ABSTRACT

Turbomachines require special investigation in regard to blade excitation due to interaction between neighbouring blade rows and forced response characteristics of blades. In the present thesis, an attempt is made to determine aerodynamic forces acting on the blades and the deflections and stresses of blades due to these aerodynamic forces.

Initially, isolated thin generalised camber aerofoil subjected to non-convecting streamwise flow perturbation is considered. Flow is assumed to be two-dimensional, incompressible and inviscid. The expressions for unsteady lift and moment are determined by making use of unsteady Bernoulli equation. These expressions are applied to flat plate aerofoil, parabolic cambered aerofoil and aerofoil with skewed mean line. A computer program is developed to obtain numerical results for various cambered aerofoils.

An elementary turbomachine stage with a single stator row and a rotor row is then considered for incompressible subsonic flow. The concepts and results of theory of an isolated thin aerofoil in non-uniform motion are applied to calculate the resulting non-steady effects on blades of turbomachine

stage. Unsteady lift and moment acting on stator blades due to steady rotor circulation and unsteady lift and moment acting on rotor blades due to steady stator circulation and vortex wakes shed by stator are determined for three types of cambered blades. In case of flat plate blades, the effect of viscous wakes shed by stator on rotor is taken into consideration.

To determine the response, the blades in a stage are considered as cantilever beams with flat plate aerofoil cross-section symmetric about mean chord line mounted on a rotating disk at a stagger angle. Effects of viscous wakes are not taken into consideration and first harmonic lift and moment are considered. Energy principles are used to obtain equations of motion and modal analysis is used to get the forced vibration response, taking into account the viscous damping. Bending and torsional deflections and stresses are calculated for various values of exciting frequency.

The blade is next considered to be flexible and aerodynamic forces due to its own motion of the blade are determined. An analysis for a flat plate blade undergoing bending and torsion vibration due to the combination of self-excited and forced vibration is presented. The effect of viscous damping is not considered. The values of deflections and stresses of stator and rotor blades are calculated for various values of exciting frequency.

The analytical solutions and results presented in this thesis will be useful to turbomachineblade designer for obtaining aerodynamic forces acting on blades and determining vibratory stresses so that a fatigue criteria to design a blade under resonant conditions can be obtained.

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