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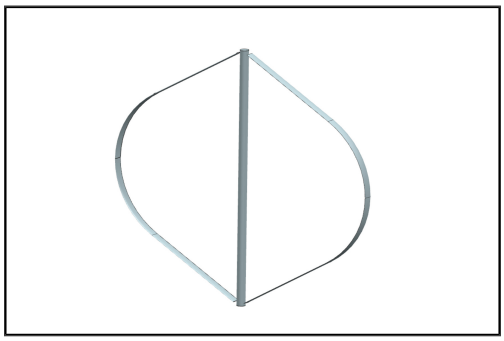
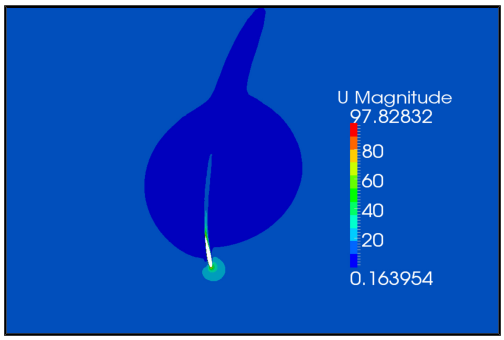
Topic	Innovation in Products, Processes and Materials

Simulation of a vertical axis wind turbine using OpenFOAM

Semesterthesis



3D blade and tower geometry of the 17 m Darrieus VAWT



Velocity distribution around the blad at a TSR of 6

Problem: This thesis focuses on the comparison of a 2D CFD simulation of a 17meter Darrieus vertical axis wind turbine (VAWT) with two 180° shifted NACA-0012 blades, using the open source simulation program OpenFOAM and the commercial program ANSYS Fluent.

Objective: In order to compare both programs the set up of the VAWT is evaluated on simplified test cases. Therefore two mesh types (unstructured and structured), the rotational setup, the force calculation and the turbulence model with wall functions are compared. It is shown that the accuracy and the computational effort are improved by using a structured mesh. To prevent checkerboarding in OpenFOAM more diffusive schemes than central differencing schemes and total variation diminishing (TVD) schemes are necessary. For the rotational set up an initiated absolute reference frame leads to a faster convergence than an initiated relative reference frame in Fluent. The force calculation in Fluent and OpenFOAM is confirmed and leads to the same result. A 2D steady state NACA-0012 blade simulation using the k-w-SST turbulence model is compared with measurements and confirms the applied simulation set up. This comparison shows that the error between the simulation and the measurements is smaller in OpenFOAM than in Fluent.The validated set up is applied to the 2D VAWT simulation calculating the power for tip speed ratios (TSR) between two and nine. At a TSR of seven or higher the assumption of a constant density is not valid anymore therefore these TSRs are calculated with a compressible solver.

Result:

- The maximum cp = 0.64 value, which is higher than the theoretical maximum, is at a TSR of 6 for Fluent initiated with relative reference frame and OpenFOAM.
- The resulting cp values for the incompressible solver are similar for Fluent initiated with relative reference frame and OpenFOAM. The results for an absolute reference frame initiation underperform slightly. The resulting cp values for the compressible solver in OpenFOAM are higher than for Fluent.
- The simulation results are different to the measurements of a VAWT, due to the 2D assumption and geometrical simplifications.
- The computational time for seven revolutions in OpenFOAM, which are required to reach convergence, is two to four times larger than for Fluent. This is due to the increased number of orthogonal corrections in OpenFOAM.