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ORIGINAL ARTICLE

Optimize the corrosion behavior of AISI 204Cu stainless steel in different environments under previous cold working and welding

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Abstract. Enhancing corrosion resistance in stainless-ssteel alloys is a paramount objective in the petroleum industry. This study investigated the effects of the previous cold working and welding processes on the mechanical properties and corrosion rates of 204 Cu stainless steel in different aggressive environments (crude oil, freshwater, and seawater). The experimental sets were supported by microstructure analysis. The mean weight loss method was employed to determine the corrosion rates, which were optimized using the Taguchi method. The ferrite and austenite phase bands, as well as the deformed portions of austenite, are pushed to flatten out during cold working, which increases the material's hardness. Cold-worked steels were welded, creating an annealed area around the HAZ in addition to the usual weld zones, which demonstrated partial microstructure recovery and hardness reduction. HAZ showed signs of iron overload and chromium nitride precipitation. Cold-worked specimens only showed reduced corrosion resistance to 30% of the initial rate and reduced thickness. Moreover, the Taguchi optimization technique indicated that the corrosion environment has the most effect on the corrosion rate compared to the cold work ratio for welded and non-welded stainless-steel specimens.

Keywords: cold working / AISI 204Cu stainless steel / corrosion behavior / Taguchi methods

1 Introduction

The recent technological developments in rolling and smelting increased the reinforcements of high-strength stainless steel [1]. The highly competitive cost and steady increase in low nickel-inforced stainless steel strongly support reinforcement techniques [2]. AISI 204Cu is a low-nickel austenite stainless steel where Mn and N elements replace a portion of the Ni component. Compared to AISI 204Cu and AISI 304, both alloys have the same corrosion resistance, but the formability is better in AISI 204Cu, and its cost is highly competitive [3]. AISI 204Cu is widely utilized in anticorrosion products such as kitchen utensils, electrical components, automotive parts, and construction materials [4,5]. As a high-corrosion-resistant material, AISI 204Cu was introduced in 2001 to replace AISI 304 stainless steel [6]. Due to the alloy's presence of copper (2.72%), the austenitic crystal structure is permanent in AISI 204Cu stainless steel. Because of the high copper content in AISI 204Cu stainless steel, the nickel content can be kept low at an estimated 1.97% [7], which lowers manufacturing costs. Copper enhances the overall resistance of corrosion in acidic environments and pitting corrosion resistance in environments containing chloride [8,9]. Austenitic stainless steel's yield point can be extremely improved by cold deformation, that is, plastic deformation at ambient temperature [10]. The austenitic 204Cu cold-worked stainless steel is characterized by the martensitic transformation that results from cold-working, where the austenite in this steel is stable at ambient temperature [11,12]. Additionally, the presence of spherical copper particles in the microstructure of austenite, which gives it a stronger hardness, explains the stability of austenite in stainless steel AISI 304 [13].

The austenitic stainless steel welding process has special requirements compared to ordinary steel alloys [14]. It has a thermal expansion of 50% more than normal steel [15] and low thermal and electrical conductivity [16]. Moreover, in austenitic stainless-steel welding, the heat is not going away very quickly, so a little heat is needed to perform the welding [17]. Failure to adopt some welding requirements leads to several problems that affect the quality and performance of the weld joint. Intergranular corrosion results from sensitization of the weld's heat-affected zone (HAZ), which in turn causes, when heated between 427 and 871 °C, chromium carbide to form and precipitate at grain boundaries in the HAZ, which results in

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