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AC loss simulation of NI REBCO pancake coils in external low-frequency magnetic field

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Rare earth barium copper oxide (REBCO) coated conductors (CC) have high thermal stability and high current density. REBCO CCs are suitable for generating high magnetic fields. It is expected that magnets wound with REBCO CCs are utilized for high magnetic field applications, such as magnetic resonance imaging (MRI), nuclear magnetic resonance (NMR), medical-use accelerators, and compact fusion. In recent years, REBCO magnets have been also developed for high-performance motors of electric aircraft and ship propulsion. REBCO magnets may be also suitable for armature windings of such high-performance synchronous motors because they can generate high DC magnetic fields. One of major problems to apply REBCO armature magnets is quench protection. As known well, when REBCO magnets are transitioned into a normal state, they often burn out in case without good protection, because it is difficult to detect a quench due to slow normal-state propagation.
In 2011, the no-insulation (NI) winding technique was proposed as a quench protection. NI REBCO coils can be avoided from burning-out in an event of normal-state transition, by removing insulation between turns. Hence, NI REBCO coils are getting a lot of attention. Moreover, the high performances of NI REBCO pancake coils containing multiple defects (defect irrelevant winding; DIW) were shown. The DIW NI REBCO coils could generate a high field with high current, without quench, despite some defects. This feature is very attractive for aircraft- or ship-propulsion motors, because it is undesired to stop motors during operation due to local hot spots or defects. Meanwhile, armature coils are exposed to external small AC magnetic fields with low frequency. When applying AC magnetic fields, NI REBCO pancake coils easily produce AC losses. The characteristics of NI REBCO pancake coils in AC magnetic fields is still not clarified, therefore, we need to clarify and evaluate them by numerical simulation.

Primary authors: DAIHO, Kazuhiro (Hokkaido University); NOGUCHI, So (Hokkaido University); ISHIYAMA, Atsushi (Waseda University)

Presenter: DAIHO, Kazuhiro (Hokkaido University)

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