AC loss computation of single isolated superconducting tapes

Department of Electrical and Computer Engineering, Miyakonojo National College of Technology

Batdalai Sukh, Hideki Noji, Yoji Akaki, Tsugio Hamada

Abstract

In this panel session, we present numerical models for computing the current density, field distribution and AC losses in high-temperature superconducting tapes. The tapes have a rectangle cross section for two-dimensional geometries. The numerical models are tested by comparing the calculation results with the predictions of analytical solutions for simple geometries. We used it successfully for investigating cases of single isolated tape and are going to aim at more complex configurations, where the interaction between adjacent tapes is important.

Method

- *Faraday-maxwell's equation :*

$$J = \nabla \times H \ ; \nabla \times E(J) = -\mu \frac{\partial H}{\partial t}$$

- *Non-liner resistivity described by the power law:*

$$E(J) = \frac{E_c}{J_c}\left(\frac{J}{J_c}\right)^{n-1}$$

- Perpendicular directional magnetic applied field (*Brandt's equation*) :

$$P = 4f\mu_0 a^2 J_c d g(x) \ ; \ g = \left(\frac{2}{x}\right)\ln\left(cosh(x)\right) - tanh(x) \ ; \ x = \frac{H_a}{H_c}$$

- Parallel directional magnetic applied field (*Slab model*):

$$P = \frac{2\mu_0 H_a^2}{3} x \ ; x<1 \quad P = 2d\mu_0 J_c H_a\left(1 - \frac{2}{3}\frac{1}{x}\right) \ ; x>1$$

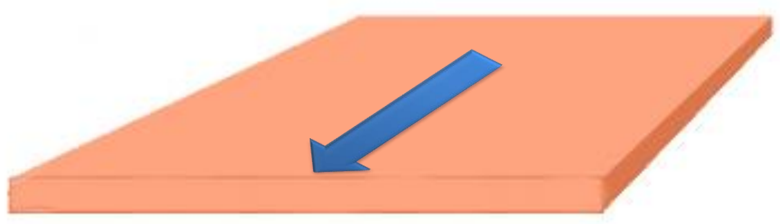
- Transport current loss formula of an elliptical *superconductor(for ellipse) :*

$$P = \frac{f I_c^2 \mu_0}{\pi} \times (1-i)\ln(1-1) + (2-i)i/2 \ ; \ i = I_0/I_c$$

Parameter	Original description	value
E_c	Critical Electric-field	$10^{-4}[V/m]$
n	Number of power low	19
I_c	Critical current	10[A]
d	Half of thickness	$10^{-4}[m]$
w	Half of width	$10^{-3}[m]$

Table 1. Conditional for HTS tape

Result



***H*=0 *I* ≠0**

Figure 1. Case A transport current.

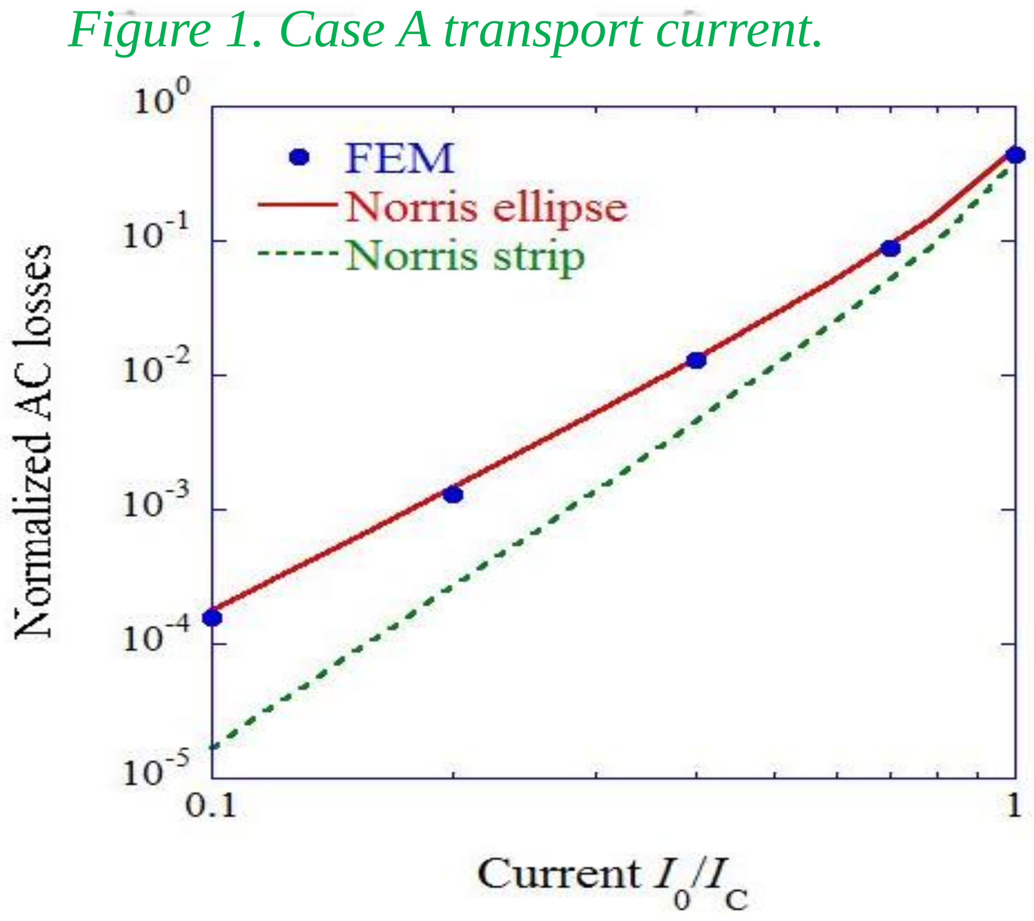


Figure 2. loss of AC

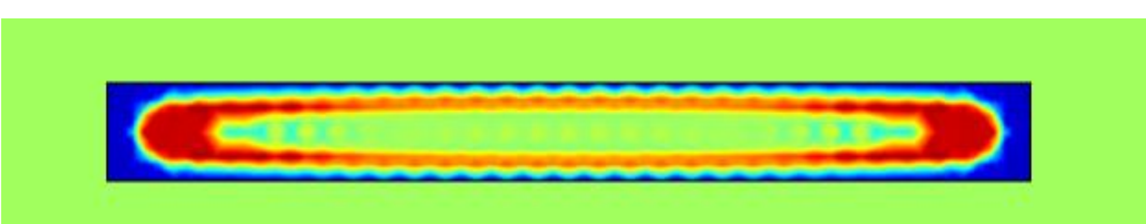


Figure 3. Current density

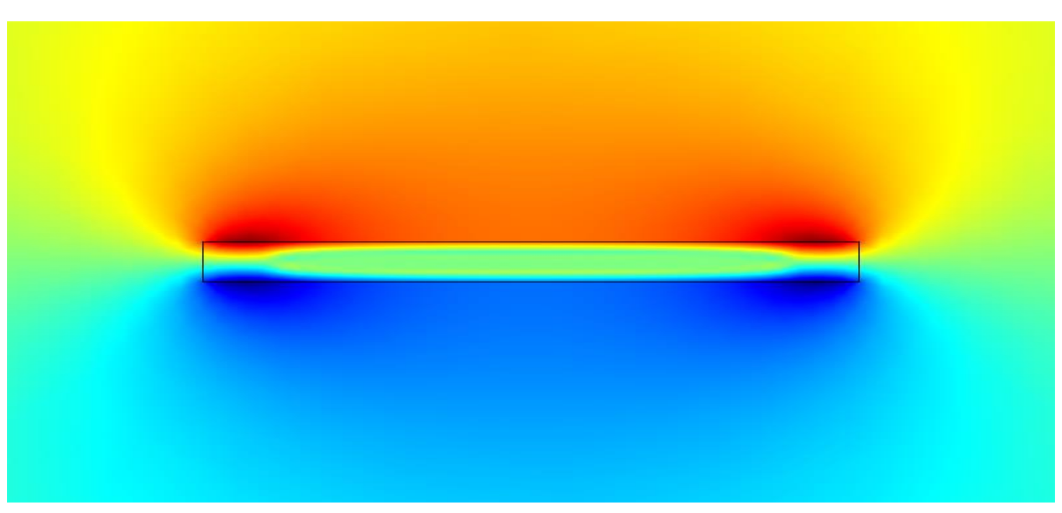


Figure 4. Magnetic field

***I*=0 *H* ≠0**

Figure 5. Case B applied magnetic field in parallel.

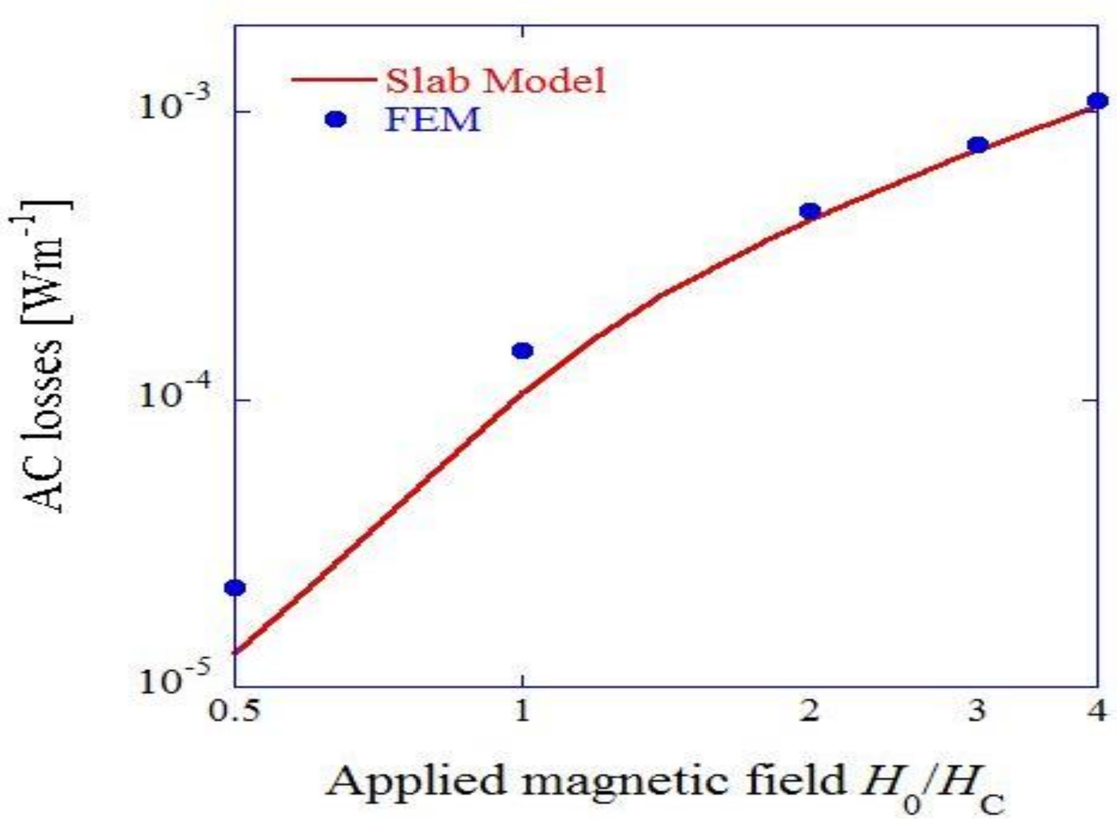


Figure 6. loss of AC

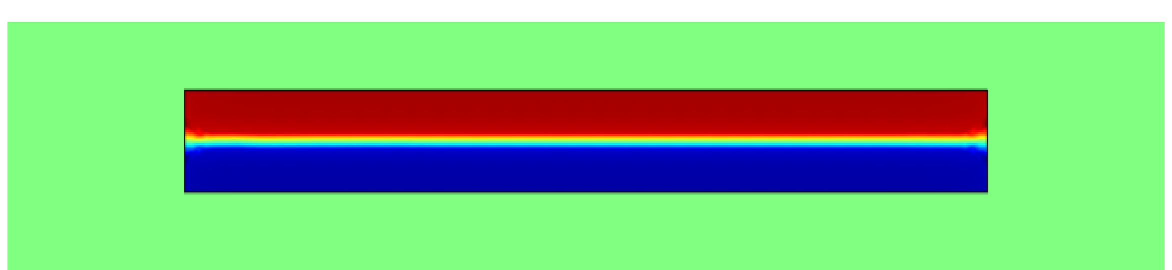


Figure 7. Current density

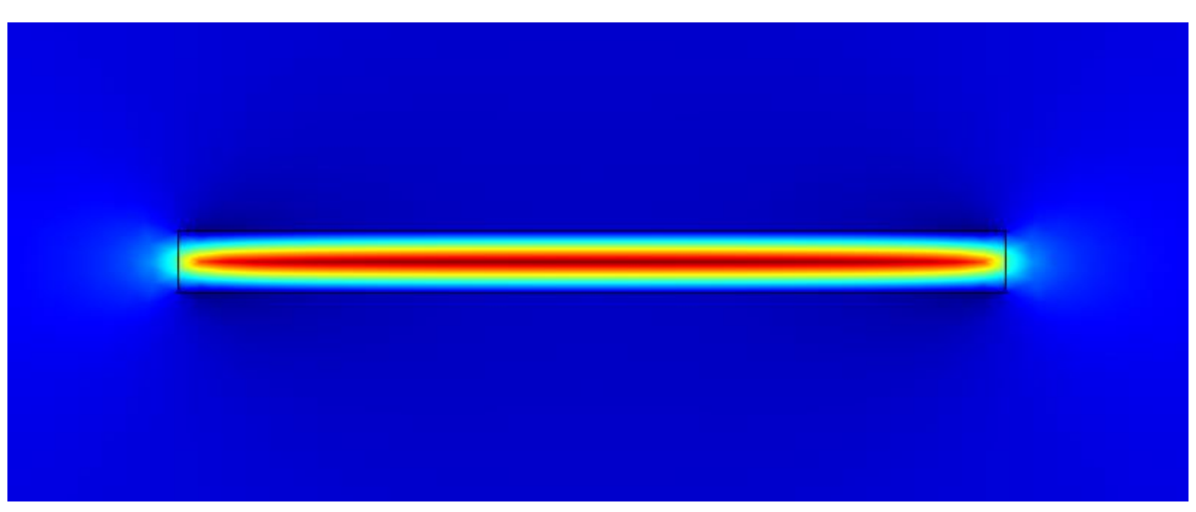
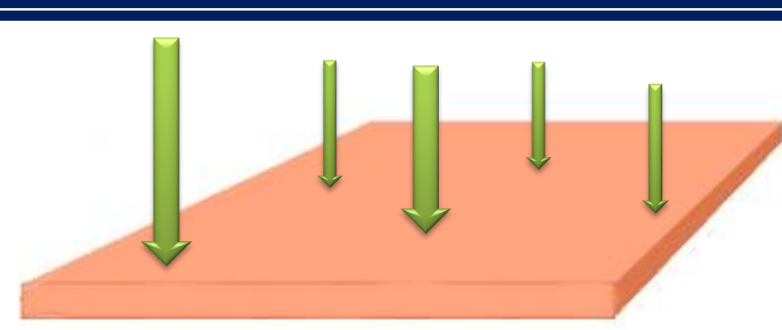


Figure 8. Magnetic field



***I*=0 *H* ≠0**

Figure 9. Case C applied magnetic field in perpendicular.

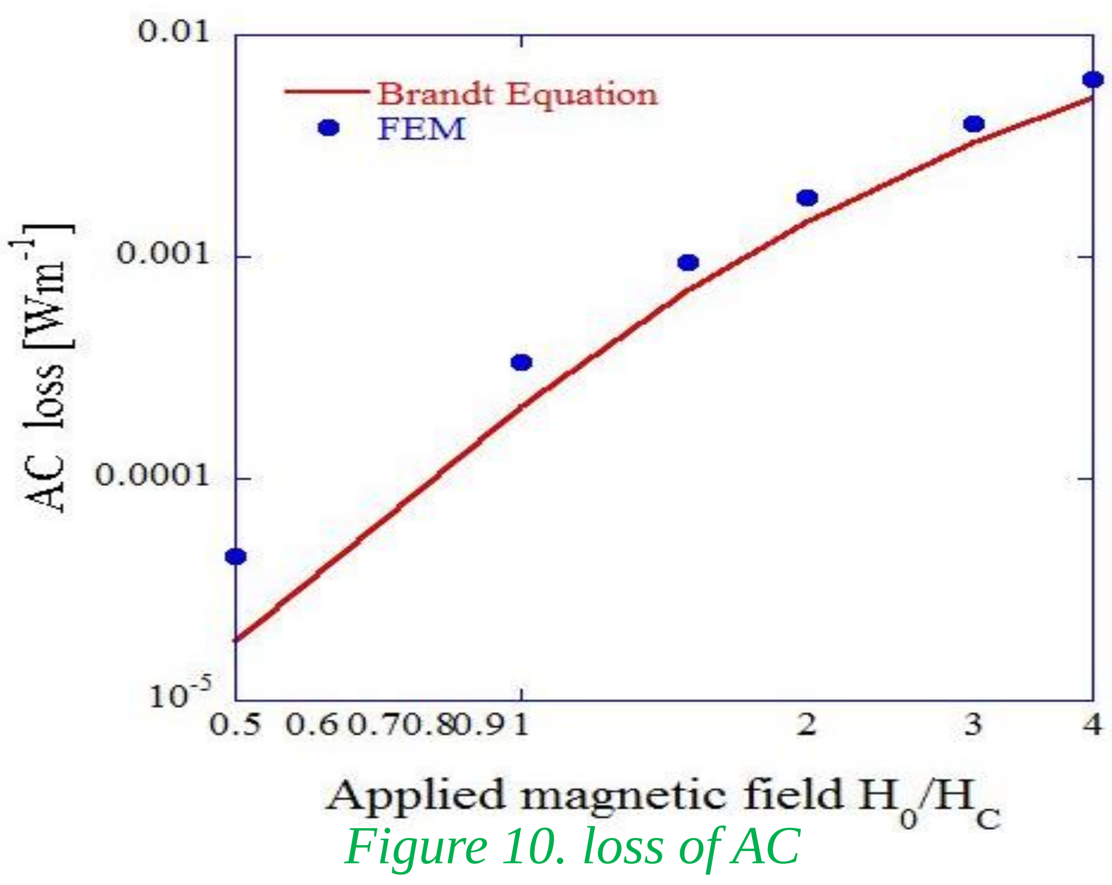


Figure 10. loss of AC

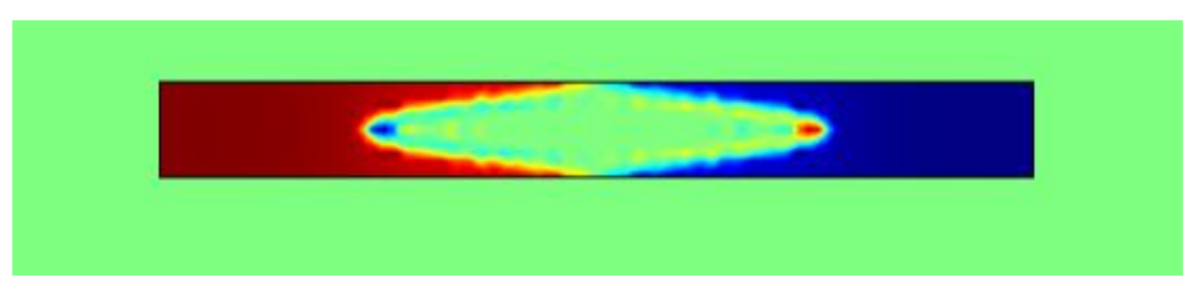


Figure 11. Current density

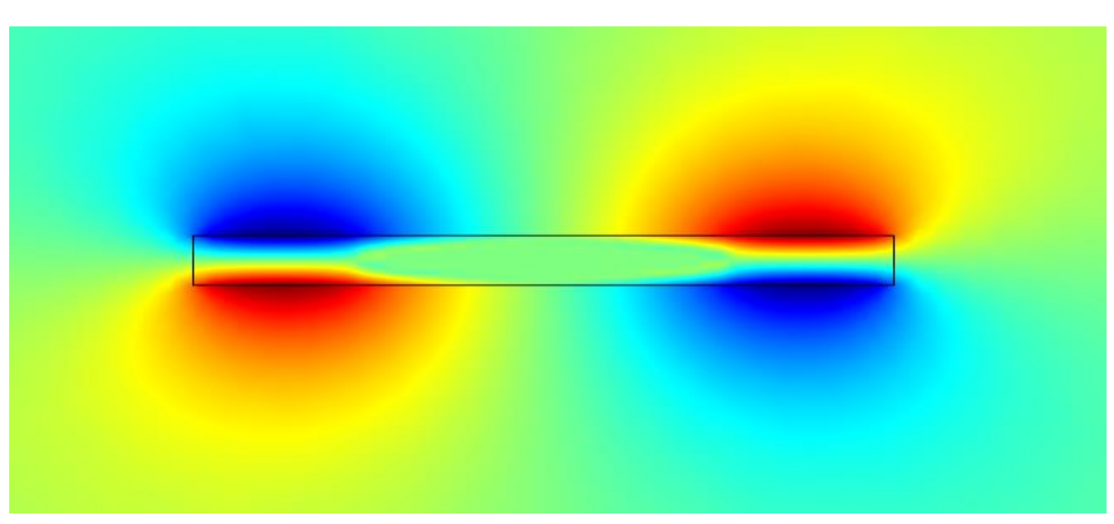


Figure 12. Magnetic field

Conclusion

The FEM analysis of AC losses of superconducting tapes by COMSOL is almost equal to 3 theories: Norris equation for ellipse, Brandt equation and Slab model.