Safety Analysis on Welded Joint of Submarine Oil and Gas Pipeline

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ABSTRACT

According to API Std 1104-2005 "welding of pipelines and related facilities", under the premise of the known lay stress and fracture toughness value of welded joints, the safety analysis was applied to the welded joints of mixed submarine oil and gas pipelines from NP1-29P to NP1-2D in Nanpu oilfield in east Hebei province in the laying stage. And the allowed sizes of the planar defects as well as the relationship between CTOD values and the defects height are determined. The allowable values of the surface defects and buried defects at the three types of CTOD values are specifically analyzed under the same operating condition. The assessment results show that under the same condition, with the CTOD values increasing, the sizes of the surface defects firstly increase, and then remain unchanged after reaching a certain value, while the sizes of the buried defects have remained unchanged. The safety analysis results provide a basis for security in pipeline laying stage, with practical engineering and economic significance.

KEY WORDS: CTOD; Surface defects; Buried defects; Safety Analysis;

INTRODUCTION

Submarine oil and gas pipelines, as transportation pipelines of offshore oil, are growing with the rate of tens of thousands of kilometers every year. Although the pipeline is a very safe oil and gas transportation, there have been numerous pipeline failure incidents in the past few decades. This not only affects the conduct of the normal production order and threaten the safety of workers, but also be bound to bring huge losses to the country's economy and national life. The reason is that distortion, scratches and other defects will be produced during the laying process of submarine pipelines [Xia and Huo, 2005; Tan and Xiao, 2005; Song and Xiao, 2004]. However, the main defects are the results of submarine pipeline welding process. Therefore the qualified limits of welding defects have been clearly provided in submarine pipeline system specification of each country.

Submarine pipelines, as a typical welded structure, the welding process often make the organization and properties of welded joints deterioration and defects. The defects which have a greater stress concentration can always be the source of crack in the process of usage. Fracture at the weld joint of the pipelines can easily result in sudden and catastrophic accident. By this token, welded joints are weakness of the piping system. Assessing strength, lifetime and safe reliability of piping system has important practical significance.

In this paper, Based on the experiment results of fracture toughness of pipeline steel welded joint, according to API Std 1104-2005 "welding of pipelines and related facilities", the safety analysis was applied to the welded joints of mixed submarine oil and gas pipelines from NP1-29P to NP1-2D in Nanpu oilfield in east Hebei province in the laying stage. And the allowed sizes of the planar defects are determined, which provide a basis for defect acceptance in pipeline laying stage.

Determination of Security Analysis Parameters

The mixed submarine oil and gas pipelines from NP1-29P to NP1-2D, with the length of 2.4km, designed life fifteen years and pipe specifications φ168.3×12.7mm, are welded by SMAW bottoming, SMAW filling and capping. The corresponding welding material is Lincoln PIPELINER 6P+ welding rod and Lincoln PIPELINER 8P+ welding rod, welding position 5G. Stress analysis at small depth of three meters in pipeline laying calculation is taken into considered.

Fracture Toughness Values of Welded Joints

Fracture toughness values of pipeline welded joints are determined by actual measurement. Test procedure strictly comply with the BS7448 std [BS 7448: Part 1, 1991; BS 7448: Part 2, 1991] and API Std 1104-2005 [API Std 1104, 2005], and the specimen shape is a standard three point bending (TPB) specimen that has a rectangular section of B×2B for weld metal and HAZ with B equal to the plate thickness of 11mm. The test temperature was 0°C. According to API Std 1104-2005, for each heat-affected zone test, The notch should be placed at the location of the area of greatest hardness, so a hardness survey is conducted on the specimen. The fracture toughness CTOD results from the weld metal and HAZ are summarized in Table 1.

Table 1 Results of the CTOD tests of all specimen