CADFEM Consulting

Stick-Slip and Other Friction Induced Vibrations

Investigation of the Relevant Excitation Mechanisms for an Electric Sliding Contact

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Task

Self-excited friction induced oscillations occur in different engineering applications. Prominent examples are annoying noise problems like squealing breaks, squealing railway wheels or squeaking door hinges. Moreover, the same mechanism may even lead to functional failure due to the inherent instability of the vibrations. For instance an electric sliding contact (Fig. 1) must rely on a steady sliding contact state without vibration instabilities. That means the steady sliding state has to be stable with respect to small perturbations for the given set of friction parameters.

Solution

After having solved the initial stationary friction state in a nonlinear static contact analysis, some of the most important friction instability phenomena have been investigated:

- mode coupling instability: two originally separated modes coincide with increasing friction, exchanging energy so that one mode is damped and the other is excited. This is done by means of a complex modal analysis ac-counting for the unsymmetric stiffness matrix.
- stick-slip effect: an alternation of sticking and sliding phases leads to typical saw-tooth response (Fig. 2). A nonlinear transient analysis with adequate contact settings and a proper time step strategy is required.
- Negative damping for some modes due to the decreasing velocity dependent friction law (Fig. 4). A nonlinear transient analysis yields in-creasing harmonic response (Fig. 3).

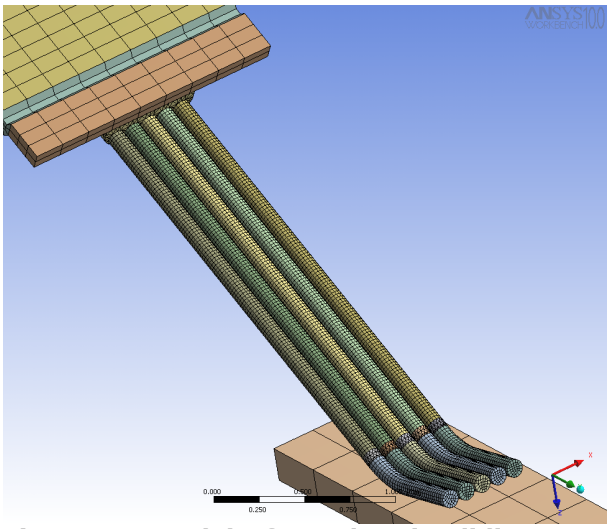

Fig. 1: FE model of an electric sliding contact. The thin wires are fixed at a plate spring (top) and sliding for the electric contact occurs between the curved beam ends and the moving rigid surface (bottom).

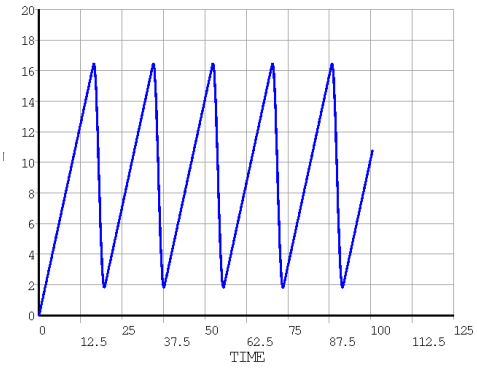

Fig 2: Typical saw-tooth displacement time response for stick-slip induced vibration.

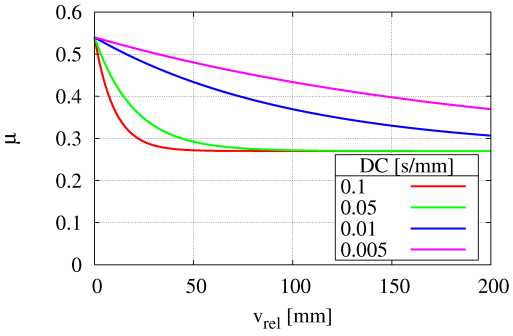

Fig. 4: Velocity dependent friction law for different exponential decay parameters DC.

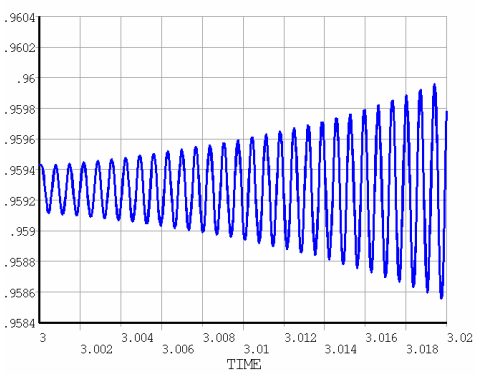

Fig. 3: Increasing harmonic vibration for decaying friction law.

Figures by Courtesy of Siemens Automation and Drives and Schleifring GmbH