ABSTRACT

Aeroelastic instabilities such as flutter are of major concern for modern large wind turbine blades. This necessitates appropriate aeroelastic tailoring of such blades. Stiffness coupling between bending and twisting modes can be used to improve the aeroelastic performance of such blades. In composite blades bend twist coupling can be achieved by imparting unbalance in the lamination sequence. Adjustment of bend-twist coupling through proper lamination sequencing of the constituent laminates of these composite blades has been proposed by several reseacrher recently. The present work is a detailed study of the effect of parameters like composite lamination sequence, blade symmetry and asymmetry on the flutter speed of large composite blades using three different aeroelastic models. The first aeroelastic model is based on Theodorsen's theory based aerodynamic model and a structural model having flapwise bending and twisting as deformation modes with linear strain-displacement relationship. Flutter speed is obtained through eigen solution. The second aeroelastic model is based on unsteady blade element momentum (BEM) method based aerodynamic model and a structural model having flapwise bending and twisting as deformation modes with linear strain-displacement relationship. Flutter speed is obtained from time domain solution. The third model is a nonlinear aeroelastic model involving unsteady BEM method based aerodynamic model and a structural model having flapwise bending and twisting as deformation modes with a strain-displacement relationship having von Karman nonlinearity. Flutter speed is obtained from time domain solution. A detailed comparison of the flutter speeds obtained using Theodorsen's model and the unsteady BEM model with linear structural model for several lamination sequence and configuration has been presented. It has been observed that both the aerodynamic models predict the highest flutter speed at the same blade configuration and lamination sequence. However, flutter limit using unsteady BEM aerodynamic model is less as compared to that obtained using Theodorsen's theory. Flutter speed obtained through nonlinear aeroelastic analysis is higher for 61.5 m long blade and lower for 100 m long blade as compared to flutter speed obtained through linear analysis. Flutter speed obtained through nonlinear aeroelastic analysis is higher for blades with symmetric skin and lower for blades with asymmetric skin as compared to flutter speed obtained through linear analysis.

Keywords: Aeroelastic instability; Slender blade; Bend-twist coupling; Asymmetric skin; Laminated composite