MODIFYING THE PULSED-FIELD-MAGNETIZATION TECHNIQUE FOR HTS BULKS IN ELECTRICAL MACHINES AND WITHOUT MAGNETIC FIELD SENSORS

João Arnaud, João Fernandes, Paulo Branco, IDMEC

Center of Intelligent Systems

Motivation

Our research is focused on the magnetization process of high temperature superconductors (HTS) bulks inside electrical machines (in-loco) and the estimation of the its trapped field without magnetic sensors, using only the voltage and current waveforms.

Therefore, two objectives are pursued: firstly, the replacement of typical permanent magnets in electrical machines by HTS bulks, in order to increase the magnetic flux density, and secondly, to avoid the use of cryogenic sensors inside the machine, which may increase its cost and the airgap between the stator and rotor.

Approach

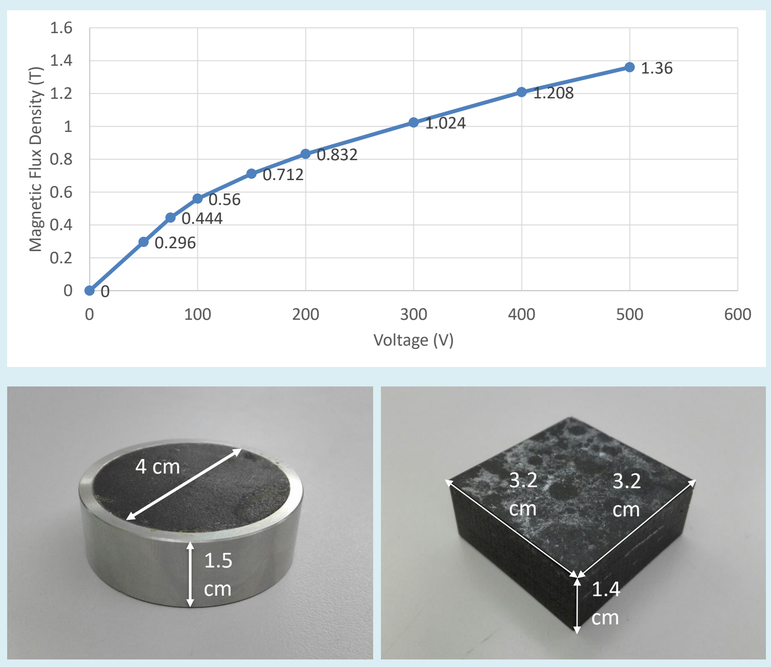
Several pulse field magnetizations (PFM) were performed for both YBCO and GdBCO bulks using an iron core to simulate the electrical machine magnetic circuit. For different amplitudes and rising and falling times of the pulses the trapped magnetic field was measured and estimated from the voltage and current waveforms (Faraday's Law).

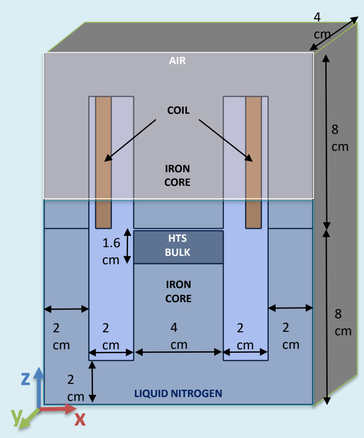
In parallel, several simulations 2D and 3D simulations were done, to better understanding of the PFM phenomenon and to simulate different scenarios from the ones experimentally done.

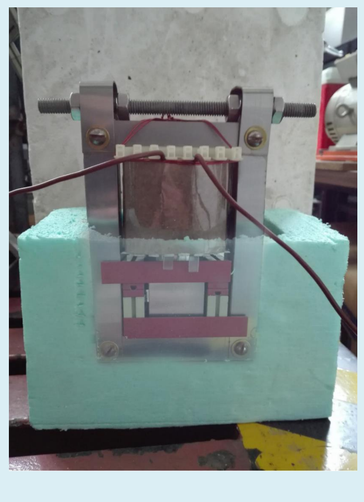
Results

EXPERIMENTAL SETUP

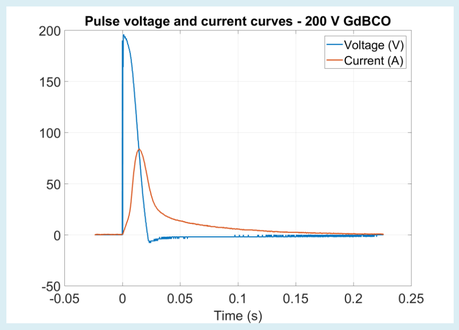
Coil	Pulse
N = 400 turns 1 mm Ø wire R = 1.571 Ω @ 20 °C L = 6.85 mH @ 20 °C	Rise time: From 10 to 30 ms.







TRAPPED FIELD RESULTS

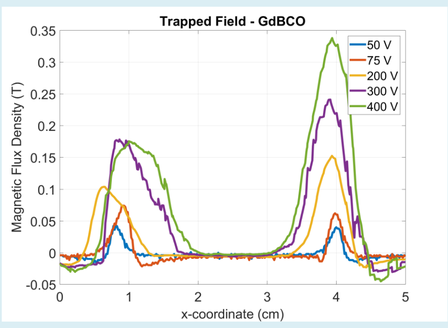


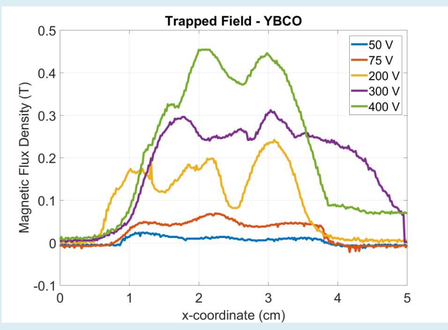
In either material, the dependency of the final trapped field with the amplitude of the applied pulse field is visible.

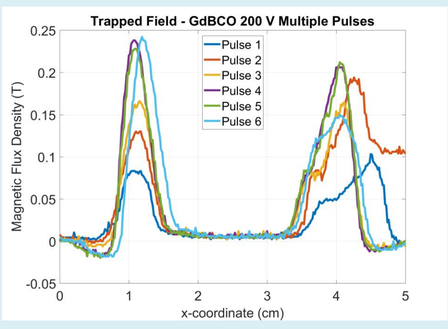
The YBCO can trap higher fields than the GdbCO bulk, for the same applied pulse, because it has a lower critical current density, which allows for higher penetration of magnetic field.

The maximum trapped field correlates well with the applied voltage, for the values obtained.

It was also observed an increase in the trapped field due to multiple consecutive pulses.







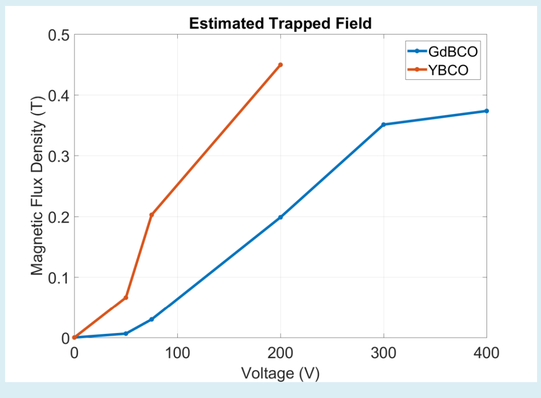
PFM SENSORLESS ESTIMATION

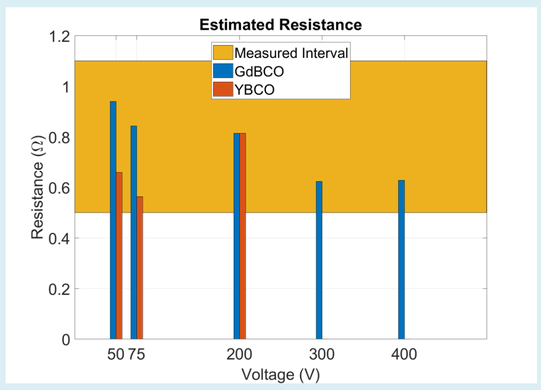
With the voltage and current waveforms, it is possible to estimate the average field in the iron core, in the area covered by the coil, and therefore, the HTS bulk trapped field reaching the windings.

The estimation of the trapped field is very sensitive to the resistance of the coil. Hence, as the resistance value varied due to the presence of the liquid nitrogen and it was not possible to measure it directly during the pulse, a FEM simulations were done to estimate its value and of the trapped field.

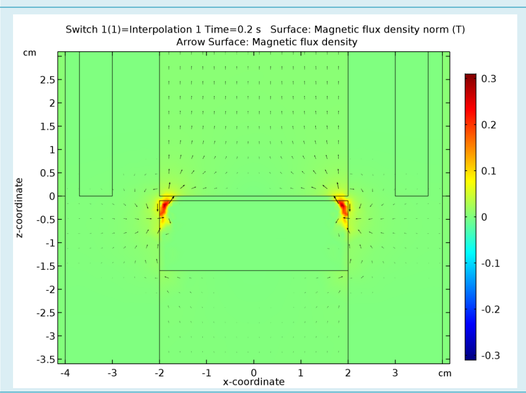
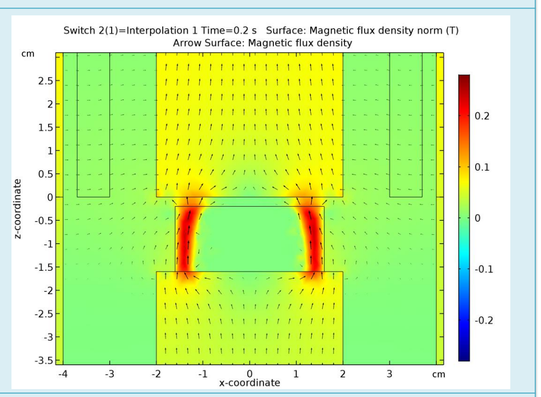
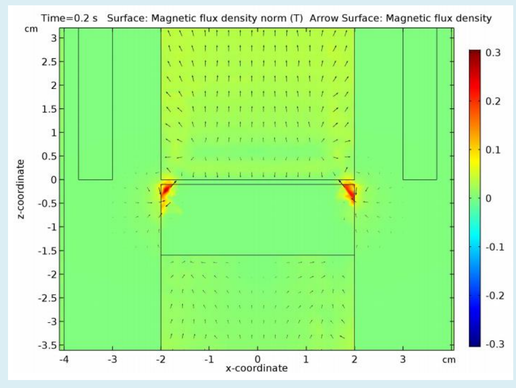
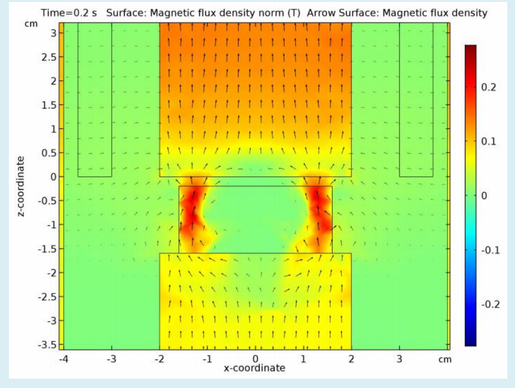
The simulations yielded resistance values consistent with those observed experimentally after the pulse, although showing trapped fields in the air gap higher than the experimental values.

To create a more accurate model, the thermal phenomena present during the pulse magnetization process will be taken into account in future works.





PFM SIMULATION RESULTS

50 V	GdbCO	YBCO
2D		
3D		

Acknowledgements

The GdBCO sample was gently provided by Nippon Steel & Sumimoto Metal Corporation.

This work was supported by FCT, through IDMEC, under LAETA, project PTDC/EEI-EEL/4693/2014.

Center of Intelligent Systems, IDMEC, LAETA, Instituto Superior Técnico

Av. Rovisco Pais, 1049-001 Lisbon, PORTUGAL, tel. +351 218417601

e-mail: csi@tecnico.ulisboa.pt, webpage: http://www.idmec.ist.utl.pt/structure_center_intelligent_systems_research