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Simplified EHL contact model and its influence on nonlinear vibrations

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The influence of elastohydrodynamic lubrication (EHL) on the nonlinear vibrational behaviour of oscillatory systems is investigated. In order to calculate the normal contact force the transient EHL problem has to be solved numerically which is computationally extremely expensive. For an efficient calculation numerous simplifications have already been proposed but mostly for highly loaded contacts. However, highly nonlinear oscillatory behaviour appears mainly in weakly and medium loaded cases. To capture the entire nonlinear vibrational behaviour for all loading cases a new simplification method of the normal contact force is proposed.

The new simplified model for elastohydrodynamic line contacts consists of a series connection of a hydrodynamic and a Hertzian force element. For the purely hydrodynamic normal contact force a new curve fit is proposed which is in particular valid under transient conditions. The Hertzian contact is approximated based on an elastic halfspace. The combination of the two limiting cases leads to a model which shows excellent agreement with numerical results for a wide range of parameters and different types of excitation.

Due to the simplicity and compactness of the new EHL contact model, it allows for fast calculations. Thus it lends itself to investigations of large and complex mechanical systems with numerous EHL contacts. To demonstrate its applicability a 1-DoF oscillator with EHL contact is analysed. By means of numerical continuation techniques frequency response curves are calculated for different types of excitation: force, base and parameter excitation are applied. The latter implies variations of the radius and the hydrodynamic velocity. The system exhibits rich nonlinear dynamic behaviour including jump phenomena as well as sub- and superharmonic resonances. It is found that the system's oscillatory behaviour resembles a softening type spring although the contact stiffness increases with increasing load.

Keywords: EHL contact, simplified model, validation, nonlinear vibrations