Cross Tidal Kites

Source: modelon.com

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I have the privilege to tell the story of this project from two perspectives. Minesto's and Modelon's. One and a half years ago I first started to work on tidal kite systems simulation. At that time, I was a simulation engineer at Minesto, a Swedish company pioneering in the field of harvesting tidal energy.

Since then, the collaboration project between Minesto and Modelon has finally delivered a simulation platform that provides considerable technical support to Minesto. I am happy that I had the chance to contribute significantly to this innovative, "bluish-greenish" project. Meanwhile, model based systems engineering got me even more… Thus, in March 2016, I became a simulation engineer at Modelon, and a consultancy partner of Minesto in tidal kites systems simulations.

Here is in short the story of MerMaid, an underwater kite systems simulation tool!

Tidal energy is an enormous sustainable resource. The challenge is to harvest this energy. It is offshore, which makes it one of the harshest environments. It needs large investments. It bears significant risks. The company Minesto from Gothenburg in Sweden has developed a new green technology to exploit this energy in places where conventional techniques fail due to weaker tidal currents.

The use of the incoming tidal velocity as the driving force for a seabed mounted turbine similar to onshore wind mills has been traditionally the preferred technique to convert seawater momentum to electric energy.

Instead, Minesto uses a turbine mounted on a kite. The kite increases the velocity of the water by a factor of eight, which in turn produces energy at a greatly accelerated rate. Leverage is huge: produced energy goes with the power of three of velocity.

This permits the design of a small, lightweight, and cost efficient power plant, rather than a few hundred tons steel wind mill of same power, which would be relatively expensive and cost-ineffective.

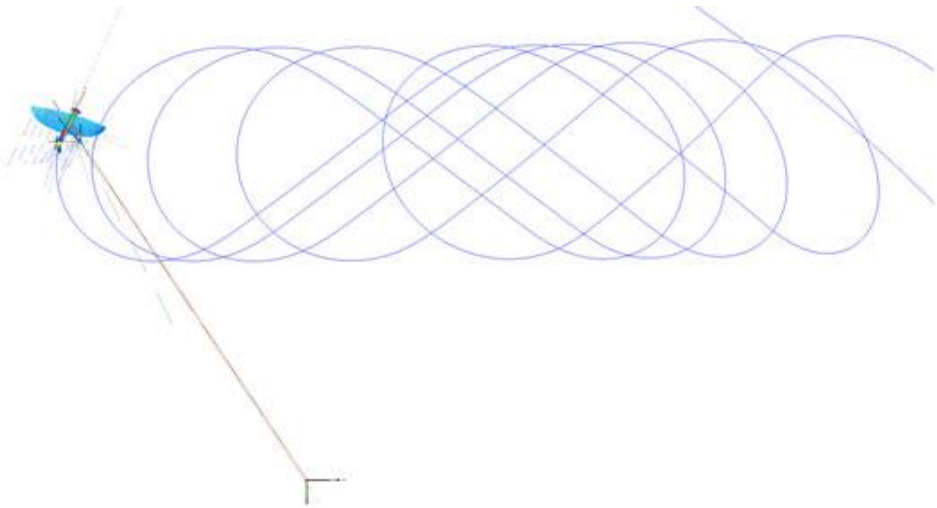

Fig. 1 Simulated trajectory of the underwater kite plant

The underwater system

The kite is attached to the seabed with a tether and sails in a figure eight pattern. A circular pattern is more efficient but to avoid twisting of the tether a figure eight pattern is the preferred way to go while in power production.

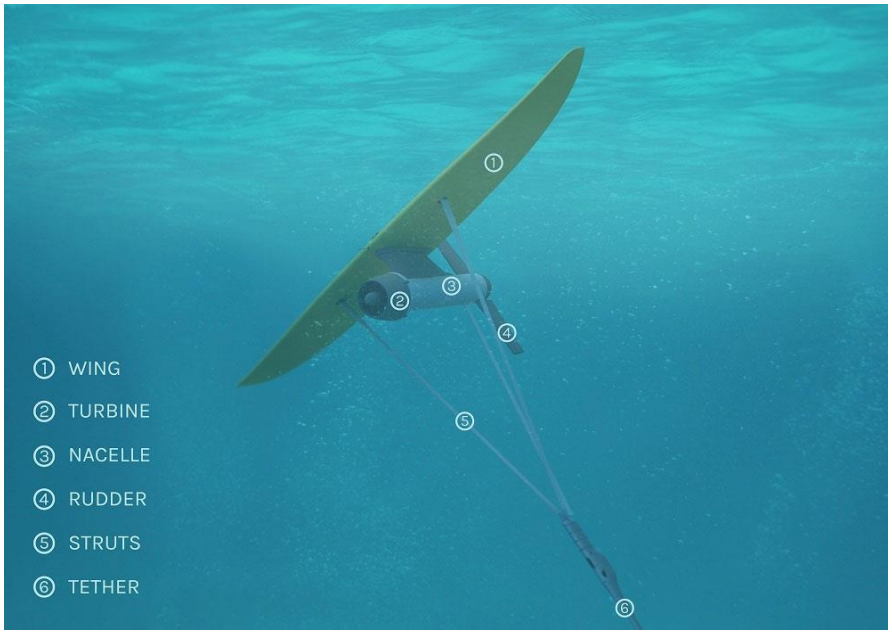

Fig. 2 Components of the tidal kite. Courtesy Minesto.

The full scale kite will be rated at 500 kW at a 1.6 m/s tidal velocity. The kite has a wing span of 12 m and weighs roughly 8 tonnes. Tether forces are quite large and limited to 1.5 MN. The top speed is 20 plus knots and is limited by the control system to make sure the structural loads are kept at an acceptable level.

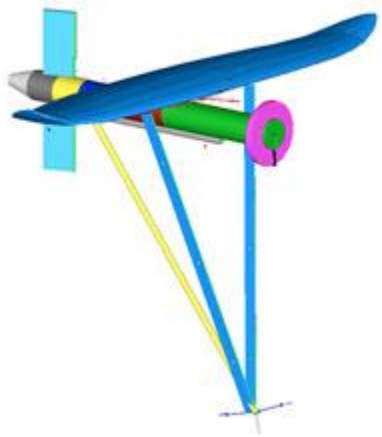

Fig. 3 Tidal kite – visualization via simulation

Modelon's contribution to the simulation project

As a result of the one and a half years cooperation between Minesto and Modelon, Minesto has not only strengthened their knowledge of Modelica and Dymola, but it became able to explore and better understand the behavior and performance of their cross tidal kite.

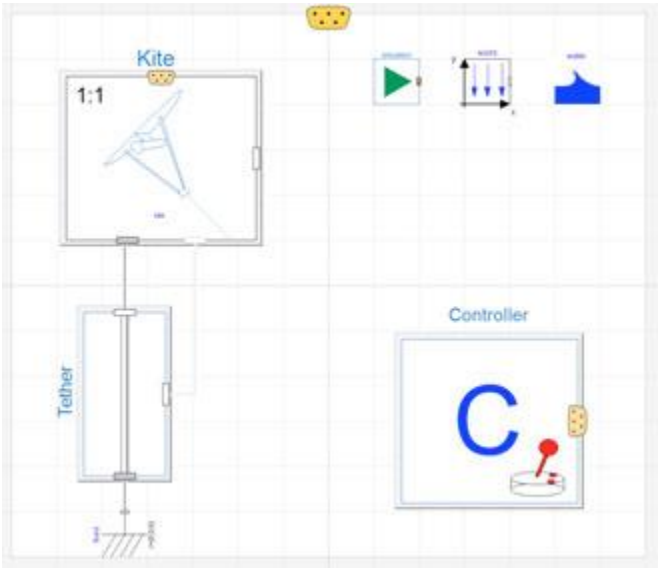

Fig. 4 Dymola diagram of the kite system

Modelon has supported this project with consulting services, software support, and training to create a fully-fledged Dymola/Modelica simulation platform.

This Modelica based platform is a package that contains 100+ kite components which were used to develop -different templates. There are templates for kite parts, kite sub-assemblies, complete kites and complete power plants.

The templates were used to rapidly build a plant from the bottom up.

This hierarchical structure makes it easy to test new concepts, perform sensitivity studies and predict full scale performance and functionality.

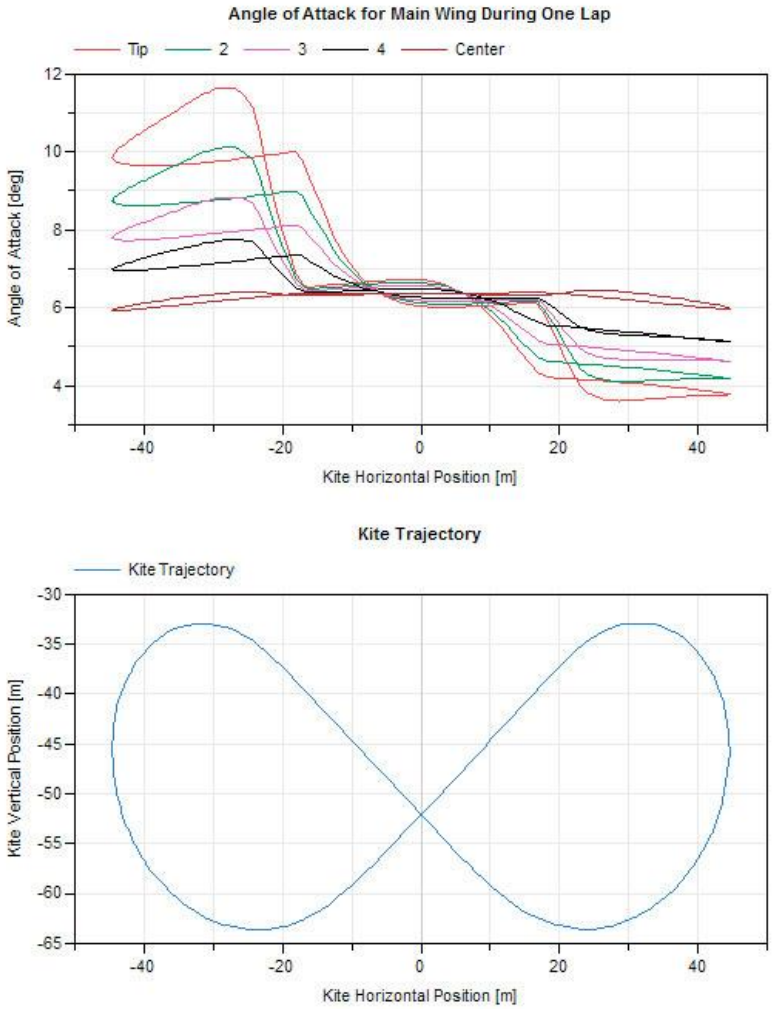

Fig. 5 The upper plot shows the angle of attack at five points from wing tip to wing center during one lap. Can you figure out which side of the wing that is plotted on each side, inner or outer?

Fig.6 Modelon team holding a 3D-printed kite

Regarding the collaboration with Modelon, Minesto CTO Heije Westberg stated:

"*We [Minesto] benefited from Modelon's support with Modelica technology and Dymola — through the training, consulting, and support efforts received, we obtained a deeper understanding of the possibilities with the tool and a better grip of the underwater kite dynamics and system as a whole. With Modelica technology and Dymola, we achieved an efficient tool not only for complete system simulations but also for evaluation of sub-systems".*

For further details or questions related to training or consulting services, do not hesitate to contact Modelon team.

Jonas Malmqvist is currently an Application Engineer at Modelon. Previously Jonas was responsible for system simulation at Minesto. He holds and MSC in Mechanical Engineering from Chalmers University.