Contribution ID: **76** Type: **Poster**

Development of Remountable Joints and Heat Removable Techniques for High-temperature Superconducting Magnets

Friday, 21 October 2016 14:00 (4h 45m)

This study addresses development of mechanical joints and a heat removable technique for the remountable HTS magnet. We carried out (i) Optimizing structure and fabrication procedure of mechanical joints, and (ii) Analyzing heat transfer performance of metal porous media inserted channel to be applied to thermal analysis of joint. The developments and discussion will be taken into account in design of the remountable magnet.
The "remountable" HTS magnet has been proposed for both tokamak and heliotron-type fusion reactors, which is assembled from coil segments with mechanical joints. Our recent study successfully developed a bridge-type mechanical lap joint of 100-kA-class HTS conductors consisting of simple stacking of REBCO HTS tapes. The joint achieved a joint resistance of 1.8 nΩ at 100 kA, 4.2 K. For the local heat removal, we have proposed a metal porous media inserted channel and experimentally evaluated its heat transfer performance with liquid nitrogen (LN2) to show heat transfer coefficient of 10 kW/mˆ2K at low mass flow rate.
However, it took over a half day to fabricate the joint because the joint piece was not integrated but just individual REBCO tapes. In addition, the fabricated joints all had straight geometry. Furthermore the joint resistance obtained with large-scale conductor joint was larger than predicted value based on small-scale conductor joint and varied largely due to non-uniform contact pressure distribution on the joint surfaces. Therefore, an integrated joint piece was newly introduced to shorten the fabrication process. Furthermore, we apply heat treatment during fabrication of the joint to reduce the joint resistivity from 25 pΩmˆ2 to 8 pΩmˆ2. This means the heat treatment is promising to be applied to large-scale conductor joints.
For the local heat removal, we need to predict heat transfer coefficient of various cryogenic liquid coolants such as liquid helium (LHe), liquid hydrogen (LH2) and liquid neon (LNe) with a metal porous media inserted channel, due to operating temperatures of <30 K. At the constant pump power and each coolant's saturated temperature, LH2 and LNe show almost the same heat transfer coefficient and DNB point. The DNB point for LH2 and LNe is about 10 times larger than that for LHe.

Paper Number

FIP/3-4Rb

Country or International Organization

Japan

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Session Classification: Poster EX/7, EX/8, TH/5, TH/6, EX/11, TH/9, FIP/3, FIP/4, PD

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design