# AEC-NASA TECH BRIEF



## Computer Program Analyzes Whirl Critical Speeds and Bearing Loads for Shafts Coupled by Nonlinear Springs to Machine Housing

**The problem:**

The classical techniques of calculating shaft critical speeds and bearing loads generally yield very crude estimates. The increased need for high-performance, lightweight turbomachinery requires accurate prediction tools for turbomachinery dynamics.

**The solution:**

A computerized method of analysis for predicting bearing loads, shaft deflections, and critical speeds for shafts coupled by rolling contact bearings to the machine housing. The bearing nonlinearities, casing as well as rotor dynamics, and rotor-imbalance forcing functions are all included in the system dynamics analysis.

**How it's done:**

Basically, the program has the capability for analyzing the forced-undamped, lateral vibrations of two elastically coupled lumped parameter beams. The program computes the amplitudes of the shears, moments, slopes, and deflection attributable to harmonic forcing functions. Shear deflections, rotary inertia, and gyroscopic effects for rotating shaft analyses are also included.

The analysis is facilitated by a lumped-parameter model using a modified Mkylestad–Thompson transfer-matrix technique.

The bearing is characterized as a spring which may be input as either constant values or load dependent functions defined by $K = A \cdot P^B$ where A and B are constants and P is applied load, or by a table of P vs K points.

As the bearings have nonlinear load-displacement characteristics, the solution is achieved by iteration. Rotor imbalances allowed by such factors as pilot tolerances and runouts and bearing clearances (allowing conical or cylindrical whirl) determine the forcing-function magnitudes. The computer program initially obtains a solution in which the bearings are treated as linear springs of given spring rates. Then, on the basis of computed bearing reactions, new spring rates are predicted, and another solution of the modified system is made. The iteration is performed a specified number of times and then solution for the next speed level is undertaken. It has been found that about five to eight iterations result in changes in bearing spring rates and bearing reactions that are negligibly small.

**Notes:**

1. The program is written in Fortran IV, MAP for use on the IBM 7094 computer.
2. Inquiries concerning this program may be made to:
   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B69-10034

**Patent status:**

No patent action is contemplated by AEC or NASA.

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