Unconventional Propeller: Prediction of the open water characteristics in model and full-scale

As unconventional propeller the P1727 was chosen.

Test description:

- The propeller shall be tested in a pull configuration. The corresponding hub cap is provided.
- The extent of the shaft behind the propeller has to be at least two propeller diameters.
- The extent of the solution domain can be chosen arbitrarily, however it is considered necessary to have a radial domain extent which gives a cross sectional area of the domain which is at least 100 times larger than the corresponding propeller disc area.
  Radial extent $D_{domain} > 10\ D_P$
- The dimensionless wall distance on the propeller blade shall be chosen such that the viscous sublayer is resolved.
- It is highly recommended to conduct the calculations in model scale under consideration of **laminar-turbulent transition** on the blade. For the full-scale calculations a fully turbulent inflow can be assumed.
- The calculations shall be carried out neglecting cavitation.
- The water characteristics shall be taken for a water temperature of $t_w = 15°C$ as provided below.
- The propeller is a fixed pitch propeller. The gap between hub and blade root is considered unimportant regarding the integral values of the propeller and shall not be taken into account.
- Whether to calculate a single blade passage or the entire propeller (4 blades) has to be decided by the participant.

Scale ratio	λ		31.428	1
Water density	ρ	[kg/m^3]	999	1025.87
Kinematic viscosity of water	ν	[m^2/s]	1.139E-06	1.188E-06
Rate of revolutions	n	[1/s]	18.00	3.21

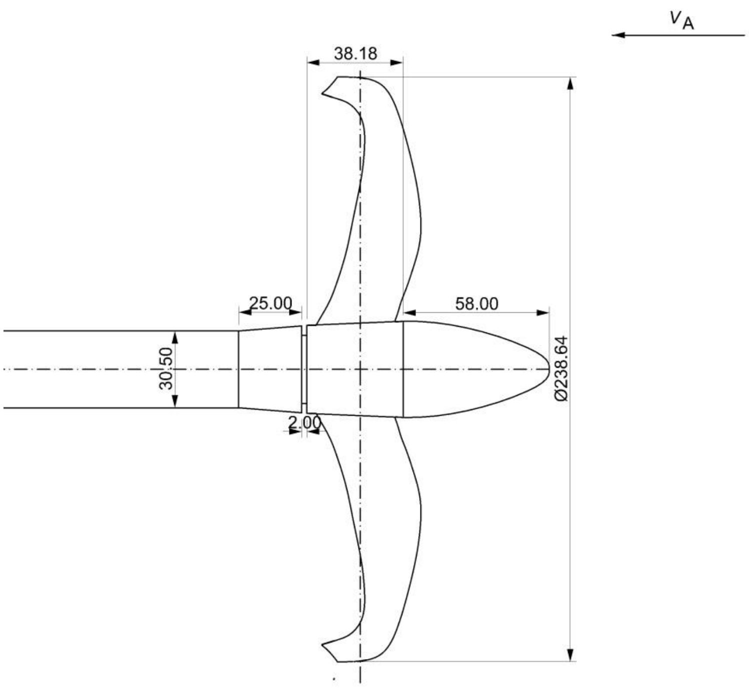

Fig.1: Arrangement (model scale)

Evaluation:

The following shall be evaluated:

- Two different scale ratios (λ = 31.428 and λ = 1).
- Solely the blade forces.
- Five different advance coefficients: J = 0.1, 0.3, 0.5, 0.7 and 0.9
- The following shall be evaluated:
  Forces on blade sections:
  The thrust and torque of different blade sections shall be evaluated. The coefficients shall be subdivided into a pressure and a frictional component. The intention is to obtain a deeper and more detailed insight into the scale effects of the propeller. The total thrust and torque is obtained via the summation of the different blade section values. The calculations shall be conducted in model and full-scale.

  Number of requested calculations: 10

- An excel-file is provided for the submission of the computational results. Please fill your results in the corresponding tables. The Excel file was generated with Office2010. The file may not be compatible with older Excel versions (artefacts in the diagrams are possible).

Equations:

Advance coefficient: $$J = \frac{V_A}{n \cdot D}$$

Thrust coefficient: $$K_T = \frac{T}{\rho \cdot n^2 \cdot D^4}$$

Torque coefficient: $$K_Q = \frac{Q}{\rho \cdot n^2 \cdot D^5}$$

Open water efficiency: $$\eta_0 = \frac{J}{2\pi} \cdot \frac{K_T}{K_Q}$$

Reynolds number of number (r/R = 0.7) $$\mathrm{Re} = \frac{c_{0.7R}}{\nu} \sqrt{V_A^2 + (0.7 D \cdot \pi \cdot n)^2}$$

Thrust loading coefficient: $$C_{Th} = \frac{8}{\pi} \cdot \frac{K_T}{J^2}$$

Dimensionless wall distance: $$y^+ = \frac{u_\tau \cdot y}{\nu}$$

With D being the propeller diameter, T the propeller thrust, Q the propeller torque, $c_{0.7R}$ the chord length of the propeller section at radius $r/R = 0.7$, u_τ the shear velocity and y the wall distance.