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SUMMARY OF DOCTORAL THESIS

Thesis title: Research on a proposed hull form of the container ship suitable for Vietnam river-sea route

Major: Transport Mechanical Engineering

Code: 9520116

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Supervisor:

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1. Thesis summary

The issue of efficient energy use for ships is urgent because of fuel-saving in ship operation and the mandatory requirements of the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) to reduce environmental pollution global and greenhouse gas emissions. For ships operating on the coastal route (both at sea and in inland waters), although they are not subject to the application of the above regulations of IMO, it is also necessary to satisfy the regulations, resolutions, and laws of Vietnam on the intended use of energy-efficient and economical. Therefore, researching solutions to design vessels to improve energy efficiency is critical for Vietnam's international fleet of ships in general and the whole coaster fleet in particular.

In this thesis, the author presents the methodology in designing the hull form of a sea-river ship and analyzes and presents the objective function of resistance based on the Holtrop semi-empirical method, considering the condition of constraining the shallow water of the Vietnamese waterway. Next, a genetic optimization algorithm was built to select suitable hull form parameters to reduce ship resistance, thereby saving fuel for

ships, improving economic efficiency, and reducing environmental pollution. Finally, the NUBS mathematical model has been established and proposed for the ship hull form to solve the discontinuity between the bow, aft, and mid-body after Lackenby variation and extended the proposed set of basis functions of NUBS is suitable for container ships on the coastal route. The computational fluid dynamic method (CFD) is used to calculate the ship resistance to evaluate and verify the hull form and confirm the results of improving the hull form of the container ship according to the proposed NUBS mathematical model.

2. The new contribution of the thesis

- The thesis has synthesized, analyzed, and selected a method of calculating ship resistance with acceptable reliability in the preliminary design stage, which the design consultants have not had the conditions to analyze.
- The thesis has successfully implemented the Genetic Algorithm in Matlab, which proposes the hull form coefficients and longitudinal center of buoyancy suitable for container ships considering the influence of river-sea depth. The results obtained are entirely reliable.
- The thesis has successfully proposed a mathematical model for the optimized ship hull form in the NUBS algorithm. NUBS function is an efficient and highly applicable geometrical model in the preliminary design and engineering design stages and can serve numerical analysis in intensive studies.
- The proposed algorithm can be used as an assistant tool to suggest suitable ship hull forms; also, it can be a potential commercial software.

This work aims to propose a more appropriate container ship hull form considering the influence of the depth of route. The Genetic Algorithm is implemented to reduce drag and fuel-saving, then the mathematical model of the container ship is proposed.

3. Achievable results, scientific and practical significance

Scientific significance: This work is the first step in integrating computer-aided ship design into intensive research directions in the further field of fluid mechanics and solid mechanics.

Practical significance:

- Support designer to explore and choose a concept design to propose the container

ship hull suitable for different route conditions in Vietnam.

- This work is also a valuable reference for training in schools and the research topics in ship design.

The author has completed the research objective to propose the container ship hull form suitable for Vietnam's waterways in the preliminary design stage. The thesis results show the improvement of resistance and geometry quality compared to the parent ship, initializing, integrating, and automating the hull form design for small river-sea route container ships under 5000 tons, demonstrated through scientific and practical contributions.

- The objective function includes frictional resistance, hull form resistance, and wave resistance affected by the change of ship form coefficients. Wet surface area, displacement, ship-hull form coefficients are calculated from the hull form value based on the finite integration of the SAC curve instead of the empirical formula, improving the accuracy in the resistance objective function. The results deviate by less than 2% compared to the specialized ship design software (Maxsurf), which is reliable in the preliminary design stage. Research findings on numerical integration in the calculation of ship hull form and resistance objective function have been published in 01 paper (Journal of Transportation Science and Technology).

- The author has successfully constructed the optimization algorithm and the flowcharts to implement the genetic algorithm applied to propose the hull form parameters of the container ship suitable for the river-sea route to reduce resistance. The calculation results show that GA is the optimization tool suitable and reliable with the design approach based on parent ship. The results show that at the design speed is 10 knots, corresponding to the Fn is 0.2, the wave resistance coefficient is reduced by 7.57%, the viscous resistance coefficient is reduced by 4.47%, the total hull resistance coefficient is reduced by 5.53% compared to parent ship. In this thesis, the improving energy efficiency for container ships running on the river-sea route is solved by optimizing the hull form design to reduce hull resistance, thereby saving fuel, improving economic efficiency, and reducing the environmental pollution. Research findings on genetic optimization algorithms have been published in 01 paper (Journal of Transportation Science and Technology).

- The author has successfully implemented NUBS mathematical model for container ship hull form, satisfying the objective of improving resistance. The NUBS algorithm is a practical and highly applicable geometrical model in preliminary and engineering design stages. Solve the discontinuity of the forward, aft, and mid-ships body after the Lackenby transform and the global smoothness of the SAC curve based on the NUBS non-square matrix inverse. The research findings on the NUBS mathematical function for the container ship-hull form in the river-sea route and the resistance assessment process based on numerical simulation CFD are shown in papers, including Science & Technology Development Journal (STDJ-ET), ISI Polish Marit. Res. Journal (ISI - Q2) and International Conference on Advanced Mechatronic Systems IEEE (ICAMechS 2020).

4. Thesis structure

After the Introduction with the prescribed sections, the research contents of the thesis are presented in 5 chapters as follows:

Chapter 1: Overview of the hull form modeling of the container ships suitable for Vietnam's river-sea route

Chapter 2: Research of objective function in resistance for the river-sea container ship

Chapter 3: Optimization research of the hull form parameters for the river-sea container ship.

Chapter 4: Research of modeling for the river-sea container ship based on NUBS

Chapter 5: Evaluating the algorithm's effectiveness for the hull form of the proposed river-sea container ship.

Ho Chi Minh City, September 30, 2021

Science supervisors | PhD Candidate

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