Heavy Wall Seamless Bends for Demanding Projects

S. Farè, E. Paravicini Bagliani
TenarisDalmine R&D, Dalmine S.p.A.
Dalmine (BG), Italy

C. Tommasi, F. Zana, Ph. Darcis
Tenaris Linepipe Product Engineering, Dalmine S.p.A.
Dalmine (BG), Italy

ABSTRACT
Increasing request of oil & gas resources has brought to the exploitation of fields technically complex and risky due to severe operating conditions, leading to more stringent requirements for linepipes and accessories. A development program was carried out to enlarge the dimensional range of heavy wall (HW) hot induction bends able to meet more stringent requirements. A new steel design based on low-C content was used to improve both toughness and control of maximum hardness of off-line quenched and tempered HW bends for demanding applications. The new steel, with carbon equivalent lower than 0.42%, was suitable to produce X65 bends with thickness up to 52 mm, very good toughness, and maximum hardness below 250 HV10.

KEY WORDS: Heavy wall bends; quenching; tempering; hardness; strength; toughness.

INTRODUCTION
During recent years, various challenging projects for oil & gas wells have been launched, promoting the development of linepipes with enhanced performances. Exploitation of deep water and ultra-deep water reservoir (higher temperature and pressure) requested the development of weldable seamless pipes with heavier wall thickness (WT), up to 40 – 60 mm, better combination of strength and toughness, and high resistance to sour environments. The latter demands a good control of hardness, with a target maximum value of 250 HV10, and even below.

In Oil & Gas market, not only straight pipes but also accessories such as bends have to satisfy these stringent requirements. Bends are usually produced by hot induction bending (HIB) and can exhibit some critical issues in the case of severe applications.

Porcu (2006) and Mannucci (2007) showed that the temperature control during HIB process is fundamental to limit hot ductility loss and material damage initiation, otherwise detrimental effects can be observed on final toughness at the bend body extrados region. Moreover, tangent lengths and bend body experience unlike thermo-mechanical histories during bend production. Also wall thickening and thinning, occurring respectively at intrados and extrados of bend body, promote different local heat treatment conditions. All these process aspects can lead to significant changes in mechanical properties, especially when on-line water cooling after HIB and stress relieving treatment are applied.

Mannucci (2009) demonstrated that better and more uniform bend properties can be achieved by off-line quenching and tempering (QT) treatment. In this case, after HIB and on-line water cooling the bends are re-austenitized and subjected to outer and inner quenching in a water tank and then tempered. However, even applying this heat treatment, in the case of heavy wall (HW) bends (WT > 35 mm), the possibility to combine the desired strength, toughness and maximum hardness becomes critical due to the need to increase the steel hardenability to guarantee the minimum strength at mid-thickness.

Typically, off-line heat treated bends exhibit maximum hardness values close to the surfaces where very high cooling rates are experienced during quenching and high hardness values are achieved due to formation of a predominant martensitic microstructure. Even after tempering the maximum hardness values may remain above 250 HV10 if proper chemical composition and heat treatment conditions are not selected.

In this paper, the new low-C steel proposed by Paravicini (2013) for HW QT X65 seamless linepipes with improved properties (maximum hardness lower than 235 HV10 and ductile to brittle transition temperatures below – 60 °C) was used to manufacture off-line QT HW hot induction bends of grade X65. The aim was to enhance both toughness and control of maximum hardness of the bends. Results of industrial trials are hereafter presented, comparing mechanical properties of bends made of the new steel with those of standard steel bends with similar geometry.

EXPERIMENTAL PROCEDURE
Steel Pipes
An extensive laboratory investigation was recently carried out by