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Influence of Work Hardening On the Microstructure and Thermophysical Properties of Austenitic Stainless Steel

Rita C.C. Rangel[1], Fábio Camargo[1], Guilherme Fernandes Nielsen[1], Selma Luiza Silva Batochio[1], Daniel Gerchman[1]
[1]Materials Laboratory, LABMAT/CINA
Sorocaba-Iperó Vicinal Road, Km 12.5, Sorocaba, Brazil
rita.rangel@gmail.com; fcamargo@alumni.usp.br; guilherme.nielsen@marinha.mil.br; selma.luiza@marinha.mil.br; gerchman@marinha.mil.br

Extended Abstract
Stainless steels (SS) are a group of steel alloys that contain at least 10.5% chromium, an element that significantly enhances the material's resistance to corrosion in humid and aggressive environments. This high chromium content creates a protective passive oxide layer on the material's surface, which prevents further oxidation and corrosion, making stainless steels highly suitable for use in various sectors, including the chemical, automotive, food processing, and construction industries [1-3]. These alloys are classified as austenitic stainless steels (ASS) due to the presence of the austenite phase, which has the face-centered cubic crystal structure of iron. This structure remains stable even at temperatures lower than ambient, making these steels ideal for use in extreme conditions [4]. Among the many types of ASS, there are those that contain niobium and tantalum. These elements serve as stabilizers in the alloy, improving its resistance to intergranular corrosion, which typically occurs along the grain boundaries of metals when they are exposed to certain environmental conditions or high temperatures. By stabilizing the grain boundaries, niobium and tantalum help ensure that the alloy performs well in demanding environments where high temperatures and corrosive substances are present, making it ideal for applications in industries like power generation and chemical processing [5-8]. The hot or cold rolling of this material enables its hardening by deforming its crystal structure. Additionally, the cold rolling process can lead to the formation of the martensitic phase, which further enhances the material's hardness and strength [9,10]. This makes this alloy particularly useful in high-stress environments where materials must withstand mechanical deformation without failure.

Due to these excellent mechanical and corrosion-resistant properties, this alloy is widely used in heat exchangers, boilers, and other components of high-temperature systems [11]. These applications require materials that not only resist corrosion but also maintain their structural integrity at elevated temperatures. Therefore, it is essential to understand the thermophysical properties of this alloy in order to optimize its performance and predict how it will behave under different operating conditions.

The objective of this study was to analyze the influence of different levels of cold work hardening on the microstructure and thermophysical properties of ASS. To achieve this, the material was subjected to various levels of cold work by reducing its thickness. This allowed for the assessment of how mechanical deformation at different intensities affects the material's structure and properties. The crystalline structure of the alloy was determined using X-ray diffraction (XRD) while optical microscopy was employed to study its microstructure. Additionally, differential scanning calorimetry (DSC) was used to determine the melting temperature and specific heat. The thermal diffusivity was measured using the laser flash method, and the coefficient of thermal expansion using a dilatometer. Finally, the influence of temperature on the material's microstructure was analyzed by conducting additional microstructural tests after subjecting the samples to thermophysical experiments. This allowed for a comprehensive evaluation of how elevated temperatures might affect the material's performance and longevity in real-world applications.

References
[1] N.R. Baddoo, "Stainless steel in construction: A review of research, applications, challenges and opportunities," *Journal of Constructional Steel Research,* vol. 64, pp. 1199-1206, 2008.
[2] A. NikmahI; et al., "Studies on Density, Corrosion Rate and Hardness Characteristics of Stainless Steel Implanted by

Nitrogen Ion," *OP Conf. Series: Materials Science and Engineering*, vol. 515 012018, pp. 1-12, 2019.
[3] H.M Hassan, "Evaluation of Several Austenitic Types of Stainless Steel's Chemical Corrosion Resistance," *Chem. Methodol.,* vol. 7, no. 11, pp. 853-871, 2023.
[4] A. J. Sedriks, *Corrosion of stainless steels*. New York, John Wiley, 1996.
[5] C.A. Teodoro, J.E.R. Silva, "Physical Characterization of Austenitic Stainless steels AISI 304 and AISI 348L*," in *Proceedings of the International Nuclear Atlantic Conference - INAC ,* Rio de Janeiro, RJ, 2009.
[6] X.Y. Li; et al., "The corrosion behavior of sputter-deposited amorphous Fe–Cr–Ni–Ta alloys in 12 M HCl." *Corrosion Science,* vol. 41, no. 9, pp. 1849-1869, 1999.
[7] G. Ma; et al., "Effect of Recrystallization Annealing on Corrosion Behavior of Ta-4%W Alloy," *Materials,* vol. 12, no. 17, 2019.
[8] V. S. P. Silva; et al., "Long-term corrosion kinetics in pressurized water loop of an accident tolerant fuel cladding candidate: AISI 348 stainless steel," in *Proceedings of the International Nuclear Atlantic Conference – INAC,* Virual Meeting, Brazil, 2021.
[9] I. Shakhova; et al., "Effect of large strain cold rolling and subsequent annealing on microstructure and mechanical properties of an austenitic stainless steel," *Materials Science and Enginnering:A,* vol. 30, pp. 176-186, 2012.
[10] S. Mohammadzehi,· H. Mirzadeh, "Cold unidirectional/cross-rolling of austenitic stainless steels: a review," *Archives of Civil and Mechanical Engineering,* vol. 22, no. 129, 2022.
[11] D.N. Adnyana, "Failure Analysis of Stainless Steel Heat Exchanger Tubes in a Petrochemical Plant," *J Fail. Anal. And Preven.,* vol. 18, no. 413, pp. 413-422, 2018.