ACCELERATION OF HIGH TEMPERATURE SUPERCONDUCTORS USING PULSED MAGNETIC FIELD

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In this contribution, we investigated the behavior of a type II superconducting armature when accelerated by a pulsed magnetic field generated by a single-stage pancake coil. While conducting this investigation, we performed a numerical finite element simulation and an experimental study of the magnetic field dynamics at the edge of the pancake coil when the payload was a superconducting disc made from YBa2Cu3O7-x, cooled down to 77 K. The magnetic field measurements were performed using a CMR-B-scalar sensor, which was able to measure the absolute magnitude of the magnetic field and was specifically manufactured in order to increase the sensor's sensitivity in the range up to 500 mT. The trajectory of the armature was also recorded during the experiments. The experiments were performed with several accelerating current pulse amplitudes. The system was modeled with quasi-static Maxwell's equations using the finite element method and treating the high temperature superconductor as a non-linear conductor with a power-law E-j relationship. The modeling results were compared to experimental data and were in good agreement in both the magnetic field dynamics and in the trajectories using realistic values of critical current density. This agreement validated the usability of the model and the system was investigated numerically beyond our current experimental capabilities. Furthermore, the performance of the superconducting armature was compared with the performance of normal metal armatures. It was obtained that type II superconducting armatures can outperform normal metals when the launch conditions are tailored to their electromagnetic properties. Superconductors perform best when slowly varying, comparatively low amplitude pulses are used, making them well suited to be employed in the traveling-wave coilguns as the magnetic diffusion is suppressed by the non-linear resistivity of these materials. Using type II superconductors in this type of coilguns would reduce some limitations imposed on normal metal armatures. This study was published in [1].

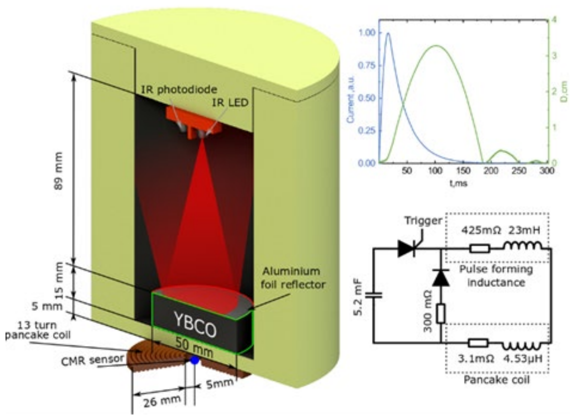

Fig. 1. Experimental setup (left). Normalized accelerating current pulse and typical trajectory of the superconducting armature (top right). Electrical schematic of the launcher (bottom right).

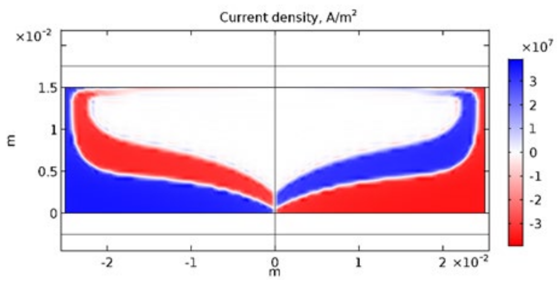

Fig. 2. Current density distribution inside the superconducting armature (j_c=3·10^7A/m) after the magnetic field pulse.

References

[1] Vertelis, V.; Balevicius, S.; Stankevic, V.; Zurauskiene, N.; Schneider, M. The Application of a CMR-B-Scalar Sensor for the Investigation of the Electromagnetic Acceleration of Type II Superconductors. Sensors 2021, 21, 1293. https://doi.org/10.3390/s21041293