Scale resolving simulation of bow thruster hydrodynamics

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1 Abstract

Reduction of strong acoustic emission and vibration is one of the key problems in hydrodynamic design of bow thrusters. These undesirable phenomena are caused by a complex flow inside the thruster, which is very non-uniform because of flow separation at the tunnel wall. Numerical resolution of the turbulent structures in the bow thruster flows requires utilization of scale resolving simulations, particularly, hybrid URANS/LES models. With its relatively modest computer resources requirements regarding the time and memory consumption, the hybrid method makes the scale-resolving simulations practical for real engineering applications. The paper presents a study of forces acting on the wheel and the whole arrangement including boards, tunnel, wheel, strut, and nacelle.
A special attention is paid to study of pressure pulsations in the bow thruster tunnel both with and without cavitation, which is modeled using the Rayleigh-Plesset model. The wheel is resolved both in time and space using the arbitrary mesh interface (AMI) implemented in OpenFOAM. Peculiarities of grid generation using Pointwise and Hexpress meshers are discussed for combination of static and rotating grids. The grid convergence is proven in a thorough verification procedure.
The pressure pulsations and forces, obtained with hybrid models (SLH and DDES), are compared with URANS simulations and measurements. The pressure pulsations are analyzed depending on the probe position inside the tunnel.
An important point is the study of the influence of the protective grid on the mean thrust and its fluctuations. Security grid would be placed, in the entrance of the tunnel. It's effect is replicated using body forces instead of imposing the security grid as the real obstacle in the flow. This method has been studied to size its accuracy in relation to affected computational time decrease.
The results of simulations are utilized for the simulation of vibrations of a bow thruster manufactured by Jastram.

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