Design of a Single Sheet Tester coils' windings for the magnetic, electric and mechanical measurements of magnetized electrical steels and soft magnetic materials

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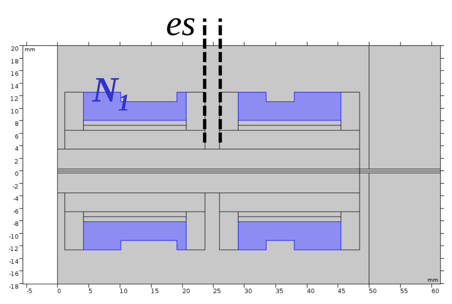
Introduction: This work aims at optimizing the design of a non-standard Single Sheet Tester (SST) dedicated to the magnetic measurements of 30*280 and 150*150 mm samples. In parallel, we would like to carry out complementary physical measurements. While measuring an average magnetization within the sample, it should be possible to measure: the surface magnetic field with field sensors, the electrical conductivity with the two or four terminals sensing method and the linear mechanical stresses, vibrations and noise with accelerometers, a laser vibrometer or/and a microphone.

Specifications: We must have access to the sample, inside the coils' opening, with measuring wires and other thin sensors. The air-gap space between the sample and the coils' windings must be increased and divided in several parts separated by small slots. We must guarantee the following performances: 1) $H_{max} > 5\ 000$ A/m, 2) $\Delta H/H < 0.5$ %, 3) $f \geq 1000$ Hz saturation polarization up to 2 T, knowing the limitations of the generator ($I_{max} = 26$ A, $V_{max} = 100$ V, $f_{max} = 20$ kHz)

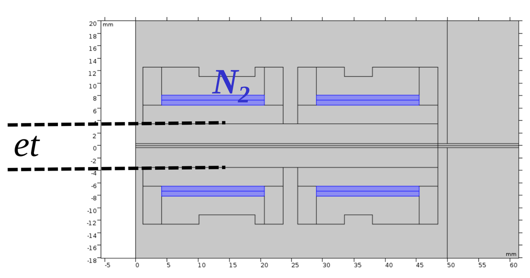
Modeling[a]

name	value	description
et	7 mm	height of sample area
es	7/3 mm	width of spaces between coils parts
N_1	? n.u.	**number of turns in primary (11 turns per coil and per layer)**
N_2	? n.u.	**number of turns in secondary (20 turns per coil and per layer)**
S	depends on sample	cross-section of sample
Smax	150**et*/2=150*3.5 mm²	maximum cross-section of sample
lm	100 mm	length of magnetic path

Primary coil, generation of H

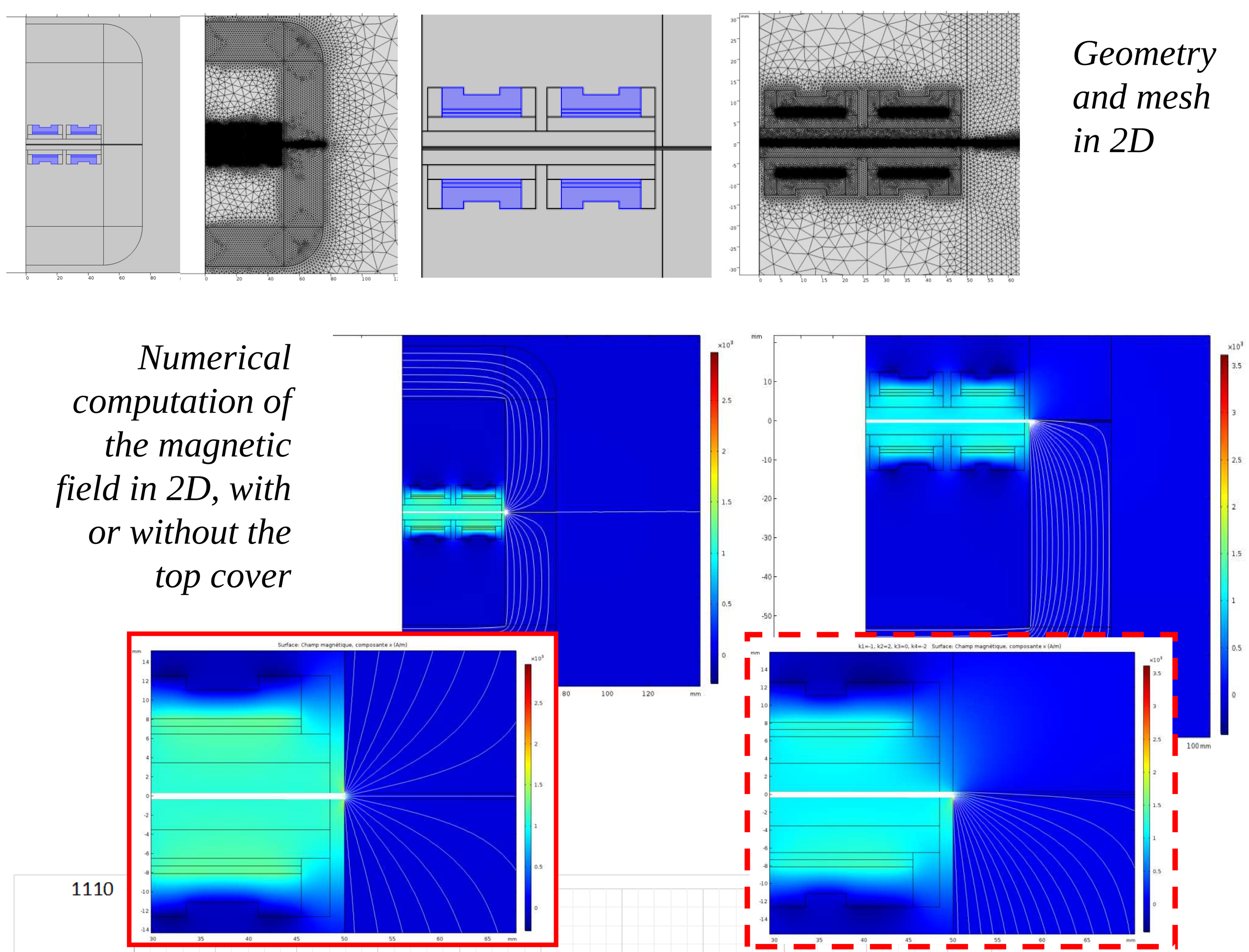


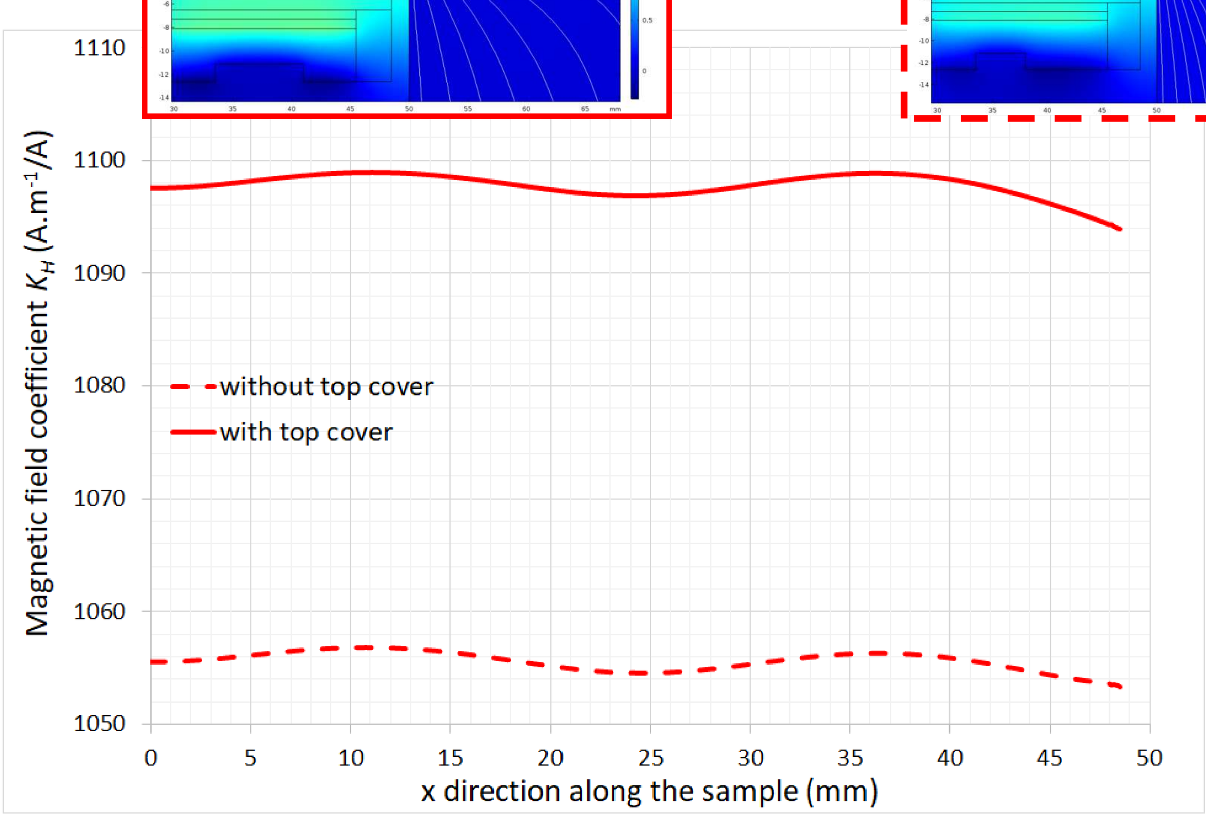
Secondary coil, meas. of B



Geometry and mesh in 2D

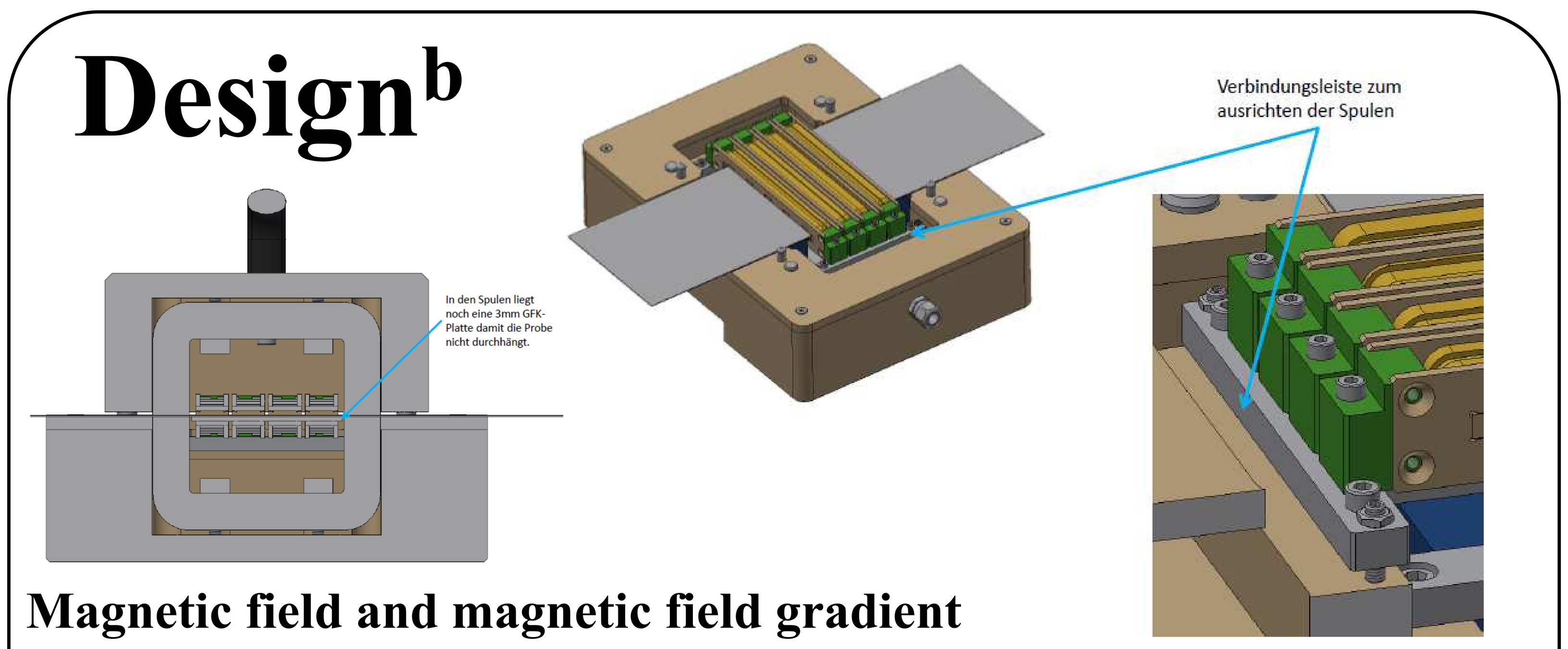
Numerical computation of the magnetic field in 2D, with or without the top cover





Computation of the magnetic field along the sample surface with or without the top cover

Design[b]

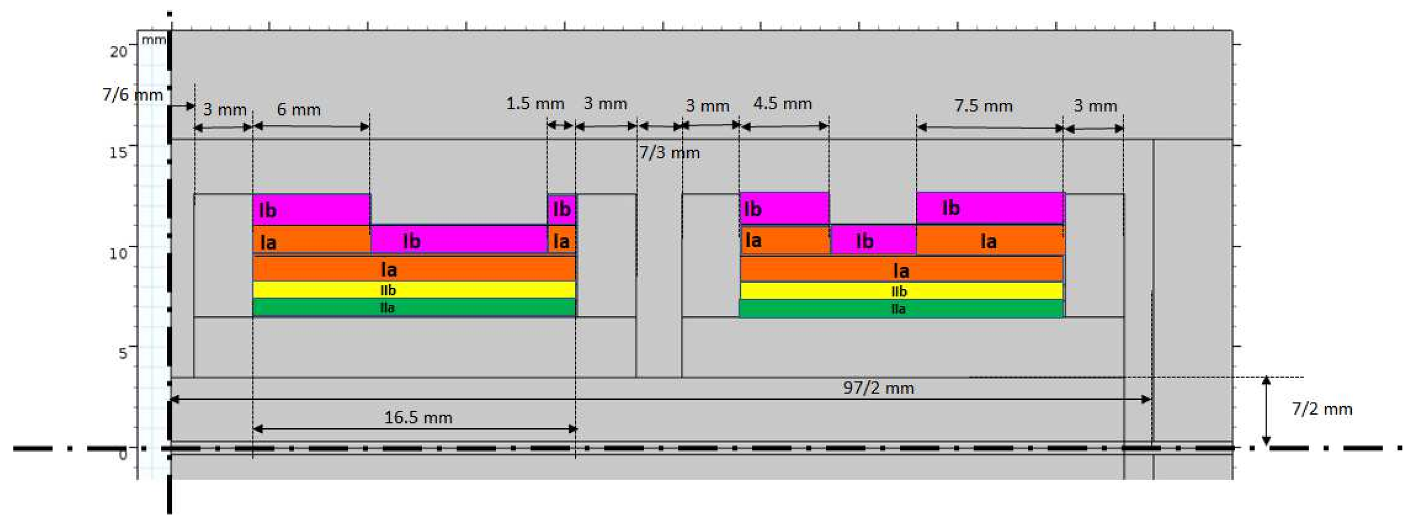


Magnetic field and magnetic field gradient

I: 11 turns per coil and per layer. 88 turns in 1st and 2nd layers. 26 turns in 3rd layer (total = 114 turns). Design of two separate coils: coil (Ia) in the 1st and 2nd layer (70 turns) and coil (Ib) in the 2nd layer and 3rd layer (44 turns) to be connected in series.

Frequency range and Accuracy

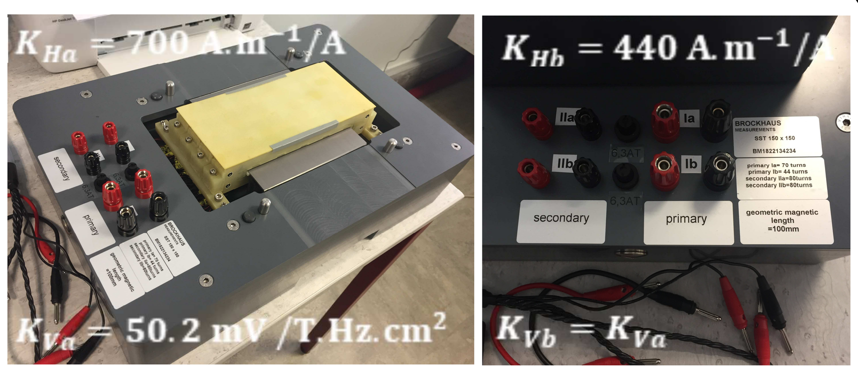
II: 20 turns per coil and per layer in secondary (total = 160 turns). Design of two separate layers: use of one layer (IIa) (80 turns) or two layers (IIa+IIb) (160 turns) in series for the measurement secondary coil.

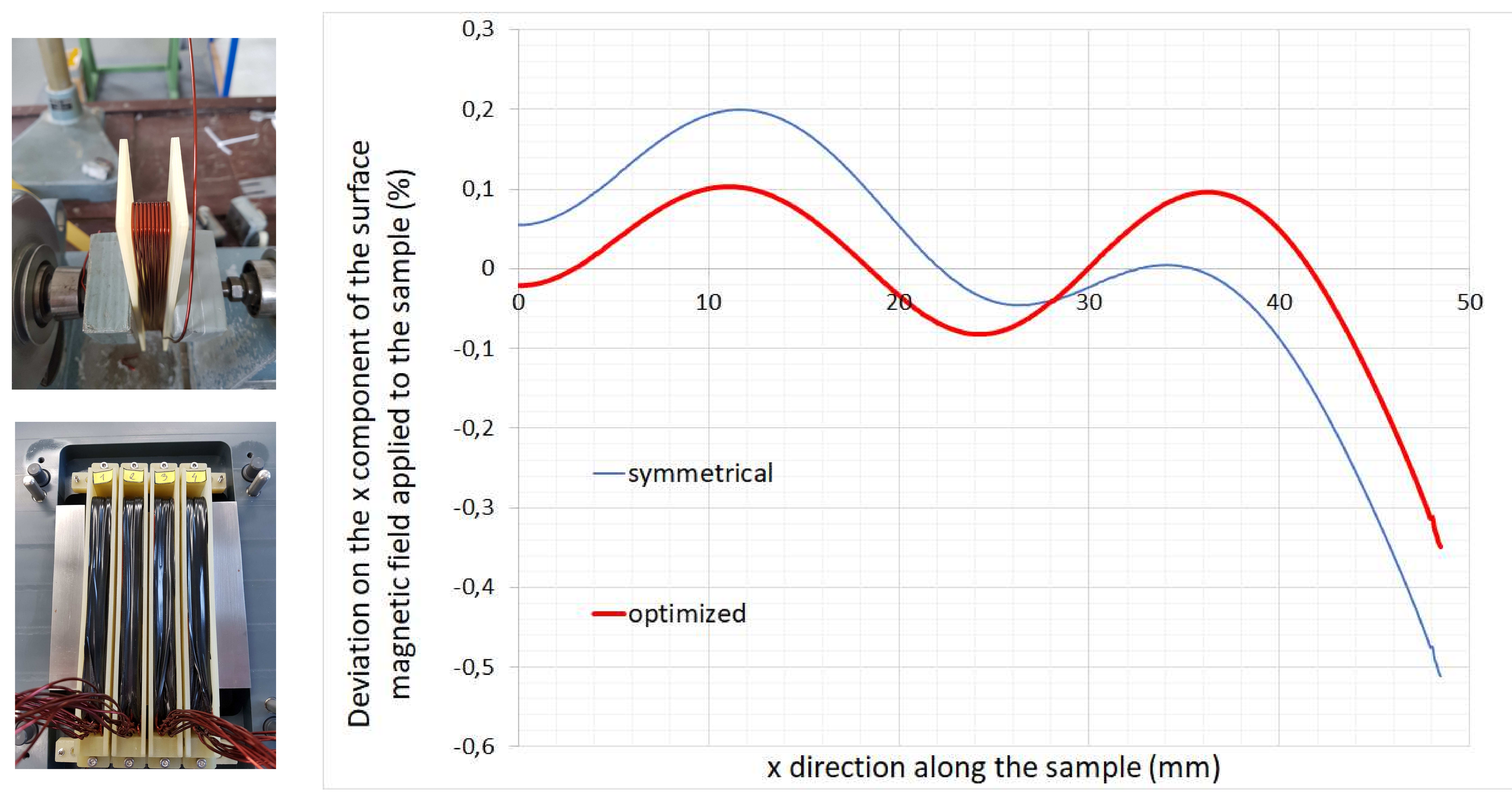


Results

$$K_H = \frac{H}{I} = \frac{N_1}{l_m} = 1140\ \mathrm{A.m^{-1}/A}$$

$$K_V = \frac{V}{fSB} = 2\pi N_2 = 0.1\ \mathrm{V/T.Hz.cm^2}$$





Conclusion:

The magnetic field coefficient is ***1140* A/m per Ampère**. The max. rms value is *7170* A/m corresponding to 6.3 A rms.
The max. peak value of the magnetic field is thus H_{max} **= *13656* A/m** corresponding to I_{max} **= *12* A peak**
The maximum relative field difference between the centre and the edge is respectively 0.5% and 0.3%.

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[b]The tester has been manufactured by BROCKHAUS MEASUREMENTS.