

Tooth Clutch and Brakes

– A Designers Guide

Publication
No.

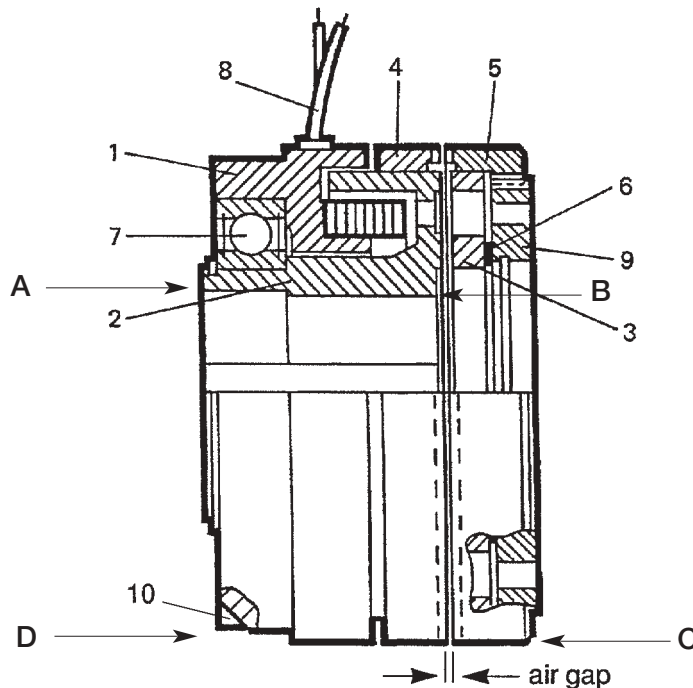
306

Page 1 of 6

March 1998

This leaflet aims to give background information and help to the Design Engineer in the selection and use of Mönninghoff tooth clutches and brakes. Further guidance is available from our Bedford office and we welcome involvement in detail machine design work.

1. How it works



Typical tooth clutch

Bearing mounted design
546.XX.3

KEY

- 1 Stator
- 2 Rotor
- 3 Armature
- 4 Toothed ring
- 5 Armature toothed ring
- 6 Spring
- 7 Ball bearing (2RS)
- 8 Flying leads
- 9 Adaptor plate
- 10 Recess to stop rotation

Tooth clutches transmit torque from a shaft with keyway through the rotor (2). When the coil in the stator (1) is energised, the armature (3) is pulled into contact with the rotor (2). This meshes the armature toothed ring (5) and toothed ring (4) on the rotor, so allowing the torque to be transmitted from rotor to armature toothed ring (5). When the stator (1) is de-energised, the armature (5) is withdrawn by a flat prestressed spring (6), on some models coil springs are used.

Thus torque can be transmitted from shaft to adaptor plate. The clutch will equally well transmit torque in the reverse direction.

2. Mounting

Alignment between rotor and armature is critical and both should be mounted from one shaft with a bearing supporting the armature. This easily allows offset drives with belts or chains. For in-line drives a flexible coupling should be used, see examples below.

Care should be taken in handling the clutch to prevent distortion of the rotor (2). Do not hammer the assembly, apply force at point A and B, not at C & D.

Flange mounted clutches design 546.XX.1 differ in that the stator (1) is separately mounted to a square and concentric surface. Higher running speeds are possible, but the costs of accurate mounting are generally higher than the cost saving compared with the bearing mounted design.

Slip ring clutches design 550.XX.1 combine the stator and rotor into one piece with power supplied to 1 or 2 slip rings with brushes. This arrangement achieves shorter lengths, higher torques on many sizes and lower costs although brushgear requires maintenance.

Armatures are available in two designs. Types 4 and 6 have tapped holes in the adaptor plate for bolts to come in from outside the clutch. Types 5 and 7 have clearance holes for bolts to come in from the rotor side, the bolt head sits inside the armature plate.

Holes are also provided in the adaptor plate for dowel pins. If the connecting bolts can be supplied in high tensile material and torque tightened correctly, then

Lenze

Lenze Ltd. Caxton Road, Bedford MK41 0HT
Tel: 01234 321321 • Fax: 01234 261815
EMail: sales@lenze.co.uk • www.lenze.co.uk

dowel pins are unnecessary. Otherwise they should be fitted. The bore of the adaptor plate is toleranced and a circlip groove is provided so that a bearing can be fitted between the adaptor plate and the shaft which will ensure concentricity. Use shims and a spacer between this bearing and the rotor to set the air gap which is measured between the crowns of the two sets of teeth. Dry running or running in an oil mist is possible. Do not immerse the clutch. Oils should be of a viscosity up to $24 \times 10^{-6} \text{ m}^2/\text{s}$ at 50°C ($3^\circ\text{E}/50^\circ\text{C}$). Vertical mounting is possible. Where the armature is downwards, no modification is needed. Where the armature is at the top consult Lenze to ensure coil springs are fitted. Avoid placement of ferrous parts close to the inside diameter of the armature (3) which can interfere with the path of the magnetic flux. Maintain an air gap in excess of 3 mm radially.

3. Engagement speeds

Clutches are designed for static or low speed engagement. The maximum speed depends on the inertias, frequency of engagement, flexibility in the drive and the tooth form of the clutch. Standard teeth typically are limited in a range 10-40 r/min, other tooth forms can allow engagement up to about 200 r/min. Disengagement can be done at high speed.

4. Selection

Tooth clutches will reliably transmit the torques given in the tables. When selecting a size, it is important to consider the peak load and the dynamic behaviour of the drive. Tooth clutches – contrary to friction clutches – must never be overloaded. Therefore safety factors must be considered. The transmittable torque of the tooth clutch must always be higher than the largest possible torque that occurs.

As slipping engagement is not permissible, the selection of the tooth clutch is always made by torque:

$$M = 9550 \frac{P}{n} \cdot K \text{ (Nm)}$$

$$M = (M_L + M_B) \cdot K \text{ (Nm)}$$

$$\text{requirement } M_{\ddot{u}} \geq M$$

P = kW

n = min-1

K = safety factor 1.5 ... 2.5

M = torque required

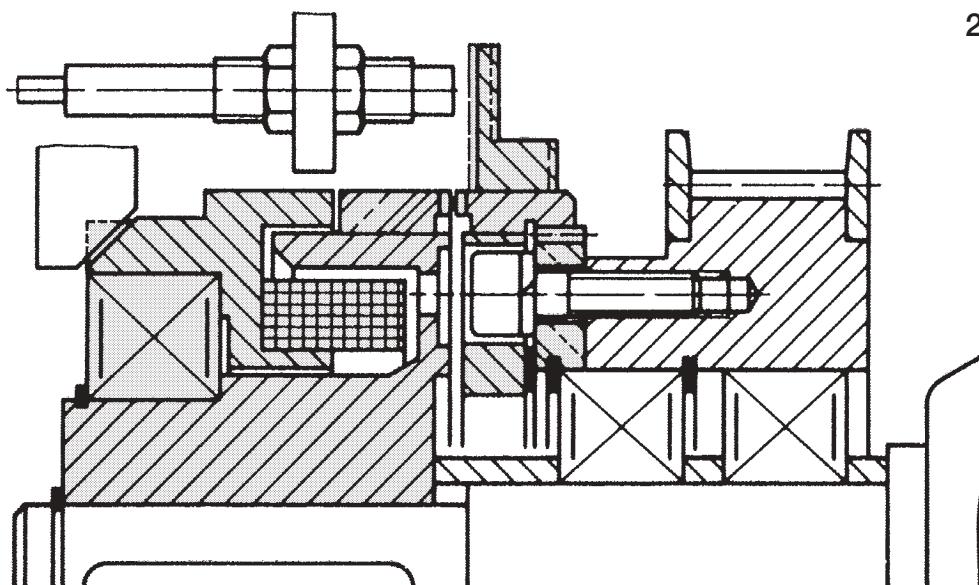
M_L = load torque

M_B = acceleration torque

$M_{\ddot{u}}$ = nominal torque of clutch

5. Mounting examples

We supply the parts shown shaded



25 – 2200 Nm

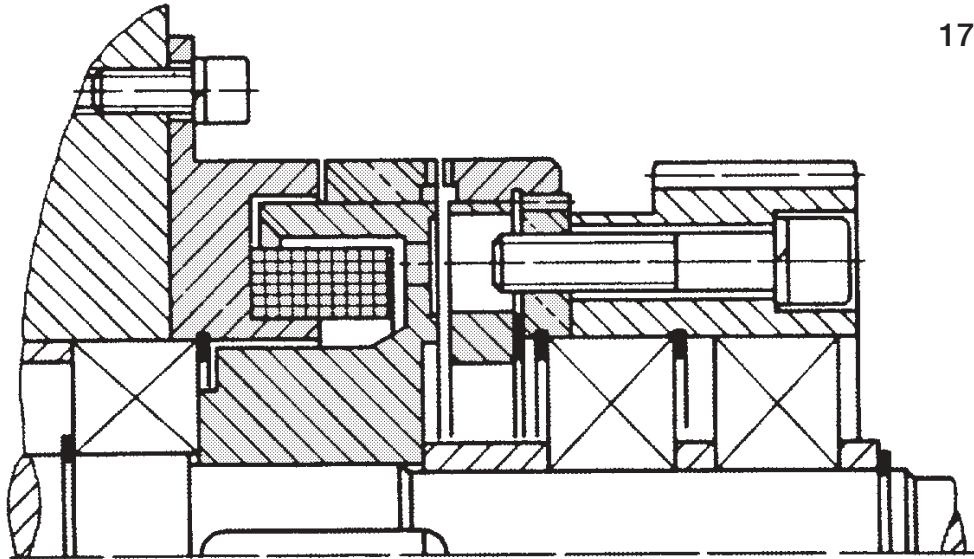
546.XX.3 clutch with switch ring, driving pulley

This two piece clutch is shown with the stator/rotor on the left hand side and the armature on the right. This armature has clearance holes to allow the bolt threads to pass through into the pulley, plus a switch ring fitted to the outside which allows clutch engagement/disengagement to be detected. It is termed the armature type 7, i.e. clutch type 546.XX.3.7.

A loose fitting tag is used to prevent rotation of the stator. The armature is mounted concentrically by means of a ball bearing location on its inside diameter. The complete assembly is spaced and locked axially so that no rotor movement can occur (alternatively an end cap could have been used). Air gap measured between the teeth is set by a spacer between the left hand ball bearing and the rotor.

Lenze

Lenze Ltd. Caxton Road, Bedford MK41 0HT
 Tel: 01234 321321 • Fax: 01234 261815
 EMail: sales@lenze.co.uk • www.lenze.co.uk

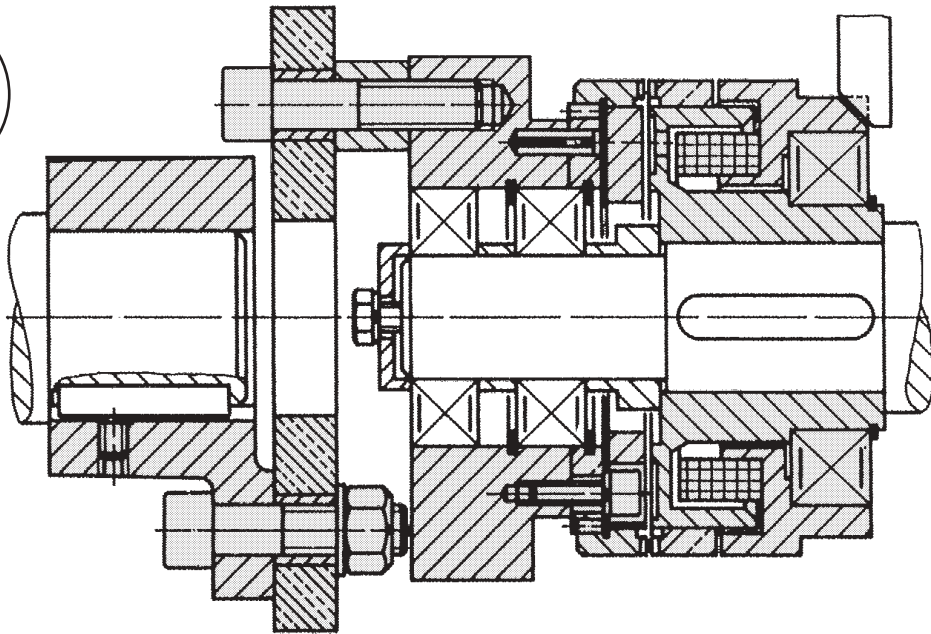


546.XX.1 clutch driving a gear

This three piece clutch design has a separately mounted stator. Accurate mounting of the stator is essential as radial air gaps are small. Here a ball bearing provides concentricity. An armature type 4 is used with threaded holes which accepts a bolted connection from outside the clutch.

A bearing inside the adaptor plate ensures concentricity of the armature. Note the keyway runs for the full length of the rotor. Mönninghoff clutches can run dry or in oil. A spacer between rotor and the first bearing sets the airgap. Usually this is ground on assembly.

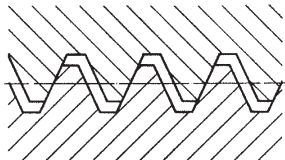
We supply the parts shown shaded



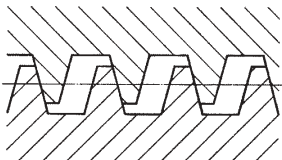
546.XX.3/313.XX clutch coupling

Where two shafts must be connected in line, it is essential to use a flexible coupling to accommodate the inevitable radial misalignment between shafts. This is a standard Mönninghoff solution where the clutch is supplied with adaptor and Hexaflex torsionally soft flexible coupling.

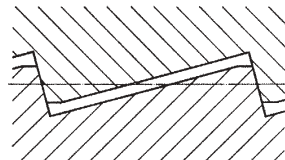
In this way the clutch is mounted on one shaft with bearings to ensure accurate alignment. The rubber Hexaflex coupling has torsional softness which allows higher engagement speeds (see below), and it allows typically 0.5 mm radial misalignment, 3° angular misalignment and 2-3 mm end float.



Standard toothform for torque transmission in both directions with minimal backlash

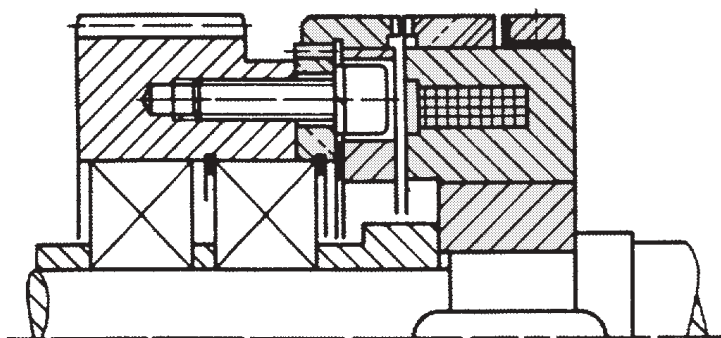


Spaced toothform for engagement at higher speeds with high backlash



Saw toothform allows engagement up to 100 – 200 r/min. Torque transmission in one direction only.

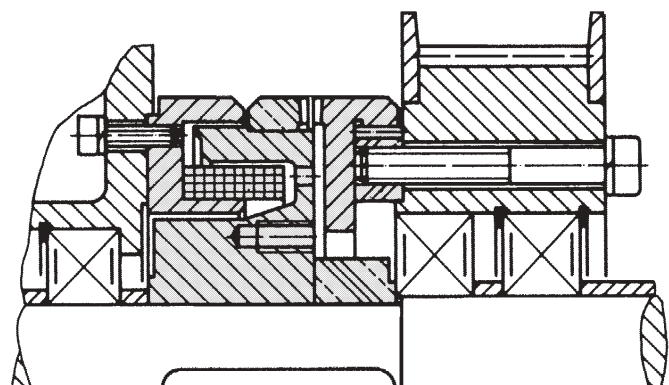
20 – 2200 Nm



550.XX.1 slip ring clutch driving a gear

This simple design with one piece coil and rotor is compact and strong. In this example an armature type 5 is shown making the assembly 550.XX.1.5. The bore of the rotor has hardened steel insert. Full length connection to a well fitted key is important. Note that a step in the shaft allows ball bearings to be selected that register inside the adaptor plate. Brushgear is not shown. Two types are available. The calliper type has two spring loaded brushes and mounts from a pillar. Spark plug types mount radially through a plate. Use of two brushes is recommended (and essential for oil running) with the +ve to the brushes and -ve return line through the machine frame. For further details ask for Publication No. 236.

3200 – 10000 Nm

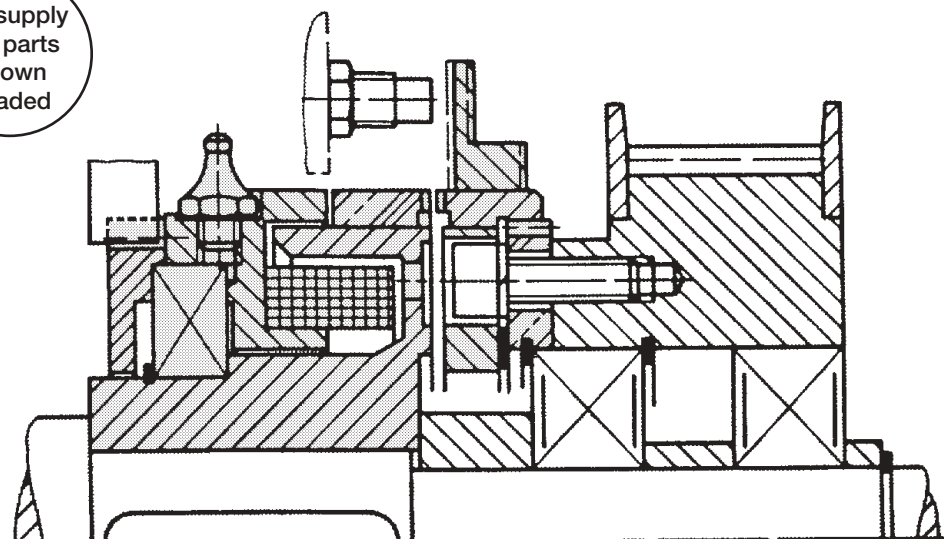


543.XX.2.4 clutch driving a pulley

The 543 range of stationary field clutches covers higher torques from 3200 to 10000 Nm (there is also a slip ring range up to 16000 Nm). Here the stator is mounted to a flat and square surface with a register to ensure concentricity. Only armature type 4 with tapped holes are available for this series. In this example the bearing does not directly register into the adaptor plate. It is important that bore of the pulley and the register for the adaptor are machined at the same set-up to minimise the possibility of concentricity errors.

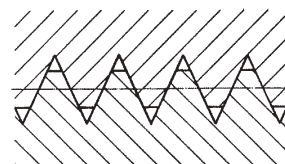
15 – 1500 Nm

We supply the parts shown shaded

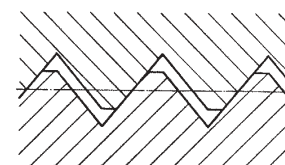


546.XX.5.7 clutch for torque limiting

This bearing mounted clutch illustrates the modifications that can be made to all clutches for torque limiting. The nature of tooth geometry means that tooth clutches give very accurate, fast acting and sensitive torque limiting at low or high speeds. Single position teeth are normally fitted to allow time for the clutch to be switched off before re-engagement occurs. A shallower tooth angle minimises friction effects and gives accuracy often better than $\pm 5\%$. A switch ring is



Standard toothform

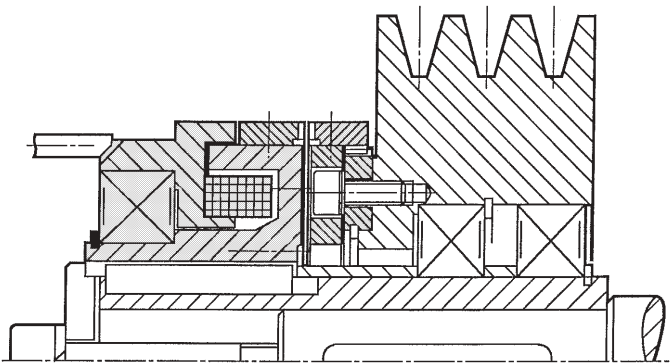


Torque limiting toothform

fitted to allow detection of overload as the teeth open. There is an optional controller type BEV which allows remote adjustment of the release torque. This example shows a clutch with a grease chamber with grease nipples to allow periodic re-lubrication of the stator bearing. This modification permits higher continuous running speeds and changes the type number from 3.7 to 5.7.

Lenze

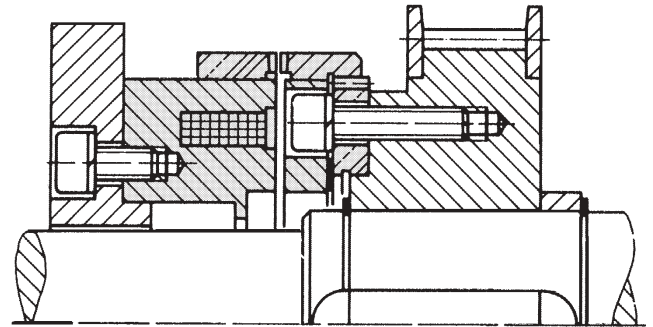
Lenze Ltd. Caxton Road, Bedford MK41 0HT
Tel: 01234 321321 • Fax: 01234 261815
Email: sales@lenze.co.uk • www.lenze.co.uk



546.XX.3.5 clutch mounted on a stub shaft

There is often not enough length available to mount clutches on the shafts of gearboxes and motor. Here we recommend the use of a sleeve to extend the shaft similar to this example. The large bore capacity of the Mönninghoff clutches makes this possible e.g. clutch 546.25.3.5 with torque of 500 Nm has a maximum bore of 55 mm.

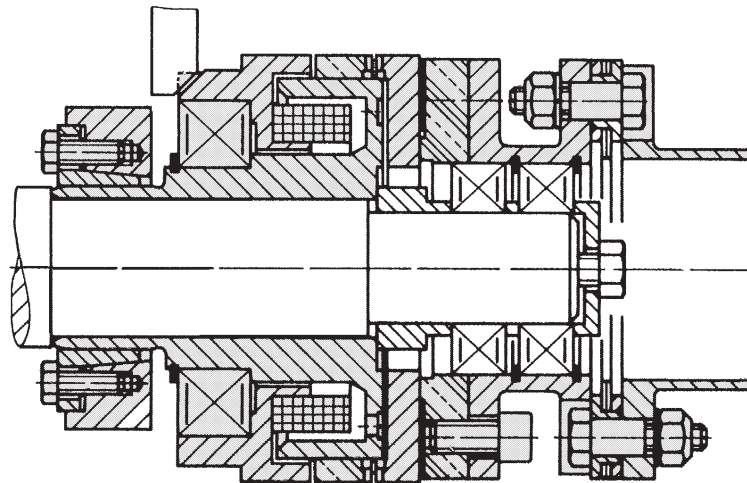
This arrangement keeps the pulley radial loads inboard close to the machine bearings. Note the use of an end cap to take out axial play, and a spacer between the rotor and the first bearing which sets the air gap. A tag is needed to prevent rotation of the stator. Connections to the stator can be either by flying leads or 2 pin AMP plug. The latter is better if there is any risk of failure of the anti-rotation tag as the plug disconnects without damaging the cables.



560.XX.4.5 brake for pulley

These energise to engage tooth brakes provide high slip free torque in a small size. The rigidity of the mounting generally means that engagement must be static or at very low rotation speeds. Typical applications are in rotating doors, turnstiles and turrets. As with all the tooth clutches, synchronising teeth are possible so a brake could engage and hold every 360°, 180°, 90°, Concentricity between stator and armature is particularly important and the air gap between the teeth tips must be set and maintained. An alternative range of **spring applied tooth brakes**, energise to release is available covering torques 10 – 350 Nm.

We supply the parts shown shaded

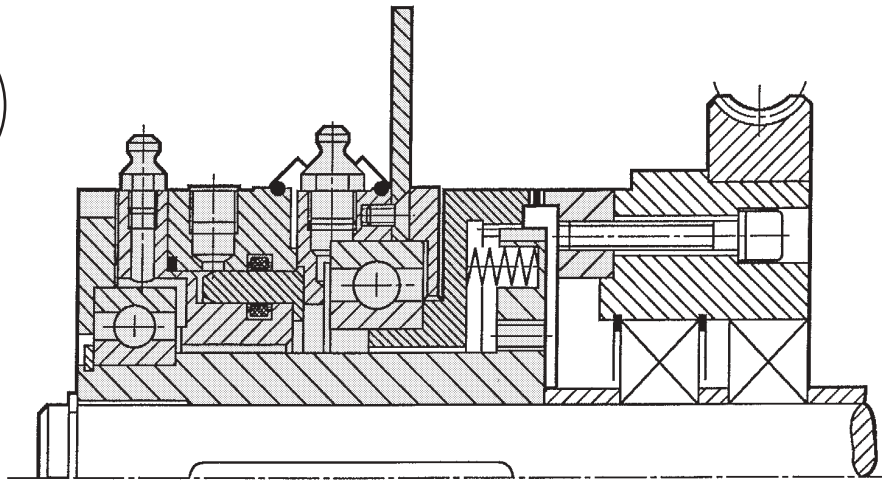


549.XX.7.4/318.XX.5.1 backlash free clutch coupling

Backlash free clutch connection is sometimes needed on machine tools and positioning systems. Such clutches are available in a torque range 25 – 300 Nm. There are two sources of backlash in the clutch, firstly a small amount in the drive teeth and here we machine to make this zero. Secondly there is backlash in the sliding splines of the adaptor plate. here fit a special backlash free diaphragm. In addition a keyway can be a source of

backlash and optionally we can supply with a keyless friction locking connection as above. This example shows a backlash free and torsionally rigid clutch coupling for an in-line drive, a standard Mönninghoff solution where we supply clutch plus adaptor plus torsionally rigid metal disc coupling. Clutches with rigid couplings can be supplied up to 2200 Nm.

We supply
the parts
shown
shaded

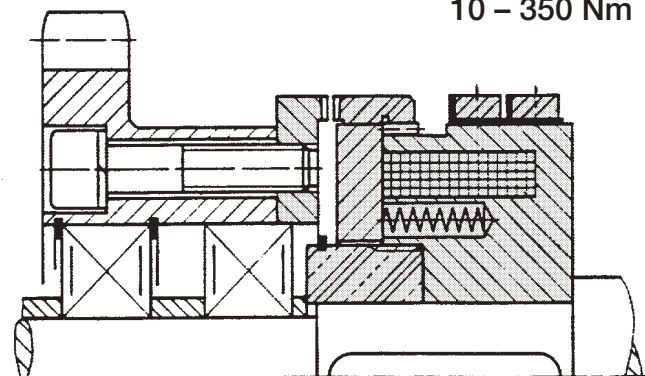


675.XX.4.4 pneumatic clutch driving worm wheel

Pneumatic clutches offer advantages of adjustable torque, good for torque limiting, they suit use in hazardous areas and can be connected to stay engaged if there is a power supply failure. This newly developed range from Mönninghoff features, stainless steel and bronze piston parts plus bearing lubrication for long life. There are no rotating air seals. When engaged there is an axial force

transmitted to the adjoining parts which must be accepted by the bearing arrangement. As usual concentricity is important. In this example the support for the worm wheel must be machined to minimise inaccuracy of the tooth ring. There should be no axial play with the clutch retained by circlip as here or by end cap.

10 – 350 Nm



548.XX.2.1 spring applied clutch driving a gear

Normally on, energise to release clutches are available. This example shows a slip ring type which can be supplied with one or two brush tracks. Springs in the clutch body press away the armature plate and tooth ring, thus meshing the teeth. When the coil is energised the armature plate is pulled back disengaging the teeth. The clutch is supplied with a bronze bushing and circlip to retain the armature plate for transit and assembly. An axial force when de-energised is exerted onto the gear support bearings. In this example the normal alignment method of putting a bearing into the bore of the toothed ring is shown. A second range of **spring applied clutches** exists with stationary field and covers a torque range 100 to 1600 Nm.

6. Other literature

Technical details including dimensions and torques are given in our Stockline catalogue for types 546, 550 and tooth brakes. Other models including large clutches, zero backlash models, clutch couplings and spring applied clutches are detailed in our Mönninghoff clutch catalogue. Both publications are available from our Bedford office.

Publication
No.

306

Page 6 of 6

March 1998

Lenze

Lenze Ltd. Caxton Road, Bedford MK41 0HT
Tel: 01234 321321 • Fax: 01234 261815
Email: sales@lenze.co.uk • www.lenze.co.uk