CFD for Pump Design

How CFD can improve the design process

Agenda

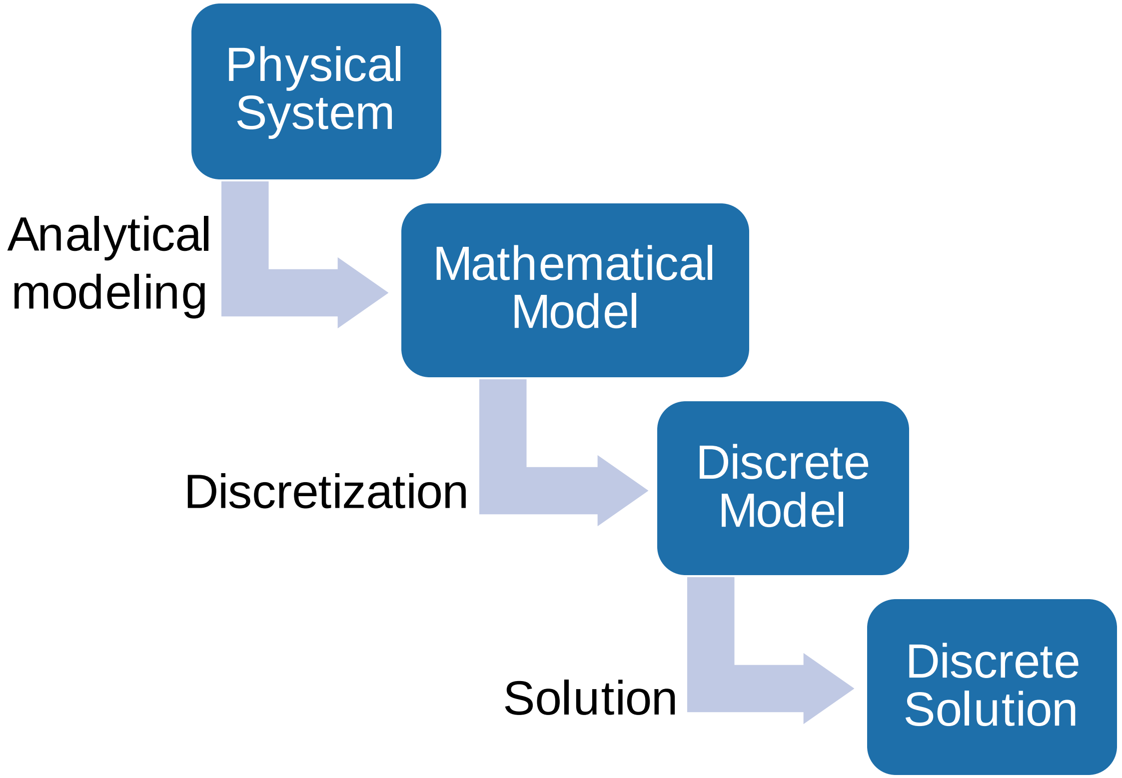
- What is CFD?
- Why CFD?
- Design Challenges
- Test Case

    1. Pre-processing
    2. Simulation Set-up
    3. Post-processing
    4. Pump Curve

- Result summary

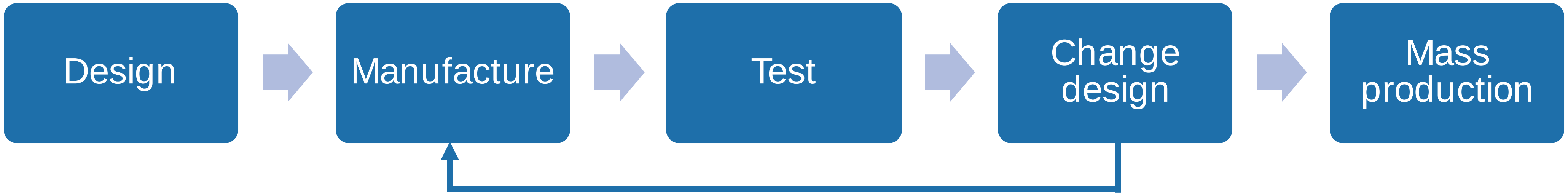
What is CFD?

- Describes the velocity and pressure fields in the computational domain
- Gives the numerical solution of the Navier-Stokes equations

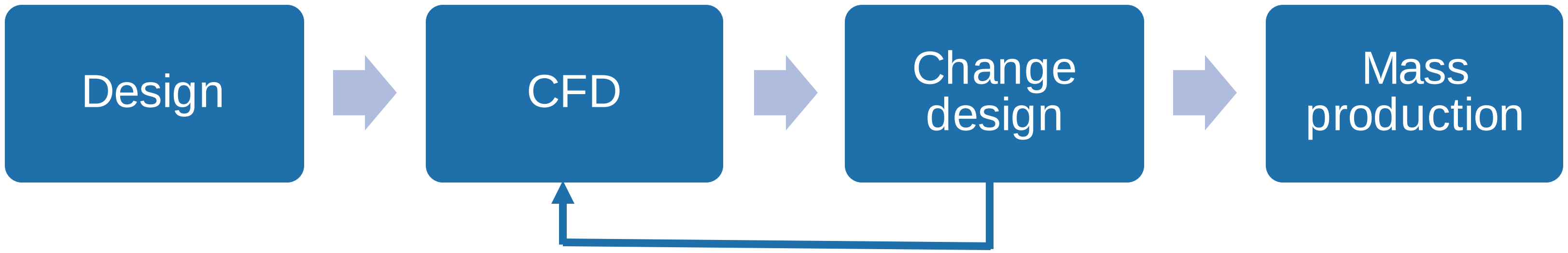


Why CFD?

Without CFD



With CFD



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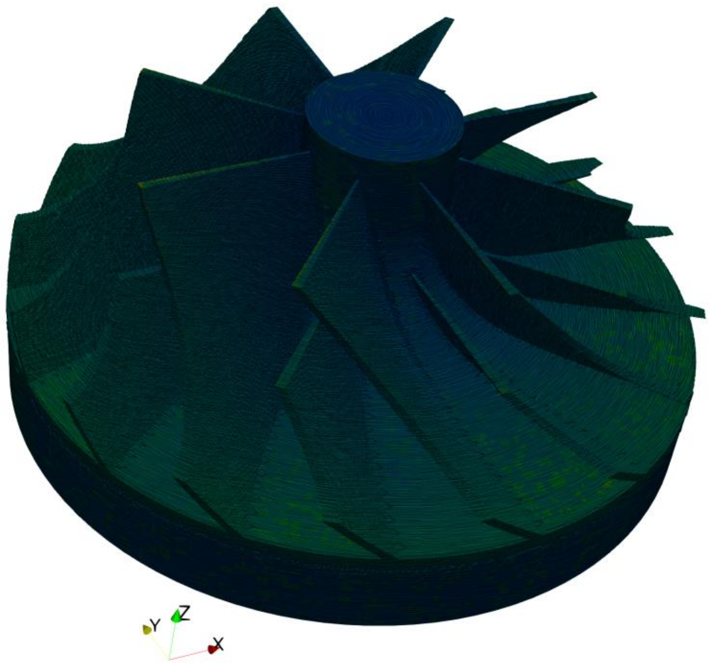
Design Challenges

How to:

- Choose the best blade count?
- Choose the best blade angle?
- Determine the optimum housing design?
- Predict cavitation?
- Determine pump curves?



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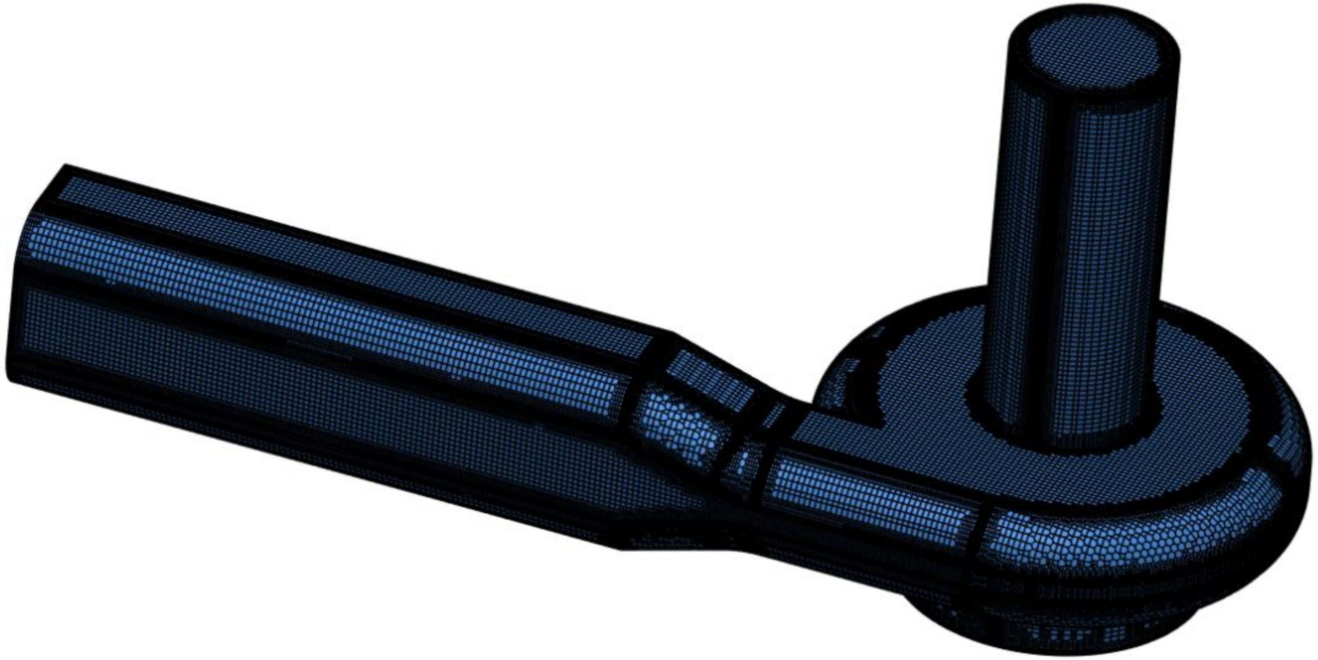
Test Case – Preprocessing

Mesh:

- Elements: 6.4 million
- Duration: 114 minutes
- Core hours: 30.4

Rotating Zone:

- Approach: Multi Reference Frame
- Used for steady-state time dependency
- Computationally cheaper than others



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Test Case – Simulation Set-up

Turbulence model:

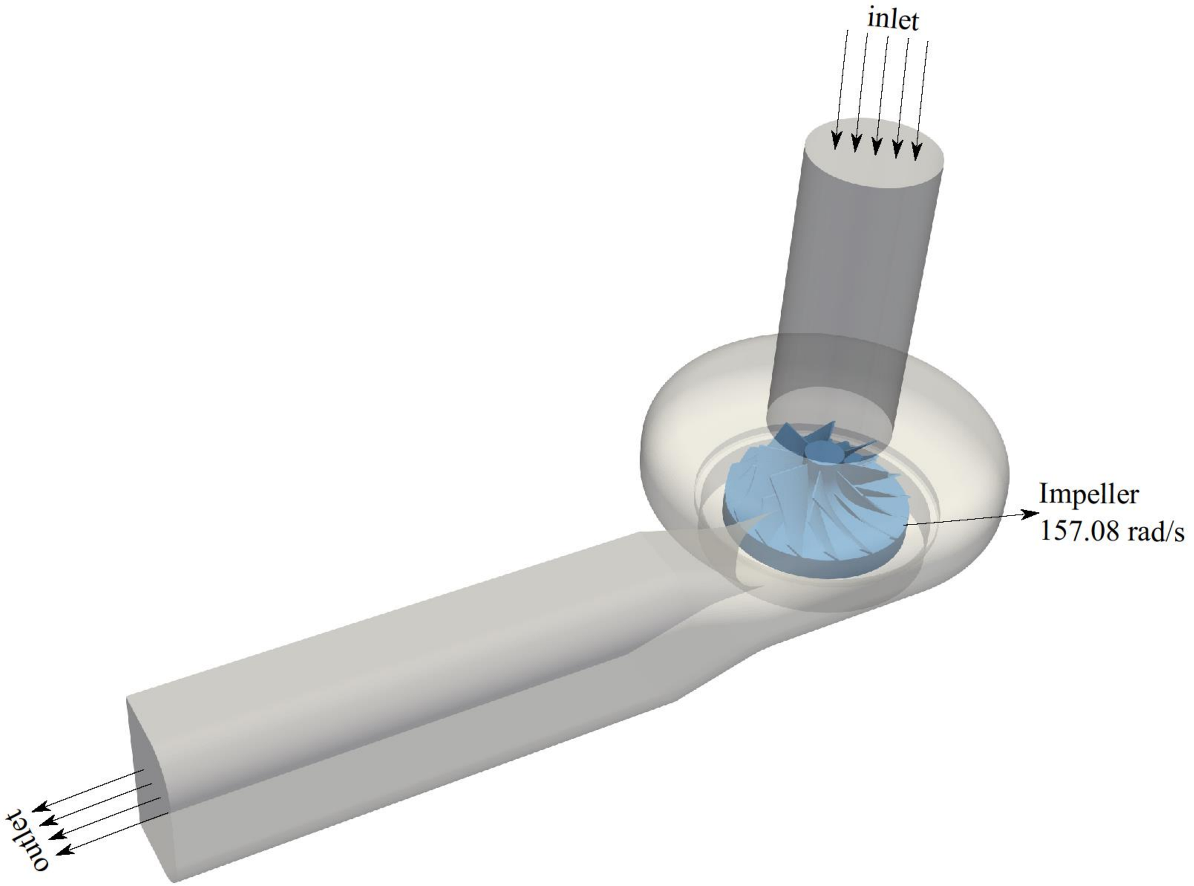
- K-ω SST
- Predicts well at both, the wall and away from it

Boundary conditions:

- Velocity inlet (Flow rate = 2.61 m^3/h)
- Pressure outlet (P_{gauge} = 0 Pa)
- No slip wall

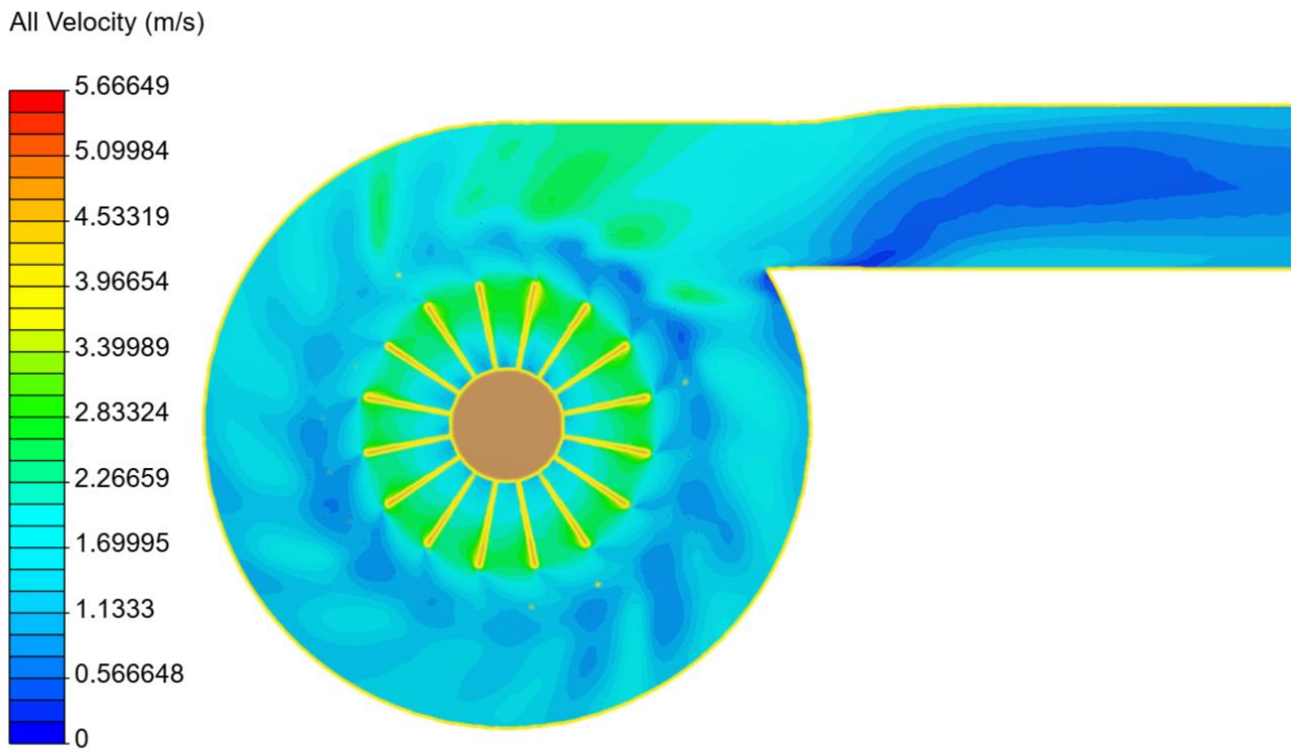
Time dependency:

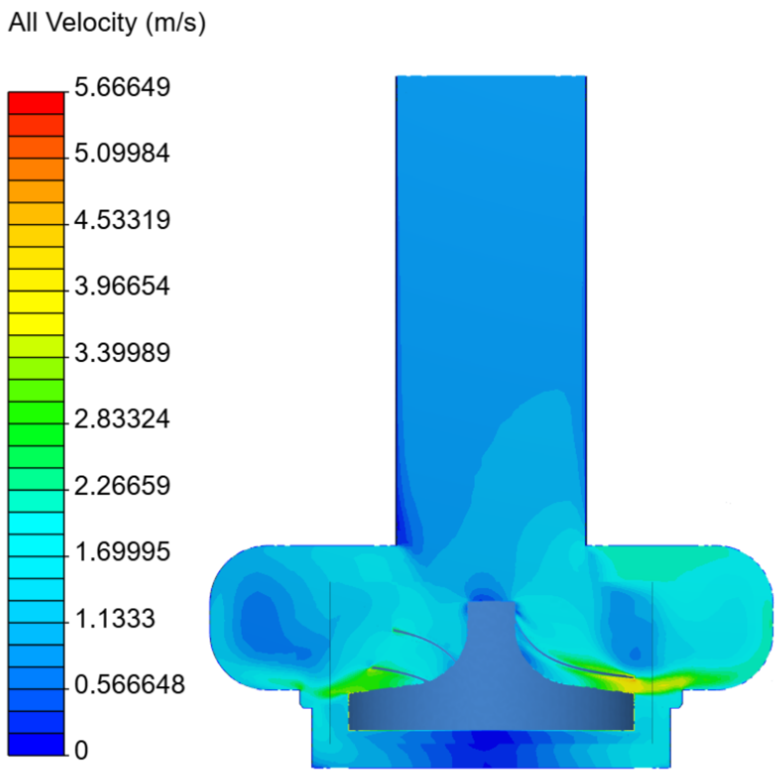
- Steady-state



Test Case – Postprocessing

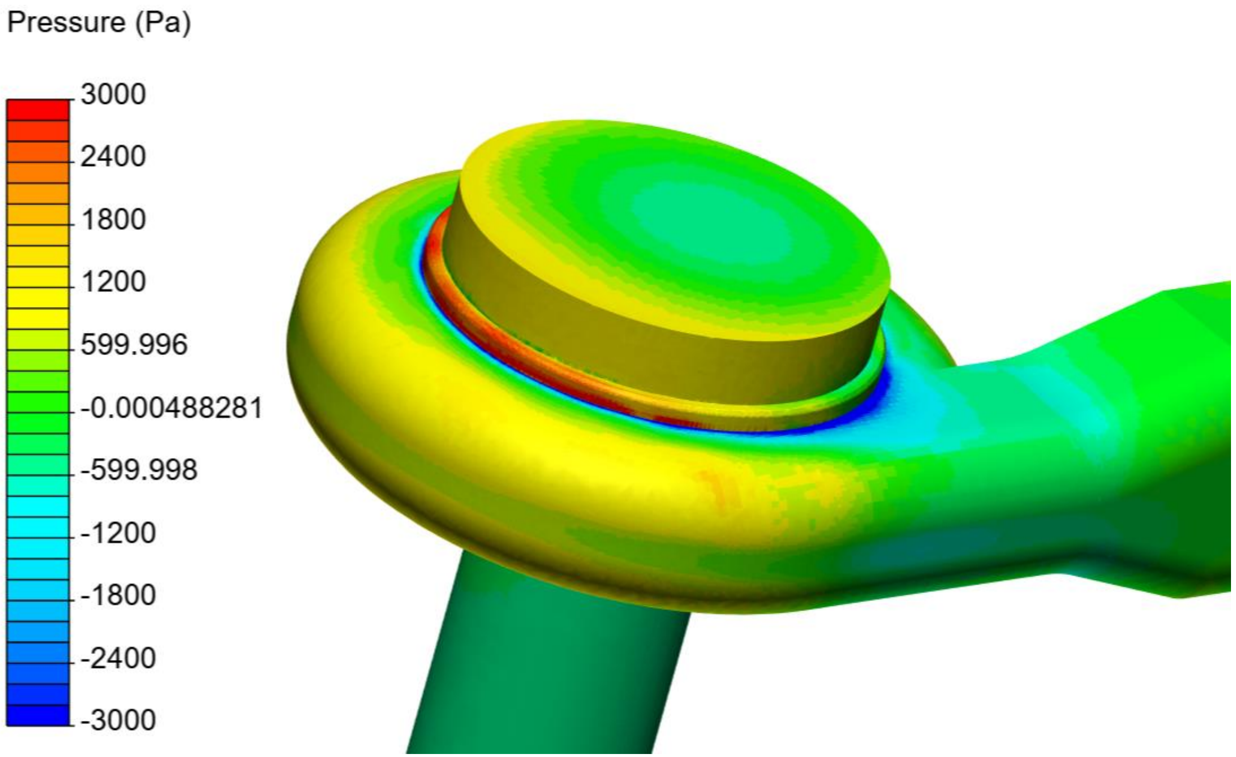
Velocity

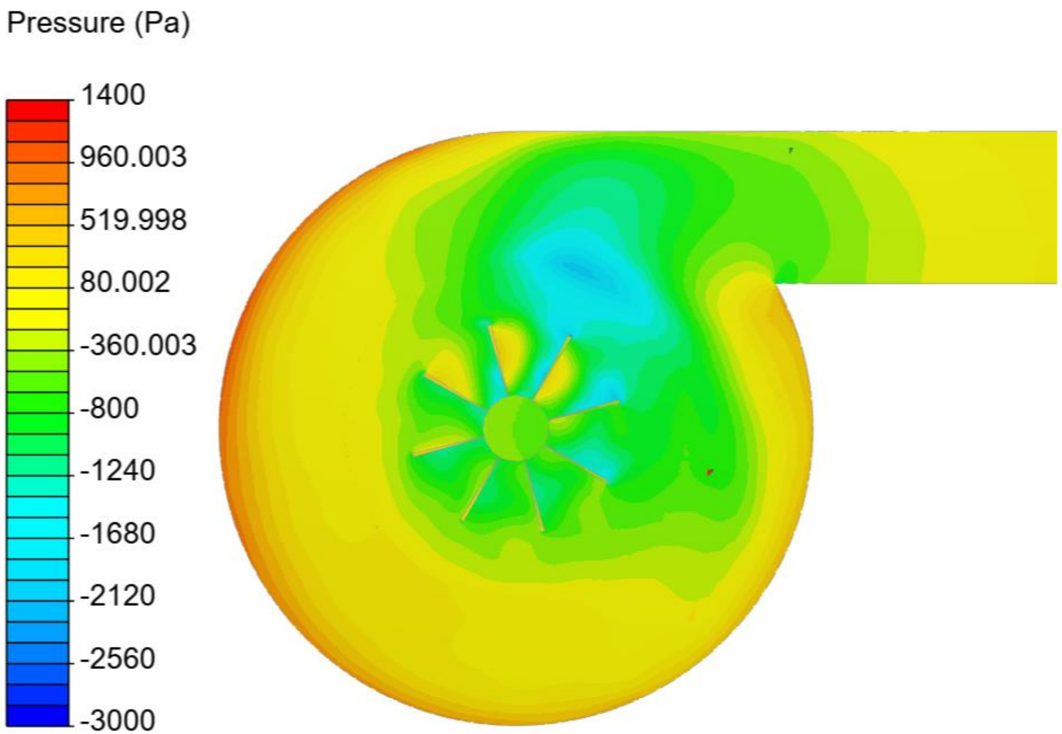




Test Case – Postprocessing

Pressure





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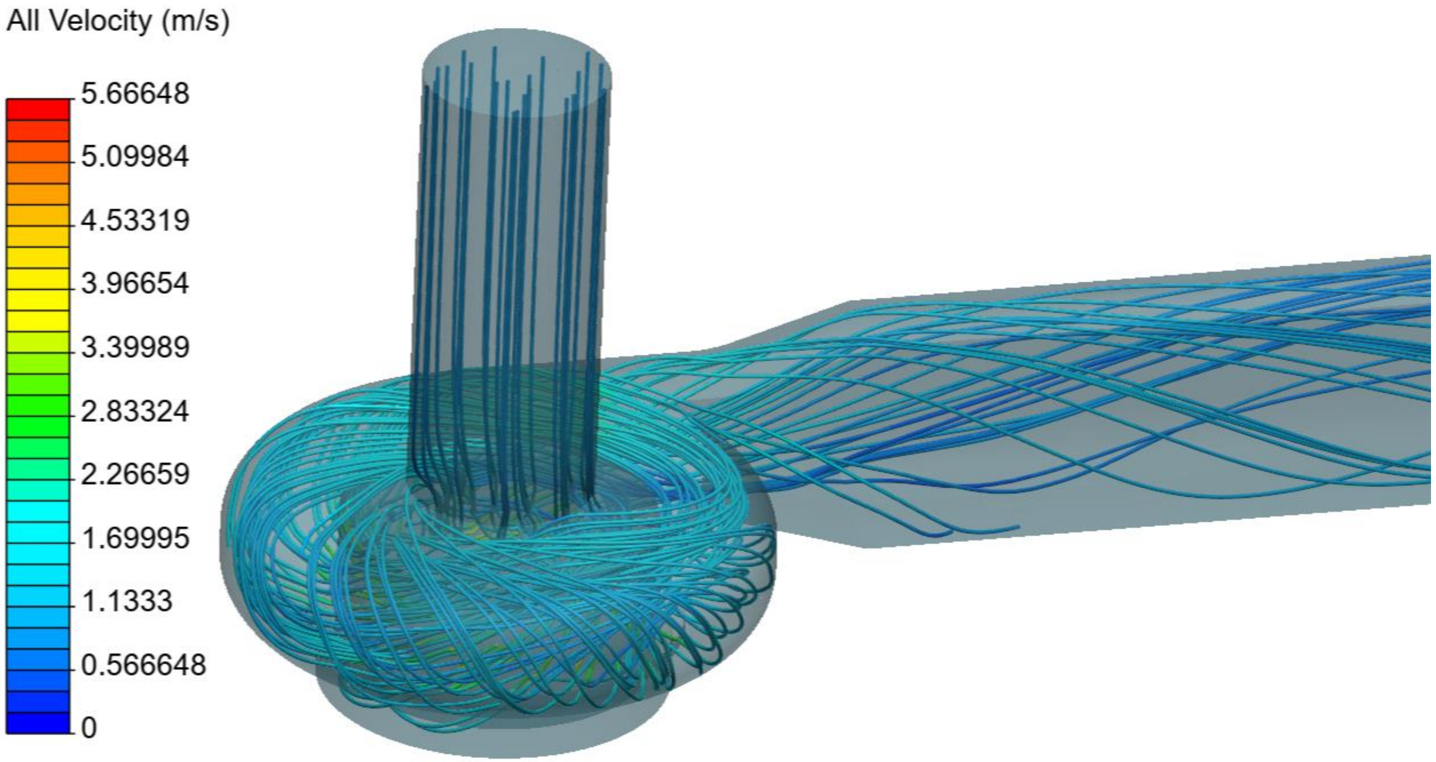
Test Case – Postprocessing

Streamlines



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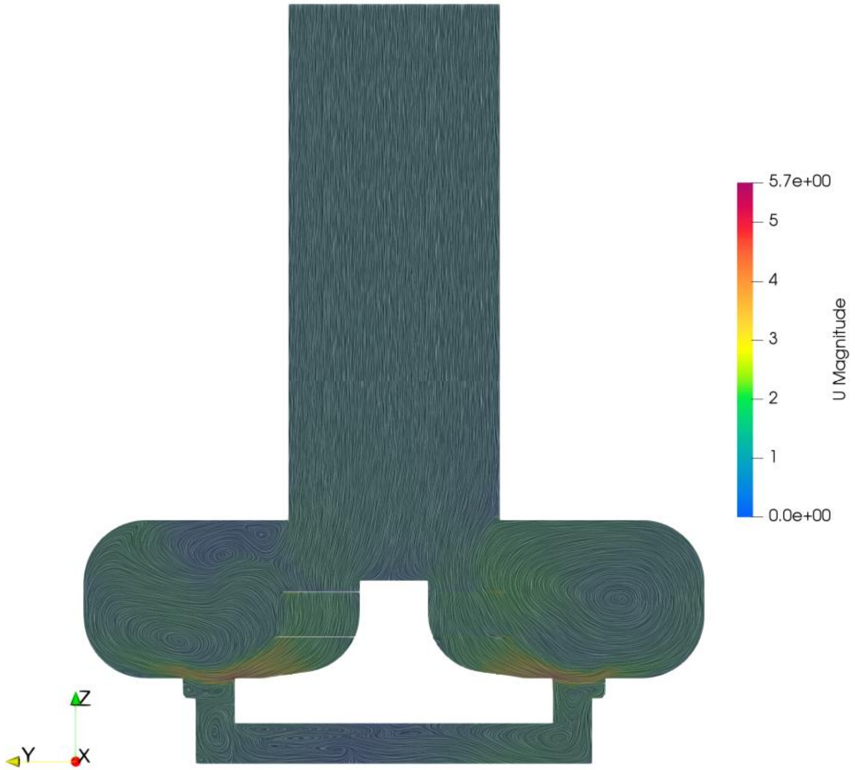
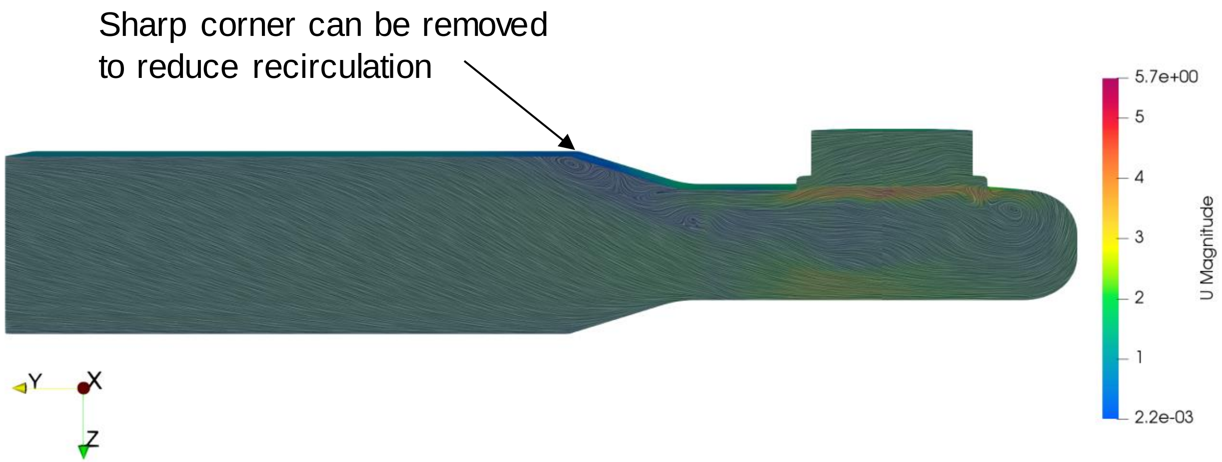
Test Case – Postprocessing

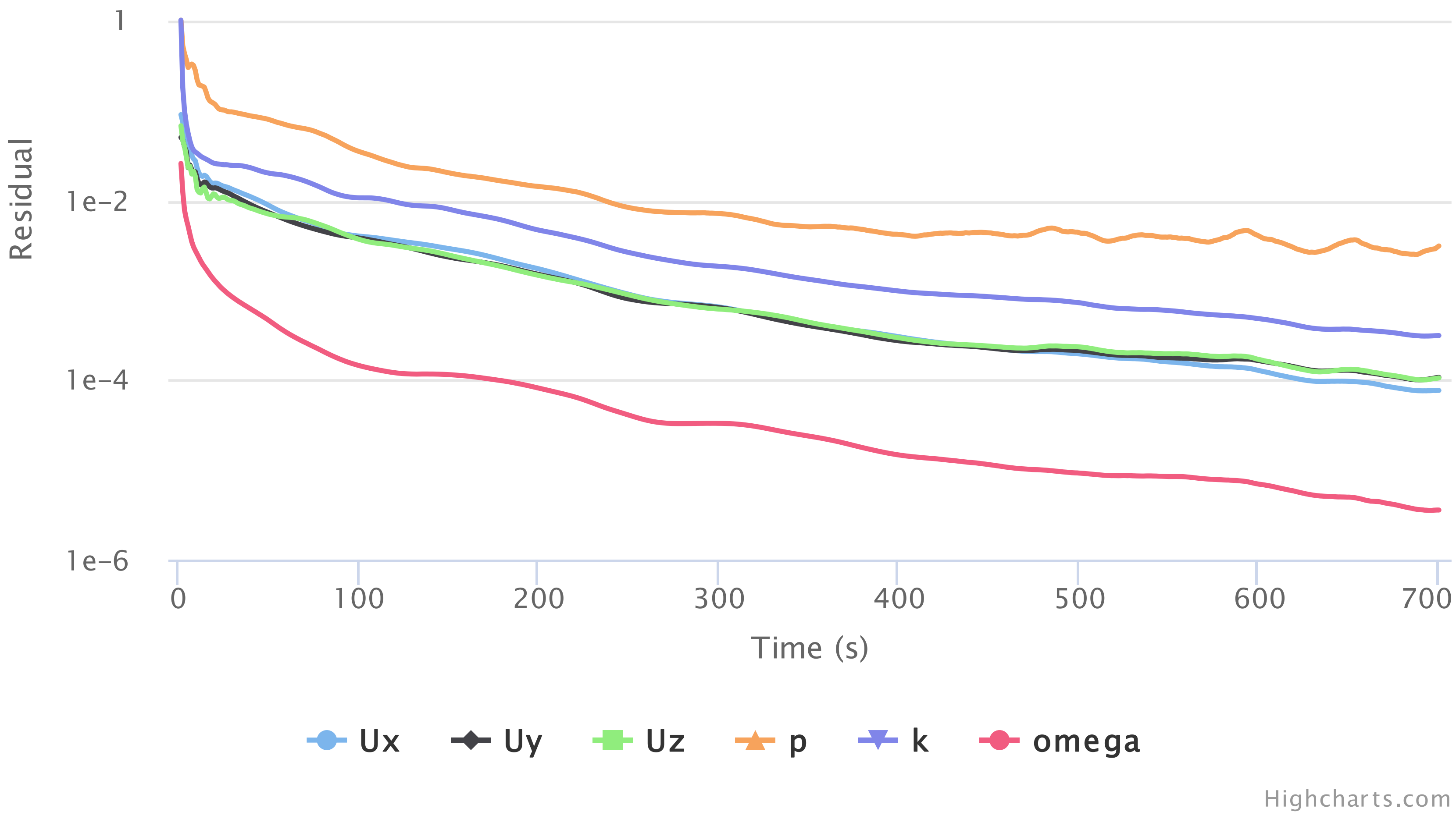
Recirculation





Test Case – Postprocessing

Convergence



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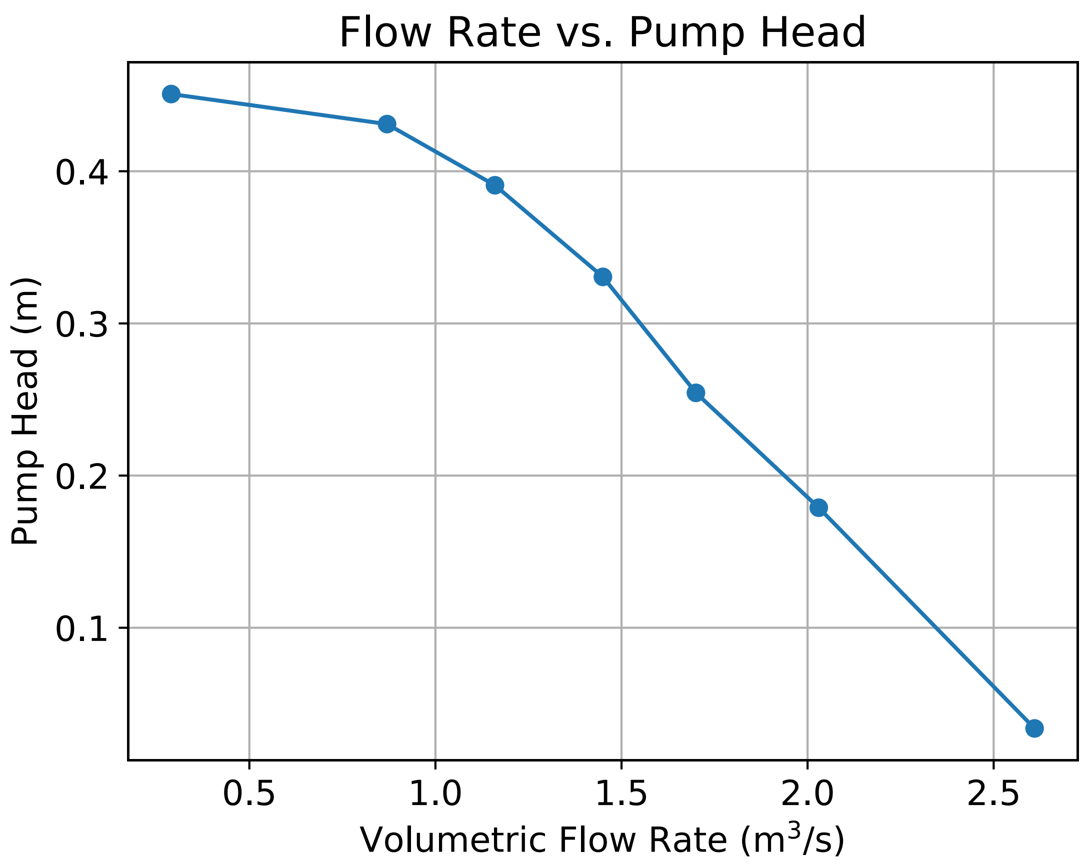
Test Case – Pump Curve



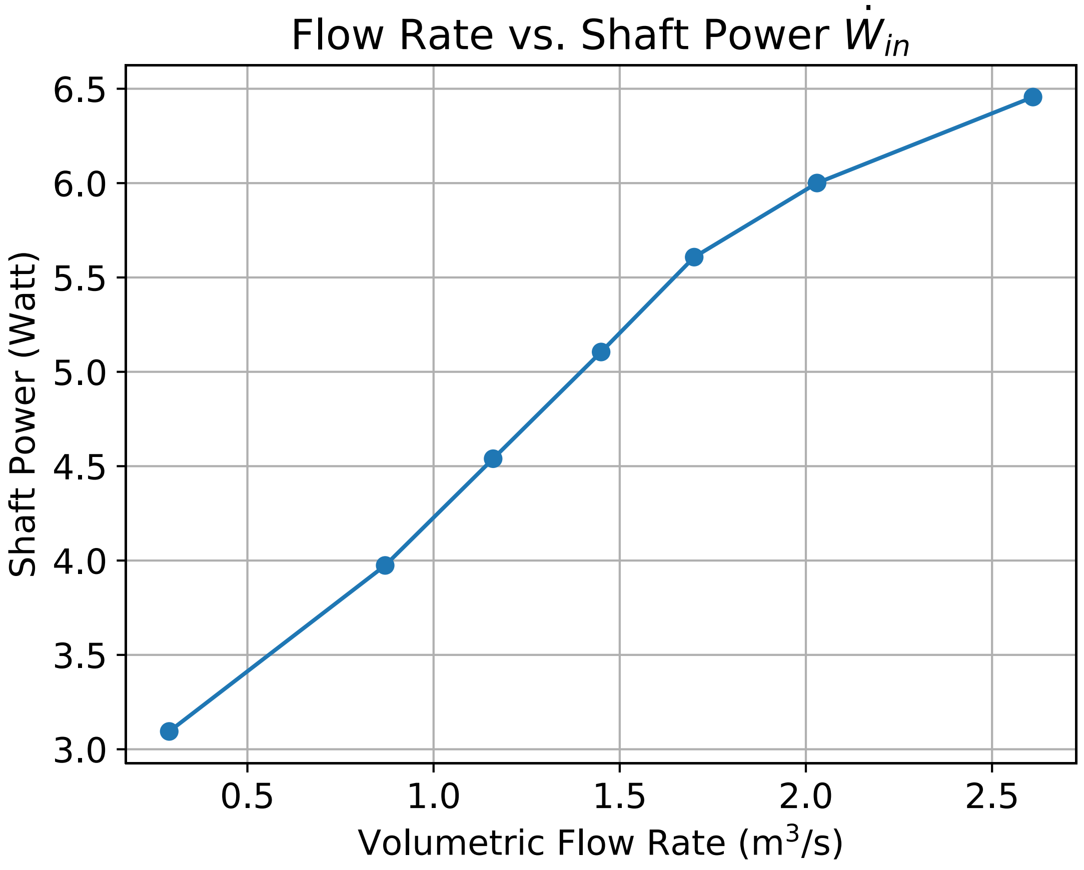
Data from the CFD results:

- Inlet and outlet velocities
- Inlet pressure

Equation:

$$H_p = \frac{\Delta P}{\gamma} + \frac{v_{outlet}^2 - v_{inlet}^2}{2g}$$

Test Case – Pump Curve

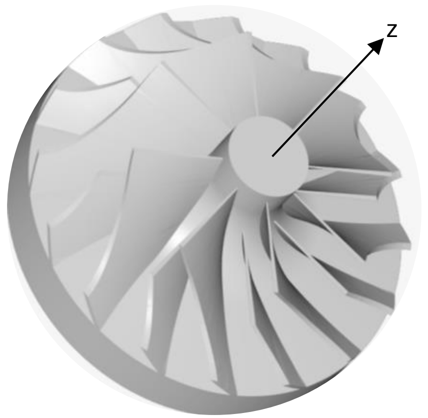


Data from the CFD results:

- Moment (z-axis) of the impeller

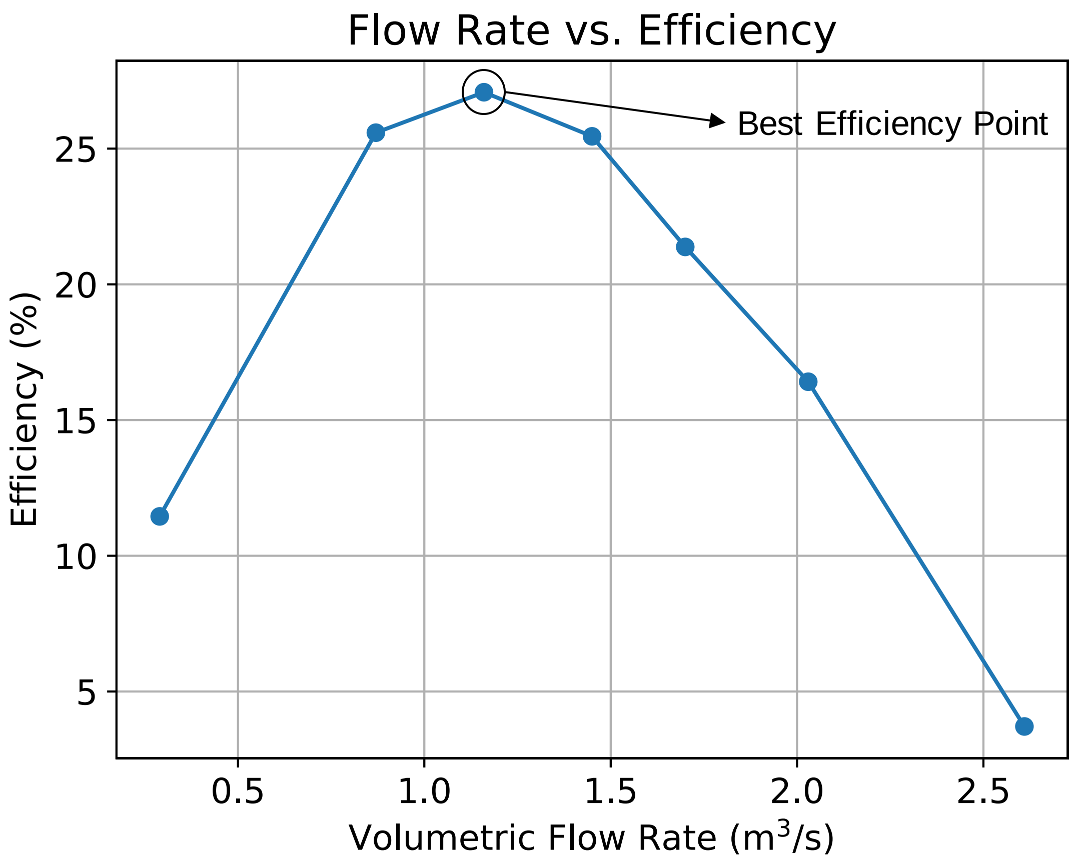
Equation:

$$\dot{W}_{in} = Torque \times \omega$$



Clockwise rotation

Test Case – Pump Curve



Equation:

$$\eta = \frac{\dot{W}_{out}}{\dot{W}_{in}}$$

Water power:

$$\dot{W}_{out} = \gamma \times flow\,rate \times H_p$$

Test Case

Area average

Volumetric flow rate	Mass flow rate	
	Inlet	Outlet
0.29	8.0E-05	8.0E-05
0.87	2.4E-04	2.4E-04
1.16	3.2E-04	3.2E-04
1.45	4.0E-04	4.0E-04
1.7	4.8E-04	4.8E-04
2.03	5.6E-04	5.6E-04
2.61	7.2E-04	7.2E-04

A stable and converged simulation:

- Can be verified with an area average at the inlet and outlet

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Result Summary

- CFD saves a lot of time and money
- It can give pump curves
- It is efficient for selecting the optimum:

1. Blade number
2. Blade angle
3. Housing geometry