ABSTRACT

Ever since the aircraft and space vehicles first exceeded the speed of sound, panel flutter has been an important structural problem. The phenomena is a self-exited oscillation of the external surface of the vehicle, resulting from the dynamic interaction of aerodynamic, inertial and elastic forces of the structural system. Flutter analysis has become a stringent requirement in the design of aerospace vehicles. But most of these analyses are restricted to isotropic materials only. Due to the introduction of composite materials in aerospace structures, the flutter analysis of laminated composite panels constitutes an important problem area. Also these structures are susceptible to moisture and temperature during their service life and the flutter analysis of laminated panels subjected to a hygrothermal environment should therefore be of considerable significance.

The present investigation is aimed at the development of finite element flutter analysis procedures for laminated composite flat, skew and curved panels. The effects of moisture and temperature on the flutter behaviour of rectangular and skew panels are also studied.An eight noded isoparametric doubly curved thin element is used to analyse the present problem. The shear deformation effect is included using YNS-shear deformation theory. Linear piston theory is employed to assess the aerodynamic loads. Material properties at the elevated moisture and temperature are used for panels subjected to a hygrothermal environment. The stiffness matrix, mass matrix, residual stress stiffness matrix and load vectors are derived by using Principle of Total Potential Energy. They are evaluated using Gauss Quadrature rules. The system equations are solved using the IMSL complex eigenvalue routine EVLRG. The normal mode method is used to reduce the system equations.

Results are presented for uniaxial, symmetric, antisymmetric and unsymmetric laminates with simply supported, clamped and cantilever boundary conditions. Parametric studies concerning the effects of fibre angle, lamination scheme, aspect ratio and boundary conditions on the flutter characteristics are presented. Results are also presented to show the effects of moisture and temperature on the stability characteristics of composite panels. Results are discussed in details and conclusions highlighting the important findings and the scope for further work are also made.

The thesis is divided into five chapters and an appendix. Chapter 1 contains a general introduction. It also includes the review of literature, and the aim and the scope of the present study. In Chapter 2 the governing aeroelstic equations are presented for a generally curved laminated composite panel. The detailed finite element formulation and the solution procedure for bracketing the critical dynamic pressure is outlined. Chapter 3 covers the validation of the finite element code. Several examples of flat, skew and curved panels are analysed. The results are presented in tabular forms and are also plotted and are then discussed in details. Chapter 4 deals with the hygrothermal formulation for laminated composite panels. The basic equations for a laminated panel subjected to a hygrothermal environment are derived. The finite element formulation of the problem is presented as well as numerical results are furnished. Fundamental conclusions drawn from the present study are listed in Chapter 5. In Appendix the flow chart of the computer code 'FLAPS'is illustrated.

keywords: aeroelasticity, aerodynamic piston theory, buckling load, composite materials, dynamic behaviour, flutter analysis, finite element method, hygrothermal environment, moisture content, thermal effects.