IPID4all Exchange [Sep 7 2016 – Oct 7 2016]

Report for IPID4all doctorate student exchange program

By SeungJoon Yang (Visiting student)

Research Area	Wind Energy - CFD	
Title	Pursing plans of CFD (Computational Fluid Dynamics) - CSD (Computational Structure Dynamics) coupling technique improvement	
Visiting Student	Seung J, Yang, Ph.D candidate	University of Maryland, USA
Home Supervisor	James, Baeder, Professor	University of Maryland, USA
Host Supervisor	Joachim, Peinke, Professor	University of Oldenburg, Germany

1. Summary

There are many challenges to simulate modern wind turbine CFD precisely. Size of modern wind turbines is often larger than 60meter in diameter, and their blades rotate and deflect. Because of these features, some advanced CFD techniques, such as rotational grid system, and CFD-CSD coupling, are required. The host institute, Forwind in University of Oldenburg has the most decent CFD-CSD technique in their flow solver, and accumulated experience and knowledge in wind energy research field. The visiting institute, the Alfred Gessow Rotorcraft Center (AGRC) in University of Maryland CFD group has developed CFD solver for the rotorcraft applications for more than 10 years, and the solver has been well validated. Furthermore, the team recently developed GPU (Graphics Processing Unit) – accelerated version of the solver, which is much faster than typical CPU-based one. During the exchange research, the flow solvers between the two research groups have been compared each other. Firstly, CFD-CSD coupling algorithms of those two groups have been compared. Secondly, grid system and initial setups for simulation have been compared and exchanged to run with identical test case for the result comparison. Thirdly, availability of GPU-accelerated computation in the solver has been discussed. Detailed direction and plans of the future co-work between institutes have been discussed and established.

2. Objectives

- Solver comparison between the Forwind CFD and the AGRC CFD
- Review CFD-CSD coupling algorithms in the current solver
- Check grid capability between the each other solvers
- Establish future co-work subject and details

3. Research Outputs

i. Solver comparisons

OpenFOAM based CFD-CSD solver (Forwind CFD group) and GPURAN3D (GPU-accelerated CFD, AGRC CFD group), PARASADUM (simplified CFD (lifting-line model) – CSD solver, AGRC) have been compared respectively. Forwind CFD's OpenFOAM solver has capabilities of solving aerodynamic and aeroelastic behaviors of wind turbines together. The CFD–CSD solvers are tight coupled, so that the aerodynamic forces and structural deformation of the turbine blade interact each other at the same time-step. While the AGRC's GPURANS3D doesn't include CSD solver, the PARASADUM has been developed to calculate both aerodynamics and aeroelastics. However, it employs the lifting-line method for calculating aerodynamic forces, and the beam theory for calculating the structural deformation rather than high order accurate methods. Since, coupling algorithms between the Forwind's OpenFOAM and the PARASADUM are very similar each other, it must be reasonable that implementing the coupling algorithm of the PARASADUM to the GPURANS3D as the first step. Also at the first step, rather than using the Forwind's complex CSD methods, using the simple beam theory of

the PARASADUM as implementing CSD module into the GPURANS3D might be realistic. For the turbulent modeling, both Navier-Stokes solvers between the institutes use mainly SA model along with gamma-Reynolds laminar-turbulent transition model. Transition models haven't been looked over deeply yet at this moment. Thus, reviewing current using transition models should be considered as future step.

ii. Grid Capability

Checking computational grid capability was one of main objectives to establish future co-work. It is obvious, when one compares two different solvers, size and topology of computational grids should be identical each other. As a result of checking grid capability between two solvers, it is found that the grid files are transferable by using typical post processing software, such as Tecplot or Paraview. And also found, although the GPURANS3D uses structured grid and solver, structured grid can be used also in Forwind's unstructured solver. As the future co-work, computational grid, generated by Maryland group is going to be sent to the Forwind CFD, and be used for the solver comparison.

4. Conference & meetings

- Attended annual Forwind group workshop
- Attended TORQUE2016 conference

5. Future Plans

- Computational grid exchange & CFD-CSD solver comparison

Currently working-on wind turbine CFD project in the University of Maryland CFD group is focusing on the SNL100meter flatback blade. In the current, the researcher has been working on blade grid generation for the SNL blade. Once the blade mesh is ready, it will be sent to the Forwind CFD team, to compare solver performance. Also, the UMD group is working on NREL 5MW blade. The Forwind CFD group has already done aerodynamic and aeroelastic simulations of the NREL 5MW blade. The UMD team is currently working on the simulations of the NREL 5MW blade, and will provide the simulation result data to the Forwind team to compare the results. For the CFD-CSD solver development, the research at the UMD will contact to the Forwind team frequently to validate the solver and results at the each steps of the code development.

END

DAAD

Federal Ministry
of Education
and Research