Study of the Mechanical Heat Generation inside the Inner Vessel installed with a Superconducting Coil

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1. Introduction

In the JR MAGLEV system, trains are operated by the electrodynamic suspension force between ground coils and on-board superconducting magnets (SCMs). When the train runs, SCMs are vibrated by the electromagnetic disturbance which occurs when the train passes over ground coils. This phenomenon increases the heat load in the SCM cryogenic equipment. In this study, the mechanical heat loss inside the inner vessel installed with a superconducting coil (SC-coil) was investigated as a phenomenon which increases the heat load in the SCM.

2. Vibration test results of SC-coil-installed inner vessel

The relation between vibration and mechanical loss (helium loss) was examined by using a vertical vibration test system for an SC-coil-installed inner vessel. The helium loss increased without a remarkable SC-coil deformation in the vibration mode. The relationship between the vertical SC-coil vibration and the helium loss was evaluated from the standpoint of vertical load which was transmitted into the SC-coil from support columns through the inner vessel. The vibration test result suggested that the mechanical loss inside the inner vessel was generated by the load transmitted from the support columns into the SC-coil.

3. Consideration of mechanical heat generation - SC-coil strain distribution analysis -

Strain distribution analysis of the SC-coil was performed to investigate the frictional heat inside the inner vessel by using the static structural FEM. The heat generation area inside the inner vessel was evaluated based on the assumption that the calculated strain at the SC-coil shows the frequency of microscopic slips between coil fasteners and an SC-coil. Figure 1 shows a result of SC-coil strain distribution analysis. The analysis result suggests that frictional heat occurs in the surrounding area of the support columns.

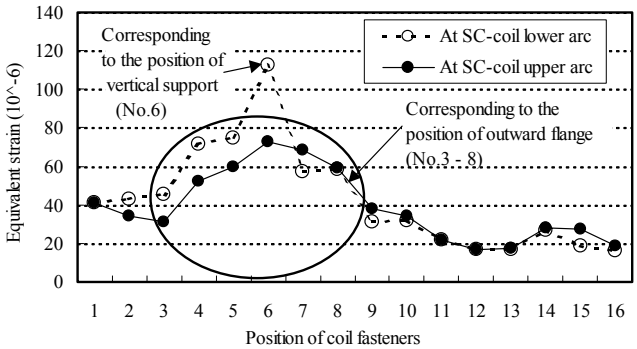

Figure 1 A result of SC-coil strain distribution analysis

4. Verification of SC-coil strain distribution analysis

The validity of the SC-coil strain distribution analysis to estimate the heat generation area was examined by comparing the analysis and vertical vibration test results between the standard and improved heat reducing inner vessels. A comparison of the vertical vibration test results between the standard and additional plate reinforcement inner vessels is shown in Figure 2. The abscissa indicates the coefficient of vertical load which acted on the SC-coil. The results of examination prove the validity of the SC-coil strain distribution analysis.

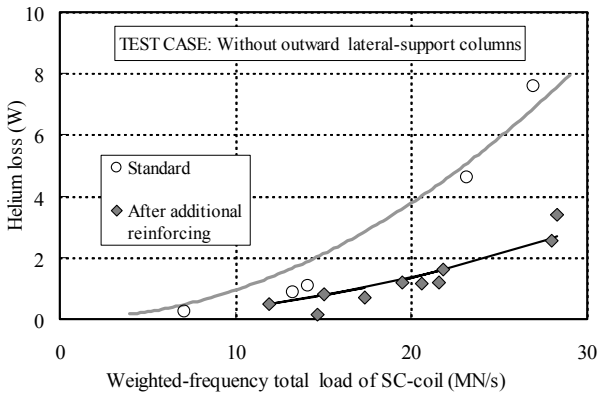

Figure 2 A comparison of vertical SC-coil vibration test results between the standard and additionally reinforced inner vessels

5. Conclusion

The results of this study demonstrate that the SC-coil strain distribution analysis is an effective method to reduce the mechanical heat generation inside the inner vessel.

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