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Thermodynamic Behavior Analysis and Heat Transfer Structure Design of Helium Bubble Aggregation in High Field Superconducting Magnets

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Helium bubble retention phenomenon was observed in the development of high field magnets by the National High Magnetic Field Laboratory (NHMFL) of the United States in 2014. The retention of a large number of helium bubbles can inevitably lead to the blocking of high field magnet cooling. In the case of the high field, the magnetic field force generated by the diamagnetism of helium bubbles makes them trapped in a certain area and piled up in large numbers. The accumulated bubbles will attach to the surface of the magnet and degrade its heat transfer performance, breaking the thermal stability of the magnet and making it quench. This study focuses on the accumulation of helium bubbles in high field magnets. Firstly, the growth and gather process of liquid boiling bubble under different magnetic field gradient magnetic field was analyzed. Secondly, the trapping behavior of bubbles and the temperature gradient distribution in the bubble aggregation region are simulated under the high magnetic field. The thermodynamic behavior of bubbles concentrated areas was analyzed, emphatically. The design of the structure of high-performance heat transfer was presented for the large helium bubble position. Finally, the reliability of the structure was verified combining with the temperature distribution and heat transfer in the high magnet.
Keywords: Helium bubbles, Diamagnetism, Boiling heat transfer, Heat transfer analysis

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