An interaction between electromagnetic field and materials: characterization of shields for automotive electromagnetic compatibility applications

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INTRODUCTION: The AC/DC module of COMSOL Multiphysics is used to study two 2D and 3D applications:

1. Magnetic shielding effectiveness of conducting materials is computed. Simulation results are used to verify a pre-established electrical homogenization model for composite materials in the automotive industry.
2. Parametric studies are conducted over a wireless power transfer setup consisting of two coils and two ferrite plates. Results are analyzed to establish a metamodel describing the studied system.

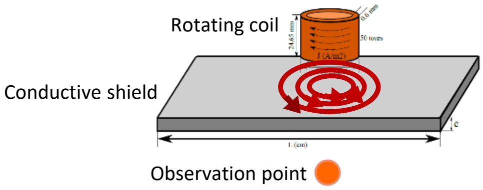

Figure 1. Magnetic shielding application

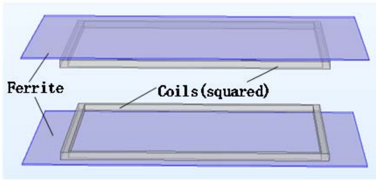

Figure 2. Wireless power transfer application

COMPUTATIONAL METHODS: Maxwell's equations are solved with a low frequency hypothesis. A particular attention is paid to the mesh: a solution mixing different types of geometrical elements is used for mesh generation to obtain an accurate solution in thin regions. More specifically, 'boundary layers' are used to take skin effect into account when meshing the shields.

1. MAGNETIC SHIELDING EFFECTIVENESS:

- Two configurations are studied: coil parallel to shield and coil perpendicular to shield. This is helpful for dealing with anisotropic materials.
- Finite element computations are validated experimentally using a near field test bench.
- A demonstrator has been developed using 'COMSOL Application' with a parameter sweep possibility.

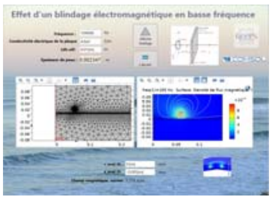

Figure 3. COMSOL application for magnetic shielding

RESULTS: Figure 4 shows a good agreement between simulation and experimental results for aluminum and copper shields. Both parallel and perpendicular configurations are tested.

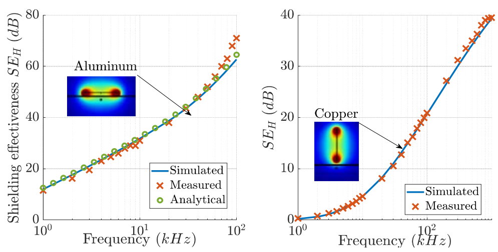

Figure 4. Magnetic shielding effectiveness for metallic plates

2. WIRELESS POWER TRANSFER:

- The studied configuration consists of two coils parallel to the ferrite. This is helpful for computing the mutual inductance between the studied transmitter and receiver in case of a misalignment along the X axis.
- Results obtained using COMSOL (parametric sweep takes 30 mins) can be used to build a metamodel (1 s) in order to save computational time.

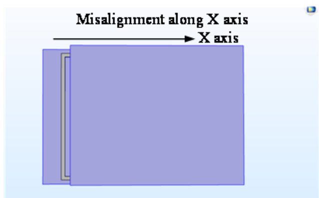

Figure 5. Misalignment along X axis

RESULTS: Figure 6 shows that when a misalignment along the X axis happens, the mutual inductance decreases. This is caused by magnetic flux leakage and the direction of the magnetic flux.

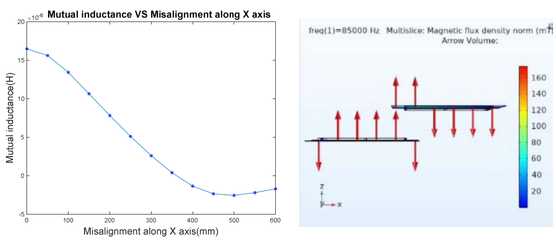

Figure 6. Mutual inductance when misalignment along X axis happens

CONCLUSIONS:

1. A simulation model used to compute shielding effectiveness of conductive plates is implemented using COMSOL. The model remains to be tested for anisotropic materials.
2. A COMSOL based simulation is conducted to build a metamodel of a power transfer system, which can be more comprehensive by varying more parameters and using cluster computing. Simulation results remain to be verified experimentally.

REFERENCES:

[Al Achkar *et al.* 2020] G. Al Achkar, L. Pichon, L. Daniel, N. Benjelloun: Effective electromagnetic properties of woven fiber composites for shielding applications, IEEE Transactions on Electromagnetic Compatibility, 62(4) : 1082-1089, 2020.

[Pei 2020] Pei, Y., Pichon, L., Bensetti, M., & Le-Bihan, Y. (2020). Uncertainty quantification in the design of wireless power transfer systems, Open Physics, 18(1), 391-396.