Development of Large-Scale Finite Element Solver for Wind Turbine Blade Structure Using Balancing Domain Decomposition Methods

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Abstract: In a wind turbine blade, laminated plates consisting of fiber reinforced plastic materials are generally used due to its high specific strength. We have been developing a large-scale finite element solver to analyze the wind turbine blade structure. For such a structure, the laminated finite element is frequently used in modeling. Each laminated finite element has multiple layers, each of which is an orthotropic body in order to model the layered fiber reinforced materials with different fiber directions. Also, since a realistic wind turbine blade structure generally requires a large number of finite elements for discretization, we adopted a domain decomposition method, which is one of the numerical methods to parallelize the finite element method for large-scale analyses. Domain decomposition methods have been studied mainly in the mathematics field and applied to large-scale finite element analyses of realistic structures. However, the application studies do not sufficiently cover practical engineering models such as the model with laminated finite elements with orthotropic layers. Some researchers in the field of domain decomposition methods stated that the change or the jump of material parameters may degrade convergence performance of the iterative solver. Therefore, we investigated the convergence performance in the present study. The convergence performance of the balancing domain decomposition preconditioner and its variations implemented in our solver were compared. The numerical tests show that thin laminated finite elements with high aspect ratios significantly increase the number of iteration counts. Moreover, the consideration of material parameter changes in the balancing domain decomposition preconditioner (the Scaled-BDD method) attained a smaller number of iteration counts than the straightforward implementation.

DOI: 10.32604/icces.2019.05231