Contribution ID: **55** Type: **15 min Oral**

Enhancing Efficiency and Reliability of Long-Pulse Tokamak DC Transmission Systems through Innovative Electromagnetic Topology Optimization

Wednesday 16 October 2024 12:25 (15 minutes)

Abstract—The pursuit of fusion energy as a sustainable and clean power source has spurred the development of advanced fusion devices, exemplified by the China Fusion Engineering Experimental Reactor (CFETR) and the Burning plasma Experimental Superconducting Tokamak (BEST). These devices aim for long-pulse steady-state operation, presenting significant challenges for their DC transmission systems. This study focuses on optimizing the electromagnetic topology and parasitic parameters of the Tokamak DC transmission system for long-pulse steady-state operation. The primary challenge is to enhance system efficiency and reliability. Through thorough exploration of electromagnetic challenges, innovative strategies are proposed. Utilizing numerical simulations and experimental validation, this study reveals critical electromagnetic characteristics and quantifies the impact of parasitic parameters. The core innovation lies in developing tailored optimization schemes for long-pulse operation conditions, addressing unique challenges such as high-parameter voltage withstand levels (up to 36 kV) and rated operating currents (up to 55 kA). By integrating theoretical analysis, finite element methods (FEM), and experimental validation, this study explores the electromagnetic characteristics of the DC transmission system, including magnetic field distribution and current density. Additionally, parasitic parameters such as stray inductance (≤0.2μH/m) and resistance (≤2μΩ/m, including two-pole conductors) are analyzed and quantified for their impact on system performance. Optimizing system performance is crucial to ensure reliability under long-pulse operation conditions. The research findings demonstrate that optimizing electromagnetic topology, improving electric field distribution, and optimizing parasitic parameters significantly enhance the performance of long-pulse steady-state operation Tokamak DC transmission systems, providing crucial support for the realization of sustainable fusion energy.
Keywords- Fusion energy, Tokamak, DC transmission system, Electromagnetic topology, Parasitic parameters, Long-pulse, Optimization, Innovation, Numerical simulation

Primary author: HUANG, Zhengyi (University of Science and Technology of China, Hefei 230026, China. Institute of Plasma Physics, Hefei Institutes of Physical Science, Chinese Academy of Sciences)

Co-authors: SONG, Zhiquan (Institute of Plasma Physics, Chinese Academy of Science); GAO, Ge (Institute of Plasma Physics, Chinese Academy of Science); ZHANG, Jie (Institute of Plasma Physics, Chinese Academy of Science); XU, Xuesong (Institute of Plasma Physics, Chinese Academy of Science); WU, Peng (Institute of Plasma Physics, Chinese Academy of Science)

Presenter: HUANG, Zhengyi (University of Science and Technology of China, Hefei 230026, China. Institute of Plasma Physics, Hefei Institutes of Physical Science, Chinese Academy of Sciences)

Session Classification: RAMI session

Track Classification: RAMI (Reliability Availability Maintainability Inspectability) and Nuclear Technologies for Long-Pulse Operation