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Abstract:

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Quasi Unsteady Blade Element Momentum Theory for Tidal Stream Turbines

As tidal stream turbines (TSTs) enter the stage of full scale prototype testing, the understanding of the loads from surface waves and currents of these devices is critical to ensure high durability and confidence in designs. Presented is a preliminary method of determining the hydrodynamic loads on TST blades operating in waves and shear current-profile using blade element momentum theory (BEMT). The goal of the project is to use time-series load data obtained from BEMT and conduct a fatigue analysis using FEM software. Shown in this abstract is a case study of a TST operating in a rough sea state.

Due to the inherent difficulties in conducting combined wave and shear current tests on TSTs, few methodologies are available for the prediction of dynamic unsteady loads. A common practice in marine engineering is to linearly superimpose the water particle velocities caused by the waves and currents in order to calculate structural loads. This is however thought to be inappropriate due to the rotational flow of a non- linear current profile used in combination with wave models based on potential theory.

The methodology chosen by the author to determine the cyclic and peak loads on TSTs in the combined wave current environment, is to use a BEMT scheme in combination with a 3rd order Stokes' wave theory coupled with a linear shear current.

Since the BEMT method was originally developed for steady state operation, several modifications have been made to it in order to accommodate for the dynamic inflow caused by the surface waves and tidal velocity profiles. A case study of the hydrodynamic loads on a 10m diameter TST operating in in moderate gale sea state is presented below to show the applicability of the method and the scale of the loads to be expected. The parameters for the case are: wave height H = 4m, wave period T = 7s, bottom current Ub = 1m/s, surface current Us = 2m/s, TSR = 5.