COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Dr. Peter Hagedorn
Distinguished Lecture Series

Sensitivity to Damping of Self-Excited Vibrations in Circulatory and Parametrically Excited Systems

Monday, January 24, 2022
2:00 – 3:00 P.M.
Engineering East - Room 106
SeaTech (Videoconference) - Room Aud 250

Peter Hagedorn

Professor, Head of Dynamic and Vibrations Group, Numerical Methods in Mechanical Engineering, Graduate School of Computational Engineering of TU Darmstadt

ABSTRACT

In mechanical engineering systems, self-excited vibrations are in general unwanted and sometimes dangerous. In most of these the linearized equations of motion, the self-excitation terms are given by non-conservative, circulatory forces and/or parametric excitation. The presentation will discuss some recent results in linear and nonlinear systems of this type. Self-excited vibrations have of course been mathematically modelled and studied at least since the times of van der Pol. The van der Pol oscillator is a one degree of freedom system; its linearized equations of motion correspond to an oscillator with negative damping. Often the self-excitation mechanism is mainly related to the interaction between different degrees of freedom (modes), and the linearized equations of motion contain circulatory terms. This together with parametric resonance is the main excitation mechanism discussed in this paper. The systems analyzed in this presentation are characterized by the M, D, G, K, N matrices (mass, damping, gyroscopic, stiffness and circulatory matrices, respectively) which may all be time-dependent. In the first part, MDGKN-systems with constant coefficients will be discussed. For a long time it has been well known, that the stability of such systems can be very sensitive to damping, and also to the symmetry properties of the mechanical structure. It turns out that the structure of the damping matrix is of utmost importance, and the common assumption, namely representing the damping matrix as a linear combination of the mass and the damping matrices, may give completely misleading results for the problem of instability and the onset of self-excited vibrations. The second part deals with MDGKN-systems with time-periodic coefficients. A typical property of parametric instability behavior is the existence of combination resonances. However, if parametric excitation in the system is simultaneously present in the K and the N matrices and/or there are excitation terms which are not all in phase, an atypical behavior may occur, namely 'total instability'. In both cases, with constant or time-periodic coefficients, the system dynamics may be highly sensitive do damping. The suppression of unwanted self-excited vibrations should therefore be robust with respect to changes in the damping matrix.

BIOGRAPHICAL SKETCH

Peter Hagedorn born in Berlin, Germany, grew up in Brazil, where he graduated (Engineer's degree) in Mechanical Engineering in 1964 at EPUSP and in 1966 earned his Doctoral degree at the same University. He then worked as a Research Assistant and later as 'dozent' (similar to lecturer) at the University of Karlsruhe, Germany. In 1971 he received his 'habilitation' (similar to Dr. Sc.) at Karlsruhe. From 1973 to 1974 he was a visiting Research Fellow at the Department of Aeronautics and Astronautics, Stanford University. Since October 1974 he is Full Professor of Mechanics at the Technische Universität Darmstadt and Head of the Dynamics and Vibrations Group. He also has served as Visiting Professor at Rio de Janeiro (Brazil), Berkeley, Paris, Irbid (Jordan) and Christchurch (New Zealand), where he also holds an Adjunct Professorship at UCC. He has served as Head of Department and Vice-President to his home University in Darmstadt and he is serving in a number of professional and editorial committees. He is author of over 200 papers and several books on a variety of topics in the general field of dynamics and vibrations and analytical mechanics. He is officially retired since 2009 but

still quite active and heads the Dynamics and Vibrations Group, presently affiliated to the Chair of Professor Michael Schäfer, at the Graduate School of Computational Engineering of TU Darmstadt. He is the recipient of the 2013 Den Hartog Award and the 2019 J.P. Lyapunov Award conferred by ASME and holds an Honorary Doctor`s degree from the University of Technology of Lodz, Poland, awarded 2017.