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Modeling and Analysis of Composite Ocean Current Turbine Blades under Fatigue Loading

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In this era of green clean energy, the energy from the ocean can be a vital source of sustainable energy. The success of harnessing energy from the ocean current greatly depends on a safe and reliable structural design of turbine blades that are used to generate the power. The purpose of the current research is to design and analyze such an Ocean Current Turbine (OCT) blade under varying and repetitive ocean current loads as encountered during its lifetime operation. Repetitive loads (Fatigue) on the ocean current turbine will originate from the randomness of ocean current due to turbulence. From statistical data it has been observed that the Gulf Stream current varies with a mean of 1.7m/s and standard deviation 0.3 m/s at 50m depth. Due to such randomness of the current, pressure loading on turbine blades will also vary. The pressure on the blade will vary with a mean of about 40000 Pa and a standard deviation of 9000 Pa and accordingly the mean of the lift force will be 1.5xl04 N. This varying pressure and forces will be the sources of fatigue loading which will create damage and cause failure of the blades. In addition, rotational fatigue will also have an impact on the life of the blade. The variation of pressure and lift forces on the turbine blades is a stochastic process. A Rainflow matrix has been developed to count the number of cycles within a specific mean and amplitude that will act on the blade. To do so, data for 10 minutes variation has been sampled with a sampling time of Is. The loading and its frequency were weighted from the Rainflow matrix and was considered as input for structural modeling. Finite element code ANSYS was used for structural modeling. A static analysis was also performed prior to fatigue modeling in order to find out the location of critical stresses in the blade where fatigue failure would begin. For fatigue modeling, an S-N diagram was approximated and Miner's rule was employed. Static analysis revealed that the largest stress will be flap wise bending stress concentrated near the root of the blade. A preliminary run of the fatigue model based on a frequency of 0.5 Hz and a loading of 40 ±9 KPa predicts a life of about 20 years for a composite blade. The finite element tool and the methodology discussed above can be successfully used to assess stress distributions and predict fatigue life of an OCT blade.