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Development of X80/X100 Linepipe Steels with High Strain Aging Resistance

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ABSTRACT

Recent pipeline design takes an important consideration of the stability of the pipeline under the differential soil movement, and thus requires the linepipe steel with excellent deformation capacity, especially with high strain aging resistance during anti-corrosion coating treatment. Under this background, the development of X80/X100 line pipe steels with high strain aging resistance was tried. As a basic study, the effects of aging temperature and specimen dimension on the strain aging of pipes were carefully studied. It was found that strain aging behavior of pipe was different along the through thickness direction. Several experimental trials with lots of process variables have been performed to enhance the strain aging resistance of X80/X100 linepipe steels. The experimental X80/X100 steel pipes with 1m length were manufactured by using UOE simulator which can do U-ing, O-ing and expansion at the same machine. The strain aging characteristics of the experimental pipes were evaluated. The effects of rolling and cooling conditions on the strain aging behavior of X80/X100 linepipe were investigated and thus the optimum process variables were derived for achieving the high strain aging resistance. The pipes made with the developed X80/X100 steels were evaluated after anti-corrosion coating and were found to have a round type stress-strain curve.

KEY WORDS: linepipe steel; X80; X100; strain aging resistance

INTRODUCTION

Buried pipelines are subject to a number of loading conditions. These include internal pressure caused by the action of the fluids they convey, axial forces induced by thermal effects, and bending caused by differential soil movements. Recently, differential soil movements are taken an important consideration in the design and assessment of buried pipelines. When a buried steel pipeline is subject to the increasing curvatures arising from differential geotechnical movements, eventually it will buckle locally. Therefore, recent pipeline design requires that pipeline has the high deformation resistance to local buckling. (Korol, 1979; Dorey, 1999; Mohr, 2002)
Under this background, studies for enhancing the deformability of X80 and X100 grade linepipe steels are being actively progressed. The deformability of pipeline is affected by many factors such as operating pressure, pipe size and mechanical properties in the longitudinal direction of a pipe. (Glover, 2004) The Y/T ratio, uniform elongation and stress-strain curve shape affect the compressive strain limit and thus it is important to control these properties. In addition, thermal aging behavior during anti-corrosion coating should be well controlled because it brings the degradation of deformability in field application of linepipe. (Shinohara, 2005; Timms, 2005; Shinohara, 2007)
In this study, the development of X80/X100 linepipe steels with high strain aging resistance was tried. As a basic study, the effects of aging temperature and specimen dimension on the strain aging of pipes were carefully examined. Also, the microstructure and thermal aging behavior of X80 and X100 steel have been investigated as functions of processing conditions.

EFFECTS OF AGING TEMPERATURE AND PRESTRAIN ON THE STRAIN AGING OF PIPE

In pipeline, anti-corrosion coating is usually performed at 200-250℃ for several minutes after expansion process. So, the strain induced by pipe making and the interaction between carbon atoms and dislocations are considered to play a main role in thermal aging behavior of pipe.(Shinohara, 2005) The strain induced by pipe forming and the thermal history of anti-corrosion coating are different in the through thickness direction of pipe. Thus, the thermal aging behavior of pipe is very complex and delicate. So, the effects of aging temperature and strain amount on the thermal aging behavior of pipe were investigated. X100 grade steel pipes with bainitic ferrite microstructure were manufactured by UOE and then the pipes were aged at 200-250℃ to simulate a coating process.

Production and aging treatment of test pipe

The X100 steel slabs were manufactured by oxygen converter and continuous cast process. Centerline segregation in slab was minimized by applying soft reduction during continuous casting. Table 1 shows typical chemical composition level of X100 steel.
The steel plates of 19.8mm thickness and 3800mm width were manufactured from 250mm thick slab. Thermo-mechanical control process (TMCP) condition of slab reheating, rolling and cooling was carefully controlled. In view of austenite conditioning for smaller grain