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Analysis of Waterjet Propulsion System for an Amphibious Vehicle

Authors : Nafsi K. Ashraf, C. V. Vipin, V. Anantha Subramanian

Abstract : This paper reports the design of a waterjet propulsion system for an amphibious vehicle based on circulation distribution over the camber line for the sections of the impeller and stator. In contrast with the conventional waterjet design, the inlet duct is straight for water entry parallel and in line with the nozzle exit. The extended nozzle after the stator bowl makes the flow more axial further improving thrust delivery. Waterjet works on the principle of volume flow rate through the system and unlike the propeller, it is an internal flow system. The major difference between the propeller and the waterjet occurs at the flow passing the actuator. Though a ducted propeller could constitute the equivalent of waterjet propulsion, in a realistic situation, the nozzle area for the Waterjet would be proportionately larger to the inlet area and propeller disc area. Moreover, the flow rate through impeller disk is controlled by nozzle area. For these reasons the waterjet design is based on pump systems rather than propellers and therefore it is important to bring out the characteristics of the flow from this point of view. The analysis is carried out using computational fluid dynamics. Design of waterjet propulsion is carried out adapting the axial flow pump design and performance analysis was done with three-dimensional computational fluid dynamics (CFD) code. With the varying environmental conditions as well as with the necessity of high discharge and low head along with the space confinement for the given amphibious vehicle, an axial pump design is suitable. The major problem of inlet velocity distribution is the large variation of velocity in the circumferential direction which gives rise to heavy blade loading that varies with time. The cavitation criteria have also been taken into account as per the hydrodynamic pump design. Generally, waterjet propulsion system can be parted into the inlet, the pump, the nozzle and the steering device. The pump further comprises an impeller and a stator. Analytical and numerical approaches such as RANSE solver has been undertaken to understand the performance of designed waterjet propulsion system. Unlike in case of propellers the analysis was based on head flow curve with efficiency and power curves. The modeling of the impeller is performed using rigid body motion approach. The realizable k-ϵ model has been used for turbulence modeling. The appropriate boundary conditions are applied for the domain, domain size and grid dependence studies are carried out.

Keywords : amphibious vehicle, CFD, impeller design, waterjet propulsion
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