RETROFIT OF ERS IN PROPELLER BLADE TO IMPROVE THE EFFICIENCY OF VESSEL

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ABSTRACT

- *In the pursuit of enhancing the operational efficiency of marine vessels, retrofitting energy recovery systems (ERS) like pre-swirl stators (PSS) has emerged as a promising solution. This study explores the potential of retrofitting PSS to existing propeller systems as a means to optimize hydrodynamic performance and reduce fuel consumption. A pre-swirl stator, positioned ahead of the propeller, alters the inflow water angles, creating a favorable pre-swirl that mitigates rotational energy losses and enhances propulsion efficiency.*

- *Through computational fluid dynamics (CFD) simulations, the interaction between the PSS and the propeller is analyzed to determine the optimal design parameters that maximize energy recovery and minimize adverse effects on propeller performance.*

- *The retrofitting process is evaluated for its cost-effectiveness, with a focus on installation challenges and expected returns on investment through fuel savings. Additionally, the study assesses the environmental benefits, particularly in terms of reduced greenhouse gas emissions, associated with the improved propulsion efficiency.*

- *This investigation underscores the potential of PSS retrofitting as a viable strategy for improving the energy efficiency of existing ships.*

- *Both economic savings and environmental sustainability in the maritime industry.*

KEY WORDS: PSS, CFD, KVLCC2, ERS.

1. INTRODUCTION

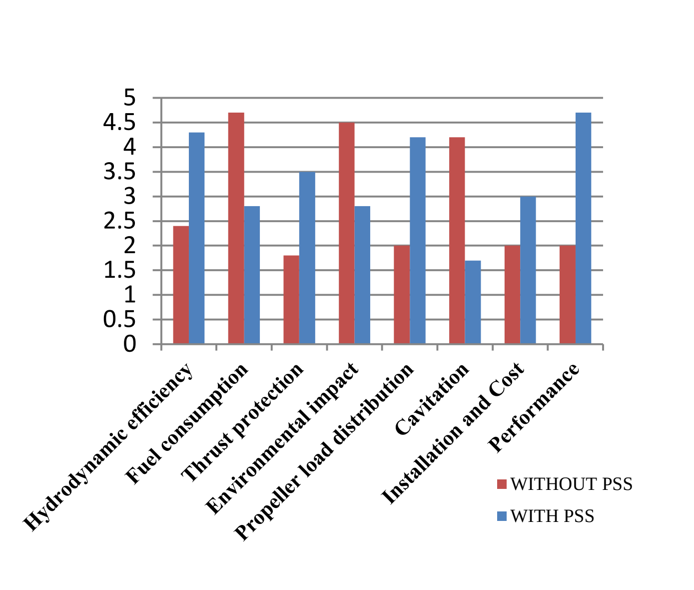
- The maritime industry, a critical backbone of global trade, faces increasing pressure to reduce operational costs and minimize environmental impact. Fuel efficiency and emission reductions have become key priorities for ship operators as they seek to comply with stringent international regulations and economic pressures. As such, enhancing the efficiency of existing vessels is not only desirable but essential for sustainable maritime operations.

- Propulsion systems, particularly propellers, play a pivotal role in the overall energy consumption of a ship. Traditional propeller designs often suffer from inefficiencies due to the rotational energy losses that occur in the wake of the propeller blades. This energy, instead of contributing to thrust, is dissipated in the form of swirling water, leading to reduced propulsive efficiency and increased fuel consumption.

- One innovative approach to addressing this challenge is the retrofitting of energy recovery systems (ERS) such as pre-swirl stators (PSS). A PSS is a fixed device installed ahead of the propeller, designed to create a counter-rotational flow in the water entering the propeller. By optimizing the inflow angles, the PSS reduces the rotational losses in the propeller's wake, leading to improved thrust and overall propulsion efficiency.

- This study focuses on the potential benefits of retrofitting pre-swirl stators to existing ships. It explores the design, installation, and performance implications of this technology, drawing on computational fluid dynamics (CFD) simulations to optimize the stator design.

- The economic feasibility, including installation costs and potential fuel savings, is evaluated alongside the environmental benefits of reduced emissions. By retrofitting PSS to existing vessels, the maritime industry can achieve significant improvements in energy efficiency, thereby enhancing both economic and environmental sustainability.



GRAPH-1 WITH INSTALLATION OF PROPELLER WITH PRE-SWIRL STATOR AND WITHOUT PRE-SWIRL STATOR.

2. PRE-SWIRL STATOR

- A pre-swirl stator is a set of stationary blades placed ahead of the propeller in the water flow.
- The purpose of these blades is to generate a pre-swirl in the water, either counterclockwise or clockwise, before it reaches the propeller.
- This pre-swirl can reduce the rotational losses in the propeller wake, leading to an improvement in propeller efficiency and overall fuel savings.

3. PRE-SWIRL STATOR OPTIMIZATION

- For a regular single screw vessel there are considerable revolving energy wounded in the propeller slip flow.
- The pre-swirl stator is one of the majority striking devices to get better that energy since it is based on well verified energy economy mechanisms and it is easy full-bodied and gainful.
- The pre-swirl concept consists of stator blades mounted on the stern boss in front of the propeller so that the flow is re-directed before it enters the propeller disc.
- The stator does not have keep energy or creates an ahead thrust in fact it adds struggle but its contact with the propeller blade improves the propulsive effectiveness and outcome in a power drop.
- Due to its multipart environment, the pre-swirl stator has been both profitable and ineffective, depending on the purpose.
- Therefore, the purpose of pre-swirl has to be included with hull design to find an optimal stator arrangement.
- The current leaflet shows a first attempt to find a best possible blade angle setting by accurately evaluate propeller wake flow character behind the stators.

4. PURPOSE OF OPTIMIZATION

- The primary goals of optimizing a pre-swirl stator are,

4.1 Increase Propeller Efficiency:

✓ By reducing rotational losses and altering the flow dynamics, the propeller can generate thrust more efficiently.

4.2 Reduce Fuel Consumption:

✓ Enhanced efficiency directly translates to lower fuel consumption, which is critical in the shipping industry.

4.3 Improve Cavitations Performance:

✓ Proper optimization can reduce cavitations, which not only improves efficiency but also extends the lifespan of the propeller.

5. CASE DESCRIPTION

- The well-known and publicly available *KVLCC2 hull* was used for the present investigation. This hull is characterized by a sort of physically powerful vortex arrangement created in the astern bilge part that enters the propeller plane and creates a **hook** like formed get up.
- The hull was appended with a couple of stators on each side just in obverse of the propeller that should modify the get up by minimizing the velocity gradients and there by an enhanced working condition for the propeller.
- The picture below shows the configuration of the stators (red blades) a surface grid on the hull. The angles of the stator wings were varied to find an optimal solution.

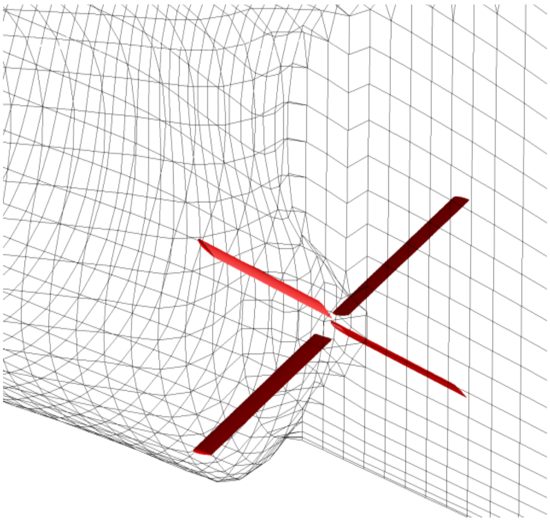


Fig1.1-PRE SWRIL-STATOR BLADE

6. OPTIMIZATION PARAMETERS

- The optimization process typically involves tweaking several parameters, including.

6.1 Blade Angle:

- ✓ The angle of the stator blades relative to the incoming flow.

6.2 Blade Number and Spacing:

- ✓ The number of blades and their spacing can significantly influence the flow pattern.

6.3 Blade Shape and Size:

- ✓ Different shapes and sizes can affect the flow dynamics in various ways.

7. COMPUTATIONS

- The calculations were approved out at model scale with a Reynolds number of 4.6x106.

- The backdrop network was shaped with XGRID from a counterbalance file while the stator wings were generated using a parametric copy included in XCHAP.

- In arrange to drop off the computational time for the optimization a somewhat uncouth net with around 400 000 cells was used.

- The calculations started with an essential answer that was iterated for 3500 iterations until the flow ground was converging, and thereafter the optimizer in progress to differ the angles of the stator wings.

- Each innovative case was restarted from the necessary one and iterated for 35 iterations.

- An Ensample study was performed by changeable the pitch of the wings in the range -15 to 15 degrees to find an optimum configuration.

- The utmost variation in the wake circumferential allocation was selected as the purpose.

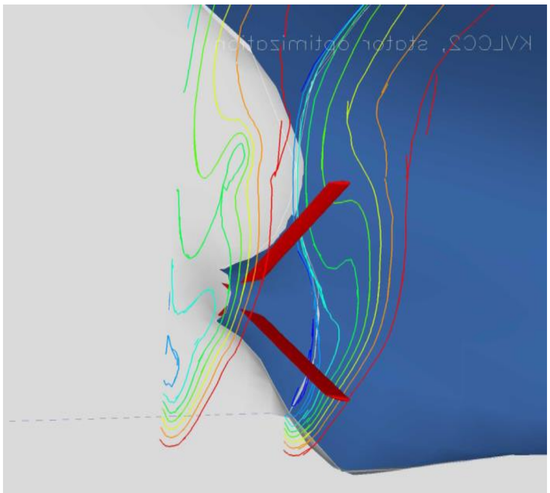


Fig1.2- PROPELLER FLOW

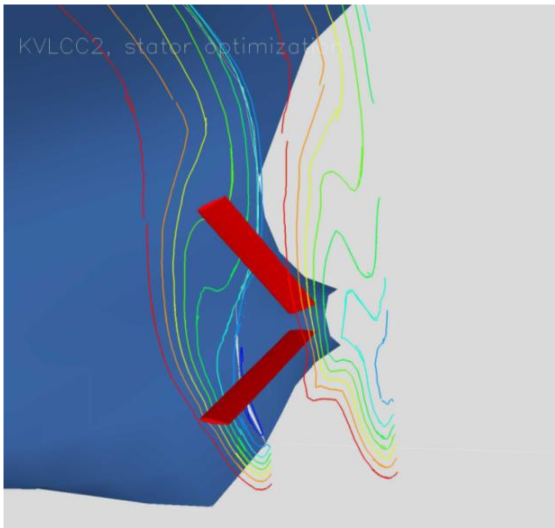


Fig1.3 PROPELLER FLOW

8. METHODS OF OPTIMIZATION

8.1 Computational Fluid Dynamics (CFD)

- ✓ Computational Fluid Dynamics (CFD) software is a class of tools used to simulate fluid flows, heat transfer, and other related phenomena using numerical methods and algorithms. These tools are widely applied in industries like aerospace, marine, automotive, and civil engineering to optimize designs, predict performance, and reduce physical testing costs. In **marine engineering**, CFD plays a crucial role in analyzing fluid dynamics around ship hulls, propellers, and other components.

- ✓ This is the most common method, where simulations are used to predict how changes in the stator design will affect flow characteristics and propeller performance.

8.2 Experimental Methods:

- ✓ Model testing in towing tanks or cavitations tunnels can provide empirical data to refine the design.

8.3 Iterative Design Process:

- ✓ Often, a combination of CFD and experimental methods is used in an iterative process to converge on an optimal design.

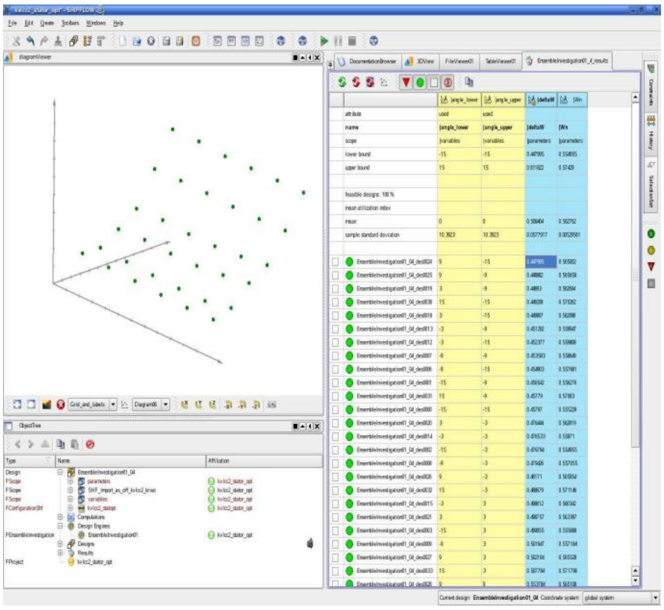


Fig1.4-CFD SOFTWARE

9. CONCLUSION

- ❖ The entire study was finished within 48 hours as well as case set up and post processing.
- ❖ It was established that the wake can be optimized with deference to the selected criteria.
- ❖ The best case had minor variations for the total wake in the circumferential trend and the velocity contours in the propeller plane were extra surrounding.
- ❖ Pre-swirl stator optimization is a crucial aspect of modern marine propulsion design, aimed at achieving higher efficiency and reducing operational costs.
- ❖ By carefully designing and optimizing the stator, shipbuilders can create more energy-efficient vessels with lower environmental impacts.
- ❖ The incorporated design atmosphere of VESSELFLOW Design tie together allows the designers to study and optimize the flow around appended hulls.
- ❖ The strong and bendable solver feature overlapping grids method can be controlled from simple to use and commanding graphical boundary that includes also optimization apparatus.

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