Assessing the effect of intentional and unintentional blade add-ons on tidal turbine performance

Nicholas Kaufmann
Introduction

• Small changes to the blade surface of tidal turbines can have large impact on the system’s performance because of the sensitivity to boundary layer effects
• Fouling poses a performance risk for tidal turbines
• Vortex generators offer an opportunity to improve the performance of tidal turbines

- Compare the power and thrust performance of “clean” and “fouled” turbine rotors in field tests
- Estimate the increase in drag and reduction of lift on the respective hydrofoils
- Predict the impact vortex generators (VGs) have on the performance of a specific instream turbine

[1] https://doi.org/10.1002/we.2191
PLAT-I & SCHOTTEL Instream Turbine

- Floating three-hull tidal energy platform
- Hosting 4 x SCHOTTEL Instream Turbines (6.3m rotor diameter)
- Each drivetrain rated at 70 kW (platform: 280 kW)
Performance Instrumentation Setup

- Valeport Current velocity:
  Valeport Electromagnetic Current Meter
  (single measurement point)
  → no ADCP as per IEC
- For each turbine individually:
  - Thrust (via load pins)
  - Power, torque, rot. speed
- Raw data sampled with 1 Hz
- Data post-processing according to IEC 62600-200
Foil Conditions

Fouling achieved by keeping rotor deployed in parked condition for 4 weeks at Grand Passage.

- An underlying biofilm was found on the “fouled” blades
- Two dominant macro-fouling species of algae had been identified with a length of up to 10 cm
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- Investigated foil conditions:
  - Clean
  - Fouled
  - Cleaned Pressure Side (PS)
- Fouling was successfully removed
Estimate Impact of Fouling using BEM

Lift polar ($c_l$)

Drag polar ($c_d$)

Control strategy

Blade Element Momentum model: Performance prediction

Foil geometry

Non-dimensional characteristics ($C_P$, $C_T$)

Dimensional characteristics (power, thrust)

Percent adjustments applied to original polar data set to match field data of “fouled” and “cleaned PS” configuration

"Fouled" Condition:
- $C_d$ increase by 700%
- $C_l$ reduction of 40%
Effect of Fouling on Turbine Performance

- BEM shows good agreement with "clean“ foils
- Fouling results in power reduction of 43%
- Fouling results in thrust reduction of 25%

→ Resulting “fouled” polar data was used as the reference for the wind tunnel tests
Predicting the Impact of Vortex Generators

- Polar data resulting from 2D CFD study were used to predict the turbine
- Resulting power and thrust characteristics were compared to the as-built reference
- Maximum performance increase at high angles of attack
- ~0.5% increased power output at the optimal operating point
- VGs have a similar effect on power and thrust characteristics
Conclusion

• Fouling has significant impact on the turbine performance → accessibility of the turbines is very important, ideally avoided

• Fouling is a very complex phenomena with high number of variable parameters → further research is required to increase understanding

• VGs had positive but minor impact on performance on the specific blade investigated
• To maximize their potential, VGs should be considered during the blade design process
Thank you

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