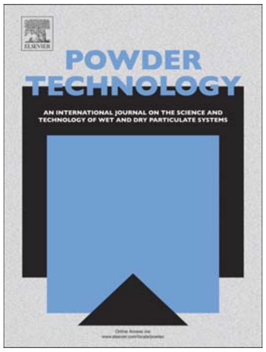

Optimal configuration analysis of superconducting cable based on the self-twist discrete element model

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Optimal configuration analysis of superconducting cable based on the self-twist discrete element model

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Abstract: Spatial configuration of superconducting cable has a crucial influence on the mechanical properties of cable and further affects its superconducting performance. In this study, a stepwise twist multi-stage cable model that can completely reproduce its manufacturing technique is established. And an innovative equivalent decomposition method is proposed to characterize the interactions among strands reasonably. Based on the modified discrete element method (DEM), the optimal production parameters that minimize the contact pre-stresses and local axial strains are suggested. The results indicate that the contact pre-stress induced by multi-twisting process is a non-negligible factor that affects the mechanical state of cable. Under equivalent operating environment, there exists a critical pitch ratio of approximate 1.5 and initial pitch of about 40-50mm that corresponds to the optimal axial strain distribution.

Keywords: Superconducting cable, discrete element method (DEM), twist large deformation, contact pre-stress, pitch ratios.

1. Introduction

Superconducting cable are formed by thousands of spiral strands through multiple stages of twisting [1]. Meanwhile, due to the extremely complex working environment, such as strong magnetic field, large current and low temperature, which will cause large deformation of strands and non-uniform contact among strands[2], and further results in the degradation of superconducting performance [3, 4]. Therefore, the investigation of mechanical properties of superconducting cable is vital for its practical application. In general, the mechanical properties of cable are mainly related to its geometry configuration and external loading. Nevertheless, it is impractical to provide guidance for the cable design based on the experimental tests due to the high cost and complex procedures [5-7]. And more importantly, the contact mechanical characteristics in cable cannot be directly measured from experiment [8].

The traditional finite element model (FEM) based on the classical continuum elastic-plastic constitution is a common tool for investigating the mechanical behaviors of cable. For example, the transverse compression load-displacement curves of single strand and three twist strands were obtained using 2-D FEM [9, 10]. Moreover, the axial tension

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