Consideration of erroneous magnets in the electromagnetic field simulation

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***Abstract*—Permanent magnets (PM) exhibit manufacturing tolerances and can be erroneous. In field simulations of e.g. electrical machines such deviations are usually not considered. In this paper we want to develop a methodology to improve the simulations by considerung measured deviations of PM-materials.**

***Index Terms*—finite element method, magnetization errors, measurements, stochastics varations**

I. Introduction

Due to their manufacturing process arc segment magnets for the use in permanent-magnet synchronous machines (PMSM) may show deviations from their intended ideal magnetization. Using magnets with unfavorable error constellations in one rotor of a PMSM will result in a spatial unsymmetric air gap field, causing undesired parasitic effects as torque harmonics (comparable to the effects described in [1],[2]). Most manufacturer informations only contain the mean values of the magnetization as well as certain guaranteed error bounds, not stating if (and how) the magnetization will vary spatial over a set of magnets. Two methods allow to handle this difficulty - robust design (as in [3],[4]) or improved simulations. Therefore the emitted radial field of a set of magnets has been measured and compared to the assumed magneziation using finite element method (FEM) simulations in order to improve the magnet error simulation. The comparison results allow a more accurate error simulation by deducing possible magnetization errors from the measured field strengths, showing that stronger deviations often appear especially at the magnet borders (fig. 1).

II. Measurements

For measurements, the magnets are mounted into a cylindric frame which rotates around its symmetry-axis, moving the magnet on a circular arc under the used hall sensors. This allows to measure the radial component of the magnetic field above each magnet's surface. To avoid field detoriations by flux guidance all relevant test bench components have been crafted from aluminium.

III. Results

55 magnets with diametral magnetization were analyzed. Figure 1 exemplarily shows the temperature compensated hall voltage of the radial flux component for three magnets in dependence of each magnet's angle. Comparisons with FEM-simulations of a magnet having an ideal diametral magnetization show that magnet 2 (continuous curve) is very close to the expected field. Most magnets as well show the expected magnetization in their middle. Significant variations appear towards the magnets borders, as depicted with magnet 1 and magnet 3. While magnet 1 (dotted) appears to have local magnetization error, magnet 3 (dashed) seems to be overlaid by a slightly radial magnetization. Measurement reproducibility has been 3.5 percent deviation, resulting in a slight offset value or a shift to the left or right. This is likely to be attributed to a non-perfect positioning of the magnets in the mounting, but does not change the curve's shape.

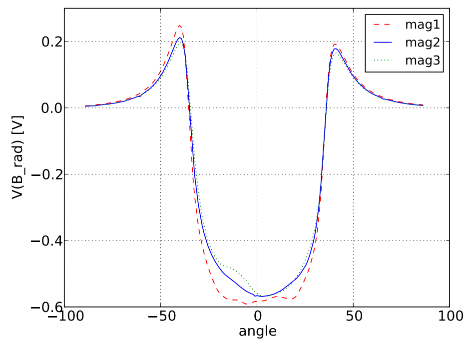

Fig. 1. Measured hall voltages of three magnets.

IV. Conclusion

Principal component analysis [5] of the measurements stresses the assumption, that relevant magnetization deviations appear towards the magnet's border. Next steps are the solution of the inverse problem, to calculate the magnetization from the measured field as well as introduction of probabilistics into the model which will be described in the full paper.

References

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