Study on the Effect of ReBCO Tape Arrangements on the Electromagnetic Field Distribution

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Abstract—**ReBCO tapes are usually arranged horizontally or vertically to obtain a larger magnetic field or transmit more current. In this paper, the *H*-formulation is used to numerically analyze the electromagnetic field distribution combining with analytical method. The influence of the number of tapes and the arrangement interval on the electromagnetic characteristics is analyzed which is beneficial for superconducting device design and optimization.**

Keywords-High-temperature superconductor (HTS); HTS tape; electromagnetic field distribution; finite element method; H-formulation

I. INTRODUCTION

In practical applications, multiple tapes are usually stacked to improve the capacity of current transmission or obtain a stronger magnetic field to meet the actual application needs. The application of superconductors is based on the basic electromagnetic properties of superconducting tapes [1].

This paper briefly analyzes the change of electromagnetic field distribution affected by the number of tapes and the arrangement interval.

II. ANALYSIS METHOD

The vertical arrangement is defined as tapes stacked along the z axis at a regular interval *D*, while horizontal arrangement is defined as tapes aligned in the x-y plane at a regular interval *L* as shown in Fig. 1. The width of each tape is 2w and their thickness d <<w.

A. Numerical Method

The PDE module based on the ***H***-formulation in the Comsol Multiphysics is established to numerically study electromagnetic field distribution [2]. Real size of the tape is modeled, and the data on the central axis of the central tape is take as the result. The relevant parameters of the ReBCO tape in simulation are shown in Table 1.

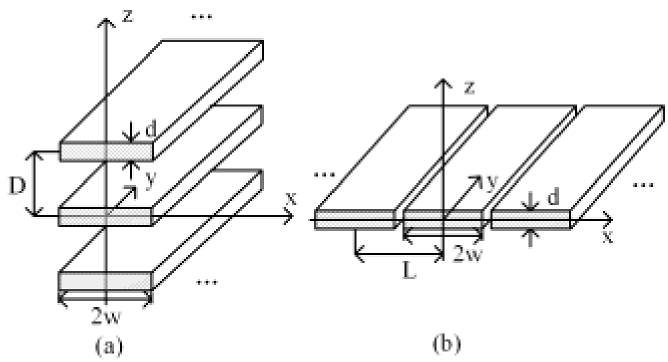

Figure 1. (a) Vertical arrangement. (b) Horizontal arrangement.

TABLE I. PARAMETERS OF REBCO TAPE

Parameters	Value
Width of the tape 2w (mm)	4
Thick of the tape d (um)	1
Critical current self-field I_c at 77K(A)	100
power-law parameter n	31
B_0 (mT)	42.65
α	0.7
β	0.29515

B. Analytical Method

The electromagnetic properties of tape arranged in complicated geometries have been theoretically investigated [3, 4]. The same transformation method is used to derived the magnetic flux and current profiles in vertical and horizontal arrangement as a transport current passes through in periodic arrangement.

III. RESULTS AND DISCUSSION

A. Analysis of the Number of Tapes

Fig. 2 shows the normalized electromagnetic field distribution when a 60A current passes through the vertical arrangement. As the number of tapes increases, flux-filed regions are increasing. The greater the number of tapes, the

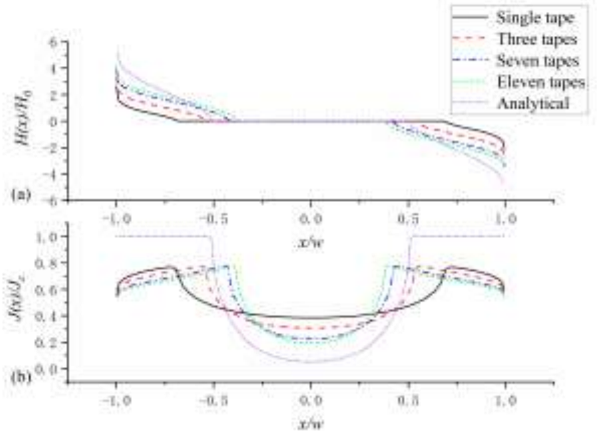

Figure 2. (a) Magnetic field distribution and (b) current density distribution in different number of tapes for vertical arrangement with D/w=0.5.

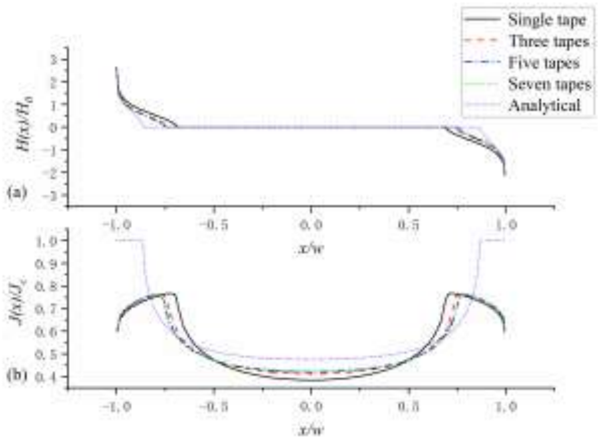

Figure 3. (a) Magnetic field distribution and (b) current density distribution in different number of tapes for horizontal arrangement with L/w=3.

closer to the infinite periodic arrangement. The numerical result has a larger flux-filed region in periodic arrangement compared with the analytical result. Fig. 3 shows the normalized electromagnetic field distribution when a 60A current passes through the horizontal arrangement. As the number of tapes increases, the flux-filed region is decreasing, and the change is decreasing. When the number of tapes increases to an infinite periodic arrangement, the simulation result has a larger flux-filed region compared with analytical result.

B. Analysis of the Arrangement Interval

Fig. 4 and Fig. 5 show the normalized electromagnetic field distributions of the tapes at different arrangement intervals D or L when 60A current pass through vertical or horizontal arrangement. As the interval D increases, the flux-filed region is decreasing due to stacking effect weakening for vertical arrangement. When the interval D is infinite, the electromagnetic field distribution close to a single tape. As the interval L increases for horizontal arrangement, the flux-filed region increases. When the interval L is large, changing the interval L has little effect on the electromagnetic field distribution.

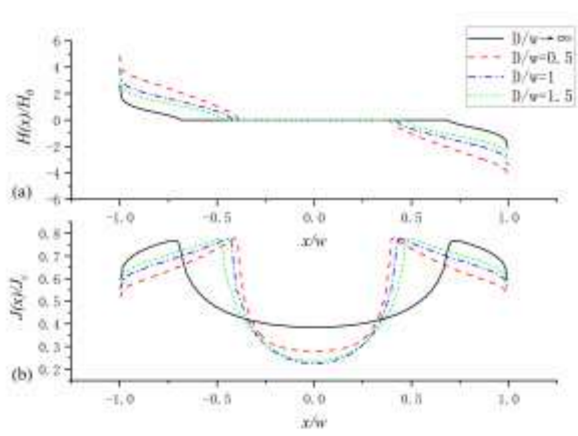

Figure 4. (a) Magnetic field distribution and (b) current density distribution in different interval D for vertical arrangement with seven tapes.

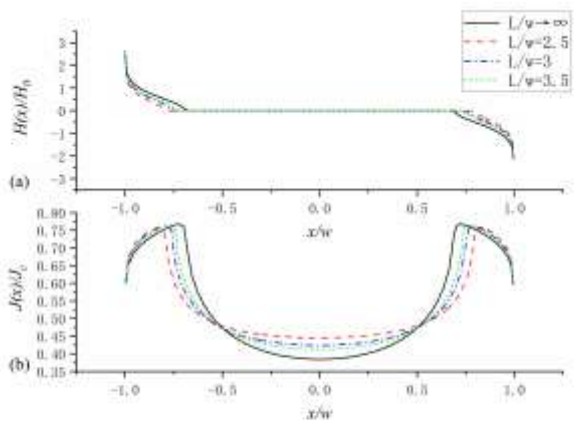

Figure 5. (a) Magnetic field distribution and (b) current density distribution in different interval L for horizontal arrangement with seven tapes.

IV. CONCLUSIONS

In this paper, the effect of the number of tapes and the arrangement interval on the electromagnetic distribution is analyzed by numerical and analytical methods. The results can be used to explain the change of AC loss in different arrangements and optimize the design of superconducting device.

REFERENCES

[1] J. X. Jin, Y. J. Tang, X. Y. Xiao, B. X. Du, Q. L. Wang, J. H. Wang, S. H. Wang, Y. F. Bi and J. G. Zhu, “HTS power devices and systems: principles, characteristics, performance, and efficiency,” *IEEE Trans. on Appl. Supercond.*, vol. 26, no. 7, pp. 3800526.

[2] M. Zhang, W. Yuan, D. K. Hilton, M. D. Canassy, and U. P. Trociewitz, "Study of second-generation high-temperature superconducting magnets: the self-field screening effect," *Superconductor ence & Technology*, vol. 27, no. 9, p. 095010.

[3] K. H. Müller, "Self-field hysteresis loss in periodically arranged superconducting strips," *Physica C Superconductivity*, vol. 289, no. 1, pp. 123-130.

[4] Y. Mawatari, "Critical state of periodically arranged superconducting-strip lines in perpendicular fields," *Physical Review B*, vol. 54, no. 18, pp. 13215-13221.