MASTER IN RENEWABLE ENERGY IN THE MARINE ENVIRONMENT

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Numerical Design of Tidal Turbine Blade

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Abstract

Tidal energy is a renewable energy source with a great potential. It is a form of hydropower. It is mainly caused by the gravitational forces acting upon the Earth from the sun and the moon. These gravitational forces cause the huge mass of water in the Earth to be moved back and forth accordingly generating tides. Tidal energy is one of the energies being developed technologically, to help in the transition to renewable energy sources and abandoning fossil fuel. All these efforts are done to face the crisis of climate change and global warming. A tidal turbine transforms the kinetic energy of the tides into electrical energy by means of a rotor, in the same manner as wind turbine takes the wind to convert it into the electrical energy. The similarity of energy concept between tidal and wind turbine indicates that some of the engineering methods can be common to both technologies to design their blades. Blade Element Momentum (BEM) theory is mainly used for the design of wind turbine blades but recently energy experts have experimentally justified that this method provides the data same to that obtained from the experiments on tidal turbine blades. Momentum theory, as applied in wind turbines reflects that turbine blades can be divided into thin and parallel segments which sometimes are called elements of the blade and they are independent of each other. In other context, with the application of BEM model the performance of each element is evaluated by considering them as hydrofoils. A model was designed using MATLAB software to design a tidal turbine, evaluate its performance under the desired environmental and operating conditions and provide an understanding of the physics of tidal turbines and how their parameters could be selected to produce as high energy as possible under the available conditions.

Blade Element Momentum Theory (BEM)

Blade element momentum theory is a theory that combines both blade element theory and momentum theory. It is used to calculate the local forces on a propeller or wind-turbine blade. Blade element theory is combined with momentum theory to alleviate some of the difficulties in calculating the induced velocities at the rotor.

Environmental conditions and design parameters

- Water depth = 50 m.
- Boundary layer thickness = 15 m.
- Roughness height = 0.0039 m.
- Tidal range = 6 m.
- Mean tidal speed = 3 m/s.
- Diameter = 25m.
- Blade number = 3.
- Design tip speed ratio = 6.
- Hub submerged depth = 25 m.
- Tip clearance = 9.5 m.
- Foil section: NACA 4418.
- The shear profile is given by:

$$u_t(z) = \frac{u_* \ln\left(\frac{z}{z_{ob}}\right)}{\ln\left(\frac{\delta}{2z_{ob}}\right) - \frac{\delta}{2h}} \quad \text{for } z_{ob} \le z \le 0.5\delta$$

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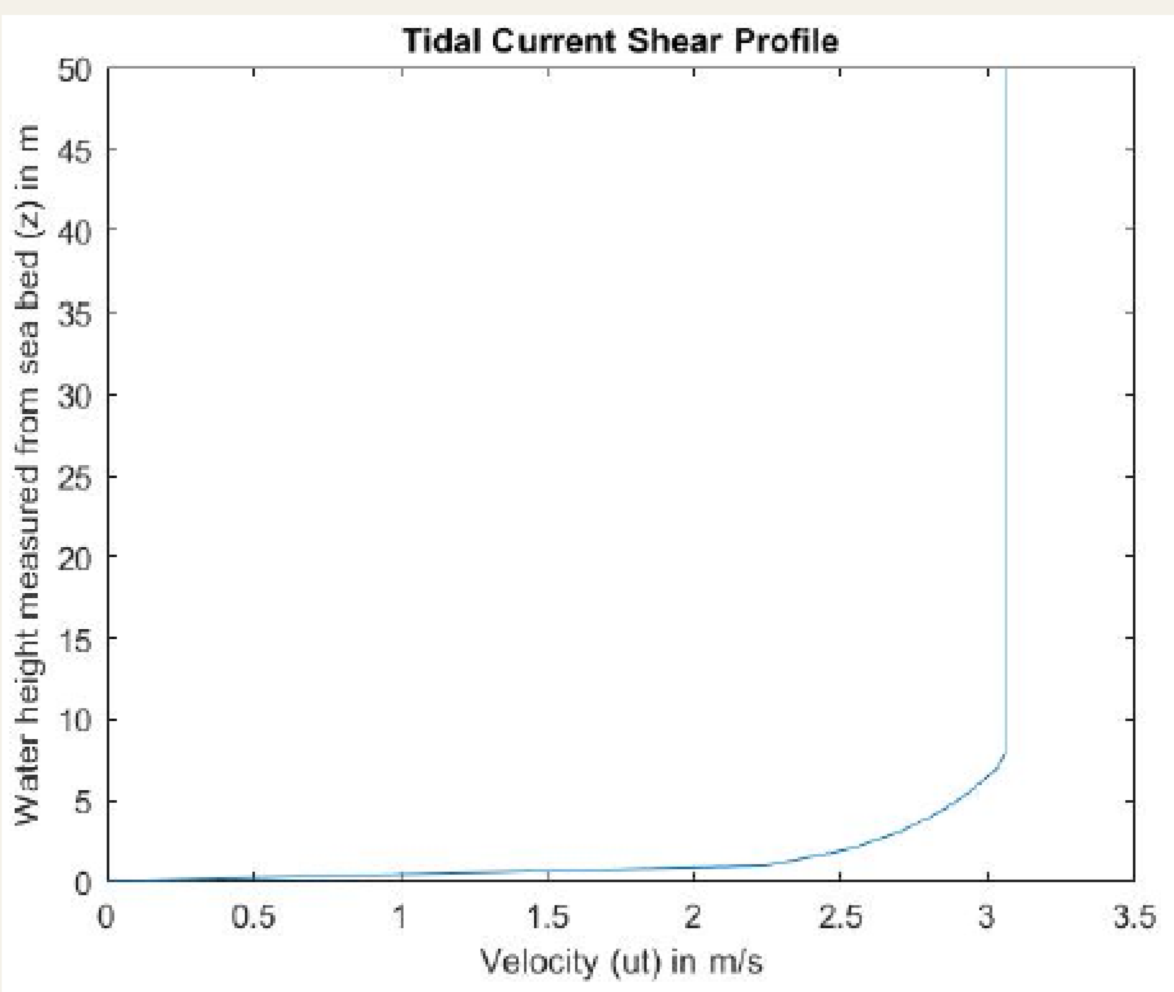
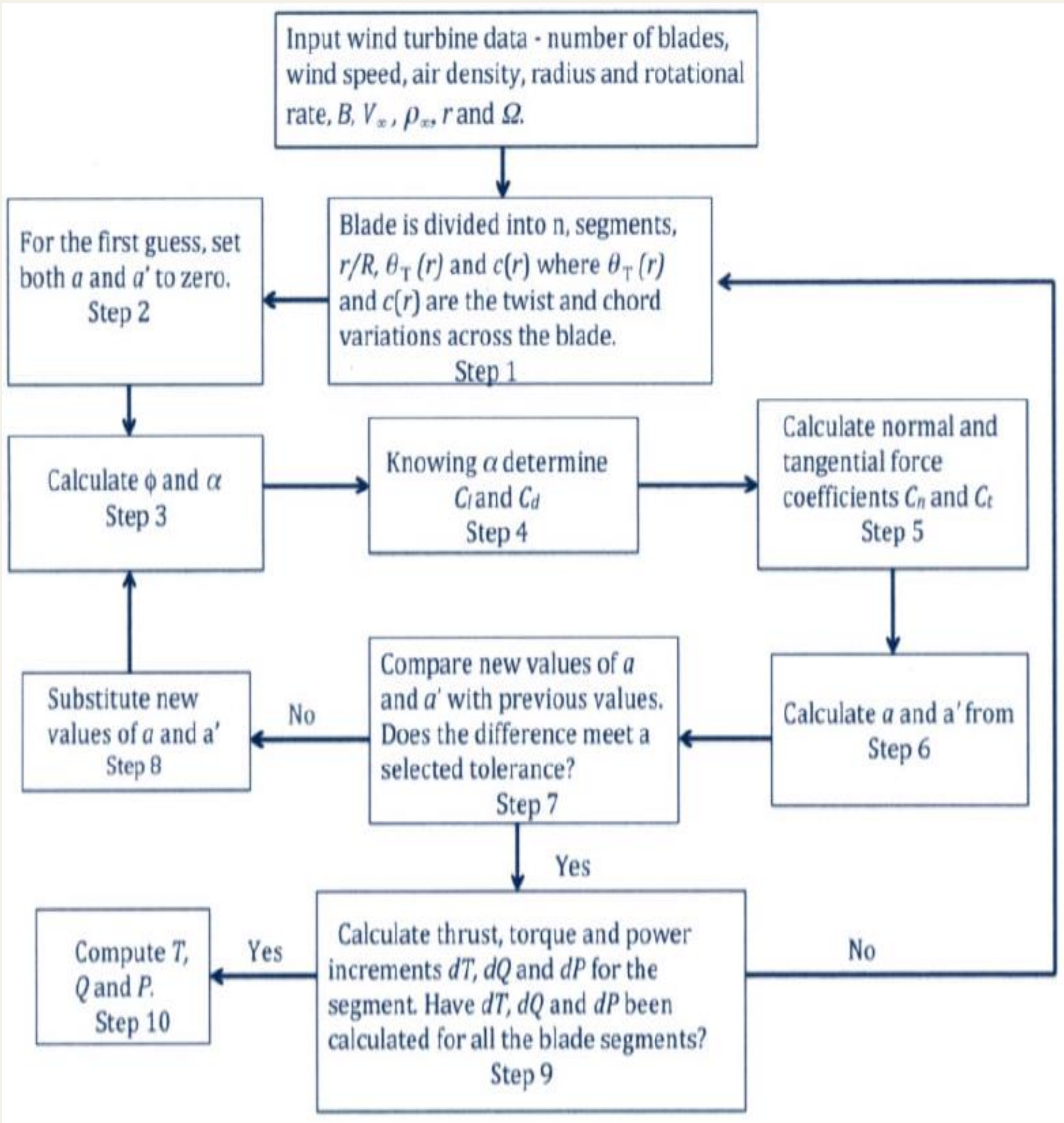
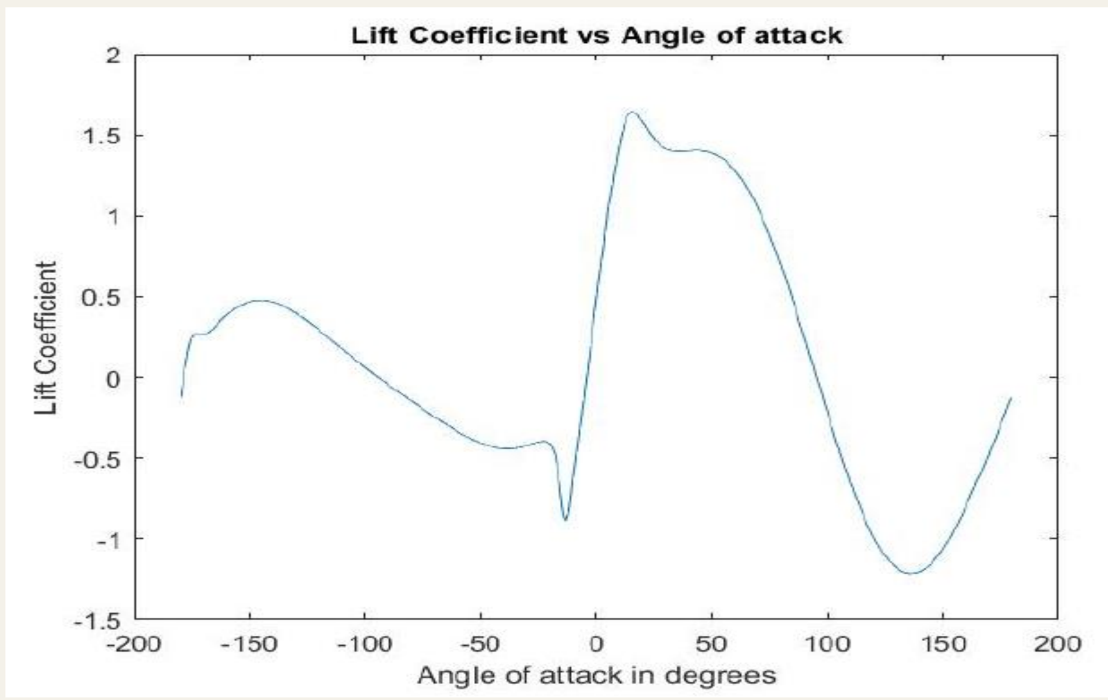
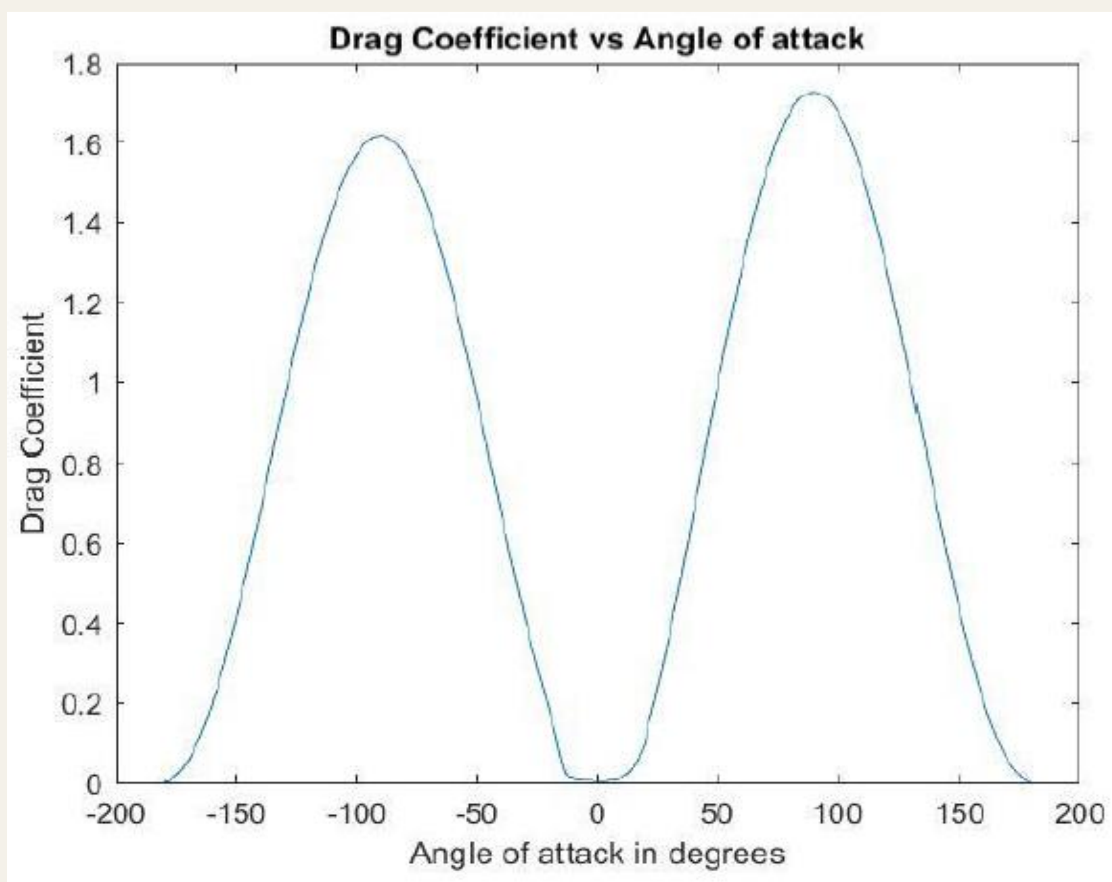


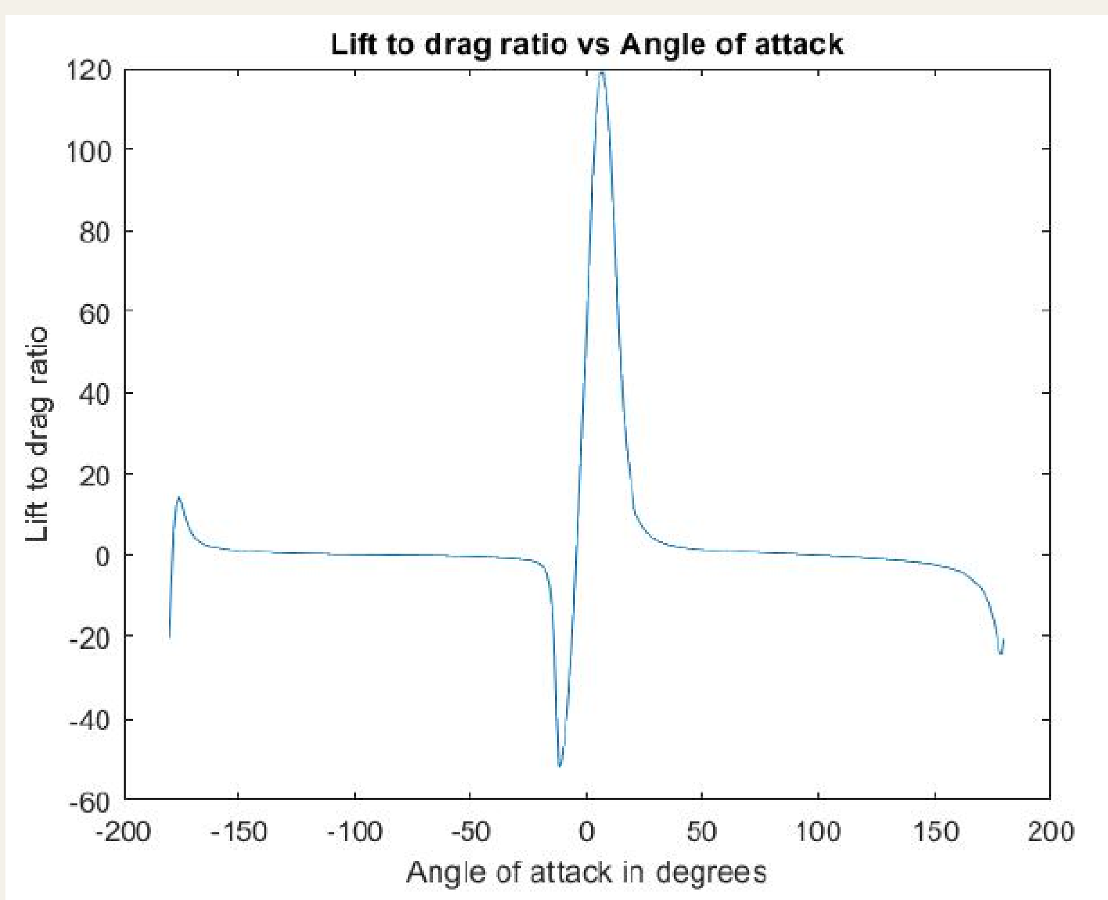
Design process

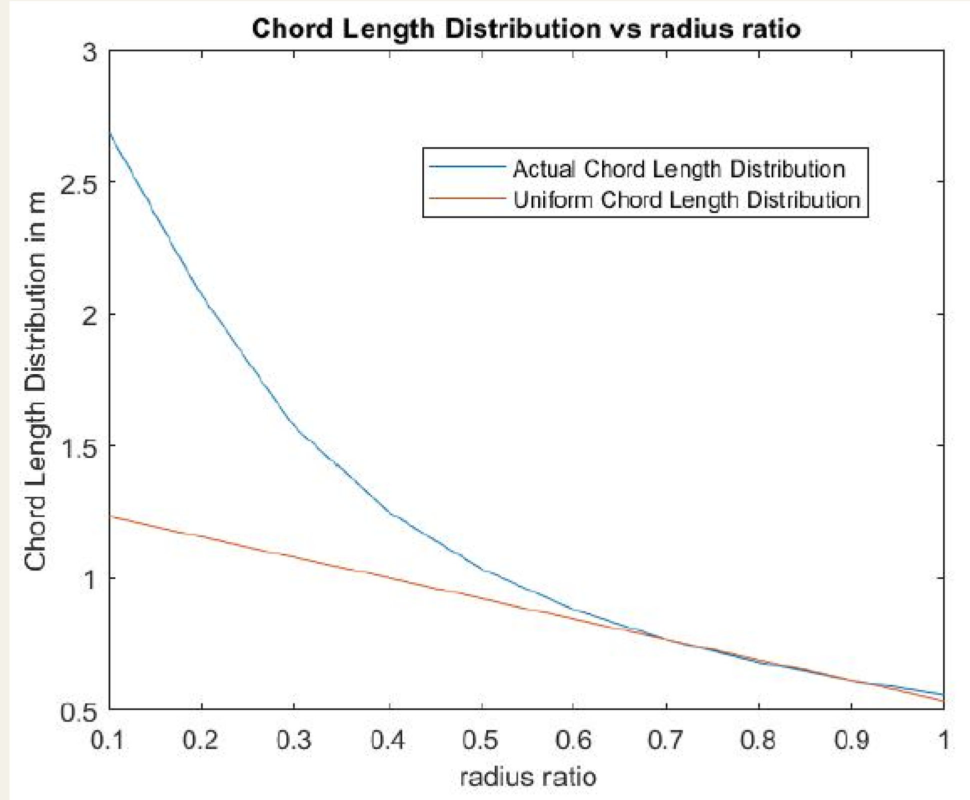


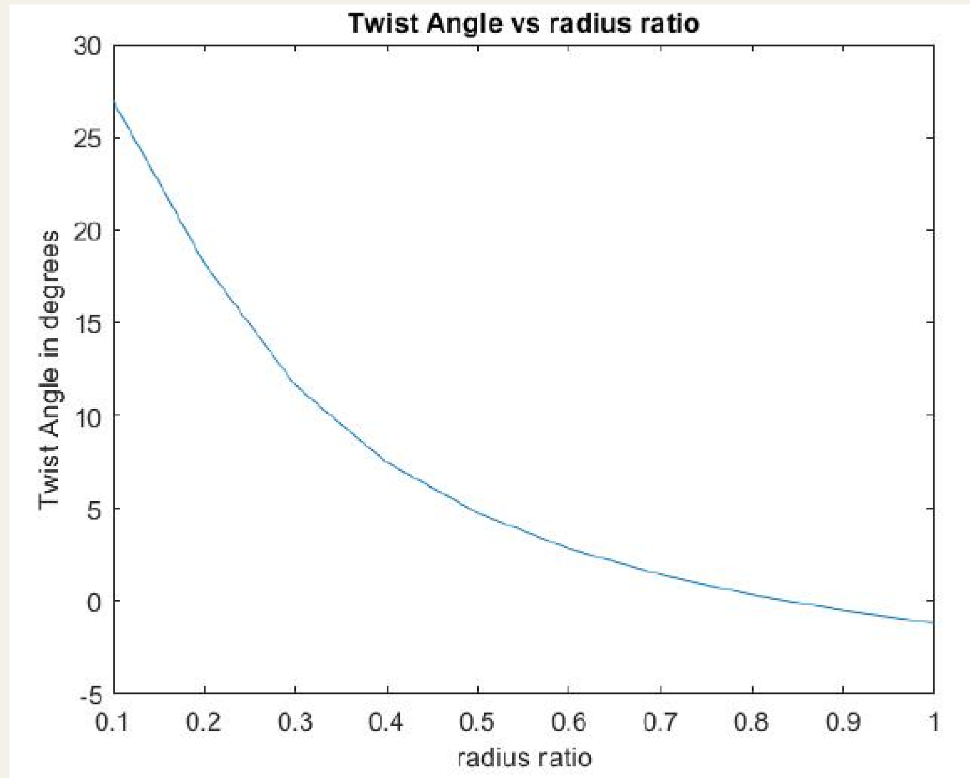
Results

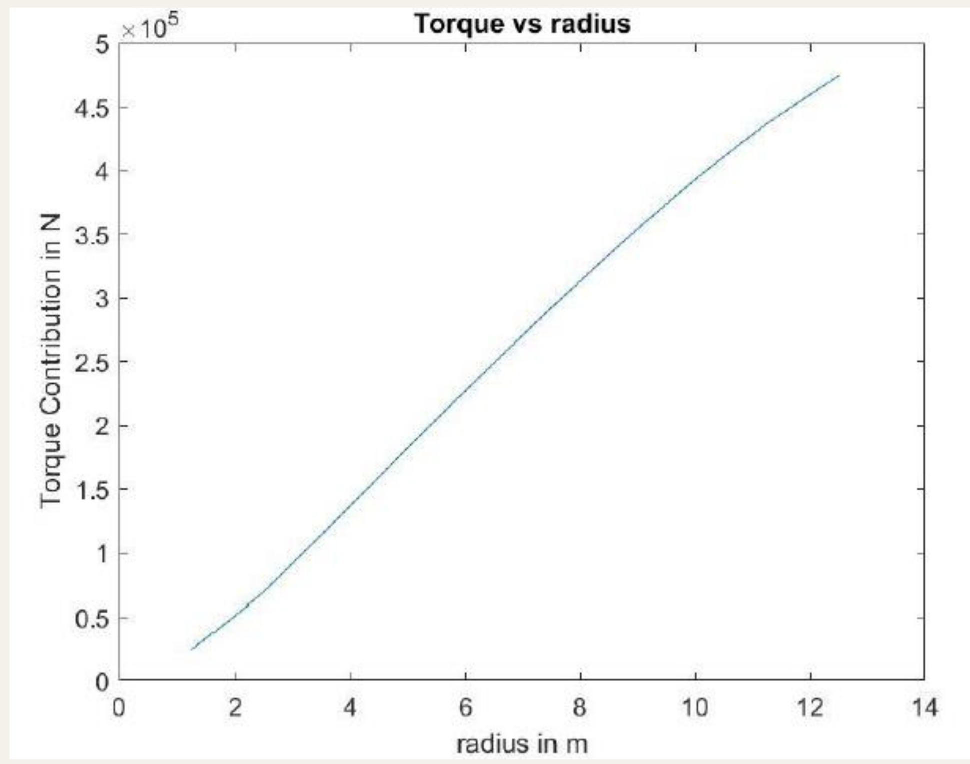


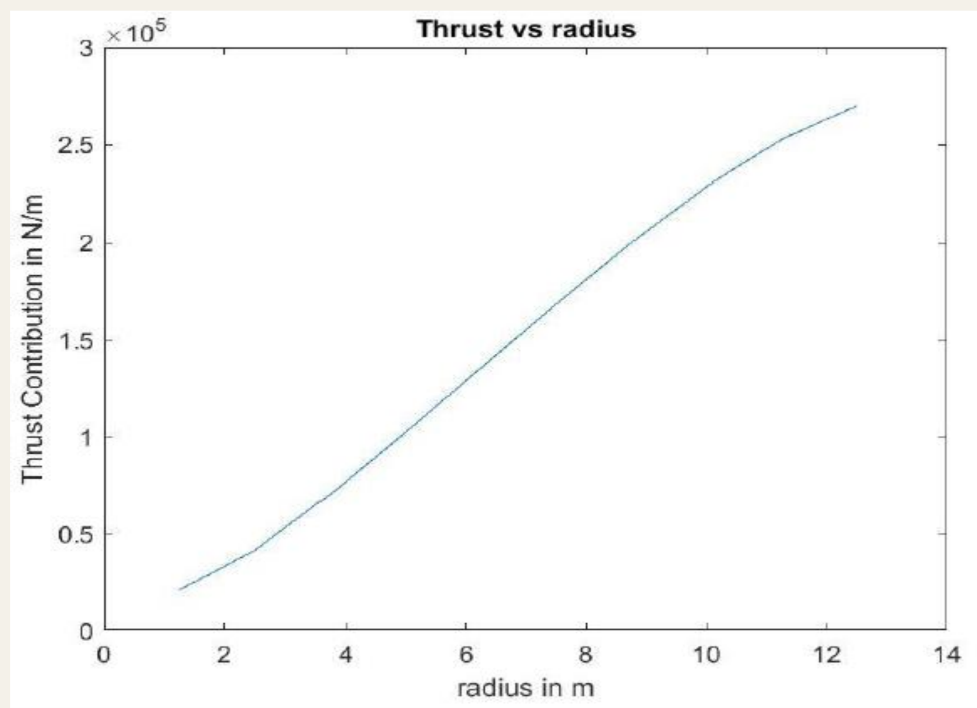












Conclusion

A user-interface code was developed to simulate the performance of a tidal wind turbine using the BEM theory. Different design parameters, environmental conditions and more complex models could be integrated into the model. This MATLAB® program could be the basis for more complex simulations.

Contact Information

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