Through-Thickness Austenite and Niobium Precipitation Evolution Developed During Hot Rolling Contribution to HAZ Ductility Performance in Structural Steel and API Welds

Knowledge from the contribution to ductility performance from the through-thickness as-rolled austenite grain size/homogeneity and niobium precipitate evolution in normalized/quench-and-tempered steels has been applied to the heat-affected zone (HAZ) ductility performance of API and structural steel welds. The through-thickness austenite grain size/homogeneity and Nb precipitation evolution developed during hot rolling has been observed to be beneficial to influencing the HAZ grain size and microstructure to peak welding temperature. This has resulted in stable and enhanced ductility performance of the HAZ in various applications such as API pipeline steels for natural gas or H_2 transmission.

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Introduction

Knowledge from the contribution to ductility performance from through-thickness as-rolled austenite grain size/homogeneity and niobium precipitate evolution in controlling the final austenite grain size/homogeneity and corresponding transformed ferrite grain or bainite/martensite packet size/homogeneity in normalized/QT steels[1,2] has been applied to the performance of the heat-affected zone (HAZ) ductility performance of API and structural steel welds. Evaluation of various Nb levels under optimized and nonoptimized processing conditions has been done in the laboratory and in production situations for API X65, X70 and X80 heavier-gauge plate/pipe. Whether the through-thickness austenite was optimized or nonoptimized and how "robust" the strain-induced Nb precipitation response that was developed have been evaluated utilizing mean flow stress and electron backscattered diffraction (EBSD) and transmission electron microscopy (TEM) characterization of the through-thickness homogeneity and Nb precipitate size and frequency. In each processing situation, laboratory vs. production and optimized vs. nonoptimized, not only were the overall strength and ductility (Charpy V-notch, TCVN/drop weight tear testing, DWTT) performance influenced either negatively or positively regarding overall stability performance, but also the CVN of the pipe weld seam/girth weld HAZ. The through-thickness austenite grain size/homogeneity and Nb precipitation evolution developed during hot rolling has been observed to be beneficial to influencing both the coarse grain heat-affected zone (CGHAZ) and intercritical coarse-grain heat-affected zone (ICGHAZ) overall grain size and microstructure formation up to peak welding temperatures as high as 1,400°C.[3–6] The key through-thickness microstructural components that have been observed that work together resulting in the improved beneficial influence on the weld CGHAZ and ICGHAZ ductility in both pipeline steels and in beginning work with EH40 steels are as follows:

- Generation of a fine and homogeneous austenite through-thickness microstructure by proper control of the key austenite recrystallization behaviors, static/no-rex, during hot rolling for the desired product being produced.
  - This becomes the starting homogeneity/fineness of the austenite microstructure of the HAZ upon