Contribution ID: **154** Type: **Poster**

Wed-Af-Po.06-05: An improved method for detecting turn-to-turn resistivity without destruction and predicting all operating conditions in full-scale REBCO coils

Wednesday 2 July 2025 14:30 (2 hours)

An improved non-destructive detection method for detecting the turn-to-turn resistivity(TTRD) of large non-insulated REBCO coils is proposed. In previous studies, a method based on ODE and GA algorithm is proposed but tested only in a circular experimental coil. This study improves the method by modifying the optimization algorithm and detecting process to raise robustness, and tests in a large-scale racetrack-shaped double-pancake(DP) coil in various operating conditions, applied in the high speed maglev project. By detecting TTRD of the DP coil and predicting various operating conditions, a more reliable detecting method for practical large-scale coils is proposed.

The voltages of each unit in the coil and the magnetic field at center point are measured during magnetization and demagnetization process to evaluate the TTRD. We first solve the ordinary differential equations derived from the MODERATE equivalent circuit model using the voltage data. This provides an initial range of the TTRD. Then, an improved genetic algorithm(GA) is adopted to fit the voltage curves. This algorithm is well-known for handling complex optimization problems, and by adding the deviation of the central point magnetic field as a penalty function, the algorithm can optimize more precisely.

By combining the heuristic genetic algorithm with an optimization algorithm that has a descent direction, the convergence speed is much faster, cutting down the computing time and resources needed, and the chance of the algorithm getting stuck in local optimal solutions is reduced, making sure we search more widely and thoroughly for the truly best TTTR.

We carry out experiments on full-size REBCO coils used in high-speed maglev. Voltage and magnetic field data under different operating conditions are collected, covering magnetization, demagnetization, quench, and external AC field conditions, to detect the TTTR. Moreover, the detected values we got are used to predict the electromagnetic characteristics under other conditions, in order to evaluates its robustness. In-depth studies have been conducted to evaluate how different operating conditions affect the robustness of the detection results. This full evaluation process helps us understand the method's reliability and adaptability better.

Finally, a highly reliable detection method for the TTTR of large REBCO coils is proposed. This method can accurately predict the electromagnetic characteristics of coils under different working conditions and provide useful guidance for practical engineering. It has the potential to greatly change the design, maintenance, and performance optimization of large coil-based systems, ensuring their long-term reliable and efficient operation.

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Session Classification: Wed-Af-Po.06 - No-Insulation Coils I