Torque Ripple and Power Optimisation of Variable Pitch Vertical Axis Tidal Turbines

J D Winchester, S D Quayle

Work stream 2:Optimisation of Collector Form and Response

Introduction

Vertical axis turbines are a method of extracting the energy from tidal streams which have the advantage of being multidirectional and well suited to low velocity flows and shallow waters. The most common type of vertical axis turbine is the Darrieus [1] turbine, which has blades running parallel to a central shaft.

A significant problem with Darrieus turbines is that the ever changing forces on the blades create a torque ripple in the shaft (see Figure 1), which reduces the fatigue life of the drive train and generator. Therefore in order to optimise a Darrieus-type turbine it is desirable to maximise power output whilst minimising torque ripple, one way of doing this is by varying the pitch of the blades. This study has used the double-multiple streamtube (DMS) method [2], with code written in Matlab. A requisite input for the DMS is blade lift and drag data, which was generated using Xfoil [3] and PROFILE [4], which are potential flow solvers (Xfoil results are presented here). The variable pitch method presented here restricts the blade angle of attack to less than 13°.

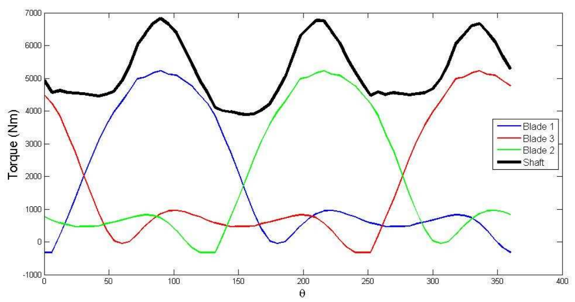

Figure 1. Torque ripple

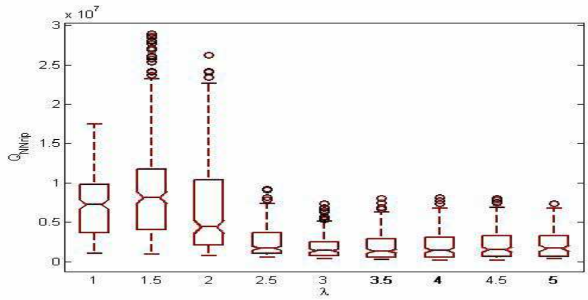

Figure 3. Torque ripple values for batch run of fixed pitch turbines

Results

With respect to power, the use of variable pitch enables turbine performance to be maintained at considerably higher solidity (Nc/r) than in the fixed pitch case, and also allows for higher power capture.

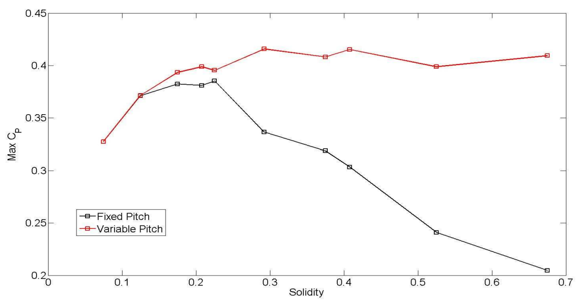

Figure 2. Maximum power coefficient values for batch run of fixed and variable pitch turbines

The key to torque ripple minimisation is the tip speed ratio (rω/U). In the fixed pitch case there is a cut off tip speed ratio (2 if Xfoil provides the blade data) above which the median value of torque ripple ($Q_{max} – Q_{min}$) does not change significantly. There is considerably more torque ripple for tip speed ratios beneath this cut off point.

If variable pitch is used then the torque ripple is greatly reduced in the problematic region of tip speed ratio less than the cut off value, but not greatly effected for tip speed ratio above this value.

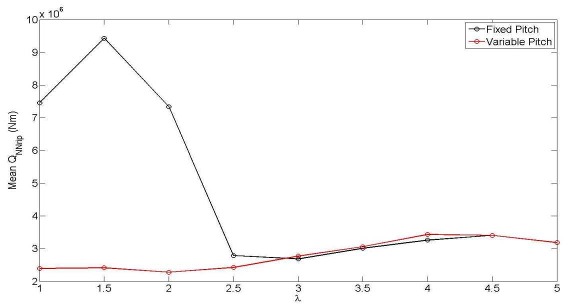

Figure 4. Mean torque ripple values for batch run of variable pitch turbines

References

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4.R Eppler, D Somers. *A computer program for the design and analysis of low speed airfoils.* NASA technical report No. TM80210. 1980

Lancaster University Renewable Energy Group
Engineering Department
Lancaster University
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