Method of reconstructing shield tunnel for mining construction

Technical Field

The present invention belongs to the technical field of mining construction inside a shield tunnel, in particular to a method of reconstructing shield tunnel for mining construction.

Tunnel construction methods include shield tunneling method, mining method, and cutting and covering method, etc. In a construction process of a certain project or a certain section, one method of construction is often used alone or multiple methods of construction are used alternatively in different sections. For interval tunnel engineering, mining method and shield tunneling method are often adopted according to strata sublevels of different sections. However, there are many uncertain factors in the process of underground engineering and construction, it may become more difficult to apply the construction of mining method due to water gushing, sand gushing, stratum changes and other unexpected circumstances, thus affecting the penetration of the whole section; and it may also be difficult to continue construction of tunneling shield because of some unexpected situations such as inaccurate stratum investigation and serious damage to equipment. At present, it is common to carry out shield tunnel construction in a mining tunnel, usually by pushing the shield tunneling machine through an interface of the mining tunnels to start the shield tunnel construction, but there is no effective method to carry out mining tunnel construction in the shield tunnel.

Summary of the invention

In order to address the mentioned shortcomings in the prior art, the present invention provides a method of reconstructing shield tunnel for mining construction. After construction of the shield tunnel is completed, the shield tunneling machine is subjected to shell abandonment and disassembly in the tunnel, the shield tunneling machine is dismantled and then transported out, a formed shield tunnel transportation system and pipeline arrangement are reconstructed and adjusted, protective measures for the shield tunnel are added and one or more ring beams are constructed in the transitional section to guarantee inter-zonal safety, and necessary conditions are provided for mining construction, such that mining construction in the shield tunnel is realized, and the problem of it not being possible for a shield to be tunneled due to unforeseen

circumstances and a mining method needing to be used to continue construction, or the problem of the construction difficulty of the mining tunnel increasing and a new working face needing to be provided in the shield tunnel are solved, thereby guaranteeing the smooth penetration of an inter-zonal tunnel, and it is easy to promote use of the present invention.

The present invention adopts following technical solutions to solve the above technical problems. A method of reconstructing a shield tunnel for mining construction comprises following steps of:

S1, carrying out construction preparation, wherein when construction of a shield tunnel is in place, reinforcement and waterproof treatment are conducted on rock formations surrounding a shield tunneling machine as per following processes of:

S101, filling a shield tail by the shield tunneling machine with grease to protect shield tail brushes;

S102, sealing and grouting last ten pipe rings of shield tunneling after construction of the shield tunnel, wherein a double-liquid slurry is used for grouting construction and injected symmetrically from bottom to top in a manner of reserving secondary grouting holes in pipe segments, at a grouting pressure of 0.3 bar ~ 0.4 bar, and in the process of grouting, monitoring the grouting pressure and the pipe segments to prevent cracking and dislocation of the pipe segments;

S103, tensioning the last ten pipe rings of shield tunneling by tensioning steel plates, wherein a total of 6~8 tensioning steel plates are provided in a longitudinal direction of the last ten pipe rings of shield tunneling to prevent loosening of the pipe segments after penetration;

S104, arranging embedded steel plates and arc steel plates on a last pipe ring of shield tunneling, and welding and sealing the same to a tail of a shield shell, then by virtue of sealing reinforcement ribs, welding the embedded steel plates, and the arc steel plates in the last pipe ring of shield tunneling to the tail of the shield shell, and injecting micro-expanding cement through grouting holes in the pipe segments to fill gaps between the pipe segments and the tail of the shield shell;

S105, arranging sealing steel plates at a head of the shield shell, sealing gaps between the head of the shield shell and surrounding rocks, injecting and filing micro-expanding cement through radial grouting holes at an intermediate part of the shield, and sealing formation water around shield body; and

S106, installing one or more smoke exhaust fans in front of a tunnel excavating face to form convection currents with an original air supply fan in the tunnel, so as to accelerate air circulation on the working face and ensure a prompt discharge of smoke and dust in the tunnel;

S2, abandoning the shield shell and disassembling the shield tunneling machine, wherein according to dismantling sequence of rear supporting trolleys, erectors, walking beams, H frames, motors, man cabins, propulsion cylinders, stone crushers, cutter heads and main bearings, shell abandoning and machine dismantling are carried out in the tunnel; the rear supporting trolleys are disconnected and pulled out of the tunnel directly, all parts of the erectors, walking beams, H frames, motors, man cabins, propulsion cylinders, stone crushers, cutter heads and main bearings are disassembled, cut off and transported out of the tunnel in pieces; and the discarded shield shell is remained in situ;

S3, carrying out horizontal road construction, wherein model-building concrete is firstly laid on the pipe rings of the shield tunnel, the model-building concrete is at a maximum thickness of 500mm ~ 700mm, in the model-building concrete are embedded single-layer steel bar meshes and connecting steel bar; on the model-building concrete is laid a concrete cover for protecting the single-layer steel bar meshes, the connecting steel bars are arranged erect, and a track bed is poured;

S4, carrying out protection on the shield tunnel, and excavating a transitional section of a mining tunnel, wherein the transitional section of mining tunnel is excavated by blasting, before blasting and excavating the transitional section of mining tunnel, on an end face of the last pipe ring of shield tunneling are installed a plurality of hanger bolts for hanging a protective door curtain, the hanger bolts penetrate into side bolt holes of the last pipe ring of shield tunneling, the hanger bolts

are used as door curtain hanging points, and the protective door curtain is made of wire rope meshes;

then, on last three to five pipe rings of shield tunneling are covered a pipe segment cover, the pipe segment cover includes a wooden board underlying layer and a cotton protective cover laid on the wooden board underlying layer;

in the construction process of the transitional section of the mining tunnel, transport vehicles reverse from a shield tunneling starting station to enter the excavating face and depart along a direction of traffic, the tunneling starting station is used as a vehicle U-turn and temporary equipment storage area to output residues generated in the construction of transitional section of the mining tunnel; and

the transition section of mining tunnel has a length of 30m ~ 50m;

S5, forming the transitional section of the mining tunnel as per following processes of:

S501, arranging one or more ring beams at an end of the last pipe ring of shield tunneling near the mining tunnel, wherein the ring beams are of a reinforced concrete structure, steel bars in the ring beams are fixedly connected with embedded steel plates and sealing reinforcement ribs in the last pipe ring of shield tunneling; one end of the ring beams extends outside the pipe rings and is fixedly connected to the shield shell , and another end of the ring beams extends 10cm into the pipe rings;

S502, roughening construction joints between the ring beams and the last pipe ring of shield tunneling, and providing the same with water-expandable water-stop strips and grouting pipes; and

S503, performing a secondary lining construction on the transitional section of the mining tunnel, wherein a secondary lining of the transitional section of the mining method tunnel is done by pouring concrete for both the ring beams and the secondary lining (19) simultaneously, and extending and lining one side of the ring beams far from the transitional section of mining tunnel to

build an extended lining of transitional section of the mining tunnel, and the extended lining extends into the last three to five pipe rings of shield tunneling, further, gaps between the shell of the shield tunneling machine and the pipe rings are filled by shield tail grouting, so that the secondary lining, the ring beams, the extended lining, the pipe rings and the shell of the shield tunneling machine are cast to be an integral structure; and

S6, constructing the mining tunnel, wherein the mining tunnel is excavated by blasting, in the process of constructing the mining tunnel, transport vehicles use the mining tunnel to as a vehicle U-turn and temporary equipment storage area to output residues newly generated during the construction of the mining tunnel.

The method of reconstructing a shield tunnel for mining construction mentioned above, is characterized in that, the embedded steel plates mentioned in the S501 are arranged in the last pipe ring via anchor ribs.

The method of reconstructing a shield tunnel for mining construction mentioned above, is characterized in that, pipelines are adjusted accordingly to meet requirements of the mining tunnel construction while carrying out horizontal road construction in the S3; the mentioned pipelines include ventilation pipes, water supply pipes, sewage pipes, high voltage cables, lighting lines, communication lines, walkway board pipelines and transformer pipelines; and the transformer pipelines removed from the shield tunneling machine are installed onto side walls of the pipe segments through bolts.

The method of reconstructing a shield tunnel for mining construction mentioned above, is characterized in that, a diameter of each mesh of the wire rope meshes mentioned in the S4 is 100mm~200mm.

The method of reconstructing a shield tunnel for mining construction mentioned above, is characterized in that, the amount of hanger bolts is 8~10, and 8~10 hanger bolts are evenly arranged on the end face of the last pipe ring of shield tunneling.

The method of reconstructing a shield tunnel for mining construction mentioned above, is characterized in that, the micro-expanding cement mentioned in the S104 is alunite expansive cement.

The present invention has following advantages compared with the prior art.

1. In the present invention, after construction of a shield tunnel is in place, reinforcement and waterproof treatment is conducted on rock formations surrounding a shield tunneling machine, the pipe segments on the tail of shield machine are strictly sealed to be water-resistant by injecting micro-expanding cement, which can also strengthen the shield body; furthermore, one or more smoke exhaust fans are installed in front of a tunnel excavating face to form convection currents with an original air supply fan in the tunnel, so as to accelerate air circulation on a working face, ensure a prompt discharge of smoke and dust in the tunnel and guarantee a good construction environment, which is easy to use.

2. In the present invention, shell abandoning and machine dismantling are carried out in the tunnel; the rear supporting trolleys are disconnected and pulled out of the tunnel directly, all parts of the erectors, the walking beams, the H frames, the motors, man cabins, the propulsion cylinders, the stone crushers, the cutter heads and the main bearings are disassembled, cut off and transported out of the tunnel in pieces; and the discarded shell of the shield tunneling machine is remained in situ to serve as a permanent support for the secondary lining and, which makes a reliable and stable structure, and has a good use effect.

3. The steps of the present invention are easy to operate. In the present invention, necessary modifications and adjustments are made to the already formed shield tunnel transportation system and pipeline arrangement, so that the vertical transport system in shield tunneling can basically meet the requirements of mining construction and support equipment on the ground can be utilized to implement mining construction; further, protective measures for the shield tunnel are added and one or more ring beams are constructed in the transitional section to

guarantee inter-zonal safety, and necessary conditions are provided for mining construction, such that mining construction in the shield tunnel is realized, and the problem of it not being possible for a shield to be tunneled due to unforeseen circumstances and a mining method needing to be used to continue construction, or the problem of the construction difficulty of the mining tunnel increasing and a new working face needing to be provided in the shield tunnel are solved, thereby guaranteeing the smooth penetration of an inter-zonal tunnel.

4. The present invention enables that the mining method and the shield tunneling method are applied alternatively in sections of the tunnel construction, which broadens the application scope of the undermining method and ensures the smooth penetration of the interval tunnel engineering, thereby providing a new method and thought for the construction selection of complex interval tunnel engineering; further in the process of mining construction of the present invention, the facilities and equipment in the original shield tunneling are fully used, so as to reduce the investment and the construction cost.

To sum up, after construction of the shield tunnel in the present invention is completed, the shield tunneling machine is subjected to shell abandonment and disassembly in the tunnel, the shield tunneling machine is dismantled and then transported out, a formed shield tunnel transportation system and pipeline arrangement are reconstructed and adjusted, protective measures for the shield tunnel are added and one or more ring beams are constructed in the transitional section to guarantee inter-zonal safety, and necessary conditions are provided for mining construction, such that mining construction in the shield tunnel is realized, and the problem of it not being possible for a shield to be tunneled due to unforeseen circumstances and a mining method needing to be used to continue construction, or the problem of the construction difficulty of the mining tunnel increasing and a new working face needing to be provided in the shield tunnel are solved, thereby guaranteeing the smooth penetration of an inter-zonal tunnel, and it is easy to promote use of the present invention.

The technical solutions of the present invention will be further described in detail below through the accompanying drawings and embodiments.

Description of the drawings

Figure 1 is a structural diagram of the shield shell reinforcement after abandoning a shell of a shield tunneling machine and disassembling the shield tunneling machine in the present invention;

Figure 2 is a structural diagram showing the horizontal road construction in the present invention;

Figure 3 is a spatial relation diagram of the mining tunnel, the shield tunnel and the shield starting station in the present invention;

Figure 4 is a schematic diagram showing the protective door curtain and pipe segment cover installed on the shield tunnel of the present invention;

Figure 5 is a schematic diagram showing the installation relationship between the protective door curtain and the pipe ring of the present invention;

Figure 6 is a schematic diagram of the position relations of the shield shell, the pipe rings, ring beams, extended lining and secondary lining of the present invention; and

Figure 7 is an installation relation diagram of the ring beams, the embedded steel plates and the pipe rings of the present invention.

The markups in the drawings are indicated as follows:

1-rock formation;

2-shield shell;

3-sealing steel plate;

4-pipe ring;

5-tensioning pipe sheet;

6- sealing reinforcement rib;

7-model-building concrete;

8-connecting rebar;

9-concrete cover;

10-track bed;

11-mining tunnel;

12-shield tunnel;

13-shield tunneling starting station;

14-protective door curtain;

15-hanger bolt;

16- pipe segment cover;

17-ring beam;

18-extended lining;

19-secondary lining;

20-embedded steel plate; and

21-anchor rib.

Specific Embodiments

As shown in Figures 1-8, the present invention discloses a method of reconstructing a shield tunnel for mining construction, comprising following steps:

S1 is to carry out construction preparation, wherein when construction of a shield tunnel (12) is in place, reinforcement and waterproof treatment are conducted on rock formations surrounding a shield tunneling machine as per following processes of:

S101, filling a shield tail by the shield tunneling machine with grease to protect shield tail brushes;

S102, sealing and grouting last ten pipe rings (4) of shield tunneling after construction of the shield tunnel (12), wherein a double-liquid slurry is used for grouting construction and injected symmetrically from bottom to top in a manner of reserving secondary grouting holes in pipe segments, at a grouting pressure of 0.3 bar ~ 0.4 bar, and in the process of grouting, monitoring the grouting pressure and the pipe segments to prevent cracking and dislocation of the pipe segments;

S103, tensioning the last ten pipe rings (4) of shield tunneling by tensioning steel plates (5), wherein a total of 6~8 tensioning steel plates (5) are provided in a longitudinal direction of the last ten pipe rings (4) of shield tunneling to prevent loosening of the pipe segments after penetration;

S104, arranging embedded steel plates and arc steel plates on a last pipe ring (4) of shield tunneling, and welding and sealing to a tail of a shield shell (2), then by virtue of sealing reinforcement ribs (6), welding the embedded steel plates and the arc steel plates in the last pipe

ring (4) of shield tunneling to the tail of the shield shell (2), and injecting micro-expanding cement through grouting holes in the pipe segments to fill gaps between the pipe segments and the tail of the shield shell (2);

wherein the micro-expanding cement mentioned in the S104 of the present embodiment is alunite expansive cement, a hydraulic cementing material compensating the shrinkage performance of concrete, with good crack resistance, good permeability resistance, low alkali and heat of hydration, high strength, and good adhesion and corrosion resistance;

S105, arranging sealing steel plates (3) at a head of the shield shell (2), sealing gaps between the head of the shield shell (2) and surrounding rocks, injecting and filing micro-expanding cement through radial grouting holes at an intermediate part of the shield, and sealing formation water around shield shell; and

S106, installing a smoke exhaust fan in front of a tunnel excavating face to form convection currents with an original air supply fan in the tunnel, so as to accelerate air circulation on a working face and ensure a prompt discharge of smoke and dust in the tunnel.

It should be noted that after construction of the shield tunnel is in place, reinforcement and waterproof treatment are conducted on rock formations surrounding the shield tunneling machine, the pipe segments on the tail of shield machine are strictly sealed to be water-resistant by injecting micro-expanding cement, which can also strengthen the shield body; furthermore, one or more smoke exhaust fans are installed in front of a tunnel excavating face to form convection currents with an original air supply fan in the tunnel, so as to accelerate air circulation on a working face, ensure a prompt discharge of smoke and dust in the tunnel and guarantee a good construction environment.

S2 is to abandon the shield shell and disassemble the shield tunneling machine, wherein according to a dismantling sequence of rear supporting trolleys, erectors, walking beams, H frames, motors, man cabins, propulsion cylinders, stone crushers, cutter heads and main bearings, shell

abandoning and machine dismantling are carried out in the tunnel; the rear supporting trolleys are disconnected and pulled out of the tunnel directly, all parts of the erectors, the walking beams, the H frames, the motors, the man cabins, the propulsion cylinders, the stone crushers, the cutter heads and the main bearings are disassembled, cut off and transported out of the tunnel in pieces; and the discarded shield shell (2) is remained in situ.

It should be noted that shell abandoning and machine dismantling are carried out in the tunnel, such that the rear supporting trolleys are disconnected and pulled out of the tunnel directly, all parts of the erectors, the walking beams, the H frames, the motors, the man cabins, the propulsion cylinders, the stone crushers, the cutter heads and the main bearings are disassembled, cut off and transported out of the tunnel in pieces; and the discarded shell of the shield tunneling machine is remained in situ to be a permanent support of the secondary lining, which makes a reliable and stable structure, and has a good use effect.

S3 is to carry out horizontal road construction, wherein model-building concrete (7) is firstly laid on the pipe rings (4) of the shield tunnel (12), the model-building concrete (7) is at a maximum thickness of 500mm~700mm, in the model-building concrete (7) are embedded single-layer steel bar meshes and connecting steel bars (8); on the model-building concrete (7) is laid a concrete cover (9) for protecting the single-layer steel bar meshes, the connecting steel bars (8) are arranged erect, and a track bed (10) is poured; and

in the present embodiment, pipelines are adjusted accordingly to meet requirements of the mining tunnel construction while carrying out horizontal road construction mentioned in the S3; the mentioned pipelines include ventilation pipes, water supply pipes, sewage pipes, high voltage cables, lighting lines, communication lines, walkway board pipelines and transformer pipelines; and the transformer pipelines removed from the shield tunneling machine are installed onto side walls of the pipe segments through bolts.

It should be noted that necessary modifications and adjustments are made to the already formed shield tunnel transportation system and pipeline arrangement, so that the vertical transport system

in shield tunneling can basically meet the requirements of mining construction and support equipment on the ground can be utilized to implement mining construction; further, the ventilation pipes, the water supply pipes, the sewage pipes, the high voltage cables, the lighting lines, the communication lines, the walkway board pipelines and the transformer pipelines with small adjustments can basically meet the requirements of mining construction, and all kinds of pipeline hangings for shield tunneling can also be utilized when separate pipelines are need to be laid.

S4 is to carry out protection on the shield tunnel (12), and excavate a transitional section of a mining tunnel (11),wherein the transitional section of mining tunnel (11) is excavated by blasting, before blasting and excavating the transitional section of mining tunnel (11), on an end face of the last pipe ring (4) of shield tunneling are installed a plurality of hanger bolts (15) for hanging a protective door curtain (14), the hanger bolts (15) penetrate into bolt holes on sides of the last pipe ring (4) of shield tunneling, the hanger bolts (15) are used as door curtain hanging points, and the protective door curtain (14) is made of wire rope meshes;

the amount of hanger bolts (15) mentioned in the S4 of the present embodiment is 8~ 10 and the 8~10 hanger bolts (15) are evenly arranged on the end face of the last pipe ring (4) of shield tunneling;

a diameter of each mesh of wire rope meshes mentioned in the S4 of the present embodiment is 100mm~200mm;

then, on last three to five pipe rings (4) of shield tunneling are covered a pipe segment cover (16), the pipe segment cover (16) includes a wooden board underlying layer and a cotton protective cover laid on the wooden board underlying layer;

it should be noted that the transitional section of the mining tunnel (11) is excavated by blasting, and the phenomenon of flying stone is inevitable; the protective door curtain is arranged to prevent flying stones from damaging pipe segments, and when the muck is transported, one side of the protective door curtain is untied and the wire rope meshes are put away, so as to facilitate the

passage of personnel and vehicles;

in the construction process of the transitional section of the mining tunnel (11), transport vehicles reverse from a shield tunneling starting station (13) to enter the excavating face and depart along a direction of traffic, the tunneling starting station (13) is used as a vehicle U-turn and temporary equipment storage area to output residues generated in the construction of transitional section of the mining tunnel (11);

and the transition section of mining tunnel (11) has a length of 30m ~ 50m.

S5 is to form the transitional section of the mining tunnel (11) as per following processes of:

S501, arranging one or more ring beams (17) at an end of the last pipe ring (4) of shield tunneling near the mining tunnel (11),wherein the ring beams (17) are of a reinforced concrete structure, steel bars in the ring beams (17) are fixedly connected with embedded steel plates (20) and sealing reinforcement ribs (6) in the last pipe ring (4) of shield tunneling; one end of the ring beams (17) extends outside the pipe rings (4) and is fixedly connected to the shield shell (2), and an another end of the ring beams (17) extends 10cm into the pipe rings (4);and

in the present embodiment, embedded steel plates (20) mentioned in the S502 are arranged in the last pipe ring (4) through anchor ribs (21);

S502, roughening construction joints between the ring beams (17) and the last pipe ring (4) of shield tunneling, and providing the same with water-expandable water-stop strips and grouting pipes; and

S503, performing a secondary lining construction on the transitional section of the mining tunnel (11), wherein a secondary lining (19) of the transitional section of the mining method tunnel (11) is done by pouring concrete for both the ring beams (17) and the secondary lining (19) simultaneously, and extending and lining one side of the ring beams (17) far from the transitional section of mining

tunnel (11) to build an extended lining (18) of transitional section of the mining tunnel (11), and the extended lining (18) extends into the last three to five pipe rings(4) of shield tunneling, further, gaps between the shell of the shield tunneling machine (2) and the pipe rings (4) are filled by shield tail grouting, so that the secondary lining (19), the ring beams (17), the extended lining (18), the pipe rings (4) and the shell of the shield tunneling machine (2) are cast to be an integral structure.

S6 is to construct the mining tunnel (11), wherein the mining tunnel (11) is excavated by blasting, during the process of constructing the mining tunnel (11), transport vehicles use the mining tunnel (11) to as a vehicle U-turn and temporary equipment storage area to output residues newly generated during the construction of the mining tunnel (11).

When the present invention is in use, protective measures for the shield tunnel are added and ring beams are constructed in the transitional section to guarantee inter-zonal safety, and necessary conditions are provided for mining construction, such that mining construction in the shield tunnel is realized, and the problem of it not being possible for a shield to be tunneled due to unforeseen circumstances and a mining method needing to be used to continue construction, or the problem of the construction difficulty of the mining tunnel increasing and a new working face needing to be provided in the shield tunnel are solved, thereby guaranteeing the smooth penetration of an inter-zonal tunnel; the mining method and shield tunneling method are applied to the tunnel construction in sections respectively, which broadens the application scope of the underground excavation method and ensures the smooth connection of the interval tunnel engineering, thereby providing a new method and thought for the construction selection of complex interval tunnel engineering; further in the process of mining construction, the facilities and equipment in the original shield tunneling are fully used, so as to reduce the investment and construction cost.

The above are only preferred embodiments of the present invention, and do not impose any limitation on the present invention. Any simple modifications, changes, and equivalent structural changes made to the above embodiments according to the technical essence of the present invention still fall within the protection scope of the technical solutions of the present invention.