AC Loss Calculation on Stacked HTS YBCO Tapes Based on Magnetic Field Characteristic Parameters Analysis

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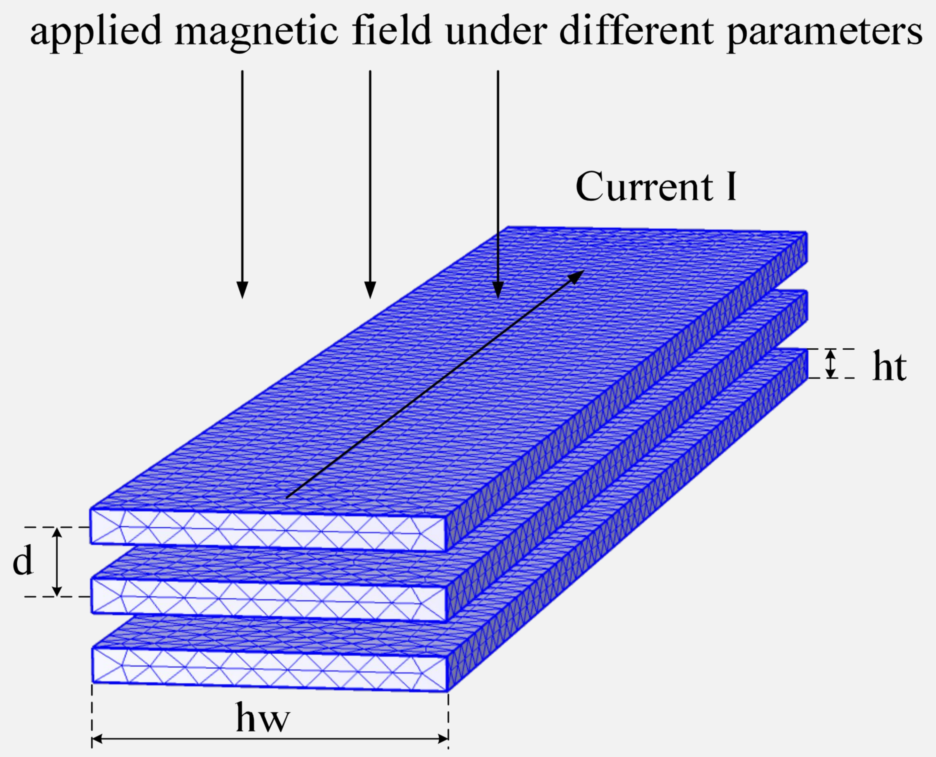
1 Introduction

- Existence of AC loss in HTS tapes generates heat and causes the temperature of the HTS CC tapes to rise, which is directly related to the cooling effect of the system, the stability and cost of operation.
- When the AC losses can be effectively reduced to a certain level，the superiority of high-temperature superconductors can be better reflected. AC losses has also been identified to play a key role in the HTS flux pumps. Therefore, it is of great significance to accurately calculate the influence of the magnetic field parameters on the AC losses of stacked HTS tapes.

2 Stacked superconducting tapes model

- Partial differential equation module (PDE) is used to study the influence of the magnetic field of different frequency, amplitude, and phase parameters on the HTS tapes which is flowing power-frequency alternating current, and calculate the AC losses value under various conditions.
- The governing equation is described as:

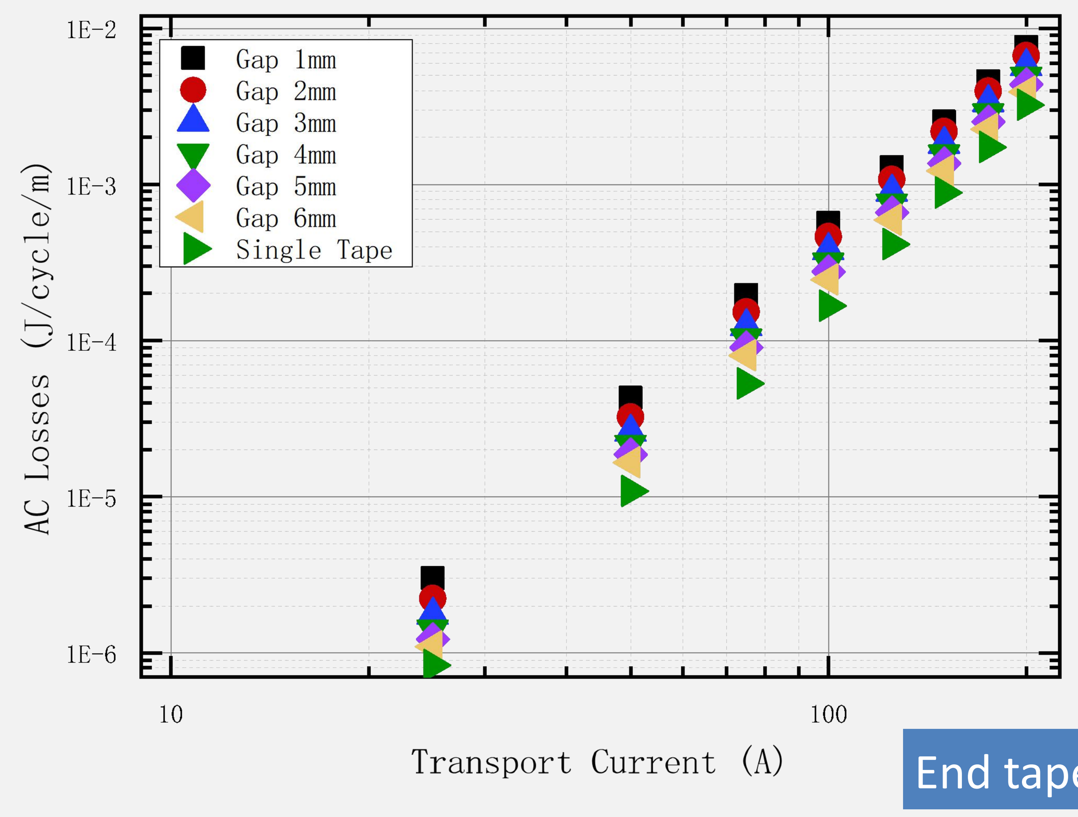
$$-\frac{\partial(\mu_0 \mu_r \boldsymbol{H})}{\partial t} = \nabla \times \left(\frac{1}{\sigma} \nabla \times \boldsymbol{H}\right)$$

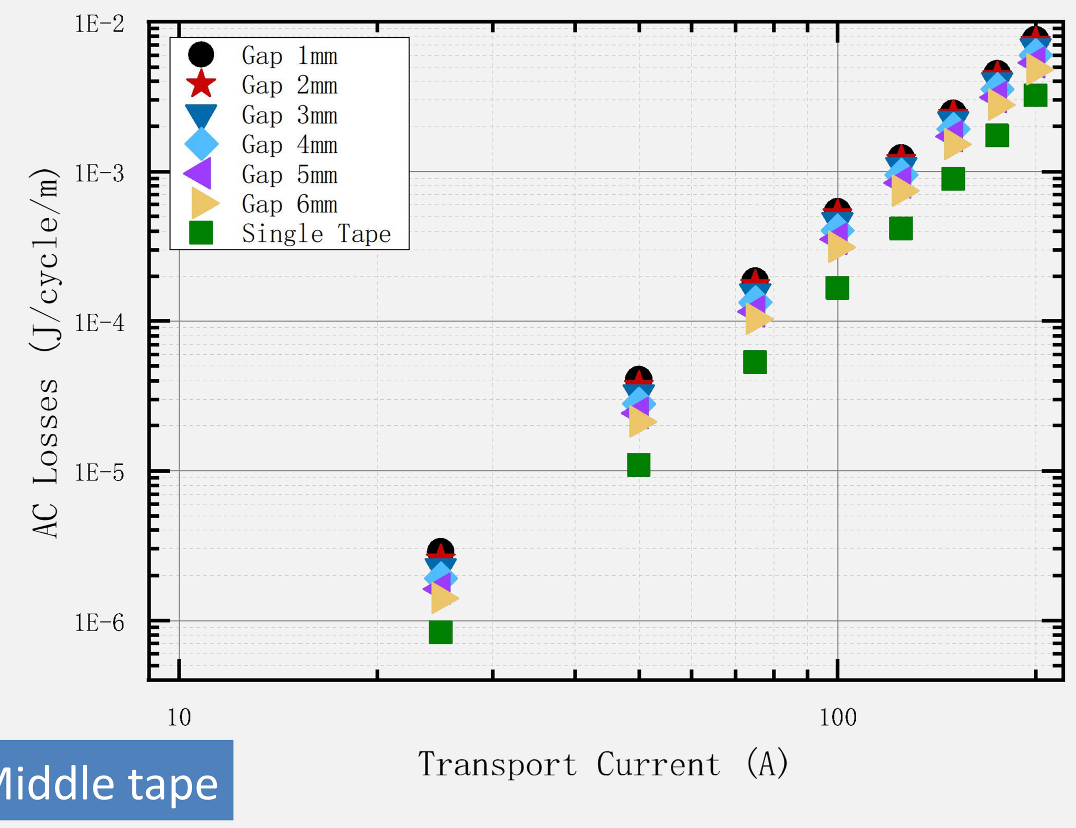


Parameters	Symbols	Value
Tape width	h_w	6mm
Superconducting layer thickness	h_s	1 µm
tape thickness	h_t	100 µm
E-J Power Law factor	n	23
Critical current (77 K)	J_{c0}	2.8×10^{10} A/m^2
Characteristic electric field	E_0	10^{-4} V/m
Current frequency	fi	50 Hz

- The detailed parameter settings of high-temperature superconducting strips are shown in the table on the right. Under this condition, the advantages and disadvantages of AC loss under different traveling wave magnetic field characteristics are compared.
- The optimal solution of the time-varying magnetic field is obtained, which provides basic parameters for the subsequent optimization of the flux pump system.

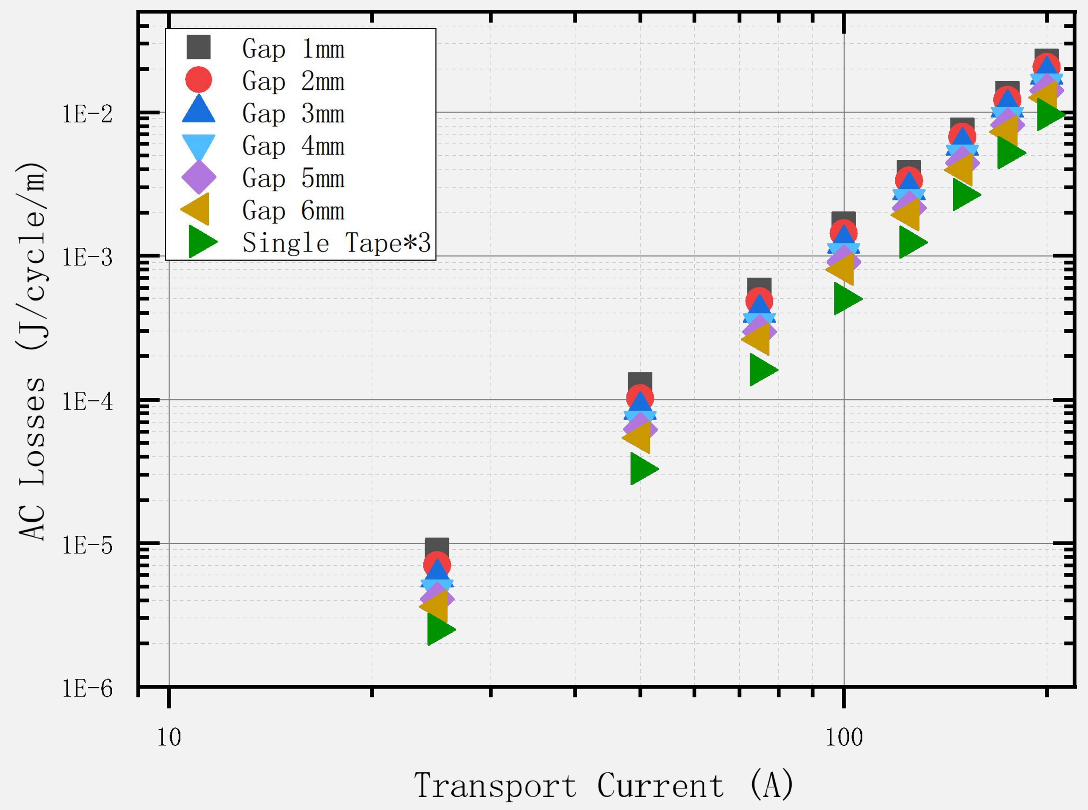
3 Results and analysis





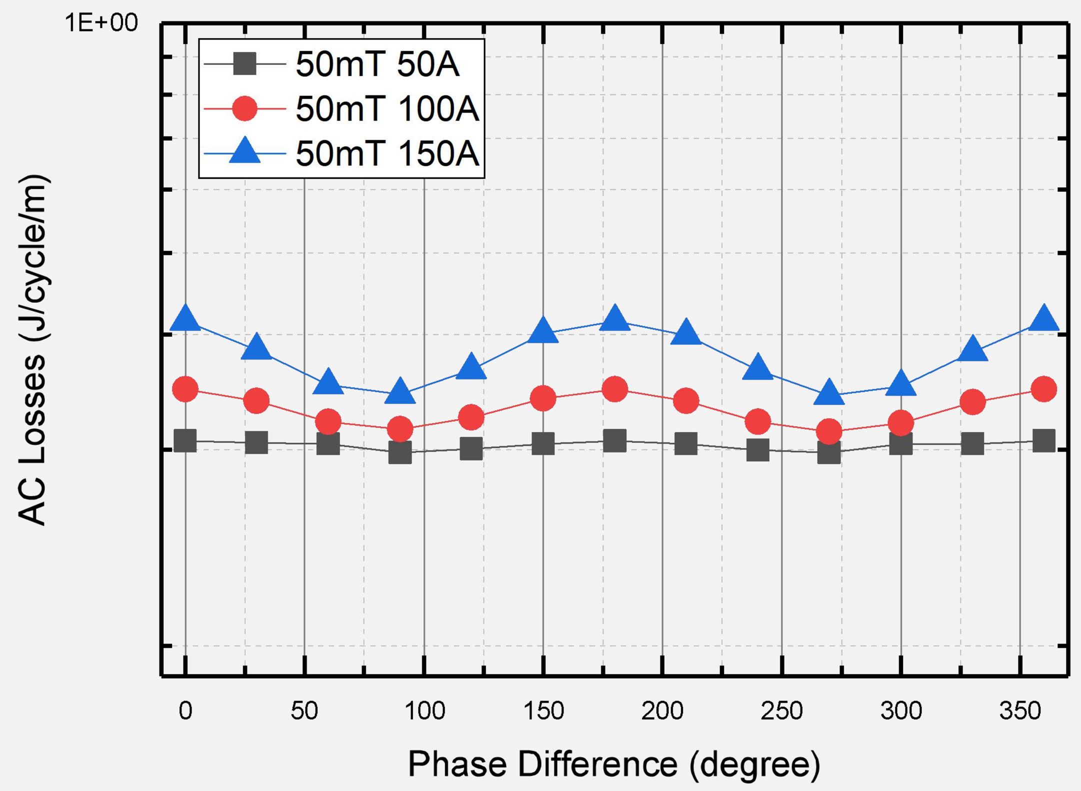
End tape and Middle tape

- Total AC losses of three stacked tapes.

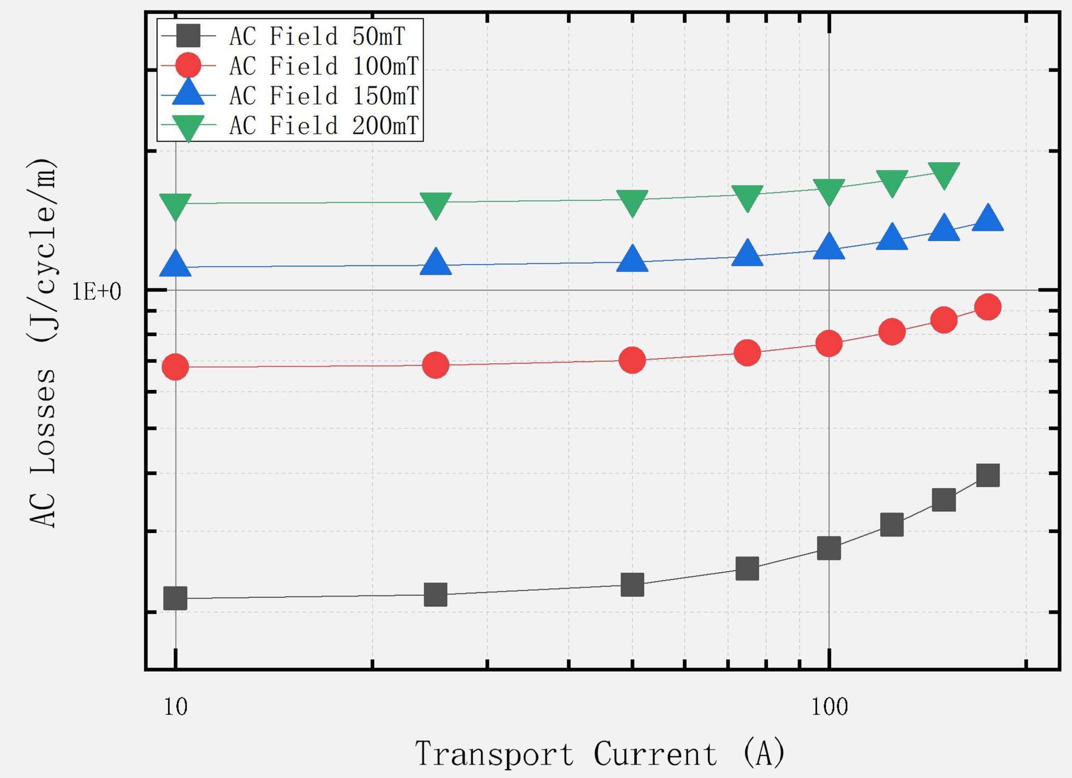


- The air gap is the main reason that affects the AC loss of stacked high-temperature superconducting tapes. When the current is 100A, the AC loss is 3.3 times the loss of 3 single tapes. When the air gap is 6mm, the AC loss reduced to 1.6 times the loss value of 3 single tapes. When the current is 200A, the AC loss is 2.3 times the loss of 3 single tapes. When the air gap is 6mm, the AC loss reduced to 1.3 times the loss value of 3 single tapes. But it can be seen that as the current increases, the impact of the air gap gradually decreases.

AC losses of stacked tapes under different phase difference



AC losses of stacked tapes under different magnetic fields



4 Conclusion

- The results show that the total AC loss of the stacked high-temperature superconducting tape varies linearly with frequency, and it has a greater dependence on the characteristic parameters of the external AC magnetic field. Due to the magnetic field induced by the end tapes is superimposed on the middle tape, when the current increases, the interactive effect of the AC loss of the middle band and the end band will become more obvious with the phase change. The conclusions obtained is beneficial to promote the infinite development and application of superconducting cable, superconducting flux pump and superconducting energy storage.

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