Bifurcations and Attractors in Vibration Conveyors

Friedrich Pfeiffer
Lehrstuhl fuer Angewandte Mechanik, TU-Muenchen
Boltzmannstrasse 15, D-85748 GARCHING, Germany
pfeiffer@amm.mw.tum.de

Vibration conveyors are frequently used machines in various manufacturing plants of chemical and of mechanical engineering. They offer a cheap and effective possibility for the transportation of granular media of all sizes on the one and of small mechanical or electrical parts on the other side. We shall concentrate on the last case considering the transport of small rectangular pieces theoretically and experimentally. Figure 1 illustrates some typical configuration. A spiral conveyor is filled with small parts from the top of the container, and then the parts are transported by vibrations from the bottom to the top and at the same time oriented by suitable obstacles. The right side of Figure 1 depicts the experimental setting being used for measurements.

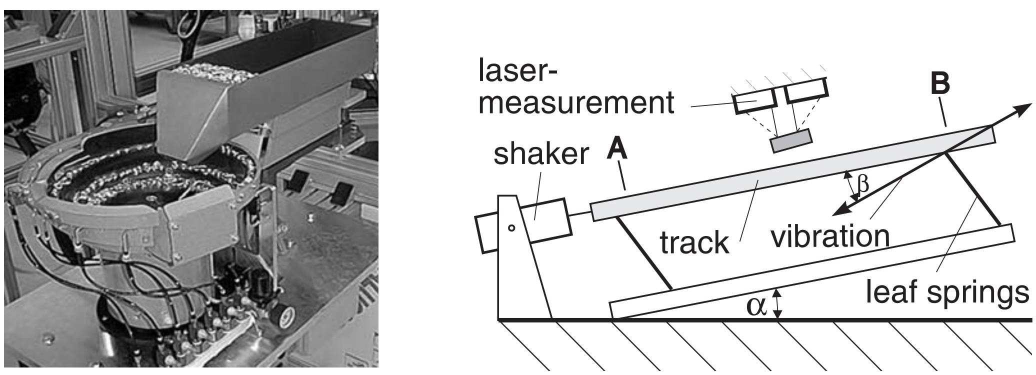

Figure 1: Spiral Vibration Conveyor and an Experimental Model [1][3]

The design of such feeders is usually performed in an empirical way without simulation support, but in the meantime also by the application of suitable models. Verified results for spatial and planar transportation cases were available from a former dissertation (see [4], [5]), which uses multibody theory with unilateral contacts and which solves the corresponding equations by Lemke's algorithm. The results indicated at that time already, that for an evaluation of the transportation performance a planar model had nearly the same outcome as a spatial one, and even more, the transportation rate for one body was nearly the same as for a cluster of bodies [5].

A newer work concentrating on the nonlinear dynamics behaviour of such processes including impacts with friction and considering particularly the bifurcation properties could show, that already a point mass model represents reasonably well the transportation process with the advantage of an analytical representation and thus with very short computing times [1]. Furthermore this really simple model can explain the measured jumps of the transportation process, which are generated by a bifurcation for the existing parameter set. This jump can also be observed by simulations applying any model, the spatial one, the planar one and the point mass model (see Figure 3). Bifurcations of nonsmooth systems are a matter of ongoing research, first convincing results are collected by Leine [2].

These findings indicate, that for a first design of such conveyor machines the planar or the point mass models are already sufficient. They offer in addition a simple access to the physical

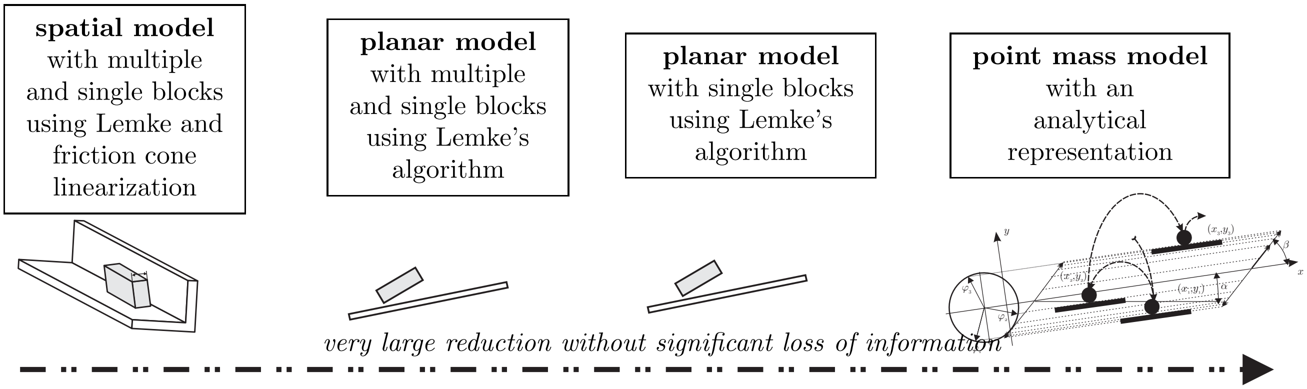

Figure 2: Reduction from Spatial to Point Mass Models for a Vibration Conveyor

understanding of the impact phenomena accompanying such transportation processes. Only for very detailed requirements one would apply a spatial model. We could interprete such a modeling concept as a kind of reduction process, as a matter of fact not on a mathematical but on a mechanical (physical) basis, which offers sometimes more insights than the purely formal approach [3]. Figure 2 illustrates the idea behind that reduction process, which for each step realized not only theory and simulations, but also comparisons with the measurements. Loss or no loss of dynamical informations has been the key point for the evolution of these models. The contribution will present the engineering background and the analysis of the point model together with corresponding results.

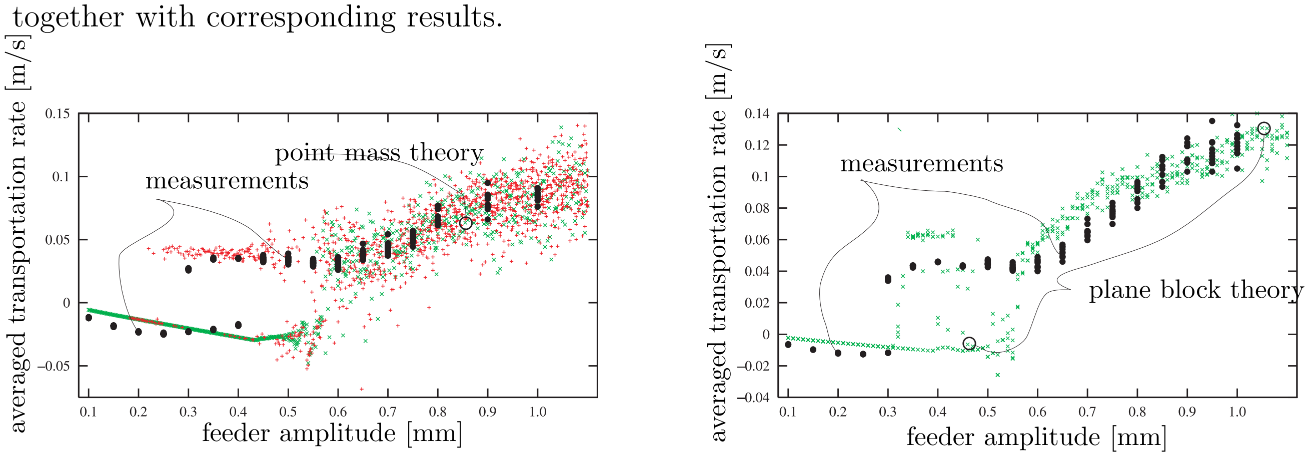

Figure 3: Comparison of Planar Block and Point Mass Models [3][4]

References

[1] Z. Gazic, "Nichtlineare Dynamik von Vibrationsfoerderern," *Dissertation Lehrstuhl fuer Angewandte Mechanik, TU-Muenchen,* 2008

[2] R.I. Leine, H. Nijmeijer, "Dynamics and Bifurcations of Non-Smooth Mechanical Systems"', *Springer Berlin Heidelberg New York,* 2004

[3] F. Pfeiffer, "Mechanical System Dynamics," *Springer Berlin Heidelberg,* 2008

[4] P. Wolfsteiner, "Dynamik von Vibrationsfoerderern," *Fortschrittberichte VDI, VDI-Verlag Duesseldorf,* Reihe 2, Nr. 511, 1999

[5] P. Wolfsteiner, F. Pfeiffer, "Modeling, Simulation and Verification of the Transportation Process in Vibratory Feeders," *ZAMM, Z.Angew.Math.Mech.* **80** (2000) 1, 35-48