Numerical Analysis and Simulation Framework Development for Innovative Maritime Energy Generation

CFD Insights services

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Objective

This project involved conducting a set of numerical analyses of a maritime vessels, designed by a young startup wishing to innovate energy generation methods. The startup aimed to establish a robust simulation framework to evaluate their designs prior to advancing to the production and experimental stages. To achieve this objective, various simulation configurations underwent testing to ascertain optimal parameters ensuring the highest degree of accuracy compared to experimentally obtained data.

Methodology

While a large number of simulation configuration were tested, only three shall be presented in here.

In the first approach, the k-omega SST turbulent model was employed to model turbulent phenomena surrounding the vessel. This model is known for its capability to accurately capture turbulent flow behavior in complex geometries. A quasi-static approach was adopted to attain dynamic equilibrium.

The second approach utilized an Euler approach, neglecting turbulence effects. Similar to the previous method, a quasi-static approach was employed to ensure computational stability and convergence.

Lastly, the third approach, once again employing the k-omega model, applied Newton's law to address the classical case of solved degrees of freedom (DOF). This approach is suitable for situations where the vessel's motion is well-defined and can be accurately modeled using classical mechanics principles.

The geometry of the vessel is shown in figure 1.

Results

The numerical results were compared with experimental data. Firstly, the forces and motions were examined. More precisely, the resistence, the trim and the sinkage were the parameters evaluated. The results are summarized in Table 1.

Table 1:Forces and Motions comparison

Simulation	C_T	T_{z0}	Ry1
QUASI-STATIC	0.00426	1.029	-0.1142
EULER	0.01611	1.0287	-0.0751
NEWTON	0.004269	1.0297	- 0.1141
EXP	0.0043	1.18	-0.108

As expected the use of the k-omega turbulence model lead to more accurate results, especially for the case of the resistence coefficient. This is attributed to the fact that the turbulence around the vessel contributes significantly on the creation of the drag it experiences. For the case of the trim the results are relatively close to those of the experiments, again if the turbulence is modelled. The average error for the drag coefficient is less than 3those two cases, while the average error between for the case of the trim is 5of the Euler approach leads to significant distances between the experimental data for all three parameters. The use of quasi-static approach does not lead to significant differences in regards to the use Newton's resolution.

Lastly, another important quantity is the the free surface elevation on the vessels hull which affects it's stability. Figure 2 and 3 present the associated field for the first two approaches.

Conclusion

The project's primary objective was to devise an effective simulation framework tailored for maritime vessels. To achieve this goal, various simulation setups were meticulously tested and compared against experimental data to assess their accuracy, efficiency, and robustness. The summary provided here encapsulates some of the key findings, ultimately leading to the selection of the K-omega SST framework as the preferred choice.

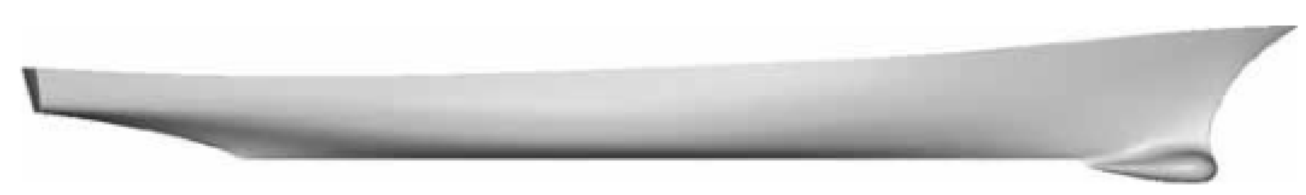

Figure 1:Vessel geometry.

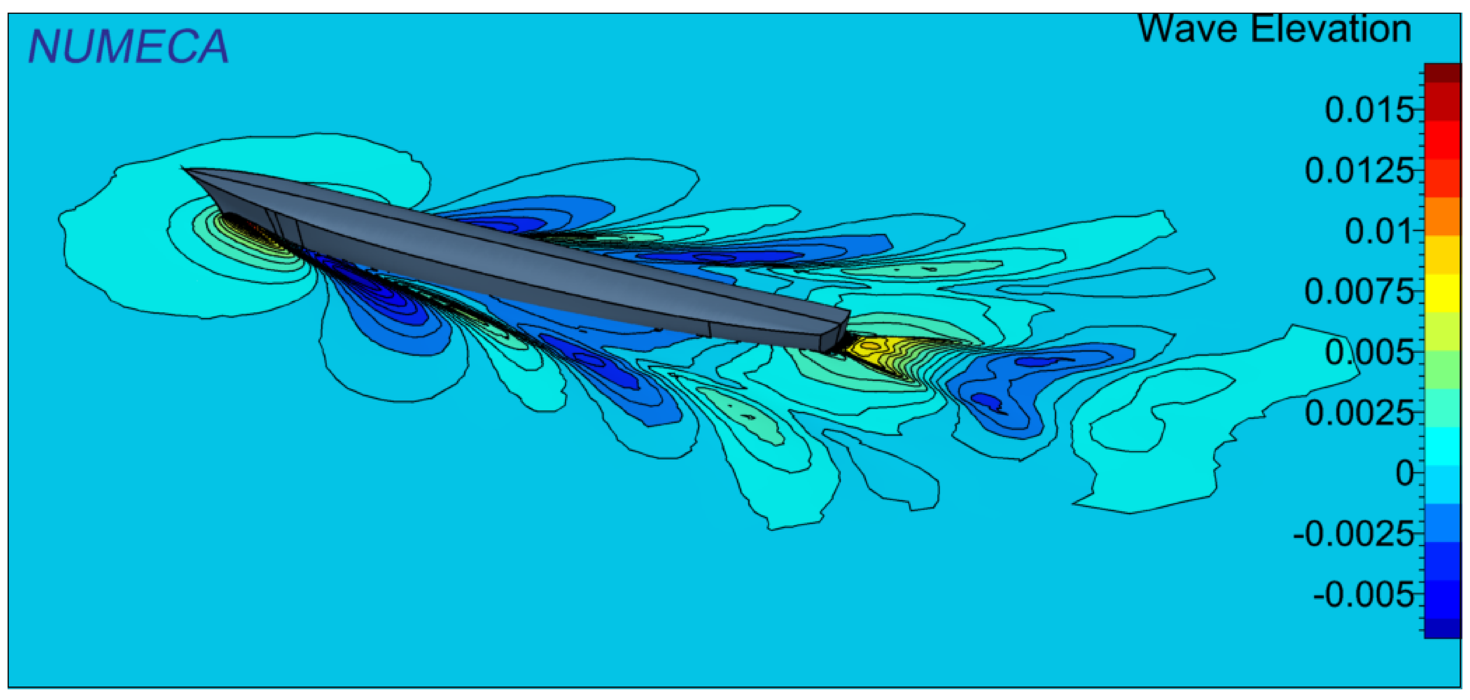

Figure 2:Wave elevation for k-omega SST.

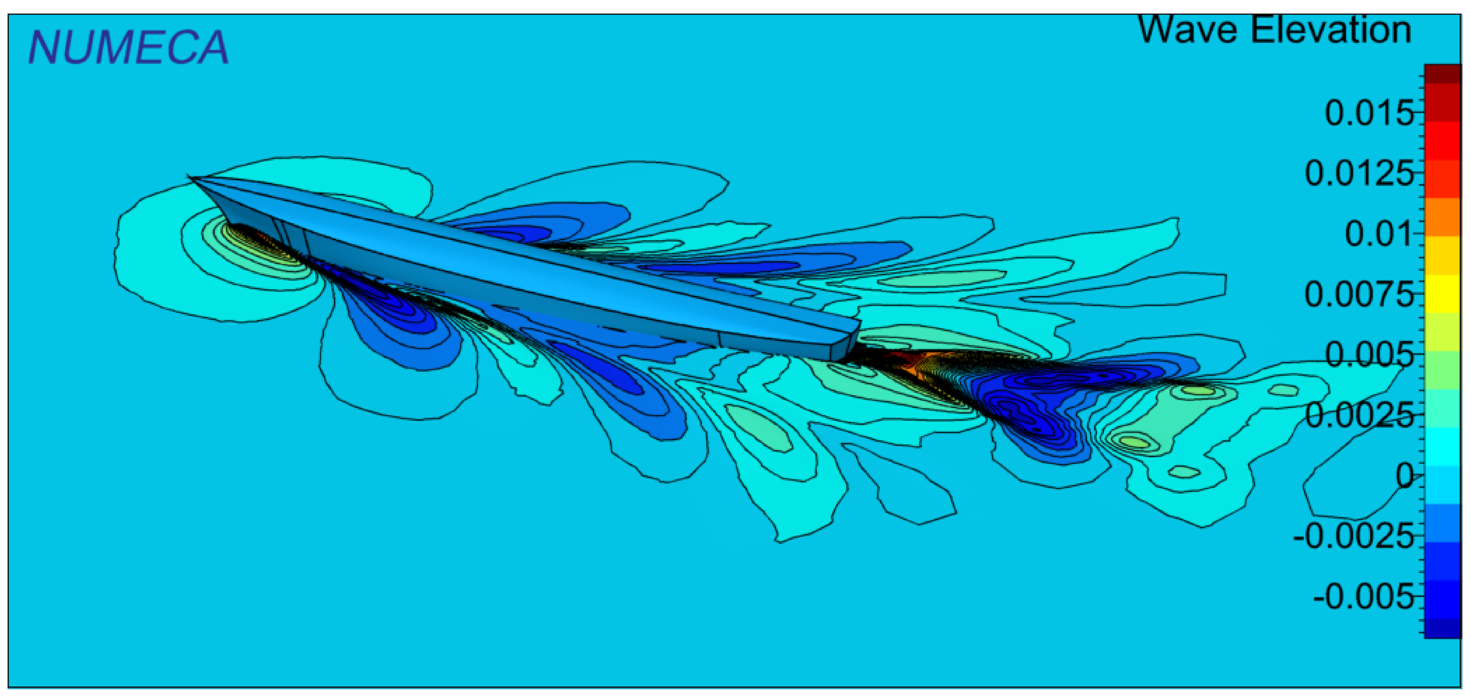

Figure 3:Wave elevation for euler approach.