JGA Paper Awards for Outstanding Research and Development, 2004

Effects of the Design Factor on the Large Deformation Behavior of X80 Straight Pipes Subjected to Bending

Hiroshi Yatabe, Pipeline Technology Center, Tokyo Gas
Tomoki Masuda, Gas Technology Department, The Japan Gas Association
Masao Toyoda, Graduate School of Engineering, Osaka University

Japan's present regulation on gas pipelines is only applicable to those with the material grade up to API (American Petroleum Institute) 5L X65 and the design factor on the deformation behavior up to approximately 0.4 SMYS (Specified Minimum Yield Stress). The Nuclear and Industrial Safety Agency, Ministry of Economy, Trade and Industry (METI), Japan established the Gas Pipeline Safety Standard Study Council in 2002 to study the gas pipelines with higher quality and design factors, which would be most probably used as long-distance offshore pipelines. The Agency (prepared the budget and) developed the experiments and EF analyses using shell elements as its research project. Tokyo Gas, Osaka University and the Japan Gas Association successfully evaluated the influence of the design factor on pipe deformability experimentally and analytically.

The bending experiments using API 5L X80 straight pipes revealed that there were differences in the deformation behavior and the limit state between the design factor values of 0.4 SMYS and 0.6 SMYS. While the limit state of the straight pipe with internal pressure below the design factor value of 0.4 SMYS was reported to have leakage with small crack at the wrinkle on the compression side, the rupture was observed on the tension side of the straight pipe with the design factor value of 0.6 SMYS. Furthermore, the bending angle at the limit state of 0.6 SMYS was considerably smaller than that of 0.4 SMYS.

Bending experiment

The FE (Finite-Element) analysis using shell elements revealed that the internal pressure and the material uniform elongation influenced the deformation behavior. The parametric studies indicated that the peak moment value tended to decrease with an increase in the design factor, while the peak moment angle tended to increase with an increase in the design factor.

In addition, the FE analysis using the solid elements effectively predicted the deformation behavior more precisely by simulating the necking on the tension side.

This study indicates that API 5L X80 straight pipes could pave the way for more competitive gas transmission pipelines.

For further information, please contact Hiroshi Yatabe (yatabe-h@tokyo-gas.or.jp), Pipeline Technology Center, Tokyo Gas.