AIMS & OBJECTIVES

Experiments using porous disc arrays to simulate short fences of tidal turbines in a confined tidal channel

- Investigating analytical partial fence theory in real flow
- Comparing experimentally observed thrust on array to predicted thrust at different intra-device spacings
- Investigating fluid behaviour downstream of the array, and its correlation to the performance of the array

THEORY

Analytical ‘partial fence’ theory [1] is a simple model, based on Linear Momentum Actuator Disc (LMADT) assumptions for a very long array, which could be used as an initial tool to design the spacing of a tidal turbine array, allowing developers to investigate the best array spacings for their turbines.

Theory predicts increasing thrust and power coefficients with increased local blockage (area ratio between device and local flow channel) for long arrays, until the array becomes ‘over-blocked’ and power reduces even as thrust continues to increase. Previous computational work [2,3] has partially verified this model.

EXPERIMENTAL SET UP

- Short fence array of 5 porous discs, d = 27cm, in 5m wide flume at University of Manchester
- Two porosities of disc
- Local and array blockage varied by changing spacing between discs
- Strain gauged support towers
- Wake profiles measured at 0.5d, 1d, 2d and 5d downstream
- Global thrust coefficient, $C_{TG}$, calculated from total thrust and average flow speed

RESULTS

- Trend of increasing thrust with decreased array spacing, as predicted by theory
- Magnitudes lower in experiment than in theory
- Device wake mixing length different between arrays: faster mixing observed for high thrust / close spacing
- Array wake velocity deficit persists beyond device wakes
- Plotting TKE for closely spaced array shows similar scale separation for device and array wakes

CONCLUSIONS

Trends of global thrust behaviour with varying array spacing correspond to those predicted by the ‘partial fence’ model based on LMADT theory, which infers increased available power at higher local blockages.

Scale separation as assumed in the model is observed, particularly in the high blockage/high thrust configurations.

These effects have been seen with a relatively short ‘fence’ array and as such could be important even in early array design for deployment in real tidal channels.

REFERENCES