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Failure analysis of girth weld cracking of mechanically lined pipe used in gasfield gathering system

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ABSTRACT

Girth weld cracking of mechanically lined pipe was occurred after 75 days operation in a gasfield gathering system in China. Failure causes were analyzed based on operation histories, field documents, and laboratory tests. Results showed that the girth weld failure was mainly due to two aspects, girth weld martensite microstructure and external stress. The crack was initiated from sealing pass zone and filling pass zone, which is a hard and brittle martensite structure with hardness of HV 350–450. The failed pipe area had undergone the heavy rain for 2 days, pulling stress, bending stress, and shear stress generated by soil movement resulted in high stress concentration at girth weld. The girth weld cracking failure was initiated from outer carbon steel, and propagated along the weld-fusion line in intergranular mode, which is a typical stress corrosion cracking failure.

1. Introduction

With the continuously growing demand in oil and gas globally, the common oil and gas reservoir was extensively exploited and which became less and less. Therefore, high pressure high temperature (HPHT) gas reservoir was increasingly developed all around the world, the typical HPHT gas well broadly exist in Gulf of Mexico, Tarim Basin of China, North Sea, South East Asia, Africa and Middle East [1,2]. The nature of HPHT gas reservoir fluids places demands upon material selection for linepipe that can only be met by the use of corrosion resistant alloys (CRAs) as an internal clad layer combined with a carbon steel substrate [3]. Although the solid CRAs are the best choice with overall desirable properties, the biggest disadvantage is that the CRAs are too expensive for using as gathering pipes. Hence, development of mechanically lined pipe is an alternative choice with consideration of cost and corrosion resistance. Mechanically lined pipe is composed of external carbon steel pipe and a thin internal layer of CRA, in which the outer carbon steel is to provide structure strength, and the inner CRA layer is designed to resist corrosion [4,5], as shown in Fig. 1.

Mechanically lined pipe combines the advantages of carbon steel (low cost and high strength) and CRA (high corrosion resistance) together, this combination enables that the mechanically lined pipe was widely used in HPHT gas field gathering systems and offshore flowlines in subsea gathering systems. Moreover, the liner of mechanically lined pipe can be customized according to the fluids corrosivity, various liner materials are available for selection, i.e., 304, 316L, 825, 625, G28. Mechanically lined pipe has been considered as a preferred pipe to replace traditional carbon steel pipe in HPHT gas field gathering systems in China.

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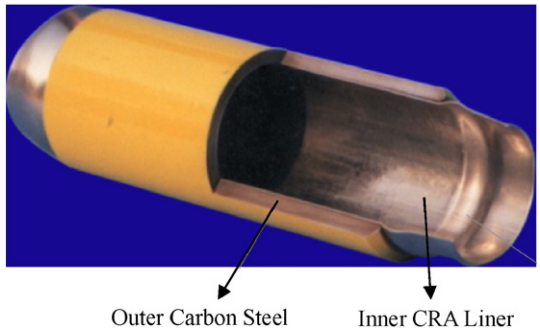

Fig. 1. The structure of mechanically lined pipe.

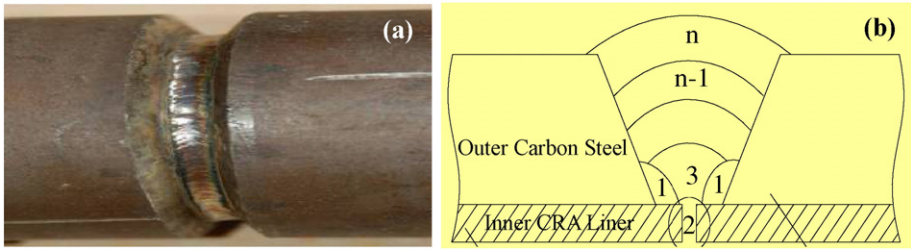

Fig. 2. Weld joint of mechanically lined pipe and weld structure.

However, the dissimilar nature of the materials abutting at the weld joint presents challenges in terms of welding processes, flaw assessment and inspection methods [6], it was found that most of the failures were related to the girth weld cracking and perforation [3,7,8]. Pipe failures may cause loss of product, temporary shutdown of production, pollution, and other unpredictable losses. Therefore, it is of significance to decrease the failure risk, failure analysis is one of the best ways to provide failure reason and prevention measure.

The objective of this work is to analyze the causes about the girth weld cracking failure of mechanically lined pipe used in northwest China gasfield, although extensive laboratory studies have been done on the girth welding of mechanical lined and metallurgical clad pipes, i.e., welding procedure, fracture assessment, fatigue behavior, full-scale mechanical test and NDT test [3,5–9]. Few works were found on the girth welding failure after period of use in oil/gas field, the weld joint of bi-metal pipe is more complicated than that of single metal pipe, i.e., welding material, welding method, welding parameters, and pre-treatment process, as shown in Fig. 2. It is expected that this work would provide the insight of mechanically lined pipe girth welding failure reasons and prevention measures.

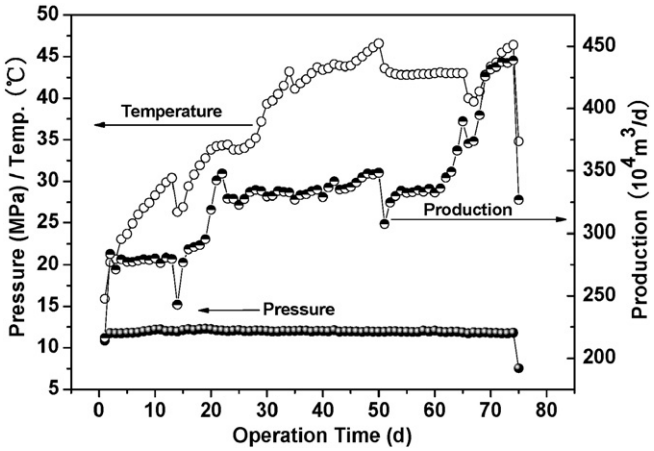

Fig. 3. Operation parameters of failed mechanically lined pipe within 75 days.