ISSN: 0973-3469, Vol.20, No.(2) 2023, Pg. 130-133

Material Science Research India

www.materialsciencejournal.org

Design and Structural analysis of Marlin Torpedo with Coupled Contra Rotating Propellers

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Abstract

The goal of propeller designers has always been to increase several settings to improve propulsion efficiency have been devised. One of the leading attractive propulsion systems is coupled contra-rotating propellers, which can be expected to significantly improve the open water efficiency with reduced rotational kinetic energy losses. The 3-Dimensional hydrodynamic contour of the coupled contra rotating propellers makes simulation with the highest rotational velocity of 2000rpm with an analytical structural design exceedingly challenging deformation must be less then 1mm. To analyze the propeller strength the Ansys FEM Simulation approach is applied. Static analysis is carried out with a Stainless Steel and has a component of strength analysis to guarantee the safety of the coupled contra-rotating propellers.

Article History

Received: 03 July 2023

Accepted: 14 August 2023

Keywords

Propeller;

Hydrodynamic;

Structural and FEM Simulation.

Introduction

Considering the mechanical complexity, the expanded cost of installation and the high demand for maintenance associated with installing the propulsion design in mechanically driven torpedoes can provide reasonable clarification. During the past half decade, improving the propulsion has removed the need for sophisticated transmission systems and brought coupled contra rotating propellers (CCRP) back to life. Due to the growing need for more load - capacity and velocity of Black Marlin transport systems. However, there are various issues when a single hose is utilized to create the required thrust in huge Torpedo displacement. These include an increased possibility of propeller blade cavitation due to unbalance of torque, in severe load conditions and vibrations. The vibrations are conveyed to the torpedo body from the propeller and induce movement instability. The CCRP are an appropriate approach to overcome these challenges. The propellers consist of two propellers which revolve in opposite directions placed on two coaxial shafts. The torque associated with various propellers approximately equal, which is used to ensure movement stability and eliminate gadgets with reverse torque. Less strain on the blades and a delay in cavitation Because of the decreased weight, higher CCRP propellers with the same diameter as single ones can offer greater power.

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Doi: http://dx.doi.org/10.13005/msri/200206

Lifting Line Methods

In a CCRP set, Compilation is required auto induced speeds coming from the induction of the trailing vortices on the lifting lines, in addition to taking the interaction into scrutiny speeds on one propeller due to the other's presence. The ties between the propellers upstream and downstream lead to time-dependent flow and strength. The back propeller blades in the slip stream of the forward propeller in particular revolve through the vortex sheets. In addition, the forward thrust is sensitive to the flow disturbance caused by the rear thrust. A fundamental approximation is the theory of time-average (or steady) forces. The start-up flow for each propeller is separated into a circumferential (radically and axially diverse) mean and periodic components (harmonics). The average speed component is supposed to produce stable propeller forces, whereas the periodic components produce zero mean alternating forces.

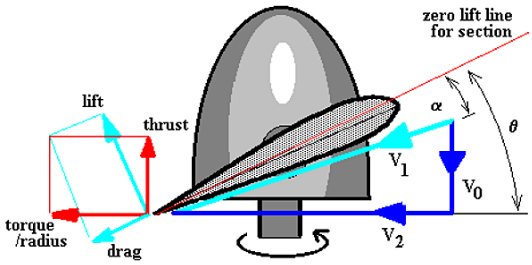

Fig. 1: Relative Velocities at Blade Sections

Therefore, both forward and back propellers are usually considered SR propeller including a starting flow to each propeller is modified to components that are both axial and radial on average of the speed-field induced by the other propeller. The propellers operated at steady, axical and symmetrical flows. This involves an iterative process, which successively determines the charges and induced speeds of each propeller until the solution is converged. Front and the blade's back speed diagrams. Both the auto-induced components and the interaction velocity are included.

Two CCRP Design Methods

It discusses the numerous methodologies utilized in the manufacture of lifting line theories for contra-rotating propellers. First, the optimal loading criteria are stated for single propellers. Implementation numerical of two CCRP design procedures. A full description of the process for calculating interaction velocities, which is a crucial aspect of the interacting components design, Finally, after calculation of the load distribution, the procedure of determining the blade's form is discussed.

The underlying general assumptions should be listed first before presenting 'Coupled' methods. The main assumption in the current wording of the optimal distribution methods is that CCRP is not streamlined. The rear propeller diameter is thus not necessary to be smaller than the rear propeller because the tip vortices of this last one are not impacted by the former propeller.

In addition, tracking the contracting streamlines is avoided, which lightens the calculation algorithms. Therefore, the same diameter is supposed to be in both propellers. For both components, the hub diameter is also the same.

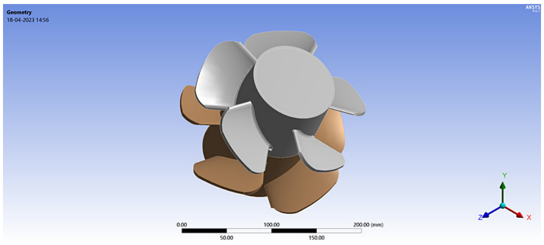

Fig. 2: Coupled contra rotating propellers set

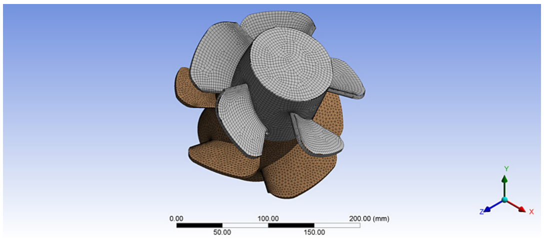

Fig. 3: Coupled contra rotating propellers Mesh

Except for the mesh size, the programme has already received all the data required to mesh the geometric model. By providing the lines in the model a number of divisions, it is possible to control the mesh size and ensure that the mesh is as regular as possible. Instead of the number of divisions, the element edge length can alternatively be chosen. The programme will automatically calculate the finite number of divisions for each line, rounding up to the nearest integer, using the element edge length divided by the overall line length.

Results and Discussions

The simplified coupled contra rotating propellers structural model with a rotational velocity of 2000 rpm (210 rad/sec) applied to both coupled propellers rotating one in a clockwise direction and the other in an anticlockwise direction with the same velocity. The results were satisfactory under the conditions that were used. The findings suggest that linked coupled contra rotating propellers have improved static structural properties.

Table 1: Model Analysis of Coupled contra rotating propellers results

Rotational Velocity Rad/sec	Total Deformation (mm)	Equivalent Elastic Strain	Equivalen t Stress (Mpa)
0	0	0	0
70	0.0027135	0.000042581	7.4928
140	0.010854	0.00017032	29.971
210	0.024421	0.00038323	67.436

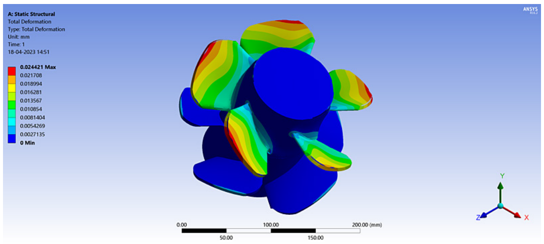

Fig. 4: Total Deformation

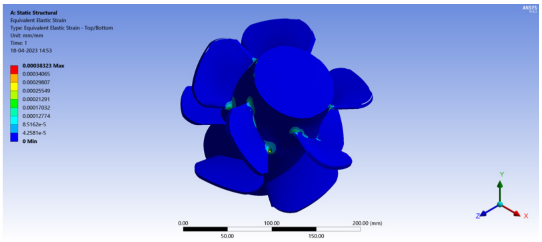

Fig. 5: Equivalent Elastic Strain

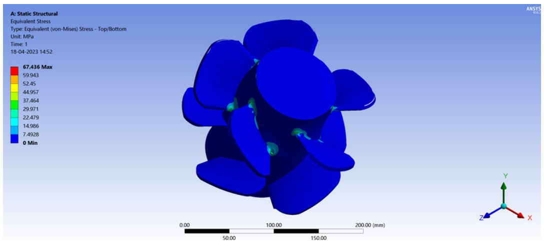

Fig. 6: Equivalent Stress

The deformation generated from the reduced structural model of rotational velocity applied to a coupled contra rotating propellers produced good results. It was observed that highest value of total deformation 0.024421mm, equivalent elastic strain 0.00038323, equivalent stress 67.436Mpa for coupled contra rotating propellers at 210rad/Sec. It was observed that lowest value of total deformation 0mm, equivalent elastic strain 0, equivalent stress 0Mpa for coupled contra rotating propellers at 0rad/Sec. It can be deduced that the coupled contra rotating propellers showed at a time with both revolutions results have shown better static structural rotational characteristics.

Conclusion

This paper presents and discusses some of the findings from the authors' recent work on the design and performance prediction methodologies of the CCRP system, along with a specific example for the object torpedo. With the aid of the CATIA modelling programme and rotational structural analysis, the CCRP is modelled in accordance with the predicted design criteria and hydrodynamic properties were determined. The CCRP calculations for the stainless-steel material with enhanced structural qualities were performed using ANSYS Static Structural.

Acknowledgement

I would like to thank to my supervisor Dr. Vivek Sachan who made this work possible and providing the resources required for this work. His guidance and advice carried me through all the stages of writing paper. I would also like to give special thanks to my friend Hari Kishan Mantravadi(Engineering assistant) for continuous support and understanding when undertaking my research and writing my project.

Funding

This research work is not sponsored or funded by any institute/organization.

Conflict of Interest

We declare that there is no conflict of interest regarding the research work carried out for the publication of this article.

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