

The present invention relates to a system for fastening a cutting tool on a cutting head of a tunnel boring machine. The invention also relates to a tunnel boring machine comprising a cutting head including cutting tools fastened in the cutting head using such fastening systems.

5 Tunnel boring machines generally comprise a cutting head provided with knurling wheels, which are circular cutting tools that rotate around an axis and make it possible to drill out the rock in the form of scaled plates. Tunnel boring machines may also comprise scraping tools called "rippers". A cutting head thus includes a plurality of knurling wheels distributed regularly on its surface. Each of the knurling wheels is fixed to the housing on the
10 cutting head most often by a set of screws, wedges and nuts. Such fastening systems, in particular manufactured by the company Robbins, generally comprise several detachable elements such as wedges making it possible to lock the knurling wheel in position, locking screws for the wedges, and optionally tightening nuts. These elements must be disassembled one by one by operators when changing worn-out knurling wheels. In some of
15 these systems, the wedges are not secured to any other part. These manipulations involve assembling and transferring a large number of independent parts that can be lost, as well as tightening and loosening operations involving high torques. These systems must be manipulated by at least one operator having special equipment. The risk of certain objects falling or being lost makes maneuvers for changing knurling wheels time-consuming and
20 relatively impractical, those operations being performed inside tunnel boring machines under difficult conditions.

WO-A-2011/076616 describes a knurling wheel fastening system comprising a bayonet secured to the knurling wheel, and rotatable relative to a support of the knurling wheel between a first position, in which the edges of the bayonet are engaged in notches of
25 the housing in which the knurling wheel is mounted, and a second position, in which the knurling wheel can be removed from the housing. In order to lock the fastener for the knurling wheel in the housing, in the first position of the bayonet, a pre-stress is applied by means of screws inserted into holes of the bayonet.

During disassembly of the knurling wheel, the screws must first be loosened, then the
30 bayonet must be rotated so that the knurling wheel can be removed. Such a method therefore requires several distinct operations, in particular pivoting the bayonet, which makes this method complex.

The invention more particularly aims to resolve these drawbacks by proposing a new system for fastening a cutting tool on a cutting head of a tunnel boring machine, allowing the
35 cutting tools to be replaced more simply and quickly than in the systems of the prior art.

To that end, the invention relates to a system for fastening a cutting tool on a cutting head of a tunnel boring machine, comprising a housing secured to the cutting head, in which the cutting tool is inserted, the cutting tool comprising two flanges between which an active part is mounted, the fastening system also comprising retractable locking elements captively connected to the flanges and suitable for locking the flanges in the housing, the locking elements being movable relative to the flanges between a first position, in which the locking elements are engaged in the housing so as to lock the cutting tool in the housing, and a second position, in which the locking elements are freed from the housing and allow the cutting tool to be removed from the housing, characterized in that it comprises movement means connected to the cutting tool suitable for translating the locking elements between their first position and their second position, and in that those movement means are suitable for being actuated in a single operation.

Owing to the invention, the cutting tool, such as a knurling wheel or a ripper, is fastened in the housing owing to locking elements whose movement does not require means outside the fastening system other than a key. The disassembly and reassembly operations for the cutting tools are therefore quick and easy, and can in particular be performed by robots able to control the movement means.

According to advantageous but optional aspects of the invention, such a system may incorporate one or more of the following features, considered in any technically allowable combination:

- The locking elements are wedges able to be inserted in notches of the housing and the wedges comprise planar rear faces suitable for abutting against parallel faces of the notches oriented opposite the removal movement of the cutting tool from the housing.

- The movement means of the wedges comprise, for each flange, a screw mounted in a tapped hole of that flange, a tightening part mounted sliding on each screw, a ring mounted on each screw and suitable for translating the tightening part along a longitudinal axis of the screw, the wedges being mounted freely translating on each of the tightening parts, while the rotation of the screws causes the translational movement of the tightening parts between a first forward position, in which the wedges are engaged in the notches, and a second rear position, in which the wedges are freed from the notches.

- Each of the screws comprises a head allowing the actuation of the movement means of the wedges.

- Each of the tightening parts comprises two inclined faces relative to a median plane of the housing and the wedges are mounted freely translating along the inclined faces.

- In the first position of the tightening parts, a space exists between the rings and the flanges allowing additional tightening of the screws.

- In the second position of the wedges, front faces of the wedges are abutting against rear faces of the flanges.

5 - In the second position of the wedges and when the cutting tool is inserted in the housing, the distance between the faces of the notches oriented opposite the removal movement of the cutting tool from the housing and the rear faces of the flanges is greater than the width of the wedges.

10 - Each of the flanges has two lateral inclined faces forming a conical profile suitable for cooperating with a hollow portion with a corresponding shape arranged on an inner surface of the housing in the first position of the locking elements.

- The cutting tool is a knurling wheel whereof the rotating part forms the active part of the cutting tool.

15 - The cutting tool is a ripper comprising a base mounted between the flanges and a scraping part that is stationary or tilts relative to the base and forming the active part of the cutting tool.

The invention also relates to a tunnel boring machine comprising a cutting head including cutting tools fastened in the cutting head using fastening systems as described above.

20 The invention will be better understood, and other advantages thereof will appear more clearly, in light of the following description of a system for fastening a knurling wheel and a tunnel boring machine according to its principle, provided as a non-limiting example in reference to the appended drawings, in which:

- figure 1 is a side view of a fastening system according to the invention,

25 - figure 2 is a perspective view of a rear side of the fastening system of figure 1, in a first configuration,

- figures 3 and 4 are views similar to figure 2, in a second and third configuration of the system of figure 1,

- figure 5 is a top view of the system of figures 1 and 4, in the configuration of figure 4,

30 - figure 6 is a perspective view, from another angle, of a knurling wheel removed from a housing belonging to the fastening system of figures 1 to 5.

Figure 1 shows a fastening system 100 for a cutting tool, formed by a knurling wheel 1 in this example, on a cutting head (not shown) of a tunnel boring machine (also not shown). The fastening system 100 comprises a hollow housing 3 fixedly secured to the cutting head, and in which the knurling wheel 1 is inserted. The housing 3 has a front face 30, from which

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the knurling wheel 1 protrudes, and designed to be across from a rocky wall to be hollowed out. The housing 3 comprises a rear face 32, by which operators have access to the fastening system 100 to disassemble the knurling wheel 1 so that it may be replaced by a new knurling wheel. An axis perpendicular to the front 30 and rear 32 faces defines the longitudinal direction X-X' of the fastening system 100. Below, the descriptors "front" and "rear" are used in reference to the front 30 and rear 32 faces.

The knurling wheel 1 comprises two flanges 5 and 6, between which a rotating part of the knurling wheel 1 is mounted comprising a cutting disc 70. This rotating part forms an active part of the cutting tool, suitable for being in contact with the terrain and hollowing it out. The flanges 5 and 6 are inserted into corresponding hollow parts 340 and 360 respectively arranged in an upper wall 34 and a lower wall 36 of the housing 3. The flanges 5 and 6 each have two lateral faces 51 and 61 forming a conical profile whose shape is complementary to the surfaces of the hollow parts 340 and 360. This shape matching facilitates the insertion and alignment of the knurling wheel 1 in the housing 3.

The fastening system 100 further comprises two screws 8 each screwed into a tapped hole of the flanges 5 and 6. The disassembly of the knurling wheel does not require completely unscrewing the screws 8 from the flanges 5 and 6, and thus, all of the parts of the fastening system remain secured to one another and the knurling wheel 1 during these disassembly and reassembly operations.

The screws 8 are mounted along longitudinal axes parallel to the axis X-X'.

The fastening system 100 also comprises tightening parts 11. A tightening part 11 is slidably mounted in translation parallel to the axis X-X' on each of the screws 8. The tightening parts 11 have a globally triangular shape that is symmetrical relative to the axes of the screws 8. A ring 13 is screwed on each of the screws 8. The screws 8 and the rings 13 are secured in translation along the axis X-X'. A head 80 of the screw 8 is accessible from the rear side of each of the tightening parts 11 so as to form a command that can be actuated by an operator or a robot performing the disassembly of the knurling wheel 1.

The tightening parts 11 are held captive by the screws 8 between the rings 13 and the heads 80, such that during the screwing of the screws 8, the tightening parts 11 are translated forward by the head 80. During unscrewing of the screws 8, the tightening parts 11 are translated toward the rear by the rings 13.

On each of the tightening parts 11, two wedges 15 and 16 are mounted. The wedges 15 and 16 are mounted on the tightening parts 11 in sliding connection on inclined faces 110 and 111 relative to the longitudinal axis of the screws 8, the wedges 15 and 16 freely translating along the inclined faces 110 and 111. The wedges 15 and 16 have a globally

parallelepiped shape. The sliding connection between the wedges 15 and 16 and the inclined faces 110 and 111 is done by sliding between rails 113 of the inclined faces 110 and 111 and slots provided in the wedges 15 and 16, the shape of which is complementary to that of the rails 113.

5 Upon removal of the knurling wheel 1, the latter forms a single piece with the screws 8, the tightening parts 11, the rings 13 and the wedges 15 and 16. None of these parts must be separated, which simplifies the removal of the knurling wheel 1 and avoids risks of lost parts.

10 The hollow parts 340 and 360 comprise lateral notches 370 that are symmetrical relative to a median plane P_m of the housing 3, passing through the axis $X-X'$, perpendicular to the walls 34 and 36 and the faces 30 and 32. The notches 370 have a parallelepiped shape complementary to the shape of the wedges 15 and 16, and the wedges 15 and 16 are able to be inserted into the notches 370. In a first locking configuration of the fastening system 100 shown in figures 1 and 2, in which the rotating part 70 of the knurling wheel 1 protrudes from the cutting head of the tunnel boring machine to destroy the rock, the
15 tightening parts 11 are in a first front position, in which the wedges 15 and 16 are engaged in the notches 370 so as to lock the knurling wheel 1 in the housing 3. In this configuration, rear planar faces 150 and 160 of the wedges 15 and 16, oriented toward the rear of the fastening system 100, are in contact with parallel faces 372 of the notches 370, oriented toward the
20 front of the fastening system 100, opposite the rear face 32 of the housing 3. The faces 372 therefore oppose the removal movement of the knurling wheel 1 from the housing 3. Thus, owing to the cooperation of the faces 150 and 160 and the faces 372, the tightening parts 11 cannot be removed toward the rear of the housing 3, and the knurling wheel 1 is therefore locked in the housing 3. The wedges 15 and 16 therefore form retractable locking elements
25 for the flanges 5 and 6 in the housing 3.

 The planar faces 150 and 160 of the wedges 15 and 16 form, relative to the median plane P_m , an angle comprised between 30 and 60 degrees.

 The disassembly maneuver for the knurling wheel 1 takes place as follows. The operation consists of unscrewing the screws 8 from the flanges 5 and 6 owing to the heads
30 80, so as to initiate a translational movement of the tightening parts 11 toward the rear of the fastening system 100, as shown by the arrow F1. During the rearward translation of the tightening parts 11, the bearing of the rectilinear faces 150 and 160 against the faces 372, as well as the translational freedom of the wedges 15 and 16 relative to the incline faces 110 and 111, translates the wedges 15 and 16 on the rails 113, as shown by the arrows F2. The
35 screws 8, the rings 13 and the tightening parts 11 therefore form means for moving the

wedges 15 and 16 between their position engaged in the notches 370 and their position freed from the notches 370. The movement means are secured to the knurling wheel 1, and the disassembly or reassembly operations do not require external means other than a key to obtain the movement of the wedges 15 and 16.

The heads 80 of the screws 8 form commands for the movement means of the wedges 15 and 16, which can be actuated in a single operation, i.e., by using a single type of movement, here a rotation, that can be done using a single tool. This allows an operator, or advantageously a robot, to obtain locking of the knurling wheel 1 in the housing 3 easily by imparting a rotation to the screws 8, which results in the translation of the wedges 15 and 16.

The fastening system 100 is therefore easy to use, since it only requires a single operation to disassemble or reassemble the knurling wheel 1.

Figure 3 shows the fastening system 100 during the translational movement of the tightening parts 11 and the wedges 15 and 16. The translational movement of the wedges 15 and 16 results in sliding of the rectilinear faces 150 and 160 against the faces 372 such that the wedges 15 and 16 are partially disengaged from the notches 370.

The wedges 15 and 16 consequently undergo a rectilinear translation relative to the flanges 5 and 6 and the housing 3. This rectilinear translation is shown by the arrow F4 in figures 3 and 5.

The rearward translational movement of the tightening parts 11 continues as far as a rear position of the tightening parts 11, shown in figures 4 to 6. In this configuration, the wedges 15 and 16 have continued their translational movement along the arrows F2 until they are completely freed from the notches 370. As shown in figure 4, the wedges 15 and 16 are now in a closed position relative to the median plane Pm, such that the rectilinear faces 150 and 160 no longer cooperate with the faces 372. It is therefore possible to remove the knurling wheel 1 from the housing 3 by exerting a rearward traction on the entire part of the knurling wheel along the arrow F3, since the faces 372 no longer obstruct the faces 150 and 160 along the axis X-X'.

In the second position of the tightening parts 11, the wedges 15 and 16 are abutting against the rear faces 53 and 63 of the flanges 5 and 6, which makes it possible to limit the translation toward the median plane Pm of the wedges 15 and 16 and the rearward translation of the tightening parts 11 relative to the flanges 5 and 6. To that end, the wedges 15 and 16 comprise front planar faces 151 and 161 that are opposite and parallel to the rectilinear faces 150 and 160, able to bear against the faces 53 and 63, as shown in figures 4 to 6. When the knurling wheel 1 is removed from the housing 3, the separation of the wedges

15 and 16 from the tightening parts 11, by sliding on the rails 113 toward the rear, is prevented by stops 115, shown in figures 5 and 6, formed on the tightening parts 11.

The assembly of the tightening parts 11, the wedges 15 and 16 and the rings 13 in a captive manner on the screws 8 as well as the fact that the wedges 15 and 16 are free from the notches 370, while the screws 8 remain engaged in the flanges 5 and 6, ensures that the parts of the fastening system 100 cannot be lost with respect to the flanges 5 and 6. The reliability of the fastening system 100 is therefore guaranteed, while reducing the risks of loss of elements during the removal of the knurling wheel 1.

The tightening of the screws 8 may cause jamming of the wedges 15 and 16 in the notches 370, between the faces 150 and 160 and the faces 372. During unlocking operations of the knurling wheel 1, the unscrewing of the screws 8 makes it possible to cancel out that jamming by causing a slight movement of the flanges 5 and 6 in the forward direction, which causes play between the faces 150 and 160 and the faces 372. Relative sliding can thus occur between these surfaces, and the release of the wedges 15 and 16 from the notches 370 can happen normally.

When a new knurling wheel 1 must be assembled in the housing 3, it is inserted in the housing until the lateral faces 51 and 61 of each of the flanges 5 and 6 are engaged against the hollow portions 340 and 360 of the housing 3, as shown in figure 5. In this configuration, the distance D1 between the faces 53 and the faces 372, taken in a direction perpendicular to those faces, is greater than the width L of the wedges 15 and 16, considered respectively between the faces 150 and 151 and between the faces 160 and 161. This makes it possible, when the screws 8 are screwed into the flanges 5 and 6 in the opposite direction from the removal process, for the wedges 15 and 16 to be correctly reengaged in the notches 370.

In the first position of the tightening parts 11, a space E, extending along the axis X-X', exists between the rings 13 and the flanges 5 and 6. This space E allows additional tightening of the screws 8 in case of wear or burring of the wedges 15 and 16 or the notches 370. This space makes it possible to continue effectively tightening the wedges 15 and 16 of the notches 370 over the lifetime of the fastening system 100.

According to one embodiment that is not shown, the locking of the wedges 15 and 16 may be obtained by actuating a shared command of the flanges 5 and 6 allowing simultaneous screwing and unscrewing of the screws 8 of each flange 5 and 6.

According to another embodiment that is not shown, the system 100 may comprise a screw 8, a nut 13, a tightening part 11 and wedges 15 and 16 on only one of the flanges 5 and 6.

According to another embodiment of the invention that is not shown, the actuation of the movement means for locking elements formed by the wedges 15 and 16 can be obtained through an operation other than screwing or unscrewing of the screws 8, for example by actuating a lever or any other system able to translate the tightening parts 11 in a single operation.

According to another embodiment of the invention that is not shown, the knurling wheel can be replaced by another type of cutting tool, such as a scraping tool called a ripper. This ripper comprises a scraping part, forming the active part of the ripper, mounted in a base that is in turn mounted between the flanges 5 and 6. The scraping part can be tilting or stationary relative to the base.

The technical features of the embodiments and alternatives described above may be combined to form new embodiments of the invention.

CLAIMS

1. A system (100) for fastening a cutting tool (1) on a cutting head of a tunnel boring
5 machine, comprising a housing (3) secured to the cutting head, in which the cutting tool (1) is
inserted, the cutting tool (1) comprising two flanges (5, 6) between which an active part (70)
is mounted, the fastening system (100) also comprising retractable locking elements (15, 16)
captively connected to the flanges (5, 6) and suitable for locking the flanges (5, 6) in the
10 housing (3), the locking elements (15, 16) being movable relative to the flanges (5, 6)
between a first position, in which the locking elements (15, 16) are engaged in the housing
(3) so as to lock the cutting tool (1) in the housing (3), and a second position, in which the
locking elements (15, 16) are freed from the housing (3) and allow the cutting tool (1) to be
removed from the housing (3), characterized in that it comprises movement means (8, 11,
15 13) connected to the cutting tool (1) suitable for translating the locking elements (15, 16)
between their first position and their second position, and in that those movement means (8,
11, 13) are suitable for being actuated in a single operation.

2. The system according to claim 1, characterized in that the locking elements are
wedges (15, 16) able to be inserted in notches (370) of the housing (3) and in that the
20 wedges (15, 16) comprise planar rear faces (150, 160) suitable for abutting against parallel
faces (372) of the notches (370) oriented opposite the removal movement (F3) of the cutting
tool (1) from the housing (3).

3. The system according to claim 2, characterized in that the movement means of the
25 wedges (15, 16) comprise, for each flange (5, 6), a screw (8) mounted in a tapped hole of
that flange (5, 6), a tightening part (11) mounted sliding on each screw (8), a ring (13)
mounted on each screw (8) and suitable for translating the tightening part (11) along a
longitudinal axis (X-X') of the screw (8), the wedges (15, 16) being mounted freely translating
on each of the tightening parts (11), and in that the rotation of the screws (8) causes the
30 translational movement (F1) of the tightening parts (11) between a first forward position, in
which the wedges (15, 16) are engaged in the notches (370), and a second rear position, in
which the wedges (15, 16) are freed from the notches (370).

4. The fastening system according to claim 3, characterized in that each of the screws (8) comprises a head (80) allowing the actuation of the movement means (8, 11, 13) of the wedges (15, 16).

5 5. The fastening system according to one of claims 3 and 4, characterized in that each of the tightening parts (11) comprises two inclined faces (110, 111) relative to a median plane (Pm) of the housing (3) and in that the wedges (15, 16) are mounted freely translating along the inclined faces (110, 111).

10 6. The fastening system according to one of claims 3 to 5, characterized in that in the first position of the tightening parts (11), a space (E) exists between the rings (13) and the flanges (5, 6) allowing additional tightening of the screws (8).

15 7. The fastening system according to one of claims 3 to 6, characterized in that in the second position of the wedges (15, 16), front faces (151, 161) of the wedges (15, 16) are abutting against rear faces (53, 63) of the flanges (5, 6).

20 8. The fastening system according to claim 7, characterized in that in the second position of the wedges (15, 16) and when the cutting tool (1) is inserted in the housing (3), the distance (D1) between the faces (372) of the notches (370) oriented opposite the removal movement (F3) of the cutting tool (1) from the housing (3) and the rear faces (53, 63) of the flanges (5, 6) is greater than the width (L) of the wedges (15, 16).

25 9. The fastening system according to one of the preceding claims, characterized in that each of the flanges (5, 6) has two lateral inclined faces (51, 61) forming a conical profile suitable for cooperating with a hollow portion (340, 360) with a corresponding shape arranged on an inner surface of the housing (3) in the first position of the locking elements (15, 16).

30 10. The fastening system according to one of the preceding claims, characterized in that the cutting tool is a knurling wheel (1) whereof the rotating part (70) forms the active part of the cutting tool.

11. The fastening system according to one of claims 1 to 9, characterized in that the cutting tool is a ripper comprising a base mounted between the flanges and a scraping part that is stationary or tilts relative to the base and forming the active part of the cutting tool.

- 5 12. A tunnel boring machine comprising a cutting head (1) including cutting tools fastened in the cutting head using fastening systems (100) according to one of the preceding claims.