Mechanical Properties and Performance Prediction for HF-ERW Line Pipes Reel-laid

Eiji Tsuru¹, Hidenori Shitamoto², Masakazu Ozaki³, Kenichiro Tomioka⁴, Taro Muraki⁵
¹ Nippon Steel & Sumikin Technology Co. LTD.
Futtsu-City, Chiba, Japan
² Pipe & Tube Research Lab., Nippon Steel & Sumitomo Metal Corporation
Amagasaki-City, Hyogo, Japan
³ Quality Management Div. Nagoya Works, Nippon Steel & Sumitomo Metal Corporation
Tokai-City, Aichi, Japan
⁴ Tubular Products Technology Div., Nippon Steel & Sumitomo Metal Corporation
Tokyo, Japan
⁵ European Office, Nippon Steel & Sumitomo Metal Corporation
Duesseldorf, Germany

ABSTRACT
Reeling lay (R-lay) is a common method used for installing line pipes on the seabed. In R-lay, girth-welded line pipes are subjected to repeated plastic strain while on reel barges. This paper discusses the mechanical properties that change in R-lay usage and describes the performance prediction of pipes installed on the seabed. Using full-scale reeling simulation (FSR), changes in the pipe profiles and the mechanical properties were measured. Then, using small-scale reeling simulation (SSR), the impact toughness was evaluated after strain aging. These simulations demonstrate plastic anisotropy in R-lay pipes. The strain capacity in laying was predicted using the FE-model, with measured geometry and strength distribution. The impact toughness is acceptable for laying line pipes in subsea areas. Based on the R-lay simulations, the applicability of HF-ERW line pipes is also discussed.

KEY WORDS: line pipe; reeling; ERW pipe; strain aging; anisotropy

NOMENCLATURE
D: Outside diameter of pipe, mm
D₀: Each diameter, mm
Dₐve: Average diameter of pipe, mm
L: Pipe length, mm
β: Oblateness
θ: Bending angle, °
e: Bending strain
ρ: Curvature radius of line pipe, m

INTRODUCTION
R-lay is an effective laying method for offshore pipeline. HF-ERW pipe with a good roundness and eccentricity is a strong candidate for line pipes used in R-lay (Denniel 2011, Tsuru 2013, Karjadi 2015). Comparing S-lay and J-lay, line pipe R-laid is characterized by the plastic strain repeatedly developed in reeling and unreeling. Before lying on the seabed, the bending and unbending on the spool change the mechanical properties and increase the geometric imperfection in the pipes. Previous studies have presented the impact toughness in seamless pipe and the collapse resistance in ERW pipe after the reeling simulation (Higuchi 2010, Shitamoto 2013, Tsuru 2015). However, there is no data on the mechanical properties and plastic anisotropy changes in reeling operation.

Figure 1 illustrates the schematic drawings for line pipe installation by R-lay. Bending capacity under external pressure is required for line pipes laid in deep water since the pipeline is subjected to reaction forces from the seabed. Therefore, the objectives of this study were to measure the changes in the mechanical properties in the reeling simulation, to predict the bending resistance under external pressure, and to clarify the impact toughness after pipe installation.

In FSR, the stress vs. strain (SS) curves and the pipe profiles were measured for the girth-welded pipes after three times bending and unbending. The finite element (FE-) models of the pipes using these data predict the bending capacity under external pressure. In SSR, the