Next-Generation Coil Power Supply System for the Tokamak: Design, Implementation, and Operational Performance

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Abstract: In order to enhance the plasma confinement and overall performance of the Tokamak machine, an advanced poloidal field coil power supply system is developed in this study based on the pulsed power endogenous supply design concept, which is the first system of its kind to adopt fully controlled power electronics and pulsed power modulation technology, and utilizes a three-phase PWM rectifier plus H-bridge scheme based on fully controlled IGBTs to realize a four-quadrant output. To address the optimal design of the new generation of poloidal field coil power supply, the relationship between current harmonics and the corresponding parameters is further analyzed, and a control strategy that combines the voltage loop and current loop is adopted, with power losses and control performance merits as constraints for the system parameter design. In addition, the power supply is connected with multiple branches in parallel to increase the power capacity, and an isolating transformer is used to avoid the influence of inter-branch loop current on the control stability. On this basis, the relationship between the transformer's wiring windings and the carrier phase shift is further analyzed to further improve the input current harmonics. Based on the proposed design, the development of the new coil power supply was completed and operated to the Tokomak machine for the first time, and it has been continuously operated in the EAST Tokomak for more than two and a half years. The experimental results confirm that the new coil power supply not only meets but also significantly outperforms the design specifications and has quite stable performance, which fully proves the correctness of the innovation of the high-power fusion coil power supply converter from thyristor phase-controlled rectification to the fully-controlled pulsed-power modulation technology, and at the same time, it also has the advantages of high-efficiency, high power factor, controllable harmonics, fast dynamic response, and other performance advantages.

Keyword: Tokamak, Coil power supply, ac/dc. Converter, PWM rectifier