§31. Conductor Irregularities in Dimensions and Mechanical Disturbances in the Large Helical Device

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i) Introduction

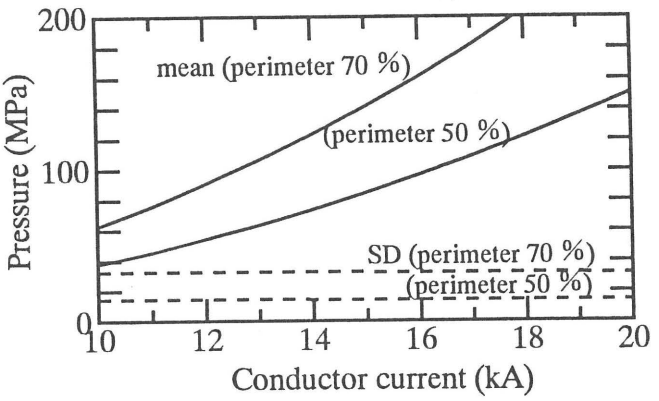
Conductors and spacers in superconducting windings inevitably have irregularities in their dimensions. Hence, even if constant-external force is applied to the conductors, contacting forces between the conductors and the spacers fluctuate. Mechanical disturbance due to conductor motion is one of the main causes of premature quenches in superconducting windings, and the motion occurs at the contacting surface where the contacting force is weak and electromagnetic force exceeds frictional force by the conductor's and spacer's irregularities.

ii) Analytical model

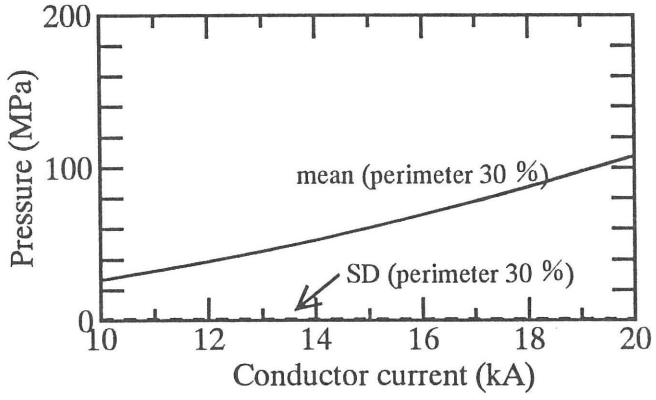
The fluctuation of the contacting forces between the conductors and the spacers due to the irregularities in their dimensions in the windings is numerically estimated based on the measured data on the dimensional irregularities and the statistic theory. The conductor and the spacer for the analysis are KISO32 and GFRP, and the coil is the solenoid coil having 20 layers of the conductors. The distribution of magnetic field on each layer in the coil is similar to that in the Helical coil. We assumed that the irregularities followed Gaussian stochastic distribution whose standard deviation was 50 μm.

iii) Analytical results

Figure 1 shows the relation between the maximum value of contacting stress in the windings and the conductor current. In the figure, the mean values of the stress are solid lines and the standard deviations of the stress are dotted lines. The cooling perimeters on the conductors affect the stress, so we calculated the stresses in the three cooling perimeters (70 and 50 % in (a), and 30 % in (b)). From the figures, the mean values increase with increasing of the conductor current, on the other hand, the standard deviations are almost constant in spite of changes of the current.



(a) 70 % and 50 % of cooling perimeters.



(b) 30 % of cooling perimeter.

Fig. 1. Mean value and standard deviation (SD) of stress between conductor and spacer.

iv) Summary

In the cases of 70 % and 50 % of the cooling perimeters on the conductors, the mean values of the stress are more than twice as the standard deviations of the stress. And in the case of 30 % of the perimeter, difference between the mean value and the standard deviation is larger than that in case of 70 % and 50 % of the perimeters. According to the characteristic of Gaussian stochastic distribution, the possibility outside the range of $\pm 2 \times \sigma$ is approximately 4.6 %. Hence, based on the the stochastic estimation, we think that the possibility of which the contacting stress between the conductors and the spacers in the solenoid coil becomes zero by the conductors' and the spacers' dimensional irregularities is small.