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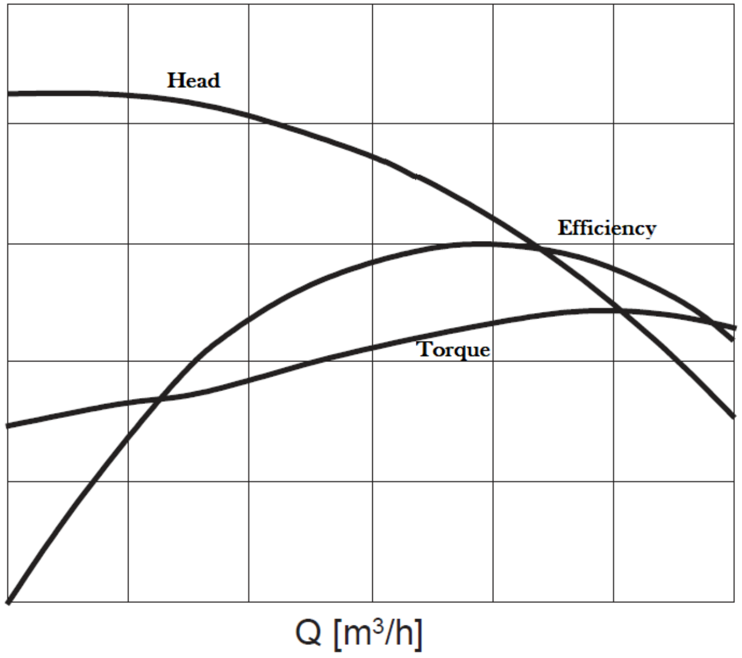
# Frozen Rotor approach for Radial Pump

## COMMERCIAL AND OPENFOAM CFD COMPARISONS

# Pump physics

- Centrifugal pumps are used for transporting liquids by raising a specified volume flow to a specified pressure level
- Head $H = \frac{p_{T_{outlet}} - p_{T_{inlet}}}{\rho g}$
- Efficiency $\eta = P_{water}/P_{shaft}$
  - $P_{water} = \rho g H Q$
  - $P_{shaft} = Torque \cdot \omega$
- Torque measured on impeller walls



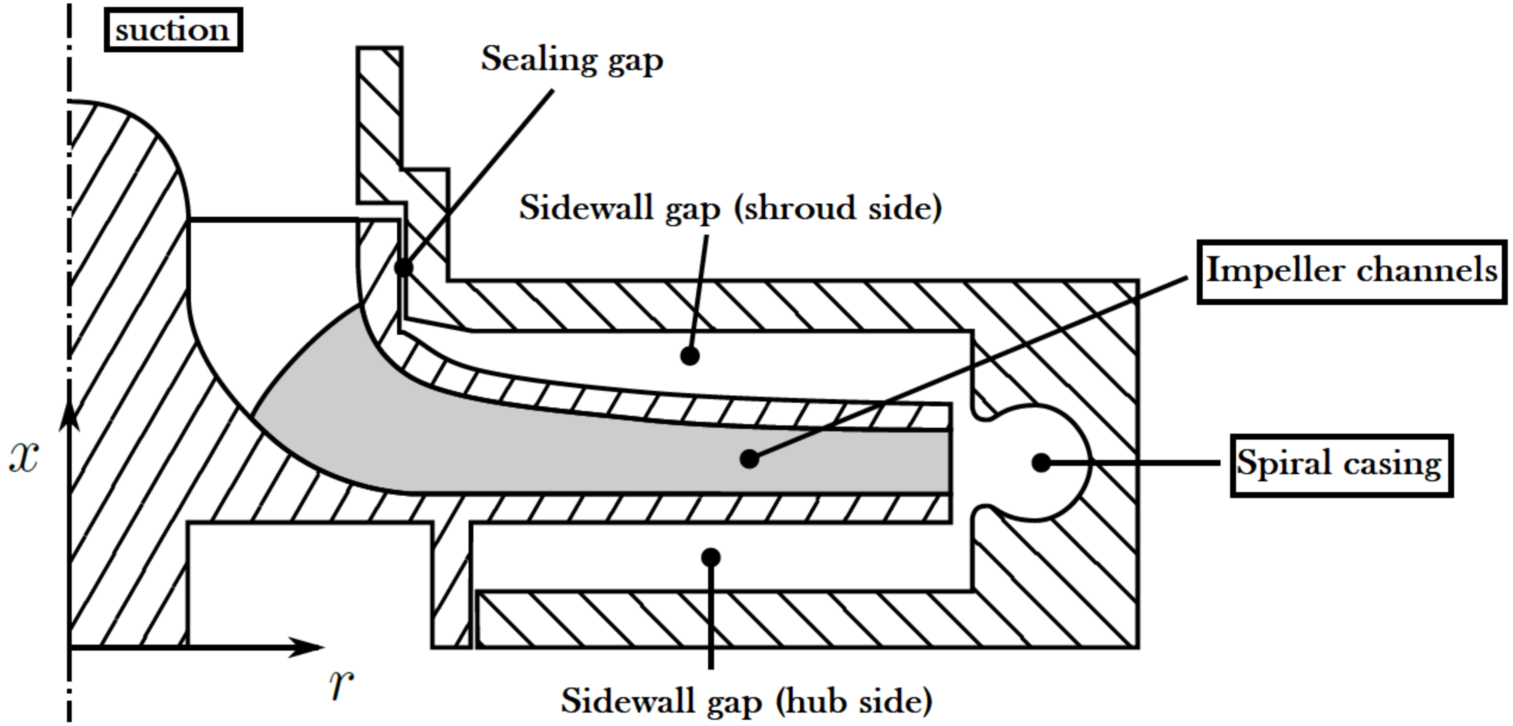

# CFD of Pumps

**Unsteady**

- *Transient Rotor-Stator*

**Steady-state**

- *<u>Frozen Rotor</u>*
- *Mixing Plane*



# Test case and Setup

***Boundary Conditions***

- Inlet $flowrate\ [10-45]\ L/s$
- Outlet $static\ pressure\ 0\ Pa$

***Turbulence model***

$k-\omega\ SST$

***Numerics***

$div(phi, U)\ Gauss\ linearUpwindV$

$div(phi, k)\ Gauss\ upwind$

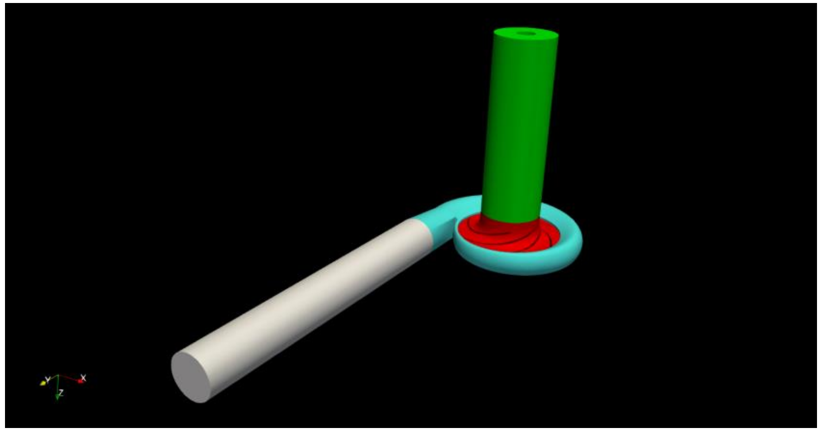
$div(phi, \omega)\ Gauss\ upwind$

***Solver***

$simpleFoam$ for 2000 iterations

***Cases***

1. $Commerial$ (Mesh + Solver)
2. $OF1$ (Mesh + cyclicAMI)
3. $OF2$ (cfMesh + cyclicAMI)
4. $OF3$ (cfMesh + cellZoneSet)

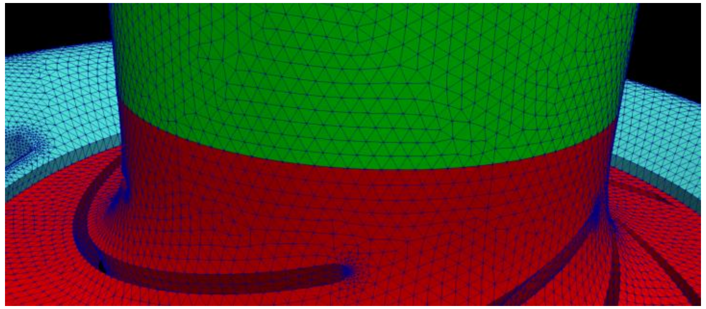


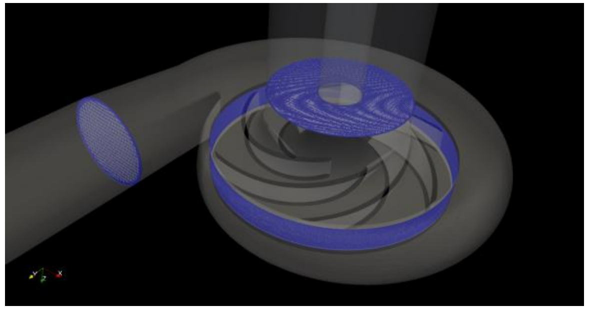
# Test case and Setup

## ***Interfaces***

AMI: Creating addressing and weights between 25000 source faces and 5020 target faces
AMI: Patch source sum(weights) min/max/average = 0.64427, 1, 0.999928
AMI: Patch target sum(weights) min/max/average = 0.842609, 1, 0.999945

- Use the same refinement for the STLs at interfaces
- Use the same mesh cell size and boundary layer size at the





## ***MRFProperties***

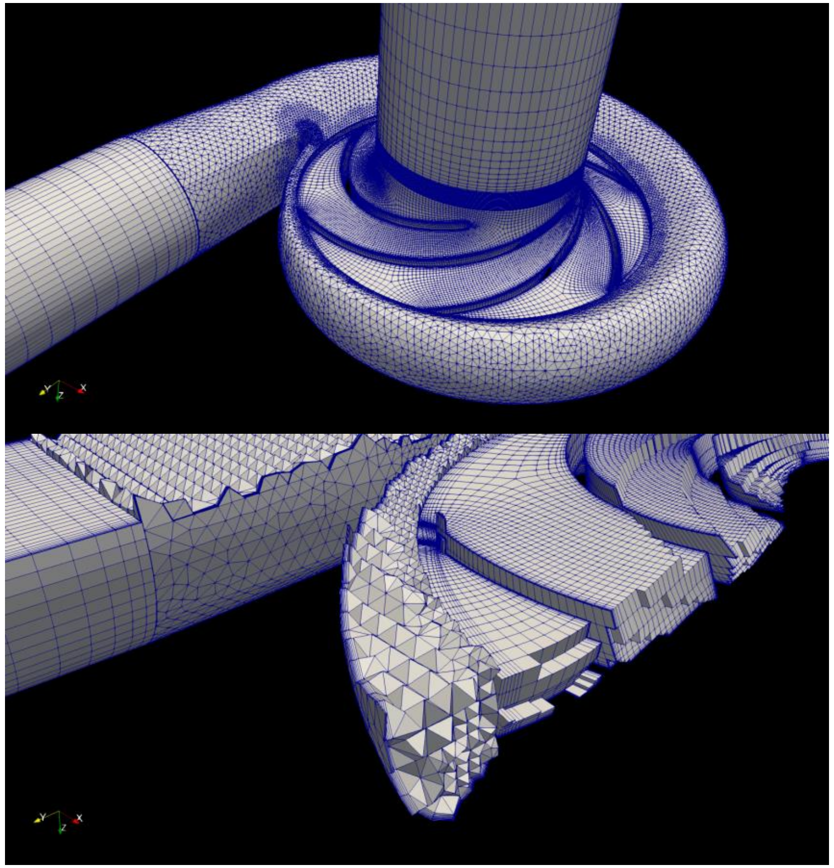
nonRotatingPatches (AMI_IMPELLER_INLET AMI_IMPELLER_VOLUTE);

## ***swak4Foam***

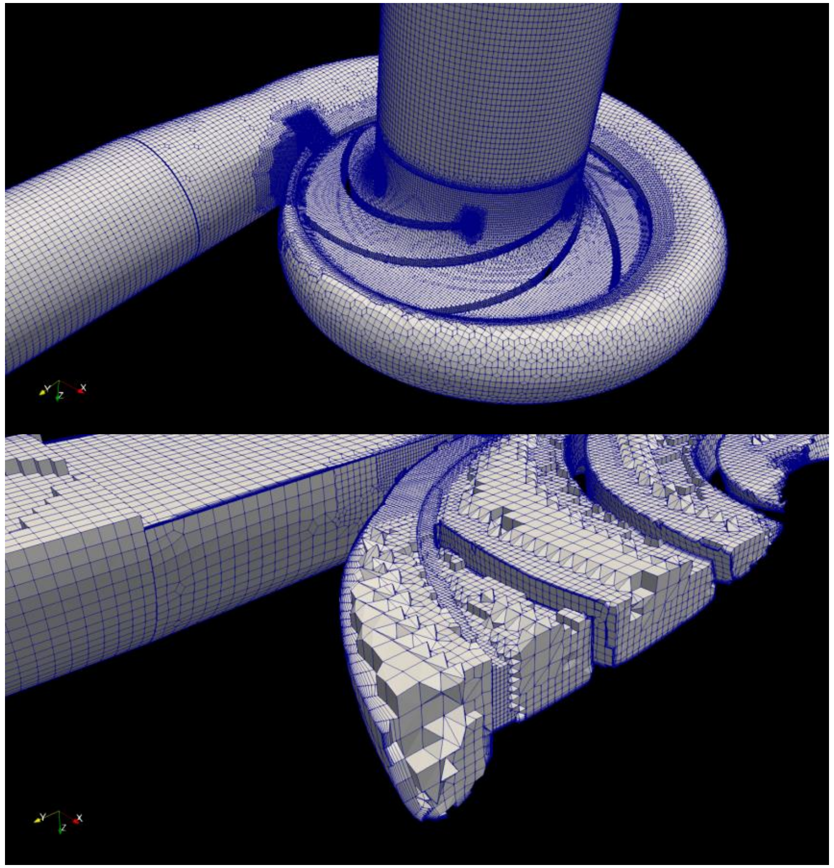
```
totalHead
{
    type expressionField;
    writeControl timeStep;
    writeInterval 1;
    fieldName Htot;
    redirectType Htot;
    expression "p/9.81+pow(mag(U),2)/(2*9.81)";
    autowrite true;
    dimension [0 1 0 0 0 0 0];
}
```

# Mesh

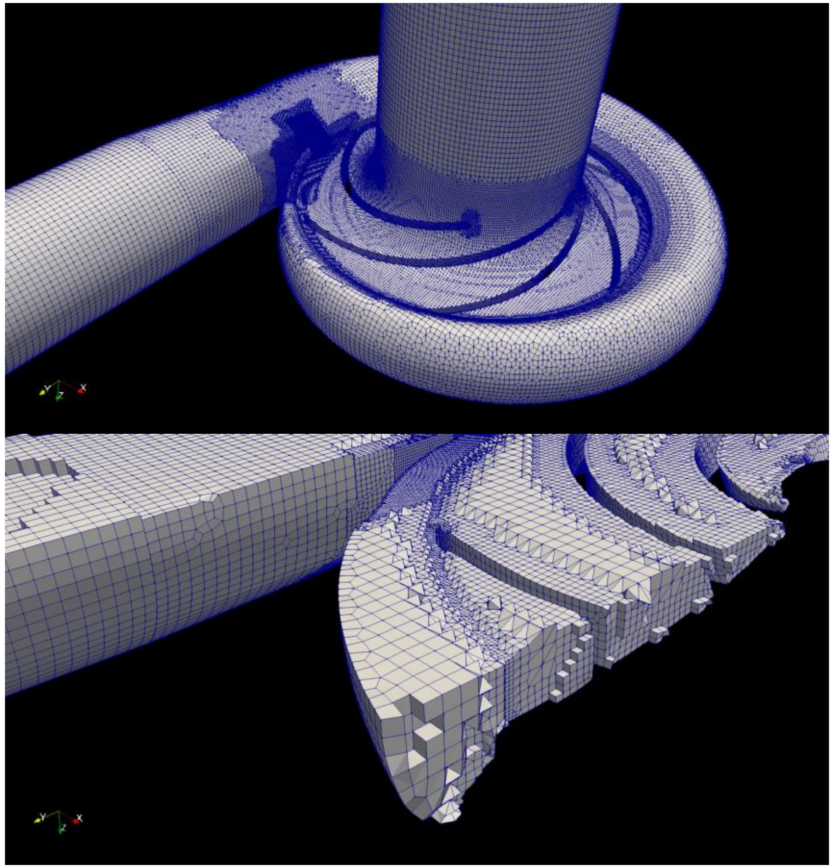
***Commercial – OF1  (1.5 Mio)***



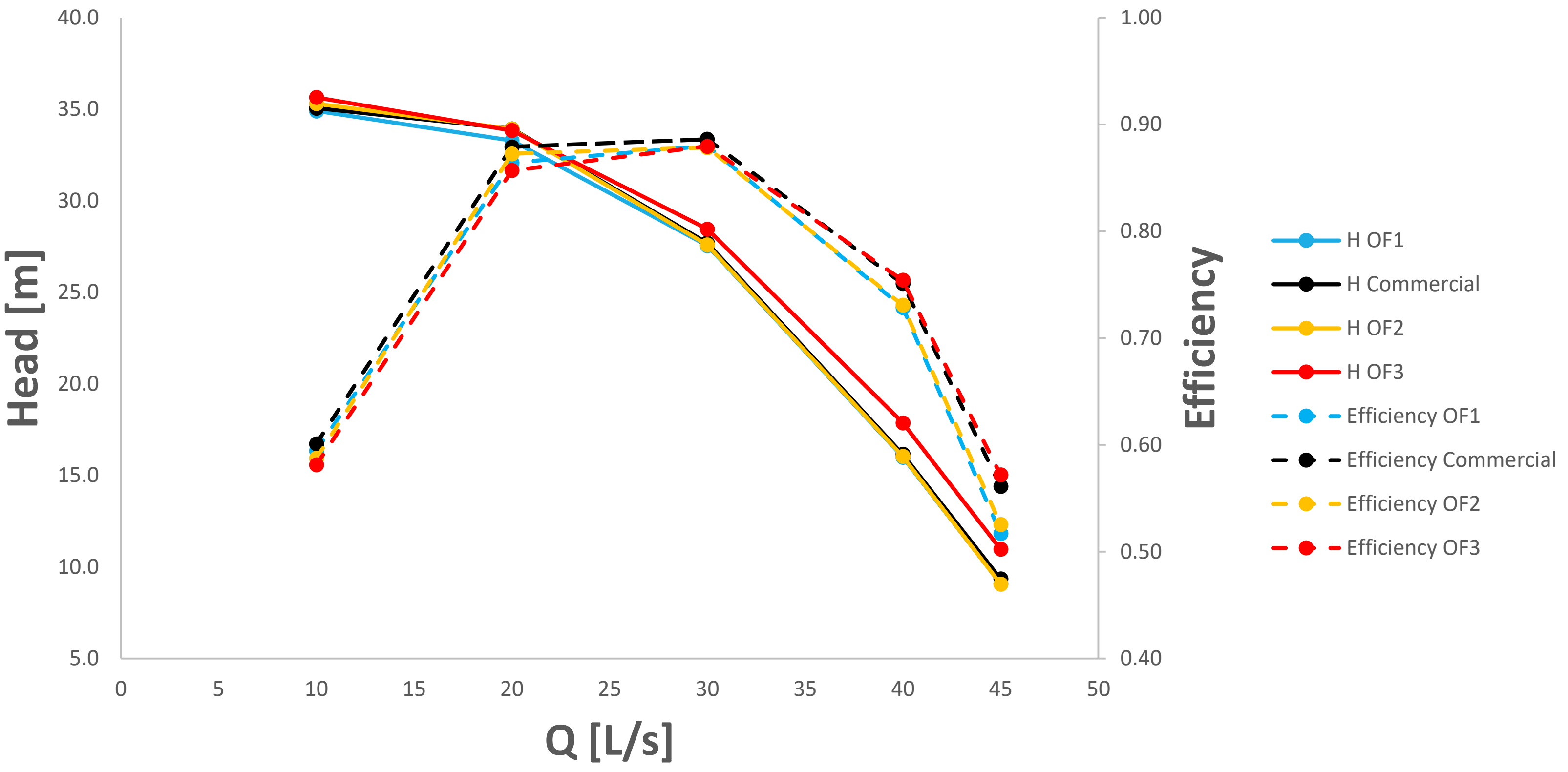
***OF2 (4.1 Mio)***



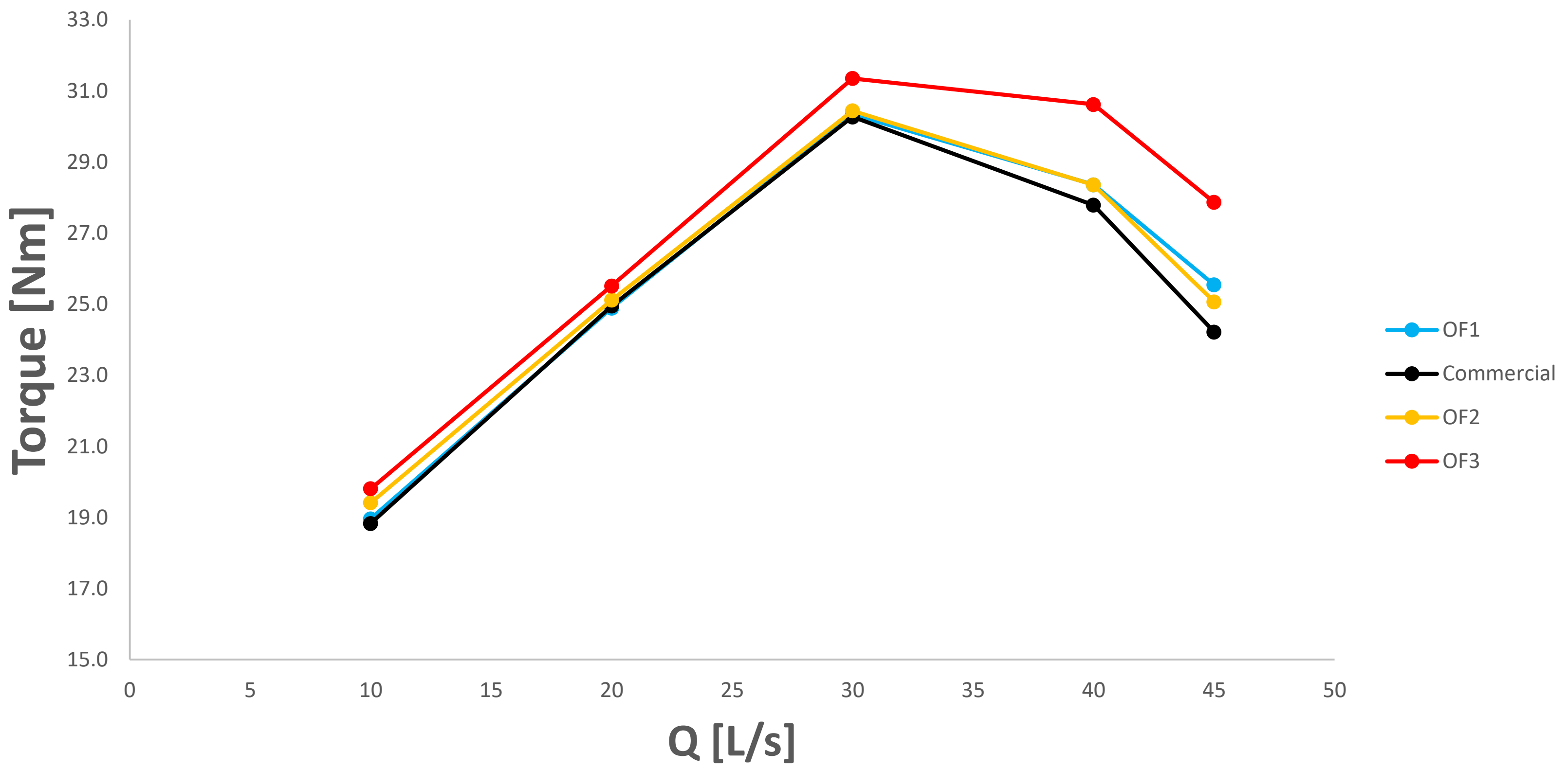
***OF3 (1.1 Mio – no BL)***



# Results : Head and Efficiency



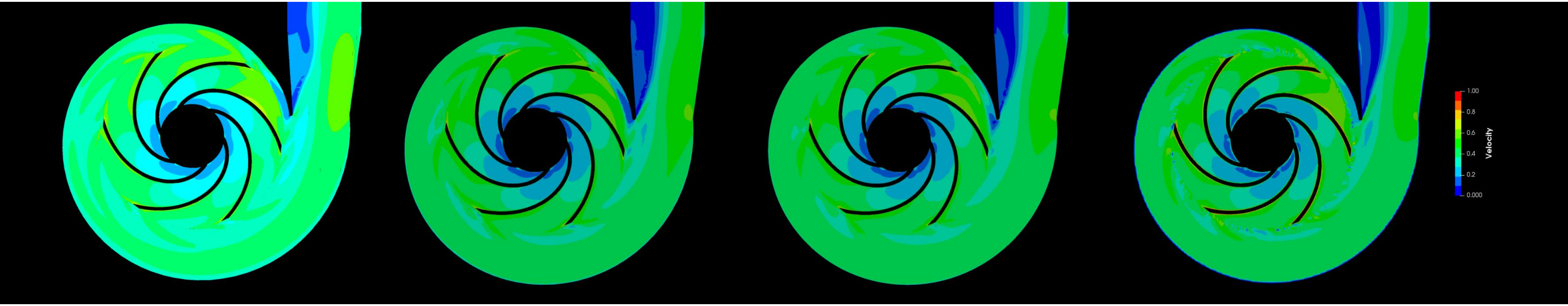
# Results : Torque



# Results : Velocity field

$$Scaled\ Velocity = U/U_2$$

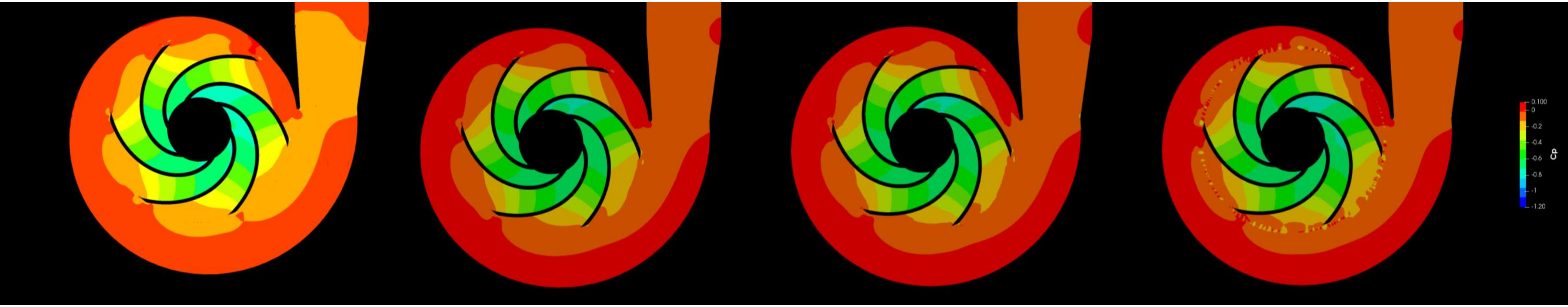
***Commercial*** ***OF1*** ***OF2*** ***OF3***



# Results : Pressure field

$$C_P = \frac{p}{\frac{1}{2}\rho U_2^2}$$

***Commercial*** ***OF1*** ***OF2*** ***OF3***



# Conclusion

1. *cyclicAMI* gives similar results than a commercial software with the Frozen Rotor approach

2. *cellZoneSet* approach showed bad results at the interface (bad setup?)

Next steps:

- Mixing-Plane (foam-extend)
- Mixing-Plane with single impeller channel
- Transient simulation
- …