

3-D Numerical Simulations of Twisted Stacked Tape Cables

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Abstract — Fusion magnet applications require compact high current cables. Several of such cable designs exist, e.g. the Roebel Assembled Coated Conductor (RACC), the Conductor On Round Core (CORC) and the Twisted Stacked Tape cable (TSTC). Each has specific benefits: the Roebel cable's foremost quality is the full transposition leading to very low hysteretic losses. The CORC cable is very flexible. The TSTC cable is easy to manufacture and has very high tape length usage. A fully three-dimensional model of a Twisted Stacked Tape Cable has been investigated using recent advances in numerical modelling. Contact resistances between tapes are modelled with newly developed boundary conditions. These allow the simulation of translational geometries without the introduction of end-effect perturbations in the magnetic field or the electric current distributions. An analytic DC model is also presented that has been used to efficiently fit cable parameters to current distribution measurements of a TSTC conductor. The results of analytic and numerical simulation are compared with experiment results. Both static as well as transient characteristics of a TSTC conductor are investigated with background magnetic field and applied transport current. The results give insight into the mechanisms governing current distribution and allow the investigation of the dynamic behaviour that is important for AC applications. The current distributions strongly depend on the operation conditions such as background magnetic field, applied electric transport current, and the presence or absence of contact resistances. The tapes in a TSTC conductor are not fully transposed resulting in different lengths and twist pitches of the tapes. This leads to an inductivity mismatch of the tapes in the TSTC conductor. An inductivity mismatch leads to an aggravation of hysteretic losses in TSTC cables. The conclusions from investigations of these analyses will be presented. The results facilitate a first comparison of the various cable designs excluding influences due to measurement techniques while at the same time helping to understand the peculiarities of the TSTC cable. The numerical model itself will be used to analyse other cable layouts in order to improve the existing designs and to find an optimal configuration.

Keywords (Index Terms) — 3-D FEM, Twisted Stacked Tape Cables, AC losses