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Effects of the adhesions between impregnation system and coil components on the training of Nb3Sn Rutherford cables

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Within the framework of the study of future high-energy particle colliders, high-field (15-16 T) Nb3Sn magnets are being developed. These magnets are usually impregnated using epoxy resin with glass fiber to provide electrical insulation and mechanical support to the conductor.
However, several phenomena are often observed: first, the high-stress conditions applied during pre-load, cool-down, and powering of magnets lead to cracks in the resin. Then, during powering, high Lorentz forces may break the epoxy bond at the interface between cables and components, and provoke a detachment of the coils and conductor motions. Later, friction phenomena may appear. This irreversible behaviors are likely to release enough energy to trigger quenches of the conductor. Understanding and reducing the causes of these phenomena can help to significantly reduce the number of quenches and increase the maximum quench current during the training phase of magnets and therefore improve the performances of future high field magnets.
First, a new experiment has been designed and carried out at CEA Paris-Saclay to reproduce and characterize the mechanical behavior of the interfaces between the impregnation system and the coil components. Various adhesion interface configurations were compared, varying the material of the component (titanium and stainless steel), and the roughness of their surface.
A second campaign has been carried out at the University of Twente. The goal is to characterize the training behavior of Nb3Sn Rutherford cables in representative conditions, and to reproduce the detachment phenomena under low contact pressures. To do so, an existing experimental setup has been redesigned to allow an accurate measurement of the compressive stress below 10 MPa. Then, Nb3Sn Rutherford cables has been subjected to a gradual release of the transverse compressive force under a background field of 11 T. The corresponding training has been studied and compared to the measurement of the critical current of the cable under stable conditions.

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