Larger Levitation Force Design of Magnetic Levitation Rail based on Topology Optimization of Halbach Array

Hang Zhang[1,2], Jianwei Li[1], Mufeng Wang[3], Ruilin Pei[1,*]

1) Shenyang University of Technology, Shenyang, Liaoning, 110870, China

2) Suzhou Inn-Mag New Energy Technology Ltd, Suzhou, Jiangsu, 215000, China

3) Université de Technologie de Troyes, Troyes, 100000, France

Background

- To increase the diversity of travel mode, the high-temperature superconductor Maglev needs to be developed.
- Conventional Maglev rail mainly adopts the isometric magnets. An advanced solution uses Halbach Array.
- The different widths of the horizontal and vertical PM in Halbach array can affect the magnetic density of the surface above the Maglev rail significantly.

Experiments Set-up

- To explore the influence of the width ratio of the horizontal and vertical magnets on the Halbach Array;
- Compared with conventional levitation rail;
- 4 schemes of the comparison was designed.

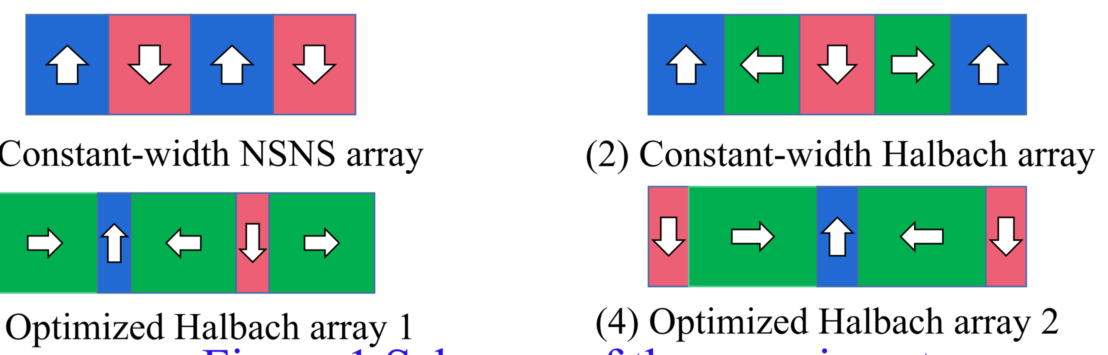


Figure 1 Schemes of the experiment

Comparisons and Analysis

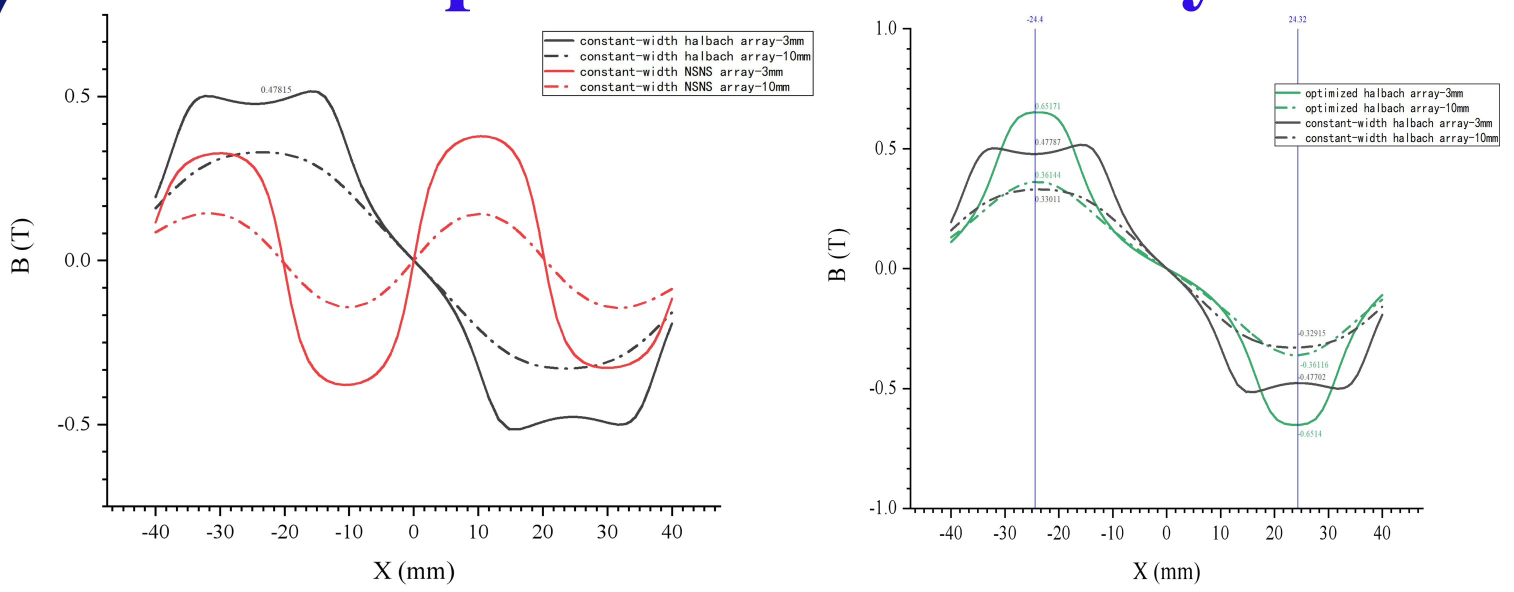


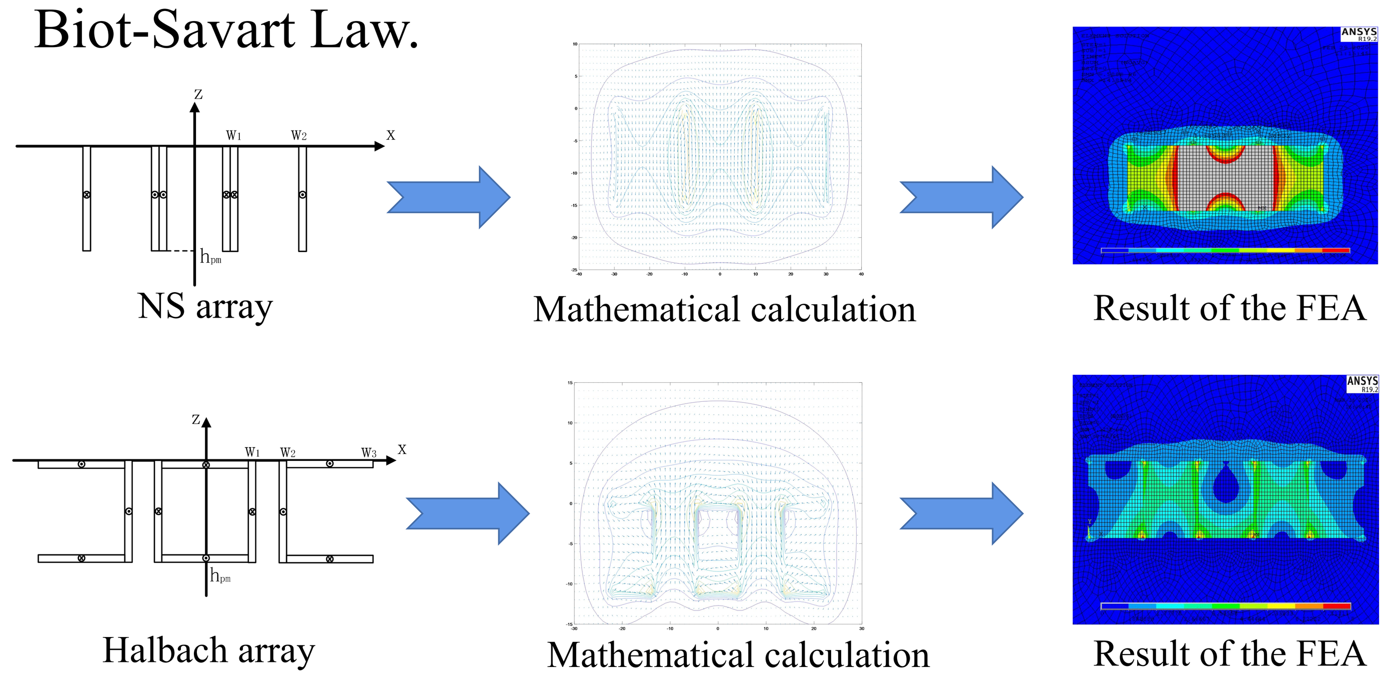
Figure 5 Comparison between simulation and measurement

- The optimization of the width ratio is based on the target suspension height;
- B_y of optimized Halbach array at 3 mm is about 18.5% higher than that of the uniform-width halbach array, and at 10 mm, the flux density of two schemes is not much different;
- As the height increases, the optimization effect gradually weakens.

Modeling and Analysis

- Mathematical modeling:

Based on the method of equivalent surface current and Biot-Savart Law.



- Optimization and Finite Element Analysis:

- 2D model is adopted and the width of the HTS bulk is supposed to be 80 mm;
- Optimization, considering the maximum value and the integral of absolute value of the flux density B_y along a 80 mm path;
- The path is supposed to be 3 mm and 10 mm above the levitation rail.

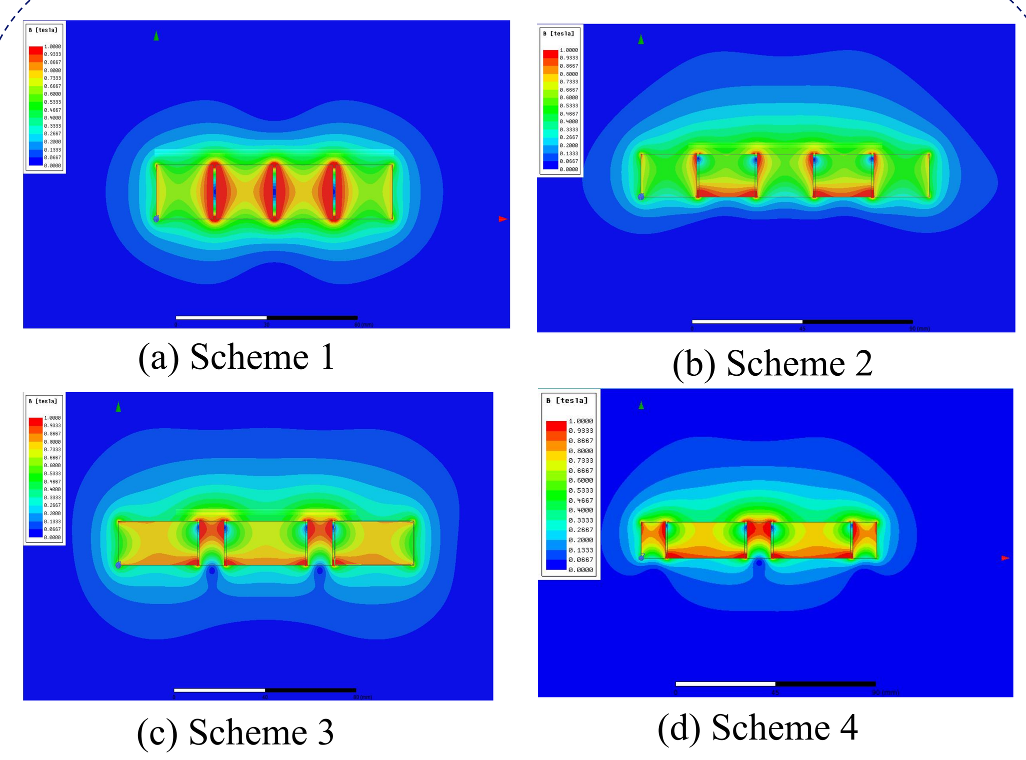


Figure 2 Results of the FEA

Results of the simulation: ($B_{y\text{-}max}$@3mm)

Scheme 1 379mT

Scheme 2 550mT

Scheme 3 652mT

Scheme 4 673mT

Construction and Measurement

- N52 NdFeB magnet is adopted;
- To ensure the safety of the assembly process, the auxiliary tools were designed;
- Using flux meter to measure the flux density of the surface at 3 mm above the levitation rail, B_z and B_y.

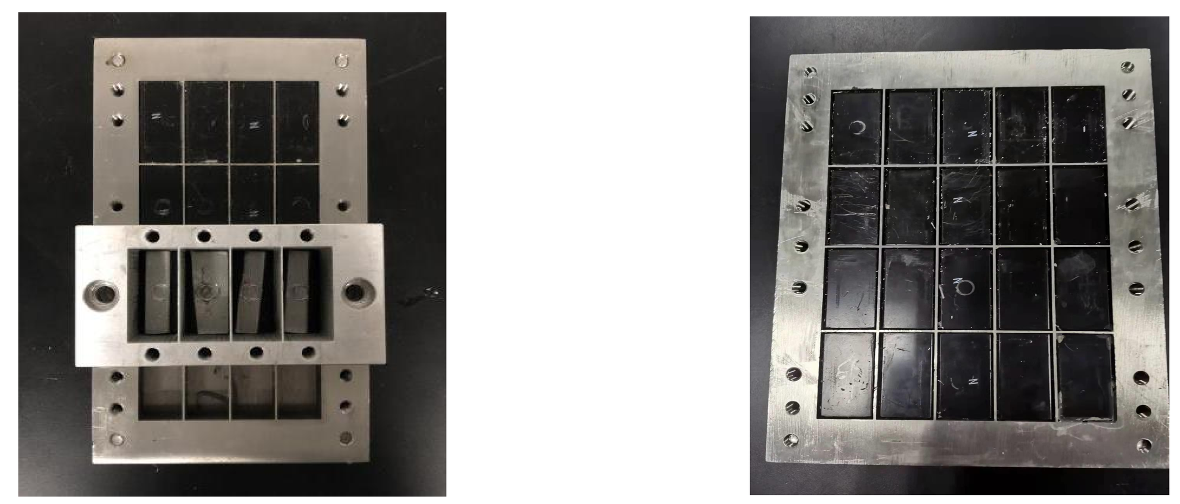
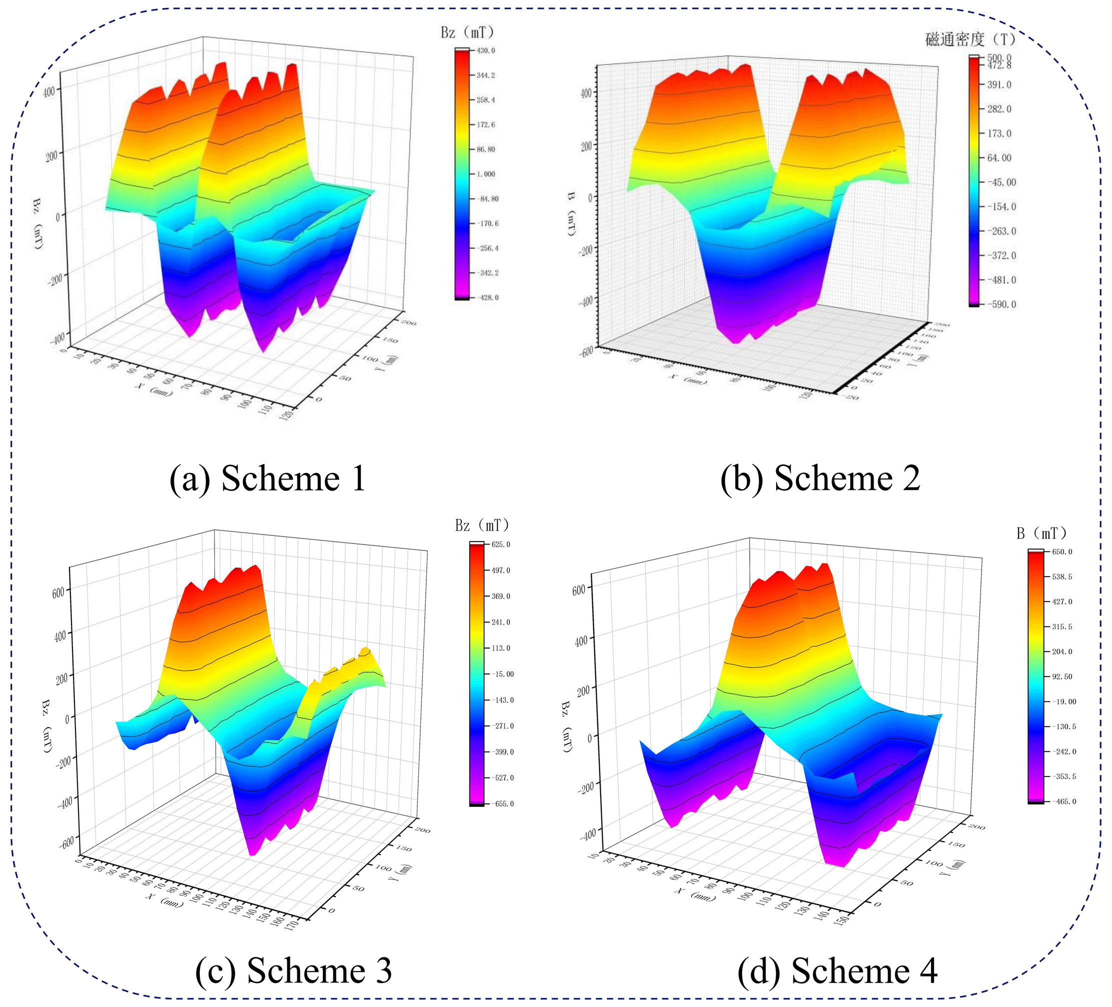


Figure 3 Levitation rails, frame and auxiliary tools



Results of the measurement: ($B_{z\text{-}max}$ @3mm±)

Scheme 1 430mT

Scheme 2 590mT

Scheme 3 625mT

Scheme 4 650mT

Figure 4 Results of the measurement

Key finding

- For our study, the best horizontal/longitudinal width ratio is 3.18;
- The ratio of the width will differ with the target suspension height.

*: Corresponding Author's Email Address : peiruilin@inn-mag.com