Material Design and Weldability of High Strength Seamless Pipe

Hiroyuki Hirata, Masahiko Hamada, Yuji Arai, Kunio Kondo
Corporate Research and Development Laboratories, Sumitomo Metal Industries, Ltd
Amagasaki, Osaka, Japan

Nobuyuki Hisamune, Keisuke Hitoshio, Tuneo Murase
Pipe and Tube Company, Sumitomo Metal Industries, Ltd
Wakayama-shi, Wakayama, Japan

ABSTRACT

Because of the strong demand for development of oil and gas fields in ultra deepwater, pipes with higher strength have been required in recent years.

In order to clarify the material design suitable for high strength seamless pipes over X80 grade from the viewpoint of weldability, the effects of chemical compositions on the weldability, especially the hardness in heat affected zone (HAZ), were investigated.

It was clarified that the material design using manganese, molybdenum and chromium instead of carbon was effective to alleviate both the hardening and the softening in HAZ. Furthermore, the circumferential weldability tests were conducted on the pipes, which were produced in consideration of this material design, and it was verified that these pipes had enough weldability.

KEY WORDS: Seamless pipe, Weldability

INTRODUCTION

Explorations of oil and gas fields in deep water have increased recently. Operation conditions, such as internal pressure and temperature, will be more severe by increasing the water depth. By the way, in deep water explorations, seamless pipes are widely used for flowlines or risers because of its higher reliability compared with welded pipes. Accordingly, higher strength and/or a thicker wall will be required for seamless pipes in deeper applications.

Concerning seamless pipes with high strength, the developments of pipes over X80 grades has been recently launched and reported. Anelli,E et al. investigated the effects of chemical compositions and heat treatment conditions on the microstructures of quenched and tempered (Q&T) steels in order to obtain the guideline for production of X100 grade pipe [Anelli,E et al., 2006]. Then it was concluded that good combinations of strength and low temperature toughness could be obtained in the steel with the microstructure, which had a volume fraction of martensite over 60% and a fine sub-grain size and packet size. Moreover, the trial productions of X100 pipes were completed by applying the suitable manufacturing process, including Q&T conditions, to the material with 0.07-0.11%C.

On the other hand, Arai,Y et al. 2) surveyed the effect of chemical compositions on strength and low temperature toughness in order to clarify the adequate metallurgical design for Q&T pipe over X80 grade, which was produced using the high cooling rate quenching process [Arai,Y et al., 2007]. It was confirmed that high strength ranging from X80 to X100 grades and good low temperature toughness were achieved in the Q&T steels with uniform bainite structure by optimizing both alloy elements and heat treatment conditions. Furthermore, the suitable chemical compositions, which lowered the carbon content and contained enough high Mn, Mo and Cr instead of carbon and vanadium, was obtained and its propriety was confirmed by the trial productions of X80-X100 grades pipes.

Meanwhile, it has been well known that weldability is affected by increase of strength and effect of alloy elements on weldability was not investigated enough, especially in higher grade pipes. Therefore, in order to obtain a material design guideline applicable for high strength seamless pipes from the viewpoint of weldability, the effect of chemical compositions on the hardness in HAZ was investigated because the hardness in heat affected zone must be closely related to the properties of welded joint such as the cold cracking susceptibility, strength or low temperature toughness. Furthermore, the circumferential weldability tests were conducted on the actual production pipes in order to verify this material design in high strength pipes.