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Dimensional Changes Measurement of Nb3Sn Cables and Strands during Heat Treatment Using Digital Image Correlation

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In the continuity of the Large Hadron Collider (LHC) large-scale projects are under development, such as the HiLumi - LHC and the Future Circular Collider (FCC), in order to produce particle collisions at higher luminosities and energies. The achievement of these projects strongly relies on the development of high field Nb3Sn magnets. The Nb3Sn intermetallic superconducting phase is produced through diffusion and phase transformations during a heat treatment at about 650 ℃. Due to the brittleness of the conductor, Coils are usually wound and then heat treated in a dedicated tooling.
During the heat treatment, phase transformations and internal stresses relaxation lead to significant dimensional changes. If these changes are not taken into account by the fabrication tooling, resulting stress may lead to mechanical damage and degradation of the superconducting properties. In order to limit these degradations it is of crucial importance to characterize and quantify the dynamics of the deformations occurring during the heat treatment.
An innovative experimental device, using high temperature in situ Digital Image Correlation (DIC), has been designed. This experiment allows the measurement of a 2D displacement field at the surface of Nb3Sn Rutherford cables as a function of temperature. A significant longitudinal contraction (of Rutherford cable) is first observed, that is consistent with results reported in the literature. The experiment provided on the other hand a measurement of a transversal swelling as a function of temperature. Associated dilatation reaches values higher than 1% at the end of the process. Observations at the microscopic scale allow a fine analysis of the strand motions within the cable and help for a global interpretation of dimensions changes.

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