International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Power Generation of Tidal Energy in Tidal Power Plant

[*1]P. Srinu,[2]Ch. Uma, [3]B. Latheesh Kumar, [4]G. Dhanujay, [5]N. Govinda Rao

Department of Mechanical Engg, GMR Institute of Technology, Rajam. AP-532127
*Email Id: srinupathivada2002@gmail.com

ABSTRACT:

This study investigates the operational performance of a tidal turbine deployed during the ReDAPT project at the European Marine Energy Centre in Orkney, Scotland. The assessment is conducted in accordance with the International Electrotechnical Commission's Technical Specification , offering guidelines for tidal turbine evaluation. The focus is on comparing two recommended orientations for deploying current profilers relative to the turbine: 'in-line' (preferred) and 'adjacent' (least preferred). Two measurement campaigns reveal the impact of instrument placement on power curve and annual energy production (AEP) estimates, with a preference for the 'in-line' orientation due to smaller AEP variation .This review explores the immense renewable energy potential within Earth's oceans, focusing on the early-stage development of technologies to harness this power. Despite notable strides, particularly in tidal current and ocean wave technologies, substantial barriers persist. The emphasis of this article goes beyond technological advancements, delving into the critical role of research, development, and innovation in overcoming these challenges. Providing an insightful overview of the current state of ocean energy research, the authors pinpoint areas where research gaps exist. The review also strategically directs attention to future research needs, guiding efforts to address obstacles and propel the field of ocean energy towards sustainable advancements.

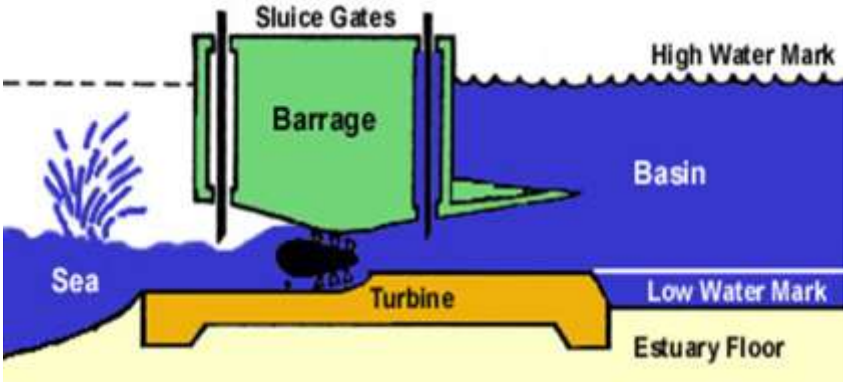
KEYWORDS: Oceans, Renewable energy, Tidal current, Ocean wave, Barriers, Obstacles. Advancements Ocean energy, Ocean wave Tidal current Research activities R&D

INTRODUCTION

The Earth's vast oceans present an unparalleled source of renewable energy, encompassing six distinct types categorized by their origin and characteristics: ocean wave, tidal range, tidal current, ocean current, ocean thermal energy, and salinity gradient. While these diverse forms of ocean energy hold immense potential, the current state of development varies across the spectrum. Notably, ocean wave and tidal current energy stand out as the most advanced among the six types, poised to significantly contribute to the global energy supply in the future.

Despite notable progress in the ocean energy industry, a considerable portion remains in the early developmental stages, with advanced prototypes currently undergoing testing. The challenges encompass not only technological aspects but also extend to deployment, risk reduction, and addressing existing knowledge gaps. The European Union, recognizing the importance of technological development, allocates 68% of its funds to this area, highlighting the industry's emphasis on enhancing reliability, reducing costs, and advancing overall robustness .

This comprehensive review aims to provide an insightful overview of the current research landscape in the realm of wave and tidal current energy. While acknowledging the importance of technological advancements, the authors direct their focus beyond the technical domain. Rather, the review aims to identify and explore research gaps that transcend technology, delving into areas where further efforts are needed for substantial progress. Drawing on extensive literature reviews and desk-based research, this paper follows a structured approach covering key aspects such as resource assessment, environmental impacts, socio-economic considerations, grid integration, array configuration, installation, operation and maintenance, and regulatory affairs. By shedding light on these aspects, the paper seeks to contribute to a holistic understanding of the current state of research and the future directions crucial for unlocking the full potential of wave and tidal current energy.



Ocean energy resources are characterized and mapped for market deployment. This involves identifying high wave energy areas, quantifying average energy resources, and describing resources using parameters like wave height, period, and direction. High-resolution estimates are needed for planning and optimizing ocean energy converter designs. Current technology development will determine resource utilization, with efficiency and capacity factors being key technical parameters. Reducing uncertainties increases investor confidence and reduces risks.

Ocean wave energy resources have been assessed globally, using buoy data and deep water numerical models to assess offshore wave resources. Recent tools incorporate radar measurements and allow modeling wave generation and propagation in coastal regions. Assessments have been conducted on global, regional, and local levels, including California, Argentina, Australia, Portugal, Sweden, Korea, Spain, Iran, and the Atlantic coast of the United States. Wave forecasting is performed using statistical techniques or physics-based models, with systems like the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Oceanic and Atmospheric Administration (NOAA) using WAVEWATCH-III. Statistical approaches include neural networks, regression-based techniques, and genetic programming. Tidal current energy resources have also been assessed, using 2D and 3D modeling techniques to assess current velocities. Forecasts are usually readily available, with NOAA Current Predictions offering up to 48 hours, one week, and annual predictions. However, it is not possible to convert all tidal current energy power due to Betz' law and mechanical losses in turbines.

This paper presents a 2 MW O2 turbine developed by Orbital Marine Power, deployed in the Fall of Warness at the European Marine Energy Centre in 2021. The turbine, which has a rotor diameter of 20m, is connected to the local electricity grid and will power Orkney communities sustainably. The blade's main structural elements were manufactured and tested, with a final mass of 4,485 kg.

The model simplifies the design by assuming strong connections between the blade and upper half, ignoring bonding details. The steel support frame is assumed to hold the blade efficiently, and displacements on the blade root section are constrained. Mesh nodes are selected to simulate load introduction, and point loads are distributed through multipoint constraint elements. The FE model contains 11615 nodes, 3898 SHELL281 elements, and 564 MPC184 elements. Static analyses validate the model's accuracy, comparing predicted strain and deflection values with recorded data.

This study uses glass fibre reinforced powder epoxy composite material for the tidal turbine blade, based on EireComposites' Composites Powder Epoxy Technology (CPET). CPET offers advantages over traditional materials, such as small through-thickness wet out requirements, good fibre volume fraction control, low exothermic during cure, and long shelf life. The blade's main structural elements are spar caps and web, with the blade trailing edge fairings and blade tip constructed separately. The blade's root connects to the turbine pitch bearing via 48 steel root inserts made from S355 grade steel. The blade's design considers water ingress and maintains the blade's optimal hydrodynamic shape.

The one-shot manufacturing process for CPET (Crystal Fibre Etch) offers a more efficient and cost-effective solution for manufacturing large tidal blades. This process is characterized by its ability to form components off-line on low-cost, low-temperature tooling, allowing for the creation of complex internal structures without secondary bonding procedures. It also allows for joints with complex ply drop-offs and overlaps that would be difficult or impossible with traditional bonding techniques. CPET forms a bond to metal during cure, allowing metal inserts to be embedded in the layup. The process is in line with tight European manufacturing regulations and is supplied in a semi-pre-impregnated form, with the glass uniformly coated in powder epoxy. However, there are some drawbacks, such as slow installation methods for metal inserts and the need for extra b-stage cures. The one-shot CPET process is only suitable for blades short enough to fit in a large industrial oven, which may be a limitation for some composite manufacturers.

METHODOLOGY :

MPPT APPLICATION TECHNOLOGY BASED ON Q-LEARNING ALGORITHM

The Q-learning model-free RL algorithm for reinforcement learning with excellent search performance. Reinforcement learning does not require an object model or prior knowledge. The most significant benefit of reinforcement learning in optimal control is that it can ignore problems such as system disturbances, time variation and non-linearity when solving large complex systems and seek the best behavioral strategy through learning. After investigation, the Q-Learning algorithm can improve the problem of maximum power point (MPP) instability caused by machine aging. The following will examine how Q-learning can be applied to MPP.

CONCLUTION

This paper presents the development of a full-scale fibre-reinforced composite blade for 1 MW power generating nacelles of a tidal turbine. The digital twin used in the design was validated using structural testing results. Advanced manufacturing technologies were developed to produce thick section composites, a novel high-friction root connection, and cured bonds. The blade underwent an advanced structural testing program, proving its structural integrity and the highest mechanical load ever reported on a tidal turbine blade. The results highlight best practices for tidal blade manufacture, such as using a combined flapwise-edgewise loading, a multi-actuator load introduction system, and holding the load for 30 seconds at each load case. These technologies will benefit the tidal turbine developer and blade manufacturer, as well as the tidal energy sector.

REFERENCES

- G. Agrawal, D. Mohan, H. Rahman, Ambient Air Pollution in Selected Small Cities in India: Observed Trends and Future Challenges, IATSS Research, 2021.
- Y. Kazancoglu, M. Ozbiltekin-Pala, Y.D. Ozkan-Ozen, Prediction and evaluation of greenhouse gas emissions for sustainable road transport within Europe, Sustainable Cities and Society 70 (2021) 102924.
- A.J. Njoh, Renewable energy as a determinant of inter-country differentials in CO2 emissions in Africa, Renewable Energy 172 (2021) 1225e1232. M. Zhai, G. Huang, L. Liu, B. Zheng, Y. Li, Economic modeling of national energy, water and air pollution nexus in China under changing climate conditions, Renewable Energy 170 (2021) 375e386. [5] G. Lonati, S. Cernuschi, S. Sidi, Air quality impact assessment of at-berth ship emissions: case-study for the project of a new freight port, Sci Total Environ 409 (2010) 192e200. D. Bailey, G. Solomon, Pollution prevention at ports: clearing the air, Environ Impact Assess Rev 24 (2004) 749e774. E. Bachvarova, T. Spasova, J. Marinski, Air pollution and specific meteorological conditions at the adjacent areas of sea ports, IFAC-PapersOnLine 51 (2018) 378e383.
- A.M. Kotrikla, T. Lilas, N. Nikitakos, Abatement of air pollution at an aegean island port utilizing shore side electricity and renewable energy, Mar Policy 75 (2017) 238e248. T. Cabral, D. Clemente, P. Rosa-Santos, F. Taveira-Pinto, T. Morais, F. Belga, et al., Performance assessment of a hybrid wave energy converter integrated into a harbor breakwater, Energies 13 (2020). I. Lopez, R. Carballo, D.M. Fouz, G. Iglesias, Design selection and geometry in OWC wave energy converters for performance, Energies 14 (2021).
- F. Taveira-Pinto, P. Rosa-Santos, T. Fazeres-Ferradosa, Marine renewable energy, Renewable Energy 150 (2020) 1160e1164.
- P. Rosa-Santos, F. Taveira-Pinto, C.A. Rodríguez, V. Ramos, M. Lopez, The CECO wave energy converter: recent developments, Renewable Energy 139 (2019) 368e384.
- E. Dallavalle, M. Cipolletta, V.C. Moreno, V. Cozzani, B. Zanuttigh, Towards Green Transition of Touristic Islands through Hybrid Renewable Energy Systems. A Case Study in Tenerife, Canary Islands, Renewable Energy, 2021.

- M. Lopez, N. Rodríguez, G. Iglesias, Combined floating offshore wind and solar PV, Journal of Marine Science and Engineering 8 (2020).
- Qing Lu, Hongda Shi. Progress and future trend of ware energy technology in China. Coast Eng 2022;41(01):1–12.
- Kai LY, et al. Current status and possible future applications of marine current energy devices in Malaysia: A review. IEEE Access 2021;9:86869–88.
- Wei Chun, Zhang Zhe, Qiao Wei. Reinforcement-learning-based intelligent maximum power point tracking control for wind energy conversion systems. IEEE Trans Ind Electron 2015;62(10).
- Hongwei Liu. Development status and tendency towards the power generation technology of tidal current energy. Zhejiang University Energy; 2009.
- Bu¸soniu L, Babuska R, Schutter BD. A comprehensive survey of multi-agent reinforcement learning. IEEE Trans Syst Man Cybern C 2008;38(2):156–72.
- Watkins CJCH, Dayan P. Q-learning. Mach Learn 1992;8:279–92.
- Even-Dar E, Mansour Y. Learning rates for Q-learning. J Mach Learn Res 2004;5:1–25.
- Zou Y, Elbuluk M, Sozer Y. Stability analysis on maximum power points tracking (MPPT) method in wind power system. IEEE Trans Ind Appl 2013;49(3):1129–36.
- Jun Yao, yong Liao, Xinghong Qu, et al. Optimal wind energy tracking control of direct-driven permanent magnet synchronous generators for wind turbines. Power Syst Technol 1996.