Proceedings of the Seventeenth (2007) International Offshore and Polar Engineering Conference
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-68-5; ISBN 1-880653-68-0(Set); ISSN 1098-6189 (Set)

Key Issues should be considered for application of strain-based designed pipeline in China

Xiao Li
School of Material Science and Engineering, Xi'an Jiaotong University.
Xi'an, ShaanXi, China

Wenzhen Zhao
School of Material Science and Engineering, Xi'an Jiaotong University.
Xi'an, ShaanXi, China

Lingkang Ji
Tubular Goods Research Center of CNPC, Key Lab of Oil Tubular mechanical and Environmental behavior of CNPC.
Xi'an, ShaanXi, China

HeLin Li
Tubular Goods Research Center of CNPC, Key Lab of Oil Tubular mechanical and Environmental behavior of CNPC.
Xi'an, ShaanXi, China

ABSTRACT

In China, geological conditions along pipelines are very complicated and pipelines may experience large displacement-controlled load in certain areas. In order to design the pipelines with adequate strain capacity, strain-based design method should be introduced. In this paper, some key issues to raise the strain capacity of pipelines were discussed. For material selection, the material properties such as Y/T ratio, uniform elongation, and strain hardening exponent should be set as stated performance index. For pipeline design, measures that enable pipeline to deform with certain flexibility should be taken. For pipeline construction, appropriate weld metal and welding process should be used to guarantee overmatching as well as adequate strength and toughness of welded joints.

KEY WORDS: pipeline; pipeline steel; stain-based design; welding

INTRODUCTION

China is a large energy production and energy consumption country. In its energy structure, the proportion of petroleum and gas is increasing year by year. By the year 2020, it's expected that the oil production in China will reach 1.8×108 tons, but the demand will reach 4×108 tons, which leaves a shortage of 2.2×108 tons. For gas, the production and demand will reach 1.2×1011 m^3, and 2×1011 m^3, respectively, and the gap will be 8×1011 m^3. Many measures will be taken to meet the domestic requirement, such as promoting more extensive exploration and importing oil and gas from Russia and middle Asia, and transmitting it into inland cities by long distance pipelines. The pipelines being built and intended to be built in the near future include second West-East Gas pipeline, China-Kazakhstan oil pipelines, China-Russia oil pipelines, and so on. It is estimated that the total length of long distance pipelines will reach 50,000 km by 2015.

To improve the transportation efficiency of pipelines, the long distance pipelines often have larger diameter, higher pressure, and thicker wall thickness. With techniques, such as micro-alloying, controlled rolling and cooling, etc., the grade of pipeline steel is becoming higher and higher. At the same time, the impact toughness, HIC resistance, and weldability of pipeline steel are excellent. However its strain hardening ability and uniform deformability are relatively poor. In addition, softening area in HAZ (heat affected zone) can appear which can cause strain concentration and affect the integrity of pipeline negatively.

In the past, only stress-based design method was used in China's pipeline projects, although some problems couldn't be thoroughly addressed with the strength criteria. One example is the Geermu-Lasa oil pipeline. The Geermu-Lasa oil pipeline was built in 1973 and has been in service for more than 30 years. The pipeline covers a distance of 1076 km and is the first oil pipeline built in permafrost area. Thirty leakage accidents due to permafrost upheaval have taken place, which caused enormous losses. Another example is Shan-Jing pipeline which has suffered by pipe floating and suspending from time to time. China is a country with a vast territory and its geological conditions are complicated and varied. There are loess plateau, wide plains, dry desserts, humid regions with rivers and lakes, permafrost areas, and areas where earthquakes and landslides occur frequently. The long distance pipeline may be severely displaced by the geological movements such as thawing of permafrost, land sliding, flood water, and ground subsiding. In this situation, the failure of pipeline is controlled by displacement or strain, and the stress-based design criterion is not applicable. In stead, the strain-based design method should be used. Although many researches on strain-based design method have been accomplished in the world, the strain based design is still in a preliminary stage in China. In this paper, the application of strain-based design method in China is discussed through 3 key issues – material selection, pipeline design, and construction process.

PIPELINE REACTION TO GEOLOGICAL DISASTERS

In geological activities (like earthquake, landslide, mud-rock flow, thawing of permafrost), deformations such as bending, ovalization-buckling (local buckling or beam buckling), can take place. Pipeline must sustain large displacement and strains. However, under some circumstances, the pipelines may fail by wrinkle or fracture (D. Hart et.al. 2002), Figure 1 shows the local buckling of Shan-Jing pipeline (Li et.al. 2006), which was caused by flood. The deformation depends on pipeline dimension, material properties (include welded joint), type of displacement, and internal pressure, etc (Vitali et.al. 1999). In general, wrinkle will not fracture under compress strain without several cycles of compress and tension strain (Das et.al. 2001).

Pipelines in harsh geological situations must have extraordinary deformability and higher strain capacity to sustain the large displacement, which requires both the linepipe steels and pipeline