

Development of High Deformability Linepipe with Resistance to Strain-aged Hardening by Heat Treatment On-line Process

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ABSTRACT

Linepipes installed in permafrost ground or seismic region, where larger strains can be expected by ground movement, are required to have sufficient deformability in order to prevent local buckling or girth weld fracture. On the other hand, deformability of linepipes usually decreases with increasing strength, and this is one of the reasons for preventing wider use of higher grade linepipe for high strain application. Furthermore, external coating is necessary for corrosion resistance of pipe, but coating heat can cause strain-aged hardening which results in increased yield strength and Y/T. Therefore, there is a strong demand for developing high strength and high deformability linepipe with resistance to strain-aged hardening for a high strain application.

Extensive studies to develop high strength linepipes with higher deformability have been conducted. One of the key technologies for improving deformability is dual-phase microstructural control. Steel plate with bainite and martensite-austenite constituent (MA) microstructure can be obtained by applying heat treatment online process (HOP) subsequently after accelerated cooling process. HOP process is the induction heating process that enables rapid heating of the steel plates. Variety of microstructural control, such as fine carbide precipitation and MA formation, can be utilized by this newly developed heating process. One of the significant features of the HOP process is to improve resistance to strain-aged hardening. Both free carbon and dislocation density can be reduced by carbide precipitation and tempering of bainite. Coating simulation test for the HOP applied high deformability linepipe revealed excellent deformability after coating heating.

Trial production of X70 to X100 high deformability linepipes was conducted by applying the HOP process. Microstructural characteristics and mechanical properties of developed linepipes are introduced in this paper.

KEY WORDS: High strength linepipe, Deformability, Dual-phase microstructure, Martensite-austenite constituent (MA), External pipe coating, Strain-aged hardening, Heat treatment On-line Process (HOP)

INTRODUCTION

In recent studies, it is indicated that there are significant economical

advantages of using higher strength linepipes in constructing long distance pipelines. Because it is possible to improve transportation efficiency by increasing internal pressure and reduce material costs. By using thinner materials, total tonnage of materials and consumables for girth welding can be reduced. On the other hand, construction of pipelines has been expanded to severe regions, such as cold region, seismic region, deepwater and sour gas environment. In addition to high strength, various material properties, such as high toughness, high deformability and sour resistance property, are required. One of the most challenging fields for pipeline developments can be seismic and permafrost regions. In these regions, large plastic deformation is expected to be induced to pipes by ground movement.

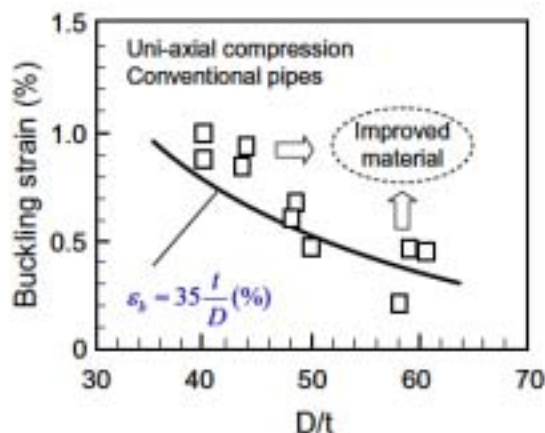


Fig.1 Relationship between buckling strain by axial compression and pipe diameter to thickness ratio (D/t).

Recently, new design methodology, so called “strain-based design”, for the pipeline engineering for seismic and permafrost region has been developed [1]. According to the new concept, higher resistance of linepipes against larger compressive and tensile strains is required. Critical failure event in compressive deformation is buckling, and enough resistance to buckling is needed for linepipes. Fig.1 shows the relationship between maximum buckling strain and pipe diameter to thickness ratio for conventional pipes [2]. Generally buckling behavior depends strongly on dimensions of pipe. Buckling strain decreases with increasing D/t ratio, which is pipe diameter to thickness ratio, and