Material design for line pipe steel to minimize HAZ softening and to obtain good HAZ toughness

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ABSTRACT

In order to develop a material design concept for strain based design, effect of HAZ softening on deformation behavior was studied by FE analysis. To control the HAZ softening and hardening, effect of chemistry on hardness in HAZ was evaluated by the taper hardness test. A UOE pipe of X80 with low carbon content of 0.05mass%, adequate Pcm value of 0.20mass% and high Ceq(IIW) of 0.50mass% was produced and its properties were evaluated

KEY WORDS: Strain based design; X80; UOE; Ceq(IIW); Pcm; HAZ softening; HAZ toughness

INTRODUCTION

In general, steel ductility decreases by increasing strength. Thus necessity of strain based design in pipeline is discussed more seriously with spreading an application of a high strength pipes more than X80. Strain based design indicates two strain limits of deformation in longitudinal direction: tensile rupture (Wang 2006) and compressive buckling (Suzuki 2006). Concerning of tensile rupture in longitudinal direction, controlling of strain concentration at the toe portion of girth welding bead is important. Mohr discussed about strain-based design for materials with HAZ softening (Mohr 2006).

From a point of view of material design, applying of rich chemistry steel must be a way to control HAZ softening. The softest point in HAZ is fine grain HAZ. In this region, steel is reheated just above transformation temperature and normalized. Thus increasing hardenability by increasing of alloying elements must be effective to decrease HAZ softening. Therefore relation between the minimum hardness in HAZ and steel chemistry is not studied enough. On the other hand, significant hardening and poor toughness at coarse grain HAZ is concerned in rich chemistry steel. From these points of view, fundamental study about the effects of steel chemistry on hardness in HAZ was conducted by taper hardness test. In this study the effect of HAZ softening on deformation behavior during pipe bending was also estimated by FE analysis.

SIMULATION OF DEFORMATION BEHAVIOR OF GIRTH WELDED PIPES DURING BENDING

FINITE ELEMENT ANALYSIS MODEL

Figure 1 shows a FE analysis model to simulate deformation behavior during pipe bending. This model includes welded portion as shown in figure 1.

Stress-strain curves used as input data for FE analysis are shown in figure 2. The stress-strain curve of base metal was measured by using a round bar tensile specimen with diameter of 12.7 mm taken from X80 pipeline steel in the direction of the pipe axis. Tensile strength of 689 MPa, yield strength of 606 MPa and uniform elongation of 7.71%