Deformation-Induced Martensitic Transformation In Fused Filament Fabricated Austenitic Stainless Steels During Tension At Wide Range Of Temperatures. Part 1: Experimental Results

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ABSTRACT

Structural components of superconducting magnets (e.g., collars, bladders, or keys) with complex shapes, operating at cryogenic temperatures (4K, 77K), as well as additional elements of tanks for storing liquid hydrogen (20K), such as hoses and valves, are made of austenitic steel. It is well known that achieving a complex shape for these elements using traditional machining methods is challenging. A viable solution lies in using additive manufacturing methods (AM), notably the cost-effective Fused Filament Fabrication (FFF) method. The scientific objective of the project is the experimental identification and numerical simulation of the evolution of the deformation-induced martensitic transformation in Fused Filament Fabricated Austenitic Stainless Steel (FFF ASS) 316L at a wide range of temperatures.

We will investigate how deformation-induced phase transformation develops in printed austenitic steels, how the initial state of the sample (e.g., pore distribution) affects it, and whether deformation-induced martensitic transformation influences the rate of damage development, especially at very low temperatures. Does the manufacturing technology of the sample affect the rate of phase transformation or damage development? Finally, but no less important, is whether, as in the case of traditional austenitic steels, the adverse effect of the microdamage field is inhibited by deformation-induced martensitic transformation. Which of these effects dominates in printed austenitic steels and under what conditions?

The experimental setup developed in the Institute of Fundamental Technological Research (IPPT PAN) allows for monitoring the evolution of the 3D strain field during the kinematically-controlled tensile tests of macroscopic specimens at 77K. Moreover, the correlation between plastic strain field evolution, martensitic transformation, thermal distributions and acoustic emission will be defined for FFF 316L at 77K and room temperatures. EBSD and EDS investigation of samples pre-strained in uniaxial tensile tests at a wide range of temperatures are also performed.

REFERENCES

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