Properties of HTS Cable-In-Conduit Conductor with Al-Slotted Core under bending stress

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Aluminum based conductor has been proposed for the development of 2G High Temperature Superconductor (HTS) tapes high current cable for fusion applications. In the proposed layout HTS tapes are stacked and inserted into helical ducts formed in an extruded Aluminum cylindrical core mostly studied in the 5-slots configuration (5 × 20 tapes – or 5 × 30, depending on tape thickness). The cable layout, designed aiming at the industrial feasibility of the manufacturing process, has shown promising electrical, thermo-hydraulic and mechanical properties assessed in several experimental studies of cable samples [1, 2, 3, 4]. As far as bending behavior is concerned, it has been observed that the cable exhibited a rather good tolerance to bending strain ascribed to the slippage occurring among tapes within the stack. However, this feature, particularly relevant for applications, needed more studies.

In the present contribution, we report on the experimental results on bending tests on Al-slotted cable sample, which was equipped with a fully superconducting stack of tapes. The sample was 1 m long and the stack consists of 20 coated conductor tapes having a twist pitch of 0.5 m. The remaining 4 slots have been equipped with stainless-steel dummy tapes. The bending experiment was carried out through a series of measurements of single tape critical current $I_c$ obtained at fixed bending radius $R_b$, the smallest radius reached being 0.15 m. By the analysis of the $I_c$ dependence as a function of $R_b$ for each tape the effect of bending strain as a function of the tape position inside the stack was investigated. The results confirmed the good bending strain tolerance of the cable. Interestingly, the most external tapes of the stack (either innermost or outermost with respect to the core central axis) exhibited the higher $I_c$ degradation starting at $R_b \approx 0.250 - 0.275$ m. On the other hand, the tapes in the central section of the stack showed a slight but measurable increase of $I_c$ with bending strain with respect to the straight condition. The whole cable behavior upon bending is explained considering a simple analytical model from which it resulted that the current sharing mechanisms occurring among the tapes within the stack play a relevant role.