Effect of Mechanical Support Conditions of Winding on the Strain Development of a Composite MgB$_2$ Based Full Body MRI Coil

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Abstract—The winding of composite superconducting wire around a mandrel is one of the first stages of manufacturing processes of a superconducting magnet. Depending on the method of mechanical support conditions during winding, the strain development at the final stage in a superconducting magnet may vary significantly. Therefore, proper selection of the winding process is important to increase the feasibility for a conduction cooled full body MRI magnet based on magnesium diboride (MgB$_2$), a strain sensitive high temperature (HTS) superconductor. A multiscale multiphysics Finite Element Analysis (FEA) model of an 18 filament MgB$_2$ wire is developed for strain estimation. The computationally homogenized representative volume element (RVE) of the composite wire is used in the coil bundle in place of the actual MgB$_2$ wire. The simulation considers winding, thermal cool-down and electromagnetic charging to estimate total strain developed at the final step—electromagnetic charging. Four different types of support conditions are studied and strain development is reported. Results suggest that a combination of radial and axial support at the inner radial surface and outermost axial surfaces of the mandrel respectively is the most favorable winding condition with a minimum strain development of 0.021% which is half in comparison to no mandrel support.

Keywords (Index Terms)—Finite element analysis, ANSYS, superconducting coils, MRI, multiphysics, multiscale modeling.

Submitted September 24, 2016; Selected November 26, 2016. Reference ST562; Category 6.
This ASC 2016 manuscript 2LOr3B-04 was submitted to IEEE Trans. Appl. Supercond. for possible publication.