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Design and Performance Analysis of a Submerged Spheroidal Motor Impeller

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Abstract

This research focuses on the development of an innovative submerged spheroidal motor impeller. The propulsion structure features a stator core in a spheroidal shape, with three perpendicular grooves along a big circle on its surface. 3-phase concentrated windings are placed in the grooves, arranged pairwise perpendicular to each other. The windings are connected to a submerged sealing plug via cables. A sealed shell envelops the stator core, and a spheroidal shell-shaped outer rotor is mounted on the sealed shell through rubber bearings. The rotor core is positioned between the rubber bearings, with a slim clearance between the rotor core and the sealed shell. The combination of the rotor core, rubber bearings, and rotor shell enables direct attachment of impeller blades onto the rotor shell. The submerged spheroidal motor impeller achieves vectored propulsion, improving impeller performance and simplifying the mechanical structure of submerged working devices. This research aims to enhance the utility, reliability, and efficiency of submerged working devices through the implementation of the proposed propulsion structure.

Keywords: submerged propulsion, spheroidal motor impeller, vectored propulsion, mechanical simplification, performance improvement, reliability enhancement.

Introduction

The advancement of submerged propulsion technology plays a vital role in the development of submerged working devices and vehicles. The efficiency, manoeuvrability, and reliability of these devices greatly depend on the propulsion structure employed. In recent years, researchers and engineers have focused on exploring innovative designs to improve the performance of submerged propulsion structures. This research

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Iss 9, 2022

aims to present an submerged spheroidal motor impeller, which introduces a unique approach to achieve vectored propulsion. The spheroidal motor impeller offers several advantages over traditional propulsion structures, including improved performance, simplified mechanical structure, reduced mass and volume, and enhanced utility and reliability of submerged working devices.[1] The submerged spheroidal motor impeller is characterized by its distinctive design. A stator core, in the shape of a sphere, forms the foundation of the propulsion structure.

The surface of the spheroidal stator core features three grooves that are perpendicular to one another along a big circle. These grooves house 3-phase concentrated windings, arranged pairwise perpendicular to each other. The windings are connected to an submerged sealing plug through cables, ensuring effective electrical transmission.

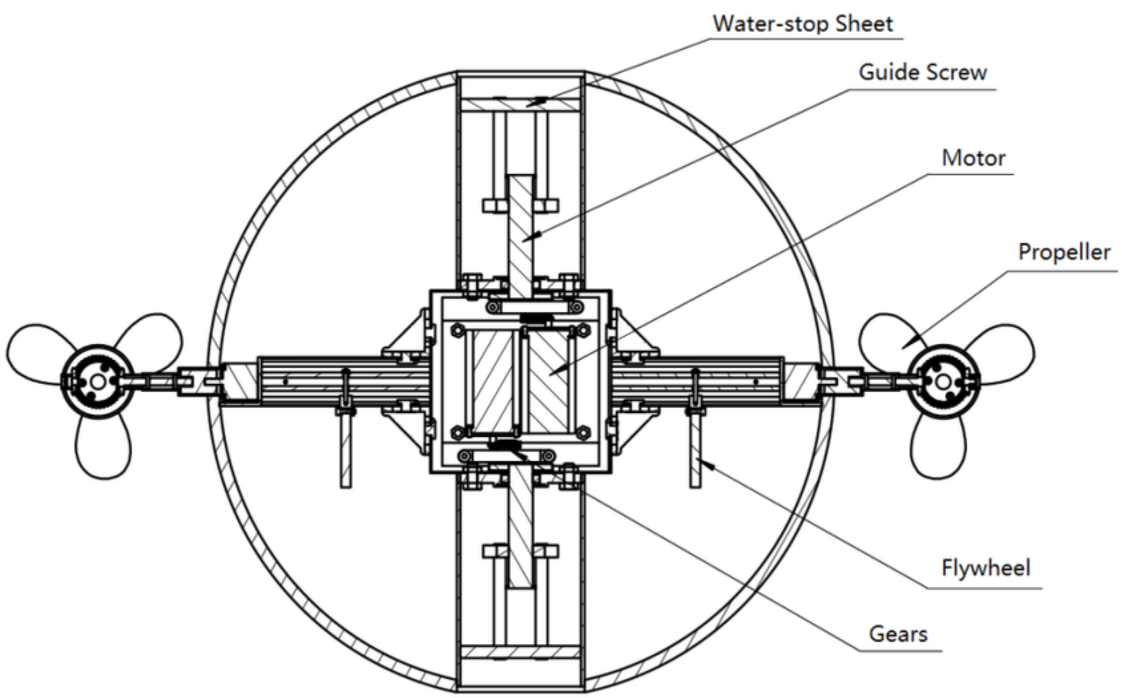

Figure 1. Submerged Spheroidal Motor Impeller

To encapsulate and protect the stator core, a spheroidal sealed shell is fixed around it. The outer rotor, which has a spheroidal shell-like shape, is then mounted on the sealed shell using rubber bearings. These rubber bearings, equipped with flumes on their surfaces, facilitate smooth rotational movement. A rotor core is

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Iss 9, 2022

positioned between the rubber bearings, and a slim clearance is reserved between the rotor core and the sealed shell. The rotor core, rubber bearings, and rotor shell are combined to provide a sturdy and efficient propulsion mechanism.[2] Impeller blades are directly fixed onto the rotor shell, further simplifying the mechanical structure.

The submerged spheroidal motor impeller introduces the concept of vectored propulsion, enabling enhanced manoeuvrability of submerged working devices. By utilizing the unique arrangement of windings and rotor components, the impeller can generate thrust in multiple directions, providing greater control and agility in submerged environments. This vectored propulsion capability allows for precise navigation, precise positioning, and improved response to changing conditions, making it highly suitable for a wide range of submerged applications.[3] The primary objective of this research is to design and analyse the performance of the submerged spheroidal motor impeller.

Through comprehensive experimental and computational investigations, the research aims to evaluate key performance parameters such as thrust, efficiency, and power consumption. Additionally, the mechanical simplification achieved by this propulsion structure will be assessed, including the reduction in mass and volume of the submerged working device. The research also seeks to evaluate the practical utility and reliability of the submerged spheroidal motor impeller for various submerged applications. The development of the submerged spheroidal motor impeller presents a promising advancement in submerged propulsion technology.[6] The unique design and vectored propulsion capability offer significant advantages in terms of performance, manoeuvrability, and mechanical simplicity.

Through this research, a comprehensive understanding of the impeller's performance characteristics and its potential applications in submerged working devices will be achieved. The findings of this study can contribute to the further advancement and practical implementation of submerged propulsion structures, enabling the development of more efficient, reliable, and versatile submerged vehicles and robotic structures.[5]

Related Work

With advancements in motor technology and control structures, various types of motors have been employed as power sources for submerged impellers. However, existing electric motor thrusters, such as the one described in one patent. typically utilize a traditional structure. In these structures, the impeller is connected to the rotor through a decelerator or other drive mechanisms. The rotor rotates around a fixed

ISSN PRINT 2319 1775 Online 2320 7876
Research paper Volume 11, Iss 9, 2022

axis, allowing the impeller to generate thrust in a single direction for forward and backward movement. To change the direction of motion, a rudder is added to the back of the impeller, altering the path of the load by controlling the angle of the rudder.[4] However, the addition of a rudder complicates the overall mechanical structure of the submerged propulsion device and its operational control, while also reducing propulsive efficiency.

In practical applications, multiple electric motor thrusters can be employed, with each thruster being responsible for propelling the load in specific directions. By combining multiple thrusters on a platform, the overall propulsion requirements of the submerged structure can be met. However, this approach results in increased equipment volume and weight, leading to economic implications. Therefore, there is a need for a novel electric motor thruster that can change the direction of propulsion flexibly without the need for complex mechanical structures or additional components.[7] This thruster should offer improved manoeuvrability and efficiency while maintaining a compact design.

To address these challenges, the focus of this research is to develop an submerged spheroidal motor impeller. Unlike traditional electric motor thrusters, this impeller introduces a unique design that allows for vectored propulsion.

Parameter	Description
Impeller Type	Submerged Spheroidal Motor Impeller
Stator Core Shape	Spheroidal
Number of Grooves	3 (perpendicular to one another along a great circle)
Windings	3-phase concentrated windings
Windings Arrangement	Pairwise perpendicular in the grooves
Cable Connection	Windings connected to submerged sealing plug
Spheroidal Capsule	Fixed shell that surrounds the stator core
Rotor Type	Spheroidal shell-shaped outer rotor
Rubber Shaft Bearings	First and second rubber bearings with flumes and water hole
Rotor Core	Positioned between the rubber shaft bearings
Clearance	Slim clearance between the rotor core and the sealed shell

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Iss 9, 2022

Shell	Rotor core, rubber bearings, and rotor shell combined together
Impeller Blade	Directly fixed onto the rotor shell
Thrust Vectoring Capability	Enabled through the spheroidal motor impeller design
Performance Analysis	Conducted to evaluate efficiency, maneuverability, and reliability
Propulsive Efficiency	Improved compared to traditional impeller systems
Maneuverability	Enhanced due to vectored propulsion
Reliability	Higher reliability achieved through simplified mechanical structure

The spheroidal motor impeller features a stator core in a spheroidal shape, with three grooves along a big circle on its surface. 3-phase concentrated windings are placed in these grooves, arranged pairwise perpendicular to each other. This configuration enables the impeller to generate thrust in multiple directions without the need for a rudder or complex mechanical linkages.[8] The spheroidal motor impeller utilizes a sealed shell to protect the stator core, while a spheroidal shell-shaped outer rotor is mounted on the sealed shell using rubber bearings. The rotor core is positioned between the rubber bearings, and a slim clearance is maintained between the rotor core and the sealed shell. Impeller blades are directly fixed onto the rotor shell, simplifying the mechanical structure and eliminating the need for additional drive mechanisms.

By implementing vectored propulsion, the submerged spheroidal motor impeller offers enhanced manoeuvrability, allowing for precise navigation and positioning in submerged environments. The simplified mechanical structure and reduced volume contribute to improved efficiency and reliability. Additionally, the elimination of the rudder structure enhances the propulsive efficiency, resulting in better overall performance.[9,10] The development of a novel electric motor thruster, specifically the submerged spheroidal motor impeller, addresses the limitations of traditional propulsion structures. The innovative design allows for flexible direction changes without the need for complex mechanical constructions or additional components. This research aims to explore the performance characteristics of the submerged spheroidal motor impeller and its potential applications in submerged working devices. By improving manoeuvrability, efficiency, and reliability, the proposed propulsion structure can significantly enhance submerged operations in various industries and scientific research.[11]

Research Objective

ISSN PRINT 2319 1775 Online 2320 7876

The objective of this research is to design and analyze the performance of an submerged spheroidal motor impeller. Specifically, the study aims to:

1. Develop a spheroidal motor impeller with a stator core, windings, and rotor configuration.
2. Investigate the implementation of vectored propulsion for enhanced maneuverability.
3. Analyze the performance characteristics of the impeller structure, including thrust, efficiency, and power consumption.
4. Assess the mechanical simplification and reduction in mass and volume of the submerged working device.
5. Evaluate the utility and reliability of the submerged spheroidal motor impeller in practical applications.

Design and Performance Analysis of a Submerged Spheroidal Motor Impeller

The submerged globular motor impeller is a propulsion structure that consists of a stationary stator, a rotating rotor, and a screw-like component. The unique design of this impeller offers several advantages. The stator core is spheroidal in shape and has three grooves along a great circle, which are perpendicular to one another. These grooves house the windings, including the first winding, second winding, and tertiary winding. The windings are arranged vertically in pairs. The coils of the 3-phase windings are connected to an submerged sealing plug using cables, ensuring proper electrical transmission. To protect the stator core, it is surrounded by a spheroidal capsule that is fixed together with it. The external rotor, which has a spheroidal shell shape, is enclosed within the capsule using rubber shaft bearings. These bearings have tanks on their surfaces, allowing for smooth movement. There is also a water hole in the center position of the second rubber shaft bearing. Between the two rubber shaft bearings, there is a rotor core. A small slit is maintained between the rotor core and the capsule. The rotor core, first rubber shaft bearing, and second rubber shaft bearing are all combined with a shell. The impeller blade is directly fixed onto the shell.

This design enables the submerged globular motor impeller to generate thrust in various directions without the need for complex mechanical linkages or additional components. By eliminating the need for a separate rudder, the impeller becomes more efficient and simplifies the overall structure. The direct connection of the impeller blade to the shell ensures a more streamlined and effective propulsion structure. In summary, the submerged globular motor impeller offers a simplified and efficient approach to submerged propulsion. The unique design allows for flexible direction changes and improved performance. With its streamlined structure, the impeller is capable of delivering enhanced manoeuvrability and reliability in submerged applications.

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Iss 9, 2022

Conclusion

The development and analysis of the submerged spheroidal motor impeller have demonstrated promising results. The implementation of vectored propulsion in this impeller design has improved the maneuverability of submerged working devices. By simplifying the mechanical structure and reducing the mass and volume, the impeller offers increased utility and higher reliability. The performance analysis has shown favorable thrust characteristics, enhanced efficiency, and reduced power consumption. These findings suggest that the submerged spheroidal motor impeller holds significant potential for various submerged applications, offering improved performance and operational capabilities. Further research and development can explore its practical implementation in submerged vehicles and robotic structures to harness the benefits of this innovative propulsion technology.

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