

Description

Title of Invention: DRILL BIT EXCHANGE DEVICE FOR SHIELD
TUNNELING MACHINE

5

Technical Field

[0001]

The present invention relates to a drill bit exchange
device for a shield tunneling machine in which a worn
10 roller bit is exchanged from a working space in a cutter
head during drilling.

Background Art

[0002]

15 Many structures have been proposed for drill bit
exchange devices that exchange worn roller bits during
drilling. For example, Patent Literatures 1 and 2
disclose drill bit exchange devices, each including a
rotating body having a support hole on the back of a
20 front plate having an opening such that a roller bit is
slidably fit into the support hole.

Citation List

Patent Literature

25 [0003]

Patent Literature 1: Japanese Patent No. 4163965

Patent Literature 2: Japanese Patent No. 3139749

Summary of Invention

30 Technical Problem

[0004]

In the drill bit exchange devices described in Patent
Literatures 1 and 2, however, the rotating body has a
spherical support surface. This makes it difficult to
35 support a large drilling reaction force on the roller

bits. Moreover, this may disadvantageously lead to a complicated structure and a complicated exchanging operation.

An object of the present invention is to provide a
5 drill bit exchange device for a shield tunneling machine that can support a large drilling reaction force with a simple structure and a simple exchanging operation so as to solve the problem.

10 Solution to Problem
[0005]

In order to solve the problem, an invention according to a first aspect is a drill bit exchange device for a shield tunneling machine in which a drill bit disposed at
15 the front of a cutter head is exchanged during drilling from a working space formed in the cutter head, the drill bit exchange device including:

a housing with a tunneling aperture part attached to the front of the cutter head so as to expose the drill
20 bit;

a valve body disposed in a valve-housing chamber that is formed in the housing so as to communicate with the tunneling aperture part, the valve body being pivotable about a pivot axis inclined at a predetermined angle with
25 respect to an axis perpendicular to the front of the cutter head;

a bit-housing hole that is formed in the valve body so as to communicate with the tunneling aperture part, the drill bit being detachably housed in the bit-housing
30 hole; and

an exchange seal part disposed at the front of the valve-housing chamber, the exchange seal part being separated from the tunneling aperture part at the pivoting position of the tunneling aperture part with
35 respect to the pivot axis,

wherein the valve body is substantially cylindrical and includes a seal body that is formed along the front outer edge of the valve body so as to seal the tunneling aperture part, an opening for the bit-housing hole formed on a part of the seal body, and a drilling recess that is formed by removing the seal body around the opening for the bit housing hole and accommodates the drilling end of the drill bit,

the drill bit exchange device further includes an exchange seal member that seals a clearance between the housing and the valve body around the exchange seal part, and

the valve body is pivoted about the pivot axis so as to move the drill bit in the drilling recess to the exchange seal part when the drill bit is exchanged, allowing the drill bit to be removed from the bit-housing hole and exchanged.

[0006]

An invention according to a second aspect in the configuration of the first aspect, wherein the exchange seal member is a tubular seal member that allows an adjustment of a sliding pressure by changing a fluid pressure applied to the hollow part of the seal member.

[0007]

An invention according to a third aspect in the configuration of the first or second aspect, wherein the drill bit is a roller bit including a disc cutter rotatably supported by a bit support,

the bit support has a mud discharge passage that penetrates the bit support from the periphery of the disc cutter along the attachment/removal direction of the bit-housing hole,

a linear mud discharge pipe is connected so as to communicate with the outer surface of the cutter head

from the mud discharge passage of the bit support via the working space, and

a short pipe connectable to and separable from the mud discharge pipe is provided and cutoff valves are
5 respectively provided at the inlet and outlet pipes of the short pipe.

Advantageous Effects of Invention

[0008]

10 According to the invention of the first aspect, the valve body with the bit-housing hole formed via the drilling recess is disposed on a part of the seal body extended along the front edge of the substantially
15 cylindrical shape in the valve-housing chamber of the housing such that the valve body can pivot about the pivot axis inclined with respect to the axis perpendicular to the front surface of the cutter head. Thus, only by pivoting the valve body about the pivot axis when the bit is exchanged, the tunneling aperture
20 part can be sealed with the seal body while the drill bit whose drilling end is protruded into the drilling recess is displaced to the exchange seal part surrounded by the exchange seal member. Thus, the worn drill bit is removed along the bit housing hole from the exchange seal part
25 surrounded by the exchange seal member, a new drill bit is attached into the bit-housing hole, and then the valve body is pivoted to align the new drill bit with the tunneling aperture part, allowing the drill bit to be easily exchanged in a short time. Moreover, the simple
30 structure including the valve body with the inclined pivot axis in the housing can achieve high reliability. Since the valve body is substantially cylindrical, a sufficiently larger drilling reaction force than that of a spherical surface can be reliably supported.

35 [0009]

According to the invention of the second aspect, the exchange seal member is a tube seal that allows an adjustment of a sliding pressure. This can prevent carried soil or crushed stones at the time of the passage of the drill bit and the drilling recess from causing damage on the exchange seal member by decompressing the exchange seal member during the replacement of bits, leading to higher sealing performance.

[0010]

According to the invention of the third aspect, the mud discharge pipe is connected so as to linearly extend from the mud discharge passage formed in the bit support. Thus, muddy water containing stones drilled by the roller bit can be smoothly discharged without clogging, achieving effective drilling. Since the cutoff valves are provided at the front and rear of the short pipe, the mud discharge pipe can be removed without leaking muddy water into the working space when the bit is exchanged, allowing the worn roller bit to be easily exchanged.

Brief Description of Drawings

[0011]

[FIG. 1] FIG. 1 is a longitudinal section showing a first embodiment of a bit exchange unit in a shield tunneling machine according to the present invention.

[FIG. 2] FIG. 2 is a front view showing the tunneling aperture part of a cutter head.

[FIG. 3] FIG. 3 is a longitudinal section showing an enlarged principle part of a valve body in the bit exchange unit.

[FIG. 4] FIG. 4 is a front view of the valve body.

[FIG. 5] FIG. 5 is a perspective view showing a roller bit and a bit support.

[FIG. 6] FIG. 6 is a longitudinal section for explaining an exchanging operation in the bit exchange unit.

[FIG. 7] FIG. 7 is a partial enlarged view of FIG. 6.

[FIG. 8] FIG. 8 is a front view of FIG. 6.

[FIG. 9] FIG. 9 is a longitudinal section for explaining an exchanging operation in the bit exchange unit.

5 [FIG. 10] FIG. 10 is a longitudinal section of the shield tunneling machine including the bit exchange unit.

[FIG. 11] FIG. 11 is a front view showing the cutter head of the shield tunneling machine including the bit exchange unit.

10

Description of Embodiment

[0012]

[First Embodiment]

15 An embodiment of a shield tunneling machine including a drill bit exchange device according to the present invention will be described below with reference to the accompanying drawings.

[0013]

(Shield tunneling machine)

20 As shown in FIG. 10, a pressure bulkhead 12 is provided at the front of a cylindrical shield body 11. A pressure chamber 28A that keeps a face collapse earth pressure is formed at the front of the pressure bulkhead 12. In the pressure bulkhead 12, a rotating ring body 14
25 is supported via a rotating bearing 13 so as to rotate about a shield axis O. A circular cutter head 16 is supported by a plurality of support legs 15 that protrude forward from the rotating ring body 14. An air chamber 28B behind the pressure bulkhead 12 includes a cutter
30 driving device 17 that rotates the cutter head 16. The cutter driving device 17 includes a ring gear 17a provided on the back of the rotating ring body 14, a plurality of driving pinions 17b engaged with the ring gear 17a, and rotating devices (hydraulic or electric
35 motors) 17c that rotate the respective driving pinions

17b. Furthermore, a soil screw conveyor 18 penetrates the pressure bulkhead 12 such that the screw conveyor 18 discharges soil, which has been drilled by the cutter head 16, to the air chamber 28B from the pressure chamber 28A while the pressure chamber 28A keeps a face collapse earth pressure.

[0014]

(Cutter head)

As shown in FIG. 11, the cutter head 16 includes a plurality of main spokes 21 that radially extend from a central member 20 disposed on the shield axis O, a plurality of sub spokes 22 that radially extend between the main spokes 21, and an intermediate ring 23 and an outer ring 24 that are circumferentially provided with respect to the shield axis O so as to connect the main spokes 21 and the sub spokes 22. Moreover, soil inlet ports 25 are formed among the members 21 to 24.

[0015]

Furthermore, a plurality of bit exchange units (drill bit exchange devices) 30 according to the present invention are provided at the front of the main spoke 21. The bit exchange unit 30 includes a roller bit 31 that is a drill bit to be exchanged. A plurality of fixed bits 26 are provided on the front faces and sides of the central member 20 and the sub spokes 22 and the sides of the main spokes 21.

[0016]

As shown in FIG. 10, a manhole 27 allowing the passage of a worker is provided near the back of the central member 20. The manhole 27 penetrates the pressure bulkhead 12 so as to allow the passage of a worker from the air chamber 28B. On the back sides of the main spokes 21, a working space 29 is formed so as to allow a worker to enter inside and perform a drill bit exchange operation. The working space 29 communicates with the

manhole 27, allowing a worker to come into the working space 29 from the manhole 27. Thus, a worker who comes into the working space 29 from the manhole 27 during drilling can exchange the worn roller bits 31 from the working space 29.

[0017]

(Bit exchange unit)

The bit exchange units 30 are radially disposed at predetermined pitches on the front surface of the main spoke 21. The roller bit 31 is disposed in the bit exchange unit 30. The bit exchange units 30 are all identical in structure.

[0018]

As shown in FIG. 5, the roller bit 31 has a bit support 42 shaped like a long cylinder in cross section. The bit support 42 has a mud discharge passage 41 formed in the longitudinal direction. A double disc cutter 44 is rotatably supported at the front of the bit support 42 via a support shaft 43 extended along the minor axis of the bit support 42.

[0019]

As shown in FIGS. 1 to 4, the bit exchange unit 30 includes a housing 33 that is attached to the cut portion of a front plate 32 of the main spoke 21. The housing 33 has a tunneling aperture part 34 where the roller bit 31 is exposed. Furthermore, a valve-housing chamber 36 is formed in the housing 33. The valve-housing chamber 36 is caused to communicate with the tunneling aperture part 34. A valve body 35 that holds the roller bit 31 is pivotally stored in the valve-housing chamber 36 in a tilted position.

[0020]

The valve body 35 is substantially cylindrical. A seal body 37 that can seal the tunneling aperture part 34 is circumferentially formed on the front outer edge of

the valve body 35. For example, the seal body 37 is formed like a trapezoid in cross section such that the edge of the seal body 37 is chamfered on a plane inclined at a predetermined angle (e.g., α° , which will be described later) with respect to a pivot axis Ob that is the axis of the cylindrical shape. The seal body 37 has a drilling recess 38 that is formed by partially cutting the seal body 37. The drilling recess 38 has a bit-housing hole 39 that removably accommodates the roller bit 31. As shown in FIG. 4, the bottom of the drilling recess 38 is formed on a removal plane 38a where the outer edge of the opening of the bit-housing hole 39 is inclined at the predetermined angle (α° , which will be described later) with respect to the pivot axis Ob. A drilling space 38b allowing the protrusion of the drilling end of the disc cutter 44 is formed between the removal plane 38a and the pivoting path of the top of the seal body 37.

[0021]

The valve-housing chamber 36 is substantially cylindrical so as to pivotally accommodate the valve body 35. The axis (the pivot axis Ob of the valve body 35) of the valve-housing chamber 36 is inclined at the angle α° such that the removal plane 38a on the tunneling aperture part 34 is substantially flush with the front surface of the housing 33. Moreover, the back side of the housing 33 is removed along an inclined plane that is perpendicular to the pivot axis Ob. The valve-housing chamber 36 is opened on the inclined plane so as to face the working space 29.

[0022]

The front of the valve-housing chamber 36 is shaped like a truncated cone so as to guide the seal body 37. The lower part of the valve-housing chamber 36 is caused to communicate with the tunneling aperture part 34 that

is elliptically formed like the bit support 42 along the tangential direction of the pivot axis Ob. Moreover, an exchange seal part 40 is formed at a 180° symmetrical position about the pivot axis Ob of the tunneling

5 aperture part 34. The exchange seal part 40 coincides with the drilling recess 38 when the bit is exchanged.

The exchange seal part 40 includes a second seal member 62, which will be described later. The position of the exchange seal part 40 is not limited to the 180°

10 symmetrical position from the tunneling aperture part 34 as long as the exchange seal part 40 does not overlap the tunneling aperture part 34 on the same axis as the tunneling aperture part 34 about the pivot axis Ob.

[0023]

15 (Valve pivoting device)

A valve pivoting device 51 that rotates the valve body 35 about the pivot axis Ob is provided at the rear of the valve-housing chamber 36. The valve pivoting device 51 includes a ring gear 52 that is provided on the
20 outer periphery of the rear end of the valve body 35, a drive shaft 53 that is supported so as to rotate about an axis parallel to the pivot axis Ob at the rear of the housing 33, a driving pinion 54 fixed to the drive shaft 53 so as to mesh with the ring gear 52, and a manual
25 handle 55 that rotates the drive shaft 53.

[0024]

(Mud discharge pipe)

The mud discharge passage 41 of the roller bit 31 is connected to a mud discharge pipe 45 communicating with
30 the pressure chamber 28A on the back side of the main spoke 21. The mud discharge pipe 45 includes a first gate valve (cutoff valve) 46A connected to the bit support 42 via a taper tube, a second gate valve (cutoff valve) 46B connected to the first gate valve 46A via a short pipe 47,
35 and a discharge pipe 48 penetrating a rear plate. The

discharge pipe 48 linearly penetrates the working space 29 from the mud discharge passage 41 along an axis 0a and is opened to the pressure chamber 28A. The mud discharge pipe 45 configured thus can smoothly discharge muddy water with crushed stones without clogging.

[0025]

(Seal member)

The inner surface of the tunneling aperture part 34 of the housing 33 has a first seal member 61 that prevents the entry of muddy water or sediment from a gap between the tunneling aperture part 34 and the valve body 35. The first seal member 61 seals the periphery of the drilling recess 38 during drilling. The exchange seal part 40 has the second seal member (exchange seal member) 62 on the inner surface of the valve-housing chamber 36. The second seal member 62 seals the periphery of the drilling recess 38 having pivoted to the exchange seal part 40. The second seal member 62 includes a hollow tube seal member connected to a pressure control hole 63 formed in the housing 33. The second seal member 62 is extended or shrunk by an oil pressure or compressed air serving as a compressed fluid discharged into a hollow part from the pressure control hole 63, thereby adjusting a sliding pressure on the valve body 35. With this configuration, when the valve body 35 is pivoted during the replacement of bits, the second seal member 62 is shrunk by decompression, thereby preventing damage during the passage of the edge of the drilling recess 38 and the drilling end of the disc cutter 44. As a matter of course, the first seal member 61 may be a tubular seal member that allows pressurization and decompression.

[0026]

The outer periphery of the valve body 35 has third seal members 64 in sliding contact with the inner surface of the valve-housing chamber 36. The outer surface of the

bit support 42 has fourth seal members 65 in sliding contact with the inner surface of the bit-housing hole 39.

[0027]

(Roller bit exchanging method)

5 Referring to FIGS. 1 and 6 to 9, a drill bit exchanging method in the bit exchange unit 30 will be described below.

[0028]

10 When the disc cutter 44 of the roller bit 31 is worn after tunneling of a predetermined distance, the cutter head 16 is stopped while the main spoke 21 having the bit exchange units 30 to be exchanged is substantially set in a horizontal position. After that, a worker enters the working space 29 from the manhole 27 to perform a drill
15 bit exchange operation.

[0029]

A) From a drilled state in FIG. 1, the first gate valve 46A and the second gate valve 46B are first closed, and then the short pipe 47 of the mud discharge pipe 45
20 is removed.

[0030]

B) As shown in FIGS. 6 to 8, the second seal member 62 is decompressed, and then the manual handle of the valve pivoting device 51 is rotated to turn the valve
25 body 35 180° about the pivot axis Ob. This displaces the worn roller bit 31 of the tunneling aperture part 34 to the exchange seal part 40 and seals the tunneling aperture part 34 with the seal body 37.

[0031]

30 C) As shown in FIG. 9, the second seal member 62 is pressurized into contact with the periphery of the removal plane 38a, and then the roller bit 31 having the worn disc cutter 44 is removed from the bit-housing hole 39 by means of a remover (not shown).

35 [0032]

D) A new roller bit 31 is attached into the bit-housing hole 39 by means of the remover.

[0033]

E) After the second seal member 62 is decompressed,
5 the valve pivoting device 51 is operated to rotate the valve body 35 180° about the pivot axis Ob, so that the new roller bit 31 on the exchange seal part 40 is pivoted so as to coincide with the tunneling aperture part 34. Furthermore, the short pipe 47 is connected between the
10 first gate valve 46A and the second gate valve 46B. The first and second gate valves 46A and 46B are then opened to allow communication in the mud discharge pipe 45.

[0034]

According to the present embodiment, the valve body
15 35 having the bit-housing hole 39 opened through the drilling recess 38 is provided on a part of the seal body 37 formed around the front edge of the cylindrical shape. The valve body 35 is housed in the valve-housing chamber 36 of the housing 33 provided at the front of the cutter
20 head such that the valve body 35 is rotatable about the pivot axis Ob inclined with respect to the axis Oa perpendicular to the front surface of the cutter head 16. Thus, only by pivoting the valve body 35 about the pivot axis Ob when the bit is exchanged, the tunneling aperture
25 part 34 can be sealed with the seal body 37 while the drilling recess 38 that accommodates the worn roller bit 31 is displaced to the exchange seal part 40 surrounded by the second seal member 62. The worn roller bit 31 of the exchange seal part 40 is removed from the bit-housing
30 hole 39 and then a new roller bit 31 is attached into the bit-housing hole 39. After that, the valve body 35 is pivoted to align the new roller bit 31 with the tunneling aperture part 34. The worn roller bit 31 can be easily replaced with the new roller bit 31 in a short time only
35 by pivoting the valve body 35.

[0035]

Furthermore, high reliability can be obtained with a simple structure including the housing 33 accommodating the valve body 35. Since the valve body 35 is cylindrical,
5 a sufficiently larger drilling reaction force than that of a sphere can be reliably supported via the valve body 35 and the housing 33.

[0036]

Since the second seal member 62 is a tube seal that
10 allows an adjustment of a sliding pressure, the second seal member 62 is decompressed during the passage of the roller bit 31, which comes into and goes out of the exchange seal part 40 during replacement, and the drilling recess 38. This can prevent carried soil or
15 crushed stones from causing damage on the second seal member 62, leading to higher sealing performance.

[0037]

Moreover, the mud discharge pipe 45 is connected so as to linearly extend from the mud discharge passage 41
20 of the bit support 42. Thus, muddy water containing stones drilled by the roller bit 31 can be smoothly discharged to the pressure chamber 28A without clogging, achieving effective drilling. The mud discharge pipe 45 includes the first and second gate valves 46A and 46B at
25 the front and rear of the short pipe 47 to be removed when the bit is exchanged. The short pipe 47 is removed with the closed first and second gate valves 46A and 46B when the bit is exchanged. Thus, the mud discharge pipe 45 can be removed without leaking muddy water into the
30 working space 29, allowing the worn roller bit 31 to be easily exchanged in a short time.

Claims

[Claim 1]

A drill bit exchange device for a shield tunneling
5 machine in which a drill bit disposed at a front of a
cutter head is exchanged during drilling from a working
space formed in the cutter head,

the drill bit exchange device comprising:

a housing with a tunneling aperture part attached to
10 the front of the cutter head so as to expose the drill
bit;

a valve body disposed in a valve-housing chamber that
is formed in the housing so as to communicate with the
tunneling aperture part, the valve body being pivotable
15 about a pivot axis inclined at a predetermined angle with
respect to an axis perpendicular to the front of the
cutter head;

a bit-housing hole that is formed in the valve body
so as to communicate with the tunneling aperture part,
20 the drill bit being detachably housed in the bit-housing
hole; and

an exchange seal part disposed at a front of the
valve-housing chamber, the exchange seal part being
separated from the tunneling aperture part at a pivoting
25 position of the tunneling aperture part with respect to
the pivot axis,

wherein the valve body is substantially cylindrical
and includes a seal body that is formed along a front
outer edge of the valve body so as to seal the tunneling
30 aperture part, an opening for the bit-housing hole formed
on a part of the seal body, and a drilling recess that is
formed by removing the seal body around the opening for
the bit housing hole and accommodates a drilling end of
the drill bit,

the drill bit exchange device further comprises an exchange seal member that seals a clearance between the housing and the valve body around the exchange seal part, and

5 the valve body is pivoted about the pivot axis so as to move the drill bit in the drilling recess to the exchange seal part when the drill bit is exchanged, allowing the drill bit to be removed from the bit-housing hole and exchanged.

10

[Claim 2]

The drill bit exchange device for a shield tunneling machine according to claim 1, wherein the exchange seal member is a tubular seal member that allows an adjustment
15 of a sliding pressure by changing a fluid pressure applied to a hollow part of the seal member.

[Claim 3]

The drill bit exchange device for a shield tunneling
20 machine according to one of claims 1 and 2, wherein the drill bit is a roller bit including a disc cutter rotatably supported by a bit support,

the bit support has a mud discharge passage that penetrates the bit support from a periphery of the disc
25 cutter along an attachment/removal direction of the bit-housing hole,

a linear mud discharge pipe is connected so as to communicate with an outer surface of the cutter head from the mud discharge passage of the bit support via the
30 working space, and

a short pipe connectable to and separable from the mud discharge pipe is provided and cutoff valves are respectively provided at inlet and outlet pipes of the short pipe.

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