DISCRETE MODELING OF ROTORS: METHODS AND LIMITATIONS

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ABSTRACT

At the designing stage, the response characteristics of rotor systems are usually predicted by Finite Element Methods. The outcome of such calculations may include mode shape and natural frequencies for both rotor and stationary support systems. However, when in real machines complex nonlinear instability occurs, this analytical method becomes very difficult and expensive to apply. In such cases, relatively simple discrete models are often very helpful in reducing the problem to a tractable level. Many such applications have been described in [1]. Such discrete models, which comprise limited number of isolated mass elements and mass-less stiffness elements, all numerically positive, must closely match the low frequency responses at low order natural frequencies of the system. System parameters must be chosen to achieve such a match.

This is accomplished in one of the two ways. The first is to simply vary all the parameters of the discrete model, until good fit is achieved, as compared with a response of the real system. This may be tedious process. The other approach is to create compliant matrices of the responses at selected points, and invert them to obtain corresponding dynamic stiffness matrices. These matrices, when compared with the corresponding matrices of the assumed discrete system, provide discrete model parameters. This method of creating discrete model of complex systems is relatively well known. What may be less known is that application of this method does not always guarantees that a satisfactory discrete model can be created. Sometimes, for example, the stiffness element is determined to be negative. This implies that the resulting discrete model is not physically meaningful. No arbitrary changes of the parameters can then improve the situation.

The goal of this paper is to illustrate such a problem, by analyzing a simple example, namely a clamped-clamped shaft with added two discrete masses. This example is chosen specifically for its simplicity, as well as, to facilitate some corresponding experimental verifications. Similar situation may be expected to occasionally arise, even for more complicated rotor systems, whenever a discrete mode has to be developed. The paper discusses cases when satisfactory discrete models can or cannot be produced.

[1] Muszyńska A., Rotordynamics, Taylor & Francis Group, CRC, 2005.

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