

Present Situation and Countermeasures of Corrosion Protection for Pipeline Crossing by Shield Tunneling

Su Jin
Sino-Pipeline International Company Limited
No. 5 Anding Road, Chaoyang District
Beijing, 100029
China

ABSTRACT

The corrosion protection problems of shield tunnel pipelines have always been ignored. In this paper, by investigating the corrosion and protection status of 5 shield tunnel pipelines, the corrosion situation of shield tunnel facilities (such as hot-bending bends, straight pipe sections and joint coating, and pipeline steel components of shield tunnels) was analyzed. It was clarified that mechanical damage during the installation of hot-bending elbows was an important source of damage to the anti-corrosion layer. The joint coating method of viscoelastic body and heat shrinkable tape can effectively reduce the risk of joint coating failure, and the sacrificial anodes can inhibit the corrosion of pipeline steel components. By analyzing the current corrosion problems that impact shield tunnel pipelines, one can consider corrosion prevention countermeasures in the overall shield tunnel pipeline design.

Keywords: Shield tunnel; Pipeline; Corrosion and protection; Coating; Cathodic protection

INTRODUCTION

At present, there were ten common crossing modes in long-distance oil and gas pipelines[1,2]. There were six ways of tunneling, such as large excavation, horizontal directional drilling, shield tunnel, drilling and blasting tunnel, ramming pipe and pipe jacking. There were four ways of spanning methods, such as truss crossing, arch bridge crossing, suspension cable crossing and cable-stayed bridge crossing. Crossing by shield tunneling, as a pipeline laying method with high mechanization and automation, extensive applicable strata and high safety, has been widely used in recent years. A shield tunnel was dug below the ground by a shield machine, with a support and excavation device in front of the shield machine, and a precast or cast-in-place concrete lining at the tail. For each ring distance advanced by the shield machine, a ring lining was supported or assembled at the tail, and cement slurry was pressed into the void at the periphery of the lining ring. After the excavation was completed, a tunnel capable for laying pipelines was formed.

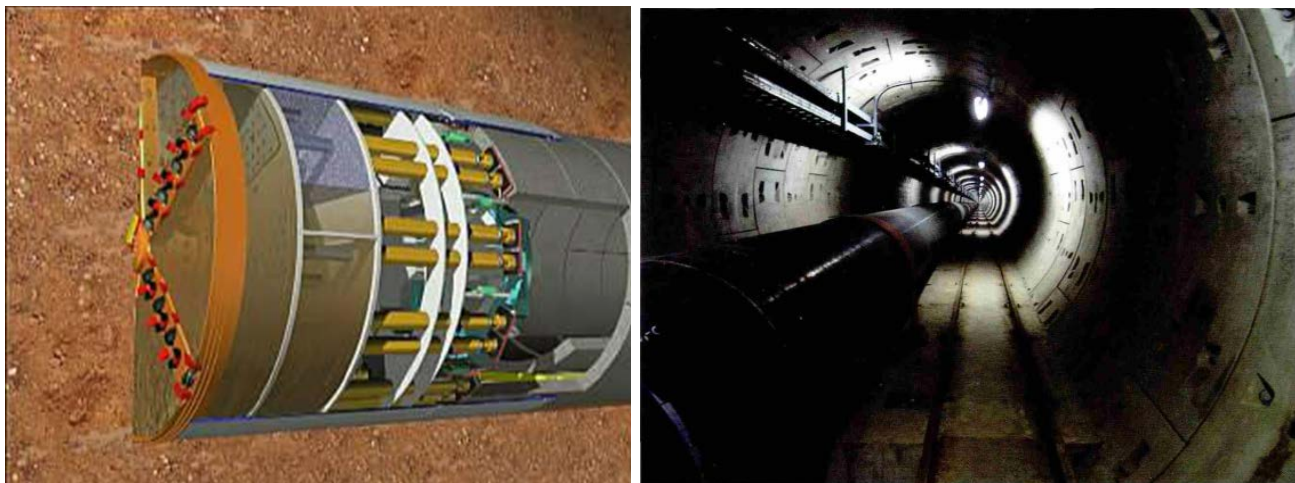


Fig. 1 Shield tunnel crossing technology

The different structures that comprise pipeline crossings within shield tunneling structures included originating well, receiving well, S-shaped hot-bending bends, pipeline, and steel support structure, etc. After the shield pipeline was completed, there was fixed piers, concrete supports, and steel supports to ensure the stability of the pipeline. When the pipeline was put into production, shield tunnels were generally filled by water, soil, or foam concrete.

Based on the field investigation of the pipelines and ancillary facilities of shield tunnels in service in China, this paper has analyzed: the effectiveness of pipeline coating and joint coating in tunnels, the corrosion situation of pipe clamp bolts, corrosion of tunnel ring bolts, the effectiveness of sacrificial anodes, and other common problems encountered during shield tunneling pipeline crossing. The causes of corrosion failures on pipelines constructed by shield tunneling methods were also summarized herein. Moreover, the current technical methods of pipeline corrosion control were compared and selected to provide references for the corrosion protection design, operation, and maintenance of future pipelines constructed by shield tunneling methods.

2 Current situation of corrosion protection of pipeline crossing by shield tunneling

Pipeline A crossing by shield tunneling has the pipe diameter of $\phi 1016\text{mm}$ and crossing length of 2200m; and was tested after 5 years of operation. The coating of main pipeline was 3LPE. The hot-bending bends is double-layer FBE and polypropylene adhesive tape. The pipeline joint coating was made of viscoelastic body and polypropylene adhesive tape. Steel structures such as pipe clamps, pipe buttresses, embedded bolts and embedded steel plates in tunnels were treated with hot dip galvanizing for corrosion protection. After installation, viscoelastic bodies were used to seal the welded parts of bolts, steel supports and embedded steel plates in exposed parts. The tunnel was filled with water.

Pipeline B crossing by shield tunneling has the pipe diameter of $\phi 1016\text{mm}$ and crossing length of 2800m; and was tested after 5 years of operation. The coating of main pipeline was 3LPE. The hot-bending bends were double-layer FBE coating. The pipe joint coating was made of viscoelastic body and polypropylene adhesive tape. Steel structures such as pipe clamps and pipe buttresses in tunnels were treated with hot dip galvanizing for corrosion protection, and bolts and nuts were treated with bluing process for corrosion protection. The tunnel was filled with water.

Pipeline C crossing by shield tunneling has the pipe diameter of $\phi 1219\text{mm}$ and crossing length of 2600m; and was tested after 6 years of operation. The coating of main pipeline was 3LPE. The hot-bending bends were double-layer FBE coating. The pipe joint coating was made of viscoelastic body and polypropylene adhesive tape. Steel structures such as pipe clamps, pipe buttresses, embedded bolts and embedded

steel plates in tunnels were treated with hot dip galvanizing for corrosion protection. The tunnel was filled with water.

Pipeline D crossing by shield tunneling has the pipe diameter of $\phi 1016\text{mm}$ and crossing length of 518m, the coating of main pipeline was 3LPE and the joint coating was heat shrinkable tape. It was put into operation in June 2003 and has been sealed by water for nearly 18 years up to now. In 2009, the pipeline was inspected and a large number of failures of the pipeline joint coating were found. In May 2018, the pipeline was inspected again. The hot-bending bends were double-layer FBE and polypropylene adhesive tape. The tunnel was filled with water.

Pipeline E crossing by shield tunneling has the pipe diameter of $\phi 813\text{mm}$ and crossing length of 1400m; The coating of main pipeline was double-layer FBE. The joint coating was made of heat shrinkable tape. It was tested after 6 years of operation. The tunnel was filled with water.

According to the field inspection data of five shield tunnels crossing pipelines, the following problems were mainly found:

1. Except for the pipeline E, the coating of pipeline main body was 3LPE, which had sound anticorrosion effect in operation.
2. The hot-bending bends were made of double-layer FBE and adding polypropylene tape. It was found through field investigation that the collision damage (maybe occurred while the pipe was being staged and prepared for installation) on the bends was significant, especially the bends in shafts, and some of them were not repaired after damage. As shown in Figure 2.



Fig. 2 On-site Collision Damage of the hot-bending bends

3. At first, heat shrinkable tape was used in the shield works of Pipeline D and Pipeline E for joint coating. It was found that the heat shrinkable tape failed in large numbers, which proved that the heat shrinkable tape was not suitable for joint coating of pipeline in tunnel under the condition that the quality of material and the mean the installation of the heat shrink sleeve over the pipeline joint could not be guaranteed. As shown in Figure 3.