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Research on high current and low inductance laminated transmission busbar in high-power long-pulse steady-state operations

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Abstract—The operation goal of future fusion reactors, such as China Fusion Engineering Experimental Reactor (CFETR), International Thermonuclear Experimental Reactor (ITER) is to realize high-power long-pulse steady-state plasma. The conventional DC busbar occupies too much space, and the large inductance leads to voltage drop, increase EMI (Electromagnetic Interference) and no on-line real-time diagnosis and detection of its state is not suitable to the long-pulse steady-state operation.

This paper presents an improved high current transmission busbar available for long-pulse steady-state operation. The fully insulated laminated transmission busbar with low inductance, low impedance, high power density and high current will be studied and analyzed. Three formulas are established to optimize the low inductance and insulation level. With same current and voltage, the new high current laminated transmission busbar can reduce 70% of the installation space, 50% of the stray inductance. Moreover, the contact resistance the transmission loss can be reduced by 20%. It can correspondingly reduce the current rise time and suppress the long-pulse current ripple.

To make the on-line real-time diagnosis during long-pulse operation, firstly, the influence of the oxide layer on the contact surface and the electrical contact resistance is analyzed. Secondly, the on-line real-time diagnosis and detection of the insulation performance of the first and second conductors of the laminated transmission busbar are studied, in which the electrical contact is analyzed for fatigue and aging test. The aging test could provide the basic information to determine for threshold of transmission busbar lifecycle. Finally, the experimental test and analysis are carried out, and the calculation results are compared with the theoretical analysis to verify the effectiveness of the method and prove the main conclusions of this paper.

Keywords - laminated transmission busbar; low impedance; low inductance; stray inductance; high insulation level; high power density; long-pulse; contact resistance.

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