§28. Numerical Analysis on Inductance Imbalance of Strands in Multi-stranded Cable

Takao, T., Watanabe, K. (Sophia Univ.)
Yamaguchi, S.

i) Introduction

It is generally known that transport currents of strands in multi-stranded cable is not same on AC or pulse excitation of superconducting windings. Therefore, the stability margin of the strands with large transport currents decreases, and the cable quenches at a current less than the sum of critical current of each strand. The current imbalance of the strands is caused by imbalance of self-inductance of the strands and coupling factors between the strands in the cables. In this study, we numerically derive the self-inductance of the strands in the model coil for quantitatively investigating the current imbalance in the multi-stranded cable.

ii) Analytical Methods

The model coil for the analysis is one-turn ring. The cable of the coil is composed by 3 strands (0.2mm in diameter). By using Neumann's equation, we calculated for the self-inductance of the strands.

iii) Analytical Results

Figure 1 shows the relation between the self-inductance of the strand and radius of the coil. The vertical axis is the difference of maximum and minimum value for the self-inductance of each strand. As shown in the figure, when the length of the cable becomes the multiple of integer of the length of cable's twist pitch, the difference becomes minimum. Figure 2 shows self-inductance of the strand and the ratio of the cable's twist pitch to the cable length when the coil radius is changed. The vertical axis for this figure is same as Figure 1 but normalized by the average of 3 self-inductance of the strands. It has also minimum value under the same situation just like Figure 1. Furthermore, the difference of the self-inductance decreases with increasing of the coil radius. For example, if the radius is 10 mm, the difference of the self-inductance is 1.0 %, and when the radius is 1000 mm, the difference becomes 0.015 %.

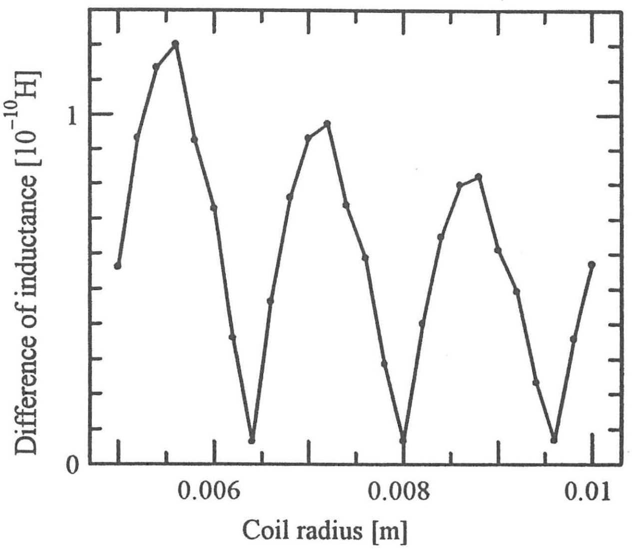

Fig. 1. Difference of inductance vs. coil radius.

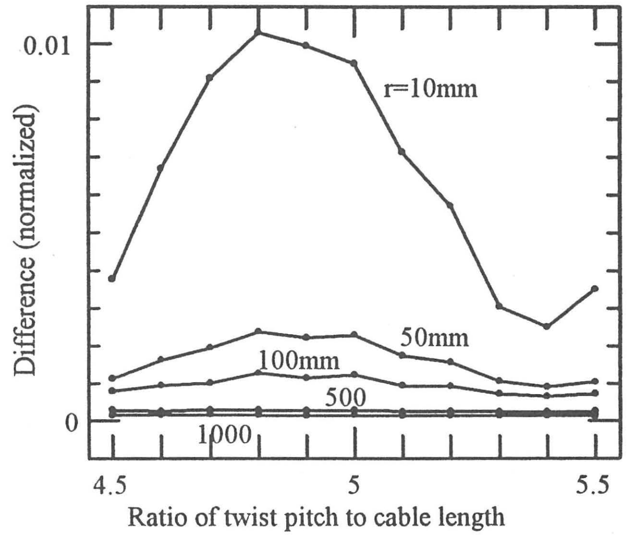

Fig. 2. Dependence of inductance on ratio of twist pitch to cable length.

iv) Concluding Remarks

We estimated the relation among the radius of the coil, the twist pitch for the cable, and the difference of the self-inductance of the strands for the one-turn ring coil. Based on the analytical results, it is figured out that the differences depend on the radius of the coil and the twist pitch of the cable. It is also important to study on the dependence of difference of the self-inductance on the coupling factors and number of turns and layers in the coil.