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M2Or2A-06: In-Situ Monitoring of Strain Field Evolution and Dissipative Effects at Cryogenic Temperatures (77K): Insights into Advanced Materials for Superconducting and Hydrogen Storage Applications

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The in-situ monitoring of strain field evolution and dissipative effects in advanced materials at cryogenic temperatures represents a significant milestone in understanding thermo-mechanical behaviour under extreme conditions. This research focuses on conducting full-field strain measurements at liquid nitrogen (77K) temperatures using an innovative DIC-enhanced experimental platform. Two type materials are tested: (i) conventional austenitic stainless steels (ASS), and (ii) additively manufactured (AM) austenitic stainless steels.
Currently, no experimental framework exists for performing such detailed 2D strain measurements on macro-specimens and structural components at 77K, particularly when coupled with multi-detector identification of dissipative effects. To address this, a unique experimental setup will be developed, integrating the following components: (i) a 4-thermistor system for precise temperature distribution measurements, (ii) a force link system for direct force application monitoring, and (iii) an acoustic emission system for detecting micro-damage and dissipative effects. The specimen will be immersed in a glass cryostat equipped with active and passive insulation to maintain thermal stability during mechanical testing at 77K. Signals from this multi-detector array will be synchronized with strain field evolution data obtained via digital image correlation (DIC), enabling comprehensive real-time monitoring of material behavior during tensile, fracture, and fatigue tests.
The experiments conducted with this advanced platform aim to achieve the following objectives:

-Identification of Dissipative Effects: The origins of dissipative effects such as plastic flow instability, phase transformation, and micro-damage evolution will be experimentally recognized.

-Material Property Determination: Mechanical properties of advanced materials, including yield strength and fracture toughness, will be accurately measured at cryogenic temperatures.

-Correlations of Dissipative Effects with Plastic Strain: Key phenomena, such as damage-induced plastic flow or phase transformations, will be correlated with incremental plastic strain during deformation.
- Coupled Effects Analysis: Coupled effects, including damage-influenced discontinuous plastic flow, will be identified and analyzed.

-Constitutive Model Validation: The data will be used to validate constitutive models describing advanced materials deformed at 77K.

Authors: TABIN, Jakub (Institute of Fundamental Technological Research PAS); BRODECKI, Adam (Institute of Fundamental Technological Research PAS); KOWALEWSKI, Zbigniew (Institute of Fundamental Technological Research PAS)

Presenter: TABIN, Jakub (Institute of Fundamental Technological Research PAS)

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