Simulation and validation of the MEXICO-Wind Turbine with OpenFOAM

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Outline

- MEXICO and MexNext projects
- Simulation model
- Results
- Conclusions
MEXICO and MexNext Projects (IEA Wind Task 29)

- **MEXICO Project:**
  - DNW wind tunnel (9.5 x 9.5 m²)
  - 4.5 m rotor diameter
  - different operating conditions
  - pressure distributions (at 5 blade sections), tower loads and PIV measurements (upstream and downstream of the rotor)

- **MexNext Project:**
  - detailed analysis of the MEXICO measurements
  - validation of different simulation models
  - better understanding of the WT aerodynamics
  - 20 research institutes from 11 countries
Simulation model

Mesh:
- Mesh done with snappyHexMesh
- Cylindrical domain (Length 15 D, Diameter 6 D)
- Only rotor and nacelle are modelled
- 32 Mio cells (Hexa and split-Hexa)
- High refinement level at the blades (trailing and leading edge → 0.48 mm, pressure and suction sides → 0.98 mm)
- 3 rows of boundary layer cells (trailing and leading edges → 0.15 mm, pressure and suction sides → 0.3 mm)
- Refinement level of the near wake area → 15 mm
- Typical snappyHexMesh problems were minimized but could not be completely avoided (poor resolution of sharp edges)
Simulation model - Mesh
Simulation model - Mesh
Simulation model - Mesh
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Jagged surface
Simulation model

- **Solver: MRFSimpleFoam**
  - Isotherm, incompressible, stationary solver (RANS)
  - Non-rotating mesh (Coriolis force added to the momentum equations)
  - Rotor in non-inertial reference frame
- **Turbulence Model: k-omega SST**
- **12000 time-steps for every wind speed (3.5 hours with 540 processors)**
Results – Pressure distributions (u = 10 m/s)
Results – Pressure distributions \((u = 15 \text{ m/s})\)

- \(r/R=0.25, \ u = 15 \text{ m/s}\)
- \(r/R=0.35, \ u = 15 \text{ m/s}\)
- \(r/R=0.60, \ u = 15 \text{ m/s}\)
- \(r/R=0.82, \ u = 15 \text{ m/s}\)
- \(r/R=0.92, \ u = 15 \text{ m/s}\)
Results – Pressure distributions (u = 24 m/s)
Results - axial velocity along traverse (r/R= 60%)
Results - axial velocity along traverse (r/R= 82%)
Results - radial velocity along traverse
Results - 3D effects
Conclusions

- The MEXICO experiment is an excellent dataset for validating numerical models.
- SnappyHexMesh is a powerful tool for mesh generation. Performance at sharp edges should be improved.
- MRFSimpleFoam simulations present in general good agreement with measurements.
- Differences between simulations and measurements could be due to:
  - tunnel effects,
  - Simulations fully turbulent, measurements with laminar-turbulent triggered transition.
- 3D effects must be analyze in more detail.
- Unsteady simulations (TurbDymFoam) are required for yaw misalignment and other transient effects.
Thanks for your attention!