Superconducting Magnetic Heterostructured Components for Electric Motor Applications

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Outline of the presentation

Problem:
- Stacks magnetization in an electrical machine
- Leakage flux

Proposed solution:
- Heterostructures
- Some experimental measurements
The conditions in an electrical machine (EM) limit the alternatives:

- Field cooling magnetization using stator (DC)
- No stator teeth
- Interior mounted stacks without iron bridges:
  - to avoid losses
  - to avoid demagnetization from stator harmonics
- Substrate: $\mu_r = 10$ (Ni-5%W @ 25 K)
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Stacks magnetization in an EM

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The conditions in an electrical machine (EM) limit the alternatives:

- Field cooling magnetization using stator (DC)
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- Interior mounted stacks without iron bridges
- $\mu_r = 10$ (Ni-5%W @ 25 K)
- After mag. -> small available flux

*Leakage flux*
Leakage flux

Higher intrinsic leakage flux is inherent to stacks (trapezoidal-triangular mmf)

Leakage increases with current ($I_{mag}$)

Exacerbated when embedding the stack in iron
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FE simulation increases its effect since $J_c \downarrow$ when $|B| \uparrow$
Proposed solution

The arrangement of a stack with lower $\mu_r$ at its sides (25%)

Either:

1) Ni-9.5%W at its sides*
2) Heterogeneous construction

Proposed solution

For $\mu_r = 1$ at both sides (25%) and $\mu_r = 10$ in the rest of the stack:

Small (6%) reduction of magnetizing flux

Increase of linked flux up to 61% at $I_{mag} = 2.4$ kA

Max. total (stack + airgap) leaked flux 20%
Heterogenous construction has been used for a preliminary assessment of the approach.

Two layers of AMSC tape in air (50 mT), and either:

- No NiFe layer
- One NiFe layer
- One NiFe insert at the center

Zero field cooling, undersaturated by 110 mT field.
Experimental results

- 19 x 19 mm central area scanned:
  - two tapes + ferromag. layer
  - two tapes + ferromag. insert

- Flux increased at the center of the stack

- Mean trapped flux in the area:
  - No ferromag: 34.2 mT
  - Ferromag. layer: 48.6 mT
  - Ferromag. Insert: 54.6 mT
Conclusions

✓ Stacks need to be surrounded by iron (shielding) in the rotor of an electrical machine

✓ The low reluctance path between its center and its sides increases flux leakage

✓ Leakage increases with the saturation of the stack and $\mu_r$

✓ Structures with different magnetic permeability would greatly reduce leakage