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Deep Cryogenic Treatment With Subsequent Aging Applied to Martensitic Stainless Steel: Evaluation of Hardness, Tenacity and Microstructure

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Abstract : The way in which the application of the deep cryogenic treatment DCT(-196°C) affects, applied with subsequent aging, was investigated, regarding the mechanical properties of hardness, toughness and microstructure, applied to martensitic stainless steels, with the aim of establishing a different methodology compared to the traditional DCT cryogenic treatment with subsequent tempering. For this experimental study, a muffle furnace was used, first subjecting the specimens to deep cryogenization in a liquid Nitrogen bath/4h, after being previously austenitized at the following temperatures: 1020-1030-1040-1050 (°C) / 1 hour; and then tempered in oil. A first group of cryogenic samples were subjected to subsequent aging at 150°C, with immersion times: 2.5 -5- 10 - 20 - 50 – 100 (h). The next group was subjected to subsequent tempering at temperatures: 480-500-510-520-530-540 (°C)/ 2h. The hardness tests were carried out under standards, using a Universal Durometer, and the readings were made on the HRC scale. The Impact Resistance tests were carried out in a Charpy machine following the ASTM E 23 – 93ª standard. Measurements were taken in joules. Microscopy was performed at the optical level using a 1000X microscope. It was found: For the entire aging interval, the samples austenitized at 1050°C present greater hardness than austenitized at 1040°C, with the maximum peak aged being at 30h. In all cases, the aged samples exceed the hardness of the tempered samples, even in their minimum values. In post-tempered samples, the tempering temperature hardly have effect on the impact strength of material. In the Cryogenic Treatment: DCT + subsequent aging, the maximum hardness value (58.7 HRC) is linked to an impact toughness value (54J) obtained with aging time of 39h, which is considered an optimal condition. The higher hardness of steel after the DCT treatment is attributed to the transformation of retained austenite into martensite. The microstructure is composed mainly of lath martensite; and the original grain size of the austenite can be appreciated. The choice of the combination: Hardness-toughness, is subject to the required service conditions of steel.

Keywords : deep cryogenic treatment; aged precipitation; martensitic steels;, mechanical properties; martensitic steels, hardness, carbides precipitaion
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