Errata 2

Models of magnetism in electrical machines
Gustav Mörée, Uppsala university, 2023-04-19
Thesis for the degree of doctor of philosophy
Faculty of Science and Technology 2248

Chapter 9.2 and 9.2.1: It should be noted that there is no force density distributed in the area surrounding the conductors, and the force density is located in the current density. This is not clear in the simple example.

The distribution of the force density is very similar when comparing Maxwell stress tensor and the Lorentz force. The only difference is that the divergence of Maxwell stress tensor is also including the change in electromagnetic momentum (which is similar to a force). That is

$$\nabla \cdot \overleftrightarrow{\mathbf{T}} = \boldsymbol{f} + \mu_0 \varepsilon_0 \frac{d\boldsymbol{S}}{dt}$$

The Lorentz force density (for magnetism) is $\boldsymbol{f} = \boldsymbol{J} \times \boldsymbol{B}$, while the force density by the (magnetic part of the) stress tensor is

$$\nabla \cdot \overleftrightarrow{\mathbf{T}} = \left(\boldsymbol{J} + \varepsilon_0 \frac{d\boldsymbol{E}}{dt} \right) \times \boldsymbol{B} = \kappa \frac{B^2}{\mu_0} - \nabla_\perp \frac{B^2}{2\mu_0}$$

The actual location is not changed between the two equations, since the force density distribution is still located in the current density. It is instead that the change of electromagnetic momentum is contributing with another term. This additional term is however not included in the simple example.

Chapter 10.5: Computation of magnetic fields in electrical machines is usually not including alternating electrical fields (i.e. $\varepsilon_0 d\boldsymbol{E}/dt = 0$), and only including current density and magnetization (i.e. only $\nabla \times \boldsymbol{B}/\mu_0 = \boldsymbol{J}$). So that the force density is either located in a current density ($\boldsymbol{J}$) or a equivalent current density ($\boldsymbol{J}_m = \nabla \times \boldsymbol{M}$). Alternating electrical fields ($\varepsilon_0 d\boldsymbol{E}/dt$) could appear outside objects, but the current density and the magnetization is only within objects.

The enclosing volume integral could then be chosen arbitrary between a rotor and a stator (when the airgap is assumed to be similar to vacuum). This enables the use of methods based on an average value of several enclosing volumes at different radius in the air gap.

Chapter 11: There are some differences regarding the energy flux density (when comparing $\boldsymbol{S}$ vs. $\boldsymbol{S}_N$) compared to the force density (when comparing $\boldsymbol{f}$ vs. $\nabla \cdot \overleftrightarrow{\mathbf{T}}$). The energy flux density has a changed location because of an additional term, while it still gives the same energy transfer. The location of the force density is not actually changed in Maxwell stress tensor, since it is including an additional term (the change in electromagnetic momentum, which is similar to a force).