JOINT DEVELOPMENT PROJECT ON SEAKEEPING SIMULATIONS USING OPENFOAM – INDUSTRIAL PERSPECTIVE

GEON-HONG KIM[1]
[1]*Hyundai Heavy Industries Co., Ltd., geonhong.kim@hhi.co.kr*

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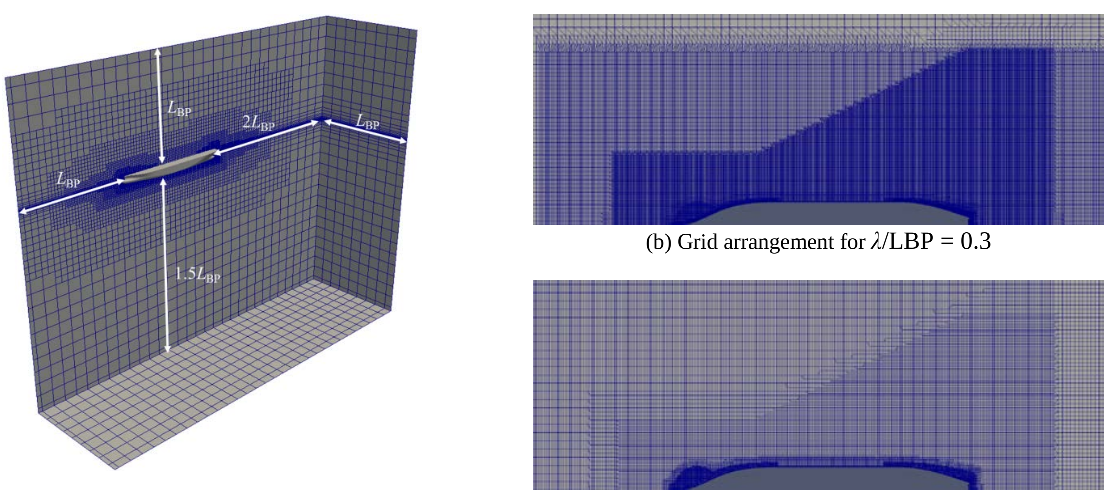
A consortium was formed in 2014 including Bureau Veritas, University of Zagreb, Seoul National University and Hyundai Heavy Industries Co., Ltd. for a Joint Development Project (JDP) to develop a numerical simulation tool capturing a combination of linear and non-linear effects in naval hydrodynamics and off-shore simulations at reasonable computational cost and accuracy. It has been successfully carried out and produced tangible academic achievements [1]-[3]. *navalFoamLevelSet* is an output of the JDP for seakeeping simulation using level set and SWENSE method for decomposition. In the first stage of development, a new numerical simulation tool is only validated and verified with limited experimental data which are fully opened to the public such as KCS [4], even though a shipbuilding company demands numerous validated cases. Furthermore an industrial field is somewhat conservative to accept a new method for replacing existing system. Thus it seems to need a strategic and long-term perspective method for OpenFOAM to make a soft landing on industrial field.

In that sense, we first validated *navalFoamLevelSet* based on massive experimental data which has been carried out by Hyundai Maritime Research Institute (HMRI). And we also tried to improve the solver for increasing its competitiveness relative to existing commercial codes in terms of accuracy, stability and efficiency. As a start point, we selected a twin LNG carrier for a validation case where the computational conditions are shown in Table 1. Figure 1 shows computational domain and grid arrangements around the ship corresponding to λ/LBP of 0.3 and 1.0, respectively. The simulation domain consists of three sub regions: SWENSE relaxation zone, fully viscous region, and buffer region blending those two regions. The grid in VOF region was generated by placing at least 100 points within a single wave length. Consequently the short period wave simulation shows much finer grid arrangement than that of longer period waves. The numbers of cells are 3.6 mil. and 1.8 mil. for λ/LBP of 0.3 and 1.0, respectively.

Table 1: Computational conditions for seakeeping simulations of a twin LNG carrier

Items	Units	Values
LBP	m	5.20
Wave Length Ratio	λ/LBP	0.3, 0.4, 0.5, 0.6, 0.8, 1.0, 1.1, 1.5, 2.0
Speed	m/s	1.249
Wave Height	m	0.1042



(a) Computational domain

(b) Grid arrangement for λ/LBP = 0.3

(c) Grid arrangement for λ/LBP = 1.0

Figure 1: Computational domain and grid arrangements

It was tested to find proper time step size to resolve the wave motion in VOF field. The time step size was varied to take 180 to 360 time steps lied within a period. The resultant resistance and elapsed time is shown in the Table 2. The values of each case are compared to those of T/360 case. By taking the resultant resistance and elapsed time into account at the same time, we selected T/200 as the max. time step size for the future simulations.

Table 2: Results of numerical tests on maximum time step size

Time steps per a period	Relative Resistance	Relative Elapsed Time
180	-0.85%	-45.2%
200	-0.69%	-42.1%
240	-0.36%	-30.6%
360	-	-

Currently we are dealing with several problems that have arisen during the validation test. Firstly it showed reasonable results for the cases of long period waves but it tended to overly estimate the performances in shorter waves as shown in Figure 2 and Figure 3. The present simulation does not predicted low frequency behaviour in pressure forces for the short wave case when it is compared to that of STAR-CCM+. And we also noted that the wave in viscous region rapidly dissipated.
Such issues and treatment on them will be discussed at presentation in detail.

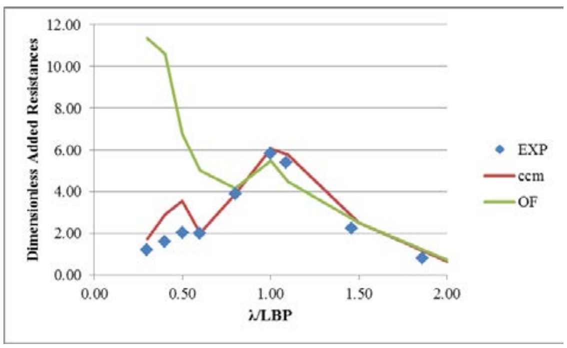
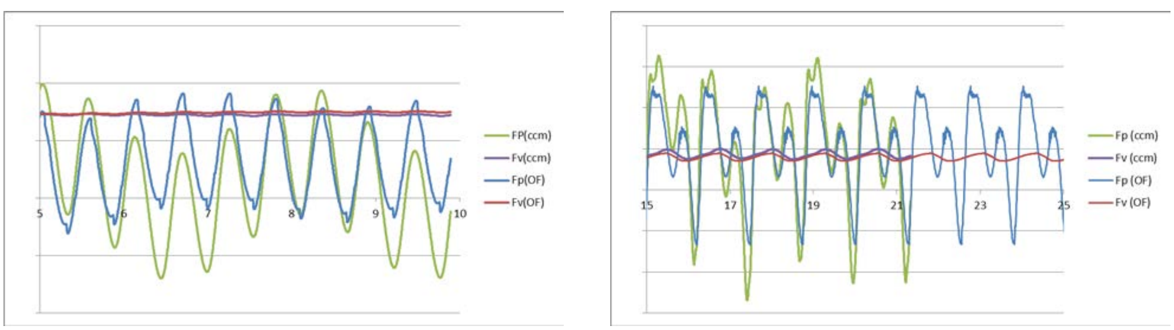


Figure 2: Added resistance with various wave lengths



(a) λ/LBP = 0.3 (b) λ/LBP = 1.0

Figure 3: Time history of force distributions

References

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