

4th DualSPHysics Users Workshop

Simulating an Archimedes Screw Pump with DualSPHysics



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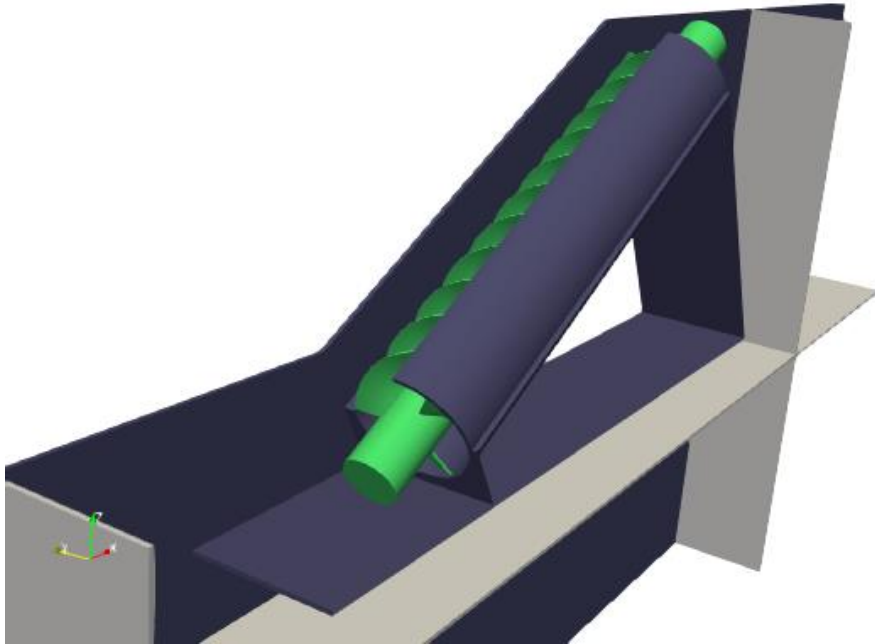
Introduction

- The case: an Archimedes Screw Pump
- Simulation settings
- Results
- Conclusions

The case: an Archimedes Screw Pump

- Real life engineering project for a fairly large water pumping station for agricultural irrigation.
- Current convention is to estimate the mass flow rate with analytical methods:
 - 1st step: 3D CAD volume analysis
 - 2nd step: Apply a factor, based on experimental results
- DualSPHysics was chosen as an experimental tool to assess if the analytical calculations are accurate enough or not.

The case: an Archimedes Screw Pump



- 13.5 m for the axle length
- 12.2 m for the screw length
- 3 screw blades, 8mm thick
- Inclination: 29°
- Splash guard: design 40° , used 90°
- Rotation speed: 27.3 RPM

Simulation settings

- DualSPHysics4 v4.2.068 (09-08-2018), pre-built GPU version
- NVIDIA GeForce GTX 1070 Ti, 8GiB of RAM
- Particle distribution dp : 0.05m
- Initial RAM occupancy: 2641214 particles, 575 MB on GPU and 227 MB on CPU
- 60s simulation took roughly 38h to run

Simulation settings

```

<constantsdef>.....
...<lattice.bound="1".fluid="1"/>
...<gravity.x="0".y="0".z="-9.81".comment="Gravitational acceleration".units_comment="m/s^2"/>
...<rho0.value="997.45".comment="Reference density of the fluid".units_comment="kg/m^3"/>
...<hswl.value="0".auto="true".comment="Maximum still water level to calculate speedofsound using coefsound".units_comment="metres (m)"/>
...<gamma.value="7".comment="Polytropic constant for water used in the state equation"/>
...<speedsystem.value="0".auto="true".comment="Maximum system speed (by default the dam-break propagation is used)"/>
...<coefsound.value="15".comment="Coefficient to multiply speedsystem"/>
...<speedsound.value="0".auto="true".comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)"/>
...<coefh.value="1.0".comment="Coefficient to calculate the smoothing length (h=coefh*sqrt(3*dp^2) in 3D)"/>.....
...<cflnumber.value="0.2".comment="Coefficient to multiply dt"/>.....
</constantsdef>.....

<parameters>
...<parameter.key="PosDouble".value="1".comment="Precision in particle interaction 0:Simple, 1:Double, 2:Uses and saves double (default=0)"/>
...<parameter.key="StepAlgorithm".value="2".comment="Step Algorithm 1:Verlet, 2:Symplectic (def=1)"/>
...<parameter.key="VerletSteps".value="40".comment="Verlet only: Number of steps to apply Eulerian equations (def=40)"/>
...<parameter.key="Kernel".value="2".comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (def=1)"/>
...<parameter.key="ViscoTreatment".value="2".comment="Viscosity Formulation 1:Artificial, 2:Laminar+SPS (def=1)"/>
...<parameter.key="Visco".value="9.3378e-7".comment="Viscosity value".units_comment="m^2/s"/>
...<parameter.key="DeltaSPH".value="0.1".comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (def=0)"/>.....

```

Simulation settings

```

<parameter key="Shifting" value="3" comment="Shifting mode: 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)"/>
<parameter key="ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)"/>
<parameter key="ShiftTFS" value="2.75" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)"/>
<parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm: 1:SPH, 2:DEM (default=1)"/>
<parameter key="FtPause" value="0.01" comment="Time to freeze the floatings at simulation start (warmup) (def=0)"/>
<parameter key="DtIni" value="0.0001" comment="Initial time step"/>
<parameter key="DtMin" value="0.0000001" comment="Minimum time step (def=0.00001)"/>
<parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)"/>
<parameter key="TimeMax" value="60.0" comment="Time of simulation"/>
<parameter key="TimeOut" value="0.1" comment="Time between output files"/>
<parameter key="IncZ" value="1.0" comment="Increase of Z"/>
<parameter key="PartsOutMax" value="1" comment="%/100 of fluid particles allowed to be excluded from domain (default=1) units_comment="decimal"/>
<parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700) units_comment="kg/m^3"/>
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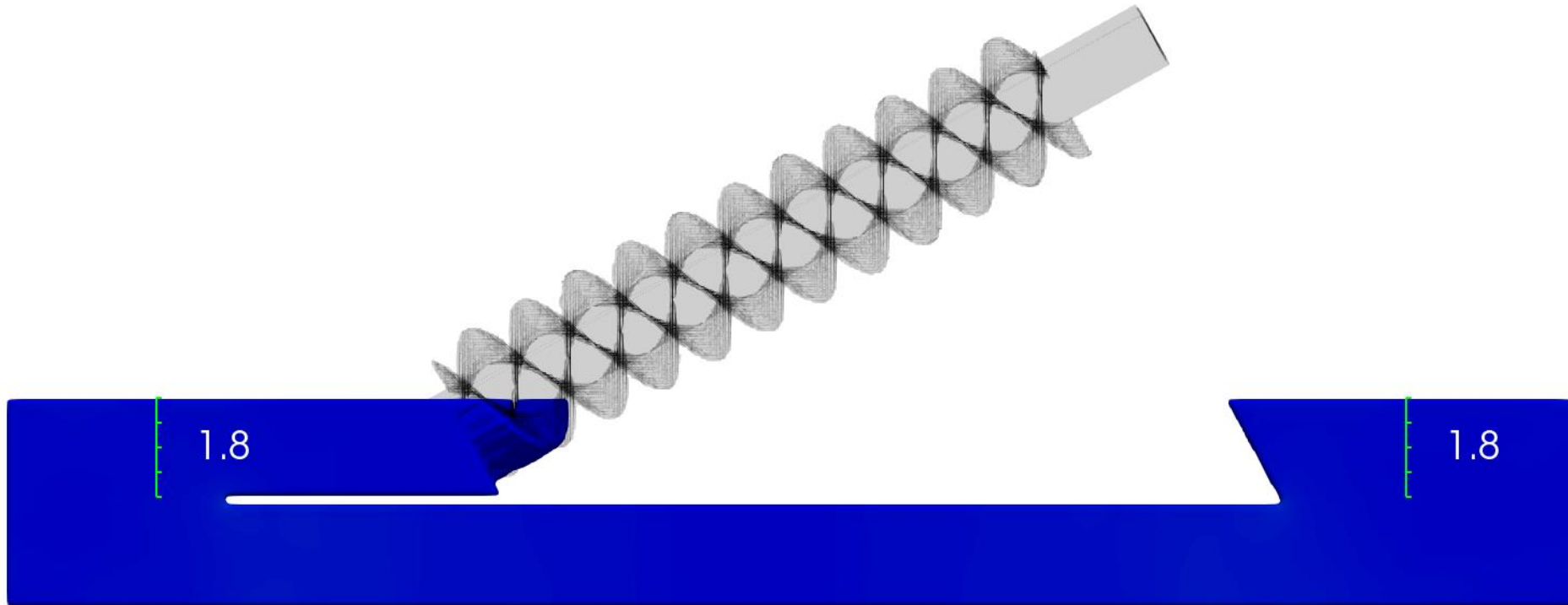
Simulation settings

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...<velini.ang="0".units_comment="rad/s"/>
...<axispl.x="-2.02349".y="0".z="0.73239".units_comment="m"/>
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...</mvrotace>
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...<axispl.x="-2.02349".y="0".z="0.73239".units_comment="m"/>
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...</objreal>
</motion>

```

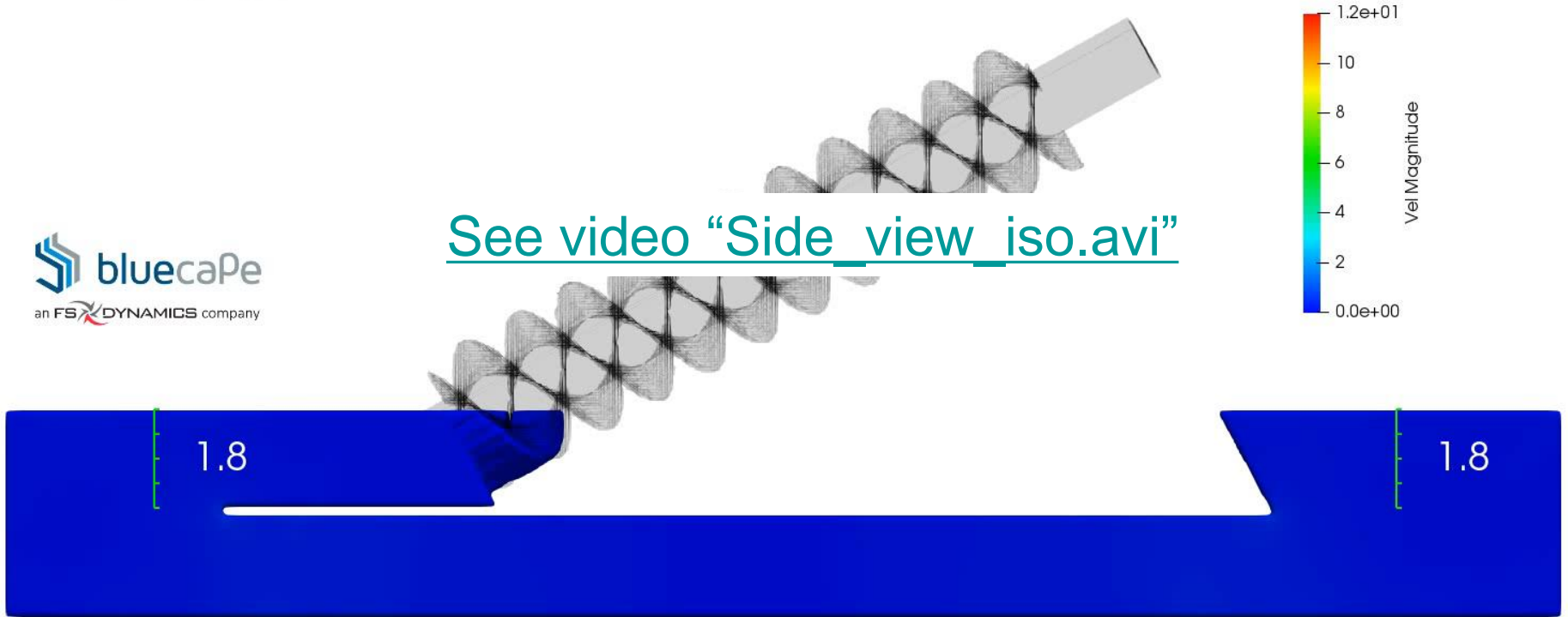

Simulation settings



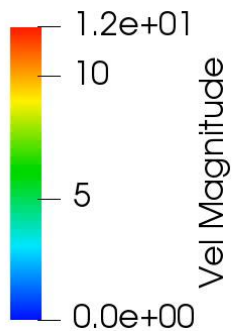
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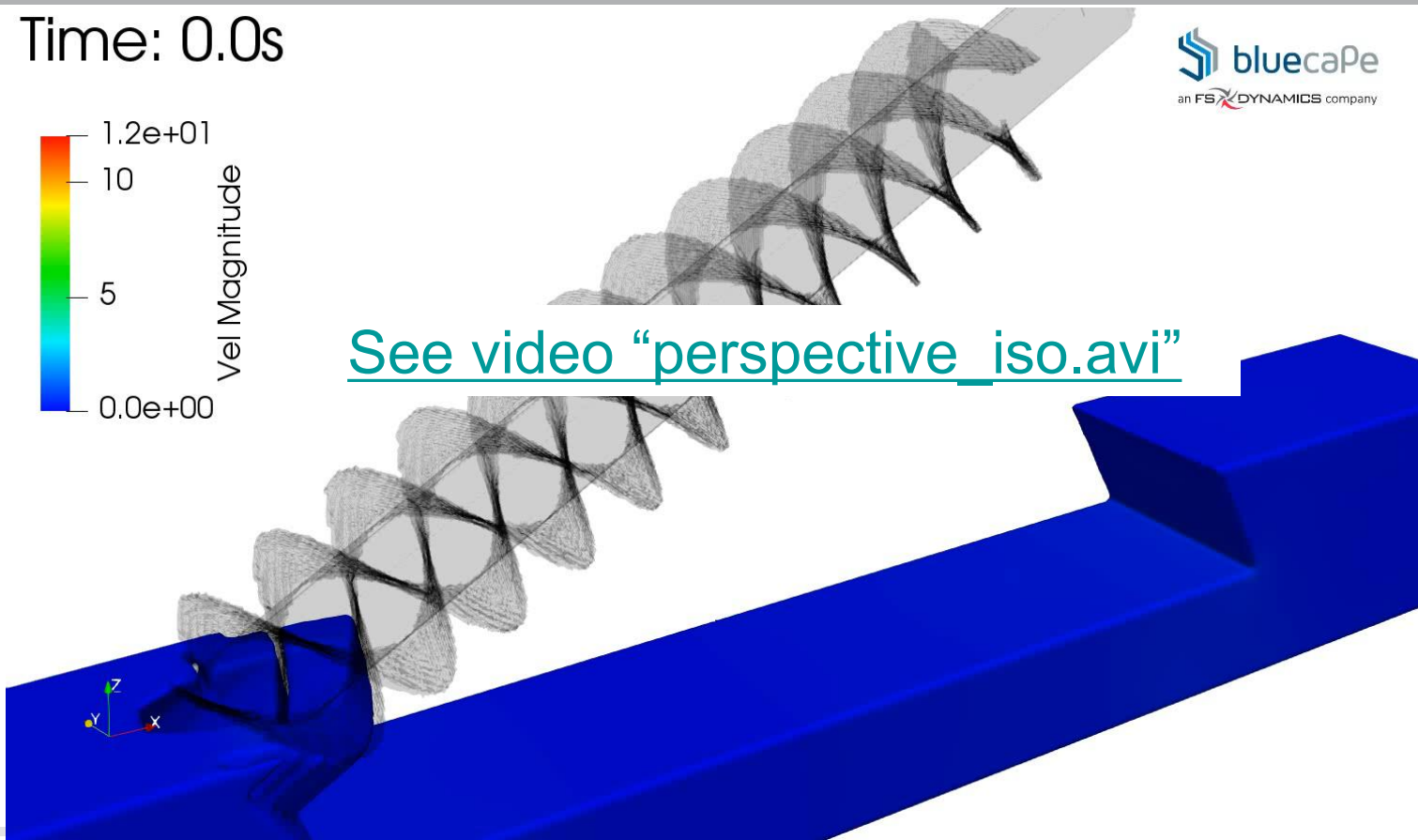
[See video "Side view iso.avi"](#)



Time: 0.0s



[See video “perspective_iso.avi”](#)

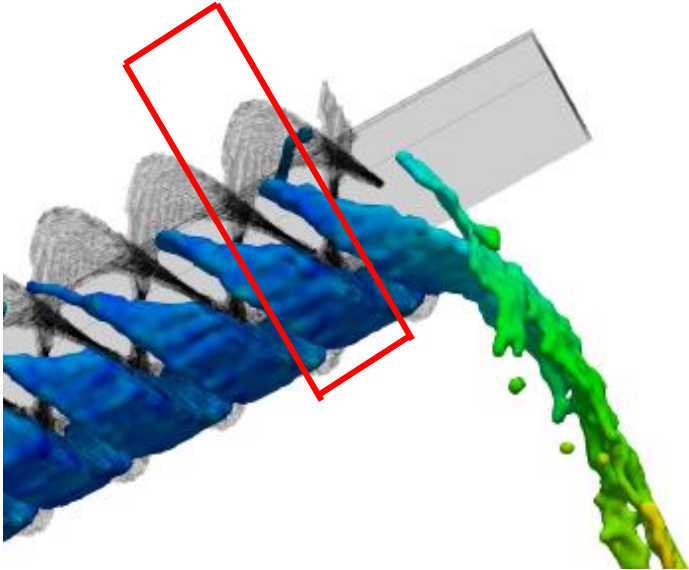


Time: 0.0s

[See video “zoom_in_perspective.avi”](#)



Results



- The objective was to measure the mass flow rate.
- Either we would to code our own utility to calculate this...
- Or we could use a sampling box, shown on the left, and correlate with the rotation speed.
- We ended up not doing this, given the missing volume.

Conclusions

- Inlet boundary conditions from DualSPHysics 4.4 are very much welcome!
- Due to hydrophobic effect on moving bounds on these scales, a new implementation is needed (it's even worse at $dp=0.0005m$)
- We need a new utility to (more accurately) calculate the mass flow rate
- Hermetic bound particles would be very helpful (we had 5-15cm thick blades, instead of 8mm)

Conclusions – post-workshop

- The hydrophobic effect on moving bounds should be reduced if we correct the speed of sound value.
 - The dynamic boundary conditions treatment in DualSPHysics 4.3/4.4 should also help minimize this effect.
- The FlowTool utility present in DualSPHysics 4.2 should allow us to calculate the mass flow rate.
- Plugging in holes on the surfaces could possibly be done by following the instructions given in the DualSPHysics 4.2 Users Guide, specifically the example **RedrawGenCase**.