

Effect of Liquid Plastic Steel and Epoxy Resin on Pipes

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Abstract: Using different materials to repair mechanical parts in cold state (non-fire repair), the mechanical properties of the repaired materials have different effects. In order to explore the advantages and disadvantages of liquid plastic steel repair agent and epoxy resin repair agent, the repair effects of two cold repair materials were compared. The mechanical properties of L245 pipeline steel before and after repair, such as tensile properties, shear properties and bonding properties, were tested with small size samples. The test results show that the average tensile strength of the reinforced tensile sample of plastic steel is 2MPa higher than that of the ordinary epoxy tree, and the tensile strength is increased by 0.4%; the average yield strength of the reinforced tensile sample of plastic steel is 5Mpa higher than that of the ordinary epoxy tree, and the yield strength is increased by 1.5%. The shear strength of the reinforced tensile specimen of plastic steel is 1.67MPa higher than that of the ordinary epoxy tree reinforced tensile specimen, and the shear strength is increased by 22%.

Keywords: Liquid plastic steel, epoxy resin, mechanical properties testing.

1. Introduction

Pipeline, as the main channel of oil and natural gas transmission, plays an important role in energy supply and production operation. However, due to long-term use and the influence of external factors, the pipeline may be damaged and corroded, resulting in leaks and accidents. To ensure the safety and reliability of pipelines, repairing and maintaining damaged pipelines is essential. Traditional repair methods include grinding, surfacing welding, patching, sleeve, steel epoxy sleeve, composite reinforcement, mechanical fixture, pressure opening and tube change, etc [1-2]. However, each of these methods has some advantages and disadvantages. This paper recommends a kind of non-pyrogenic repair with liquid plastic steel. Compared with the traditional method, the cold repair process of metal parts has many advantages in the repair of metal parts. Cold repair is to repair metal parts by using high-strength bonding materials, which can effectively repair metal losses, cracks, deformation and weld defects. The method has the following advantages: high safety, environmental friendliness, energy saving, fast repair speed, retaining material properties, and wide application range. Cases of the use of different repair agents in the repair of metal parts show that fast drying repair agents, liquid plastic steel repair agents and titanium alloy repair agents show excellent repair effects under different conditions. For example, the ship repair plant of Yangtze River Barge Company used liquid plastic steel repair agent to repair the Chonghai No. 2 steamer tail shaft bearing, and the repaired bearing stop met the strength of use. Wang Taibu et al. used the quick-drying repair agent to repair the medium corrosion perforation leakage at the gas ammonia outlet welding passage of the shell of the alkali making equipment, reducing the maintenance cost. Guo Feng used plasticized steel repair agent to repair the erosion and corrosion part of the volute shell of the centrifugal pump, and the centrifugal pump ran in a stable state [3-5]. These cases show the application and effect of different repair agents in the repair of metal parts, providing valuable reference and experience for the repair work of metal parts [6-12]. In order to explore the advantages and disadvantages of liquid plastic steel repair agent and

epoxy resin repair agent, the repair effect of two cold repair materials was compared. In this paper, a small size sample of L245 pipeline pipe was taken, and tensile, shear and bonding tests were carried out on the repaired pipe with liquid plastic steel and epoxy resin, respectively, to verify the mechanical properties of liquid plastic steel. The results of this study are expected to provide a feasible choice and reference for oil and gas pipeline repair, and provide theoretical and practical support for the application of liquid plasticized steel in industrial production.

2. Performance Test of Liquid Plastic Steel Repair Agent and Epoxy Resin on Metal Parts After Repair

L245 is a domestic standard low-wire steel with yield strength $\geq 245\text{MPa}$ and tensile strength $\geq 415\text{MPa}$. In this paper, several small-size L245 pipeline and pipe specimens were selected, and liquid plastic steel repair agent and epoxy resin were applied to them in different ways to conduct small-size tests to verify the tensile properties, shear properties and bonding properties of L245 pipe after repair. Epoxy resin is a thermosetting resin, usually composed of epoxy compounds and amine hardeners. Plastic Steel (Plastic Steel) is a mixture of steel (or copper, aluminum, zinc, stainless steel, rubber, etc.) and special resins, which are mixed by special methods.

2.1. Strength test

Metal strength refers to the ability of metal materials to resist deformation and damage under external loading, and is one of the important indexes to describe the mechanical properties of metal materials. The CMT5105 material test was used in this test, and the tensile properties of uniformly coated tensile specimens were tested according to GB/T 228.1-2021 "Tensile Test of Metal Materials Part 1: Test method at room temperature". According to GB/T9711, 273 \times 6.5mm seamless steel pipe was selected as the base material of the steel pipe. 16 plate tensile samples were axially cut and applied to the upper and lower surfaces of the sample working area (length 65mm, width 38mm) with plastic steel repair agent and

epoxy resin. After being applied, 10 pieces were machined to the thickness of the upper and lower surfaces of each 8mm. As shown in Figure 1, apply the plasticizable steel repair agent sample, K-1-1 ~ K-1-5; Apply common epoxy resin sample, S-1-1 ~ S-1-5; In order to compare the reinforcement effects of plasticizable steel repair agent and epoxy resin on the tensile strength and yield strength of the sample, two plate tensile samples Y-1 and Y-2 were taken without the repair agent. Based on the analysis of the test data of the tensile properties of 12 samples, the tensile strength and yield strength distribution were calculated respectively, as shown in FIG. 2 and FIG. 3. According to the calculation, the average tensile strength and yield strength of the coated plasticized steel were 490MPa and 347MPa respectively. The average tensile strength and yield strength of ordinary epoxy resin were 488MPa and 342MPa respectively. The tensile strength of uncoated tensile specimens is 480MPa, and the average yield strength is 336MPa. The tensile strength and yield strength of all samples meet the requirements of the minimum standard technical conditions. The average tensile strength of the reinforced tensile test specimen of plasticized steel is 2MPa

higher than that of the ordinary epoxy resin reinforced tensile test specimen, and the tensile strength is increased by 0.4%. The average yield strength of the reinforced tensile specimens of plasticized steel is 5MPa higher than that of the ordinary epoxy resin reinforced tensile specimens, and the yield strength is increased by 1.5%.



Figure 1. Physical diagram of plate specimen

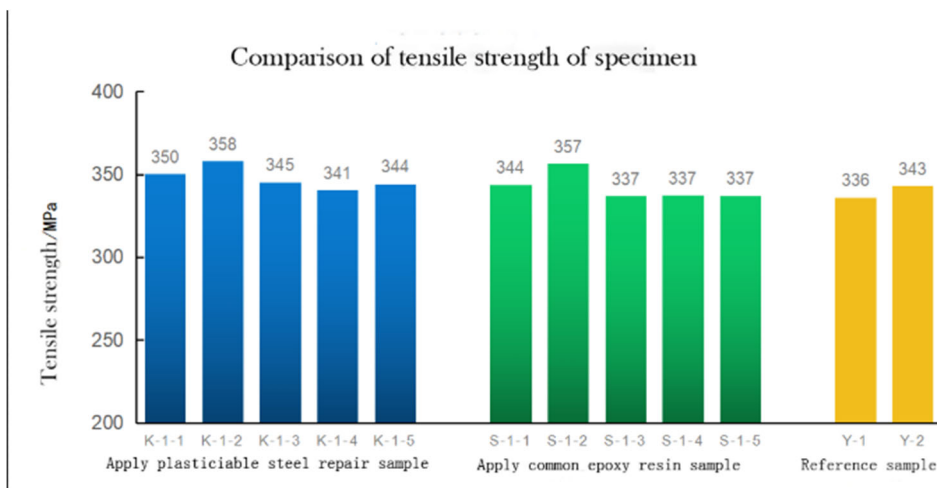


Figure 2. Comparison of tensile strength of specimens

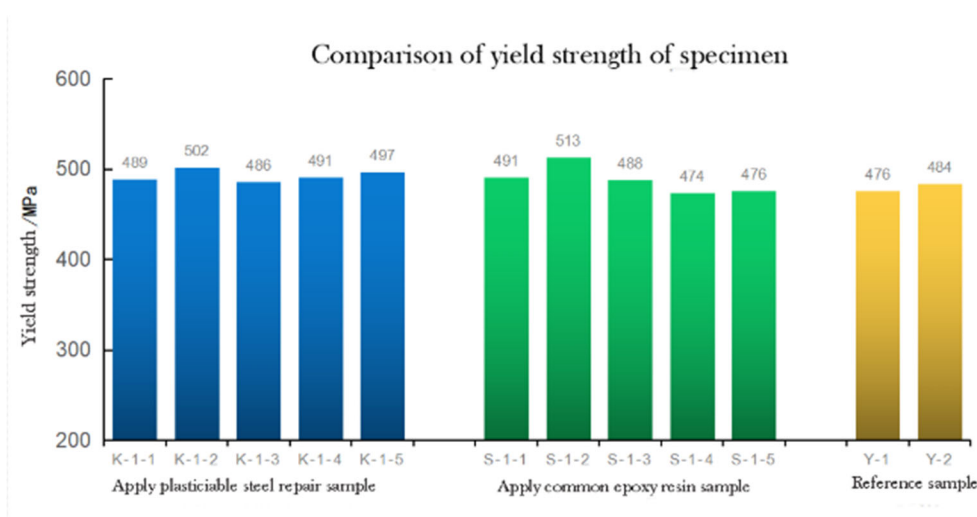


Figure 3. Comparison of yield strength of specimens

2.2. Shear test

Shear strength refers to the maximum shear stress that a material can withstand when subjected to shear forces. The CMT5105 material test was used in this test, which was designed according to GB/T 228.1-2021 "Tensile Test of

Metal materials Part 1: Test Method at room temperature" and ASTM D1002-10 "Test Standard for Tensile Shear Strength". Total length of sample: 190.5mm. Sample width: 25.4mm. Sample thickness: 1.62mm. Lap length: 25.4mm. Lap thickness 0.025mm. Lap sample with plastic steel repair agent, K-2-1 ~ K-2-6. The sample is bonded with epoxy resin, S-2-

1 ~ S-2-6. There are 6 tensile samples with uniform overlap thickness and length for each sample, as shown in Figure 4. Tensile load was used to determine the shear strength of

intermetallic plasticized steel repair agents and common epoxy resins.



Figure 4. Real picture of shear strength measurement

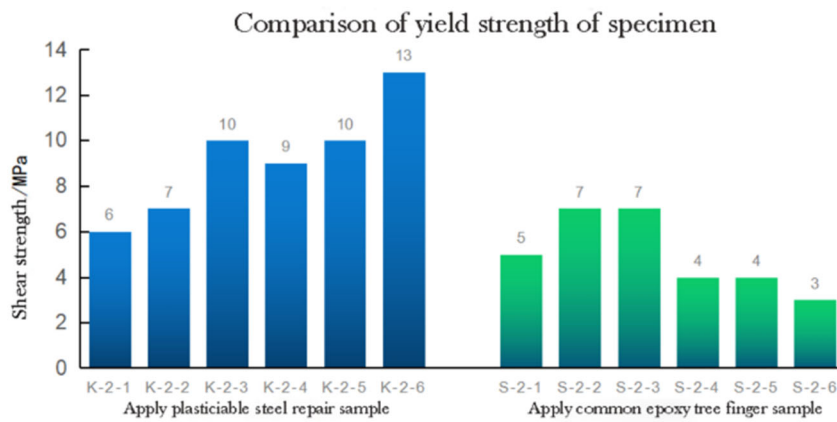


Figure 5. Comparison of shear strength of samples

The shear strength of 12 specimens was obtained by analyzing the test data of their shear properties, and the results are shown in Figure 5. It is calculated that the average shear strength of the coated plasticized steel is 9.17MPa. The average shear strength of ordinary epoxy resin is 7.5MPa. The shear strength of the reinforced tensile specimen of plastic steel is 1.67MPa higher than that of the ordinary epoxy resin reinforced tensile specimen, and the shear strength is increased by 22%.

3. Conclusion

(1) The average tensile strength of the reinforced tensile specimen of plasticized steel is 2MPa higher than that of the ordinary epoxy resin reinforced tensile specimen, and the tensile strength is increased by 0.4%. The average yield strength of the reinforced tensile specimens of plasticized steel is 5Mpa higher than that of the ordinary epoxy resin reinforced tensile specimens, and the yield strength is increased by 1.5%. The plasticizable steel repair agent has a certain reinforcing effect on the yield strength of plate tensile specimens.

(2) The shear strength of the reinforced tensile specimen of plastic steel is 1.67MPa higher than that of the ordinary epoxy resin reinforced tensile specimen, and the shear strength is increased by 22%. In terms of shear strength, plasticizable steel repair agent can completely replace the original epoxy resin.

(3) Compared with ordinary epoxy resin, the liquid plasticizable steel has a significant improvement in the shear

resistance, but the improvement in the tensile and bonding resistance is not obvious, because the liquid plasticizable steel has a significant increase in the shear resistance parameters, and the other parameters have a small improvement.

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