Universität Rostock Traditio et Innovatio

Resistance Prediction of the JBC Bulker using CFD Method

EMship+ Advanced Design

STUDENT: Cheng Xu
SUPERVISOR: Prof. Robert Bronsart
Dipl.-Ing. Lutz Kleinsorge
REVIEWER: Prof. Pierre Ferrant

Master Thesis Presentation

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CONTENTS

Objective

Predict the total resistance and its components of JBC (Japan Bulker Carrier) bulker with the RANS method —— OpenFOAM Solver

JBC Bulker

KVLCC2

main particulars		JBC	KVLCC2
Length between perpendiculars	L_{PP}(m)	280.0	320.0
Maximum beam of waterline	B_{WL}(m)	45.0	58.0
Depth	D(m)	25.0	30
Draft	T(m)	16.5	20.8
Block coefficient (C_B)		0.858	0.8098

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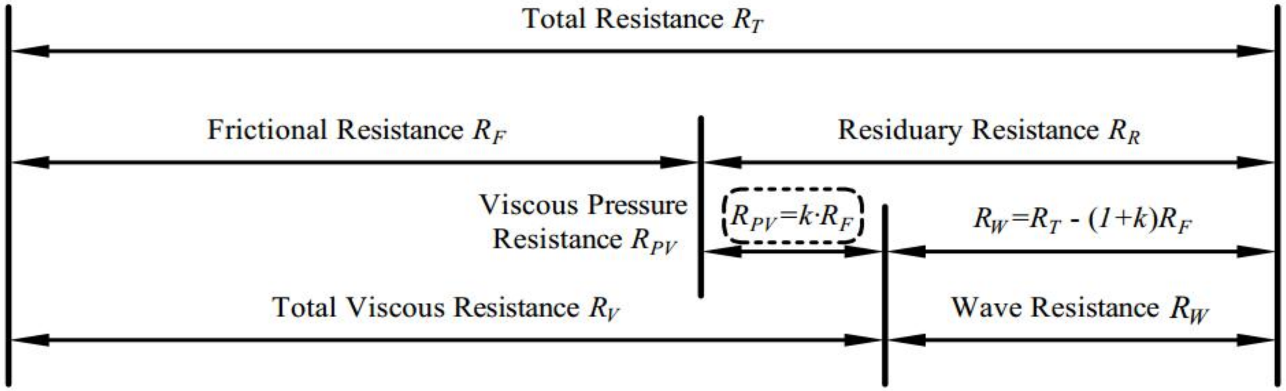
THEORIES

1. Resistance Components

LTSInterFoam

simpleFoam

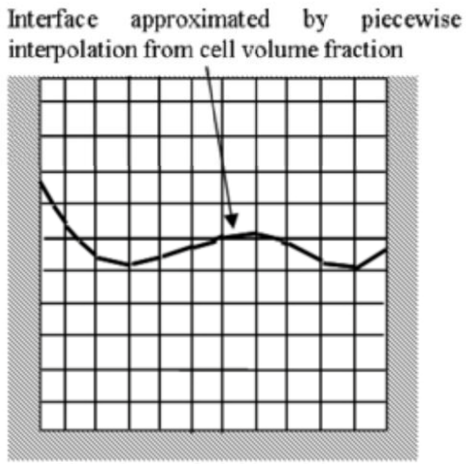


2. RANS Equation

Turbulent Model: k - ω SST model

3. VOF (Volume of Fluid)

A typical surface capturing method



(a) Volume of Fluid model

Available From 6^{th} *OpenFOAM Workship* (Maki, 2011)

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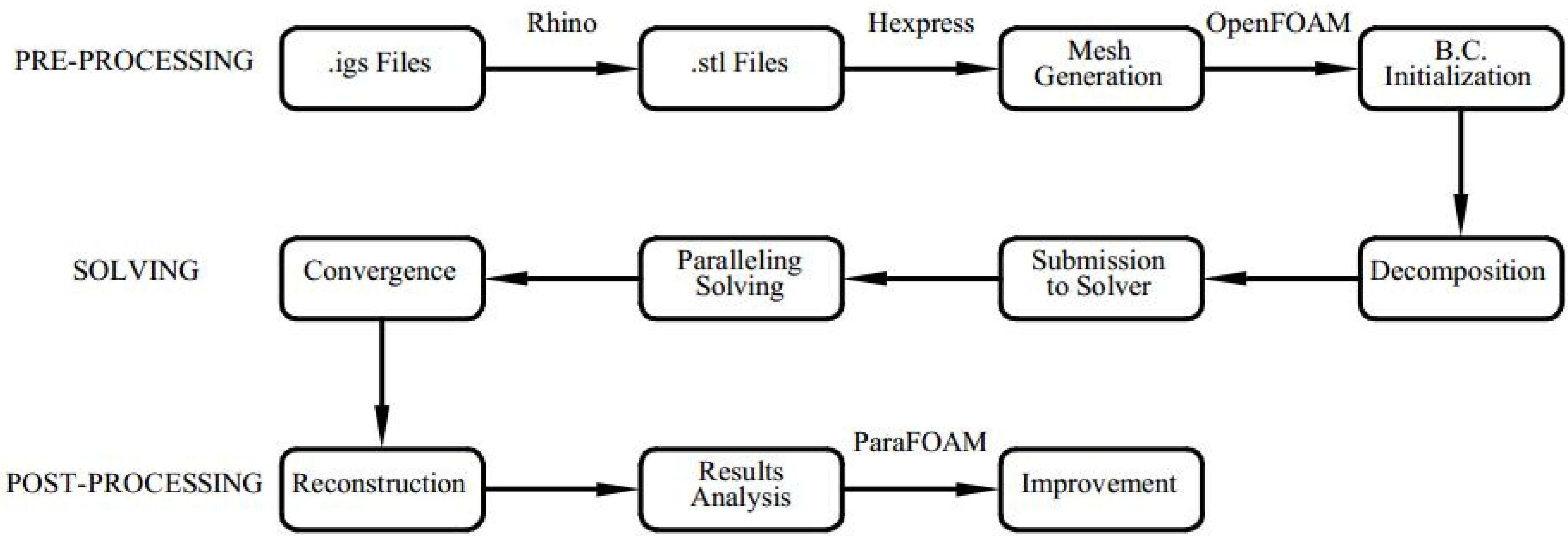
CASE SETUP

Flow Chart (OpenFOAM)



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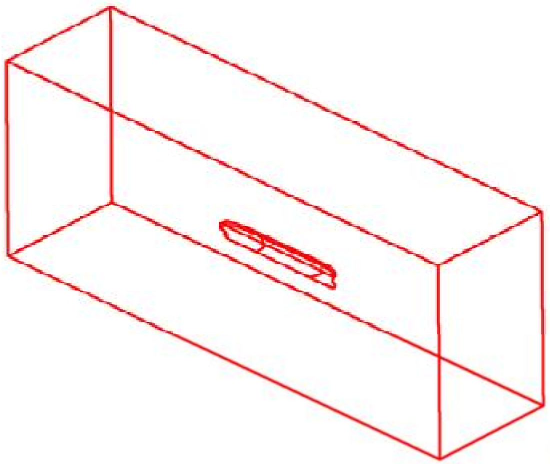
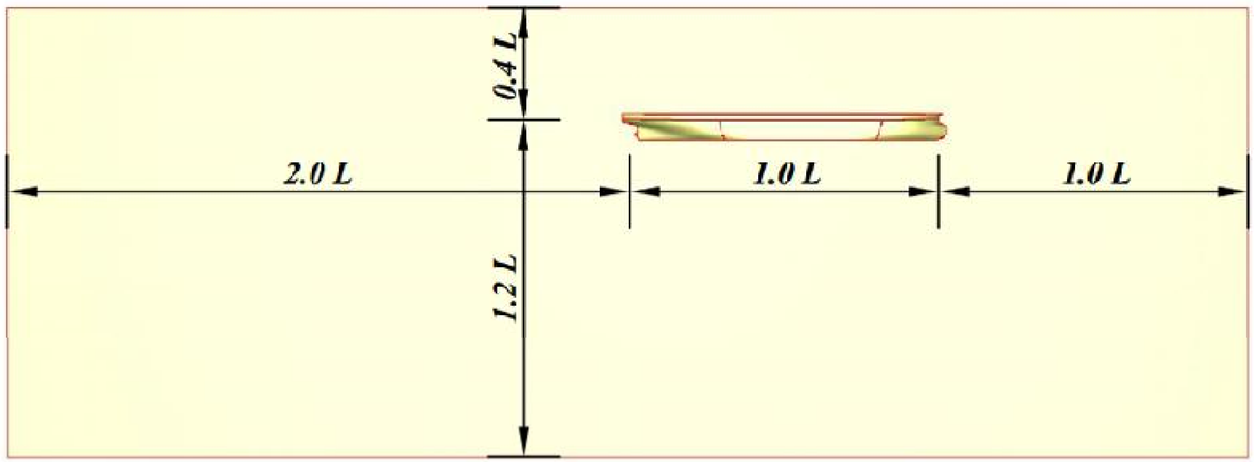
CASE SETUP

1. Model (KVLCC2)

1. Geometry: *igs* file from http://www.simman2008.dk

2. Computational Domain





3. Boundary Conditions

7 Patches： in, out, top, bottom, farps, sym, ship

CASE SETUP

2. Mesh (KVLCC2)

Numeca Hexpress

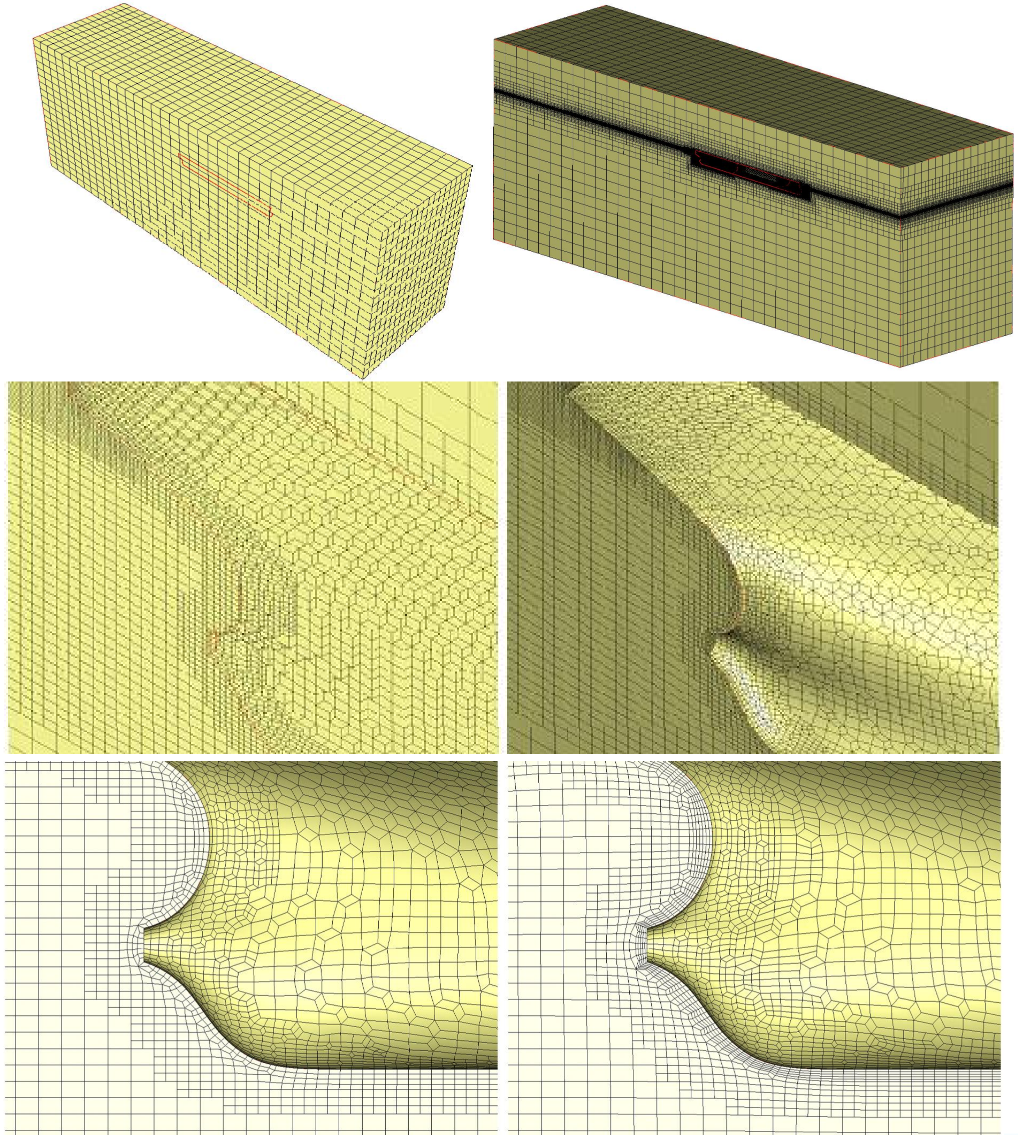
1. Initial Mesh

2. Adapt to Geometry

3. Snap to Geometry

4. Optimize

5. Viscous Layers



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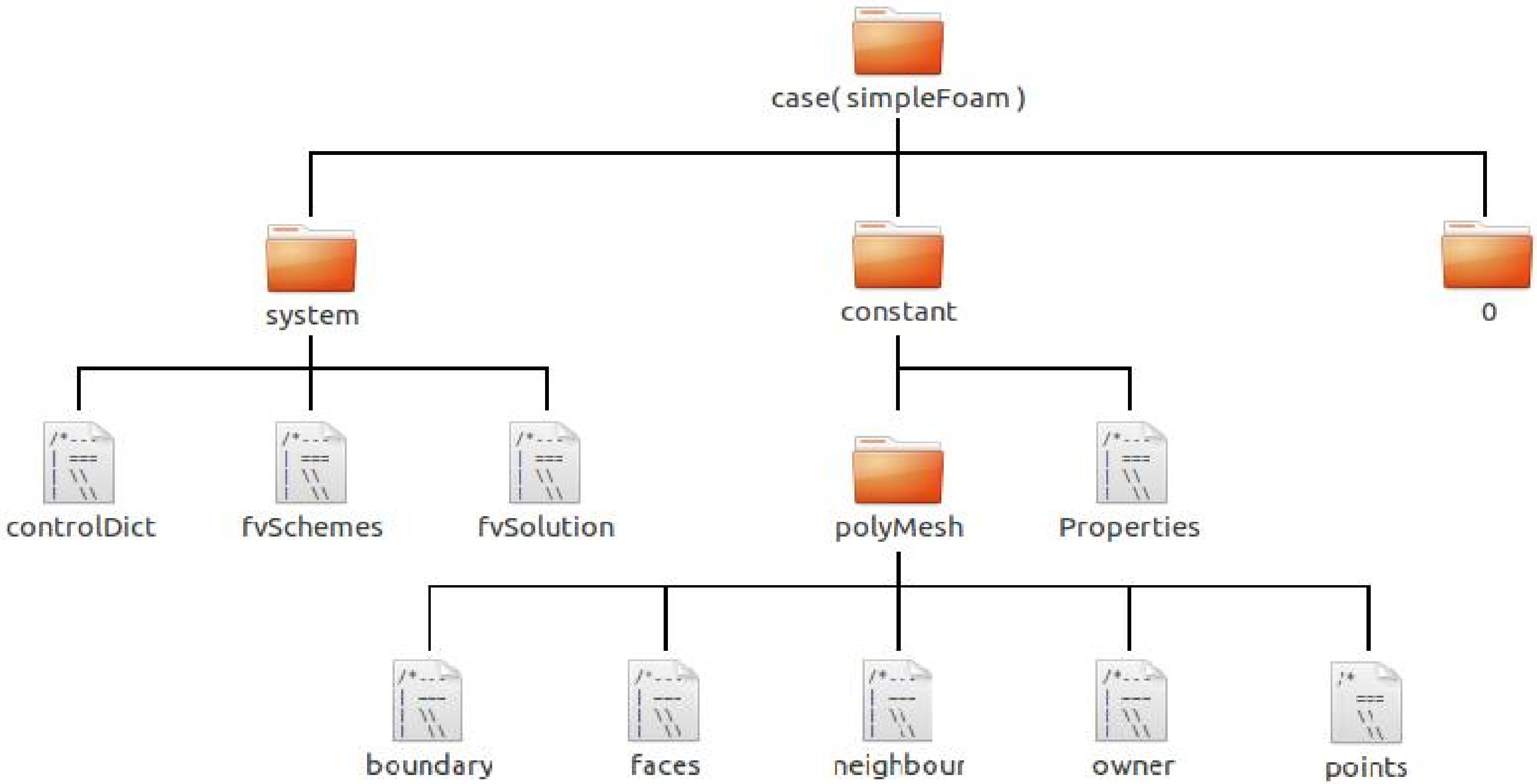
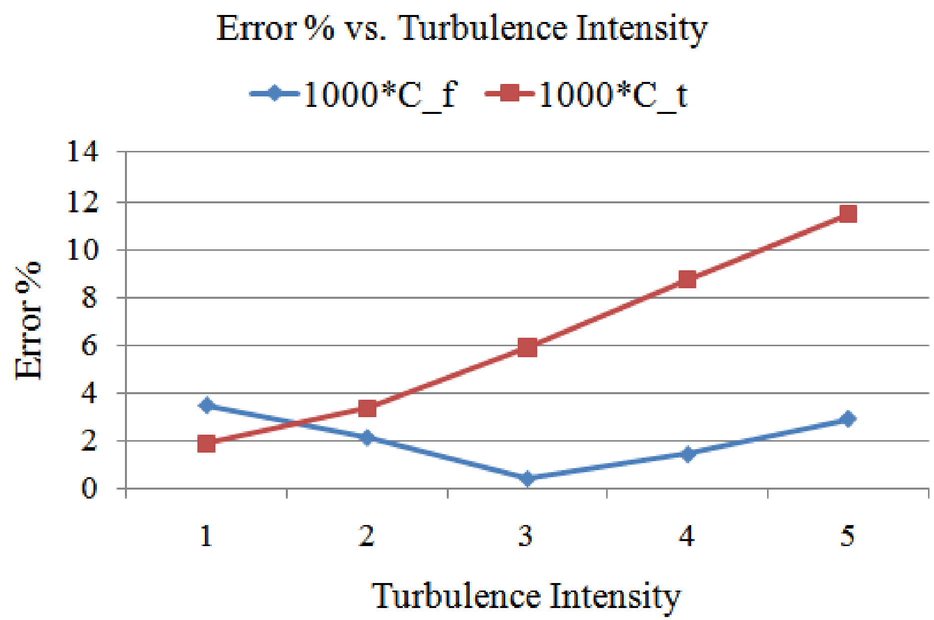
CASE SETUP

3. OpenFOAM Files

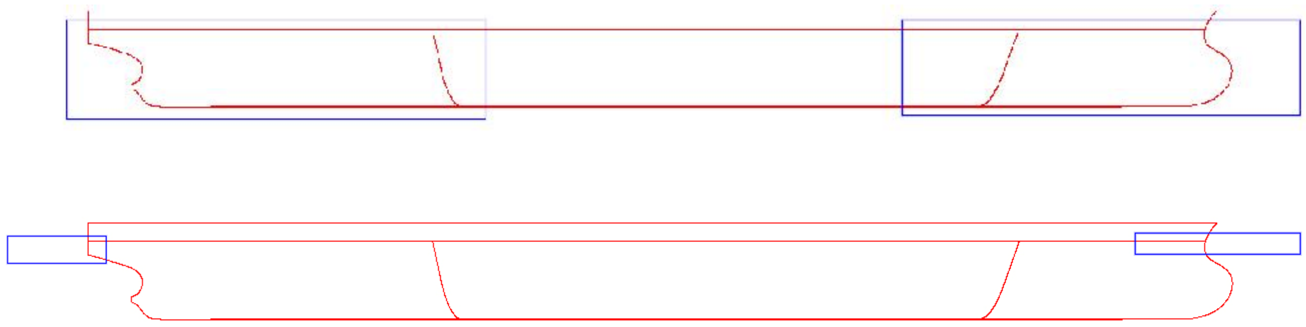


4. Adjustments

A. Determination of Turbulence Intensity



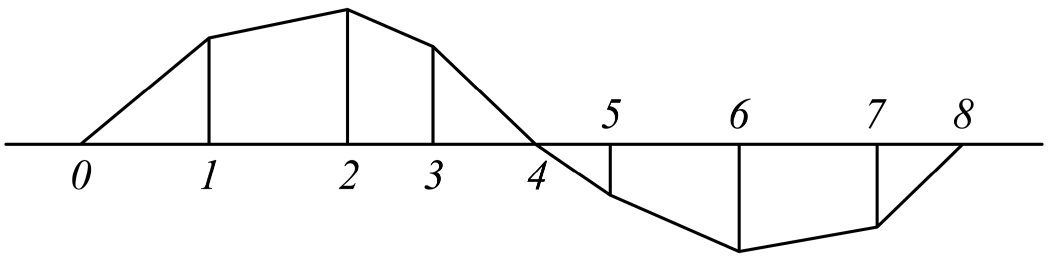
B. Local Box Refinement

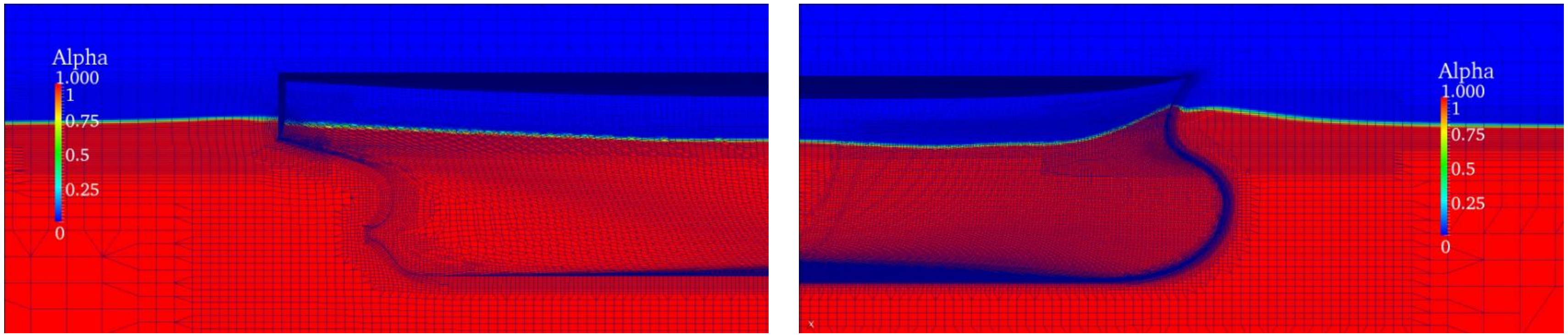


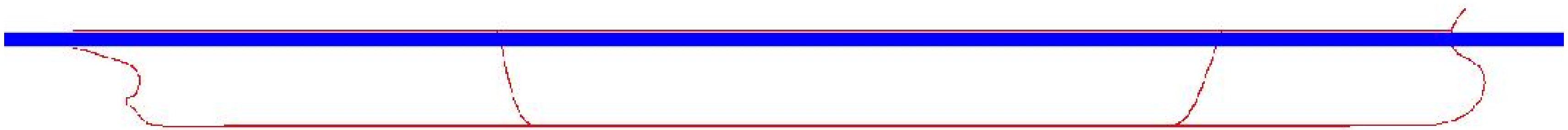
4. Adjustments

C. Discretization of Free Surface

Longitudinal:	0.08 m
Transversal:	0.06 m
Vertical:	0.004 m







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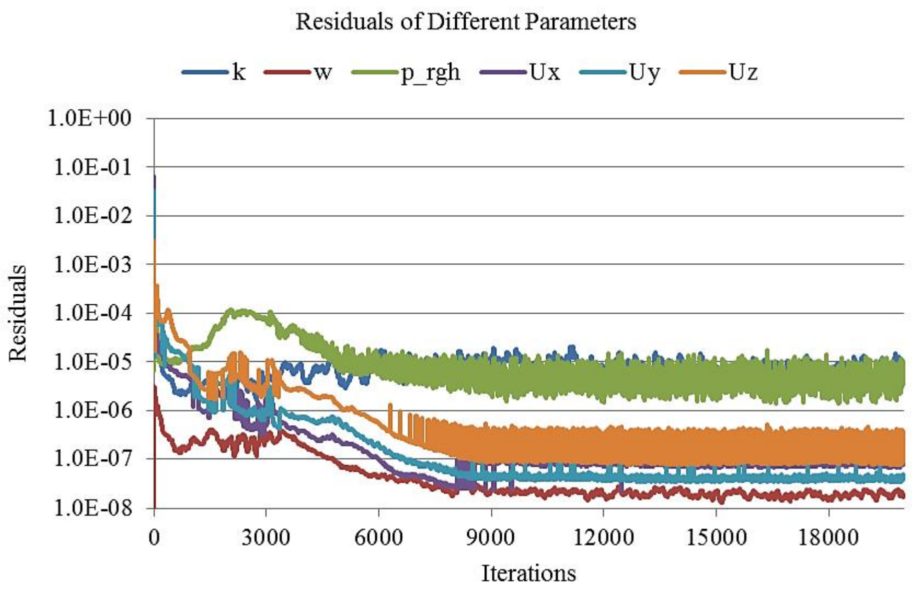
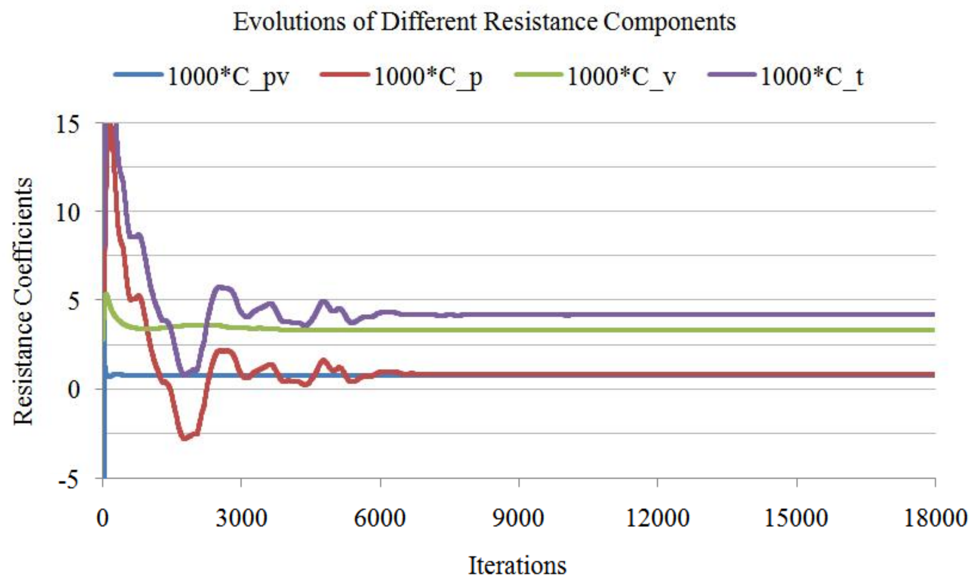
MESH VALIDATION

1. Iteration Convergence



Parameter Residuals

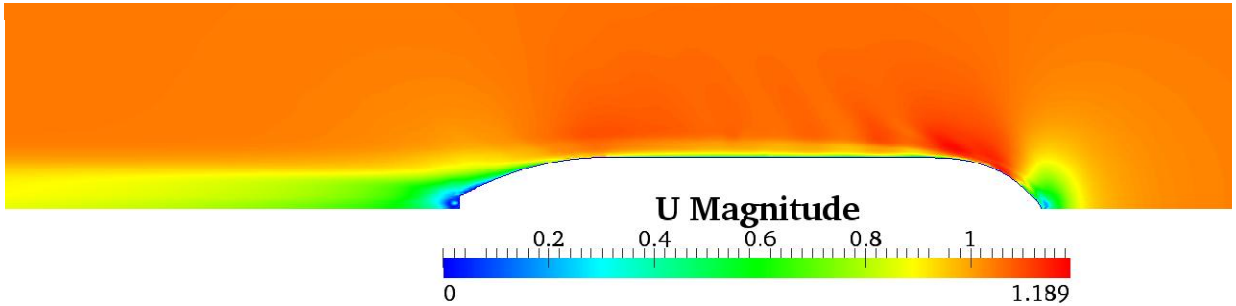


Resistance Coefficients

2. Post-processing (paraFoam)

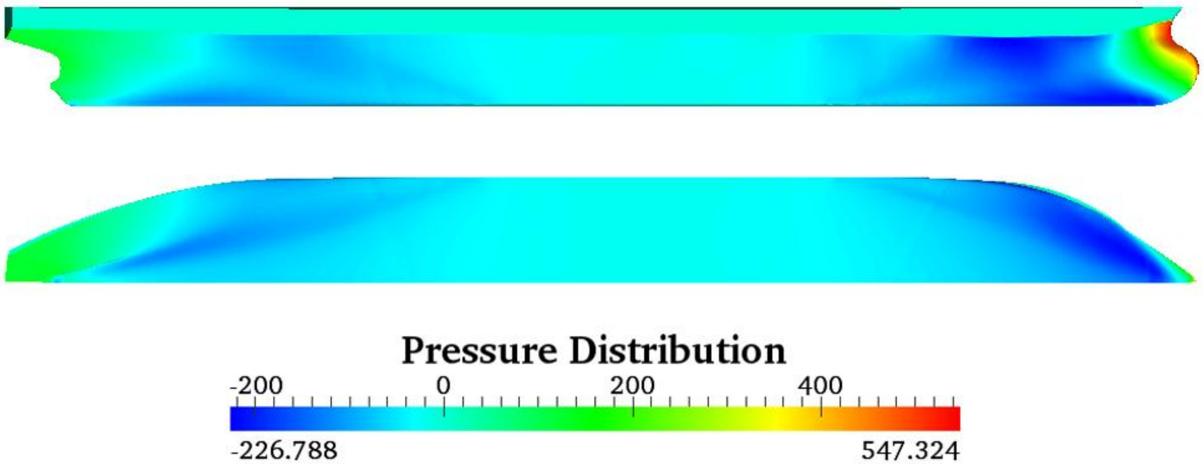
Velocity Magnitude

$U_{in} = 1.047\ m/s$



Pressure Distribution

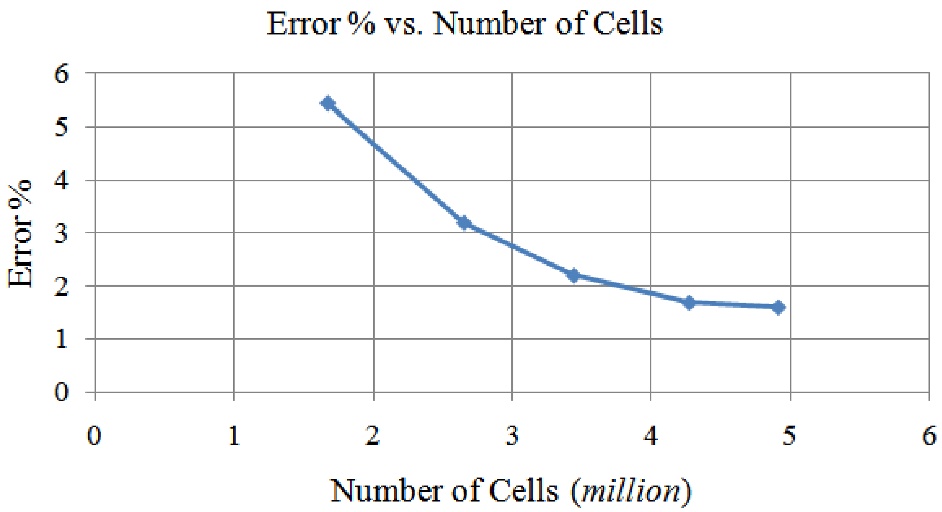
$P = \frac{1}{2}\rho U_{in}^{2} = 548.1\ N/m^{2}$

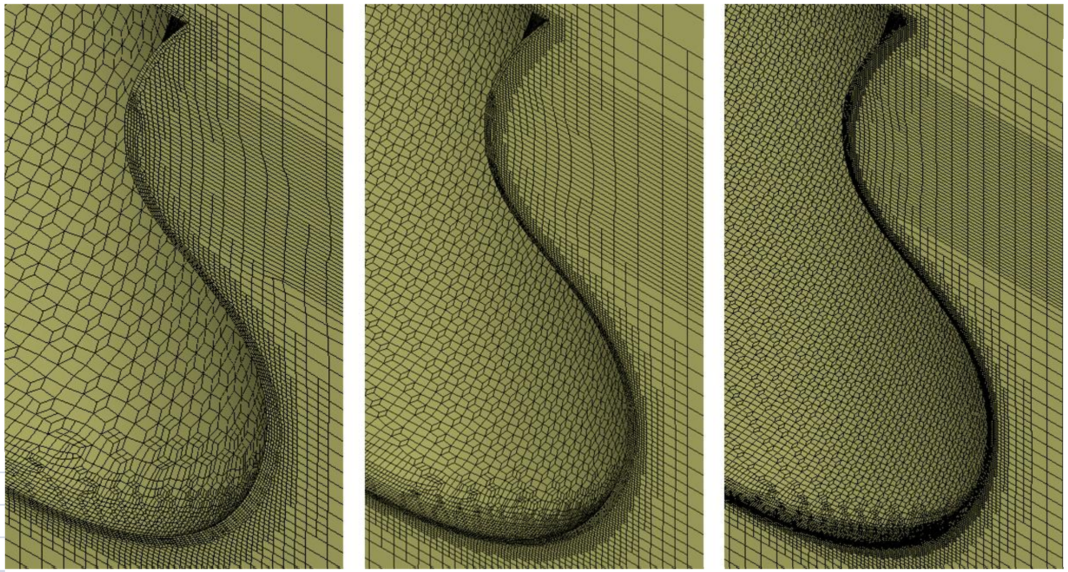


MESH VALIDATION

3. Grid Convergence

	initial mesh			cell No.
	x	y	z	(*million*)
Level 1	23	10	12	1.67
Level 2	36	16	19	2.65
Level 3	40	18	21	3.44
Level 4	45	20	23	4.27
Level 5	51	23	26	4.91



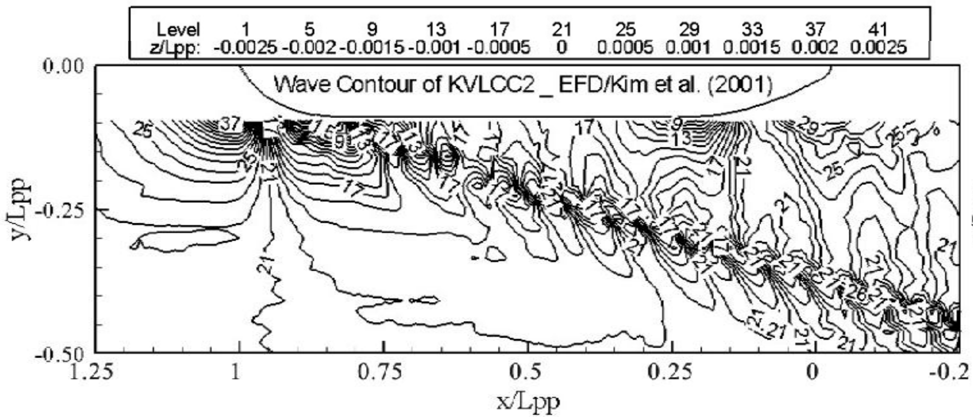


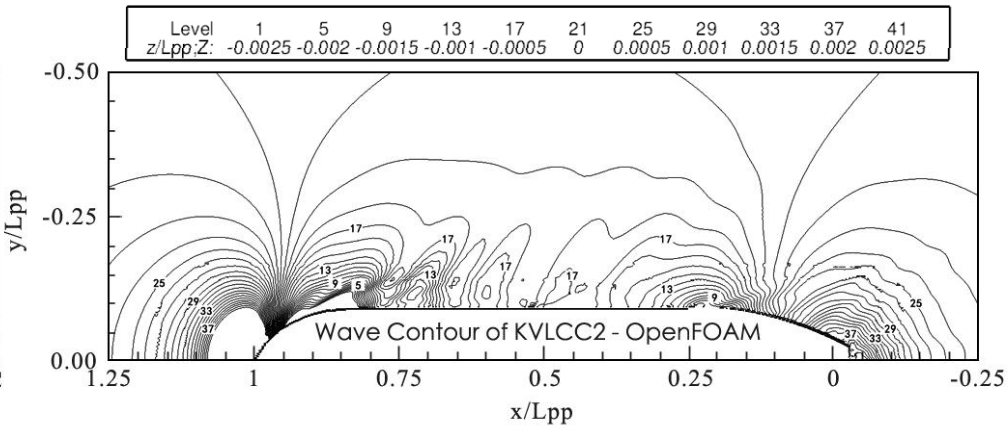
Level 1 Level 3 Level 5

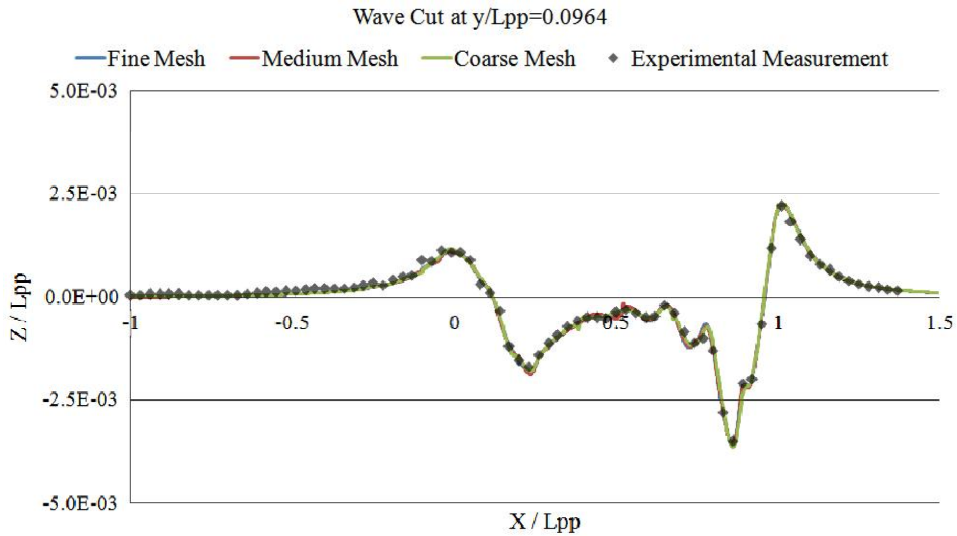
Error% of Total Resistance

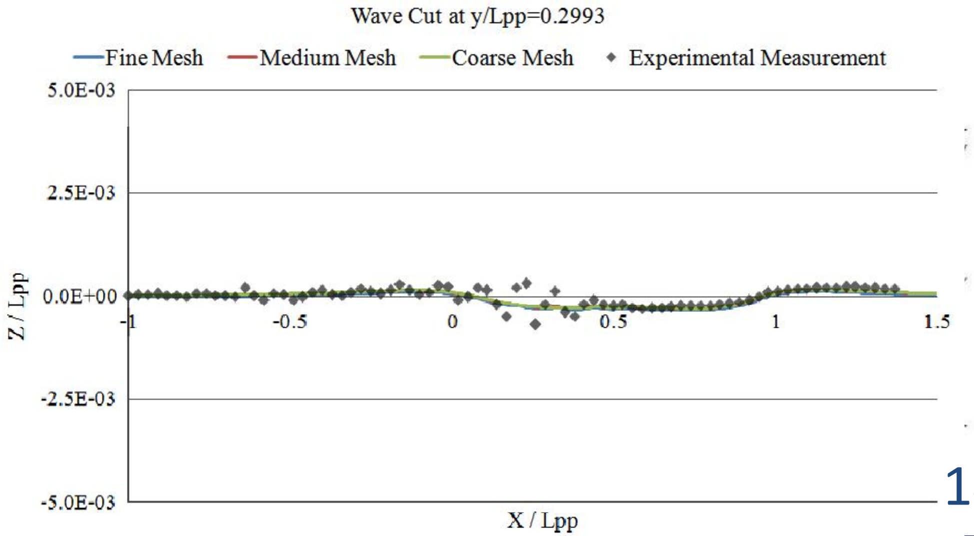
CFD: $1+k=1.187$ EFD: $1+k=1.191$

4. Wave Elevation









Model Scale

1. KVLCC2 to JBC : Reynolds Number Similarity

$$Re = \frac{U_{KVLCC2} L_{KVLCC2}}{\nu_{KVLCC2}} = \frac{U_{JBC} L_{JBC}}{\nu_{JBC}}$$

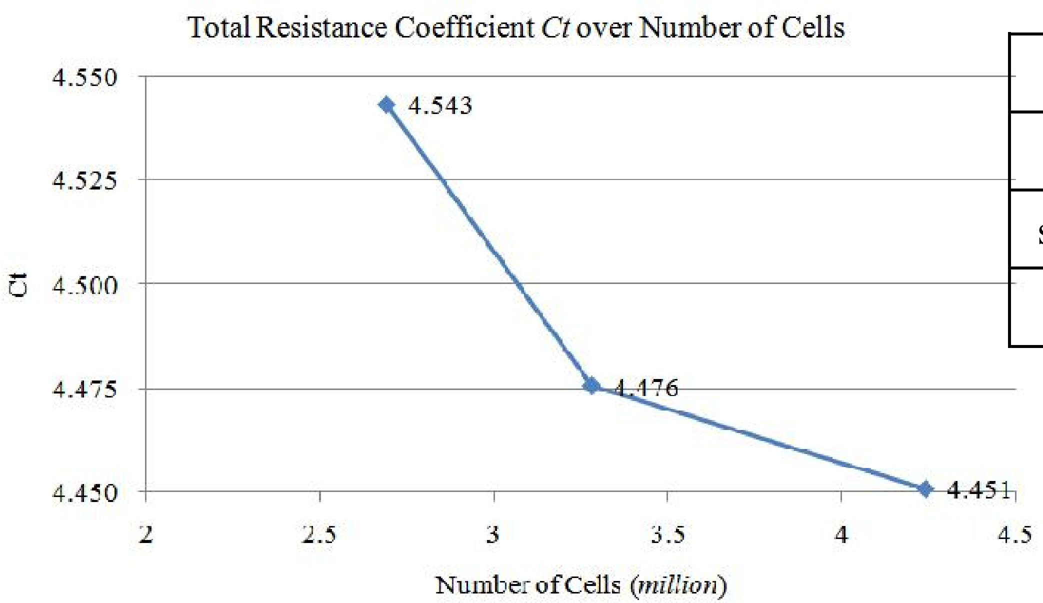
2. Full Scale to Model Scale : Froude Number Similarity

$$Fr = \frac{U_{ship}}{\sqrt{g L_{ship}}} = \frac{U_{model}}{\sqrt{g L_{model}}}$$

Model Scale of JBC Bulker: λ = 1:55.1

Calculated Results

	minimal target size (*m*)			cell No. (FSM) (*million*)	cell No. (DBM) (*million*)
	x	*y*	*z*		
coarse	0.064	0.050	0.003	2.69	0.96
medium				3.28	1.20
fine				4.24	1.56
*FSM is for free surface model and DBM is for double body model					



Parameters		EFD (D)
$C_T \times 10^3$	Value	**4.29**
sinkage [%LPP]	Value	**-0.086**
trim [%LPP]	Value	**-0.180**

$$\text{Error}\%C_t = \frac{(C_{t\_CFD} - C_{t\_EFD})}{C_{t\_EFD}} \times 100\% = 4.3\%$$

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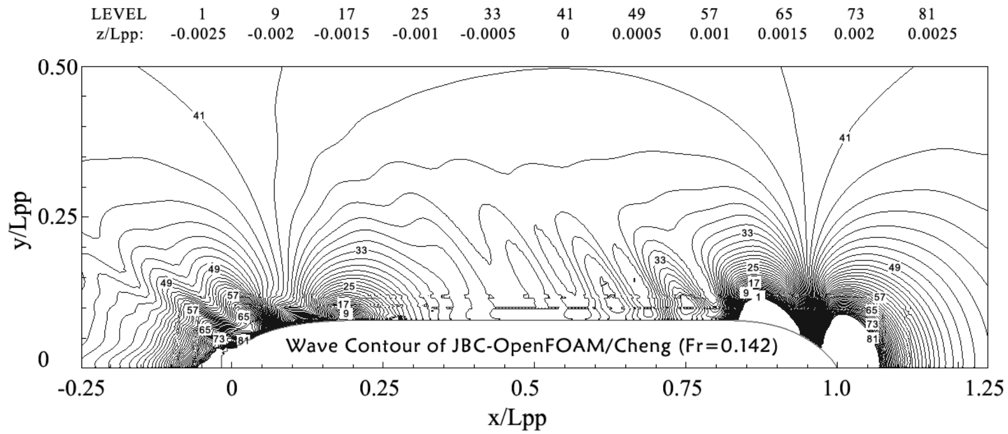
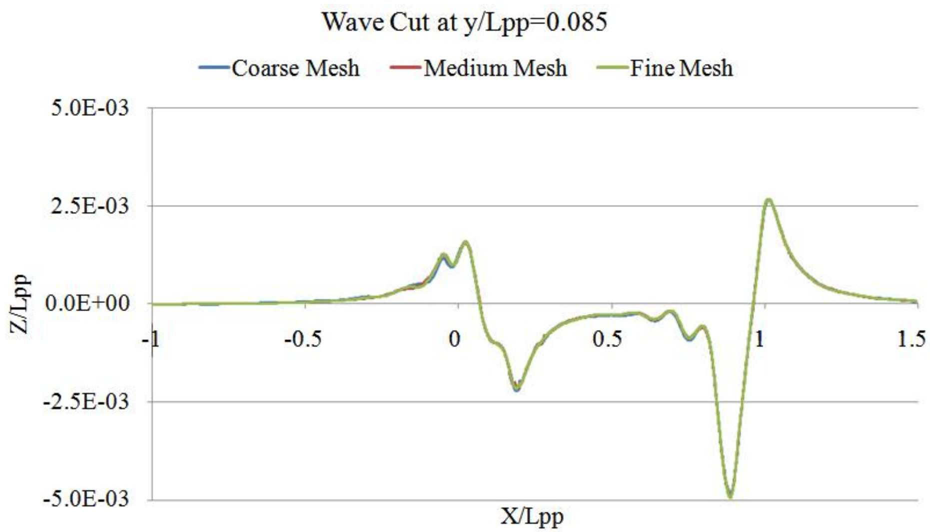
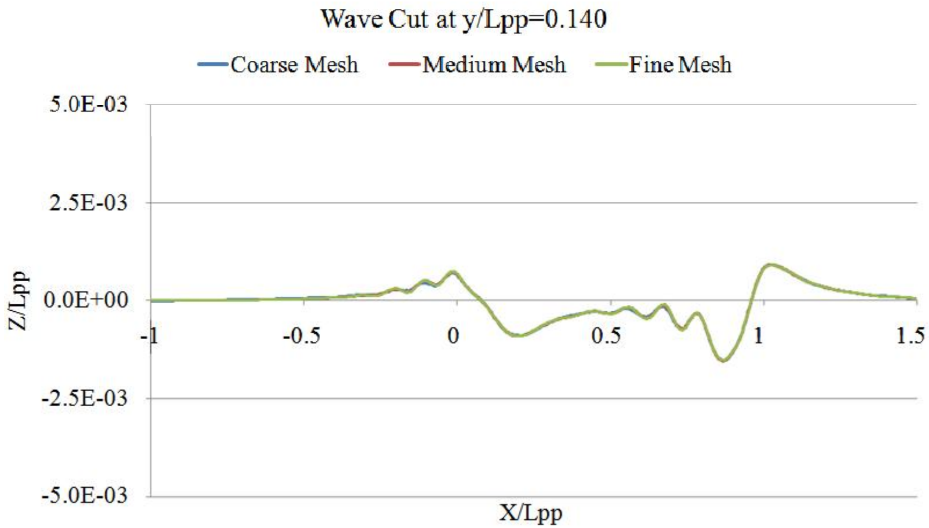
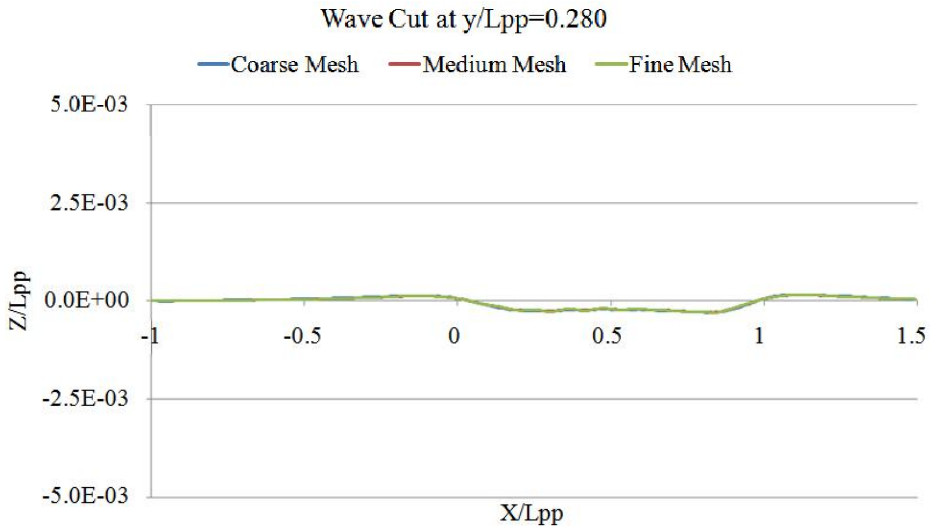
JBC BULKER

Wave Elevation









CONCLUSIONS

1. The Mesh Configuration obtained from Hexpress is Reliable.

2. The CFD Method to Predict the Resistance Components by OpenFOAM solvers is feasible. The Calculated Results are Acceptable.

3. Type of Turbulence Model and Parameters in OpenFOAM Files are Important.