Bifurcations and stiffness identification of impact oscillators

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A simple impact oscillator is introduced, and experimental bifurcation diagrams and stability analysis is presented, in order to show the importance of accurate measurement of the impact parameters. The resulting response is shown to be due to an interplay between smooth and nonsmooth bifurcations, where grazing is a precursor to a smooth bifurcation. This is a result of the absence of singularity in the Jacobian matrix unless there is a prestress in the secondary spring, and therefore a discontinuity in the force at grazing conditions. This is verified experimentally.

An application is considered, in the form of resonance enhanced drilling. Depending on the system under consideration, the bit-rock interaction is modelled by either linear or nonlinear springs, and the resonance and bifurcation conditions are determined by the ratio of stiffnesses in the system. As a result, any resonance enhanced drilling application will be optimised only when the properties of the drilled formation are known. Various methods are considered for identifying the impact parameters, based on measurement of the acceleration time histories of the drill-bit response.

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