Microstructure evolution during tensile elongation of stainless-steel welded joint in cryogenic conditions

A. Szyszko[1,*], J. Tabin[1], H. Nejman[1], J. Kawałko[2]

[1]Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland
*e-mail: aszyszko@ippt.pan.pl

[2]Academic Centre for Materials and Nanotechnology, AGH University of Krakow, 30-059, Krakow, Poland

KEYWORDS: *Stainless steel, Cryogenic temperatures, Deformation induced martensite, Microstructure, Discontinuous plastic flow*

In low temperature BCC materials become brittle thus making them unsuitable for such conditions [1]. Making materials with FCC crystal structure like stainless steel leading contenders for such applications. At temperatures near 0K, in certain modes of deformation an effect called discontinuous plastic flow (DPF) occurs. This effect is sometimes accompanied by Luders like propagation of deformation [2].

Laser welding of stainless-steel is a great method of joining long elements such as mantle for superconducting cables [3]. Unfortunately, such process results in complex microstructure and appearance of internal stresses. Understanding the behaviour of such joints in cryogenic conditions is crucial for developing engineering solutions for such conditions.

The following research was conducted to characterise DPF behaviour and better understand the mechanisms od destruction of welds in cryogenic conditions. Miniature tensile samples were used to examine tensile elongation of such welded joints in temperatures of 77K and 4.2K. Electron microscopy as well as EBSD and eddy currents have been used to characterize the evolution of microstructure. Tensile tests and microhardness measurements have been used to characterize mechanical properties.

ACKNOWLEDGEMENT: This work has been supported by the national science centre through the grant no 2023/51/D/ST8/02370

[1] J. Zhang, T. Zhao, T. Hou, Y. Li, K. Wu. Metals 2025;15:743. https://doi.org/10.3390/met15070743.
[2] J. Tabin, J. Kawałko, D. Schob, R. Roszak, A. Brodecki, P. Bała, Ph. Maasch, Z. Kowalewski, M. Ziegenhorn. Materials Science and Engineering: A 2026;950:149552. https://doi.org/10.1016/j.msea.2025.149552.
[3] T. Bevilacqua, A. Gumenyuk, N. Habibi, P. Hartwig, A. Klawonn, M. Lanser, M. Rethmeier, L. Scheunemann, J. Schröeder. Results in Engineering 2025:108827.