International Journal of Offshore and Polar Engineering
Vol. 14, No. 1, March 2004 (ISSN 1053-5381)

Pipe Production Technology and Properties of X120 Linepipe

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ABSTRACT

To provide a lower-cost option for long-distance gas transmission, X120 UOE linepipe has been developed. After development of heavy-plate and basic seam-welding technology, finite element models and forming tests in the UOE mill established the forming conditions and tooling design criteria to solve the problem of the large springback that occurs during forming of the plate. To confirm X120 mass production technology, more than 100 pipes were manufactured in a small-scale, commercial-production run—a mini-roll. The produced pipe generally met the dimensional tolerances and mechanical property targets, but improvements are planned. Field bending of the X120 pipe has been demonstrated, and the resistance to hydrogen embrittlement by cathodic protection has been confirmed.

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 to reduce transmission costs, but conventional steels typically lack sufficient strength. 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 pipe produced was grade X65 or lower, and very limited amounts of X80 had been manufactured. Thus, a large step in linepipe manufacturing technology was required to develop X120 from the existing technological base. As Fig. 1 illustrates, the development of X120 required advancement of technology for plate making, UOE forming and seam welding. After heavy-plate and basic seam-welding technology were developed (Asahi, Hara, Sugiyama, Maruyama, Terada, Tamehiro, Koyama, Ohkita, Morimoto, Tomioka, Doi, Murata, Ayukawa, Akasaki, Fairchild, Macia, Petersen, Koo, Bangaru and Luton, 2003), pipe production technology was developed. This paper describes the development of pipe forming technology and the results of a small-scale, commercial-production run.

DEVELOPMENT OF PIPE PRODUCTION TECHNOLOGY

Pipe Property Targets

The strength of the pipe in the circumferential direction determines the pressure-carrying capacity of the pipeline. For X120 pipe, a specified minimum yield strength (SMYS) of 827 MPa (120 ksi) and a specified minimum tensile strength (SMTS) of 931 MPa (135 ksi) are targeted for the circumferential direction (C-direction). Because the strength in the longitudinal direction (L-direction) of the pipe does not directly affect its pressure-carrying capacity, no strength targets were developed for the L-direction. However, the strength and ductility in the L-direction may affect the ability to make cold bends with the pipe and the tolerance of the pipeline to axial deformation in service.

One of the challenges in manufacturing higher-strength linepipe is producing high toughness at high-strength levels. Early in the X120 development program, a base metal Charpy V-notch (CVN) toughness target of 231 J was developed by applying an empirical equation that predicts the CVN energy required to arrest a running ductile fracture. Details of the development of a Charpy V-notch toughness for the base metal are presented elsewhere

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Received August 18, 2003; revised manuscript received by the editors December 23, 2003. The original version (prior to the final revised manuscript) was presented at the ISOPE Symposium on High-Performance Materials in Offshore Industry, the 13th International Offshore and Polar Engineering Conference (ISOPE-2003), Honolulu, Hawaii, USA, May 25–30, 2003.
KEY WORDS: High-strength linepipe, UOE linepipe, long-distance pipeline.