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Multiphysics study of phase transformations in Nb3Sn strands during Heat Treatment

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In order to improve the current performance of the Large Hadron Collider (HL-LHC project) or to construct the particle accelerators for the Future Circular Collider (FCC), the development of high field Nb3Sn magnets is of high importance. A Heat Treatment (HT) is required for the formation of the Nb3Sn superconducting phase that leads to various physic-chemical phenomena inside the superconducting wires with significant dimensional changes of the coils.
The current study is focused on Rod Restacked Process (RRP) conductors. The heat treatment is composed of several dwells, activating different diffusion mechanisms and phase transformations. During the HT formation of different intermetallics between Sn, Cu and Nb take place. The growth of intermetallics is mainly controlled by diffusion mechanisms at large times. These mechanisms, located into each strand's sub-element area, naturally lead to variations of the crystalline structure and compactness. To predict the mechanical state and therefore the stress conditions of Nb3Sn conductors at a higher scale –cables and coils –it is primordial to first study the phase transformations occurring at the level of sub-elements inside the strands.
Thus, a simplified one-dimensional model is proposed to evaluate the temporal evolution of different phases in the system during HT. Special attention is paid to the consideration of residual stresses inside the system and their influence on the diffusion process. The set of observations was performed on cross-sections of Nb3Sn strands at the different times of HT. The amount of each component is here determined experimentally using Scanning Electron Microscopy. Experimental observations are compared with the model predictions.

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