Design of an actuator based on the Thomson effect.

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Introduction

Good limitations of the current in a circuit using an electromechanical breaker suppose a very fast opening of the contacts. Due to the fact that the electrodynamic repulsive forces do not generate enough acceleration, an actuator has to be used to improve the breaker performances. Since a traditional reluctant magnetic device is too slow for the application concerned, a propeller based on the Thomson effect has been chosen. FLUX2D simulations make possible a good understanding of the propeller's operation and thus the improvement of its design. The ergonomics brought by Solver2D and Postpro2D modules of the last FLUX2D versions makes it possible to effectively perform parametric studies, which help the designer to carry out a fast dimensioning of the device.

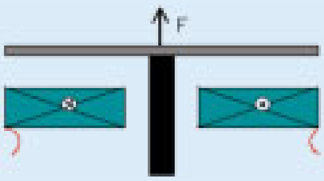

Figure 1: Description of the device based on the Thomson effect.

The Thomson effect

Figure 1 shows an actuator based on Thomson effect. High current time variations are generated in a coil by using a capacitive discharge. Induced currents are thus developed in a metal disk placed face to the coil. According to Lenz's law, these currents generate a magnetic flux, which is opposed to the one that has created them. As a consequence, a repulsion effect appears between the coil and the disk. Since the coil is fixed, the disk is propelled to the top and undergoes a high acceleration.

FLUX2D simulation

The propeller based on the Thomson effect we study is axisymmetric and therefore able for finite element analysis with FLUX2D. The magnetic transient regime characterises the operation of this actuator. That is why it is advisable to use a time-varying magnetic simulation, with translating air-gap feature and circuit equations taken into account. Indeed, the induced currents developed in the disk must

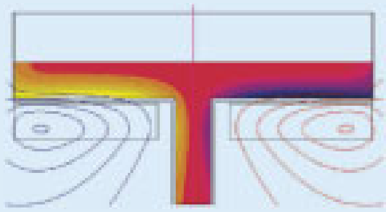

Figure 2: Magnetic flux lines and current density chart.

be correctly evaluated, since they are the very basis of the propeller operation. The motion of the disk with respect to the coil must also be taken into account, and this is possible by using the translation air-gap feature of FLUX2D. Our case is slightly particular, as shown in figure 2, due to the shape of the considered moving part. In such a case, the user should pay attention to the evolution of the mesh during the simulation, especially in the lower part of the displacement zone. The stranded type coil of the actuator is connected to an external electric circuit. The coupling with the circuit equations allows the simulation of the capacitive discharge.

Multi-parametric study

The total volume of the actuator, the capacity value and its initial voltage, the peak value of the current in the coil or the response time of the device are as many significant quantities for dimensioning. Parametric studies allow the user to analyse the interactions between these parameters. For example, as figure 3 shows, the influence of the capacitor parameters on the time response can be studied. Geometrical parameters such as the initial air-gap between the coil and the disk or the thickness of the disks can be also investigated.

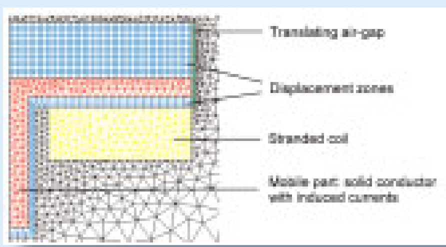

Figure 3: Mesh of the geometry. A particular case of using the translating air-gap.

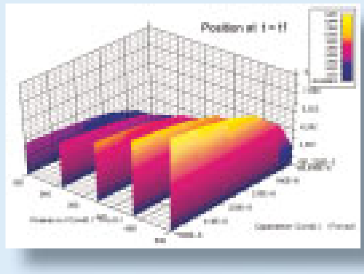

Figure 4: Influence of the capacity on the response time.

Energy balance

Figure 4 proposes a representation of the energy balance for the study of such electromechanical devices. It gives an idea of how the energy provided initially by the capacitor is distributed in time. It can be noted that the propeller based on the Thomson effect has a very weak efficiency, of about a few %. This is the price paid to obtain a quick movement of the mobile part.

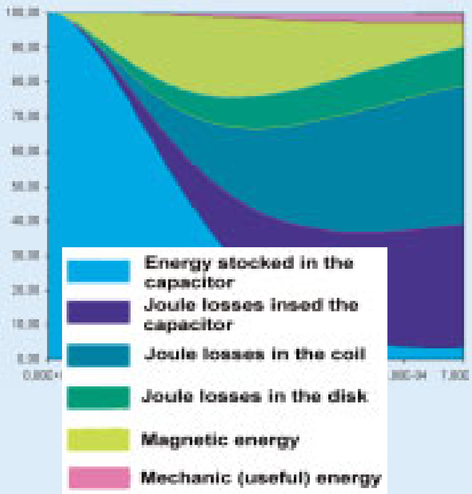

Figure 5: Distribution of energy in the device vs time.

Conclusion

FLUX2D allows the accurate simulation of devices based on the Thomson effect. The parameterization tools offered by Solver2D allows the user to carry out the sensitivity analysis with respect to various design parameters – geometrical, electric or physical. To go further in the design process, it would be necessary to include this parameterization in experimental plans or optimisation algorithms.