FLUX Version 8.1: 3D linear and rotating motion.

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The dynamics of 3D contactors has been one of the main development lines for the FLUX 8.1 version.

Two essential issues have been implemented:

- The translation movement with respect to an axis,
- The rotation movement of a non-cylindrical part with respect to an axis.

Equations and Use of FLUX

Thus, 3D models of contactors, taking into account the movement of mobile parts in rotation can be described in FLUX, considering the following dynamic equation:

$$j\,\ddot{\beta} = \Gamma_e - \Gamma_f$$

with $\Gamma_f = \Gamma_{f\_self} + \Gamma_{f\_exter}$,
and $j = j_{self} + j_{exter}$

where:

β : angular position (or linear position, respectively, in the case of a linear movement)
$\dot{\beta}$: angular speed (or linear, respectively)
$\ddot{\beta}$: angular acceleration (or linear, respectively)
j_self : moment of inertia (or mass, respectively) of the mechanical set
j_exter : moment of inertia (or mass, respectively) of the external load
Γf_self : friction torque (force, respectively) of the mechanical set
Γf_exter : friction torque (force, respectively) of the external load
Γ_e : electromagnetic torque (force, respectively)

The user can choose from among three types of models:

- **Multi-position models :**
The varying parameter corresponding to the position (angular or linear) can be modified and varied as any other varying parameter. This allows for the modeling of a contactor for different positions of the mobile magnetic core

- **Models with imposed speed:**
The displacement speed of the mobile part is defined by the user, who can set it to a constant or variable value, function of the values of other parameters such as the time, the kinematic parameters or any other varying parameter.

- **Models with "coupled load" :**
As its name indicates, this type of models takes into consideration the mechanical coupling of an external load to the studied device. In fact, there is an electromagnetic torque (or force, in the case of linear movement) exerted on the mobile part, which creates the movement. In this case, the equation above is solved taking into account the friction, the inertia (or the mass, respectively), as well as the initial position and speed of the mobile part. Each of these values can be defined by a constant or even as function of any other varying parameter of the model. Besides, the frictions being complex enough, they can be defined

- either by 3 coefficients such as:

$$\Gamma f_{\text{-exter}} = f_0 + f_1\,.\,\dot{\beta} + f_2\,.\,\ddot{\beta}^2$$

with f_0, f_1, f_2 as the torque (or force, respectively) coefficients of dry viscous friction and as function of the square value of the speed.

- or by varying parameters that can be defined by means of a table (see page 11).
- or by formula.

3D model.

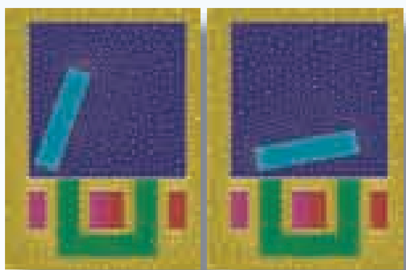
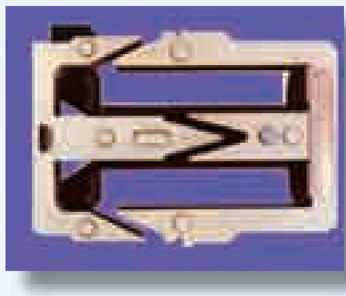


Figure 1: Rotation of a non cylindrical part. 2D section of the 3D model.

Compressible zone and automatic re-mesh

When a non-cylindrical part is in a rotation or translation movement, with contact possibility, the surrounding area of that part will be modified and therefore requiring be re-meshed. Thus, you have to define a zone that will be re-meshed at each variation step: this is the "compression zone", that surrounds the mobile part. The case of mobile parts in rotation movement is shown in the figure 1.
The compression zone is coloured in blue. The case of mobile parts in translation movement is shown in the figure 2.



Contactor modelled (Schneider Electric).

3D mesh of the contactor.

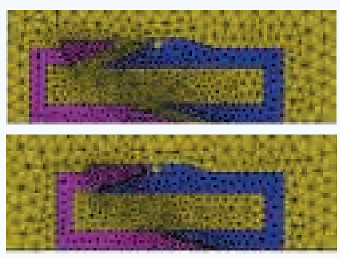


Figure 2: Translation of mobile parts. Re-mesh of the compression zone function of the position of the mobile part (2D cross section).

(continued on page 16)

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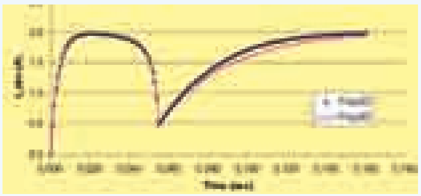
Validation of the models

These models have been developed and validated in cooperation with Schneider Electric.
One validation consisted in the comparison of results obtained in a 2D plane case to the corresponding 3D ones. It refers to the well-known contactor by the participants in the magnetism training course (figure 1).

Electrical circuit associated at the problem

The positions of these two cases have then been compared.

2D/3D comparison of the position of blade.



Comparison of the current in the coil Vs time.

Other tests have been carried out on industrial devices, such as a bistable of Schneider Electric. The results obtained with FLUX correspond to the experimental results obtained for the real device (figure 3).

Conclusion

All the possibilities of kinematics coupling of the rotation type for cylindrical parts can now be found

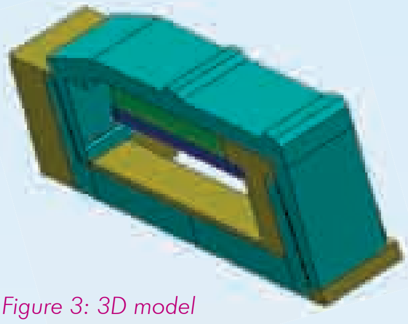
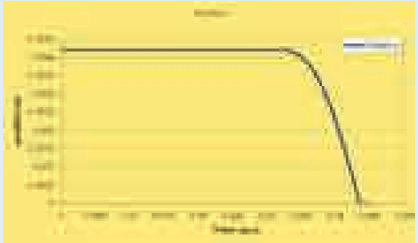


Figure 3: 3D model of the contactor.

in two supplementary cases in 3D modeling:

- Rotation of non-cylindrical parts,
- Translation of any type of parts.

Discover now those new modules! You have no excuses any longer: 3D is lending you a helping hand in order to model your actuators !!



Closing time of the bistable with electrical circuit and kinematic (coupled load) coupling (FLUX results)

Current in the coil of the contactor (FLUX results).

Iron losses in FLUX.

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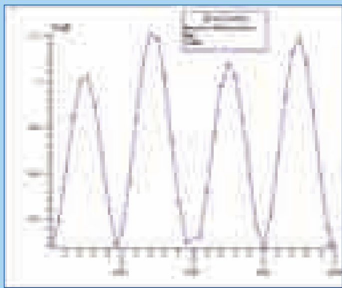
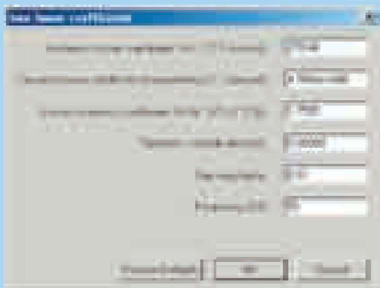
Since 1997 and 7.30 version, iron losses can be computed in the standard version of FLUX2D.

The law governing the calculation in time transient is the following (see below).

Once given two coefficients (k_h et k_e, the rest being already known once the model of the device is created) that are defined with the losses data as function of frequency and flux density given by the manufacturers, FLUX2D compute the iron losses accounting for the three components : hysteresis, classical and excess losses. PostPro2D interactivity does the





$$\frac{1}{T}\int_0^T dP_{iron}(t)\,dt = k_h B_m^2 f k_f + \frac{1}{T}\int_0^T\left[\sigma\frac{d^2}{12}\left(\frac{dB}{dt}(t)\right)^2 + k_e\left(\frac{dB}{dt}(t)\right)^{3/2}\right]k_f\,dt$$