silentdynamics

Tutorial Ship Resistance Analysis

Hannes Kröger hannes.kroeger@silentdynamics.de

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| Overview | Single Phase | Two Phase | Efficiency Improvements | |
|----------|--------------|-----------|-------------------------|--|
|----------|--------------|-----------|-------------------------|--|

Overview

Efficiency Improvements

At small Froude Numbers and low wave making resistance: Simulation assuming a flat water surface

- enable single phase simulation
- stationary solver
- faster than two-phase simulation

 \Rightarrow simpleFoam solver

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Overview

ingle Phase |

Two Phase

Efficiency Improvements

Approximate consideration of free surface in single phase simulation possible: potentialFreeSurfaceFoam

through special boundary condition "waveSurfacePressure"

Efficiency Improvements

If wave making resistance cannot be neglected: Resolution of water surface

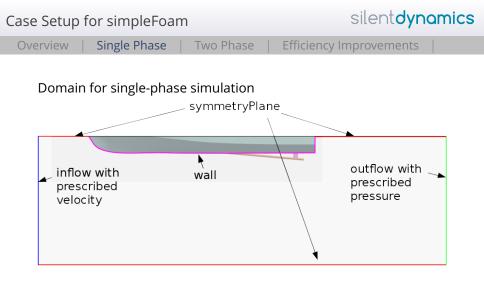
- two-phase simulation (water + air)
- only time resolved solvers in OpenFOAM
 interFoam
- for steady problems: quasi-steady approach with local timestepping

 \Rightarrow LTSInterFoam / localEuler



If trim and sinkage is freely changing and needs to be determined: Resolution of water surface + mesh deformation

- two-phase simulation (water + air)
- only time resolved solvers in OpenFOAM
 interDyMFoam



Meshing

Overview

Single Phase

Two Phase

- 1. create template mesh using blockMesh
- 2. setup snappyHexMesh
- 3. run snappyHexMesh
- 4. setup solver, BCs
- 5. run solver
- 6. postprocessing

Extract Wake Field for Propeller

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Overview

Single Phase

Two Phase

Efficiency Improvements

Example post processing: extract wake field for propeller design

- Method 1
 - 1. using tool sample
 - 2. star-shaped pattern of multiple line sampleSets
- Method 2
 - using ParaView
 - cutting plane

Wake Field

Overview

Single Phase

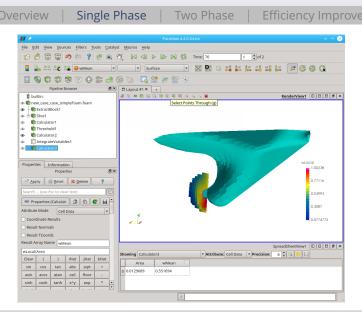
Efficiency Improvements

Propeller location: $\vec{p} = (0.17 \ 0 \ -0.21)^T$, R = 0.1

- 1. Slice Filter: Origin \vec{p} , Normal \vec{e}_x
- 2. Calculator Filter: Result "R", Expression
 "sqrt((coordsX-0.17)^2+coordsY^2+(coordsZ+0.21)^2)"
- 3. Threshold Filter: "R" between 0 and 0.1
- Calculator Filter: Mode "Cell Data", Result "wLocal", Expression "(2.196+U_X)/2.196"
- 5. Integrate Variables Filter: Field Association "Cell Data"
- Calculator Filter: Mode "Cell Data", Result "wMean", Expression "wLocal/Area"

Wake Field

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Two Phase Modelling

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Volume-of-Fluid method (VOF)

Single Phase

• volume fraction α

$$\rho = \alpha \rho_{\rm W} + (1 - \alpha) \rho_{\rm L}$$

Two Phase

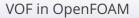
$$\nu = \alpha \nu_{\rm w} + (1 - \alpha) \nu_{\rm L}$$

transport of volume fraction

$$\frac{\partial \alpha}{\partial t} + \nabla \cdot (\alpha \vec{u}) = 0$$



- volume fraction is not continuous
- problem: numerical simulation, such that
 - interface stays sharp and is not excessively smeared
 - solution remains stable
 - spurious velocities at boundary are avoided
 - mass conservation is fulfilled



Solution of VOF equation in OpenFOAM

Single Phase

sharpening of interface by additional compressive term

Two Phase

$$\frac{\partial \alpha}{\partial t} + \nabla \cdot (\alpha \vec{u}) + \nabla \cdot (\alpha \vec{u}_c) = 0$$

time integration my MULES

VOF in OpenFOAM

Overview

Single Phase

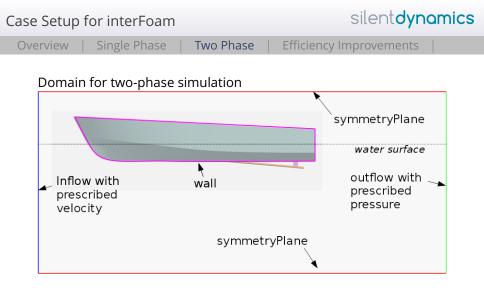
Two Phase

Efficiency Improvements

For steady state problems:

local time stepping approach

- spatially varying time step size
- as large as possible according to stability criterion
- unphysical, but convergent at infinite time
- requires spatial smoothing of time step size



BCs for α

- walls:
 - type zeroGradient;
- inlet: specification if incoming water level necessary type fixedValue;
- outlet: extrapolation from interior type zeroGradient;

BCs for Pressure

interFoam calculates with modified pressure $p_{rgh} = p - \rho gh$ (with $h = \vec{x} \cdot \vec{g} / |\vec{g}| - h_{ref}$)

walls:

```
type fixedFluxPressure;
```

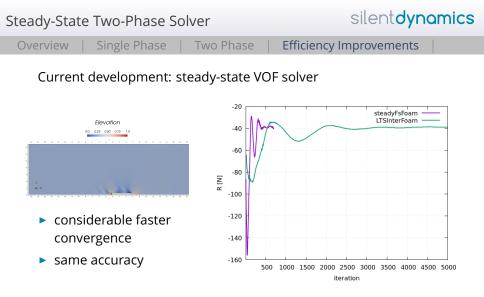
- inlet with prescribed velocity type fixedFluxPressure;
- outlet (water surface needs to be aligned with h=0)
 type fixedValue;
 value uniform 0;

Two Phase: Initialisation

| Overview | Single Phase | Two Phase | Efficiency Improvements | |
|----------|--------------|-----------|-------------------------|--|
| | | | | |

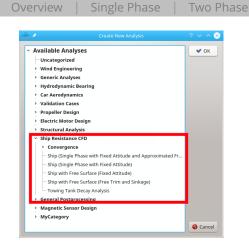
- α fields needs to be initialised
 1 in water
 0 in air
- tool setFields

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Insight Automated Workflows

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 different automated workflows available

- single-phase
- two-phase
- dynamic mesh

Insight Automated Ship Resistance Analysis

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Overview

Single Phase

Two Phase

| <u>ia</u> * | | | Insight Workbench - (Ship with Free Surface (Fixed Attitude)) | |
|-------------|----------------|--------------|--|-----------------|
| Analysis | | | | |
| Input | Run | Output | | Save parameters |
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| -9 | grad_zhi | 2 | Arely | |
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- most parameters need not to be touched
- only some required (red)

Insight Automated Ship Resistance Analysis

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Overview

Single Phase

Two Phase

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|-------------------------------|---------------|--------------------------|------------------|
| Analysis | | | ିଂ |
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| Parameter Name | Current Value | hWater | Merge parameters |
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| anamikina | | Apply | |

- most parameters need not to be touched
- only some required (red)



Single Phase

Two Phase

Efficiency Improvements

Thank you for your attention!

Dr.-Ing. Hannes Kröger Email: hannes.kroeger@silentdynamics.de Tel.: +49 381 36 77 98 53

http://silentdynamics.de http://sourceforge.net/projects/insightcae