

SHIELD TUNNELING MACHINE

BACKGROUND OF THE INVENTION

The present invention relates to a shield tunneling machine that excavates a tunnel or other similar passage while crushing obstacles encountered during excavation.

There has heretofore been known a shield tunneling machine having water jet spray nozzles provided on a cutter head that is provided at the forward end of a shield body in the excavation direction and rotatable relative to the shield body to excavate a tunnel or the like while crushing obstacles encountered during excavation [see Japanese Patent Application Unexamined Publication (KOKAI) No. Hei 10-280880].

However, the conventional shield tunneling machine still has a problem to be solved. That is, because the spray nozzles are immovable, it is impossible to properly control the spray nozzles according to the size and configuration of each particular obstacle encountered during excavation, and hence difficult to break it into easily removable pieces with high cutting quality.

SUMMARY OF THE INVENTION

In view of the above-described circumstances, an object of the present invention is to provide a shield tunneling machine capable of breaking obstacles effectively with high cutting quality by properly controlling movable abrasive jet spray nozzles according to the size and configuration of each particular obstacle.

To attain the above-described object, the present invention provides a shield tunneling machine including a shield body and a cutter head provided at the forward end of the shield body in the excavation direction. The cutter head is rotatable relative to the shield body. An abrasive jet spray nozzle for spraying abrasive jet water is movably provided on the cutter head.

Preferably, the abrasive jet spray nozzle is radially movable and thus capable of cutting an obstacle encountered during excavation into a round shape and further cutting it radially.

Preferably, the abrasive jet spray nozzle is oscillatable to allow the spray direction to be changed.

Preferably, a slurry is mixed in the abrasive jet water sprayed from the abrasive jet spray nozzle.

5 Preferably, a fixed spray nozzle for spraying high-pressure jet water is provided on the cutter head, and the obstacle is searched for on the basis of reflected sound of high-pressure jet water sprayed from the fixed spray nozzle.

10 The fixed spray nozzle may be used for cleaning cutter bits provided on the cutter head.

Preferably, cutter bits are provided in proximity to the abrasive jet spray nozzle to protect it.

15 Preferably, a drive mechanism for the abrasive jet spray nozzle is a hydraulic cylinder drive system comprising a cylinder and a piston rod.

The drive mechanism for the abrasive jet spray nozzle may be a threaded rod drive system comprising a drive motor and a threaded rod.

20 The drive mechanism for the abrasive jet spray nozzle may be a rack-and-pinion drive system comprising a drive motor, a rack and a pinion.

25 Preferably, at least two radially spaced abrasive jet spray nozzles are provided as the above-described abrasive jet spray nozzle. Each abrasive jet spray nozzle is supported by a nozzle head and radially movable.

30 Preferably, the nozzle head is provided in a radially extending enclosure. The enclosure is always supplied with cleaning water. The nozzle head is immersed in the cleaning water and radially movable.

Preferably, each abrasive jet spray nozzle is swivelable.

Preferably, the swivelable abrasive jet spray nozzle is decentered with respect to the swivel axis.

35 In the shield tunneling machine according to the present invention, the abrasive jet spray nozzles are movable relative to the cutter head. Therefore, obstacles encountered during excavation can be broken effectively

with high cutting quality by properly controlling the movable abrasive jet spray nozzles according to the configuration and size of each particular obstacle.

Thus, according to the present invention, abrasive jet spray nozzles are provided on the cutter head. While the cutter head is being rotated, abrasive jet water is sprayed from the nozzles to cut an obstacle into ring shapes. Then, while the abrasive jet spray nozzles are being moved radially, abrasive jet water is sprayed therefrom, thereby breaking a large obstacle into fan-shaped pieces.

The above and other objects, features and advantages of the present invention will become more apparent from the following description of the preferred embodiments thereof, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a fragmentary longitudinal sectional view of the shield tunneling machine according to an embodiment of the present invention, showing a shield body including a cutter head.

Fig. 2 is a front view of the cutter head shown in Fig. 1.

Fig. 3 is a diagram showing a hydraulic cylinder drive mechanism for abrasive jet spray nozzles shown in Fig. 2, in which (a) shows a state where a nozzle head is positioned radially outward, and (b) shows a state where the nozzle head is positioned radially inward.

Fig. 4 is a diagram showing in detail the arrangement of the nozzle head shown in Fig. 2.

Fig. 5 is a diagram showing in detail the arrangement of the abrasive jet spray nozzle shown in Fig. 4.

Fig. 6 is a schematic view for explaining the operation of the abrasive jet spray nozzles shown in Fig. 2.

Fig. 7 is a diagram showing a threaded rod drive mechanism as another example of the abrasive jet spray

nozzle drive mechanism shown in Fig. 2.

Fig. 8 is a diagram showing a rack-and-pinion drive mechanism as another example of the abrasive jet spray nozzle drive mechanism shown in Fig. 2.

5 Fig. 9 is an explanatory view showing an arrangement in which the nozzle head shown in Fig. 2 is reciprocatably immersed in cleaning water.

Fig. 10 is a schematic view showing various examples of the layout of nozzle heads shown in Fig. 2, in which:

10 (a) shows an arrangement in which nozzle heads are provided on both sides, respectively, of one mounting plate, and a fixed spray nozzle is provided on this mounting plate; (b) shows an arrangement in which one
15 other nozzle head is installed on the other mounting plate, and moreover, a fixed spray nozzle is provided on the first-mentioned mounting plate; (c) shows an arrangement in which nozzle heads are provided on one mounting plate at respective positions opposite each other across the
20 rotating shaft, and a fixed spray nozzle is installed on this mounting plate; and (d) shows an arrangement in which nozzle heads are provided on one mounting plate at respective positions opposite each other across the
25 the other mounting plate.

Fig. 11 is a conceptual view showing an example in which the abrasive jet spray nozzle is provided swivelably.

Fig. 12 is a conceptual view showing another example in which the abrasive jet spray nozzle is provided
30 swivelably and decentered with respect to the swivel axis.
DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the shield tunneling machine according to the present invention will be described below in detail with reference to the accompanying drawings.

35 Fig. 1 is a fragmentary longitudinal sectional view of the shield tunneling machine according to an embodiment of the present invention, showing a shield body 1 of the shield tunneling machine. In Fig. 1, the shield body 1

includes a cutter head 2 having a rotating shaft 3. The shield body 1 further includes a slurry discharge pipe 4'. The cutter head 2 is provided at the forward end of the shield body 1 in the excavation direction. As shown in Fig. 2, the cutter head 2 has a ring plate 3'. The ring plate 3' has mounting plates 4 and 5 secured thereto. The mounting plates 4 and 5 extend diametrically of the ring plate 3' and intersect each other perpendicularly.

The mounting plates 4 and 5 intersect each other at the rotating shaft 3. The mounting plates 4 and 5 are provided with center bits 6, cutter bits 7, leading bits 8 and trimming bits 9 appropriately.

In this embodiment, the mounting plate 4 is provided with nozzle heads 10 on both lateral sides thereof. Each nozzle head 10 has abrasive jet spray nozzles 10a. Cutter bits 11 are provided at both sides of each abrasive jet spray nozzle 10a to protect it.

The nozzle head 10 is driven by a drive mechanism (drive system) 10A as shown in parts (a) and (b) of Fig. 3. In this embodiment, the drive mechanism 10A is a hydraulic cylinder drive system comprising a piston rod 12 and a hydraulic cylinder 13. The nozzle head 10 is secured to one end of the cylinder 13 through a mounting head 14. The cylinder 13 is movable in reciprocating directions along the piston rod 12 in response to switching between IN and OUT of oil pressure.

The piston rod 12 is formed with a passage 12a for supplying ultra-high pressure water from the rotating shaft 3. The passage 12a communicates with the abrasive jet spray nozzles 10a through a supply pipe 12b.

The piston rod 12 has a space 12c for allowing the supply pipe 12b to advance and retract in the piston rod 12. Figs. 4 and 5 show the arrangement of the nozzle head 10 in detail. The nozzle head 10 is connected with supply pipes 15 for supplying a slurry (starch-based cutting fluid). As shown in Fig. 5, abrasive jet water 10e is sprayed with air 10d surrounding it. In this embodiment, three abrasive jet spray nozzles 10a are provided for each

nozzle head 10, as shown schematically in Fig. 6. The abrasive jet spray nozzles 10a are spaced in the radial direction of the cutter head 2, in which the mounting plate 4 extends. It should be noted, however, that one or two abrasive jet spray nozzles 10a may be provided for each nozzle head 10.

As shown in Fig. 1, the cutter head 2 is rotated about the rotating shaft 3 by a drive motor 17. While the cutter head 2 is rotating, abrasive jet water 10e is sprayed from the abrasive jet spray nozzles 10a, thereby allowing an obstacle 18 encountered during excavation to be cut in ring shapes. Further, by moving the abrasive jet spray nozzles 10a radially at high speed, the obstacle 18 cut in ring shapes can be cut radially.

With the abrasive jet spray nozzles 10a, because a slurry is mixed into high-pressure jet water, it is possible to cut and break the obstacle 18 efficiently while minimizing the wear of the abrasive jet spray nozzles 10a.

The drive mechanism 10A for the abrasive jet spray nozzles 10a according to the present invention is not limited to that shown in Fig. 3. The drive mechanism 10A may be arranged as shown in the following modifications. (First Modification)

For example, as shown in Fig. 7, the nozzle head 10 is secured to the forward end of a threaded rod 19, and a gear 20 is provided on the rear end of the threaded rod 19. An output shaft 22 of a drive motor 21 is meshed with the gear 20. With this drive mechanism, the rotation of the drive motor 21 is converted into forward or backward movement of the threaded rod 19, thereby moving the nozzle head 10 back and forth in the radial direction.

(Second Modification)

For example, as shown in parts (a) and (b) of Fig. 8, the nozzle head 10 is provided with a rack 23, and a pinion 24 that is meshed with the rack 23 is mounted on an output shaft 26 of a drive motor 25. With this drive mechanism, the rotation of the drive motor 25 is converted

into forward or backward movement of the rack 23, thereby moving the nozzle head 10 back and forth in the radial direction.

(Third Modification)

5 It is desirable from the viewpoint of protecting the drive mechanism 10A from sludge and other contamination that the nozzle head 10 according to the present invention should be arranged as shown in Fig. 9. That is, a
10 radially extending vessel 27 is provided on the mounting plate 4, and cleaning water 28 is always supplied into the vessel 27. The inside of the vessel 27 is held at a positive pressure, and the nozzle head 10 is immersed in the cleaning water 28.

15 With the above-described arrangement, it is possible to prevent adhesion of contamination to the drive mechanism 10A. Hence, it is possible to allow the nozzle head 10 to reciprocate smoothly and to minimize the incidence of failure. It should be noted that in Fig. 9 reference numeral 29 denotes a nozzle cover, and reference
20 numeral 30 denotes seal rings.

(Fourth Modification)

 In the foregoing embodiment, the nozzle heads are provided on both lateral sides of the mounting plate 4 as shown schematically in (a) of Fig. 10. However, the
25 present invention is not necessarily limited to the above. The arrangement may be such that, as shown schematically in (b) of Fig. 10, one nozzle head 10 is installed on the mounting plate 4, and the other nozzle head 10 is installed on the mounting plate 5, which extends in a
30 direction perpendicular to the mounting plate 4. The arrangement may also be such that, as shown schematically in (c) and (d) of Fig. 10, the nozzle heads 10 are provided at respective positions opposite each other across the rotating shaft 3.

35 Further, the arrangement may be such that, as shown in (a) to (c) of Fig. 10, a fixed spray nozzle 31 that sprays high-pressure jet water is provided on the mounting plate 4. Sound generated by spraying of high-pressure jet

water from the fixed spray nozzle 31 and reflected from the obstacle 18 is analyzed with an oscilloscope. In this way, the presence of the obstacle 18 is searched for, and the nozzle heads 10 are moved based on the result of the analysis.

The fixed spray nozzle 31 may be provided on the mounting plate 5, which intersects the mounting plate 4 perpendicularly, as shown in (d) of Fig. 10.

Although in this embodiment the fixed spray nozzle 31 is used to search for an obstacle 18, it may be used for cleaning the cutter bits 7.

(Fifth Modification)

Although in the foregoing embodiment the nozzle heads 10 are radially movable, the arrangement may be as follows. As shown in Fig. 11, the nozzle head 10 is mounted on a hydraulic rotary actuator 32. The spray direction O2 of the abrasive jet spray nozzle 10a is set obliquely to the swivel axis O1 of the nozzle head 10. Thus, the spray direction O2 is changed by swiveling the nozzle head 10. The arrangement may be as shown in Fig. 12. The abrasive jet spray nozzle 10a is provided swivelably and decentered with respect to the swivel axis O1 to broaden the range of changes in the spray direction O2 of abrasive jet water.

The shield tunneling machine according to the present invention is usable in construction work of tunnels, underground passages, trenches for piping of water supply and sewerage systems, manholes, and so forth.

It should be noted that the present invention is not limited to the foregoing embodiments but can be modified in a variety of ways.

WHAT IS CLAIMED IS:

1. A shield tunneling machine comprising:
a shield body;
a cutter head provided at a forward end of said shield body in an excavation direction, said cutter head being rotatable relative to said shield body; and
an abrasive jet spray nozzle for spraying abrasive jet water, said abrasive jet spray nozzle being connected to said cutter head for rotational movement with said cutter head, and said abrasive jet spray nozzle being radially movable relative to said cutter head.
2. A shield tunneling machine according to claim 1, wherein said abrasive jet spray nozzle is oscillatable to allow a spray direction to be changed.
3. A shield tunneling machine according to claim 1, wherein a slurry is mixed in the abrasive jet water sprayed from said abrasive jet spray nozzle.
4. A shield tunneling machine according to claim 1, wherein a fixed spray nozzle for spraying high-pressure water as a jet is provided on said cutter head, and an obstacle encountered during excavation is searched for on a basis of reflected sound of high-pressure jet water sprayed from said fixed spray nozzle.
5. A shield tunneling machine according to claim 1, wherein a fixed spray nozzle for spraying high-pressure water as a jet is provided on said cutter head, said fixed spray nozzle being alignable for cleaning cutter bits provided on said cutter head.
6. A shield tunneling machine according to claim 1, wherein cutter bits are provided in proximity to said abrasive jet spray nozzle to protect it.
7. A shield tunneling machine according to claim 1, wherein said abrasive jet spray nozzle is radially moveable by means of a hydraulic cylinder drive system comprising a cylinder and a piston rod.
8. A shield tunneling machine according to claim 1, wherein said abrasive jet spray nozzle is radially moveable by means of a threaded rod drive system

comprising a drive motor and a threaded rod.

9. A shield tunneling machine according to claim 1, wherein said abrasive jet spray nozzle is radially moveable by means of a rack-and-pinion drive system comprising a drive motor, a rack and a pinion.

10. A shield tunneling machine according to claim 1, wherein said abrasive jet spray nozzle comprises at least two radially spaced abrasive jet spray nozzles, each of said abrasive jet spray nozzles being supported by a nozzle head and radially movable.

11. A shield tunneling machine according to claim 10, wherein said nozzle head is provided in a radially extending enclosure, said enclosure being operationally supplied with cleaning water, said nozzle head being operationally immersed in the cleaning water and radially movable.

12. A shield tunneling machine according to claim 3, wherein said abrasive jet spray nozzle is swivelable.

13. A shield tunneling machine according to claim 11 or 12, wherein said abrasive jet spray nozzle is decentered with respect to a swivel axis.