Development of X80/X100 Linepipe Steel Plates and Pipes for Strain Based Design Pipeline

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ABSTRACT
In order to effectively transport the gas in arctic or seismic region, pipeline demands linepipe steels with high deformation capacity since earth movement occurs by frost heave or earth quake. New concept of strain based design (SBD) was proposed for safe pipeline construction. In view of obtaining the material properties of X80 and X100 for SBD application, many efforts to achieve superior strain capacity have been made. The X80/X100 linepipe steel plates and pipes for strain based design were developed. The chemical composition an TMCP (Thermo-mechanical controlled process) parameters were designed to achieve high strength and improved toughness at body and heat affected zone, and high strain aging resistance after coating. Dual phase microstructure results in enhancing the strain aging resistance of X80/X100 linepipe steels. Several pipes of 1 meter length were made by UOE simulator and submerged arc welding was carried out for seam welding with optimum heat input, welding material and process. Mechanical properties were evaluated through plate, pipe and aged treatment specimen. In order to evaluate the compressive strain limit, buckling test was performed with long pipes of X100 before and after aging treatment. It could be realized that the developed pipes satisfy the minimum requirement of strain capacity for strain based design linepipe.

KEY WORDS: strain based design, linepipe steel, X80, X100, strain aging resistance, strain capacity

INTRODUCTION
The demand of high strain capacity responding to severe earth movement has been gradually increased in recent pipeline project. The concept of strain based design (SBD) linepipe steel was proposed and many developments were actively progressed (Suzuki, 2001; Glover, 2002; Shinohara, 2005; Ishikawa, 2006; Shinohara, 2007). In order to install the pipeline at the severe region, the use of strain based design linepipe steel having high deformability is most important. Although main factors to influence the deformability of pipe are not fully understood, it is generally known that the factors are deeply related to yield ratio (yield stress/tensile stress), exponent of work hardening, and uniform elongation of linepipe steel. In addition to these, thermal aging behavior during anti-corrosion coating after pipe forming should be well controlled because it brings the degradation of deformability due to strain aging effect (Hara, 2008; Ishikawa, 2008; Liessem, 2008; Schwinn, 2008; Seo, 2008).

At the pipe having discontinuous yielding behavior, when deformation is occurred by outer environment, strain can be easily localized at special region to wrinkle or buckle (Suzuki, 1999). Basically continuous yielding, low yield ratio and large uniform elongation might be important at strain based design pipeline even though after coating. The X80/X100 linepipe steel plates and pipes using strain based design have been developed. The chemical composition was designed to achieve high strength, improved toughness at body and heat affected zone, and high strain aging resistance. The TMCP (Thermo-mechanical controlled process) parameters were optimized to have appropriate microstructure for each grade steels of X80 and X100. To enhance the strain aging resistance of X80/X100 linepipe steels, microstructure was controlled as dual phase.

The microstructures were observed by optical microscope and transmission electron microscope. Several pipes of 1 meter length were made by UOE simulator and submerged arc welding was carried out for seam welding with optimum parameters of heat input, welding consumable and process. Mechanical properties of the plate, pipe and aged treatment specimen were evaluated.

Both strain limits are requested at compression and tensile mode in strain based design linepipe (Kan, 2008). To satisfy demands of strain limit in compression mode, pipe body’s property is important. In this article, compression bending test with whole pipe was performed to evaluate strain limit value before and after coating treatment. In order to evaluate the compressive strain limit, buckling test was performed with long pipes of X100 before and after aging treatment.

RESULTS AND DISCUSSION

Production of Plate
To make the strain based design linepipe steel of X80 and X100, the slabs were manufactured by oxygen converter and continuous cast