Influence of Flux Diverter on Energy Storage Performance of Mini-Size SMES Magnet Wound by 100-Meter-Class GdBCO Tape

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I. Abstract

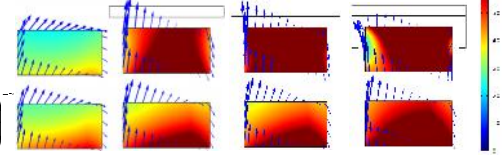
Solenoid-type SMES magnets have strong anisotropic magnetic field dependence at 77K. Ferromagnetic flux diverter with a new raised-edge structure is introduced in this work for adjusting the magnetic field orientations near the two coil ends, so as to maintain the easy-to-wind solenoid structure and enhance the critical current simultaneously. A 100-m-long 12-mm-width GdBCO tape assembly is used to design and wind a mini-size SMES magnet. FEM simulations and analyses of critical current improvements with one/two diverters at each end are presented. The results demonstrate the merits of raised-edge diverter for improving the critical current and energy storage capacity in such a mini-size SMES magnet for high-power applications.

II. Basic Principle

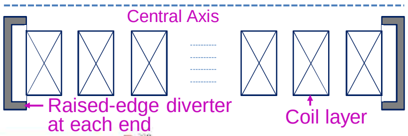
Anisotropic magnetic field dependence at 77K

$$I_c(B_{//},B_\perp)=I_{c0}\times\left(1+\frac{\sqrt{¥^{-2}B_{//}^2+B_\perp^2}}{B_1}\right)^{-~}$$

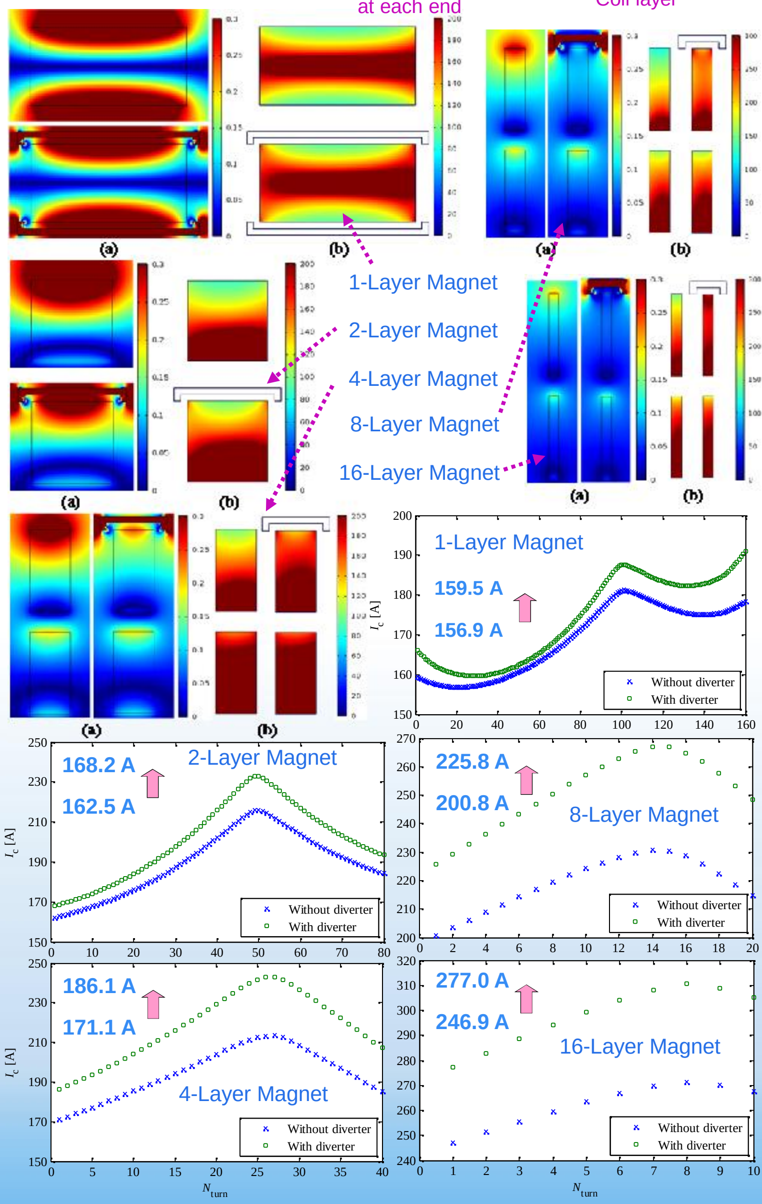
FEM modeling and simulation:
-COMSOL Multiphysics 4.3b
-multi-turn coil domain feature
-Each layer is modeled as a homogenized current-carrying bulk



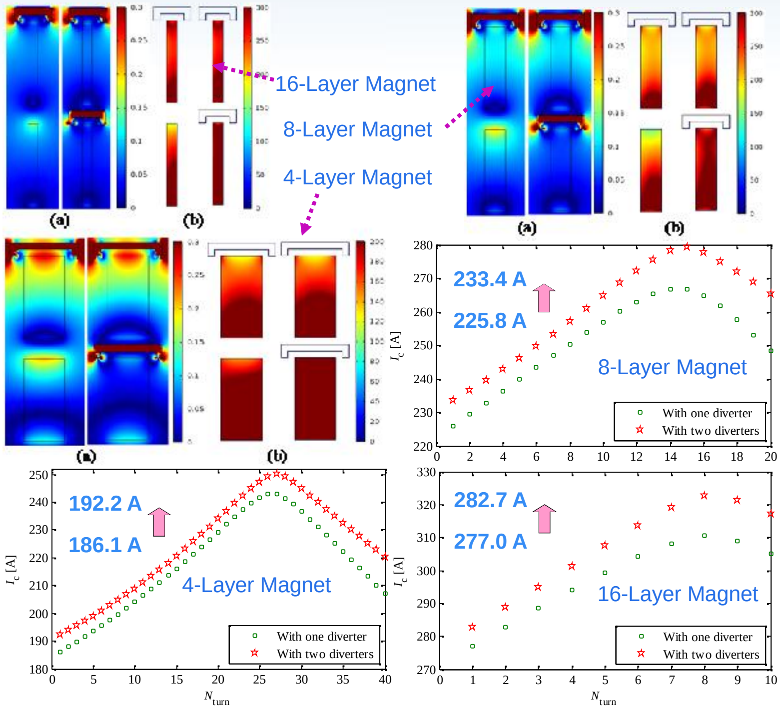
A 0.2H HTS solenoid case



III. With One Diverter



IV. Critical Current Improvement With Two Diverters



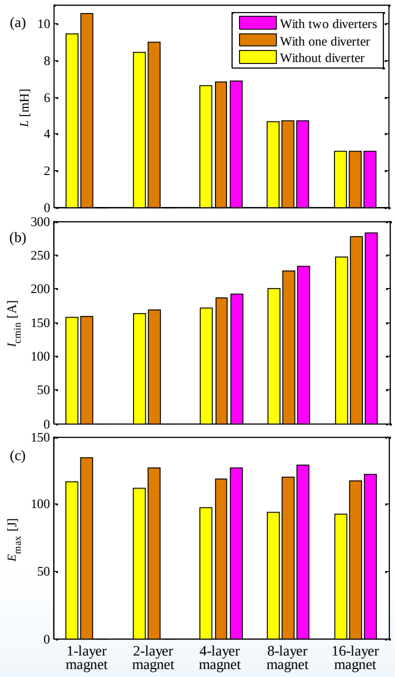
V. Influences of Diverter on Energy Storage Performance

1) With the increase of number of layers in one air-core magnet, both the self inductance and the maximum energy storage capacity are reduced, while the minimum critical current is improved.

2) When one or two disks is/are added, the self inductance has a certain increase, and the minimum critical current is found to be further improved.

3) When one or two disks is/are added, the maximum energy storage capacities have very small changes even with different coil layers.

4) When three or more disks are added, the minimum critical current has a very very slight increase, i.e., from 282.7A to 283.0A in a 16-layer magnet.



5) When the required output current and power to external system are relatively large, the available energy that can be output increases as the number of layers increases. For instance, it is increased from 15.52J in a 1-layer magnet to 87.85J in a 16-layer magnet. This means that a thin and long SMES magnet with the proposed diverter more suitable for high-current high-power applications compared to thick and short magnet having the same tape usage.

282.7 A
159.5 A
87.85 J
15.52 J

L	I_c	E_c	$E_{use}(I_{rated}$=150A)	$E_{use}(I_{rated}$=100A)	$E_{use}(I_{rated}$=50A)
0.0105	**159.5**	**134.3**	**15.52**	81.51	121.10
0.0089	168.2	127.2	26.04	82.25	115.98
0.0069	192.2	127.2	49.74	92.79	118.63
0.0047	233.4	128.8	75.61	105.17	122.91
0.0031	**282.7**	**122.3**	**87.85**	106.98	118.45