성긴 격자의 결과를 초기 유동장으로 이용한 선박의 저항추정 시간단축

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Research background

- Commercial CFD programs are commonly used for prediction of ship resistance
  (10 ~ 100 cases are calculated for a hull design.)
  – Large license fee
  – Huge calculation time

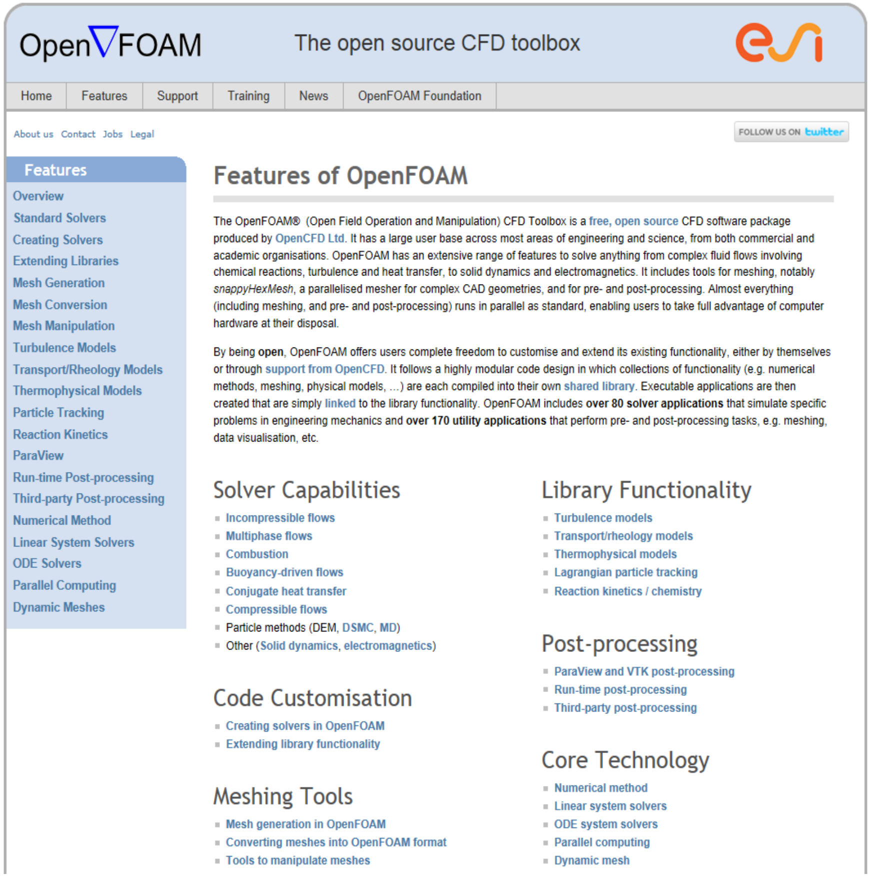
- Open source CFD codes are considered as an alternative
  – Free to add or modify numerical methods or functions
  – No license fee

Research purpose

- Check the applicability of OpenFOAM to ship resistance prediction
- Present a method to reduce the calculating time

OpenFOAM

- OpenFOAM
  - **Open F**ield **O**peration **a**nd **M**anipulation
  - Open source CFD toolbox written in C++
  - Freely available and open source
  - Licensed under the GNU General Public License
  - Homepage: http://www.openfoam.org
- Solver
  - Over 80 solvers
  - Over 170 applications
- Library
  - Turbulence, Thermophysical, Chemistry
- Mesh
  - Mesh Generator, Converting
- Core Tech.
  - Numerical Method
  - Dynamic Mesh, Parallel Computing



Numerical Methods

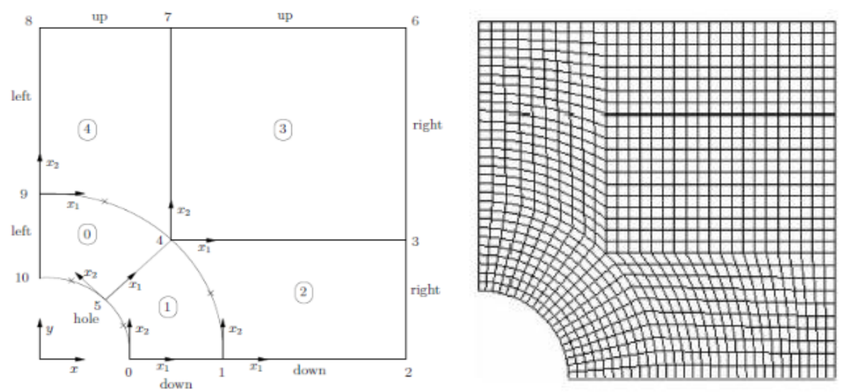
- LTSInterFoam (a standard solver of OpenFOAM)
  - Solver for steady, incompressible, turbulent, two-layer flows
- Solving algorithm
  - PIMPLE (hybrid method between PISO and SIMPLE)
- Time Integration
  - Backward Euler
    - Local time stepping
- Spatial Discretization
  - Second order central difference: linear
  - Second order upwind: linearUpwind
- Matrix Solver
  - Iterative Method (e.g. Gauss-Seidel): smoothSolver
  - Geometric and algebraic multigrid: GAMG
- Turbulence Models
  - Two equation models: k-ω SST
- Free surface model
  - VOF

Object ship

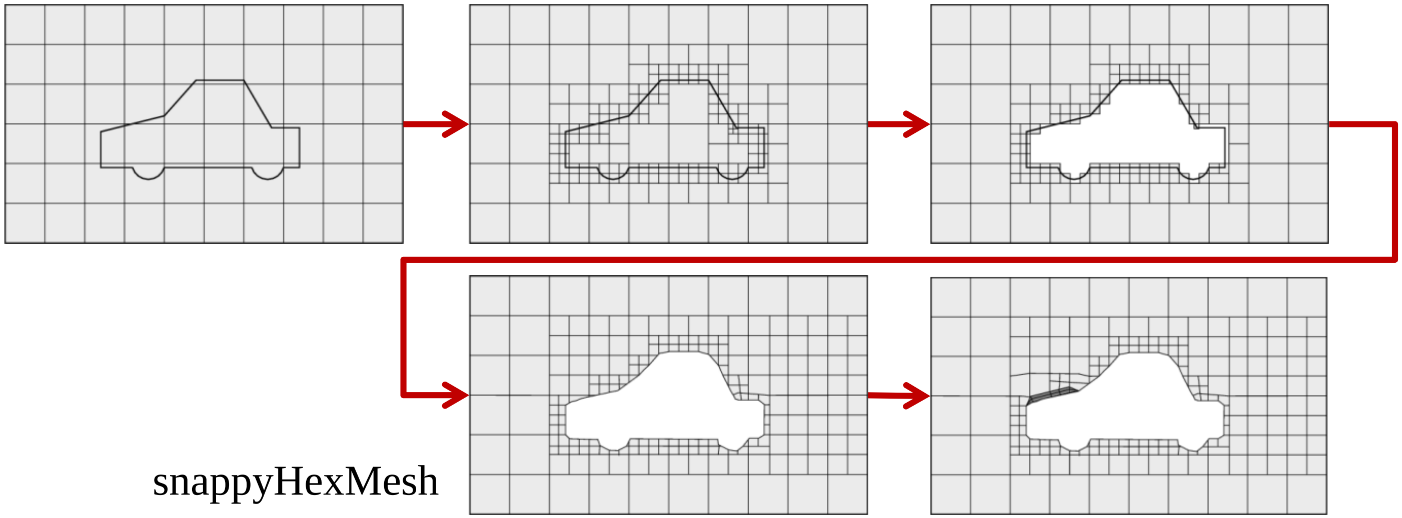
- KCS (KRISO Container Ship)
  - Scale factor : 31.6 (model LBP : 7.2786 m)
  - Speed : 2.1964 m/s (design speed)
  - Rn : 1.4×10^{7}
  - Fn : 0.26
  - Draft : 0.3418 m (design draft)

Grid generation tool

- OpenFOAM utility: blockMesh, snappyHexMesh
  - blockMesh
    - Structured block mesh generation utility
    - Usually for background mesh of snappyHexMesh
  - snappyHexMesh
    - Automatic Mesh generation utility
    - Refine base mesh
    - Remove unused cells
    - Snap mesh to surface
    - Add layers

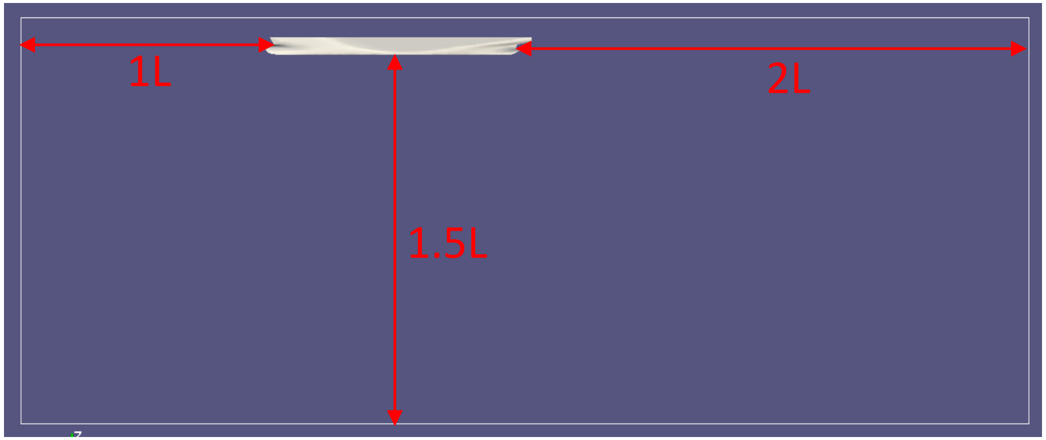


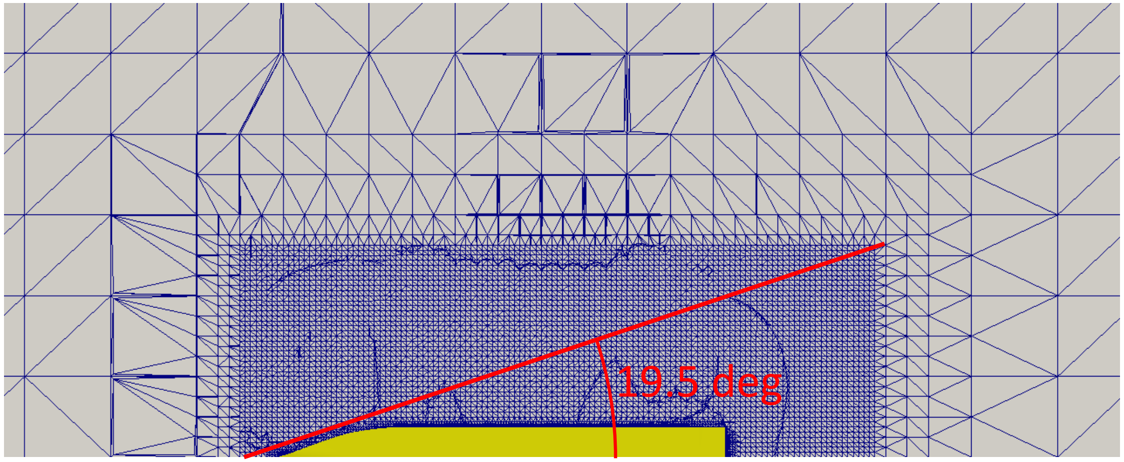
Block mesh



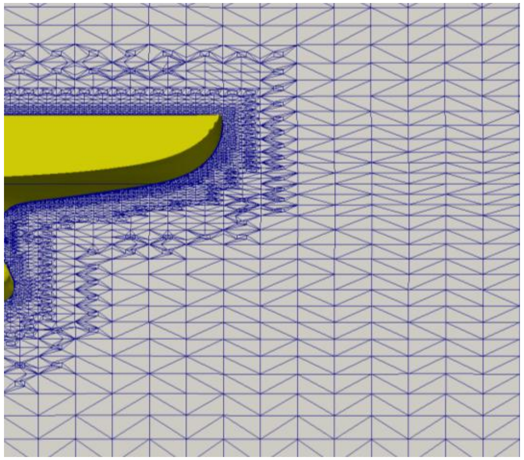
snappyHexMesh

Grid generation for KCS





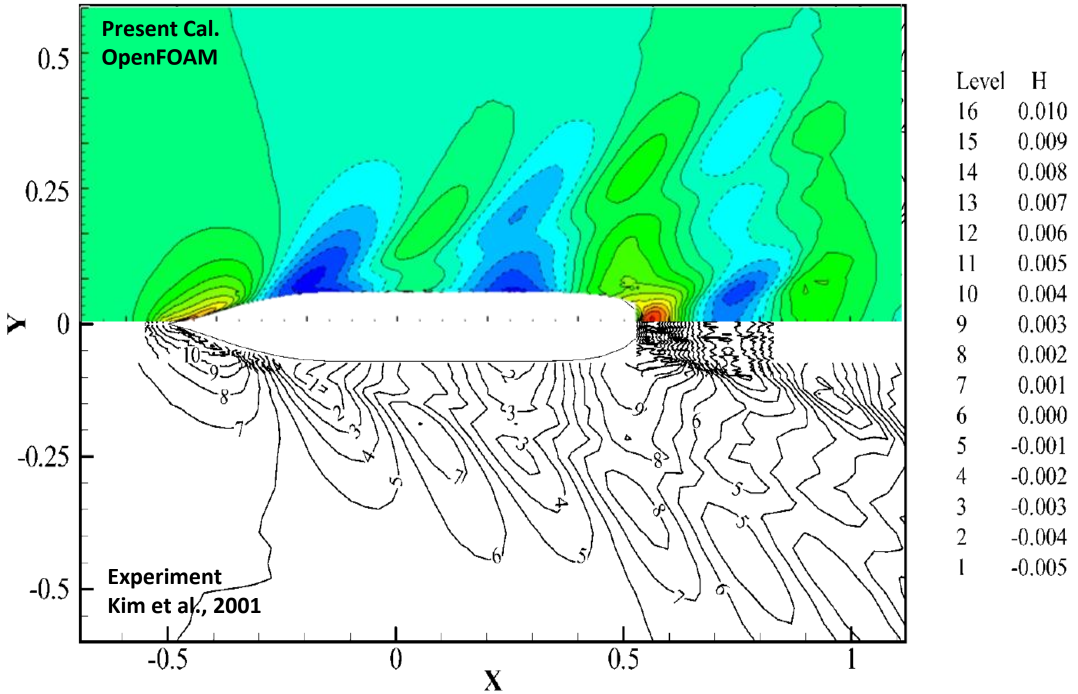
For ship making waves

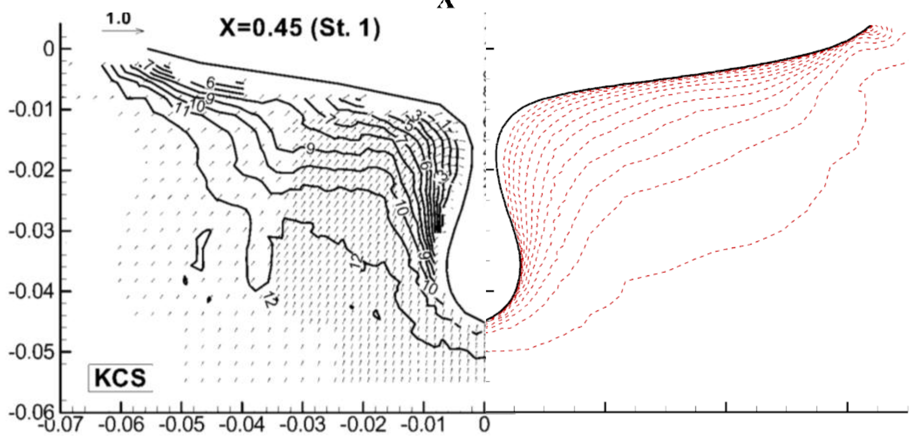


For boundary layer

- Number of grids : 1030 k

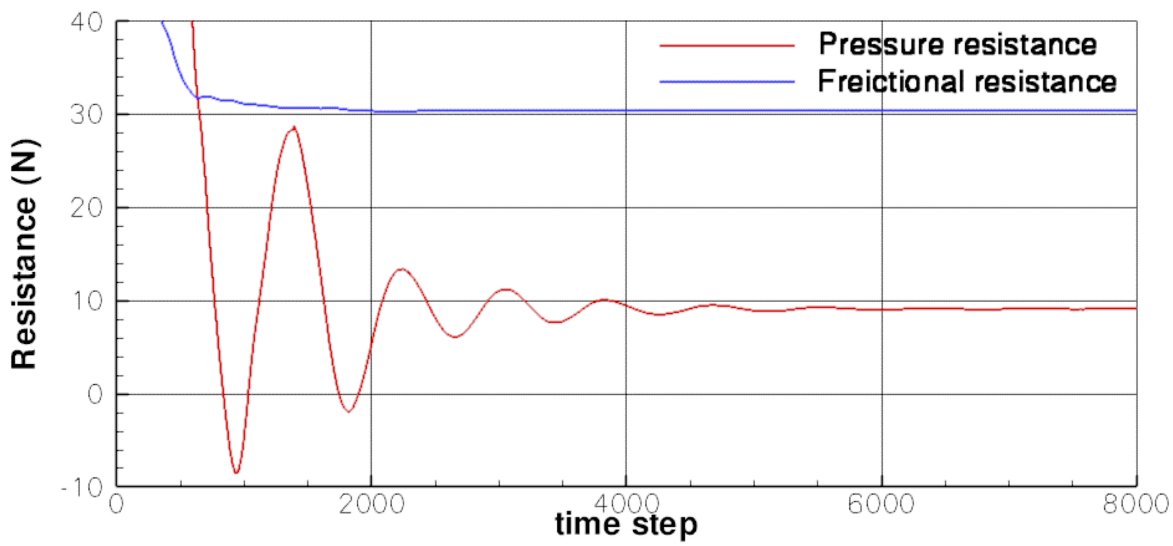
Calculation results

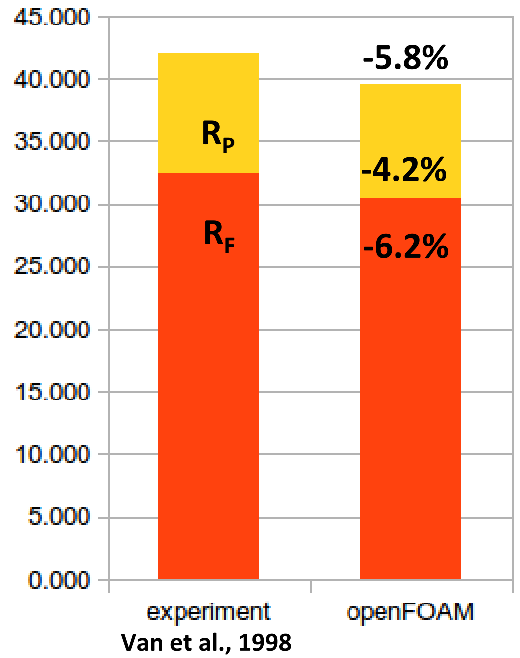




Results of KCS

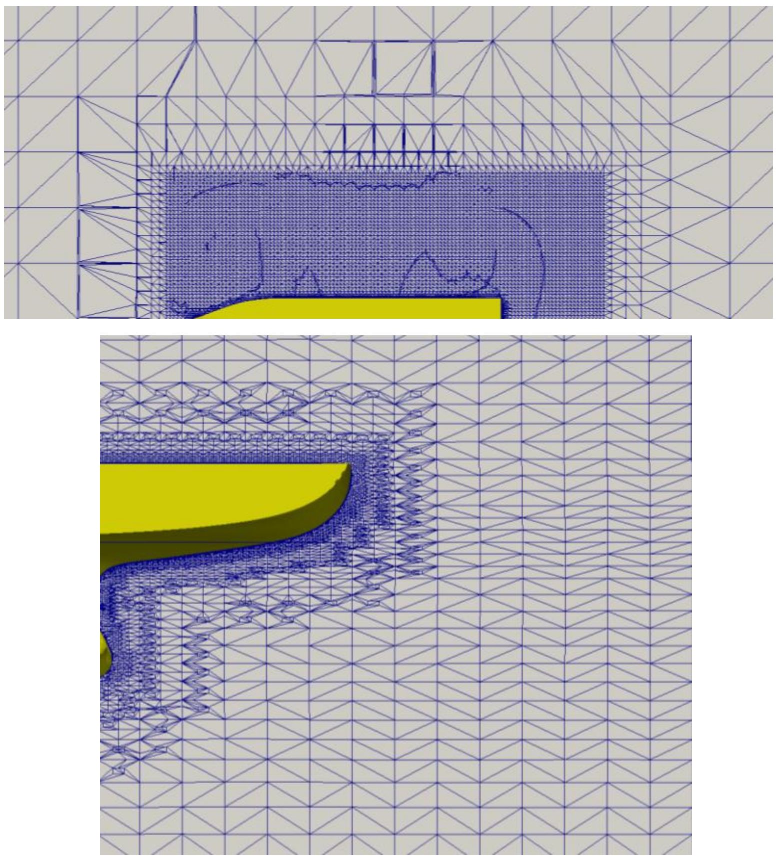
- Grid generation and calculating time : 4 hour 10 min (with16 cores)
  - Calculation time depends on wave generation time



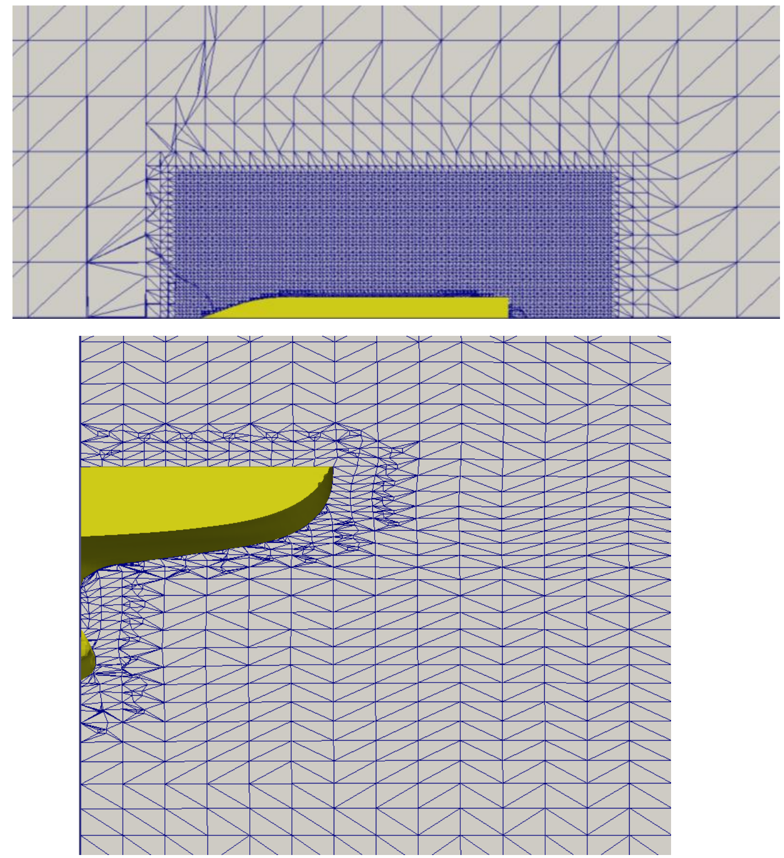


Coarse grid generation for waves

- Almost of grids for boundary layer are removed (1030 k → 201 k)
  - The same calculation domain with original grid system
  - The grid resolution for waves are not changed



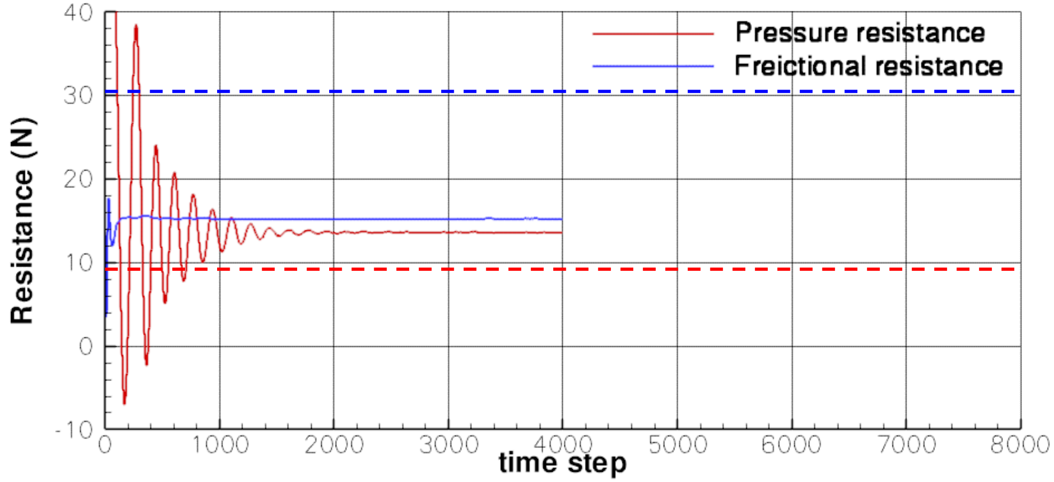
Original grid system

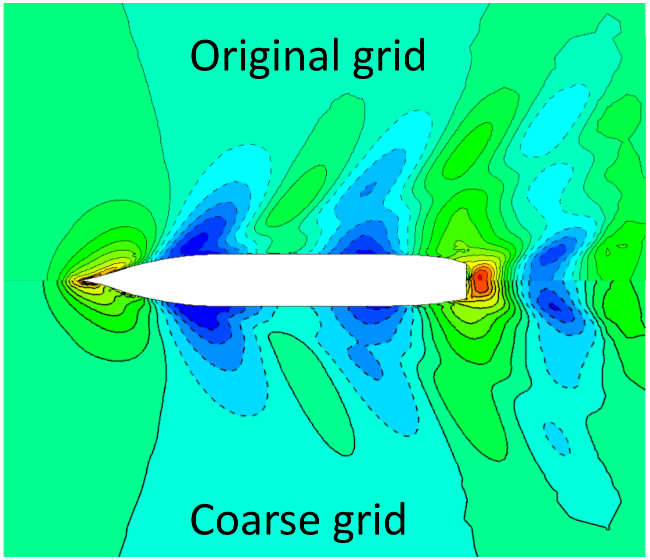


Coarse grid system

Results from coarse grid

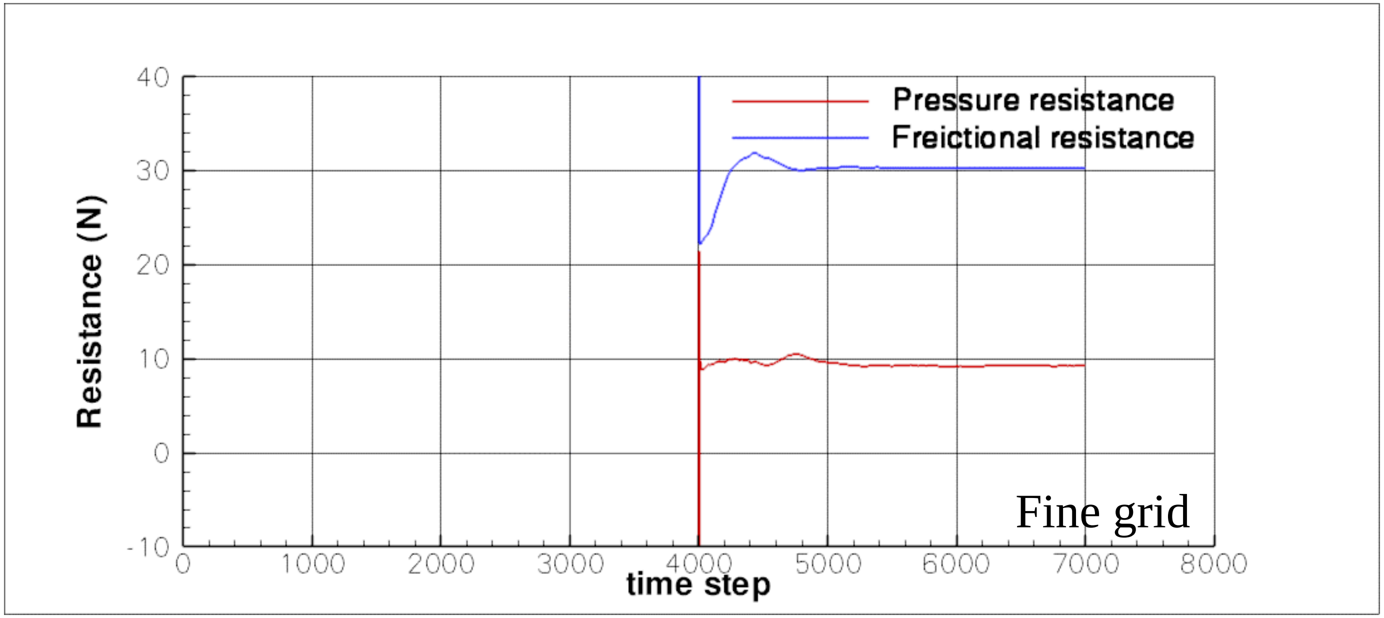
- Grid generation and calculating time : 18 min (with16 cores)





Initialization with coarse grid result

- Mapping VOF function, velocity and pressure to original grid system
  - Initialization of turbulence kinematic energy, eddy viscosity and specific dissipation
- Time for mapping and calculation : 1 hour 40 min



Remarks

- Open source CFD code (OpenFOAM) is applicable to prediction of ship resistance.
  - More verifications are required for practical use
- By mapping the results of coarse grids to fine grids, the calculation time is reduced
  - about 4 hours → about 2 hours
  - Grid refinement test required for more accurate assessment.
  - The effects of boundary layer on waves is not significant.
- Further research will be conducted to improve the accuracy of the solver.
  - Wall function, turbulence model

Thank you for your attention