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Pump-Jet Hydrodynamic Performance and Design: A Study

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Abstract

This paper summarises in a comprehensive and specialised manner the pump-jet hydrodynamic performance, noise performance, flow field characteristics involving cavitation erosion and vortices properties of tip-clearance, the interaction between the rotor and the stator, and the wake field, as well as the optimal design. The design technique is described, as well as the benefits and breadth of applications of numerical and experimental methods. Furthermore, it offers a vision for future research and draws conclusions about the key problems found in application.

Keywords: Pump-jet • Hydrodynamic performance • Flow field • Design

Introduction

A pump-jet is made up of a rotor, a stator, and a duct. It is used on underwater vehicles for everything from deep sea exploration to mine clearing. It has high critical speed, high propulsion efficiency, great anti-cavitation performance, and low radiated noise. The high degree of coupling with the appendage and the complex interaction of the flow field between the various components necessitate extensive research on the hydrodynamic performance and flow field for application and design. There is a dearth of research on pump-jet performance and optimal design due to its initial military application and complex structure.

The pump-jet was found to be significantly different due to its compact structure and intricate internal and external flow fields, resulting in improved performance. Vortices are the focus of research on cavitation because they interact with the complex pump-jet structure, causing flow field instabilities like vibration, radiated noise, and cavitation erosion. The sawtooth duct is installed and the tip clearance is removed in order to effectively reduce radiated pump-jet with minimal impact on hydrodynamic performance. With promising prospects, cutting-edge optimal technology is capable of achieving high cavitation and acoustic performance. The primary focus of future research ought to be on further advancements in pump-jet research and application in the multidisciplinary integration of fluid dynamics, acoustics, materials, chemistry, and bionics [1-3].

Literature Review

The current development of propulsion systems has made numerous advancements in underwater vehicles possible, including a significant expansion of technology and its application scope. Underwater vehicles face significant difficulties in terms of maneuverability and crypticity as a result of the variety of underwater tasks and the advancement of ocean detection technology. However, the efficiency of the propulsion system is a significant contributor to the length of missions, which is one of the limitations imposed by current technology. In order to give the underwater vehicle a certain speed and range [4], the propulsion system is used to power the vehicle's automatic navigation. In the meantime, the focus of research has shifted to finding ways to reduce propulsion noise and boost hydrodynamic performance. So, one of the best options for the high-speed underwater vehicle is the pump-jet, which was first installed on a Trafalgar-class submarine in the 1980s. Both the low-noise feature and the high-efficiency performance, respectively, guarantee underwater vehicles' maneuverability and enhance their overall acoustic concealment. Pump-jets are able to meet the requirements of underwater vehicles, such as high speed, high efficiency, no cavitation, and low noise, when compared to traditional propellers or ducted propellers. Contra-rotating propellers, another type of propulsion that is frequently utilized in underwater vehicles, are also capable of better meeting the relevant requirements; however, the shafting is complicated and the requirements for sealing are high. The pump-jet, on the other hand, still needs work to be done, and its complicated structure makes design and performance evaluation more difficult. This makes the flow characteristics, noise mechanisms, and hull-matching requirements more complicated. Therefore, it is essential to investigate the performance and design strategies of pump-jets [5].

Discussion

Pump-jet propulsion, which consists of a rotor, stator, and an axisymmetric duct, has primarily been utilized in the military. However, due to their superior performance, pump-jets are gradually being utilized in the civil sector. The pump-jet distinguishes itself significantly from the ducted propeller with stator due to its compact structure and intricate internal and external flow fields. Most of the time, the rotor is in the symmetrical duct, which slows down the inflow through the rotor blades to make cavitation work better and make it faster underwater. The stator is a set of stationary blade cascades that are positioned either in front of or behind the rotor in the axial direction, at an incidence angle to the direction of the inflow. The pump-jet can be divided into post-swirl pump-jet and pre-swirl pump-jet based on the stator's axial positions relative to the rotor. The pump-jet-installed rear stator is typically found in small high-speed vehicles like torpedoes and focuses on high efficiency and moment balance performance. It can reduce the rotor's circumferential rotating wake and contribute up to 25% of the total thrust. On the other hand, cavitation performance and radiated noise reduction are the primary goals of the pump-jet with front stator, which provides pre-swirl and filters out wakes from the appendages before they reach the rotor. Due to the fact that the number of blades has a significant impact on pump-jet performance, pump-jets are typically installed with a large number of blades, but not all of them are equally spaced out. This prevents impacts from issues like blade passing frequency [2]. It is important to avoid having the same number of blades in more than one row, and the number of blades should be a prime number to avoid harmonics. The rotor and stator's blade numbers typically range from 12 to 20. The corresponding design is more complicated to meet the requirements. In the development of pump-jets for underwater vehicles, it is expected that the method for making full use of the underwater vehicle's tail section line and wake, which can lessen the wake

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effect, reduce radiated noise, improve hydrodynamic performance, and match the various components to one another, will be taken into consideration. As a result, the design of any component must match the vehicle and meet the requirements; Otherwise, it will harm the pump-jet flow field, which affects hydrodynamic performance and acoustic properties.

An overview of the most recent developments in pump-jet design, performance, and mechanism is provided in this review. Additionally, the particular performance analysis of pump-jets and the particulars of complex flow fields and their performance were discussed. The pump-jet hydrodynamic performance, noise performance, and flow-field characteristics involving cavitation erosion and vortices properties of tip-clearance were examined in depth and in depth in this paper; the wake field's interaction with the rotor and stator; as well as the most effective pump-jet layout. The following are the primary challenges and conclusions:

As a foundation for design, performance evaluation can be accomplished in one of two ways: the experimental and numerical methods. The open-water performance test, the cavitation test, and the self-propulsion test comprise the experimental method. These tests are used to determine whether the pump-jet matches the hull, predict the cavitation performance, and measure the pump-jet's open-water performance. For numerical performance prediction, the potential-flow method and the viscous-flow method are the most commonly used? In pump-jet prediction, the CFD method based on viscous flow is more accurate and reliable than the potential flow method. Numerous researchers have used experiments and simulations to show that the pump-jet has better hydrodynamic performance. The pre-swirl pump-jet is typically found in low-speed and heavy-duty underwater vehicles, whereas the post-swirl pump-jet is typically used in the propulsion of small and high-speed underwater vehicles. Scale effects are also important for accurately predicting pump-jet performance because they have different effects on the various components. There are numerous factors that contribute to the complexity of the variation by scale effects, including changes in duct loading and the thickness of the boundary layer on the blade surface. More research is needed to determine the specific reasons for this. When compared to other types of propulsion, the pump-jet's larger axial dimension and stronger coupling with the prior appendage have a significant impact on a pump-jet operating in a complex environment like oblique flow [1,2].

Cavitation is an irregularity of the stream prompting apparent impacts that not just outcome in that frame of mind of drive execution and the vibration of submerged vehicle yet in addition the development of cavitation clamor. Noise and vibration are two potential negative effects of tip-clearance cavitation. In the meantime, the interaction between the tip vortex and the cavitation bubbles is more complicated which can affect the flow field's consistency and may make it worse. Vortices are the focus of research on cavitation because they interact with the complex pump-jet structure, causing flow field instabilities like vibration, radiated noise, and cavitation erosion. In addition, the pump-jet leaves behind a large vortex. Instabilities in the flow are caused when these vortices interact with one another. Due to the presence of significant separating vortices, the interaction with the wake vortices of the rotor and stator during the destabilization process is enhanced in special circumstances like oblique flow.

Conclusion

The structure of the stator has a negative effect on the rotor's surface flow in the pre-swirl pump-jet, so the rotor follows the stator. The stator improves the recycling of the rotor wake and has a slight effect on tip-clearance flow in the post-swirl pump-jet. Propulsion, cavitation erosion, and noise performance are all determined by the interaction of the wake's vortices with the surrounding components.

References

1. Kim, Kwang-Hee, Jin-Han Ree, YoungHee Kim and Sungshil Kim, et al. "Assessing whether the 2017 M w 5.4 Pohang earthquake in South Korea was an induced event." *Science* 360 (2018): 1007-1009.

2. Juanes, Ruben, Bradford H. Hager and Howard J. Herzog. "No geologic evidence that seismicity causes fault leakage that would render large-scale carbon capture and storage unsuccessful." *Proc Natl Acad Sci* 109 (2012): E3623-E3623.

3. Vilarrasa, Victor and Jesus Carrera. "Geologic carbon storage is unlikely to trigger large earthquakes and reactivate faults through which CO_2 could leak." *Proc Natl Acad Sci* 112 (2015): 5938-5943.

4. Weingarten, Matthew, Shemin Ge, Jonathan W. Godt and Barbara A. Bekins, et al. "High-rate injection is associated with the increase in US mid-continent seismicity." *Science* 348 (2015): 1336-1340.

5. Colglazier, William. "Sustainable development agenda: 2030." *Science* 349 (2015): 1048-1050.

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