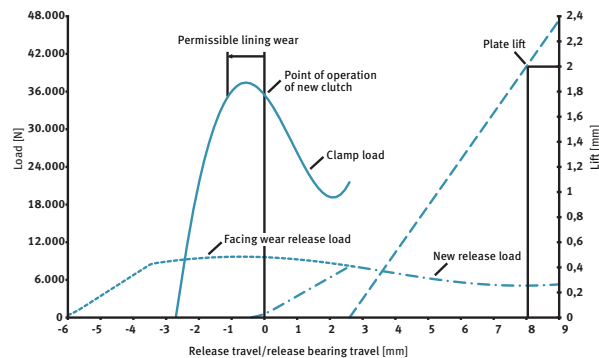


Fig. 5

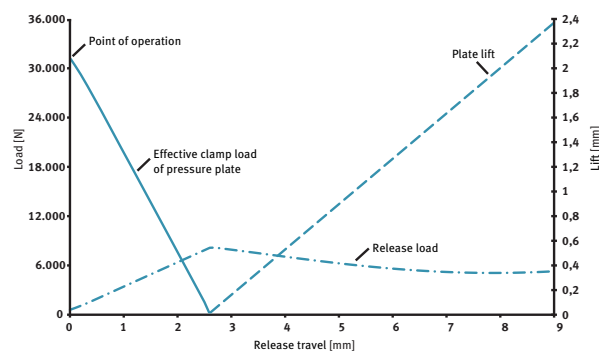


Fig. 6

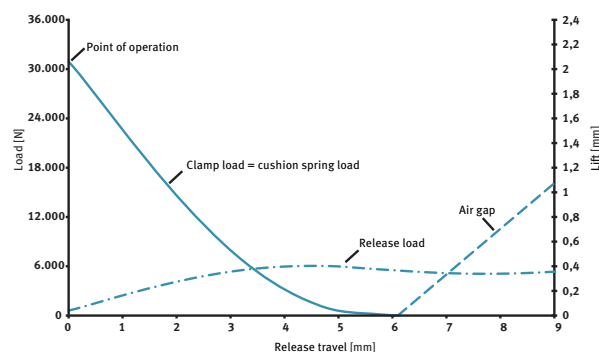


Fig. 7

The dashed/dotted line shows the development of the release load, i.e. the load required to actuate the clutch when the clutch is new and— shown by the dotted line—the load after lining wear. The release load initially rises until the point of operation is reached, and then slowly drops again. The curve for the release load with lining wear has been moved to the left to illustrate more clearly the ratio of clamp load to release load. The higher clamp load at the point of operation with lining wear is reflected by a correspondingly higher release load. The dashed line shows the development of the pressure plate lift above the release bearing travel. The diagram clearly shows the lever ratio in the clutch: 8 mm of release travel corresponds to 2 mm of lift, i.e. to a transmission ratio of 4:1 (excluding the elasticities of the clutch). This ratio also applies to the above-mentioned ratio of clamp load to release load. In the center (Figure 6) and bottom (Figure 7) diagrams, the measurements are compared for clutches including

and excluding the cushion deflection of a clutch disc. The advantages of cushion deflection are gentle clutch engagement and more favorable wear characteristics. Without cushion deflection, the effective clamp load (solid line) falls linearly and relatively sharply during disengagement. Conversely, it increases just as steeply and suddenly during clutch engagement. However, in the diagram at the bottom we see that the available release travel along which the clamp load diminishes is about twice as great. On the other hand, as the clutch is engaged, the clamp load slowly increases along a curve as the cushion springs must first be compressed. Thanks to the relatively gentle decline and/or increase in the clamp load curve (solid line), the pronounced peak in the required release load is reduced. As long as the pressure plate is still making contact with the clutch disc, the clamp load and cushion spring load are balanced in relation to each other.

2.3 Designs

Depending on the design and actuation system of a clutch, a distinction is drawn between:

Push-type diaphragm spring clutches (Figure 8)
(opened by pushing the release bearing onto the diaphragm spring fingers)

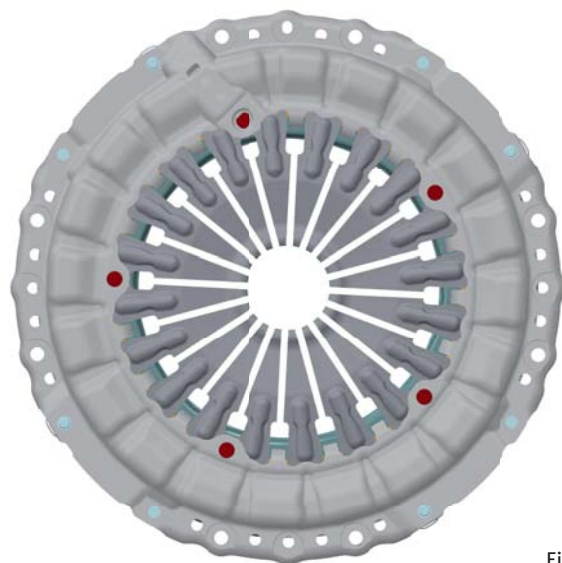


Fig. 8

Pull-type diaphragm spring clutches (Figure 9)
(opened by pulling the release bearing onto the diaphragm spring fingers)

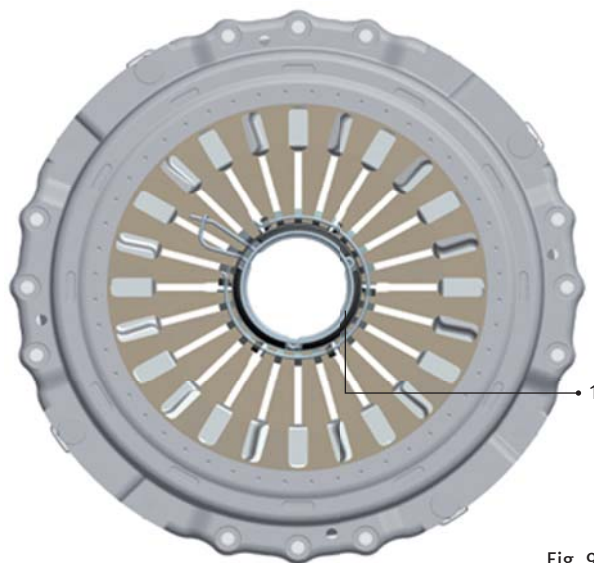
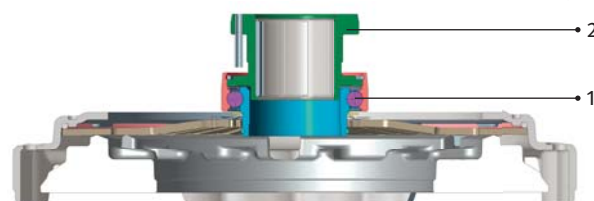


Fig. 9

- 1 Snap ring
- 2 Release bearing



2.3.1 Standard Push-Type Diaphragm Spring Clutch

With this design, the diaphragm spring is guided via spacer bolts and support rings.

The pressure plate is linked to the clutch cover via tangential leaf springs and lies on the outer edge of the diaphragm spring.

The tangential leaf springs perform three basic functions:

- Lifting the pressure plate during disengagement
- Transmitting the engine torque
- Centering the pressure plate

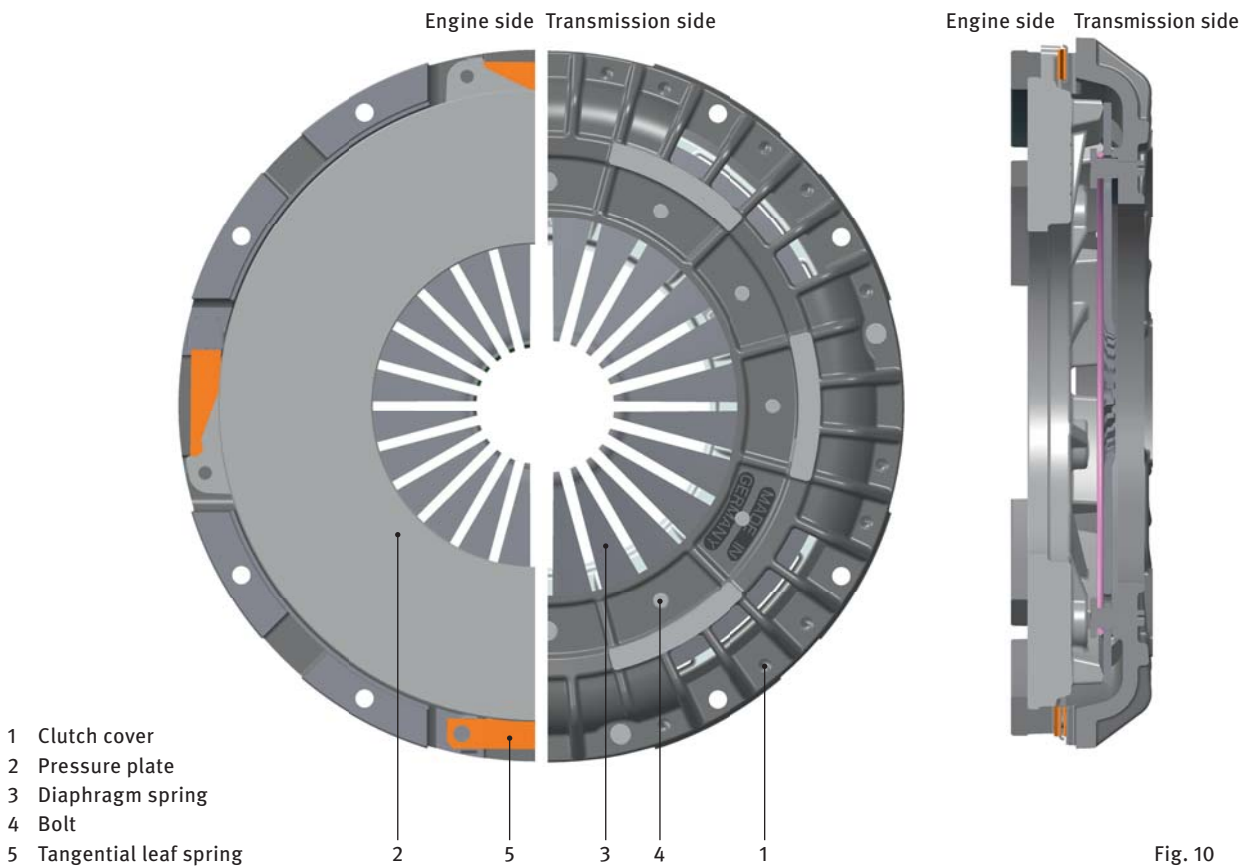


Fig. 10

The diaphragm spring is clamped between the pressure plate and the clutch cover in order to produce the clamp load required to clamp the clutch disc with friction lock-up between the flywheel and pressure plate. In doing so, the diaphragm spring is supported by a ring that is fixed by bolts in the clutch cover. As an option, these bolts can also be replaced by a bead in

the clutch cover. The outside diameter of the diaphragm spring is seated on the pressure plate. When the clutch is actuated, the release bearing pushes onto the diaphragm spring fingers. The pressure plate is lifted by the tangential leaf springs and the clutch disc is disengaged.

2.3.2 Push-Type Diaphragm Spring Clutch with Keyhole Tabs

The diaphragm spring clutch with keyhole tabs is a further development of the standard design. The keyhole tabs are modeled in such a way that they pull the pins in the clutch cover outwards. This compensates the

wear in the bearing arrangement of the diaphragm spring. The advantage of this design is a uniform lift throughout the entire clutch life.

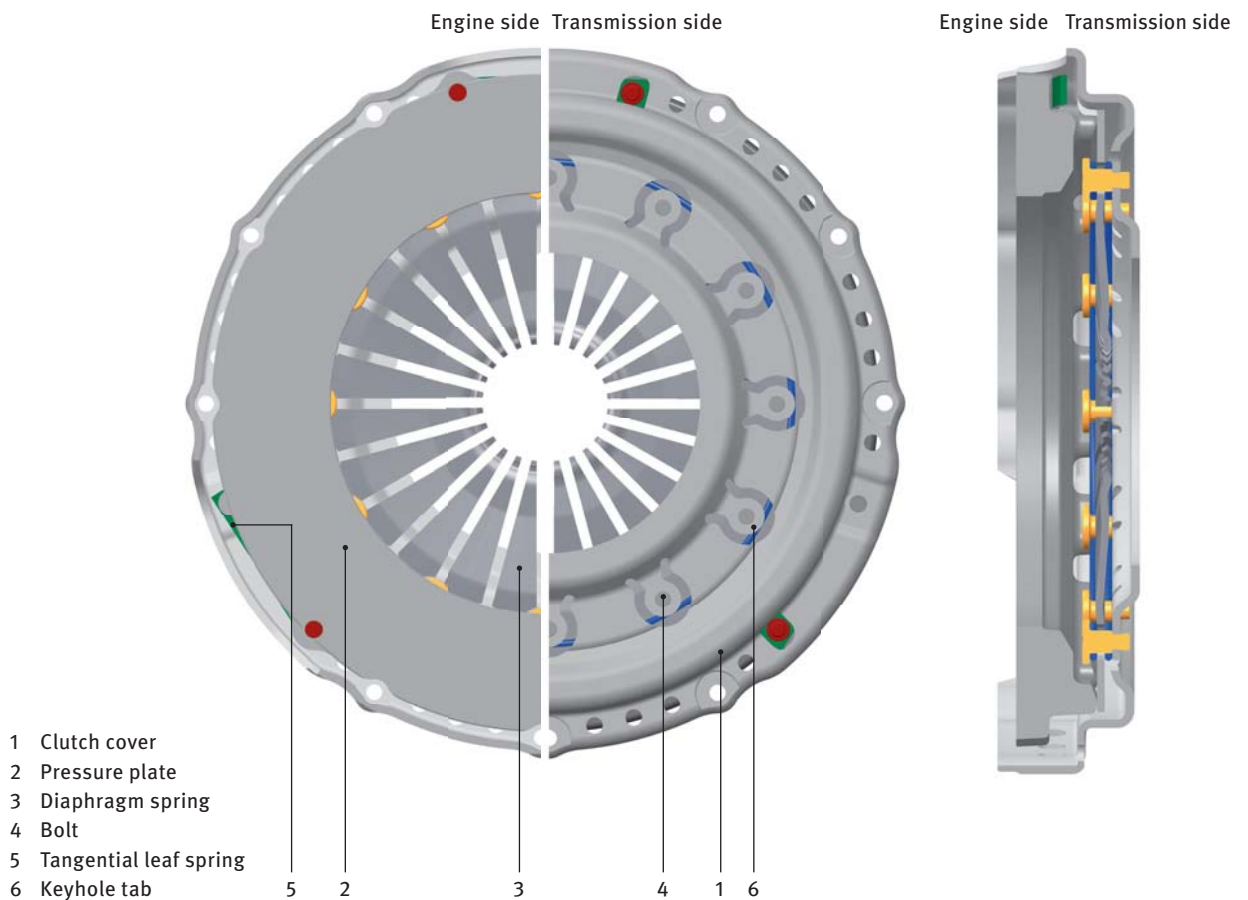


Fig. 11

2.3.3 Push-Type Diaphragm Spring Clutch with Support Spring

The diaphragm spring clutch with a support spring is a special version. The diaphragm spring is supported against the clutch cover by a ring, which can optionally be replaced by a bead in the clutch cover. The support spring serves as a mating bearing surface. This design

allows for clearance-free and stress free mounting of the diaphragm spring with automatic wear adjustment. Otherwise, this type does not differ from those described above.

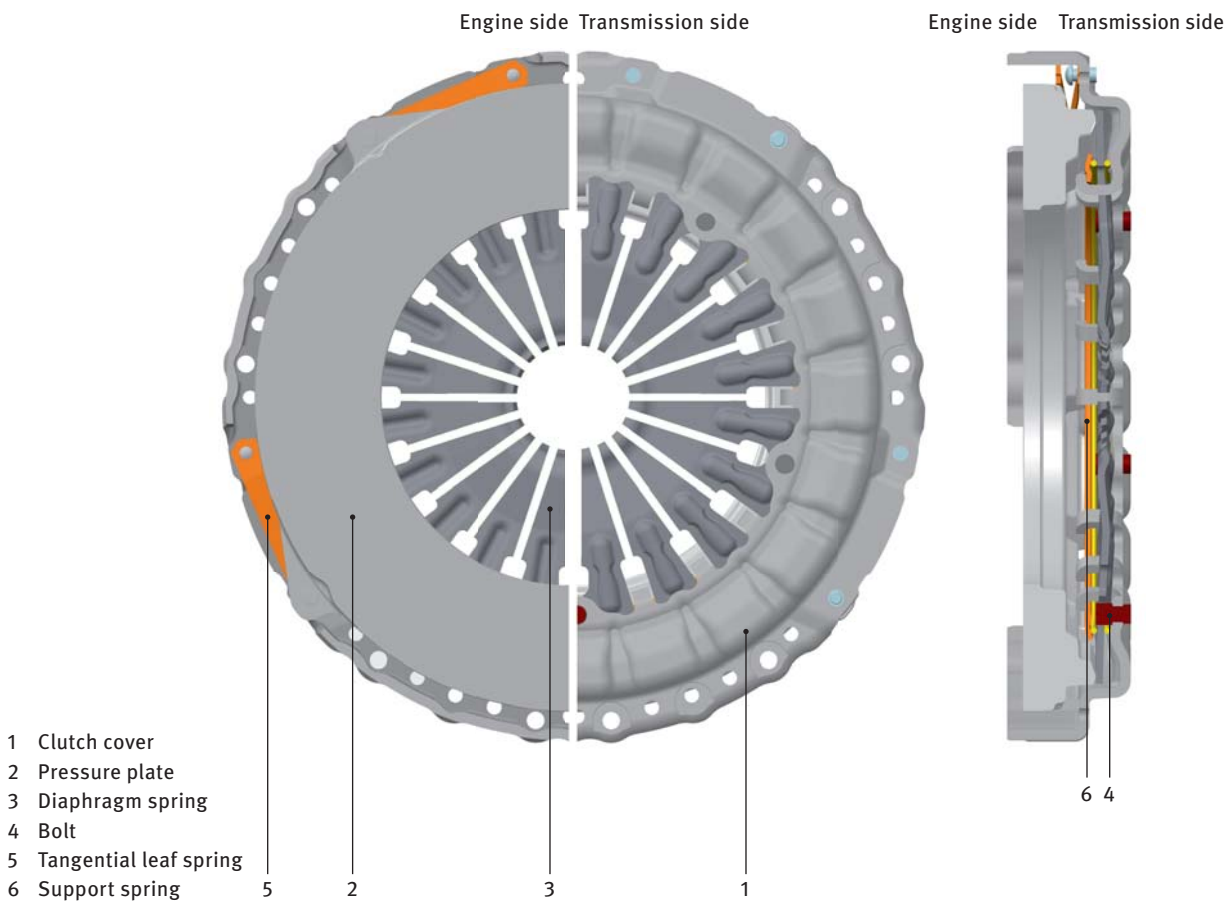


Fig. 12

2.3.4 Pulled Diaphragm Spring Clutch

The diagram below shows the pulled diaphragm spring clutch. Contrary to the pushed diaphragm spring clutch, this design is characterized by the reversed installation of the diaphragm spring. With this type, the clutch is actuated by pulling on the diaphragm spring fingers. The outer edge of the diaphragm spring is supported by the clutch cover and the inner edge by the pressure plate. The benefit of this clutch design is not only the minimal mounting space required, but also the possibility, on the basis of the lever ratios, of

reducing release forces compared with a pushed diaphragm spring clutch while requiring the same clamp load. In addition, pull-type clutches are more efficient than the push-type diaphragm spring clutches owing to the diaphragm spring being supported at the outside diameter of the clutch cover.

Unlike the pushed version, the pull-type clutch is more difficult to install and remove. This is due in part to the more complex design of the release bearing.

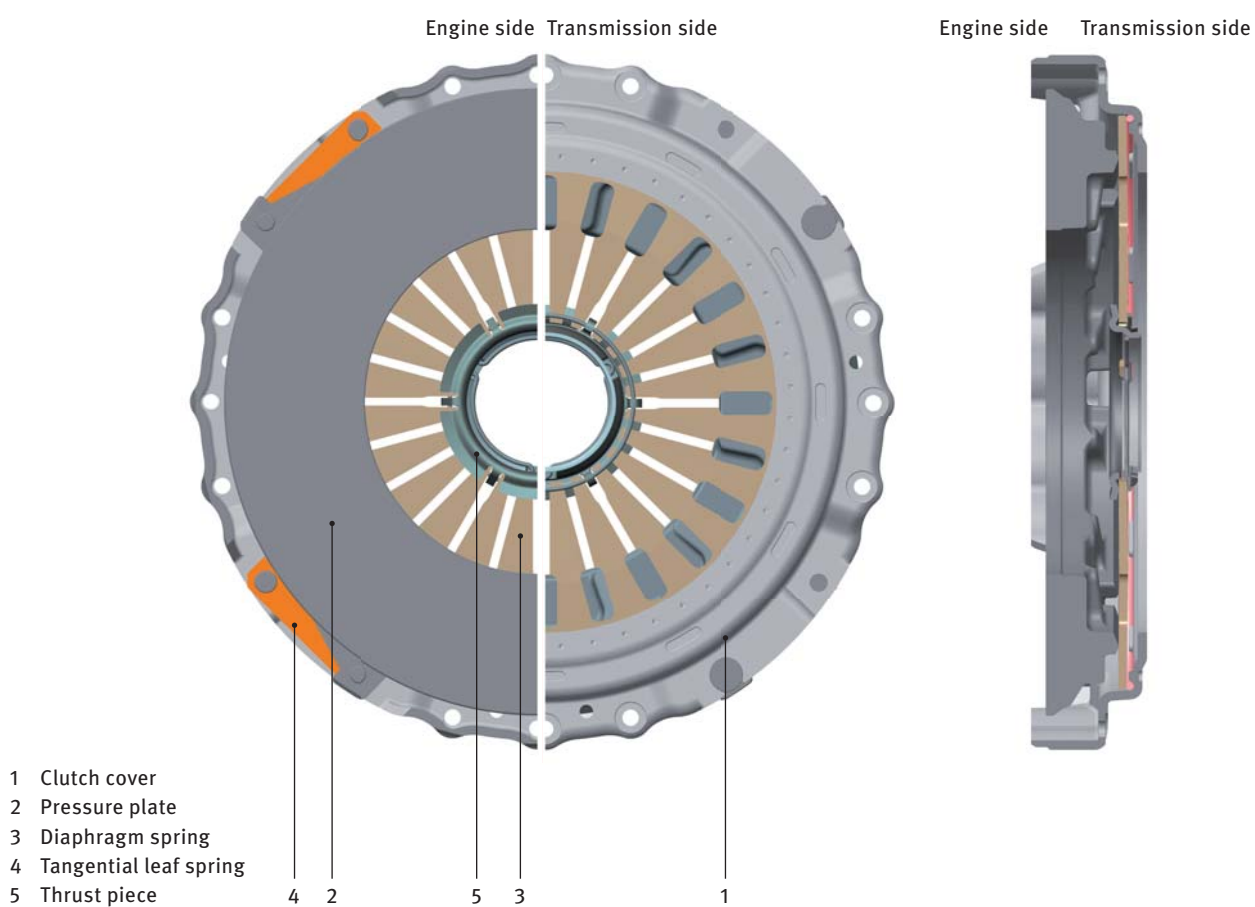


Fig. 13

2.3.5 SmarTAC self-adjusting diaphragm spring clutch (travel-controlled)

Unlike force-controlled wear compensation (self-adjusting clutch), the SmarTAC adjustment process is effected by the travel measurement during engagement and disengagement.

If the distance between the pressure plate and fly-wheel changes, the axial travel change is converted into a radial movement of the adjuster ring by a pinion with a directly coupled spindle. The distance is compensated by a ramp system.

Components of the self-adjusting clutch with travel control

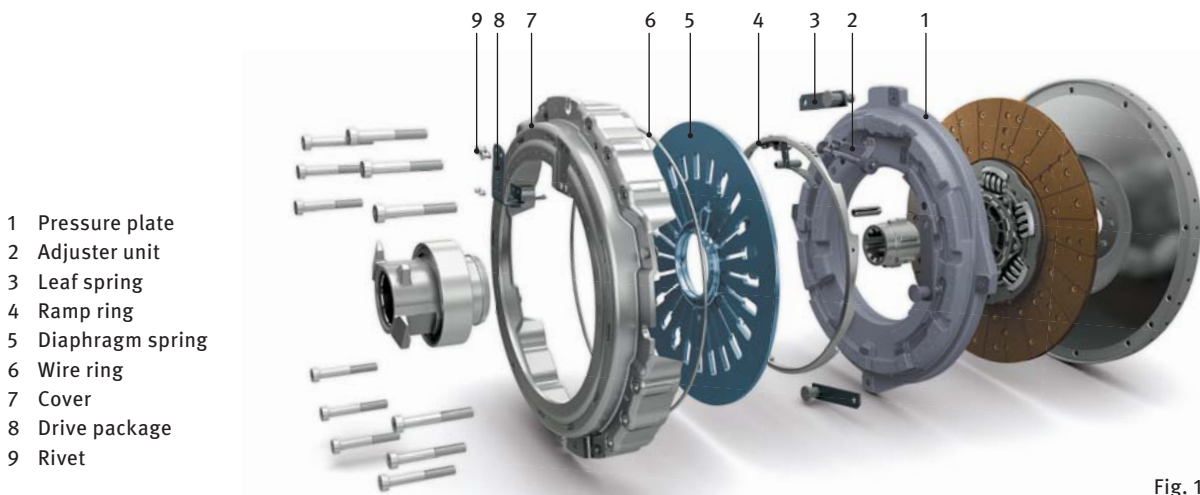


Fig. 14

Function

The diaphragm spring is connected to the drive pawl/adjuster spring (3) of the self-adjustment mechanism via a spacer bolt (1, Figure 15). Owing to the lift of the diaphragm spring, the spacer bolt is raised further as wear increases; the drive pawl is therefore also achieving a higher lift. This movement is transferred from the drive pawl/adjuster spring to the pinion equipped with teeth. If the thickness of the friction lining and hence the travel changes, the pinion turns.

In order to achieve finely tuned self-adjustment, there is also a detent (2) split into interim phases, as well as the drive pawl. This allows the pinion (2, Figure 16) to be turned in very small increments. The torsion of the

pinion drives the spindle (4) and induces an axial movement of the nut (5). This is fitted with a driver, which engages into the ramp ring (1). The transmission ratio between pinion and nut effectively compensates the height at the ramp ring in 2/1000 mm increments. A lining wear of 0.2 mm over the course of 100 clutch actuations can therefore be adjusted. There is no other system with such a sensitive self-adjustment mechanism. As a result, the operating comfort of the clutch remains at a constant high level from the start through to the wear limit. In addition, the minimum wear range of 6 mm is almost twice as great as the wear reserve in conventional clutch systems.

Sectional view of adjustment mechanism

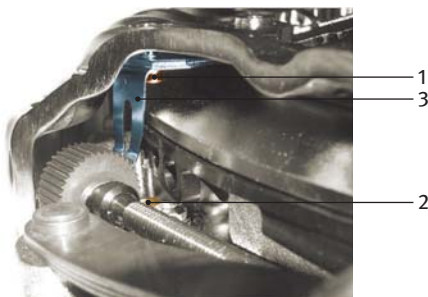


Fig. 15

Components of the adjuster unit

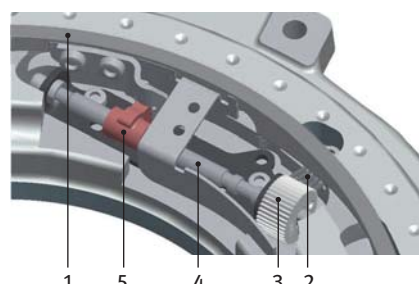


Fig. 16

3 Clutch Disc

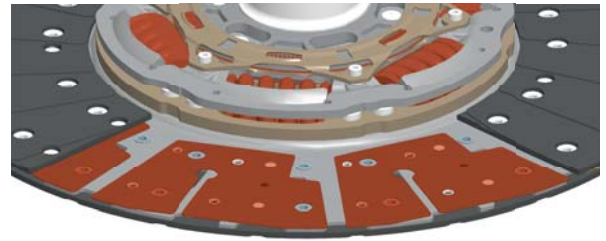
3.1 Function

The clutch disc is the mating component between the flywheel and pressure plate and as such transfers the engine torque to the transmission input shaft.

To synchronize the engine and transmission speeds and to transfer engine torque, friction linings are used. The friction linings must not only fulfill the technical requirements of low wear, a consistent frictional coefficient and smooth torque build-up, but also comply with current environmental standards. The linings used on the clutch discs are developed and produced by Schaeffler Friction Products.

Clutch discs can be designed to meet the particular requirements of the vehicle model concerned. The cushion deflection influences both the torque build-up when moving away and also the ergonomically synchronized pedal force curve as the clutch engages. As well as standard versions with individual segments, multiple-wave double segments are used for demanding applications. A uniform bearing area is achieved by supporting the linings effectively. This reduces the running in and sagging under temperature and minimizes changes in cushion deflection throughout the disc life.

Individual segments



Double segments

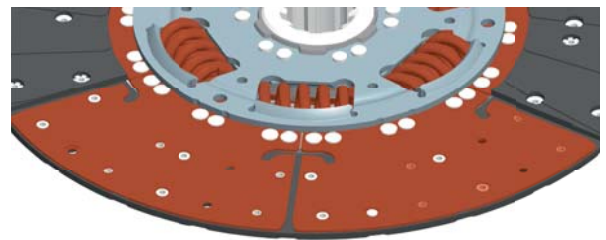
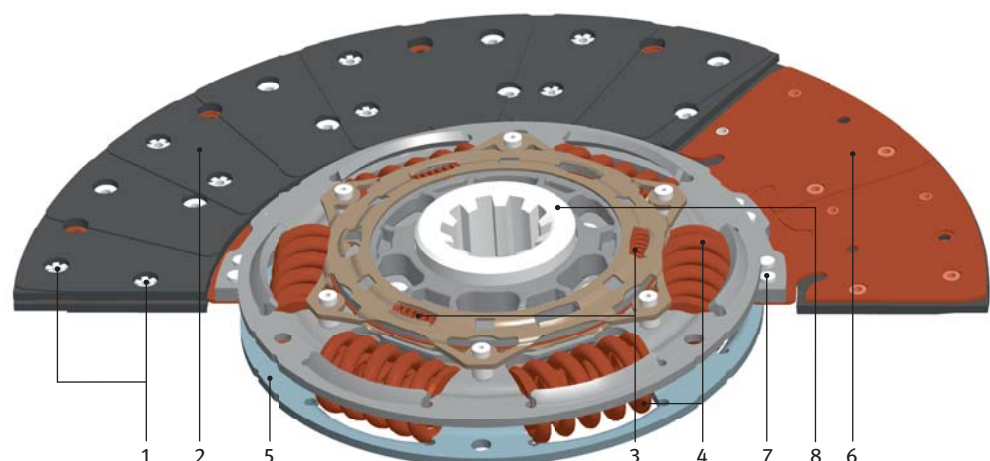


Fig. 17

3.2 Clutch Disc with Torsional Damper

Torsional dampers are used to reduce the rotational irregularities induced by internal combustion engines that create vibration in the transmission and lead to undesirable noise.

Clutch disc with various spring damping systems (multi-stage)



- 1 Friction lining rivets
- 2 Friction lining
- 3 First stage damper (idle or low shock absorber)
- 4 Main damper (shock absorber)
- 5 Hub flange
- 6 Axial spring segment
- 7 Spring segment rivet
- 8 Hub

Fig. 18

Meeting current comfort requirements, despite weight-optimized and fuel-efficient powertrains, calls for ingeniously designed spring damping systems with friction control elements. The challenge is to align separate torsional damper characteristics with defined spring stiffness and a friction damper (hysteresis) for each operating condition or load.

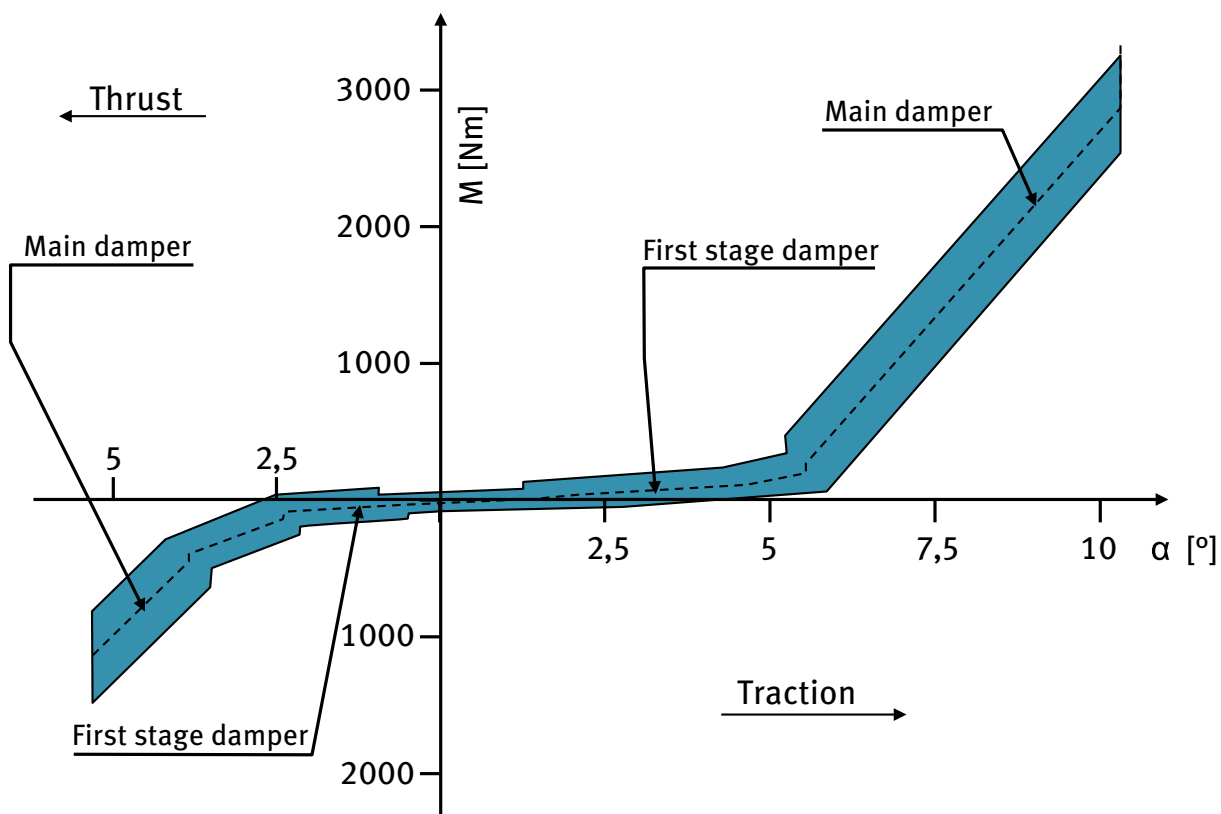


This is achieved using the different clearance angles of the springs, amongst other things. This means that, e.g., the internal springs of the main damper are shorter than the external springs in multi-stage torsional dampers. At a low engine torque, i.e. at a small rotation angle, only the longer external springs are therefore in use. If the engine torque increases, the rotation angle also increases and the shorter springs engage.

In addition, the friction can be adjusted to the different engine torques in multiple stages to achieve optimum damping.

The torsional damper characteristic curve can therefore be adapted to the vehicle manufacturer's specific requirements. The solutions available range from multi-stage designs with the best vibration-related adjustment for all characteristics to solutions with first stage dampers for idle speed or single-stage characteristic curves.

First stage dampers are only “active” at idle speed and enable the idle speed to be reduced. They also reduce wear on the toothed gears and, if present, on the synchronizer. Possible transmission or idle rattle is minimized and driving comfort increased.



Example: torsion damper characteristic curve with rotation angle in relation to the transferred engine torque.

Fig. 19

3.3 Designs

Clutch disc with single-stage torsional damper



Fig. 20

Torsional damper characteristics:

- Single-stage torsional damper with defined spring stiffness and friction damper

Advantages of torsional dampers:

- Reduction of vibration and noise in the powertrain
- Smooth torque build-up when starting up
- Compensation of the offset between the transmission input shaft and the crankshaft without functional impairment

Clutch lining characteristics:

- Specially tuned cushion deflection

Clutch lining advantages:

- Smooth torque build-up when starting up
- Safe torque transmission through partial compensation of the thermal deformation of flywheel and pressure plate
- Enables ergonomic pedal forces

Clutch disc with multi-stage torsional damper, and separate first stage and main dampers

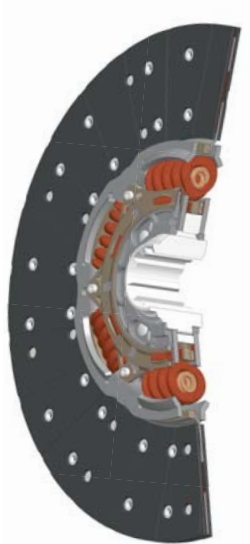


Fig. 21

Torsional damper characteristics:

- Multi-stage torsional damper with separate first stage and main dampers
- The individual dampers take effect sequentially (one after the other) (Figure 19)
- The individual stages are adapted to the respective load conditions and can be defined independently

Advantages of torsional dampers:

- Reduction of vibration and noise in the powertrain, designed specifically for weight-optimized and fuel-efficient transmissions
- Improved vibration damping
- Smooth torque build-up when starting up
- Compensation of the offset between the transmission input shaft and the crankshaft without functional impairment
- Reduces wear on toothed gears

Clutch lining characteristics:

- Specially tuned cushion deflection

Clutch lining advantages:

- Smooth torque build-up when starting up
- Safe torque transmission through partial compensation of the thermal deformation of flywheel and pressure plate
- Enables ergonomic pedal forces

4 Clutch Lining

4.1 Conventional Clutch Lining

The clutch lining is one of the most heavily stressed power transmission components. In most cases, the clutch lining is riveted to the clutch disc and, in connection with the clutch pressure plate and flywheel, it creates first a sliding and then an adhesive friction system. The main challenge is to transfer the engine torque to the transmission with maximum comfort in all operating states.

Dry couplings were already in use in the early motor vehicles. Linings made of beech or oak were used as a friction material. The invention of phenolic resin at the beginning of the 20th century laid the foundations for the organic clutch lining technology that is usual today.

The benefits of phenolic resins were quickly recognized and they were used as a binder for brake and clutch linings. For the first time, it was possible to produce parts from an easily malleable mass that retained its shape after hardening, even in extreme heat.

There are two main types of clutch lining:

- Inorganic linings
- Organic linings, wrapped or pressed

The inorganic linings, also known as sintered or ceramic linings, are mainly used for the tractor sector. The advantage of these linings is a higher frictional coefficient $\mu \sim 0.4$ at temperatures of up to 600°C . By contrast, organic linings have a frictional coefficient of $\mu \sim 0.3$ and are able to withstand thermal loads of up to 350°C . The advantage of organic linings is the much better levels of comfort (less likely to judder). That is why they are still essential for the PC sector and most commercial vehicle applications.

Manufacturing processes

Organically wrapped clutch linings as we know them today have been manufactured since 1930. An impregnated ribbon forms the basis for this. Raw materials such as rubber, resins or extenders are dissolved in an organic solvent (e.g. toluene or water) to manufacture solvent-based ribbon. Self-produced yarn made from glass, copper, aramid and synthetic fibers are first of all passed several times through a tank containing dissolved raw materials (friction cement). The yarn absorbs the friction cement within the tank. The impregnated yarn is then routed through a drying tower, where the solvent is evaporated and recovered in a complex process. The raw materials used have a major influence on the properties of the friction lining.

Solvent-based ribbon production

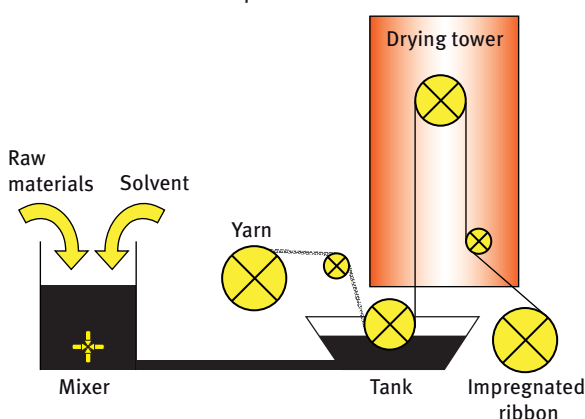


Fig. 22

Solvent-free ribbon production

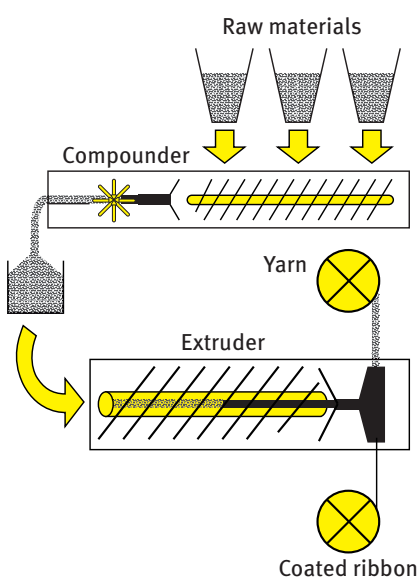


Fig. 23

Looking back over the history of clutch linings, it should be noted that technical advances in clutches have for a long period had only a minimal impact on clutch lining technology and manufacture. This changed with the newly developed solvent-free manufacturing process.

The impregnated or coated ribbons are used to mechanically produce the wrapped parts (Figure 25) in the next process step. Hydraulic presses are then used to form the pressed parts using pressure and high temperatures. Special furnaces with different temperature programs control the hardening process, which lasts up to 30 hours. Finally, the pressed parts are ground to the required size, drilled and impregnated against dust or corrosion.

Different clutch lining designs



Fig. 24

Wrapped part



Fig. 25

In contrast to solvent-based ribbon manufacturing, in the solvent-free process, the raw materials are kneaded to a friction cement (Figure 26) or compounded (mixed together) and then granulated. This has the advantage that, due to the extreme toughness of the kneaded mass, no settling or floating of the raw materials takes place, as happens when solvents are used. The granular friction cement is then softened again in an extruder (screw press) under high pressure and at a high temperature to coat the yarn. This trend-setting process, which dispenses with solvents, produces significantly less CO₂ than solvent-based production, due to the lower level of energy consumption. However, the main benefit is the much larger selection of raw materials that can be used as they are not determined by the solvent. This significantly improves the performance of the clutch linings. In addition to the frictional coefficient, wear and ease of movement (tribological properties), which have been improved by using the new, solvent-free ribbon manufacture, there are various design and material solutions that have a positive effect on the mechanical properties of the lining (strength and thermal resistance).

Granular friction cement



Fig. 26

This manufacturing process created specific opportunities for developing the lining. One example is organic “sandwich” technology. The so-called sandwich design connects two different wrapped parts pressed together to form an inseparable unit.

The friction layer (first wrapped part) can be specifically optimized in terms of tribological properties without needing to consider strength. The strength is increased by using a special carrier layer (second wrapped part).

Stages of lining manufacture

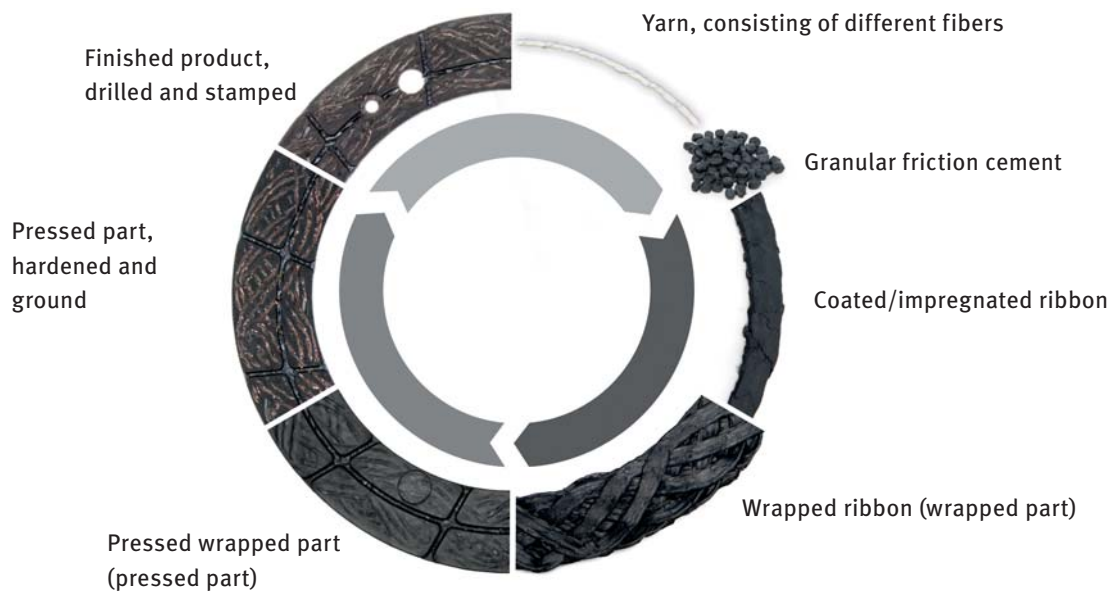


Fig. 27

4.2 HD 30 PLUS Clutch Lining

The HD 30 PLUS clutch lining is a sandwich-design lining made from two different wrapped parts (see chapter 4.1). The bottom layer is designed for high temperature resistance, dimensional stability and strength. The lining material used for the surface layer is designed for the highest possible level of friction, a low wear rate and optimum comfort characteristics. This two-part construction of the friction lining allows optimum interaction of all required properties.

The material used is free from asbestos and lead and does not contain cadmium, mercury or hexavalent chromium. It therefore conforms to legal requirements, conserves resources and is environmentally friendly.

HD 30 PLUS exhibits outstanding wear behavior even under high thermal stress, excellent burst strength, high thermal stability and good fading stability and so satisfies all quality criteria and produces excellent comfort characteristics.

These properties result in less downtime and fewer failures, significantly improved efficiency and — depending on load stress and driving style — an increase of up to 30 % in the durability of the clutch system.

HD 30 PLUS is used on all common LuK clutch discs with diameters of 362 mm, 395 mm and 430 mm.

Conventional friction lining

A compromise must be found to unite all of the required properties in a single lining.

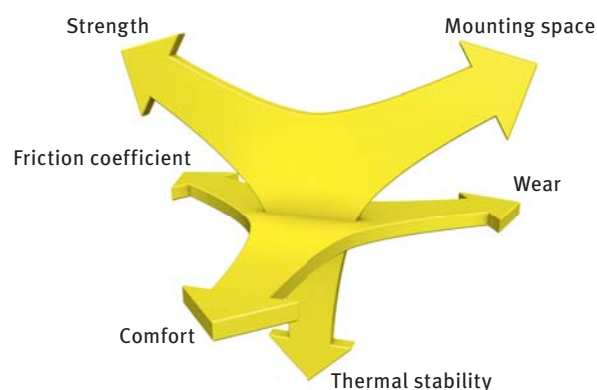
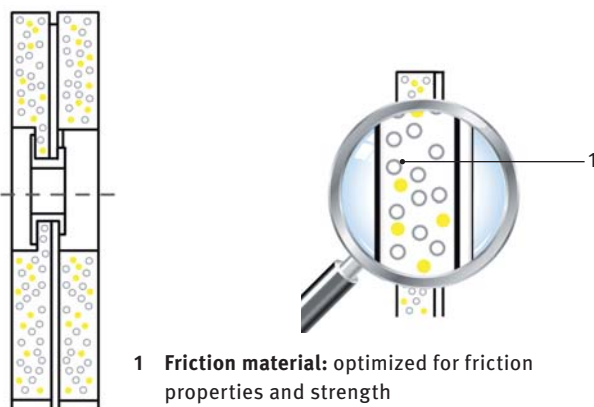


Fig. 28

The latest generation of LuK friction linings

Using the HD 30 PLUS clutch lining optimizes the friction layer (front lining) properties noticeable to the driver. The structure of the carrier layer (rear lining) guarantees strength and thermal stability. This two-layer structure enables all demands on the clutch lining to be satisfied to the optimum level.

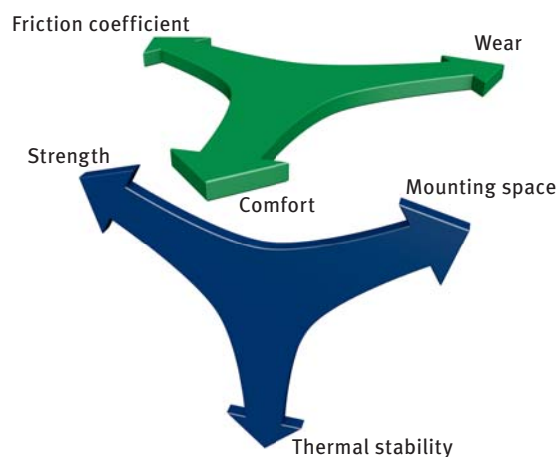
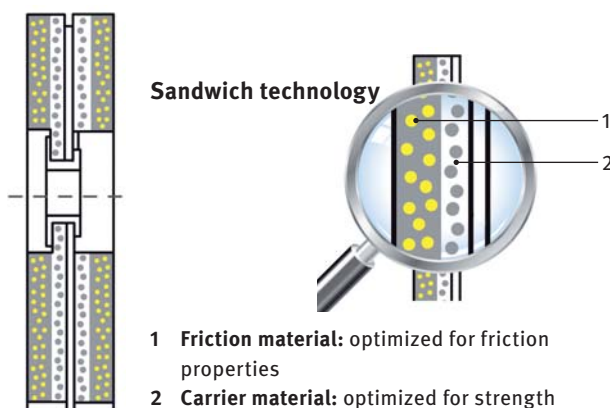


Fig. 29

5 Release System

For vehicles with manually operated dry clutches, the pedal force applied by the driver needs to be amplified using a mechanism and transmitted to the clutch. Vehicle developers have come up with various solutions to perform this function.

Hydraulic or hydraulic-pneumatic clutch control is used in modern foot-actuated clutches. In principle, a distinction is made between four systems:

- Semi-hydraulic
- Hydraulic-pneumatic
- Fully hydraulic
- Pneumatic

Semi-hydraulic systems contain a hydraulic and a mechanical line. The hydraulic line consists of a master

cylinder on the pedal, a pipe and a slave cylinder on the outside of the transmission. The mechanical part includes the release lever and the release bearing.

The hydraulic-pneumatic system structure corresponds to that of the semi-hydraulic system. However, the purely hydraulic clutch slave cylinder is replaced by a hydraulic-pneumatic clutch booster (Figure 30) in this system.

The fully hydraulic and the pneumatic systems contain no mechanical line. The functions of the transmission-side release mechanism are taken over by a concentric slave cylinder (CSC) or a concentric pneumatic clutch actuator (CPCA). This is directly located in the bell housing between the transmission and the clutch.

Clutch booster



Fig. 30

5.1 Master Cylinder

The master cylinder (Figure 31) consists of a housing, a piston with piston rod and a configuration of two seals (primary and secondary). It has a hydraulic connection for the pressure line to the slave cylinder. The hydraulic connection is generally designed as a quick connector. However, some applications still use the screw connections such as those conventionally used in brake technology. The master cylinder also has a connection for supplying the system with hydraulic fluid. In the PC sector, the master cylinder is often connected to the brake fluid reservoir via a hydraulic line connection. However, the commercial vehicles sector exclusively uses solutions in which the clutch cylinder has its own reservoir.

The primary seal separates the reservoir from the hydraulic pressure chamber. It allows the pressure build-up required to actuate the clutch. The secondary seal separates the low-pressure area of the reservoir from its surroundings. When the pedal is released, a spring on the pedal or in the master cylinder ensures that the piston moves back fully. The connection between the reservoir and the pressure chamber is open when the pedal is in the resting position. Trapped air in the system is now able to escape and liquid can flow in. This is where the self-adjusting mechanism of the hydraulic system comes into play.

Master cylinder



Fig. 31

5.2 Hydraulic Pressure Line

The hydraulic pressure line is based on the brake lines in the vehicle. The hydraulic pressure line consists of a hose and a steel tube or completely of plastic. A hose is required for the steel tube to offset movements between the vehicle's powertrain and chassis. The prescribed progression of the line must be maintained in any case to ensure that there is no contact with other components in the engine compartment. Effective heat protection must be implemented for plastic lines and hoses that are placed in the vicinity of hot zones, such as turbo chargers or exhaust manifolds.

5.3 Slave Cylinder

In a semi-hydraulic system, the slave cylinder is located outside the bell housing and is used to activate the release lever. The slave cylinder consists of a housing, the piston and seal, a preload spring and a vent screw. The preload spring ensures a permanent preload of the release bearing, so that this also rotates reliably with the clutch in a pressure-free state of the release system, and undesirable noise between the bearing and diaphragm spring fingers are prevented. The vent screw allows for the filling and bleeding of the system in case of maintenance.

5.4 Hydraulic Concentric Slave Cylinder

Fully hydraulic systems are equipped with a concentric slave cylinder (CSC). This consists of a ring-shaped hydraulic cylinder with a built-in release bearing located in the clutch bell between the transmission and the clutch, positioned centrally in relation to the transmission input shaft. This eliminates the need for a lever in the bell housing, which is the format used for slave cylinder arrangements. Additionally, this system has a high degree of design flexibility in terms of the placement of the hydraulic line in the engine compartment.

Hydraulic concentric slave cylinder



Fig. 32

5.5 Concentric Pneumatic Clutch Actuators

Concentric pneumatic clutch actuators (CPCAs) are used exclusively in commercial vehicles with auto-shift gearboxes. In contrast to hydraulic concentric slave cylinders, CPCAs are operated pneumatically. The supply of compressed air is controlled by the transmission controller. However, the arrangement and operation of both solutions are identical. The advantages of this system are savings in terms of mounting space and weight, plus a significant reduction in part variety.

Concentric pneumatic clutch cylinder



Fig. 33

5.6 Preload Spring

The preload spring can be fitted in the slave cylinder, the concentric slave cylinder or the clutch booster. The preload spring ensures that the thrust ring is always in contact with the fingers of the rotating diaphragm spring. This arrangement compensates for manufacturing tolerances and reduces wear on the clutch system.

5.7 Release Bearing

The release bearing forms the link between the rotating diaphragm spring on the engine side and the immovable release mechanism on the transmission side. It is operated on a flange-mounted sleeve in the bell housing. The guide sleeves of release bearings and concentric slave cylinders are designed such today that the thrust ring can be move radially by a defined amount. As a result, a central position in relation to the diaphragm spring fingers of the clutch is achieved at all times in drive operation. This self-centering action reduces wear in the area of the diaphragm spring fingers and thereby compensates possible misalignment between the engine and transmission. Angular contact ball bearings are used to transfer the release forces to the clutch pressure plate. This design can transmit high axial forces, is resistant at high speeds and can be used up to an operating temperature of 150°C.

Release bearing for pull-type clutches

In contrast to the standard clutch, the power flow for this design is interrupted by pulling on the diaphragm spring fingers. As a connection element, generally a locking plate with a lock washer and retaining clip is used on the diaphragm spring.

Release bearings for pull-type clutches are thereby secured using a mounting kit to the diaphragm spring of the clutch pressure plate. In this case, it is necessary to distinguish between release bearings that are already mounted on the clutch pressure plate, and those that are inserted in the diaphragm spring only once the clutch has been installed in the vehicle.

Release bearings have a high service life and are maintenance-free due to permanent lubrication.

Release bearing for push-type clutches



Fig. 34

Release bearing for pull-type clutches



Fig. 35

5.8 Work on the Release System

Clutch control

Clutches in commercial vehicles can be actuated purely hydraulically or with compressed air support. Clutch slave and master cylinders are used at low actuation forces. At higher actuation forces, the hydraulic slave cylinder is combined with a master cylinder supported by compressed air. Clutch boosters are available in many variants that meet the most diverse requirements in terms of force, lift and interfaces.

Clutch control systems are essentially available in three different configurations:

1. Purely hydraulic system without compressed air support. In these systems, the master cylinder is located on the pedal unit in the cab, and is supported by the slave cylinder that is usually located on the bell housing. The master cylinder is connected to a compensation tank by a hose. The compensation tank is filled with brake fluid or hydraulic oil, depending on the system.

The hydraulic fluid (brake fluid or hydraulic oil) absorbs water as a result of being used in the vehicle. This can result in damage to the seals or to the development of noise at the master cylinder. To prevent this, it is necessary to replace the hydraulic fluid at least every two to three years. When choosing the replacement fluid, it is strongly recommended that the recommendations of the respective vehicle manufacturer be followed. The maintenance of a hydraulic release system is normally limited to the replacement of the hydraulic fluid. Similarly to the brake, the fluid is refilled by pumping on the pedal and synchronous opening and closing of the vent screw. So that the rinsing process is carried out as completely as possible and no air bubbles can enter the system, the specific recommendations of the vehicle manufacturer should also be considered in such cases. Cleanliness is imperative during all work on the hydraulic system. Even the smallest contaminations due to dirt particles can result in leakage and malfunctioning. For systems that are designed for brake fluid, mineral oil may under no circumstances enter the interior. For this reason, the cylinders or the connectors must not be relubricated. Even the smallest amounts of mineral oil can result in the destruction of the seals.

2. Hydraulic system with compressed air support. In these systems, the master cylinder (or servo cylinder) is also located on the pedal unit in the cab and is also supported by compressed air. The clutch booster is located on the bell housing. The clutch booster absorbs the pressure from the master cylinder and transfers it to the clutch.

3. Electro-pneumatic system for automated transmissions. With this solution, there is no clutch pedal (see chapter 5.9). The shifting process is transmitted electronically by a selector lever in the passenger compartment. The signal is transmitted to the electro-pneumatic actuator that is also located on the bell housing.

Release fork, shaft and bearing arrangement

The release shaft must always be removed to assess damage because a test in the installed state is impossible. The release fork, release shaft and all bearing arrangements in the release system must be checked and replaced if necessary. A run-in or worn bearing arrangement eventually leads to misalignment of the release fork and therefore to stiffness and/or grabbing. The bearing arrangement must always be lubricated.

Release lever/bearing arrangement

Professional corrective maintenance of a clutch includes an inspection of the clutch release lever and its bearing arrangement. During this inspection, the supporting surfaces of the lever and the counter bearing in the transmission must be examined carefully for signs of wear. If there is pronounced wear, the components must be replaced.

Guiding sleeve

The guiding sleeve must be positioned absolutely centrally and exactly parallel to the main transmission shaft. Pressure or wear points on the sleeve can interfere with the sliding of the release bearing and result in grabbing or slipping of the clutch. Damaged or worn guiding sleeves must always be replaced, as this represents one of the main reasons for stiff clutch operation.

Release bearing

A functional test of the release bearing in the workshop is not possible. Even a worn thrust ring inevitably leads to noise. The release bearing must therefore generally be replaced when the clutch is replaced. After installation it must slide easily on the guiding sleeve. Release bearings with plastic guiding sleeves must not be greased.

Concentric slave cylinder (CSC)

To prevent damage to the CSC, the following procedure is recommended during installation:

- Install the CSC and manually hand tighten the bolts
- Mount the hydraulic line adapter (if present)
- Tighten bolts according to information from the vehicle manufacturer

5.9 Auto-Shift Gearboxes

Auto-shift gearboxes are available in various levels of development — from partially automated manual transmissions with clutch pedals to the latest, fully automated manual transmissions. The fully automated transmissions are no longer designed to use a clutch pedal. The pedal is folded away in the footwell and is optional. The entire shifting process is electronically transmitted to the gearbox controller using a selector lever and a connected bus system. The gear best suited to the current driving situation is automatically engaged.

This reduces interference by the driver to a minimum, e.g. in the form of choosing an inappropriate gear or moving off with a slipping clutch.

The more precise clutch processes in auto-shift gearboxes reduce wear on the clutch. Furthermore, gearbox synchronizers can be dispensed with completely. Commercial vehicle downtime is minimized accordingly.

In the latest generations, the control units are now even using GPS data. The optimum gear is engaged at exactly the right time according to the topography stored in a cloud, coupled with intelligent speed control, e.g. before an uphill or downhill gradient.

As the engine is always driven in the best possible operating range, fuel consumption and thus the total operating costs are reduced.

In fully automated systems, a suitable configuration or “learning procedure” (see chapter 6) must be performed after replacing the clutch, as specified by the information provided by the vehicle manufacturer.

6 General Notes

Lubrication

When it comes to the clutch and release system, the message “less is more” always applies. Thanks to modern materials, additional lubricants are no longer essential. However, there are still some older systems on the market that must be provided with lubricant at precisely defined points. The choice of medium depends on the information provided by the vehicle manufacturer. In the absence of any specification, a temperature and age-resistant, high-performance grease with MoS₂ can be used (e.g. Castrol Olista Longtime 2 or 3). Professional greasing of the transmission input shaft and the clutch disc hub is recommended as follows:

- Apply grease to the clutch disc hub and gearing of the transmission input shaft
- Guide the clutch disc onto the transmission input shaft in three different angular positions, and then remove the clutch disc
- Remove excess lubricant from the hub and shaft

Please note:

Chemically nickel-plated hubs (recognizable from the slightly silvery sheen of the surface) must not be greased.

Flywheel

When replacing the clutch, it is advisable to check the friction surface of the flywheel for wear marks, such as scores, hot spots or discoloration. It is crucial that these marks are removed, since they impair the function of the new clutch. The rework, i.e. the grinding/truing, must remain within the tolerances specified by the vehicle manufacturer. It is important to ensure that the clutch mounting surface is finished to the same dimensions as the contact surface. At the same time, the ring gear should also be visually inspected. The mounting bolts must be replaced each time they are loosened.

Pilot bearing

Unobtrusive and small, but extremely effective in the event of a malfunction: The pilot bearing, also known as guide bearing, guides the transmission input shaft and is therefore essential to clutch functionality. The pilot bearing should be inspected, and if necessary changed, whenever the clutch is replaced.

Rotary shaft seals

Even slight traces of oil and grease significantly impair the function of the clutch. Traces on the bell housing or on the clutch indicate leaks. With older, high-mileage vehicles, the rotary shaft seals around the clutch should generally be replaced.

Clutch disc

Weight-optimized discs react to rough treatment with lateral runout. It is therefore advisable to check lateral runout prior to installation if the packaging is missing or damaged. The maximum permissible lateral runout is 0.5 mm.

Centering

The centering of the clutch disc is key to the correct installation of the transmission and to the clutch function. Centering ensures that the transmission input shaft can be smoothly guided through the hub profile of the clutch disc during installation. This prevents the risk of damage to the clutch disc or to the hub profile.

Clutch learning process

The final point of clutch repair for vehicles with automatic transmissions is the learning process. After a clutch replacement, the electronic system no longer recognizes the exact position of the clutch. This leads to malfunctions in the control of various systems, which are often interpreted incorrectly as clutch disengagement problems. The control unit must therefore “learn” the engagement and disengagement points of the new clutch. This is known as the “minor learning procedure”. A “major learning procedure” must be performed only if the entire gearbox is replaced.

As the minor learning procedure can differ from vehicle to vehicle, it must be performed in line with the vehicle manufacturer's specifications.

7 Failure Diagnosis

It is extremely important to know the exact nature of the complaint if the cause is to be remedied. This facilitates subsequent troubleshooting, which can lead to one or several possible causes. Perform a visual inspection or control measurement on the parts either while they are still mounted or once removed. This process will provide information concerning the correct failure Diagnosis and suitable repair or replacement work on the affected clutch components.

The most common causes of complaints regarding clutches:

- Clutch does not disengage
- Clutch slips
- Clutch grabs
- Clutch makes noise
- Clutch operation is stiff

If a clear statement is given regarding the complaint, troubleshooting can be restricted to a specific area. One common error is to immediately begin disassembling the clutch components, which requires considerable effort in most cases. However, technicians often fail to first look for the fault in locations in which it could be remedied by relatively simple means. This involves looking at the area surrounding the clutch, such as at the release system. On closer inspection, a wide range of external influences that impair clutch function can be detected.

7.1 Clutch Disc

Burst lining

Cause:

- The clutch disc speed was higher than the burst speed of the lining. This condition occurs when the vehicle coasts with the clutch depressed, when the vehicle speed is higher than the corresponding maximum speed of the engaged gear. This damage is not related to the engine speed; the decisive factor is the speed of the main transmission shaft.

Impact:

- Clutch does not disengage

Solution:

- Replace the clutch



Fretting corrosion on the hub (rust film)

Cause:

- Hub splines not greased

Impact:

- The clutch grabs and does not disengage correctly

Solution:

- Remove rust and grease the hub splines; if necessary, replace the clutch



Axial runout by the clutch disc (lateral runout / deformation of disc assembly)

Cause:

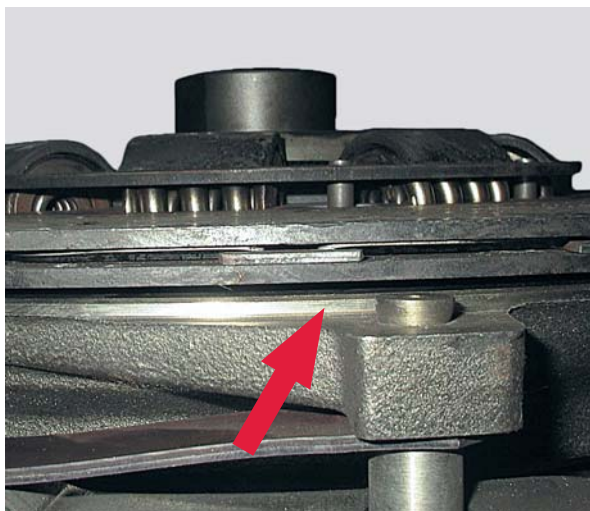
- Clutch disc was not checked for lateral runout before installation (max. 0.5 mm permitted)
- Shipping damage
- Assembly error
 - The clutch disc was deformed when the transmission and engine were connected
 - Engine or transmission dropped when being connected

Impact:

- Clutch does not disengage

Solution:

- Replace the clutch



Traces of overheating on the pressure plate and friction linings burned

Cause:

- Thermal overload caused by:
 - Driving error (allowing the clutch to slip for too long when moving off and shifting)
- The release system is stiff or defective
- Clutch disc worn beyond the wear limit

Impact:

- Clutch slips

Solution:

- Replace the clutch
- Check the flywheel and release system



Lining area carbonized

Cause:

- Thermal overload caused by:
 - Driving error (allowing the clutch to slip)
 - Rotary shaft seal on the engine/transmission leaking

Impact:

- Clutch slips

Solution:

- Replace the clutch
- Seal the leaks



Lining greasy or oily

Cause:

- Hub over-greased
 - Excess grease on the hub profile was not removed
- Rotary shaft seal on the engine or transmission is defective

Impact:

- Clutch slips

Solution:

- Replace the defective rotary shaft seal, clean the parts, replace the clutch if necessary



Lining worn down to the rivets

Cause:

- Lining wear
 - Vehicle was still driven despite the clutch slipping
- Driving error
 - Allowing the clutch to slip for too long
- Incorrect clutch
- Defective release system

Impact:

- Clutch slips

Solution:

- Replace the clutch, check the flywheel



Contact tracks on the torsional damper

Cause:

- Assembly error
 - Disc installed in the wrong position
- Incorrect disc or clutch

Impact:

- Clutch does not disengage and makes noises

Solution:

- Replace the clutch, ensuring that the correct installation position is selected



Lining scored on the flywheel side

Cause:

- Flywheel has not been replaced
- The friction surface on the flywheel was not reworked
 - Scores on the flywheel work themselves into the friction lining

Impact:

- Clutch grabs

Solution:

- Replace the clutch and flywheel



Hub profile damaged

Cause:

- Assembly error
 - The transmission shaft was forced into the hub splines of the clutch disc (clutch disc was not centered during installation)
- Wrong disc

Impact:

- Disengagement problems, possibly because the clutch disc can no longer slide freely on the transmission input shaft

Solution:

- Replace the clutch, check the transmission input shaft



Cover plate on the torsional damper has been destroyed

Cause:

- Driving error
 - Torsional damper overstressed by driving at a low engine speed
- Defective release system
- Incorrect clutch disc installed

Impact:

- Clutch makes noise

Solution:

- Replace the clutch, check the flywheel
- Replace the defective parts of the release system



Hub profile deformed

Cause:

- Missing or defective pilot bearing
- Parallel or angular offset between the engine and transmission
- Defective bearing arrangement on the main transmission shaft or transmission input shaft
- Vibration damage
- Worn splines on the transmission input shaft

Impact:

- Clutch makes noise

Solution:

- Check the pilot bearing and replace if necessary
- Check the bearing arrangement on the transmission shafts
- Replace the clutch



7.2 Pressure Plate

Pressure plate broken

Cause:

- Overheating of the pressure plate as a result of allowing the clutch to slip for too long (driving error)
- Release system stiff
- Slave cylinder defective

Impact:

- Clutch slips

Solution:

- Replace the clutch, and replace the flywheel and slave cylinder if necessary



Tangential leaf spring broken

Cause:

- Play within the powertrain
- Operating error
 - Shifting error
 - Vehicle towed incorrectly

Impact:

- Clutch does not disengage

Solution:

- Replace the clutch, check the powertrain



Tangential leaf spring deformed / buckled

Cause:

- Play within the powertrain
- Operating error
 - Shifting error
 - Vehicle towed incorrectly
- Incorrect storage/transport
 - Clutch dropped before or during assembly

Impact:

- Clutch does not disengage and grabs

Solution:

- Replace the clutch



Worn diaphragm spring fingers

Cause:

- Preload on the release bearing is not OK

Impact:

- The clutch grabs, slips, makes noises

Solution:

- Check the release system (preload spring)



Pressure plate greasy or oily

Cause:

- Hub over-greased
 - Excess grease on the hub profile was not removed
- Rotary shaft seal on the engine or transmission is defective

Impact:

- Clutch slips

Solution:

- Clean the parts and replace the clutch if necessary



Broken cam

Cause:

- Clutch dropped
- Shipping damage

Impact:

- Clutch does not disengage

Solution:

- Replace the clutch



7.3 Flywheel

Flywheel exhibits temper colors, scoring and heat cracks

Cause:

- Thermal overload caused by:
 - Driving error (allowing the clutch to slip)
 - Flywheel was not reworked/replaced

Impact:

- Clutch grabs

Solution:

- Replace the clutch and flywheel



Centering edge of the flywheel is broken

Cause:

- Assembly error
 - External centering was not considered
 - Mounting bolts were tightened unevenly

Impact:

- Clutch does not disengage

Solution:

- Replace the flywheel



7.4 Release system/Transmission shaft

Worn release fork

Cause:

- Defective release system
 - Defective guide sleeve
 - Defective bearing arrangement on the release shaft

Impact:

- Clutch makes noise

Solution:

- Replace defective parts



Worn release fork mount on the release bearing

Cause:

- Worn release fork
 - Worn bearing arrangement on the release shaft
 - Worn guide sleeve

Impact:

- Clutch makes noise

Solution:

- Check the release system, replace defective parts



Release fork shaft is stiff

Cause:

- Worn bearing arrangement on the release fork

Impact:

- Clutch grabs

Solution:

- Check the release fork shaft and replace the shaft if necessary
- Check the release bearing



Worn transmission input shaft

Cause:

- Transmission input shaft was not greased/replaced
 - Clutch disc jams on the splines and can therefore not disengage

Impact:

- Clutch grabs

Solution:

- Check the transmission input shaft and replace the shaft if necessary
- Check the clutch, replace it if necessary



Guide sleeve for the release bearing shows traces of run-in wear

Cause:

- Worn guide sleeve
- Release bearing sleeve was not greased/was greased incorrectly
- Bearing arrangement on the release fork is worn and the release fork is misaligned

Impact:

- Clutch grabs

Solution:

- Replace the guide sleeve and release bearing
- Repair the bearing arrangements in the release system



7.5 Clutch Booster

Clutch is having problems disengaging and is grabbing

Cause:

- Clutch was not configured
- Clutch was configured incorrectly
- Tappet on the clutch booster was not set accurately

Impact:

- Clutch grabs

Solution:

- Configure the clutch according to the information from the vehicle manufacturer
- Adjust the tappet on the clutch booster



8 Overview of Fault Causes

The fault causes and associated solutions listed below are divided into possible complaints to simplify the troubleshooting process.

Clutch does not disengage

This is not necessarily caused by the clutch itself. Often, malfunctions are related to the release system or a defective pilot bearing. In addition, important installation instructions have often not been followed.

Feature	Cause	Solution
Tangential leaf springs are bent	<ul style="list-style-type: none"> – Clutch pressure plate dropped – Tip-in-back-out clunk 	<ul style="list-style-type: none"> – Replace the clutch pressure plate – Check the powertrain
Cover is bent	<ul style="list-style-type: none"> – Centering pin not considered – Incorrect mounting/incorrect handling/shipping damage 	Replace the clutch pressure plate
Excessive lateral runout of the clutch disc	Shipping damage/incorrect handling (lateral runout not checked — max. 0.5 mm)	Align or replace the clutch disc
Lining seized with rust	Vehicle not used for a long period of time (high humidity)	Remove rust on seized parts (including the lining surface)
Linings are sticking	Linings oily/greasy	Replace the clutch disc/seal the area around the clutch
Clutch disc is sticking on the transmission shaft	<ul style="list-style-type: none"> – Hub profiles are deformed – Hub is seized with rust – Incorrect grease used – Profile of hub or transmission shaft is worn 	<ul style="list-style-type: none"> – Rework the hub profile – Ensure free-running and lubrication – Use grease without solid content – Replace the clutch disc or transmission shaft or both
Clutch disc dimensions are not OK	Incorrect clutch disc installed	Use the correct parts
Torsional damper is touching other parts	<ul style="list-style-type: none"> – Clutch disc installed backwards – Incorrect clutch disc 	Install the correct clutch disc in line with specifications
Guide sleeve is worn	<ul style="list-style-type: none"> – Incorrect release bearing installed – Incorrect pairing – Not greased (pairing of metal to metal) 	<ul style="list-style-type: none"> – Replace the guide sleeve – Use the correct parts – Lubricate
Pilot bearing is defective	<ul style="list-style-type: none"> – Wear – Angle or parallel offset between the engine and transmission 	Replace the pilot bearing
Release travel is too short	<ul style="list-style-type: none"> – Air in the hydraulic system – Defective master/slave cylinder 	<ul style="list-style-type: none"> – Bleed the system – Replace the defective components and bleed the system

Clutch slips

In addition to a defective clutch disc and pressure plate, there may be other causes for the clutch slipping. Clutch slipping is often caused by a defective

release system. Furthermore, an incorrectly reworked flywheel or the installation of an incorrect clutch may be the cause.

Feature	Cause	Solution
Pressure plate is overheating	<ul style="list-style-type: none"> – Thermal overload (e.g. caused by allowing the clutch to slip) – Incorrect parts – Diaphragm spring broken – Oily 	<ul style="list-style-type: none"> – Replace the entire clutch – Seal the area around the clutch
Clutch linings are worn	<ul style="list-style-type: none"> – Normal wear – Allowing the clutch to slip for too long – Clamp load too low 	Replace the entire clutch
Clutch linings are oily/greasy	<ul style="list-style-type: none"> – Oil leaking from the rotary shaft seal (on engine/transmission) – Hub profile over-greased – Grease loss from the release bearing (overheating) 	<ul style="list-style-type: none"> – Replace the sealing ring – Replace the clutch
Friction lining on the flywheel side exhibits scoring	Scoring on the flywheel running surface	Rework the friction surface on the flywheel and replace the flywheel if necessary
Friction surface on the flywheel is deeper than the mounting surface (does not apply to a dished flywheel)	The mounting surface was not turned by the same degree when reworking the friction surface on the flywheel	<ul style="list-style-type: none"> – Rework the entire flywheel – Replace the flywheel
Guide sleeve is worn	Not lubricated/incorrectly lubricated (only for metal guide sleeves)	<ul style="list-style-type: none"> – Replace the guide sleeve – Lubricate correctly
Stiff operation	<ul style="list-style-type: none"> – Worn bearing arrangement on the release shaft – Bearing arrangement on the release shaft not lubricated – Worn guide sleeve 	<ul style="list-style-type: none"> – Replace bushes – Lubricate

Clutch grabs

A defective engine bearing or an inaccurate engine setting can prevent smooth clutch engagement. Installing an incorrect clutch can also cause the clutch to grab.

Feature	Cause	Solution
Pressure plate lifts at an angle	Bent/buckled tangential leaf spring(s)	Replace the clutch pressure plate
Lining is oily/greasy	<ul style="list-style-type: none"> – Rotary shaft seal defective (on engine/transmission) – Hub profile over-greased – Grease loss from the release bearing (due to overheating) 	<ul style="list-style-type: none"> – Replace sealing ring and clutch disc – Replace the clutch disc – Replace the release bearing
Incorrect clutch disc		Use the specified clutch disc
Stiff operation	<ul style="list-style-type: none"> – Wear or stiffness on the bearing arrangement of the release system – Worn guide sleeve – Defective master or slave cylinder 	Replace worn or defective components
Air in the hydraulic system for the clutch	Leaking/defective hydraulic system	Replace defective components if necessary and bleed in line with the manufacturer's specifications
Guide sleeve is worn	Not greased/incorrectly greased	<ul style="list-style-type: none"> – Replace the guide sleeve – Use the specified grease
Engine/transmission mounting	Suspension defective/deformed	Repair or replace the suspension
Pilot bearing is defective	Angular or parallel offset between the engine and transmission	<ul style="list-style-type: none"> – Replace the pilot bearing – Check the centering of the engine and transmission
After replacing the clutch or the piston rod, the vehicle grabs in various driving situations	<ul style="list-style-type: none"> – Clutch was not configured – Clutch was configured incorrectly – Tappet on the clutch booster was not set accurately 	<ul style="list-style-type: none"> – Configure the clutch according to the information from the vehicle manufacturer – Adjust the tappet on the clutch booster

Clutch makes noise

Whistling noises are often caused by eccentric contact of the release lever, a defective pilot bearing or an eccentric transmission input shaft. Incorrect installation of the clutch disc or installation of incorrect parts

can also cause noises. Clutch discs with first stage dampers can cause clicking noises when the load changes. However, this does not impair the function of the clutch disc.

Feature	Cause	Solution
Vibrations when the engine is running	Clutch imbalanced (due to e.g. incorrect assembly/shipping damage)	Replace the pressure plate and/or clutch disc
Incorrect clutch disc	Torsional damper does not match the vehicle	Install the correct clutch disc
Torsional damper has been destroyed	<ul style="list-style-type: none"> – Incorrect clutch disc installed – Play within the powertrain (universal shafts) – Incorrect driving behavior (e.g. driving at a low engine speed) 	<ul style="list-style-type: none"> – Use the specified clutch disc – Eliminate wear in the powertrain
Release bearing is defective	<ul style="list-style-type: none"> – Grease loss due to overheating – Fault in the release system 	<ul style="list-style-type: none"> – Replace the release bearing – Repair the release system
Pilot bearing is defective	Pilot bearing is worn or missing	Replace the pilot bearing
Diaphragm spring fingers have run in	Incorrect preload on the release bearing (slave cylinder is defective)	<ul style="list-style-type: none"> – Replace the slave cylinder – Replace the clutch

Clutch operation is stiff

The clutch disc, pressure plate or flywheel are very rarely the cause in these cases. The fault is often in the release system and in the related components,

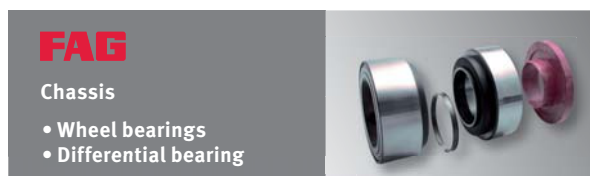
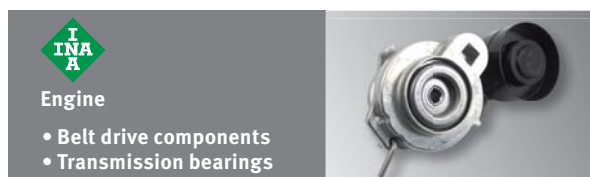
e.g. the release bearing, release shaft or guide sleeve.

Feature	Cause	Solution
Incorrect clutch pressure plate	Release load is too high	Use the correct clutch pressure plate
Guide sleeve is worn	<ul style="list-style-type: none"> – Release bearing is corroded – Incorrect pairing – Not greased – Incorrectly greased 	<ul style="list-style-type: none"> – Replace the guide sleeve – Use the correct combination – Lubricate – Use grease without solid content
Release shaft bearing is worn	<ul style="list-style-type: none"> – Worn bushings – Bearings not greased 	<ul style="list-style-type: none"> – Replace the release shaft – Lubricate

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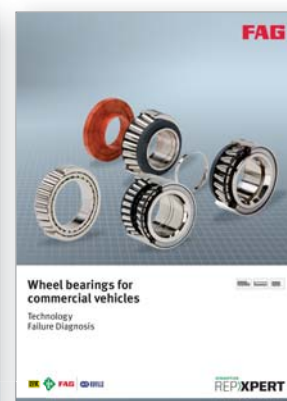
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