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PARALLEL SIMULATING FLOWS PASSING A WIND TURBINE WITH A FULLY IMPLICIT METHOD ON A MOVING DOMAIN

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Accurate numerical simulations of flows around wind turbines play an important role in rotor blades design and operation control. The computation is very challenging because of the large size of the blades, the large fluids domain, the complex moving geometry, and the high Reynolds number. A popular method for this kind of simulations is the blade element momentum method which is relatively easy to implement, but has low fidelity. More recently, some high fidelity methods have been developed for the wind turbine simulations based on the 3D unsteady Navier-Stokes equations [1]. In this talk, we study the numerical simulation of flows passing a large scale 3D wind turbine. The flow in the moving domain is modeled by the 3D unsteady incompressible Navier-Stokes equations in the arbitrary Lagrangian-Eulerian form. A stabilized $P1-P1$ moving mesh finite element method, based on an unstructured tetrahedron mesh, is introduced to discretize the problem in space, and a fully implicit scheme is used to discretize the temporal variable. A parallel Newton-Krylov method with a domain decomposition type preconditioner is applied to solve the fully coupled nonlinear algebraic system at each timestep [2]. We mainly focus on the performance of the domain decomposition preconditioner. To understand the efficiency of the algorithm, we test the algorithm on a supercomputer for the simulation of a real scale 5MW wind turbine. The numerical results show that the newly developed algorithm is scalable with thousands of processors for problems with tens of millions of unknowns.

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