Effects of reduction magnitude and different hot-working processes on the microstructures, mechanical properties and pitting corrosion resistance for SANMAC SAF 2205.

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Abstract

This paper presents the influence of thickness reduction, rolling and forging process on the microstructures, mechanical properties and pitting corrosion resistance of continuous cast strand SANMAC SAF 2205. Three different industrially-relevant diameter solid bars for each process were investigated. Chemical composition conformed to the ASTM A484 and material was soaked at 1280 °C for 3 hours. The hot-working was performed at temperatures maintained between 1000 °C and 1280 °C and reheating was performed at 1280 °C during each process. Then, the billet was hot-worked with the level of reduction ratio (RR) of 6:1, 4:1, 3:1 at Sandvik Materials Technology. The final hot-worked bars were quenched in water between 1065 °C and 1070 °C to avoid intermetallic phases. The forging process was performed on hydraulic press with flat dies and at a strain rate of ~ 1.3 s^{-1}. The rolling process was firstly performed at blooming rolling mill in the strain rate range of 0.5-3.0 s^{-1} and secondly at billet mill with varying the strain rates from 0.2 to $\sim$ 1.7 s^{-1}. The number of hot working passes varied depending on the total reductions, typically between 19 and 21 passes were used. Characterization included ultrasonic, tensile, hardness, impact and corrosion testing and microstructural observation by using optical microscope.

The results showed that no internal defects (pores, cracks or segregation) in the centre region was observed, in particularly for those bars with the total area reduction of 3:1. The microstructure was found free from harmful phases such as intermetallic sigma phase and no continuous the secondary phase, Cr_2N, along grain boundaries, except for individual grains, that are not representative of the nature of the microstructure. However, the shape of austenite in the forged sample is somewhat more elongated grain relative to the rolled one. Moreover, the average ferrite content results for the forged specimens were 1% lower than those after rolling. However, a fraction of ferrite content with the highest deformation (i.e. RR= 6:1) in rolled samples was 2 % larger than in the microstructure with lowest reduction ratio (i.e. RR= 3:1), but the same ferrite content in the forged samples. Tensile test results show that all samples satisfied the requirements of the relevant standard: ASTM A 479. However, the ultimate σ_{UTS} and yield strength σ_Y results for the forged specimens were 3 % and 9 % respectively lower than those after rolling. This could be attributed to a smaller average austenite spacing. In addition, variations in the tensile properties for different levels of height reductions in each process were very small indicating that they were not dependent on either the reduction ratio or process-type. Toughness results in the rolled samples were 1.5 % higher than for forged samples. Furthermore, Rockwell hardness values for the specimens after rolling were slightly higher than those after forging. For all conditions, the studied samples exhibit average weight loss between 0.03 and 0.4 g/m^2, leading to the pitting corrosion resistance does not depend on the degree of hot-work performed.

Key words: SANMAC SAF 2205, reduction ratio, forging process, rolling process, microstructures, mechanical properties, pitting corrosion resistance (ASTM G48 E)