





# Parallel Fluid-Structure Simulation of Cycloidal Rotors

Julian Schließus and Louis Gagnon



MMCP22 12. - 24. January 2022

#### Contents

- 1. Principle
- 2. Simulation Setup
  - 2.1. OpenFOAM
  - 2.2. MBDyn
- 3. Coupling Setup
  - 3.1. Coupling Infrastructure
  - 3.2. Parallel Explicit Coupling Scheme
  - 3.3. MBDyn-Adapter
  - 3.4. Beam Mapping
  - 3.5. Mesh
- 4. Challenges
- 5. Speedup
- 6. Results



#### 1. Principle Fluid Structure Interaction (FSI)



- Motivation: current state of the art Computational Fluid Dynamics (CFD) simulations of cycloidal rotors neglect the deformation of the blades
- Interaction between deformable structure and aerodynamic flow
- Coupling of fluid- and structure solvers

displacement perpendicular to chord span plane (mm) displacement in chord direction (mm)

1.0

0.5

-1.0

-0.5

• Exchange of boundary conditions (forces and displacement) at the interface  $\Gamma_{FS}$ 

-20

20

- 2. Simulation Setup
- 2.1 OpenFOAM 2D Mesh

# Open√FOAM®

- approx. 70.000 cells
- cell edge length at the finest mesh: 0.1 mm









Simulation Setup
MBDyn















# 3.2 Parallel Explicit Coupling Scheme



- **timewindow:** defines the maximum timestep size
- parallel: simultaneously execution of both solvers
- explicit: every timewindow is executed only once (no repetition)

 $t^n$  n-th timewindow [s]  $\tau^k$  k-th timestep [s]









#### 3.3 MBDyn-Adapter



#### 3.3 MBDyn-Adapter



# 3.4 Beam Mapping





- beam nodes
- interpolated mesh solid solver
- mesh interpolation

- Radial Basis Function (RBF) mapping requires fluid and solid meshes of same dimension (2D and 2D)
- creation of *interpolated mesh* between MBDyn and the MBDyn-Adapter
  - → mapping between the beam nodes and the *interpolated mesh*

 mapping between interpolated mesh and structured mesh of the fluid solver 3.5 Mesh

2D rotorblade



- mesh of the fluid-solver and of the solid-solver in preCICE
- only one blade layer is mapped because of 2D case
  - → neglecting z-coordinate

### 3.5 Mesh

2D rotorblade



**3D rotorblade** 

۸Y

• • •	• • • •	
• • •	• • • •	•••••••••••
• • •	• • • •	

# 4. Speedup



5. Results





University of Stuttgart

# Thank you!



## 5. Results



Velocity Magnitude (m/s)

