OPTIMAL LAMINATE SEQUENCE OF HYBRID COMPOSITE THIN-WALLED BEAMS, PLATES AND SHELLS USING EVOLUTION STRATEGIES AND GENETIC ALGORITHMS

ABSTRACT

Since the early dawn of civilization, the strong and light material have always fascinated mankind for typical applications. With the technological leaps in recent times, focus has been on developing the materials required to perform in stringent conditions - high temperature and pressure, highly corrosive environment, higher strength but without much weight implications etc., which the conventional materials failed to service.

The dramatic increase in the use of composite materials in all types of engineering structures such as aerospace, automotive, underwater structures as well as in medical prosthetic devices, electronic circuit boards and sports equipment has led people to take a major effort to develop composite systems and analyze and design structural components made from composite materials.

Composite materials are much suited for weight sensitive structures like aircraft where the thinner and lighter members made of advanced fibre reinforced composite materials are used. When the full advantages of composite materials are utilized, the weight sensitive structures like aircraft will be designed in an efficient manner. Composite materials and their manufacturing process can be tailored specifically to the given design constraints. The superior physical properties of composites allow for design with minimum concern for dimensional stability, corrosion and crack formation. Composite materials offer more possibilities for a design than the isotropic material. It can be seen that varying fibre orientation in each ply or a number of plies can produce large number of acceptable designs for a specific loading conditions subjected to deflection, buckling and dynamic constraints. Hence, it is necessary to find the structure with the best possible properties for a specific application. An optimal structure for one application need not be optimal for another application. Hence, optimum techniques can keep the design engineer to show various dependencies between design variables and structural properties and identify the best one for a specific application.

Even though number of techniques have been developed, many of them may not be appropriate for optimum design of composite structure problem. An attempt is made to obtain the optimal lay up for composite thin-walled spatial members of generic section, thin plates and shells treating fibre orientation, thickness of layer and material of layer as design variables using Evolution Strategies **(ES)** and Genetic Algorithms **(GA)**. A user friendly software “HYDYN” is developed for the optimal lay-up of non-prismatic helicoidal girder of any generic section subjected to various constraints. But for the composite plates and shells, “FEAST-C” is applied to find the optimal lay-up. The behaviour of various structures predicted using “HYDYN" and “FEAST-C” is compared with the results of benchmark experiments conducted by many investigators. A wide variety of structures is analyzed using “HYDYN” and “FEAST-C” and the capability of these software is illustrated.