World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:16, No:01, 2022

Study of Wake Dynamics for a Rim-Driven Thruster Based on Numerical Method

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Abstract : The present work examines the wake dynamics of a rim-driven thruster (RDT) with Computational Fluid Dynamics (CFD). Unsteady Reynolds-averaged Navier-Stokes (URANS) equations were solved in the commercial solver ANSYS Fluent in combination with the SST k-ω turbulence model. The application of the moving reference frame (MRF) and sliding mesh (SM) approach to handling the rotational movement of the propeller were compared in the transient simulations. Validation and verification of the numerical model was performed to ensure numerical accuracy. Two representative scenarios were considered, i.e., the bollard condition (J=0) and a very light loading condition(J=0.7), respectively. From the results, it's confirmed that compared to the SM method, the MRF method is not suitable for resolving the unsteady flow features as it only gives the general mean flow but smooths out lots of characteristic details in the flow field. By evaluating the simulation results with the SM technique, the instantaneous wake flow field under both conditions is presented and analyzed, most notably the helical vortex structure. It's observed from the results that the tip vortices, blade shed vortices, and hub vortices are present in the wake flow field and convect downstream in a highly non-linear way. The shear layer vortices shedding from the duct displayed a strong interaction with the distorted tip vortices in an irregularmanner.

Keywords : computational fluid dynamics, rim-driven thruster, sliding mesh, wake dynamics
Conference Title : ICCFDCE 2022 : International Conference on Computational Fluid Dynamics in Civil Engineering
Conference Location : Bali, Indonesia
Conference Dates : January 14-15, 2022