World Academy of Science, Engineering and Technology
International Journal of Computer and Systems Engineering
Vol:14, No:09, 2020

Hysteresis Modeling in Iron-Dominated Magnets Based on a Deep Neural Network Approach

Authors : Maria Amodeo, Pasquale Arpaia, Marco Buzio, Vincenzo Di Capua, Francesco Donnarumma

Abstract : Different deep neural network architectures have been compared and tested to predict magnetic hysteresis in the context of pulsed electromagnets for experimental physics applications. Modelling quasi-static or dynamic major and especially minor hysteresis loops is one of the most challenging topics for computational magnetism. Recent attempts at mathematical prediction in this context using Preisach models could not attain better than percent-level accuracy. Hence, this work explores neural network approaches and shows that the architecture that best fits the measured magnetic field behaviour, including the effects of hysteresis and eddy currents, is the nonlinear autoregressive exogenous neural network (NARX) model. This architecture aims to achieve a relative RMSE of the order of a few 100 ppm for complex magnetic field cycling, including arbitrary sequences of pseudo-random high field and low field cycles. The NARX-based architecture is compared with the state-of-the-art, showing better performance than the classical operator-based and differential models, and is tested on a reference quadrupole magnetic lens used for CERN particle beams, chosen as a case study. The training and test datasets are a representative example of real-world magnet operation; this makes the good result obtained very promising for future applications in this context.

Keywords : deep neural network, magnetic modelling, measurement and empirical software engineering, NARX
Conference Title : ICSEKE 2020 : International Conference on Software Engineering and Knowledge Engineering
Conference Location : Toronto, Canada
Conference Dates : September 21-22, 2020