Strain Capacity of Large Diameter X80 Pipeline including Hot Bend

Nobuaki Takahashi
Pipe Dept., Kashima Steel Works, Sumitomo Metal Industries Ltd.,
Kashima-city, Ibaraki, Japan
Hidenori Shitamoto
Corporate Research and Development Laboratories, Sumitomo Metal Industries Ltd.,
Amagasaki-city, Hyogo, Japan
Shusuke Fujita
Technology Dept., Sumitomo Metal Pipeline and Piping Ltd., Warabi-city, Saitama, Japan
Masakazu Matsumura, Izumi Takeuchi
Sumitomo Metal Industries Ltd., Chuo-ku, Tokyo, Japan

ABSTRACT
Construction of high-pressure gas pipelines with API X80 grade welded large diameter pipes is progressing for the improvement of transportation efficiency. The issue has been suggested that the benefit of higher strength steel of thinner wall pipe diminishes the strain capacity of line pipes by larger D/T ratio and higher Y/T ratio of higher strength steel pipe in general. Authors reported that API X80 grade 48-inch (1,219mm) diameter line pipe has enough strain capacity against ground displacement by seismic wave propagation and lateral spread by liquefaction in seismic area based on the JGA guide line. However the pipelines are not always straight, but also curved to follow the route. Hot bends are employed to make curved portion. Mechanical properties and pipe dimensions of hot bends are different from straight pipes due to the heat treatment and deformation during bending. The characteristics of X80 hot bend are going to be investigated, and the strain capacity and the strain demand of curved portion in pipeline are evaluated by FEA for the assessment based on SBD concept.

KEY WORDS: Induction hot bend; X80 line pipe; Bending Moment; Strain Capacity; Strain Demand; Lateral Spread

INTRODUCTION
The operating pressure of natural gas transmission pipelines has been increased for transportation efficiency. High strength line pipes have been developed to carry high pressure gas economically and safely by long distance pipelines. High strength line pipes have secured internal pressure containment capacity, which is the most essential requirement to line pipes. However to secure the safety of high pressure gas pipelines constructed by high strength line pipes, the strain capacity of high strength line pipes has been investigated and discussed, as it is assumed that high strength line pipe is inferior to low strength one in deformability (Liessem et al., 2007).

We, pipe manufactures, have focused to develop high strength and high toughness steel for pressure containment capacity and the resistance to fracture initiation and propagation. High quality and high strength line pipes have contributed to the expansion of transportation capacity and the safety of gas pipelines. The safety record of gas pipeline has been continuously improved by the effort of concerned parties. The major causes of pipeline accident are still damage by the external force and corrosion, though the rupture by the unexpected ground movement is reported (EGIG, 2005, Jeglic, 2004). To avoid pipeline rupture by the ground movement, it is reasonable to apply SBD to high pressure pipelines. For the assessment of buried pipeline based on SBD concept, the strain capacity and the strain demand of pipeline for targeting ground movement must be evaluated.

The strain capacity of line pipes has been investigated by the compression and bending test of large diameter steel pipes. It was found that the strain capacity could be improved by heavy wall pipes whose D (diameter)/ T (wall thickness) ratio is smaller (Mohr, 2003) In term of steel property low Y/T ratio in pipe axial direction is beneficial for compressive strain limit of high strength line pipes (Suzuki, Toyoda, 2002). In case of tensile strain limit, the study has been conducted to evaluate strain limit of girth weld joint with weld defects by curved wide plate test (Fairchild et al. 2008, Wang et al., 2008). At the same time the strain demand has been tried to calculate by FEA based on historical events of ground movement (Barbas, Weir, 2007). But the geotechnical factors vary depending on pipeline route, which spreads broad area on the globe. There remain many issues to establish universal standard of strain demand assessment.

The ground movements, which make damage to pipelines, are classified into two categories based on time dependence. One is slow movement such as frost heave, in which the deformation can be monitored to take measures. Another one is quick movement such as earthquakes and followed landslides, which happen suddenly. It is supposed that the most significant ground movement for pipeline is lateral spread or fault movement followed by earthquake because pipeline must prepare for the events before hand. It is reported that relative size, which is pipe diameter to magnitude of movement, is considered to be another factor on the possibility of damage (EIGI, 2005). It is reasonable to take into consideration the pipe size between small diameter distribution line and large diameter gas transmission line.

The authors (Takeuchi et al., 2008) reported that 1,219mmOD x 22mmWT X80 line pipes as a typical long distance gas transmission pipeline have enough resistance to seismic wave propagation and lateral spread supposing that the JGA guideline (JGA, 2000,2001) is applicable to X80. In this report X80 induction hot bend, whose production process is deferent from straight pipes, are going to be focused. Quenching and tempering process is applied for X80 hot