

A Slurry Shield Machine Split Launching Slurry Pipe Replacement System and Method

Technical Field

The present invention relates to the field of slurry shield machine construction, and in particular to a slurry shield machine split launching slurry pipe replacement system and method.

Background Art

A slurry shield machine operates by pumping slurry of a certain concentration into its slurry chamber; as the excavated soil and groundwater cut by the cutter disk flow along the cutter grooves into the excavation, the concentration and pressure of the slurry in the chamber gradually increase and balance against the soil pressure and water pressure at the excavation face, forming a slurry membrane or a permeation wall resulting from the slurry pressure on the excavation face, thereby achieving stable excavation. A slurry circuit is formed via the slurry feed and slurry discharge pipes; slurry carries the excavated soil to the slurry separation station through the slurry discharge pipe, where dry residue is separated out, thereby enabling cyclic forward tunneling, with continuous tunneling achieved by continuously extending the slurry pipeline.

Split launching of a large-diameter shield machine is a technical challenge in shield construction; in particular, under space-constrained conditions, how to achieve split launching of the shield machine and reassemble it inside the tunnel has become a key issue. For the split launching process of a large-diameter slurry shield machine, in addition to considerations regarding the assembly and hoisting of the machine, primary attention must be given to the process of extending the slurry pipes. In existing slurry shield machines, slurry pipe extension is accomplished by reserving a sufficiently long flexible hose on top of the trolley to accommodate the forward movement of the slurry feed and slurry discharge pipelines, while the trolley position remains relatively unchanged, with the pipe replacement operation completed by moving the traveling frame of the pipe replacement device. However, since the pipe replacement device is generally installed at the tail end of the last trolley, in cases where the launching shaft is too small to allow all trolleys to be lowered into the shaft for split launching, it is impossible to carry out the pipe replacement process underground. Furthermore, conventional slurry pipe replacement devices occupy large amounts of space and are complex to operate, making it impossible to install such devices in confined spaces

with limited room. As the shield machine advances through tunneling, how to achieve telescopic pipe replacement for large-diameter, high-strength slurry pipes is also a prerequisite for the successful implementation of split launching. In response to the above problems, the present invention has developed a slurry shield machine split launching slurry pipe replacement system.

Summary of the Invention

In view of the deficiencies of the prior art, the present invention provides a slurry shield machine split launching slurry pipe replacement system and method; the pipe replacement system can achieve the telescopic pipe replacement process for slurry pipes in confined spaces, thereby ensuring the normal progress of large-diameter slurry shield machine split launching.

To achieve the above technical objective, the present invention provides a slurry shield machine split launching slurry pipe replacement system for slurry circulation during split launching of a shield machine, comprising a slurry station located at ground level and a shield machine trolley located within a launching shaft, wherein the slurry station and the shield machine trolley are cyclically connected via a slurry feed pipe and a slurry return pipe; the slurry pipe replacement telescopic system comprises a slurry pipe sliding track arranged on the side wall of the shield machine launching zone, a slurry feed pipe support platform located at ground level, and a slurry return pipe support platform located at ground level; the slurry feed pipe and the slurry return pipe each comprise a telescopic flexible hose section located at ground level, a fixed section connected to the tail end of the shield machine trolley, and a vertical support section connecting the telescopic flexible hose section and the fixed section; the telescopic flexible hose section of the slurry feed pipe is slidably disposed on the slurry feed pipe support platform; the telescopic flexible hose section of the slurry return pipe is slidably disposed on the slurry return pipe support platform; the slurry pipe sliding track is parallel to the direction of travel of the shield machine; the vertical support sections of the slurry feed pipe and the slurry return pipe are each slidably connected to the slurry pipe sliding track via a sliding mechanism; the sliding mechanism comprises a pipe bracket and a travelling pulley fixed on the pipe bracket; the pipe bracket fixedly connects the vertical support sections of the slurry feed pipe and the slurry return pipe; and the travelling pulley is slidably connected to the slurry pipe sliding track.

A preferred technical solution of the present invention: a slurry pipe traction mechanism is further provided at the starting end of the slurry pipe sliding track; a traction bracket is provided on the pipe bracket; a traction rope of the slurry pipe traction mechanism is connected to the traction bracket; and the traction mechanism is configured to, when the pipe bracket moves to the tail end of the slurry pipe sliding track, pull the pipe bracket and the vertical support sections of the slurry feed pipe and the slurry return pipe back to the starting end of the slurry pipe sliding track.

A preferred technical solution of the present invention: at least two sets of pipe brackets are provided, distributed at the upper and lower portions of the vertical support sections of the slurry feed pipe and the slurry return pipe; at least two slurry pipe sliding tracks are correspondingly arranged on the side wall of the shield machine launching zone; each slurry pipe sliding track is a concave track with the track surface facing upward, and limit stop plates are provided at both ends thereof; the pipe bracket comprises two integrated pipe clamp structures fixedly sleeved on the outer walls of the vertical support sections of the slurry feed pipe and the slurry return pipe respectively; and the travelling pulleys are fixedly mounted on the sides of the pipe bracket and slidably connected to the corresponding slurry pipe sliding tracks.

A preferred technical solution of the present invention: the fixed section of the slurry feed pipe is detachably connected to the slurry inlet at the tail end of the shield machine trolley; the fixed section of the slurry return pipe is detachably connected to the slurry return port at the tail end of the shield machine trolley; control valves are provided at both the slurry inlet and the slurry outlet at the tail end of the shield machine trolley; and a construction platform is provided in the area of the lower end of the side wall of the shield machine launching zone at the same height as the fixed sections.

A preferred technical solution of the present invention: the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe each comprise a horizontal flexible hose section and a curved flexible hose section, laid flat on the corresponding support platforms and connected to the corresponding vertical support sections via elbow joints; and a lubricating layer is applied to the contact surfaces between the slurry feed pipe support platform and the slurry return pipe support platform and the telescopic flexible hoses.

A preferred technical solution of the present invention: the length of the slurry pipe sliding track is 4–6 m; and the sliding distance of the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe on the corresponding support platforms is 4–6 m.

A preferred technical solution of the present invention: the traction mechanism comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms are provided for each slurry pipe sliding track; the traction bracket is vertically arranged on the outer side of the pipe bracket, and two traction rope connection ports are provided on the traction bracket; and the traction rope is a wire rope wound on the drum of the electric winding mechanism or the hand chain hoist.

The present invention also provides a slurry pipe replacement method applicable to large-diameter slurry shield machine split launching; the pipe replacement method uses the above-described slurry shield machine split launching slurry pipe replacement system for the pipe replacement process, comprising the following specific steps:

S1. Constructing the slurry feed pipe support platform and the slurry return pipe support platform at ground level, wherein the two platforms are parallel to each other and parallel to the slurry pipe sliding track and the tunneling direction of the shield machine; then placing the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe located at ground level on the slurry feed pipe support platform and the slurry return pipe support platform respectively, and applying lubricant to the contact areas between the platforms and the telescopic flexible hose sections;

S2. Connecting the vertical support sections of the slurry feed pipe and the slurry return pipe as one unit via one or more sets of pipe brackets, and slidably connecting each set of pipe brackets to the slurry pipe sliding track at the corresponding height; prior to shield machine launching, all pipe brackets are positioned at the starting end of the corresponding slurry pipe sliding track;

S3. Connecting the fixed sections of the slurry feed pipe and the slurry return pipe to the slurry inlet and the slurry outlet at the tail end of the last trolley in the launching shaft respectively, at which point shield machine launching can begin; during the shield machine launching process, the vertical support sections of the slurry feed pipe and the slurry return pipe advance synchronously along the slurry pipe sliding track, while the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe 3 slide forward on the slurry feed pipe support platform and the slurry return pipe support platform respectively;

S4. When tunneling has advanced to the point where the vertical support sections of the slurry feed pipe and the slurry return pipe have moved to the tail end of the slurry pipe sliding track (7), stopping tunneling; closing the control valves at the slurry inlet and slurry outlet at the tail end of the shield machine trolley, and closing the control valves at the slurry outlet and slurry return port of the slurry station, to ensure that the slurry feed pipe and the slurry return pipe are free of slurry; disconnecting the fixed sections of the slurry feed pipe and the slurry return pipe from the shield machine trolley, and pulling the slurry feed pipe and the slurry return pipe back to the starting end of the slurry pipe sliding track via the traction mechanism;

S5. Installing an extension slurry pipe between the fixed sections of the slurry feed pipe and the slurry return pipe and the shield machine trolley, completing the pipe replacement process and preparing for the next stage of tunneling.

A preferred technical solution of the present invention: in step S3, the tunneling length per advance of the shield machine is 4–6 m; the length of the slurry pipe sliding track is 4–6 m; and the sliding distance of the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe on the corresponding support platforms matches the length of the slurry pipe sliding track.

A preferred technical solution of the present invention: the traction mechanism in step S4 comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms are installed at the starting end of each slurry pipe sliding track, and the traction ropes of the traction mechanisms are connected to the corresponding sliding brackets; when the sliding brackets slide to the tail end, all traction mechanisms are controlled to operate simultaneously to pull the slurry feed pipe and the slurry return pipe back to the starting end of the slurry pipe sliding track 7.

The present invention is capable of achieving the slurry pipe replacement process without the need for a dedicated pipe replacement device. During the advancing process of the shield machine, the vertical support sections of the slurry feed pipe and the slurry return pipe can move in parallel along the sliding track, and the flexible hose sections of the slurry feed pipe and the slurry return pipe can also slide out on the platform, thereby ensuring that the slurry pipes can perform normal slurry circulation for the shield machine. When the slurry feed pipe and the slurry return pipe have moved to the tail end of the sliding track, the control valves at the slurry inlet and slurry outlet at the tail end of the shield machine trolley can be closed, and

the control valves at the slurry outlet and slurry return port of the slurry station can also be closed, to ensure that the slurry feed pipe and the slurry return pipe are free of slurry; the connections between the fixed sections of the slurry feed pipe and the slurry return pipe and the shield machine trolley are then detached, and the slurry feed pipe and the slurry return pipe are pulled back to the starting end of the sliding track by the traction mechanism; extension pipes are added between the tail end of the shield machine trolley and the fixed sections of the slurry feed pipe and the slurry return pipe respectively, whereupon shield machine tunneling can resume.

The overall pipe replacement process of the present invention is simple and convenient; the installation and construction of the overall structure requires minimal space; the process enables rapid pipe replacement in confined spaces; and it is applicable to situations where the available space is too limited to accommodate a dedicated pipe replacement device.

Brief Description of the Drawings

FIG. 1 is a structural schematic diagram of the present invention;

FIG. 2 is an enlarged schematic view of detail A in FIG. 1;

FIG. 3 is a schematic view showing the slurry feed pipe and the slurry return pipe positioned at the starting end of the sliding track;

FIG. 4 is a schematic view showing the slurry feed pipe and the slurry return pipe positioned at the tail end of the sliding track.

In the figures: 1—slurry station; 2—slurry feed pipe; 3—slurry return pipe; 4—slurry feed pipe support platform; 5—slurry return pipe support platform; 6—side wall of the shield machine launching zone; 7—slurry pipe sliding track; 8—sliding mechanism; 800—pipe bracket; 801—travelling pulley; 9—slurry pipe traction mechanism; 10—traction bracket; 11—traction rope; 12—construction platform; 13—shield machine trolley.

Detailed Description of Embodiments

The present invention is further described below with reference to the accompanying drawings and embodiments. FIGS. 1 to 4 are all drawings of the embodiments, drawn in a simplified manner, and are intended solely for the purpose of clearly and concisely illustrating

the embodiments of the present invention. The technical solutions presented in the accompanying drawings are specific implementations of the embodiments of the present invention and are not intended to limit the scope of the claimed invention. Based on the embodiments of the present invention, all other embodiments obtained by persons of ordinary skill in the art without creative effort fall within the scope of protection of the present invention.

In the description of the present invention, it should be understood that the orientations or positional relationships indicated by the terms “upper,” “lower,” “inner,” “outer,” “left,” “right,” and the like are based on the orientations or positional relationships shown in the accompanying drawings, or are the orientations or positional relationships in which the product of the invention is customarily placed when in use, or are orientations or positional relationships customarily understood by persons skilled in the art, and are provided solely for the purposes of facilitating the description of the present invention and simplifying the description, and do not indicate or imply that the devices or elements referred to must have a specific orientation or be constructed and operated in a specific orientation, and therefore shall not be construed as limiting the present invention. Furthermore, the terms “first,” “second,” and the like are used solely for distinguishing between descriptions and shall not be construed as indicating or implying any relative importance.

Embodiment 1 provides a slurry shield machine split launching slurry pipe replacement system for slurry circulation during shield machine split launching, comprising a slurry station 1 located at ground level and a shield machine trolley 13 located in the launching shaft. The slurry station 1 is provided with a slurry outlet and a slurry return port, each fitted with a control valve; the tail end of the shield machine trolley 13 is provided with a slurry inlet and a slurry outlet, each also fitted with a control valve. The slurry station 1 and the shield machine trolley 13 are connected in a circulation circuit via a slurry feed pipe 2 and a slurry return pipe 3: the inlet end of the slurry feed pipe 2 is connected to the slurry outlet of the slurry station 1; the outlet end of the slurry feed pipe 2 is detachably connected to the slurry inlet at the tail end of the last shield machine trolley 13 in the shaft; the inlet end of the slurry return pipe 3 is detachably connected to the slurry outlet at the tail end of the shield machine trolley 13; and the outlet end of the slurry return pipe 3 is connected to the slurry return port of the slurry station 1. A construction platform 12 is provided in the area of the lower end of the side wall 6 of the shield machine launching zone at the same height as the fixed sections, so as to facilitate workers standing on the construction platform 12 to detach

the connections between the slurry feed pipe 2 and the slurry return pipe 3 and the shield machine trolley 13, and to install extension pipes.

The telescopic slurry pipe replacement system of Embodiment 1, as shown in FIGS. 1 to 4, comprises a slurry pipe sliding track 7 arranged on the side wall 6 of the shield machine launching zone, a slurry feed pipe support platform 4 and a slurry return pipe support platform 5 located at ground level. The slurry feed pipe 2 and the slurry return pipe 3 each comprise a telescopic flexible hose section located at ground level, a fixed section connected to the tail end of the shield machine trolley 13, and a vertical support section connecting the telescopic flexible hose section and the fixed section. The telescopic flexible hose section of the slurry feed pipe 2 is slidably disposed on the slurry feed pipe support platform 4, and the telescopic flexible hose section of the slurry return pipe 3 is slidably disposed on the slurry return pipe support platform 5. The slurry pipe sliding track 7 is parallel to the direction of travel of the shield machine, and the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 are both slidably connected to the slurry pipe sliding track 7 via the sliding mechanism 8. The telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 each comprise a horizontal flexible hose section and a curved flexible hose section, laid flat on the corresponding support platforms and connected to the corresponding vertical support sections via elbow joints; a lubricating layer is applied to the contact surfaces between the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 and the telescopic flexible hoses, so as to facilitate the sliding of the slurry feed pipe 2 and the slurry return pipe 3.

In the slurry shield machine split launching slurry pipe replacement system of Embodiment 1, as shown in FIGS. 1 to 4, two sets of sliding mechanisms 8 are provided, distributed at the upper and lower portions of the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3. At least two slurry pipe sliding tracks 7 are correspondingly arranged on the side wall 6 of the shield machine launching zone, each slurry pipe sliding track 7 being a concave track with the track surface facing upward, and each track being provided with end-stop plates at both ends. Each set of sliding mechanisms 8 comprises a pipe bracket 800 and a travelling pulley 801 fixed to the pipe bracket 800. The pipe bracket 800 comprises two integral pipe clamp structures respectively fixedly sleeved on the outer walls of the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3; the travelling pulley 801 is fixedly mounted on the side face of the pipe bracket 800 and is slidably connected to the corresponding slurry pipe sliding track 7, enabling back-and-forth movement along the corresponding slurry pipe sliding track 7. The forward movement of the sliding mechanism 8

is powered by the shield machine; as the shield machine and the shield machine trolley 13 move forward, a traction force is applied to the slurry feed pipe 2 and the slurry return pipe 3, driving the sliding mechanism 8 to move along the slurry pipe sliding track 7.

In Embodiment 1, the power for returning the sliding mechanism 8 to its initial position is provided by the slurry pipe traction mechanism 9 installed at the starting end of the slurry pipe sliding track 7. As shown in FIGS. 1 and 2, the traction mechanism 9 comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms 9 are provided for each slurry pipe sliding track 7. A traction bracket 10 is provided on the pipe bracket 800, with the traction bracket 10 vertically arranged on the outer side face of the pipe bracket 800 and provided with two traction rope connection ports; the traction rope 11 of the slurry pipe traction mechanism 9 is connected to the traction bracket 10. When the pipe bracket 800 has moved to the tail end of the slurry pipe sliding track 7, the traction mechanism 9 is used to pull the pipe bracket 800 and the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 back to the starting end of the slurry pipe sliding track 7. The traction rope 11 is a wire rope wound on the drum of the electric winding mechanism or the hand chain hoist.

The slurry station 1 of the present invention is positioned at ground level and connected to the slurry feed pipe 2 and the slurry return pipe 3 of the shield machine to separate and process the muck generated during shield machine tunneling. The telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 are located at ground level and are supported by the respective support platforms; the telescopic flexible hose sections slide on the corresponding support platforms, and lubricant or petroleum jelly may be applied to the upper contact surfaces of the support platforms where they contact the flexible hoses to ensure smooth sliding. The slurry feed pipe support platform 4 and the slurry return pipe support platform 5 are installed at ground level; their specific heights are adjusted according to the elevation of the station foundation pit, with columns set at the base to form either a two-tier structure or structures at the same elevation, provided that the pipe sliding requirements are satisfied. Multiple elbow joints are installed between the rigid pipes and the telescopic flexible hoses of the slurry feed pipe 2 and the slurry return pipe 3 to effect the connection while ensuring that the pipe routing remains reasonable during extension and movement. Two sets of sliding brackets are provided for the slurry pipes—one at the top and one at the bottom—to ensure stable sliding; to ensure safety and prevent the pipes from falling, fall-prevention devices are installed on the outer side of the pipes, with wire ropes used for additional protection.

During the advancing process of the shield machine, the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 can move in parallel along the slurry pipe sliding track 7, and the telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 can also slide out on the corresponding platforms, thereby ensuring that the slurry pipes can perform normal slurry circulation for the shield machine. When the slurry feed pipe 2 and the slurry return pipe 3 have moved to the tail end of the slurry pipe sliding track 7, the control valves at the slurry inlet and slurry outlet at the tail end of the shield machine trolley 13 can be closed, and the control valves at the slurry outlet and slurry return port of the slurry station 1 can also be closed, to ensure that the slurry feed pipe 2 and the slurry return pipe 3 are free of slurry; the connections between the fixed sections of the slurry feed pipe 2 and the slurry return pipe 3 and the shield machine trolley 13 are then detached, and the slurry feed pipe 2 and the slurry return pipe 3 are pulled back to the starting end of the slurry pipe sliding track 7 by the traction mechanism 9; extension pipes are added between the tail end of the shield machine trolley 13 and the fixed sections of the slurry feed pipe 2 and the slurry return pipe 3 respectively, whereupon shield machine tunneling can resume.

Embodiment 2 provides a slurry pipe replacement method applicable to large-diameter slurry shield machine split launching, using the slurry shield machine split launching slurry pipe replacement system of Embodiment 1 for the pipe replacement process, comprising the following specific steps:

S1. Constructing the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 at ground level, wherein the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 are parallel to each other and parallel to the slurry pipe sliding track 7 and the tunneling direction of the shield machine; then placing the telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 located at ground level on the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 respectively, and applying lubricant to the contact areas between the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 and the telescopic flexible hose sections.

S2. Connecting the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 as one unit via one or more sets of pipe brackets, and slidably connecting each set of pipe brackets to the slurry pipe sliding track 7 at the corresponding height; prior to shield machine launching, all pipe brackets are positioned at the starting end of the corresponding slurry pipe sliding track 7.

S3. Connecting the fixed sections of the slurry feed pipe 2 and the slurry return pipe 3 to the slurry inlet and the slurry outlet at the tail end of the last trolley in the launching shaft respectively, at which point shield machine launching can begin; during the shield machine launching process, the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 advance synchronously along the slurry pipe sliding track 7, while the telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 slide forward on the slurry feed pipe support platform 4 and the slurry return pipe support platform 5 respectively; the tunneling length per advance of the shield machine is 4–6 m; the length of the slurry pipe sliding track 7 is 4–6 m; and the sliding distance of the telescopic flexible hose sections of the slurry feed pipe 2 and the slurry return pipe 3 on the corresponding support platforms matches the length of the slurry pipe sliding track 7.

S4. When shield machine tunneling has proceeded to the point where the vertical support sections of the slurry feed pipe 2 and the slurry return pipe 3 have moved to the tail end of the slurry pipe sliding track 7, stop shield machine tunneling; close the control valves at the slurry inlet and slurry outlet at the tail end of the shield machine trolley 13, and also close the control valves at the slurry outlet and slurry return port of the slurry station 1, to ensure that the slurry feed pipe 2 and the slurry return pipe 3 are free of slurry; detach the connections between the fixed sections of the slurry feed pipe 2 and the slurry return pipe 3 and the shield machine trolley 13, and use the traction mechanism to pull the slurry feed pipe 2 and the slurry return pipe 3 back to the starting end of the slurry pipe sliding track 7; the traction mechanism comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms 9 are installed at the starting end of each slurry pipe sliding track 7, and the traction ropes of the traction mechanisms 9 are connected to the corresponding sliding brackets 800; when the sliding brackets 800 slide to the tail end, all traction mechanisms 9 are controlled to operate simultaneously to pull the slurry feed pipe 2 and the slurry return pipe 3 back to the starting end of the slurry pipe sliding track 7.

S5. Installing extension slurry pipes between the fixed sections of the slurry feed pipe 2 and the slurry return pipe 3 and the shield machine trolley 13, thereby completing the pipe replacement process and preparing for the next phase of shield machine tunneling.

The present invention utilizes the tunneling of the shield machine to provide the driving force for movement of the slurry feed pipe 2 and the slurry return pipe 3, thereby enabling smooth movement of the pipes during shield machine tunneling. After tunneling a certain distance, the existing pipes are disconnected; the original pipes are then pulled back to their initial positions by the traction mechanism, and extension pipes are added in between to ensure that the pipes can continue to advance. The slurry pipes on the slurry station side are provisionally

and permanently connected to the slurry pipes arranged along the side wall structure, until modification is carried out after the completion of the split launching phase; the flexible hoses installed at ground level simultaneously extend and retract accordingly. To ensure operational convenience, a work platform is provided at the location where the slurry pipes are replaced to facilitate each pipe replacement operation; the shield machine trolley has a portal frame structure with a vehicle passage reserved internally to meet the transportation requirements for tunnel segments, materials, and consumables during shield machine tunneling.

The foregoing describes only one embodiment of the present invention, and the description thereof is relatively specific and detailed, but shall not therefore be construed as limiting the scope of the present invention. It should be noted that, for persons of ordinary skill in the art, several variations and improvements can also be made without departing from the concept of the present invention, and all such variations and improvements fall within the scope of protection of the present invention. Therefore, the scope of protection of the present invention shall be governed by the appended claims.

Claims

1. A slurry shield machine split launching slurry pipe replacement system for slurry circulation during split launching of a shield machine, comprising a slurry station (1) located at ground level and a shield machine trolley (13) located within a launching shaft, wherein the slurry station (1) and the shield machine trolley (13) are cyclically connected via a slurry feed pipe (2) and a slurry return pipe (3), characterized in that: the slurry pipe replacement system comprises a slurry pipe sliding track (7) arranged on the side wall (6) of the shield machine launching zone, a slurry feed pipe support platform (4) located at ground level, and a slurry return pipe support platform (5) located at ground level; the slurry feed pipe (2) and the slurry return pipe (3) each comprise a telescopic flexible hose section located at ground level, a fixed section connected to the tail end of the shield machine trolley (13), and a vertical support section connecting the telescopic flexible hose section and the fixed section; the telescopic flexible hose section of the slurry feed pipe (2) is slidably disposed on the slurry feed pipe support platform (4); the telescopic flexible hose section of the slurry return pipe (3) is slidably disposed on the slurry return pipe support platform (5); the slurry pipe sliding track (7) is parallel to the direction of travel of the shield machine; the vertical support sections of the slurry feed pipe (2) and the slurry return pipe (3) are each slidably connected to the slurry pipe sliding track (7) via a sliding mechanism (8); the sliding mechanism (8) comprises a pipe bracket (800) and a travelling pulley (801) fixed on the pipe bracket (800); the pipe bracket (800) fixedly connects the vertical support sections of the slurry feed pipe (2) and the slurry return pipe (3); the travelling pulley (801) is slidably connected to the slurry pipe sliding track (7); a slurry pipe traction mechanism (9) is further provided at the starting end of the slurry pipe sliding track (7); a traction bracket (10) is provided on the pipe bracket (800); a traction rope (11) of the traction mechanism (9) is connected to the traction bracket (10); and the traction mechanism (9) is configured to, when the pipe bracket (800) moves to the tail end of the slurry pipe sliding track (7), pull the pipe bracket (800) and the vertical support sections of the slurry feed pipe (2) and the slurry return pipe (3) back to the starting end of the slurry pipe sliding track (7).

2. The slurry shield machine split launching slurry pipe replacement system according to claim 1, characterized in that: at least two sets of pipe brackets (800) are provided, distributed at the upper and lower portions of the vertical support sections of the slurry feed pipe (2) and the slurry return pipe (3); at least two slurry pipe sliding tracks (7) are correspondingly

arranged on the side wall (6) of the shield machine launching zone; each slurry pipe sliding track (7) is a concave track with the track surface facing upward, and limit stop plates are provided at both ends thereof; the pipe bracket (800) comprises two integrated pipe clamp structures fixedly sleeved on the outer walls of the vertical support sections of the slurry feed pipe (2) and the slurry return pipe (3) respectively; and the travelling pulleys (801) are fixedly mounted on the sides of the pipe bracket (800) and slidably connected to the corresponding slurry pipe sliding tracks (7).

3. The slurry shield machine split launching slurry pipe replacement system according to claim 1, characterized in that: the fixed section of the slurry feed pipe (2) is detachably connected to the slurry inlet at the tail end of the shield machine trolley (13); the fixed section of the slurry return pipe (3) is detachably connected to the slurry outlet at the tail end of the shield machine trolley (13); control valves are provided at both the slurry inlet and the slurry outlet at the tail end of the shield machine trolley (13); and a construction platform (12) is provided in the area of the lower end of the side wall (6) of the shield machine launching zone at the same height as the fixed sections.

4. The slurry shield machine split launching slurry pipe replacement system according to claim 1, characterized in that: the telescopic flexible hose sections of the slurry feed pipe (2) and the slurry return pipe (3) each comprise a horizontal flexible hose section and a curved flexible hose section, laid flat on the corresponding support platforms and connected to the corresponding vertical support sections via elbow joints; and a lubricating layer is applied to the contact surfaces between the slurry feed pipe support platform (4) and the slurry return pipe support platform (5) and the telescopic flexible hoses.

5. The slurry shield machine split launching slurry pipe replacement system according to claim 1, characterized in that: the length of the slurry pipe sliding track (7) is 4–6 m; and the sliding distance of the telescopic flexible hose sections of the slurry feed pipe (2) and the slurry return pipe (3) on the corresponding support platforms is 4–6 m.

6. The slurry shield machine split launching slurry pipe replacement system according to claim 1, characterized in that: the traction mechanism (9) comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms (9) are provided for each slurry pipe sliding track (7); the traction bracket (10) is vertically arranged on the outer side of the pipe bracket (800), and two traction rope connection ports are provided on the traction bracket (10); and the traction rope (11) is a wire rope wound on the drum of the electric winding mechanism or the hand chain hoist.

7. A slurry pipe replacement method applicable to large-diameter slurry shield machine split launching, characterized in that the pipe replacement method uses the slurry shield machine split launching slurry pipe replacement system according to any one of claims 1 to 6 for the pipe replacement process, comprising the following specific steps:

S1. Constructing the slurry feed pipe support platform and the slurry return pipe support platform at ground level, wherein the two platforms are parallel to each other and parallel to the slurry pipe sliding track and the tunneling direction of the shield machine; then placing the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe located at ground level on the slurry feed pipe support platform and the slurry return pipe support platform respectively, and applying lubricant to the contact areas between the platforms and the telescopic flexible hose sections;

S2. Connecting the vertical support sections of the slurry feed pipe and the slurry return pipe as one unit via one or more sets of pipe brackets, and slidably connecting each set of pipe brackets to the slurry pipe sliding track at the corresponding height; prior to shield machine launching, all pipe brackets are positioned at the starting end of the corresponding slurry pipe sliding track;

S3. Connecting the fixed sections of the slurry feed pipe and the slurry return pipe to the slurry inlet and the slurry outlet at the tail end of the last trolley in the launching shaft respectively, at which point shield machine launching can begin; during the shield machine launching process, the vertical support sections of the slurry feed pipe and the slurry return pipe advance synchronously along the slurry pipe sliding track, while the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe 3 slide forward on the slurry feed pipe support platform and the slurry return pipe support platform respectively;

S4. When tunneling has advanced to the point where the vertical support sections of the slurry feed pipe and the slurry return pipe have moved to the tail end of the slurry pipe sliding track (7), stopping tunneling; closing the control valves at the slurry inlet and slurry outlet at the tail end of the shield machine trolley, and closing the control valves at the slurry outlet and slurry return port of the slurry station, to ensure that the slurry feed pipe and the slurry return pipe are free of slurry; disconnecting the fixed sections of the slurry feed pipe and the slurry return pipe from the shield machine trolley, and pulling the slurry feed pipe and the slurry return pipe back to the starting end of the slurry pipe sliding track via the traction mechanism;

S5. Installing an extension slurry pipe between the fixed sections of the slurry feed pipe and the slurry return pipe and the shield machine trolley, completing the pipe replacement process and preparing for the next stage of tunneling.

8. The slurry pipe replacement method applicable to large-diameter slurry shield machine split launching according to claim 7, characterized in that: in step S3, the length of each tunneling advance of the shield machine is 4–6 m; the length of the slurry pipe sliding track is 4–6 m; and the sliding distance of the telescopic flexible hose sections of the slurry feed pipe and the slurry return pipe on the corresponding support platforms matches the length of the slurry pipe sliding track.

9. The slurry pipe replacement method applicable to large-diameter slurry shield machine split launching according to claim 7, characterized in that: the traction mechanism in step S4 comprises an electric winding mechanism and a hand chain hoist; one or two sets of traction mechanisms are installed at the starting end of each slurry pipe sliding track, and the traction ropes of the traction mechanisms are connected to the corresponding sliding brackets; when the sliding brackets slide to the tail end, all traction mechanisms are controlled to operate simultaneously to pull the slurry feed pipe and the slurry return pipe back to the starting end of the slurry pipe sliding track.