Contribution ID: **505**

Type: **Invited Oral**

M3Or4B-04: [Invited] Cryogenic mechanical properties of large forgings for high field fusion magnets

Wednesday 21 May 2025 17:25 (25 minutes)

Nuclear fusion represents a promising pathway to a sustainable and virtually inexhaustible energy future, offering a low-carbon alternative to conventional power sources. Achieving fusion relies on high-field superconducting magnets to confine plasma within reactors, which in turn depend on advanced structural materials capable of withstanding extreme cryogenic environments, high magnetic fields, and steep thermal gradients. This presentation examines the metallurgical and fabrication challenges encountered in developing these critical materials. Drawing on historical and contemporary examples, we trace the evolution of design strategies and highlight key lessons learned from early alloys that have guided modern developments. Recent advances in alloy design and fabrication have significantly enhanced cryogenic mechanical properties, notably increasing toughness and yield strength at cryogenic temperature. However, achieving isotropic and homogeneous properties in the large, forged parts required for these magnets is exceptionally challenging due to material inhomogeneities and the complexities associated with scaling, thereby demanding innovative processing and manufacturing solutions.

For certain complex shapes, additive manufacturing is essential; yet a major challenge remains in guaranteeing that the mechanical properties match those of traditionally forged parts while maintaining homogeneity. Additionally, the exploration of new material compositions holds the potential to further boost toughness and yield strength, opening new design possibilities for next-generation nuclear fusion systems. This discussion provides a comprehensive overview of current structural material challenges and emerging solutions, setting the stage for more reliable and performant fusion devices.

Author: KIND, Markus (Rolf Kind GmbH)

Co-authors: RUIZ PALENZUELA, Berta (University Carlos III (ES)); RODRIGUEZ CASTRO, Enrique (University Carlos III (ES)); AVILES SANTILLANA, Ignacio (CERN); Dr SGOBBA, Stefano (CERN)

Presenter: KIND, Markus (Rolf Kind GmbH)

Session Classification: M3Or4B - [Special Session] Materials for High Field Magnets