ABSTRACT

The world demand for natural gas is increasing due to the rise in energy consumption along with the growth of the world’s population and industry. Another cause is the change from oil to natural gas as clean energy that emits less carbon dioxide as a greenhouse gas and NOx or SOx as air pollution. However, the areas of the development of natural gas have been shifting from near the market to more remote areas including the polar region. Thus it is necessary for natural gas development companies to decrease the construction costs of the pipelines to maintain safety during operation and to improve transport efficiency with high-pressure operation. Nippon Steel Corporation has endeavored to improve the properties of linepipe quality and the optimization of manufacturing processes/conditions to satisfy the needs for higher strength and toughness of linepipes for many years. Through the development, issues to be solved have been found in the mechanical properties of plates and pipes, geometry of pipes and the quality in welds. We addressed these issues and invested in new processes from steel making to UOE Mill. As a result, we have established steady commercial production for high-strength UOE linepipes up to X120. To date, we have already produced X80, X100 and X120 grade linepipes. The production amount is 70,000 tons and the quality requirements have been greatly satisfied.

KEYWORDS: High strength linepipe, X100, X120, Commercial production, UOE mill

NOMENCLATURE

- C-: circumferential
- CC: continuous casting machine
- CLC-µ: improved continuous on line control process
- dS: difference from conventional width S₀
- EL: elongation
- FEA: finite element analysis
- FL: fusion line of weld
- L-: longitudinal
- LD-OB: linz-donawitz oxygen bottom blowing converter
- OOR: out of roundness
- S₀: conventional width between axes position of rocking die
- TMCP: thermo-mechanical control process
- TS: tensile strength
- YS: yield strength

INTRODUCTION

Due to steady growth of the world’s population, world energy demand will generally increase despite significant fluctuations in industry consumption, depending on the economic situation. Against the background of such energy demand, world demand for natural gas will increase due to the fact that it is a clean form of energy that provides an alternative to oil. It also emits low CO₂, which is a well-known greenhouse gas, and emits low SOₓ and NOₓ, which are common air pollutants. In contrast, however, the drilling sites for natural gas often change year by year, at times being close or far from the urban areas where demand exists. Therefore, natural gas pipelines themselves have to become longer and such a construction cost will become a large burden for natural gas developers (Corbett, 2003). To supply natural gas constantly at a low cost, reduction of pipeline construction costs, improvements in the safety of pipeline operations, and improvements in the efficiency of high-pressure transport are required (Glover, 2004, Barbas, 2003). However, this would not only entail just applying high-strength steels, but would also include the improvement of low temperature toughness and deformability of materials. Experimental, small-scale production of high-strength and high-toughness pipes is available for existing mills (Asahi, 2003). Nippon Steel has made a large number of production trials exceeding 600 pipes in total using X120-grade steel in existing mills, and revealed issues concerning stable quality and productivity. Based on the results of these trials, commercial mass production of high-strength pipes from X80 to X120 has been achieved by improvements of forming shape and welding quality and by elimination of factors hindering productivity.

PRODUCTION ISSUES CONCERNING HIGH-STRENGTH AND HIGH-TOUGHNESS LINEPIPES

The UOE manufacturing process

High-strength and high-toughness linepipes are manufactured by adding alloy to steel. According to the alloy composition, the intended microstructure of the material is obtained through a controlled rolling