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Optimization Based Design of Decelerating Duct for Pumpjets

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Abstract : Pumpjets are one of the marine propulsion systems frequently used in underwater vehicles nowadays. The reasons for frequent use of pumpjet as a propulsion system are that it has higher relative efficiency at high speeds, better cavitation, and acoustic performance than its rivals. Pumpjets are composed of rotor, stator, and duct, and there are two different types of pumpjet configurations depending on the desired hydrodynamic characteristic, which are with accelerating and decelerating duct. Pumpjet with an accelerating channel is used at cargo ships where it works at low speeds and high loading conditions. The working principle of this type of pumpjet is to maximize the thrust by reducing the pressure of the fluid through the channel and throwing the fluid out from the channel with high momentum. On the other hand, for decelerating ducted pumpjets, the main consideration is to prevent the occurrence of the cavitation phenomenon by increasing the pressure of the fluid about the rotor region. By postponing the cavitation, acoustic noise naturally falls down, so decelerating ducted systems are used at noise-sensitive vehicle systems where acoustic performance is vital. Therefore, duct design becomes a crucial step during pumpjet design. This study, it is aimed to optimize the duct geometry of a decelerating ducted pumpjet for a highly speed underwater vehicle by using proper optimization tools. The target output of this optimization process is to obtain a duct design that maximizes fluid pressure around the rotor region to prevent from cavitation and minimizes drag force. There are two main optimization techniques that could be utilized for this process which are parameter-based optimization and gradient-based optimization. While parameter-based algorithm offers more major changes in interested geometry, which makes user to get close desired geometry, gradient-based algorithm deals with minor local changes in geometry. In parameter-based optimization, the geometry should be parameterized first. Then, by defining upper and lower limits for these parameters, design space is created. Finally, by proper optimization code and analysis, optimum geometry is obtained from this design space. For this duct optimization study, a commercial codedparameter-based optimization algorithm is used. To parameterize the geometry, duct is represented with b-spline curves and control points. These control points have x and y coordinates limits. By regarding these limits, design space is generated.

Keywords : pumpjet, decelerating duct design, optimization, underwater vehicles, cavitation, drag minimization
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