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# AC Loss Analysis of High Temperature Superconducting Conductors on Round Core


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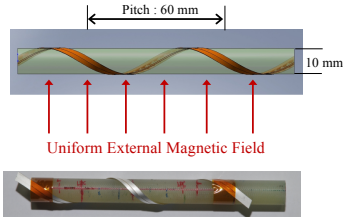
## I. Introduction

- The applications of high temperature superconducting (HTS) tapes for high field magnets need the stacking of multiple tapes to increase the capacity of the current. Several types of the conductors with the large capacity are recently developed. Conductor on round core (CORC) is one of them.
- For the power application of HTS conductors, we need not only the large capacity of the conductor but also the low AC losses. The striation on the tape is one of the solutions for the loss reduction because the AC losses depend on the width of the tape.
- We proposed a loss calculation method for a solenoid coil wound with striated CORC. A straight short sample of CORC with single strand with striations were made and tested. And the magnetization losses of the solenoid coil with 22 turns of striated CORC were calculated.

## II. Methodology of magnetization loss calculation of CORC



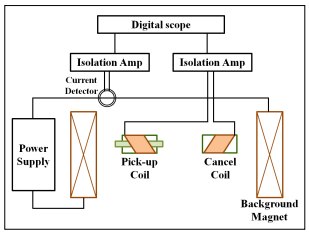

[The CORC model for the test]
Width of the HTS strand : 4 mm

$$\Delta_i = S_i \cdot l_i$$

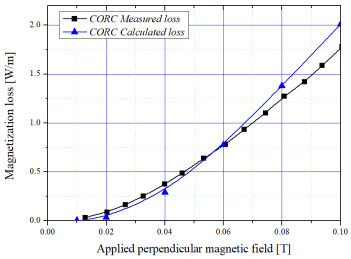
$$P_i = \frac{4\pi a^2}{\mu_0 \Delta_i} B_c B_i \left[ \frac{2}{\beta_\perp} \ln(\cosh \beta_\perp) - \tanh \beta_\perp \right] \quad [J/m^3/cycle]$$

$$P_{total} = \sum_{i=1}^{n} (P_i \cdot \Delta_i) \quad [J/cycle]$$

*$S$ : the HTS strand*
*$l$ : unit length of HTS strand*
*$B_i$ : perpendicular magnetic flux density*
*$B_c$ : $\mu_0 J_c a$*
*$P_i$ : magnetization losses of unit volume*

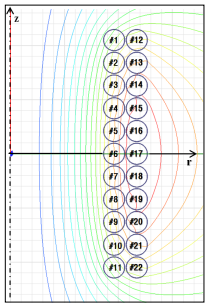



[Measurement system with Linked Pickup Coils]

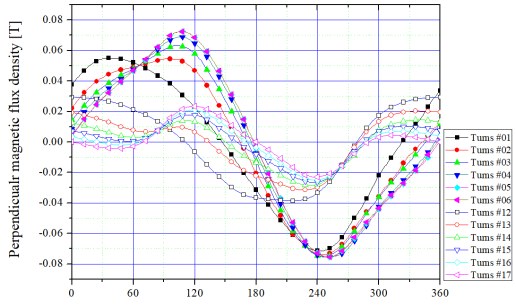



Magnetization losses of the model CORC

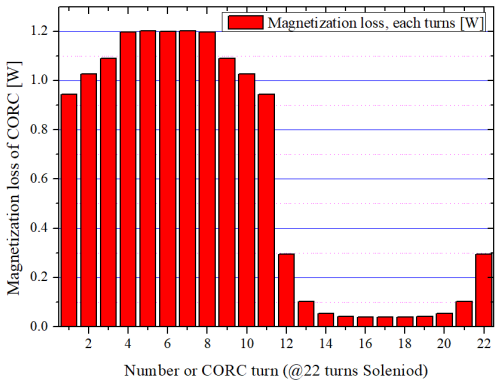
## III. Magnetization losses of a coil wound with CORC



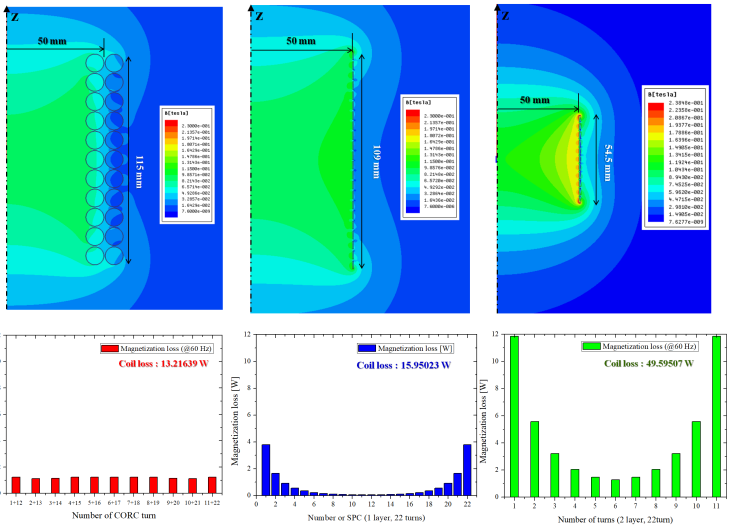

[Cross-section of the CORC coil]




[Perpendicular magnetic fields on each turn of the CORC coil]



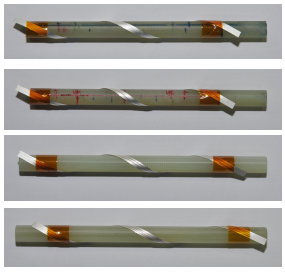

[Magnetization losses in the CORC solenoid coil]



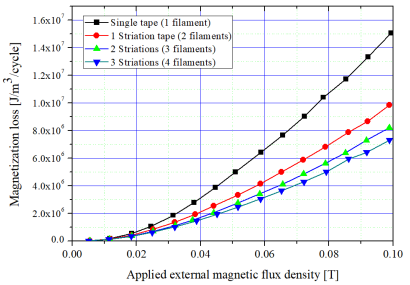

a) Case. 1 (4 strands **CORC**)
b) Case. 2 (4 stacked CC)
c) Case. 3 (4 stacked CC)

[Magnetization losses in the solenoid coils wound with CORC and stacked CC]

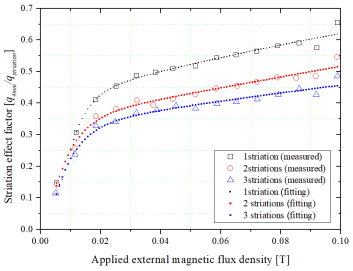
## IV. CORC with striated strand HTS tape



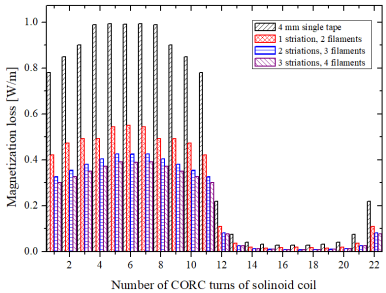
[CORC models with striations]




[Measured magnetization losses of CORC with striations]




[The effect of striations in CORC strands on the magnetization losses by the perpendicular fields ]




[The magnetization losses of the CORC solenoid coil with different No. of striations]

## VI. Conclusion

We suggested a calculation method of the magnetization losses in a solenoid coil wound with CORC. CORC is one of the candidates with the large capacity for high field magnet applications. On the other hand, the electrical power transformer, AC reactor, or SMES need not only the large capacity but also the low AC losses.

For the calculation of the AC losses, we first calculated the perpendicular magnetic field on the strand in every single turn of the coil and then the loss density was calculated. The results from the proposed method were compared with the measured ones in case of a straight short sample of CORC with single strand. The discrepancy was 15 %.

We assumed a solenoid coil wound with CORC for the calculation of the magnetization losses. It has 22 turns. For the comparison, we also assumed two other solenoid coils with 4 stacked CC. Both of them had different shapes from the CORC coil and also showed different patterns of the loss distribution.

We also measured the magnetization losses of CORC with a striated strand and calculated the losses in the coil when CORC turns had 4 striated strands. The strands of CORC were helically wound on the former, so the perpendicular fields on the strand differ with the position or arc angle on the former.

CORC with striations proved itself to have low AC losses due to the perpendicular magnetic fields. But it does not mean that CORC is the better conductor for AC applications than other conductors because it experiences the perpendicular magnetic fields everywhere. We are trying to make and test a solenoid coil with striated CORC. And then we design HTS devices for AC applications with various types of the conductors.