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Development of Plate and Seam Welding Technology for X120 Linepipe

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ABSTRACT

To provide a lower-cost option for long-distance gas transmission, X120 UOE linepipe has been developed. An interrupted direct quench (IDQ) process and boron additions were employed on a low-alloy steel to obtain a lower bainite microstructure with extremely small austenite grains. Plates of up to 20-mm thickness are possible with at least 231 J of Charpy energy at −30°C. For longitudinal seam welding, a new wire and a new flux were developed. Heat-affected zone (HAZ) softening is limited by using a low heat input welding procedure. HAZ cold cracking resistance is excellent due to the low carbon content and Pcm relative to the X120 strength level.

INTRODUCTION

Natural gas is an increasingly attractive energy source, but major reserves are often located far from potential markets. High operating pressures and/or thin wall pipes are a means of reducing transmission costs, but conventional steels typically lack sufficient strength to utilize those cost-saving measures. To solve these challenges, a high-strength grade of large-diameter linepipe, X120 UOE linepipe, has been developed. The major challenge associated with the development of any high-strength linepipe is to increase both strength and fracture toughness while providing adequate weldability and structural integrity in the seam weld (Fairchild, Macia, Papka, Petersen, Stevens, Barbas, Bangaru, Koo and Luton, 2002). When Nippon Steel and ExxonMobil started joint development of X120 linepipe in 1996, most linepipe produced was grade X65 or lower, and very limited amounts of X80 had been manufactured. Hence a large step in linepipe manufacturing technology was required to develop X120 from the existing technological base. As Fig. 1 shows, development of X120 required advancing plate-making, UOE-forming and seam-welding technology. This paper describes the development of plate and seam-welding technology.

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KEY WORDS: High strength linepipe, UOE linepipe, long-distance pipeline, boron steel, lower bainite, low-carbon steel, cold cracking.

DEVELOPMENT OF PLATE

Targets of Plate Properties

X120 pipe should have a specified minimum yield strength (SMYS) of 827 MPa (120 ksi) and a specified minimum tensile strength (SMTS) of 931 MPa (135 ksi) in the circumferential direction. Because only the circumferential strength affects the pressure-carrying capacity of the pipe, a SMYS for the longitudinal direction of the pipe was not targeted.

When manufacturing pipe from plate, the yield strength may increase as a result of work hardening from deformation during pipe forming. Thus, only the SMTS in the transverse direction was considered a target for the plate, and this paper's tensile data are in the transverse direction if not otherwise mentioned. Early in the X120 development program, a base metal Charpy

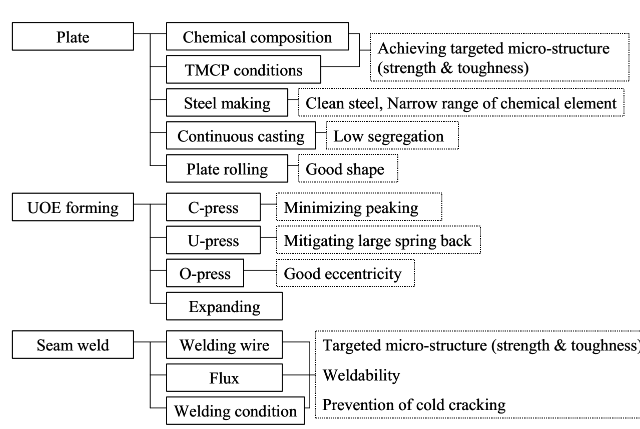

Fig. 1 Development items of X120 UOE linepipe