Université de Bretagne Occidentale

Call of interest for welcoming MSCA post-doc

Job Title	Post-Doctoral Position: **On the detection and estimation of biofouling in tidal stream turbines**
Main Research Field	Information Science and Engineering (ENG)
Sub Research Field	Electrical engineering, signal processing
Key words	Tidal turbine, electric generator, signal processing, biofouling, detection, estimation
Job Summary	In a context of marine renewable energies harvesting, two potential performance issues for tidal turbines are the roughening of the turbine blades due to impact, cavitation or scour due to particulates, and the fouling of the turbine blades by marine growth. In this critical context, the proposed project objective is the detection and the estimation of a tidal turbine biofouling. This issue is expected to be addressed using electrical terminals (mainly the current) of the tidal turbine generator. Indeed, biofouling main effects on a tidal turbine system should include: reduced power generation, reduced turbine durability, physical deformations in turbine blades, serious eccentricity of the turbine shaft, and bearing damages. These effects will obviously impact the turbine electric generator current. To achieve the project main objective, a modeling step is expected and should lead to a first-order modeling of the biofouling. This first-order model will therefore be used for the design of specific advanced signal processing techniques of the generator current for the detection of the biofouling. It is also expected to estimate the detected biofouling using either a failure (i.e. biofouling) severity index or designing a specific observer to estimate the inertia, which is impacted by the biofouling.
Job Description	In recent years, a number of studies have been performed to assess the damages caused by biofouling, which is simply the attachment of organisms to a surface in contact with water for a period of time. In a context of marine renewable energies harvesting, biofouling can easily cause obstructions in marine renewable energy converters (tidal turbines) and/or increase the weight and drag, thus significantly affecting the device performance. Biofouling is therefore a major engineering concern, influencing the loading of offshore structures by increasing structural elements size, increasing drag and inertia coefficients, as well as increasing the structural weight. Two potential performance issues for marine current turbines are the roughening of the turbine blades due to impact, cavitation or scour due to particulates, and the fouling of the turbine blades by marine growth. In this context, there is a clear need for high reliability given the difficult maintenance access issues in an underwater environment. There have been few studies

	investigating roughness effects or fouling on tidal turbines. The effect of blade fouling was investigated and it was found that a significant decrease in power could arise at higher tip speed ratio. Care will therefore be required in this aspect of turbine maintenance, depending on factors such as areas of operation and sea temperature. Furthermore, biofouling may damage protective coating and interfere with sensitive areas necessary for monitoring and maintenance. One major economic consideration for renewables industry is the maintenance and survivability of devices. This may be of particular relevance to the marine renewable energy industry as maintenance of devices in highly energetic environment will be a costly and difficult task [1-2]. In this critical context, the proposed project main objective is the detection of tidal turbine biofouling than its estimation. The biofouling issue is expected to be addressed using electrical terminals (mainly the current) of the tidal turbine generator (doubly-fed induction or permanent magnet synchronous generators). Indeed, in addition to the increase to the above-cited impacts and the increase in the structural weight, the main effects of biofouling on a tidal turbine system should include: reduced power generation, reduced turbine durability, physical deformations in turbine blades, serious eccentricity of the turbine shaft, and bearing damages. These effects will obviously impact the turbine electric generator current [3-5]. It is therefore of paramount importance to achieve an early detection and estimation of biofouling so as to plan early stage removal before accumulation. To achieve the project main objective, a modeling step is expected. Indeed, based on the available biofouling literature [2], a first-order modeling of the biofouling should be achieved. This first-order model will therefore be used for the design of specific advanced signal processing techniques of the generator current for the detection of the biofouling. Afterwards, it is also expected to estimate the detected biofouling using either a failure (i.e. biofouling) severity index or designing a specific observer of the generator rotor angular acceleration to estimate the inertia, which is impacted buy the biofouling. The developed detection techniques and estimation observers are expected to be evaluated on a Matlab-based tidal turbine emulator developed by our team. The project will be carried out at the Institut de Recherche Dupuy de Lôme (FRE CNRS 3744 IRDL) of the University of Brest. [1] M.E.H. Benbouzid, H. Titah-Benbouzid and Z. Zhou, Ocean Energy Technologies, Chap. 10097, *Elsevier Encyclopedia of Sustainable Technologies*, p. 2-13, ISBN 978-3-319-08421-1, 2017.

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Supervisor(s)	**Mohamed Benbouzid** received the Ph.D. degrees in electrical and computer engineering from the National Polytechnic Institute of Grenoble, Grenoble, France, in 1994, respectively, and the Habilitation à Diriger des Recherches degree from the University of Picardie "Jules Verne," Amiens, France, in 2000. Since September 2004, he has been with the University of Brest, Brest, France, where he is a Full Professor of electrical engineering. Prof. Benbouzid is also a Distinguished Professor at the Shanghai Maritime University, Shanghai, China. His main research interests and experience include analysis, design, and control of electric machines, variable-speed drives for traction, propulsion, and renewable energy applications, and fault diagnosis of electric machines. Prof. Benbouzid is an IEEE Senior Member. He is the Editor-in-Chief of the *International Journal on Energy Conversion*. He is also an Associate Editor of the *IEEE Transactions on Energy Conversion*, the *IEEE Transactions on Industrial Electronics*, the *IEEE Transactions on Sustainable Energy*, and the *IEEE Transactions on Vehicular Technology*. Since January 2018, he is a Subject Editor (Wave Tidal Energy) for the IET Renewable Power Generation. [1] M.E.H. Benbouzid, J.A. Astolfi, S. Bacha, J.F. Charpentier, M. Machmoum, T. Maître et D. Roye, *Concepts, Modeling and Control of Tidal Turbines*, *Marine Renewable Energy Handbook*, Chap. 8, p. 219-278, ISBN: 978-1-84821-332-6, Wiley, ISTE, Paris 2011. [2] Y. Amirat, M.E.H. Benbouzid, T. Wang, K. Bacha and G. Feld, "EEMD-based notch filter for induction machine bearing faults detection," *Applied Acoustics*, vol. 133, pp. 202–209, April 2018.

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Department/Research	The IRDL_Lab (http://irdl.fr/) is a multidisplinary research laboratory in the field of mechanical and electrical engineering. Specifically, the project will be conducted within the PTR4 (Energetic Systems and Thermal Processes) department of the IRDL_Lab. This department has 25 full-time researchers (full and associate professors) and 12 PhD students. Specifically, the department researchers on fault detection and diagnosis are internationally recognized. After simulation validation, experiments on a real tidal turbine could be carried out in collaboration with the Shanghai Maritime University. The PTR4 department is involved in a project funded by the ANR (National Research Agency) on smart grids. The IRDL_lab is involved in several ANR projects mainly on mechanical engineering.
Suggestion for interdisciplinary / intersectoral secondments	For biofouling modeling, a secondment could be scheduled in the Laboratory of Marine Biotechnology and Chemistry LBCM_lab (http://www-lbcm.univ-ubs.fr/). Indeed, this laboratory has expertise on the biofouling issue (characterization and protection solutions).
Skills Requirements (optional):	The potential candidate is expected to come from the electrical and computer engineering community. A background in system failure detection and diagnosis could be plus (but is not mandatory). It is expected that the candidate should have a proven publication activity (at 1 journal paper per year since the PhD defence).