Inverse Problems in Rotordynamics

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A challenging inverse problem is the identification of imbalances in rotating systems. An imbalance is an asymmetrical mass distribution that leads to vibrations of the system. In the worst case the system can be destroyed. Thus, rotating systems have to be balanced after mounting and in regular intervals. Currently, the balancing process is mostly done by expert knowledge only.

In our talk, we will present model-based methods that allow the reconstruction of an imbalance from measurements of the system oscillations. Using a finite element ansatz, the connection between a given imbalance f and the resulting oscillations for a fixed rotation frequency Ω is given by the ordinary differential equation

$$M \cdot u'' + D(u) \cdot u' + S \cdot u = \Omega^2 \cdot Pf \ , \tag{1}$$

with Mass matrix M, Damping matrix D and stiffness matrix S. The *direct problem* associated with (1) consists in the computation of the vibrations u, while the *inverse problem* requires the computation of f from a few measurements of u.
In many applications, the Damping matrix depends on the oscillation, and therefore we have to solve a nonlinear problem. In our talk, we will present a fast method that allows a stable identification of the imbalance even in the case of high noise in the data.
In some applications it is not of interest to identify the imbalance but to reduce the remaining vibrations of the systems as much as possible by placing a set of balancing weights. As for this task the location of the balancing weights is fixed, we will present an algorithm that determines an optimal mass distribution for a given set of fixed balancing locations.
Our method will be illustrated with three applications: We will consider aircraft engines (in cooperation with Rolls Royce), generators (in cooperation with Siemens AG) and wind power stations (in cooperation with Fielax GmbH). For all examples the models will be derived and we will present numerical results obtained with real data.