NEMMO Project
OEE
WP2

December 8th 2021

Michael Leer-Andersen, SSPA

NEMMO
MAKING BLADES BETTER

Cavitation tunnel testing

Cavitation tunnel can be used to create a controlled and uniform flow over turbine blades for, either testing non-rotating constant cross section blade profiles at different angle of attack, or a full rotating turbine. Advance ratio for the scaled model is the main parameter to keep equal to the full scale turbine.

Cavitation tunnel testing should not be confused with cavitation testing. The main purpose is performance evaluation and validation, even though cavitation was investigated.

SSPA have designed and build two test rigs

- Rotating turbine:

To test the performance and efficiency of the actual turbine blade in model scale. Used for evaluation of performance of blade geometry and validation of simulation models.

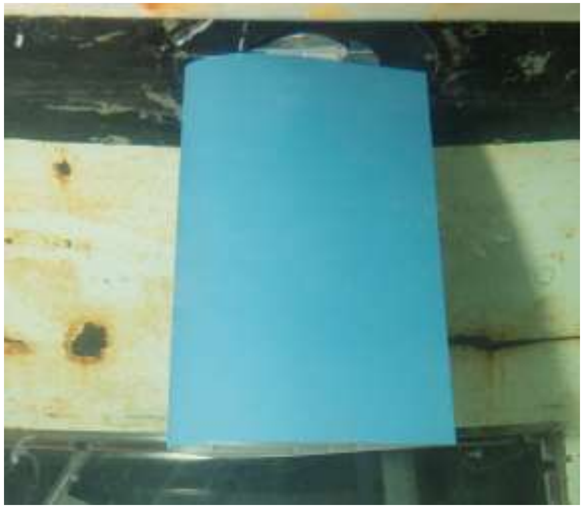
- Constant cross section profile

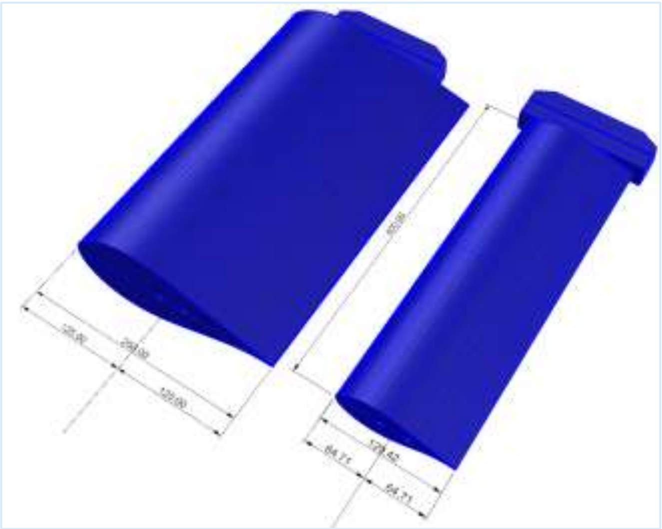
To measure the lift and drag coefficients of the hydrofoil in two sections of the blade. The data is used as to verify the CFD simulation and also for investigating the flow control methods effectiveness.

Constant cross sectional profiles

Constant cross-sectional profiles have been manufactured and tested at SSPA. The profiles are not rotating but are instead attached to the roof of the SSPA cavitation tunnel on a rotating table to be able to test a range of angle attack. The reason for this approach is two folded:

- The scale is significantly increased (from 1/38 for rotating turbine to 1/7 for the constant cross-sectional profiles), which allows less Reynolds number scaling to full scale. This is important for flow control methods, as the scale for the rotating turbine makes it almost impossible to create the necessary tubing and flow outlets inside the blades.

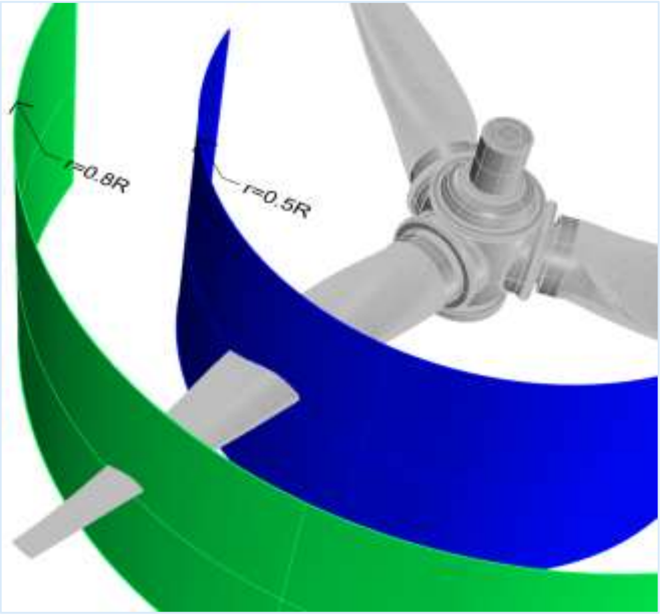


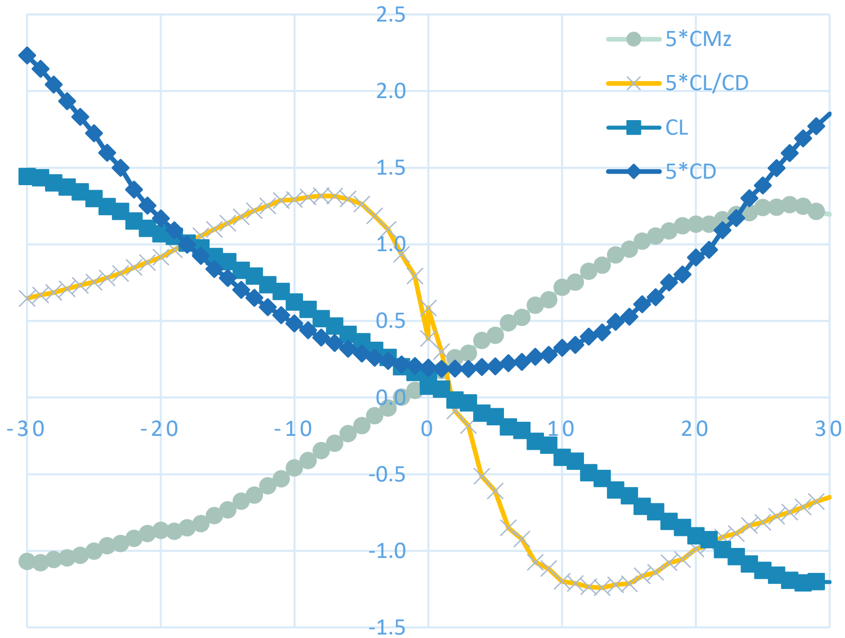


NEMMO
MAKING BLADES BETTER

Constant cross sectional profiles

- A range of flow speeds and and angle of attacks was tested in SSPA's cavitation tunnel. The same angle of attack as for the rotating turbine has been used as the design point.





Task 2.2 (Turbine test)

Rotating turbine blades were built in scale 1:39, as the blockage effect otherwise would have been too large.

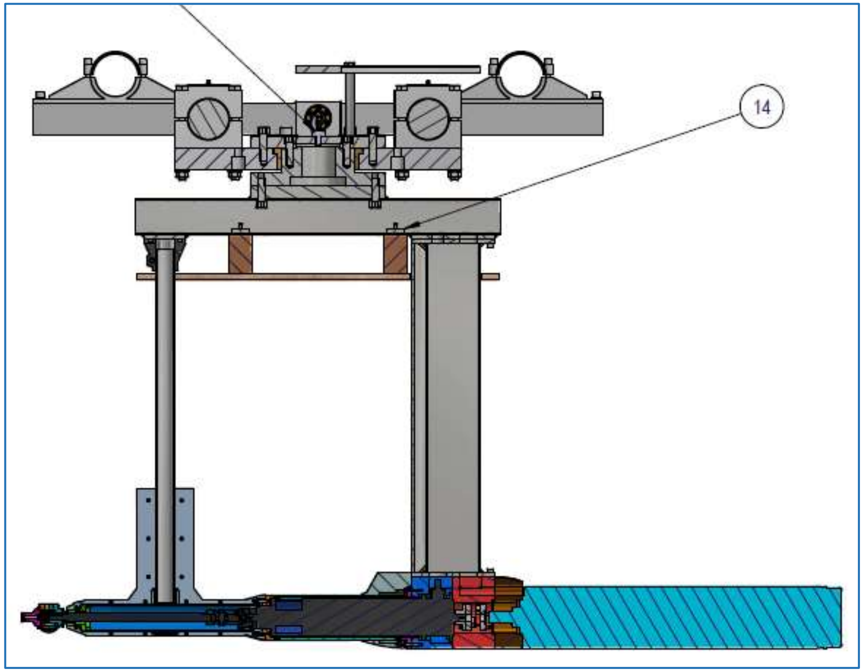
The turbine model was designed with the following goals i mind:

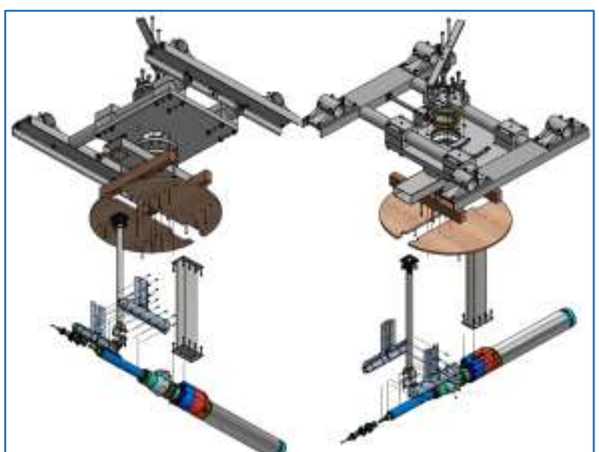
- Manual or automatic pitch control (+/- 20degrees)
- Blades from CANOE must be interchangeable on the hub (SSPA produced blades was used)
- Scale: 1:39
- RPS (in model scale) is in the range from 8-15, with a flow speed of 2.5m/s
- Pitch angle +/- 20 degrees, manual setting.
- Nacelle should be same geometry as full scale
- Nacelle and blades must be able to rotate relative to the free stream direction (ie. sword must be able to rotate)
- Torque and thrust are measured

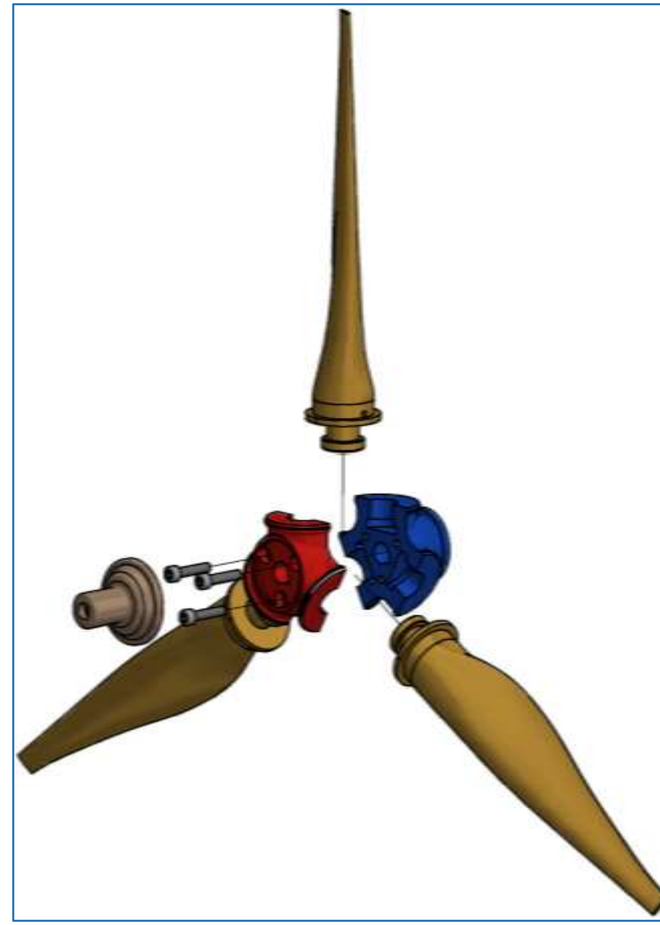
NEMMO
MAKING BLADES BETTER

Turbine test

Model is designed and manufactured by SSPA



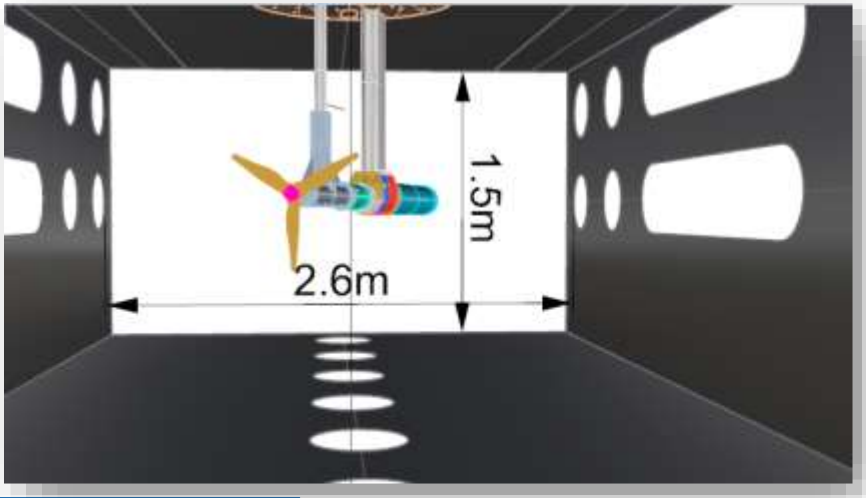


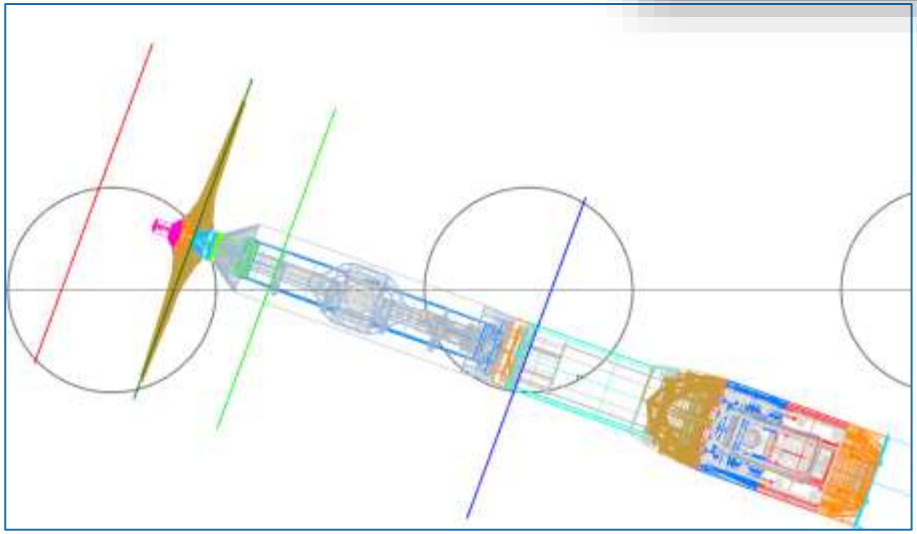


NEMMO
MAKING BLADES BETTER

Turbine performance test

- Tests were performed in four different yaw angles between zero and 19.5 degrees.
- 4 pitch angles in different tip speed ratios were tested, all the way till stall.

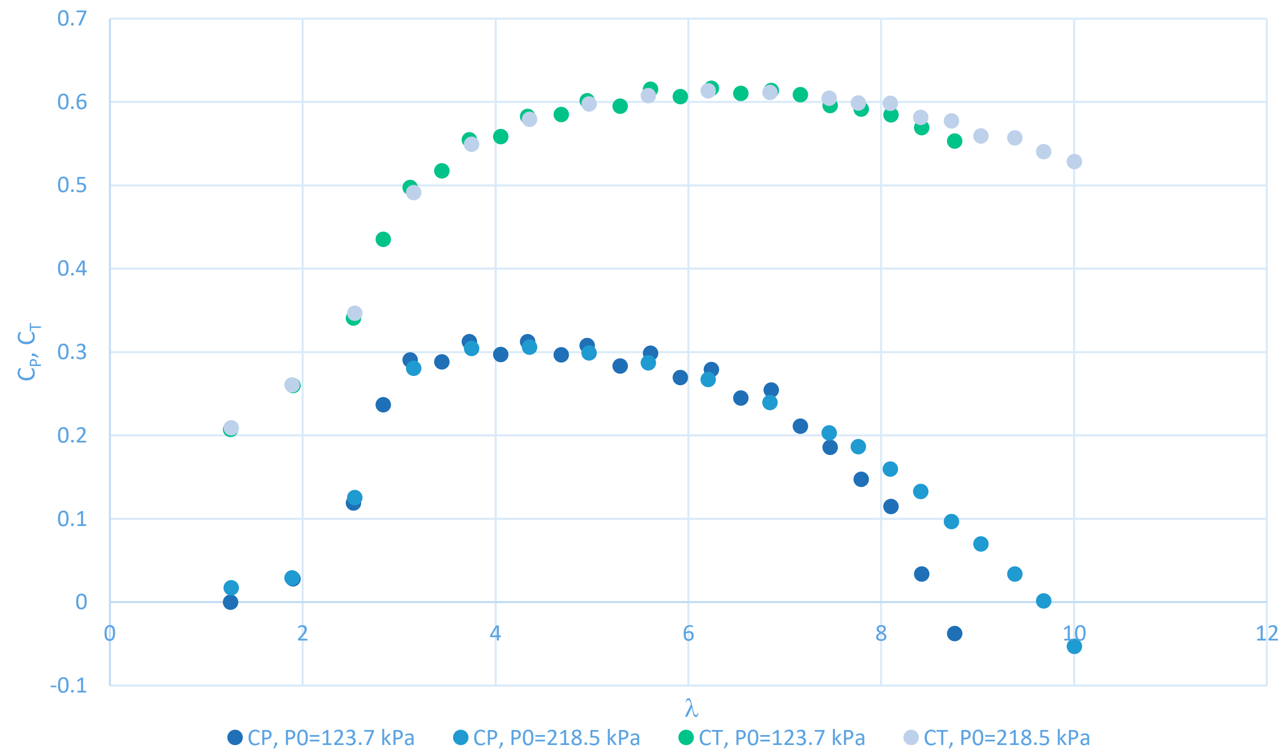




NEMMO
MAKING BLADES BETTER

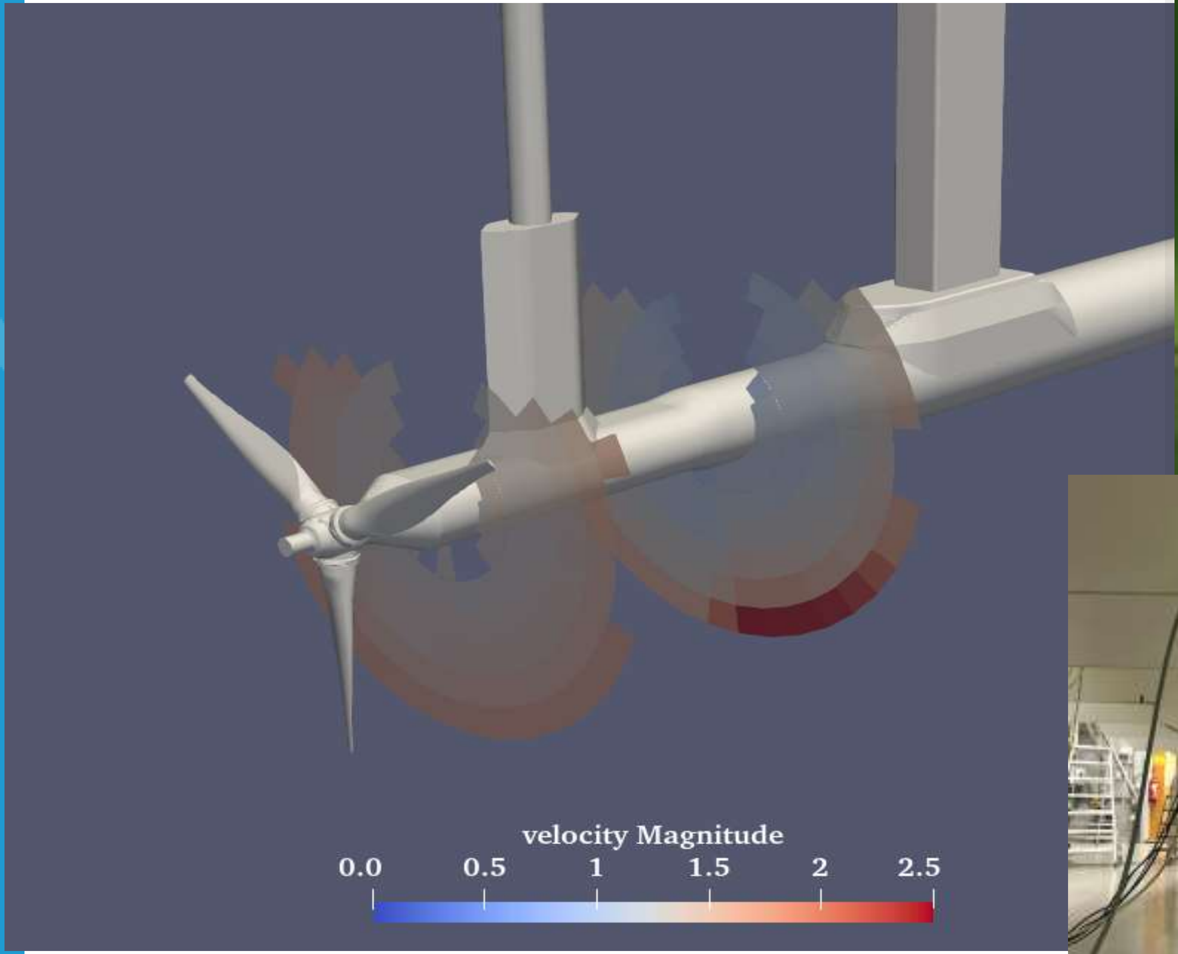
Task 2.2 (Turbine performance test)

Cavitation and centering of turbine in atmospheric pressure and full-scale pressure test.



Turbine

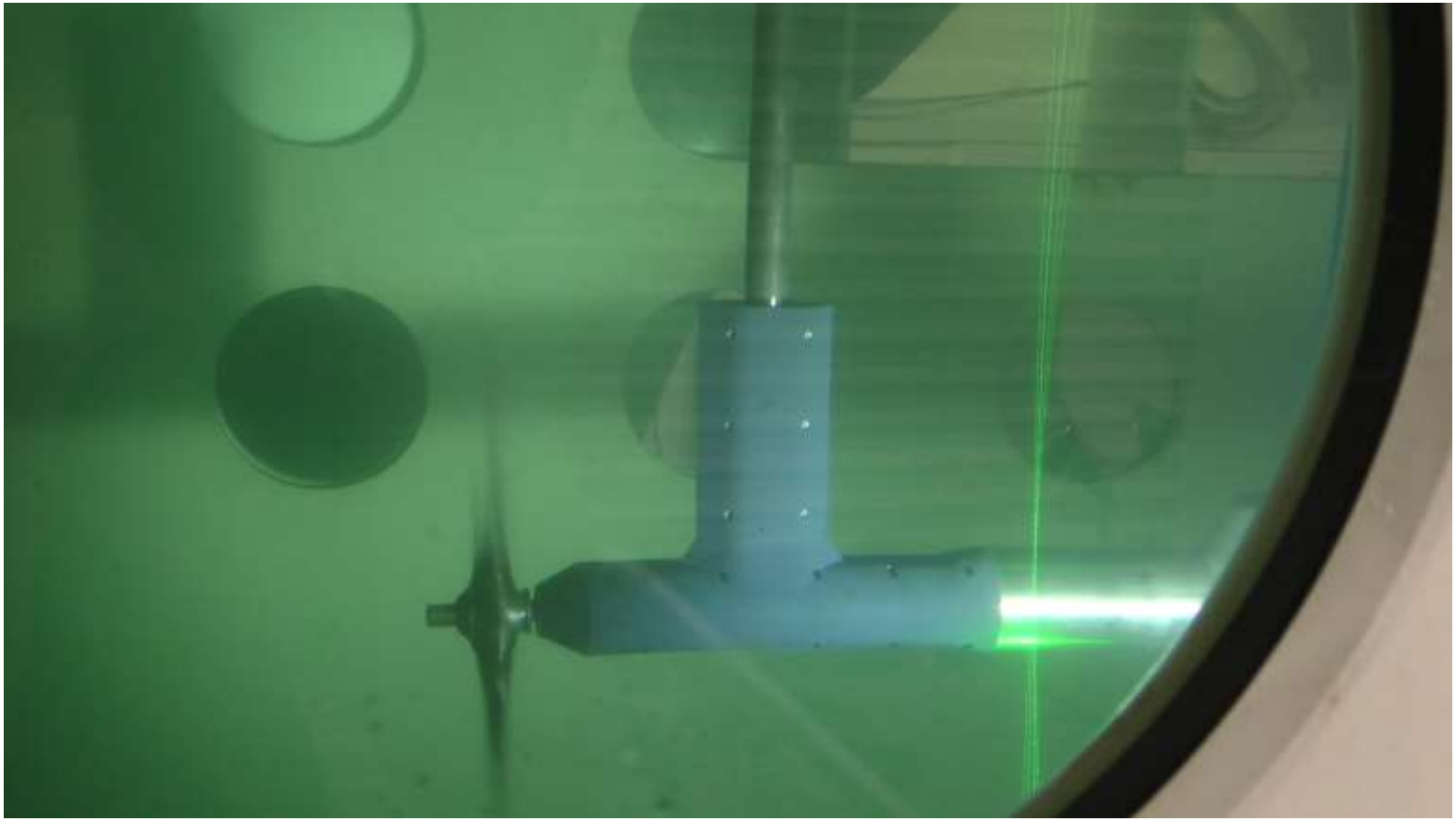
LDV measurements performed in two yaw angles.



NEMMO
MAKING BLADES BETTER

Turbine

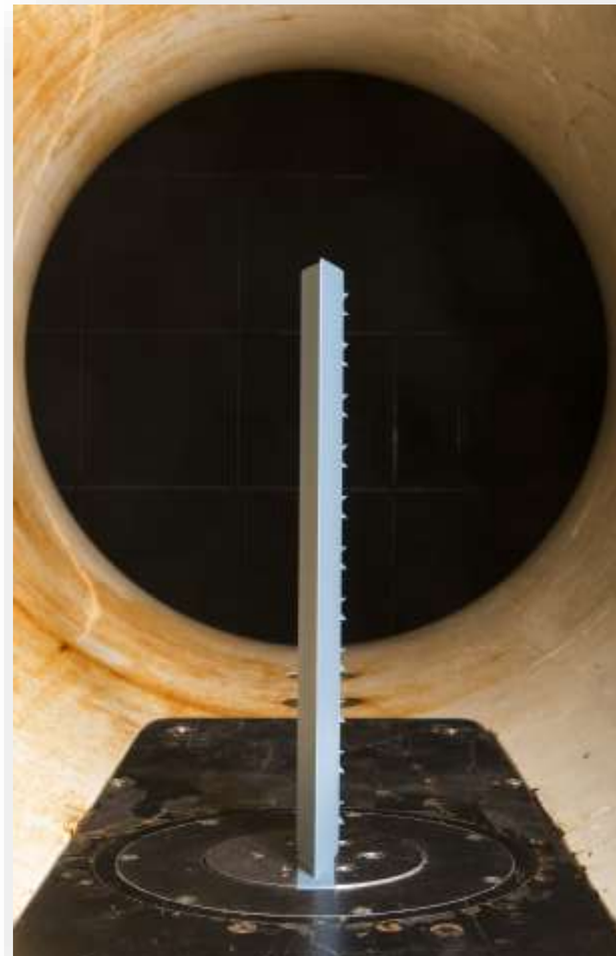
LDV measurements with rotating turbine



Active flow control

Two different approaches to AFC was chosen (or more accurately one active and one passive)

- Blowing
- Vortex generators



NEMMO
MAKING BLADES BETTER

Blowing

Higher stall angle, but not enough performance increase compared to cost

NEMMO
MAKING BLADES BETTER

Thank you for your attention

MAKING BLADES BETTER