Systematic Study on Filament Fracture Distribution in ITER Nb3Sn Strands

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Abstract— In ITER CICCs, the strands experience varying mechanical strain levels due to thermal compression and electromagnetic loading, cumulating into severe periodic bending and contact strain. Depending on the choice of the cabling pattern, the strain may exceed the irreversibility limit leading to cracks in the Nb_3Sn filaments and degraded performance of the conductors. We present a systematic microscopy study of filament fracture at gradually varied axial tensile strain levels in a bronze and internal tin processed type of Nb_3Sn ITER strand. The axial stress-strain relation of the wires was measured at 4.2 K, up to a different peak load for each sample, successively increasing from 0.0% to 0.7%. Longitudinal cross sections were prepared from cut sections of the specimens. The crack pattern and distribution in the isolated filaments could thus be studied as a function of applied strain, revealing different fracture mechanisms. Electrical measurements were performed with applied strain with special attention for the tensile strain range. Finally, the microscopic information was correlated back to the observed macroscopic I_c degradation.

Index Terms— Tin, Capacitive sensors, Tensile strain, Niobium, Microscopy, Strain measurement, Thermal loading, Image coding, Power cables, Thermal degradation