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Advanced High Frequency Electric Resistance Welding (HFW) Linepipe "Mighty Seam™" with High Quality Weld Seam

1. Introduction

JFE Steel's high frequency electric resistance welding (HFW) steel pipes for linepipe applications are manufactured by the 24-inch HFW pipe mill at East Japan Works (Keihin) and the 26-inch HFW pipe mill at Chita Works, and manufacturing and inspection technologies for Mighty Seam™ have been established at both plants. Mighty Seam is an HFW linepipe in which the quality of the weld seam of the HFW pipe is enhanced to a level that can be used as a substitute for UOE steel pipes and seamless steel pipes[1)], and has already accumulated an extensive record of use in Japan and overseas. This report introduces the features of Mighty Seam, which has excellent weld reliability, together with examples of application.

2. Features of Mighty Seam™

2.1 Manufacturing Method

The existing HFW linepipe production lines are used in the manufacture of Mighty Seam. HFW pipes are manufactured by gradually forming a hot-rolled coil which has been uncoiled to the strip shape into a cylindrical shape from the leading end, and then melting the two edges with a high frequency electric current and pressure bonding the seam. The weld seam is heat-treated if necessary, and then the pipes are cut to the specified length. Following cutting, various inspections are performed, including the hydrostatic test, nondestructive testing (NDT), dimensional inspection, weighing, and material tests.

Mighty Seam is an HFW linepipe with enhanced weld seam reliability. In manufacturing Mighty Seam, a technology that suppresses oxides, which are one cause of reduced HFW seam quality, and nondestructive testing technology, which makes it possible to detect fine oxides that form in the HFW weld seam, are applied over the full length of the pipe.

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Table 1 Mighty Seam™ available size (As of March 2024)

Manufacturing plant	– 24 inches (609.6 mm) High Frequency Electric Resistance Welding (HFW) Pipe Mill, East Japan Works (Keihin), JFE Steel
	– 26 inches (660.4 mm) High Frequency Electric Resistance Welding (HFW) Pipe Mill, Chita Works, JFE Steel
Outside diameter	219.1 mm–660 mm
Wall thickness	4.8 mm–25.4 mm
Grade (API 5L)	Max. X80M (L555M) PSL2 Offshore, Sour (Max. X70)

API: The American Petroleum Institute

2.2 Available Size Range

The available size range of Mighty Seam is shown in **Table 1**. This size range is the same as that of general HFW linepipes. Mighty Seam is available in grades up to a maximum of X80 with outside diameters from 219.1 mm to 660 mm and wall thicknesses from 4.8 mm to 25.4 mm.

2.3 Characteristics of Mighty Seam

The following introduces the characteristics of Mighty Seam, focusing particularly on the characteristics of the HFW weld.

2.3.1 Weld toughness

Excellent toughness is achieved in Mighty Seam by applying the technologies mentioned above. **Figure 1** shows an example of the Charpy test results.

Although the ductile-brittle transition temperature (vTrs) of welds in HFW steel pipes generally shows a tendency to be higher than that of the base material (low toughness), the toughness of the HFW weld of Mighty Seam is the similar to that of the base material.

2.3.2 Fracture resistance performance of actual pipe

Linepipes are required to safely perform their functions against fracture over the long period from instal-

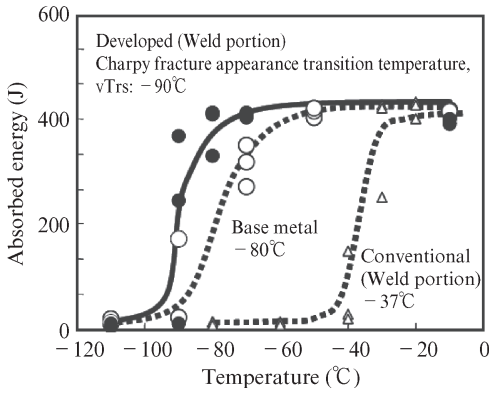

Fig. 1 Low temperature Charpy toughness of high-frequency electric resistance welding (HFW) seam

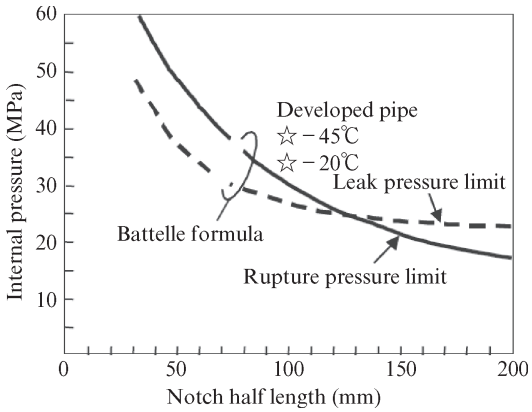

Fig. 2 Low temperature full pipe burst test result

lation to actual operation. Therefore, it is crucial to obtain characteristic data on the deformation and fracture behavior of full-size pipes. To clarify the safety performance of Mighty Seam, a low-temperature static hydraulic burst test and a fatigue test and tensile test under high internal pressure of full-scale pipes were conducted [2,3]. For example, as shown in **Fig. 2**, in burst tests at low temperatures of -20˚C and -45˚C, Mighty Seam showed sufficiently high values in comparison with the results of a prediction formula for the critical burst pressure, at which UOE steel pipes based. The crack initiation mode demonstrates a leak-before-break mode, where ductile cracks initiate and penetrate from the notch bottom rather than causing large-scale unstable fractures. This indicates that even under low-temperature conditions, large-scale fractures do not occur in Mighty Seam linepipes, thereby proving the material's reliability. Furthermore, the test results of both the fatigue tests and tensile test under high internal pressure have favorable results, indicating that there are no issues concerning the actual use of the material.

2.3.3 Evaluation of earthquake resistance

In Japan, which is one of the world's most earthquake-prone countries, it is necessary to clarify applicability to the seismic environment when laying linepipes. A uniaxial compression test and bending test with internal pressure were carried out with actual-size Mighty Seam pipes according to the seismic design standards of the Japan Gas Association (JGA)[4]. **Photo 1** shows the result of penetrant testing of an HFW weld seam after the uniaxial compression test. Although the pipe body deformed into a corrugated shape due to compression, no cracks or fractures were observed in the HFW seam, indicating that the HFW seam of Mighty Seam can withstand significant deformation. Additionally, in the bending test with internal pressure, Mighty Seam showed a high strain capacity, demonstrating that it conforms to the JGA seismic

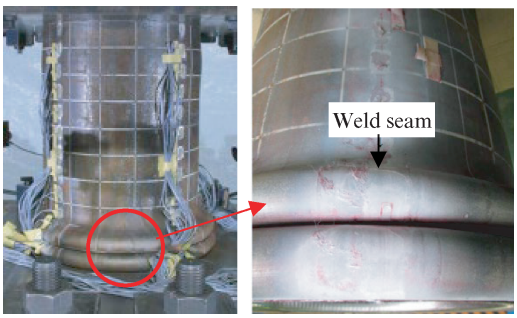

Photo 1 Penetrant testing result after uniaxial compression test

standards.

3. Examples of Application of Mighty Seam™

Because pipelines are frequently designed on the precondition that the linepipe will be exposed to a severe environment such as an low temperature environment, sea bottom laying or a corrosion environment, product characteristics that can cope with projects throughout the world are demanded. In overseas projects, Mighty Seam has an extensive track record of use in long distance pipelines with specifications for low temperature and pipelines in sour environments, responding to the expectations of customers not only in terms of strict material property requirements, but also high reliability of the weld seam of the HFW linepipe (high-accuracy flaw detection over the full length of the weld). Moreover, in recent years, Mighty Seam has also been evaluated for compatibility with linepipes for transportation of hydrogen, which has been expected to become a new energy source in recent years. Thus, Mighty Seam is expected to be one option that can meet the needs of a decarbonized society[5].

On the other hand, earthquake resistance is required in linepipes used in Japan, and the reliability of Mighty Seam has also been highly evaluated through various

tests, as described above. As a result, the delivery record of Mighty Seam products is increasing, particularly for high-pressure gas trunk lines in Japan.

4. Conclusion

JFE Steel's high frequency electric resistance welding (HFW) linepipe "Mighty Seam™" is steadily accumulating a record of use, including fields with difficult specifications where UOE linepipes and seamless linepipes had been studied preferentially in the past due to concerns about the reliability of the weld of conventional HFW pipes.

References

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