Contribution ID: **572** Type: **Poster Presentation**

Computational Investigation of Superconducting Magnetic Energy Storage (SMES) Devices to Optimize Energy Density

Monday 10 July 2017 14:00 (2 hours)

Superconducting magnetic energy storage (SMES) devices offer attractive and unique features including no theoretical limit to specific power, high cycling efficiencies and charge/discharge rates, and virtually no degradation with cycling. The mass-specific energy density (MSED) of SMES systems; however, falls short of many needs. This paper examines SMES energy densities of solenoid-type magnets for YBCO, MgB2 and Nb3Sn wires using present-manufactured wires and future advancements predicted from lab samples. Scaling of maximum energy density with the stored energy, length of the conductor and radius of the bore were established with numerical simulations, and studied for a range of stored energies from 0.1 MJ to 250 MJ and operating temperatures of 4.2, 18, 40 and 65 K. With dependence of critical current on field taken into account, the optimum magnet design for varying superconducting wires also including H//c is a pancake coil with scaling of energy density ε ˜ Eˆ1/3. Thus, current and magnetics limits achievable ε only at a fixed E. The overall limit on ε is also imposed by the virial theorem. Without additional structural support ε of SMES magnets is limited to ˜ 30Wh/kg. However with introduction of light-weight and strong support materials the upper limit MSED of SMES is expected to exceed that of the best batteries ε ˜ 150 Wh/kg.

Acknowledgments: Air Force Office of Scientific Research (AFOSR) and The U.S. Air Force Research Laboratory, Aerospace Systems Directorate (AFRL/RQ).

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Session Classification: M1PoA - Focused Symposia - Propulsion III: Materials, Technologies, Drivetrain Machines