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Modeling and Research on AC Loss of HTS Tapes with Magnetic Substrate under Harmonic Current

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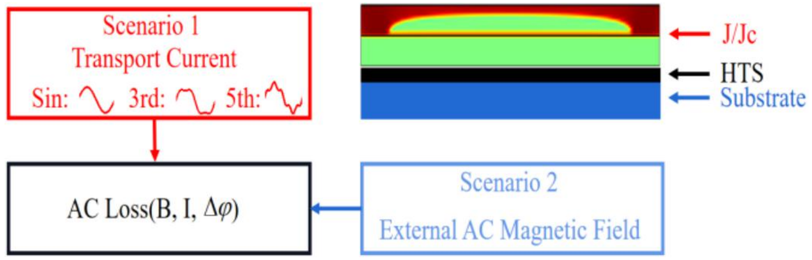
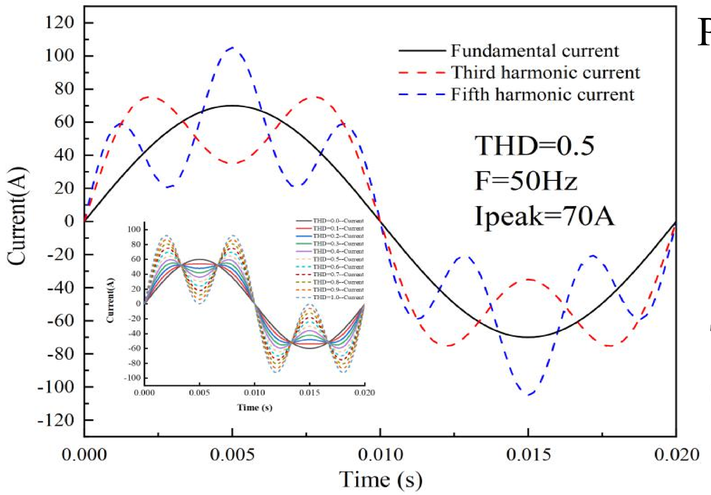
1. Introduction

This article starts from two scenarios, Discussed the influence of harmonics on magnetic substrate tape, The loss of the magnetic substrate under harmonics is also used as part of the research, which will make the loss assessment more comprehensive and contribute to the theoretical foundation for the practical application of superconducting equipment and electronic devices.



2. Methodology



PDE equation can solve the magnetic field intensity H_x,H_y

$$\frac{\partial\left(\rho\left(\frac{\partial H_y}{\partial_x}-\frac{\partial H_x}{\partial_y}\right)\right)}{\partial_x}-\mu_0\frac{\partial H_y}{\partial_t}=0 \quad\Rightarrow\quad \frac{\partial\rho\left(\frac{\partial H_y}{\partial x}-\frac{\partial H_x}{\partial y}\right)}{\partial x}=\mu_0\left[\mu_{rH}\frac{\partial H_y}{\partial t}+H_y\frac{\partial\mu_{rH}}{\partial t}\right]$$

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The transmission current is added in the form of stagnation point constraint

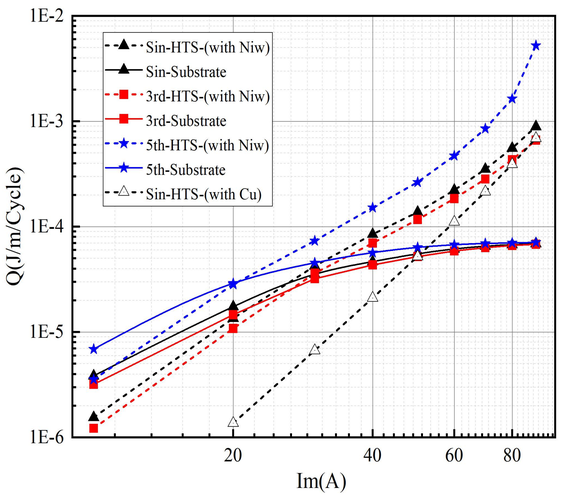
$$I_m\sin(\omega t+\theta)=I_t \quad\Rightarrow\quad I_m\sin(\omega t+\theta)+0.2\,I_m\sin(5\omega t+\theta)=I_t$$

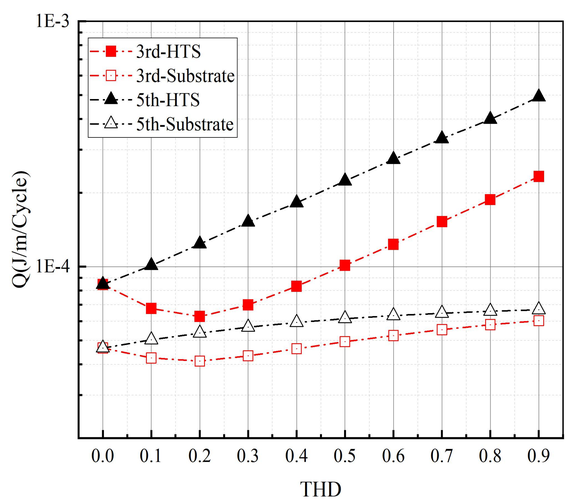
Use the H-formulation to establish a simulation model in COMSOL to solve the electromagnetic and harmonic current problems in the HTS carrier tape. The simulation strip adopts AMSC8501, and its specific parameters are shown in the table on the right.

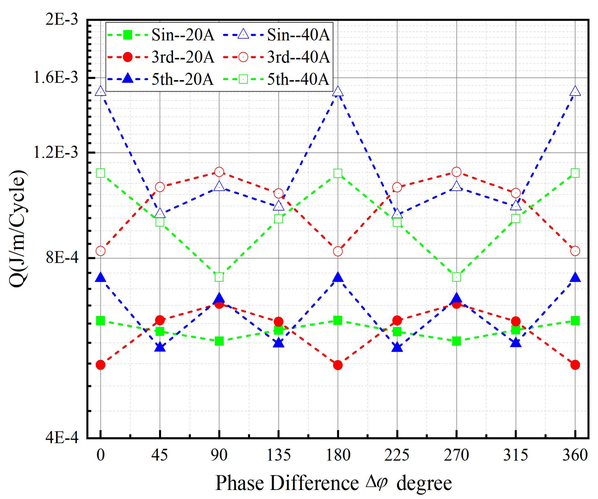
Parameters	VALUE	Unit
Thickness of superconducting layer (t_{sc})	1	μm
Width of tape (w_{tape})	4	mm
Thickness of substrate layer (t_{sub})	75	μm
Width of tape (w_{sub})	4	mm
Tape Self-field I_c at 77 K	98.7	A
E-J power law factor (n)	30	--

3. Analysis and Discussion

The influence of harmonic order and harmonic distortion rate THD on AC loss
The influence of AC magnetic field amplitude and phase on AC loss







4. Conclusion

1. Both the superconducting layer and the magnetic substrate layer have $Q_{5th}>Q_{3rd}$ and $Q_{5th}>Q_{sin}$.
2. Under THD=0.5, the instantaneous loss waveform containing harmonic current has more waveform variation and higher waveform maximum value.
3. As the amplitude of the applied magnetic field increases, the overall AC loss shows a trend of increasing but the slope is slowing down.