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NASA TECH BRIEF

Critical Speed Analysis of Rotors

Many theoretical studies of rotor critical speeds assume firm foundations for simplicity in analysis. Models that treat foundation flexibility, however, are more representative of aircraft and spacecraft installations. A flexible-foundation model has the added complication of two more variables than a firm-foundation model. There is little information available on flexible-foundation critical speed analysis.

A general frequency equation has been developed for both forward and backward precession of rigid rotors in undamped bearings on flexible foundations. One set of two solutions comprises the bouncing-mode natural frequency. This frequency is a function of foundation-to-rotor mass and spring-constant ratios, but is independent of rotor speed and moments of inertia. Another set, the conical mode, which is a function of rotor speed and moments of inertia, contains four solutions.

Maps have been developed for a wide range of these variables. The spring-constant ratio is varied to represent the entire range from zero (floating foundation) to infinity (firm foundation). The moments of inertia are varied to represent configurations ranging from pencil shapes to disks. Besides locating major critical speeds, the maps locate nonsynchronous critical speeds that may result from bearing defects. Therefore, for a given rotor, the maps display the succession of critical speeds encountered during startup or shutdown.

Plots may be constructed for variations of major critical speed parameters over the entire range of the spring-constant ratio for pencil-shaped rotors, as well as for disks and intermediate shapes. Successive major critical speeds are located at a constant spring-constant ratio on a given set of two moment-of-inertia ratio curves.

A single two-branch curve that represents all rotor shapes applies at both extremities of foundation flexibility–floating and firm. With this curve to set the boundaries, only three calculations are required to define critical speed solutions over the entire flexibility range.

Compared with a firm-foundation model, a flexible-foundation model introduces one additional bouncing-mode solution and two additional conical-mode solutions. This analysis shows, however, that the critical speeds that the firm-foundation model does predict agree well with the corresponding flexible-foundation values.

Notes:

1. This technique should aid in the preliminary design of turbomachinery by providing guidance to the location of potential synchronous and nonsynchronous critical speeds.
2. This information should be useful to manufacturers of electrical power generating equipment.
3. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA-TN-D-4858 (N68-37214), Critical Speed Analysis of Rigid Rotors on Flexible Foundations

(continued overleaf)

4. Technical questions may be directed to:

Technology Utilization Officer
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Reference: B70-10288

Patent status:

No patent action is contemplated by NASA.

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