Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

Modeling and experiments

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Contents

1 Basic information
   - Superconductivity
   - Superconducting magnetic shields

2 Experiments

3 Model
   - General
   - Equations

4 Results
   - Experimental
   - Model

5 Conclusions
Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

Basic information

Superconductivity

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Superconducting state properties
Characteristics

- No resistance
- Meissner effect (magnetic field expulsion)
- Josephson effect (Cooper pairs tunnelling)
Superconducting state properties

Critical values

- Temperature
- Electric current density
- Magnetic field
Division of superconductors

- Due to critical temperature
  - Low temperature (LTS)
  - High temperature (HTS)

- Due to magnetic behaviour
  - 1st kind
  - 2nd kind
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- Basic information
- Superconductivity

Meissner effect
Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

Basic information

Superconducting magnetic shields

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Basic information

- Meissner-Ochsenfeld effect blocking magnetic field
- Applications in science and medicine
- Low full penetration field
- Improvement with a tape screen
Plan

- Measurements in AC and DC magnetic fields
- The application of bulk and tape screen
- Search for frequency effect
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Experiments

Shields
Specimens
Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

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   - Model

5. Conclusions
General information

- Created in Matlab
- Models magnetic field produced by an electromagnet and shielded by the superconducting shields
- As a result gives magnetic field distribution and currents in superconductors
- Current distribution found by minimising magnetic field in the shielded cavity
Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

Model mesh
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   ■ Model

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Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

**Model**

**Equations**

**Biot-Savart**

- Base form for an infinitesimal current element
  \[ d\vec{B}_{nA} = \int_{-\pi}^{\pi} \vec{I} \frac{\mu_0 l}{4\pi} dl \times \frac{\hat{r}}{|r|^2} = I_n \frac{\mu_0}{4} \frac{|x_n| \cdot \hat{r} \times \hat{l}}{(y_n - y_A)^2 + r_x(x_n, x_A)^2} \]
- Average distance from a half-circle
  \[ r_x(x_n, x_A)^2 = |x_n^2 - x_n x_A + x_A^2| \]
- Total magnetic field at a point
  \[ \vec{B}_A = \sum_{x, y=0}^{n} I_n \frac{\mu_0}{4} \frac{|x_n| \cdot \hat{r} \times \hat{l}}{(y_n - y_A)^2 + r_x(x_n, x_A)^2} \]
Threshold frequency and AC field

- Current induced by AC field
  \[ I_{\text{ind}} = -\frac{B_m \cdot \omega}{R} \cdot \sin(\varphi) \]
- Joint resistance
  \[ R = \frac{\rho \cdot d}{S} \]
- Threshold frequency
  \[ f_{\text{th}} = \frac{R}{2\pi L} \]
- Inductance
  \[ L = \mu_0 r_t \left( \ln \frac{8r_t}{r_{\text{in}}} - \frac{7}{4} \right) \]
Combined magnetic screen made of Bi-2223 bulk cylinder and YBCO tape rings

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Results

Experimental

Experimental results
Experimental results

- Unaffected points
- Affected points
- Regression for unaffected
- Regression for affected

Average field attenuation in constant range (%) vs. Temperature (°C)
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Model results
Comparison

![Graph showing comparison between experimental and model results. The graph plots frequency (Hz) on the x-axis and penetration magnetic field (mT) on the y-axis. The experimental data is represented by solid circles, while the model data is represented by open circles. The graph shows a linear increase in magnetic field with increasing frequency.]
Conclusions

- Clear shielding quality improvement visible
- Model results agree quite good with experimental
- Threshold frequency estimation was confirmed by experiments