STATE-OF-THE-ART IN ROTOR-DYNAMICS OF AEROSPACE PROPULSION SYSTEMS

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ABSTRACT

The design objectives of gas turbine based arerospace propulsion devices, viz., high fuel efficiency and low thrust/weight ratio with assured structural integrity under extreme operating conditions are closely linked to sound high speed rotor system design. The multifarious problems involved in meeting the ever rising performance needs in the civil and military applications of these hardware call for detailed analysis of the synchronous, asynchronous and transient rotor whirl modes for avoidance / management of the associated critical states. The design effort, therefore, aims at suitable system configuration, application of ingenious control devices and determination of preventive measures. The paper highlights the essentials of the present day concerns of the related rotor-dynamic design technology.

The rotor-dynamics problems peculiar to an aviation gas turbine primarily arise from variable high speed operation of rotors of coaxial multi-spool construction, with large radial and axial dimensions and multiplicity of supports, with gas-flow path constraints on the support structure. While the severe thermal environment and the corrosive and erosive nature of the working medium contribute to balance degradation, the complex energy transfer mechanisms capable of sustaining self-excited rotor motion, coupled with rotor functioning in a moving inertial frame further hinder smooth rotor operation.

The modeling and simulation techniques in the field of aircraft gas turbine rotor dynamics have been evolving in response to the fast rising performance and durability goals in the problem-ridden field. The analytical solutions at design stage address, in the first place critical speed analysis - involving cross-excitation between rotors; the next design priority is steady state response simulation for optimization of suspension design and balancing. Rotor-dynamic stability mapping vis-a-vis the various self-excitation phenomena, e.g. hysteresis, aerodynamic cross-coupling, trapped fluid and seal rubs is yet another important analytical requirement aiming at demarcation and augmentation of the performance envelope. Study of Rotor excursions under extreme operating conditions, e.g., impact and maneuvers is also crucial in rotor-dynamic design in the aviation field.

Support damping by means of passive and active devices has been the major thrust area as the single most effective ameliorative measure and development of these is a major concern in the aircraft turbine engine field.