

Tunnel boring machine

The invention relates to a tunnel boring machine according to the features of the preamble of claim 1.

Such a tunnel boring machine is known from CN 207829897 U. This tunnel boring machine has a number of sliding tubes, in each of which one excavation tool is slidably mounted for a tool change. Furthermore, a number of load measuring elements are present, which are configured to measure the loads exerted on the excavation tools. The load measuring elements are integrated, together with simple connecting screws, into the connection between a ring collar connected to a sliding tube and a sliding tube receptacle. Therefore, a relatively high number of load measuring elements are required for sufficient measuring accuracy due to the construction-related force flows.

The invention is based on the object of specifying a tunnel boring machine of the above kind, which is characterized by a relatively accurate load measurement in excavation tools mounted in sliding tubes, accompanied by simple handling during a tool change.

This object is achieved in a tunnel boring machine of the above kind according to the invention with the features of claim 1.

Due to the fact that, according to the invention, at least some of the sliding tubes are designed with at least one load measuring element receptacle extending in the axial direction, which is designed to hold a load measuring element, the or each load measuring element can be installed and calibrated once in a firmly mechanically coupled manner and are then located in a force flow, which runs purely axially through the sliding tube, in the case of sliding tubes that are generally cylindrical in design, in which the or each load measuring element receptacle and the or each load measuring element installed in a load element receptacle experience essentially the same compression and extension. Therefore, the measurement accuracy of very few load measuring elements, possibly only a single load measuring element, of loads acting on the excavation tools is permanently relatively high and is not affected by a tool change.

Further expedient embodiments of the invention are the subject of the dependent claims.

Further expedient embodiments and advantages of the invention will become apparent from the following description of an embodiment with reference to the figures in the drawings.

Fig. 1 shows, in a front view, an embodiment of a cutting wheel of an exemplary tunnel boring machine according to the invention,

Fig. 2 shows, in a sectional view, an exemplary embodiment of an excavation tool displaceably mounted in a sliding tube, with load measuring elements integrated in the sliding tube,

Fig. 3 shows, in a sectional view, a load measuring element receptacle designed in a sliding tube and in a sliding tube flange, with a load measuring element arranged therein,

Fig. 4 shows, in a perspective view, an embodiment of a load measuring element,

Fig. 5 shows, in a perspective view, an embodiment of a mounting protective housing for receiving a connecting cable and an adapter cable for connection to a connection cable, and

Fig. 6 shows, in an illustrative view, an arrangement for wireless transmission of data provided by load measuring elements to a data processing unit.

Fig. 1 shows a cutting wheel 103 of an exemplary tunnel boring machine according to the invention, as viewed from the side facing the direction of advance and thus facing a tunnel face. The cutting wheel 103 has a number of cutting rollers 106 as one type of excavation tools. At least some of the cutting rollers 106 are arranged in tool receptacles 109 that are configured for a particularly pressureless tool change on the rear side located on the rear, in the direction of advance, of the cutting wheel 103.

Fig. 2 shows, in a sectional view, a cutting roller 106 arranged in a tool receptacle 109. The cutting roller 106 is mounted rotatably about a cutting roller axis 203 and displaceably in a cylinder-like sliding tube 209 of a sliding tube unit by means of a tool

fastening set 206, in order to perform a tool change. The sliding tube 209 is connected at its front end in the direction of advance to a sliding tube bearing ring 212 of the sliding tube unit, for example, by welding, via which the sliding tube 209 is mounted in the radial direction. At the end facing away from the sliding tube bearing ring 212, which is the rear end, in the direction of advance, the sliding tube 209 is connected to a sliding tube flange 215 of the sliding tube unit, for example, by welding.

The sliding tube flange 215 has an axial section 218 that is directly adjacent to the sliding tube 209 and connected to it, for example, by welding, and a radial portion 221 extending perpendicularly to the axial portion 218 in a radially outward direction. A number of screw recesses 224 are designed in the radial portion 221, through each of which a fastening screw 227 is passable.

The radial portion 221 rests with its forward side in the direction of advance against a sliding tube receptacle 230, which surrounds a rear region, in the direction of advance, of the sliding tube 209. The sliding tube receptacle 230 is designed with blind holes 233 that are aligned with the screw recesses 224 of the sliding tube flange 215 and have an internal thread, into which the fastening screws 227 for fixing the sliding tube flange 215 to the sliding tube receptacle 230 and thus for clamping the sliding tube 209 can be screwed in.

Furthermore, it can be seen from the illustration according to Fig. 2 that, in the illustrated embodiment, the sliding tube 209 has a number of load measuring element receptacles 236 which are designed in a blind hole manner and which extend from the end of the sliding tube 209 arranged at the rear, in the direction of advance, in the axial direction towards the end arranged at the front, in the direction of advance. In this embodiment, the axial portions 218 of the sliding tube flanges 215 are designed with a number of load measuring element bushings 239 corresponding to the number of load measuring element receptacles 236, which are aligned with the load measuring element receptacles 236.

Furthermore, it can be seen from the illustration according to Fig. 2 that a single load measuring element 242 is arranged in a single load measuring element receptacle 236 with an associated load measuring element bushing 239. Expediently, it is provided that

at least some load measuring element receptacles 236 with associated load measuring element bushings 239 have load measuring elements 242 arranged therein.

The sliding tube flange 215 carries at least one of the number of mounting protective housings 245 associated with the number of load measuring elements 242, which are arranged in the region of an associated load measuring element 242.

Furthermore, it can be seen from the illustration according to Fig. 2 that the sliding tube 209 with the associated sliding tube flange 215 is closable on the side located on the rear, in the direction of advance, by means of a closure arrangement 248.

Fig. 3 shows, in a sectional view enlarged in comparison to the illustration according to Fig. 2, a load measuring element 242 in an arrangement inserted into a load measuring element receptacle 236 and into a load measuring element bushing 239.

It can be seen from the illustration according to Fig. 3 that the load measuring element receptacle 236, which is designed in the sliding tube 209 in a blind hole manner, is designed in its closed end region to be conically tapered with a conical portion 303 and, adjoining the conical portion 303, with a first cylindrical portion 306. At the end opposite the conical portion 303, the first cylindrical portion 306 has an internally threaded region 309. The internally threaded region 309 of the first cylindrical portion 306 is adjoined, in the direction of the rear end, in the direction of advance, of the sliding tube 209, by a second cylindrical portion 312 which widens in cross-section compared to the first cylindrical portion 306, which opens into the load measuring element bushing 239 with a substantially identical cross section.

In turn, the load measuring element 242 has a front portion 315 which is designed in a lens-like rounded manner, which, in the illustration according to Fig. 3, rests against the conical portion 303 in the peripheral direction in a practically line-like closed manner. A head portion 318 adjoins the front portion 315 which expediently has a reduced cross-section compared to the front portion 315. The head portion 318 of the load measuring element 242 is adjoined by an externally threaded portion 321 which carries a complementary external thread to the internally threaded region 309 such that the load measuring element 242 is connectable to the sliding tube 209 as the only component via a screw connection with a tightening torque predetermined for one-time calibrating.

Therefore, the combination of the sliding tube 209 and the load measuring element 242 experiences the same loads in their axial direction, without significant strain decoupling occurring.

The externally threaded portion 321 continues into a neck portion 324, which is connected to the load measuring element bushing 239. In the region of the end region of the neck portion 324 facing away from the externally threaded portion 321, bearing rings 327, which are designed in an O-ring-like manner and are formed from a relatively soft elastic material, are present, which mount the end region of the neck section 324 in a manner that is damped against vibrations and secured against twisting by friction.

In a not illustrated modification, a load measuring element is designed with a relatively short neck portion 324 compared to the load measuring element 242 illustrated and explained with reference to Fig. 2 and Fig. 3, such that this load measuring element 242 is completely received by the load measuring element receptacle 236 designed in the sliding tube 209.

A connecting cable 330 emerges from the end of the neck portion 324 which is located in a cable feed-through chamber 333 designed in the sliding tube flange 215 and extends into a cable receiving chamber 336 designed in the mounting protective housing 245.

Due to the structure explained above, a relatively simple installation of a load measuring element 242 in a sliding tube 209 before mounting the sliding tube flange 215 is achieved, since the neck portion 324 is exposed in some regions and is therefore easily accessible for a tightening tool, in particular for a torque wrench.

In the modification with a relatively short neck portion, the load measuring element is mounted with a socket wrench that engages the load measuring element at the end facing the opening of the load measuring element receptacle 236.

Furthermore, the or each load measuring element 242 remains untouched after installation in the sliding tube 209 and subsequent calibration, even during a tool change, for example when cutting rollers 106 are replaced, and is protected by the then

mounted sliding tube flange 215, such that a tool change can be carried out relatively easily.

Fig. 4 shows a load measuring element 242 in a perspective view in the embodiment already explained with reference to Fig. 3. It is clearly evident from Fig. 4 that the front portion 315 is designed to be rounded and flattened, or also to be referred to as lens-like. The contact between the load measuring element 242 and the load measuring element receptacle 236, which is effected in a quasi-linear manner or in a narrow strip in the circumferential direction by means of the conical portion 303 of the load measuring element receptacle 236, results in a spatially defined and temporally unchanging introduction of force into the load measuring element 242.

Furthermore, it can be seen from Fig. 4 that in this embodiment a number of flat, platelet-like designed load sensor plates 403 are attached as load sensor parts to the head portion 318, which is located between the front portion 315 and the externally threaded portion 321 and has an angular, for example square, cross-section with flat outer portions. Mechanical deformations of the head portion 318 can be measured by means of the load sensor plates 403 and can be fed to the connecting cable 330 as electrical signals characteristic of the load on the sliding tube 209.

Fig. 5 shows, in a perspective view, an embodiment of a mounting protective housing 245 with associated components. The mounting protective housing 245 is attached to the sliding tube flange 215 by means of connecting screws 503 and receives in the one hand the end portion of the connecting cable 330 of the load measuring element 242 and in the other hand an adapter cable 506 in its cable receiving space 336. The adapter cable 506 is connected to the connecting cable 330 via an adapter plug connection 509 as a first connection and is connected to a connecting cable plug 512 as a further connection, which is arranged in a connection chamber 515 separate from the cable receiving chamber 336.

In order to ensure a reliable electrical contact under the rough environmental conditions during the operation of a tunnel boring machine, the connecting cable plug 512 is designed with external contact strips 518 that are relatively easy to clean.

A connection cable 521 is present for connecting the load measuring element 242, which carries a connection cable socket 524 at one end. The connection cable socket 524 can be inserted into the connection space 515 through a wall recess 527 made in the mounting protective housing 245 in the region of the connection cable plug 512 in a wall of the connection space 515 and is connectable to the connection cable plug 512.

Expediently, the bottom-closed cable receiving space 336 is closable with a closure cover 530 for protecting the intermediate plug connection 509, while the connection space 515 is open on both sides of the connecting cable plug 512 for relatively easy cleaning of the contact strips 518.

Fig. 6 shows, in an illustrative view, an arrangement for wirelessly transmitting data provided by load measuring elements 242 to a data processing unit 603. The arrangement according to Fig. 6 has a transmission module 606 that can be electrically connected to the or each load measuring element 242 via the connection cable 521, which is not illustrated in Fig. 6.

By means of the transmission module 606, the load signals output from the respective load measuring element 242 and characteristic of the loads exerted on the relevant sliding tube 209 can be fed via a wireless transmission path 609 to a receiving module 612, which in turn is connected to the data processing unit 603 via a connecting line 615.

By means of the data processing unit 603, the load conditions of the sliding tubes 209, which are recorded by means of load measuring elements 242, can be output, in particular in order to avoid, as far as possible, local critical stresses or even overloading of excavation tools connected to the relevant sliding tubes 209, such as, in particular, cutting rollers 106, by means of a corresponding less stressful operation of the tunnel boring machine.

CLAIMS

1. A tunnel boring machine having a number of sliding tubes (209) in each of which one excavation tool (106) is displaceably mounted for a tool change, and having at least one load measuring element (242) which is configured to measure loads exerted on excavation tools (106), **characterized in that** at least one load measuring element receptacle (236) extending in the axial direction is designed in at least some sliding tubes (209), and in that a load measuring element (242) is arranged in at least one load measuring element receptacle (236).
2. The tunnel boring machine according to claim 1, characterized in that the or each load measuring element receptacle (236) designed in a sliding tube (209) has an internally threaded region (309) and the load measuring elements (242) have an externally threaded portion (321) associated with the internally threaded region (309).
3. The tunnel boring machine of claim 2, characterized in that each load measuring element (242) comprises a front portion (315) and a head portion (318) extending between the front portion (315) and the externally threaded portion (321), wherein the front portion (315) and the termination of the load measuring element receptacle (236) designed in the sliding tube (209) are shaped in such a way that a line- or strip-like peripheral contact region is designed between the front portion (315) and the termination of the load measuring element receptacle (236) designed in the sliding tube (209).
4. The tunnel boring machine according to claim 3, characterized in that each load measuring element (242) is arranged on the head portion (318) of at least one load sensor part (403).
5. The tunnel boring machine according to claim 4, characterized in that each sliding tube (209) is connected to a sliding tube bearing ring (212) on the side opposite the load measuring element (242).

6. The tunnel boring machine according to claim 5, characterized in that each sliding tube (209) rests against a sliding tube flange (215) in the region of a load measuring element (242).
7. The tunnel boring machine according to claim 6, characterized in that the sliding tube flange (215) has a number of load measuring element bushings (239) corresponding to the number of load measuring element receptacles (236) designed in the sliding tube (209), which load measuring element bushings (239) are aligned with the respectively associated load measuring element receptacle (236).
8. The tunnel boring machine according to any of claims 1 to 7, characterized in that each load measuring element (242) is connected to a connecting cable (330) for outputting electrical signals.
9. The tunnel boring machine according to claim 8, characterized in that a mounting protective housing (245) is present into which the connecting cable (330) opens.
10. The tunnel boring machine according to claim 9, characterized in that an adapter cable (506) with two connectors (509, 512) is present which is arranged in the mounting protective housing (245).
11. The tunnel boring machine according to claim 10, characterized in that the adapter cable (506) is connected to a connecting cable plug (512) which is designed with external contact strips (518).
12. The tunnel boring machine according to claim 11, characterized in that the connecting cable plug (512) is arranged in a connection chamber (515) and in that a wall recess (527) is designed in a wall of the connection chamber (515) in the region of the connecting cable plug (512).