Anisotropic Strain Aging Behavior of High Strength UOE Linepipes

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ABSTRACT
A strain-based design (SBD) was discussed for pipelines constructed in discontinuous permafrost areas. For SBD, we need to consider the tensile strain limit and the compressive strain limit. The compressive strain limit is affected by many factors, such as operation conditions, pipe size and mechanical properties in a pipe. In the mechanical properties, the shape of stress-strain curves (Yield to tensile ratio: Y/T, Yield point elongation, Uniform elongation, Work-hardening exponent: n value) affects the compressive strain limit. The mechanical properties of UOE pipes are complicated. The major concern in this study is estimating the mechanical properties of UOE pipes from the tensile prestrained plate. The absolute values such as the uniform elongation, n value and yield to tensile ratio were different, but the tendency of each parameter with the aging temperature was almost the same.

KEY WORDS : Strain based design, Yield to tensile ratio, Uniform elongation, n value, Strain aging, Work-hardening

INTRODUCTION
Oil and natural gas are being to serve as the dominant energy source in the future. Therefore demand for oil and natural gas is anticipated to increase throughout the entire world.

The production field of oil and natural gas is far from the consumption field. As a result, a low cost transportation system is important, and the pipeline plays an important role in the long distance transoartion system of natural gas.

In recent years, pipelines have been built in the fields of discontinuous permafrost areas and earthquake regions. In these fields, line pipes were plastically strained by settling or upheaval of the ground. The plastic design method such as strain-based design is applied to pipe lines in such hostile environments (Glover 2002).

For SBD, the tensile strain limit and the compressive strain limit should be considered. For the tensile strain limit, the relation of strength between pipe and girth weld is important. The allowable defect size and required toughness were estimated for the tensile strain limit (Deny, 2002), and then the yield strength (YS) and flow stress (FS) were controlled at 2% so that strain in the pipe’s longitudinal direction could achieve an overmatch of the girth weld strength.

The compressive strain limit is affected by many factors, such as operation condition, pipe size and mechanical properties in the longitudinal direction of the pipe. Especially, in the mechanical property, as the shape of the stress-strain curve evaluated by the yield to tensile strength (Y/T) ratio, uniform elongation, and n value affect the compressive strain limit (Tsuru 2008), it is important to control these properties.

A line pipe is coated to protect the pipe from corrosion. While there are many types of coating method, Fusion bonding epoxy (FBE) has been the predominantly used type recently. In the case of FBE coating, the pipe is heated at 200°C and higher. The heating of the pipe causes strain aging because of cold pipe forming (Shinohara 2005, Timms 2005). The shape of the stress-strain is changed by the strain aging.

Figure 1 shows the schematic illustration of the pipe forming process of UOE. The UOE pipe is manufactured by three presses (Edge Crimping,