Abstract

Despite the development of various numerical methods, there has been consistent need of numerical approach which facilitates the integration of computer-aided design (CAD) model to the analysis framework smoothly. The finite element method (FEM) developed between 1950s to 1960s became the most popular analysis tool in various engineering fields. Computer-aided engineering (CAE) in general utilizes Lagrange polynomial in FEM to construct assumed solutions, while non-uniform rational B-splines (NURBS) is used as a geometric basis function in CAD. Therefore, a disconnection between finite element analysis (FEA) and CAD design is unavoidable, which has been the prominent reason for many practical issues arising in CAE. Moreover, the use of different basis functions made the communication between CAD and CAE time-consuming, and hence there was a necessity to build an advanced finite element model which utilizes the same basis function, and simultaneously maintains the harmony with existing practices. Substantial contributions have been made by Hughes et al. of the University of Texas at Austin, to integrate CAD and CAE within the framework of isogeometric analysis (IGA), which utilizes NURBS as basis functions.

In this thesis, an effective NURBS-based isogeometric model is developed for linear and nonlinear static and dynamic analysis of multilayered composite plate structure with/without considering hygrothermal load. For the incorporation of nonlinearity, both von Karman as well as Green-Lagrange strain-displacement relations, are considered. A nonpolynomial shear deformation structural kinematics is considered which assumes nonlinear variation of displacements over the thickness. The requirement of C^1 continuity of the field variables is accomplished without any additional variables. A detailed mathematical formulation is derived using Hamilton's principle, and a MATLAB program is developed for numerical studies. The Newton-Raphson iterative method is applied in association with Newmark's time integration scheme to solve the nonlinear transient problem, and direct iterative method is employed to obtain the nonlinear free vibration solution. Fourier

transformation is also carried out on the transient response to obtain the natural frequency using the present model.

It has been observed that the use of present NURBS-based IGA model for nonpolynomial shear deformation theory (NPSDT) reduces the computational cost significantly. The accuracy, performance, and applicability of the developed IGA approach are examined through various benchmark problems. Through this study, it has been shown that the present IGA model is an efficient technique and can be conveniently implemented for the structural analysis of laminated and sandwich composite plates.

Keywords: Non-uniform rational B-splines, Isogeometric analysis, Nonpolynomial shear deformation theory, Geometric nonlinearity, Green-Lagrange, Fast Fourier transform, Static analysis, Dynamic analysis, Hygrothermal, Laminated plates, Sandwich plates.