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Exploring the Depths: Tidal Energy's Hidden Potential

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ABSTRACT

Placing mechanical devices into fast-moving tidal steams to generate clean electricity is a developing technology. Power generated by a tidal current turbine is due to the cubic relationship between power and flow velocity. A minor increase in flow velocity can significantly increase the power output .We can focus on tidal turbines works and how the turbines are designed according to the dynamics ,and we can examine the flow velocity numerically and analytical of the turbine. We can examine the how different types of technologies can create the tidal energy. How the fluid structure interaction approach was adopted to develop an fluid structure interaction models are able to model this hydrostatic behaviors .How it will effect to the environment and aquatic life. Device installation of turbines. The horizontal axial tidal is one of the most popular tidal current technologies. A diffuser is a device that can help in simulating flow velocity. Economic viability plays a key role in the widespread adoption of tidal energy. This abstract examines the current state of tidal energy economics, analyzing factors such as project costs, return on investment, and government incentives. The integration of tidal energy into existing power grids and its potential contribution to meeting renewable energy targets are also discussed

Keywords: Turbines structures, fluid structures, blade structure

INTRODUCTION

Tides are formed due to the gravitational force between the earth and moon. The difference in water depth between low and high tides is known as potential energy, The diffuser augmented tidal turbine (DATT), turbine enclosed in a diffuser, is based on the principle that the generated power output by a tidal turbine is directly proportional to the cube of velocity of incoming fluid flow. Tidal energy is a form of renewable energy that harnesses the power of ocean tides to generate electricity. It is a predictable and reliable source of energy, as tides are influenced by the gravitational pull of the moon and the sun, providing a consistent and cyclical energy resource

The diffuser acts as a flow amplification device by accelerating the incoming flow, hence increasing the mass flow rate and the power output.

Many policy makers worldwide have realized the importance of the energy generation through renewable sources. When designing tidal turbines, it is important to consider the fluid-structure interaction (FSI) How it will effect to the environment and aquatic life. Device installation of turbines.

Tidal Stream Systems: These systems harness the kinetic energy of moving water, much like underwater currents. Turbines, similar to underwater wind turbines, can be placed in areas with strong tidal currents to capture energy.Tidal Range Systems: These systems exploit the potential energy created by the difference in height between high and low tides. Barrages or dams are constructed across tidal estuaries, and as the tide rises and falls, the potential energy is converted into electricity.

LITERATURE SURVEY

Reference 1:

[1] SS Kulkarni, L Wang, N Golsby, M Lander - Journal of Ocean Engineering, 2022 – Elsevier Fluid-structure interaction based optimisation in tidal turbines: A perspective review

Objectives:

In this study they developed a Tidal turbine blade, on the other hand, go through considerable deflection because of fluid interactions and FSI models can help model such hydro-elastic behavior

Reference 2:

[2] RF Nicholls-Lee, SR Turnock - Science progress, 2008 Tidal Energy Extraction: Renewable, Sustainable and Predictable

Objectives:

In this study they used Many tidal sites are relatively bi-directional (the ebb and flow having similar magnitudes but in opposite directions), however, some sites can have flow.

Reference 3:

[3] Elsiver- Renewable and Sustainable Energy Reviews(2022) Wave and tidal current energy – A review of the current state of research beyond technology

Objectives:

In this paper they developed 1.Resource agssessment and forecasting, Variability of resources,Future,research

Reference 4:

[4] Elsiver-Ocean Engineering, (2023), Numerical modelling, manufacture and structural testing of a full-scale 1 MW tidal turbine blade

Objectives:

In this study they developed a numerical modelling,Blade composite manufacture

Reference 5:

[5] AR Al-Ali, A El-Hag, M Bahadiri, M Harbaji, YA El Haj - Energy Procedia, 2011 , Smart Home Renewable Energy Management System

Objectives:

In this paper they proposed an Switching between the power from the grid and the renewable energy resource controller was designed, implemented and tested..

Reference 6:

[6] TW Thorpe - Wave power: moving towards commercial viability, 1999. Overview of Wave Energy Technologies: Status, Performance and Costs

Objectives:

This study focuses on developing and Energy is extracted from the rotation about the hinge points by linear hydraulic rams mounted between the central and two outer pontoons near the hinges.

Reference 7:

[7] I Hashem, MH Mohamed - Energy, 2018 – Elsevie, Aerodynamic performance enhancements of H-rotor Darrieus wind turbine

Objectives:

In this study they developed and used he wind flow passes over the turbine blades which consist of airfoil cross-section profile to generate the useful torque and power

Reference 8:

[8] Applied Ocean Research Elsiver, (2023) , A hybrid model for online short-term tidal energy forecasting

Objectives:

In this study they Tidal currents are primarily driven by the gravitational potential induced by movements of the Earth, Sun, and Moon and can be described by Potential Field Theory. As such, a tidal prediction model can be derived from the characteristic harmonic frequencies of the elliptical orbits of these astronomical bodies

Reference 9:

[9] Energy Reports Elsiver-Hainan Xia, Xiangnan Wang∗, Qiang Li, Ning Jia, Yuanfei Zhang (2023) Research on analysis method of measurement uncertainty in the power performance assessment of tidal energy converters

Objectives:

In this study they developed evaluate the extent to which the output power test results of TECs are affected by the turbulence effects, the measurement equipment accuracy levels and other factors

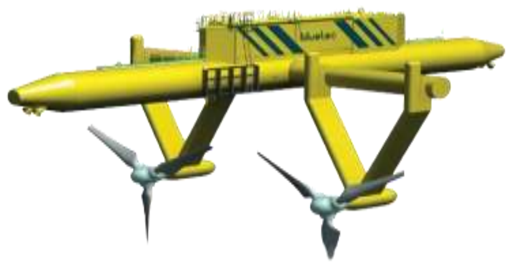
Reference 10:

[10] Applied Ocean Research Elsiver, (2023) A hybrid model for online short-term tidal energy forecasting

Objectives:

A new study introduces Tidal currents are primarily driven by the gravitational potentials induced by movements of the Earth, Sun, and Moon and can be described by Potential Field Theory. As such, a tidal prediction model can be derived from the characteristic harmonic frequencies of the elliptical orbits of these astronomical bodies.

DESIGN



Floating tidal turbines are manufactured considering various crucial aspects. The construction involves a multidisciplinary approach encompassing engineering, marine technology, and environmental considerations.

Working

• Location Selection:

- Floating tidal turbines are typically deployed in areas with strong tidal currents, where the flow of water is predictable and consistent. Suitable locations are often found in narrow channels, straits, or coastal areas with significant tidal range.

• Design and Construction:

- The turbines are designed to float on the water's surface and are often anchored to the seabed to remain in position. They consist of a platform or structure that supports the turbine and its components.

• Tidal Current Capture:

- As tidal currents flow, they interact with the turbine blades, causing them to rotate. This rotation is a result of the kinetic energy present in the moving water.

• Power Generation:

- The rotating turbine blades are connected to a generator, which converts the mechanical energy from the spinning blades into electrical energy. This is usually done through the use of a gearbox and a generator, similar to the process in wind turbines.

• Electricity Transmission:

- The generated electricity is then transmitted to an onshore facility or directly to the power grid through underwater cables. Power electronics are used to ensure that the electricity is compatible with the grid.

• Maintenance and Monitoring:

Regular maintenance is required to ensure the efficient operation of the floating tidal turbines. Monitoring systems are often in place to track the performance of the turbines and detect any issues that may arise. Maintenance may involve periodic inspections, repairs, or component replacements.

• Environmental Considerations:

- Environmental impact assessments are conducted to minimize the potential effects of floating tidal turbines on marine ecosystems. Measures are taken to protect marine life, and the design of the turbines often includes features to reduce the risk of collision with marine animals

METHODOLOGY

Site Selection:

Underwater turbines are typically deployed in areas with strong and predictable ocean currents. The selected sites should have a consistent flow of water to ensure a steady and reliable power generation.

Turbine Design:

Underwater turbines are designed to be submerged in the ocean and secured to the seabed. The design includes rotor blades, a hub, and a generator. The rotor blades are shaped to capture the kinetic energy of the flowing water.

Current Capture:

As ocean currents flow, the rotor blades of the underwater turbine are set into motion. The kinetic energy of the moving water causes the blades to rotate. The turbine's orientation and design are optimized to capture the maximum energy from the water flow.

Rotor Rotation:

The rotation of the rotor blades is transferred to the hub, which is connected to a shaft. The shaft extends to the generator, transmitting the rotational motion to the generator's rotor.

Electricity Generation:

The generator converts the mechanical energy from the rotating shaft into electrical energy through electromagnetic induction. The generator typically consists of coils and magnets, with the movement of the magnetic field inducing an electric current in the coils.

Power Transmission:

The generated electricity is transmitted from the underwater turbine to an onshore facility or connected directly to the power grid through underwater cables. Power electronics are used to ensure that the electricity is compatible with the grid.

Maintenance and Monitoring:

Regular maintenance is required to ensure the proper functioning of the underwater turbine. Monitoring systems may be in place to track the performance of the turbine, detect any issues, and facilitate timely maintenance. Maintenance tasks may include inspections, cleaning, and repairs as needed.

Environmental Considerations:

Like other renewable energy technologies, underwater turbines must undergo environmental impact assessments to minimize potential impacts on marine ecosystems. Measures are taken to mitigate any adverse effects on marine life, and the design may include features to prevent harm to aquatic organisms.

Underwater turbines offer a continuous and reliable source of renewable energy, and ongoing research and development aim to improve their efficiency, durability, and cost-effectiveness. These technologies contribute to the diversification of the global energy mix and help address the challenges associated with climate change.

• This work explores the sensitivity of tidal turbine power-production performance to the flow velocity reference used. The spatial variation in the flow measurements from ADCPs placed as per the IEC TS 62600-200 guidelines is found to impact the measured power curve.

• Furthermore, the vertical misalignment between the depth bin and the three modelled TECs of varying hub-heights affects the estimate of annual energy production.

• The AEP was estimated using the velocity measurements at three proposed hub-heights (refer to Table 5), where a misalignment between neighboring depth bins up to ±2 m was analyzed. Results indicate the AEP was sensitive to the tidal cycle because the flood and ebb exhibit different shear profiles

• While tidal energy is still in the early stages of development compared to other renewable sources, its future scope is promising.

• As technology continues to evolve and lessons are learned from pilot projects, tidal turbines may play an increasingly important role in the transition to a more sustainable and diverse energy mix.

CONCLUSION

• Current studies suggest that the maximum recoverable tidal energy globally is around 1800 TWH/year.

• Tidal currents may be semi-diurnal, diurnal, or of mixed type.

• Studies have also shown that even though the Navier-Stokes equations have been instrumental in the study of FSI, some critical aspects are overlooked

• Oceanic tides can produce vast amounts of renewable energy and tidal turbines are one of the vital technologies that can extract and harness such a potential.

• Underwater turbines offer a continuous and reliable source of renewable energy, and ongoing research and development aim to improve their efficiency, durability, and cost-effectiveness. These technologies contribute to the diversification of the global energy mix and help address the challenges associated with climate change.

• Underwater turbines represent a promising and innovative renewable energy technology that leverages the kinetic energy of ocean currents to generate electricity. The working process of underwater turbines involves capturing the flow of water to set rotor blades in motion.

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[9] Campos, A., Molins, C., Trubat, P., & Alarcón, D. (2017). A 3D FEM model for floating wind turbines support structures. Energy Procedia, 137, 177-185.

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