A 1D Kinematically Enriched Ribbon Model for Simulation of Winding of Superconducting Tapes for CORC-like Cables

Mohammad Ali Saadat*[1], Alexandre Torre[2], and Damien Durville[1]

[1]LMPS – Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, LMPS - Laboratoire de Mécanique Paris-Saclay, 3 rue Joliot-Curie, Gif-sur-Yvette, 91190, France – France
[2]CEA – CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France – France

Abstract

CORC® (Conductor on Round Core) superconducting cables are an innovative technology designed to enable high-current, high-field applications in compact and flexible configurations. These cables consist of multiple high-temperature superconducting (HTS) tapes wound around a cylindrical core, forming a structure capable of carrying significant electrical current with minimal loss. Understanding the mechanical behavior of the tapes in such cables during the winding process is crucial to improving their design and performance.
In this work, a novel one-dimensional (1D) ribbon model was developed to study the deformation mechanics of tapes used in CORC-like cables. The model incorporates enriched kinematics in the ribbon's cross-section, based on polynomial expansions with respect to transverse coordinates, to account for the complex deformation patterns that arise during wrapping. This representation enables the accurate prediction of in-plane and out-of-plane deformations, including warping, twisting, and bending of the ribbon, which are commonly observed in practice.

The ribbon model was applied to simulate the wrapping of a superconducting tape around a cylindrical core. The simulation results provided detailed insights into the mechanical response of the tape during the process, including stress and strain distributions across its cross-section. These results are critical for optimizing the ribbon's material properties and geometric parameters, ensuring minimal damage to the superconducting layer and enhancing the overall performance of the cable.
The proposed ribbon model offers a computationally efficient approach to addressing the complex deformation behavior of ribbons in CORC-like cable manufacturing. By improving the understanding of tape mechanics, this work contributes to the advancement of superconducting cable technology, supporting its application in fusion, energy transmission, particle accelerators, and other high-field systems.

*Speaker