Application Analysis of RTP Non-Metallic Pipelines in Different Scenarios

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Abstract. The strength of RTP non-metallic pipes is provided by the reinforcement layer structure, which comes into contact with the medium inside the pipe and provides corrosion resistance as the lining material. In order to overcome the weakness of high gas permeability of traditional plastic lining materials, with the continuous progress of polymer material technology, the design of sulfur resistant non-metallic pipes using new thermoplastic materials as RTP pipe lining materials is becoming a current research focus. RTP non-metallic pipes are lightweight, with good self-corrosion resistance and low internal friction coefficient. In terms of oil and gas gathering and transportation pipelines, they have the characteristics of easy installation, low construction cost, low safety risk, low environmental impact, and low investment throughout the entire life cycle. From the perspective of the entire life cycle, they can save more than 25% of costs. At present, the application scenario of non-metallic pipes is mainly small diameter oil field gathering and transportation pipes. Research has shown that through technological breakthroughs, the diameter of RTP non-metallic pipelines can reach 600mm, and the maximum pressure bearing capacity can reach 32MPa. Therefore, if based on standards and legal compliance, it has certain application prospects in oil and gas pipelines, and can be used for long-distance high-pressure small and medium-sized pipelines for crude oil and finished oil, as well as high-pressure pipelines for natural gas long-distance branch lines, medium and high-pressure pipelines connected to urban pipelines. In terms of hydrogen transmission pipelines, RTP pipes have unparalleled advantages over metal pipes. Currently, pure hydrogen explosion tests have been conducted on non-metallic pipes, and the tests show that the technical performance indicators of the pipes can meet the design requirements. But from the perspective of standards and legal compliance, just like the application of oil and gas pipelines, The RTP tube still needs further development and improvement.

Keywords: RTP non-metallic pipelines; Application analysis; Hydrogen Pipeline Application; Engineering conditions

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1 Introduction

According to the latest statistical data, the total length of in-service oil and gas pipelines worldwide is about 2.019×10^6 km, including natural gas pipelines of about 1.35×10^6 km, crude oil pipelines of about 4.01×10^5 km, and finished oil pipelines of about 2.68×10^5 km. North America, Europe, Russia, Central Asia, and the Asia Pacific region are the main distribution areas of global oil and gas pipelines, with the United States, Russia, and China ranking among the top three in total pipeline mileage. Pipeline transportation is an important way to achieve large-scale and long-distance transportation of hydrogen energy. The long-distance pipeline transportation of gas and hydrogen has a history of more than 80 years, and the United States and Europe are the earliest regions in the world to develop hydrogen pipelines. Liquid hydrogen pipeline transportation is generally used in situations where it is utilized in liquid form, and the transportation distance is relatively short, which is more common in the aerospace field [1]. With the large-scale development of the hydrogen energy industry, the scale of hydrogen transportation pipelines is becoming larger and larger. According to statistics, the total length of hydrogen transportation pipelines worldwide has exceeded 4600km. In recent years, China's natural gas industry has developed rapidly, and natural gas consumption has grown rapidly. Underground gas storage, as one of the most important natural gas peak shaving methods in China, plays an important role in the steady development of China's natural gas industry and is of great significance [2]. However, the construction of gas storage facilities in China is relatively lagging behind. In 2020, the working gas volume of gas storage only accounted for 4.3% of the consumption gas, far lower than the average level of 12% to 15% abroad.

2 The Current Application Status of RTP Tubes in Different Scenarios

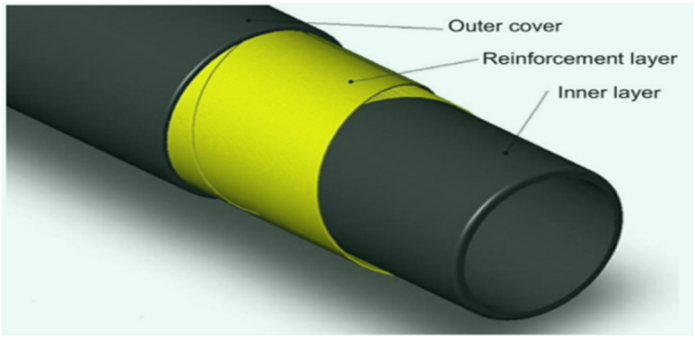

Fig. 1. Typical Structure of RTP Tube[3]

The strength of RTP pipes is provided by the reinforcement layer structure, which contacts the medium inside the pipe and provides corrosion resistance as the lining

material. In order to overcome the weakness of high gas permeability of traditional plastic lining materials, with the continuous progress of polymer material technology, the design of sulfur resistant non-metallic pipes using new thermoplastic materials as RTP pipe lining materials is becoming a current research focus. RTP reinforced thermoplastic pipes have a relatively simple structure and are suitable for use in both land and marine environments. RTP pipes are generally composed of three layers, as shown in figure 1.

2.1 Application of Oil and Gas Pipelines

The development of RTP pipes in foreign countries started earlier. In June 1995, the world's first RTP pipe produced by Shell was put into use in the UK. At the end of 1996, Shell is constructing an RTP pipeline with a nominal diameter (DN) of 150 mm and a length of 7 km in an oil field in Oman to address the serious corrosion and leakage issues of the local oil pipeline. In 2000, Germany laid a 1 km long road, A DNl00mm RTP pipeline for transporting non dry sulfur-containing natural gas. At present, international RTP pipes are mainly used in the field of oil and gas field development, The DN range of RTP pipes is 75-150 mm, and the pressure range is 1.6-9 MPa. After decades of development, the RTP tube technology abroad has become relatively mature, as shown in figure 2.

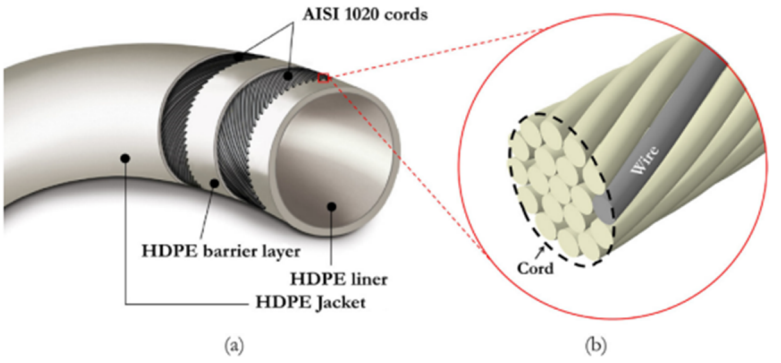

Fig. 2. FlexCord Pipeline Section Diagram[4]

2.2 Hydrogen Pipeline Application

Dutch company SoluForce has developed a wrapped reinforced thermoplastic industrial piping system (RTP, also known as FCP) for hydrogen applications. SoluForce H2T is a HDPE pipe reinforced with aramid fibers, compounded with a bonded aluminum layer to prevent penetration. It operates at a maximum temperature of 60C ° C and has a design life of 50 years. The product is supplied in continuous coils (400m per roll). Certified, SoluForce H2T has been certified by the authoritative European gas safety agency KIWA GASTEC and can be used in hydrogen applications with

working pressures up to 42 bar. SoluForce's flexible hydrogen pipeline solution solves the most critical issues of high installation costs and hydrogen damage in traditional steel pipelines.SoluForce first deployed the SoluForce flexible composite pipeline solution in the Middle East in 2000, and these pipelines are still in use today. As of now, SoluForce has installed over 3500km of flexible pipelines worldwide and has conducted extensive on-site verification in various applications, including oil and gas utility pipelines, water distribution/injection pipelines, oil and gas transmission pipelines, and oil and gas collection lines. The first application of the SoluForce Hydrogen solution at the Port of Groningen. SoluForce has arranged a 4km long, 42bar pressure flexible hydrogen pipeline to transport green hydrogen produced by wind power in the North Sea region to Eemshawen's chemical and industrial enterprises.

According to relevant information, RTP can save 20% compared to steel, The cost of RTP materials is 2-3 times higher and the cost of laying is 2-3 times lower (Table 1). The reason for the low cost of RTP is that it greatly reduces the cost of pipeline laying and welding; Short construction time and fewer personnel working hours; No need for re coating of welding areas; The RTP scroll is located at the end of the trench, parallel to the steel pipe section of the trench, requiring less space; The drainage cost is relatively low. The cost of RTP for full life comparison is still relatively low.

Table 1. Comparison between RTP pipes and steel pipes

	RTP pipe	Steel pipe (X52)
Diameter	6inches	6inches
Wall thickness	14~16mm	7.11mm
Weight	6~9kg/m	13kg/m
Pipe section length	250~600m	12m
Pipe cost	-	30~50 Euro/meter

3 The Conditions that RTP Tubes should Meet in Different Application Scenarios

3.1 Technical Conditions

There are essential differences between RTP pipelines and traditional steel pipelines. Currently, the design, construction, and testing technologies of steel pipelines are difficult to apply to oil and gas transportation RTP pipeline engineering. At the same time, the technical conditions of traditional small diameter and low pressure RTP pipelines cannot meet the requirements of oil and gas transportation RTP pipeline engineering [5]. Therefore, relevant research work is still needed to apply large diameter and high pressure RTP pipes to oil and gas transportation pipeline engineering, such as in-depth basic research work, especially research on pipe technical conditions,

pipeline reliability design, pipeline connection technology, pipeline construction and inspection technology, pipeline maintenance and repair technology, to solve technical problems in engineering applications.

3.2 Engineering Conditions

RTP pipes have been applied on a large scale in oilfield water injection, alcohol injection, and some gathering and transportation pipelines. However, the existing oil and gas pipeline design standards all indicate that the material should be metal steel pipes, which also limits the application of RTP pipes in long-distance pipelines. At the same time, whether the existing joint methods can meet the high-pressure transportation conditions also needs further verification [6]. The application of RTP pipes is currently not supported in the approval, supervision, and evaluation of oil and gas long-distance pipelines (see section 3.2.2 for details). At the same time, RTP pipes have good resistance to vibration deformation due to material issues, and there is no hydrogen embrittlement or corrosion. Based on the experience of using RTP pipes in oil and gas pipeline engineering, it can also be seen that the pipeline laying is simple, has strong adaptability to terrain, fewer joints, and higher construction efficiency. But considering the engineering characteristics of long-distance hydrogen pipelines, The limiting factors for the application of RTP pipes in hydrogen transmission pipelines in China are manifested in the following aspects:

1) In terms of standards

The domestic production standards SY/T 6662.2-2020 and API Spec 15S for non-metallic flexible composite high-pressure conveying pipes are not included in long-distance pipeline engineering; From the perspective of engineering project procurement standards, the design of hydrogen long-distance pipelines still needs to comply with the "Design Specification for Gas Pipeline Engineering" (GB50251-2015), or "Pressure Pipeline Specification for Long Distance Pipeline" (GB/T 34275-2017), all of which require the pipeline material to be steel pipe.

2) Approval aspect

Generally, long-distance pipeline projects adopt an approval system, GA pressure pipelines need to comply with the Regulations on Safety Management and Supervision of Pressure Pipelines during the construction process. The government regulatory department will entrust local pressure pipeline regulatory units to conduct safety inspections, mainly including production permits, quality certificates, welding and non-destructive testing of pipeline materials, as well as pressure testing.

3) Regulatory aspects

At present, there are no regulatory testing standards for the operation stage of non-metallic composite pipes. For non-metallic pipelines with a pressure rating of 4MPa or above, metal compression joints are used. The tightness and compliance standards of the joints can usually only be judged by pressure testing, and cannot be evaluated by non-destructive testing like for welded joints in steel pipelines. During the pipeline operation phase, it is also impossible to determine the tightness of the joint through internal inspection technology.

4) In terms of engineering design period

The general design specifications for long-distance pipelines do not have a clear design service life for pipelines. Referring to the Economic Evaluation Parameters for Investment Projects of National Petroleum and Natural Gas Pipeline Network Group Co., Ltd. (2021) and the Economic Evaluation Parameters for Investment Projects of China National Petroleum Corporation Limited (2020), the comprehensive depreciation life for natural gas long-distance pipeline investment projects is 40 years. After consulting with relevant non-metallic composite pipe manufacturers, the design service life of the flexible composite high-pressure conveying pipe currently produced is 20 years, which does not match the economic evaluation depreciation life of long-distance pipelines.

4 Conclusions

RTP pipes are lightweight, have good self-corrosion resistance, and have a small internal friction coefficient (about 0.005, only 1/8 of steel). In terms of oil and gas gathering and transportation pipelines, they have the characteristics of easy installation, low construction cost, low safety risk, low environmental impact, and low investment throughout the entire life cycle. It is based on standards and legal compliance, it has certain application prospects in oil and gas pipelines. In terms of hydrogen transmission pipelines, RTP pipes have unparalleled advantages over metal pipes, namely excellent resistance to hydrogen embrittlement and hydrogen corrosion. At present, pure hydrogen explosion tests have been conducted on non-metallic pipelines with an outer diameter of D250mm and a design pressure of 6.3MPa in China. The tests show that the technical performance indicators of the pipes can meet the design requirements.

From the perspective of standards and legal compliance, just like the application of oil and gas pipelines, The RTP tube still needs further development and improvement.

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