

## Axial-Field Eddy-Current Couplings: a 3D Test Problem for Numerical Experiments

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This paper deals with an application which is particularly relevant to test 3D quasi-static magnetic numerical computations: axial eddy-current couplings. It consists in two rotors, a driving and a driven one. The driving rotor is made with a ring of magnets, alternating north and south poles, glued on an iron yoke. The driven one is constituted by only a copper ring and another yoke (see Figure 1). The rotating permanent magnets induces eddy currents in copper, producing an electromagnetic torque and the rotation of the copper side. The phenomena are analogous to those existing in an induction machine (T. Lubin, A. Rezzoug “Steady-State and Transient Performance of Axial-Field Eddy-Current Coupling”, in IEEE Trans. Ind. Electron, vol. 62(4), pp. 2287-2296, 2015).

This application is a really interesting test case because of the following advantages:

1. Its geometry is purely 3D but simple. It can be meshed with structured or unstructured grid and includes anti-periodic symmetries.
2. The eddy currents due to movement can be treated without remeshing.
3. There are two kinds of field sources: magnets and eddy-currents.
4. The simplicity of the device permits to easily build prototypes and to obtain experimental measurements needed to validate computational results.

The authors had performed several numerical FEM computations on this particular device. The eddy currents problem is solved thanks to two classical formulations based on magnetic vector and scalar potentials, i.e.  $(\mathbf{a}, v)$  and  $(\mathbf{h}_e, \phi)$ . The general GPL solver GetDP had been chosen because it really suits to our weak formulations (P. Dular and C. Geuzaine, “GetDP reference manual: the documentation for GetDP, a general environment for the treatment of discrete problems”, <http://www.geuz.org/getdp/>). A comparison between these two formulations has been performed. Problems can be solved both considering a linear  $b(h)$  relationship, or a more realistic curve. A special focus is put on the electromagnetic torque evaluation thanks to three post-processing computations: Laplace forces (L-F), average Maxwell stress tensor in the airgap (M-T), and global Joule losses (J-L). Results are compared with experimental measurements made on a magnetic transmission already designed and built by ourselves. A non-linear example is given in table 1; in all cases, numerical results are closed to the real values (relative errors between 1.5 and 9 %).

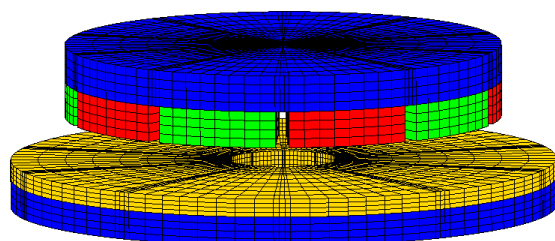


Figure 1: Geometry and mesh (example)

Table 1: Example of results (slip speed: 140 rpm)

Method	Torque (N·m)	
	$(\mathbf{a}, v)$	$(\mathbf{h}_e, \phi)$
L-F	8.886	8.256
J-L	8.802	8.255
M-T	8.667	8.318
Measures	9.02	