Case 3: Pressure pulses

Description:
The propeller induced pressure pulses were measured in the cavitation tunnel K 15 A (Kempf & Remmers) of the SVA Potsdam. The shaft was inclined by 12°. The plate with the pressure sensors was positioned 50 mm above the propeller tip. Altogether 15 pressure sensors were used.

For the workshop it is requested to provide the calculated time history of the pressure at **3** measuring points (2, 5 and 10). In the following the measuring points will be denoted **p2, p5** and **p10.** The CAD data will be provided in full detail and will also contain the measuring positions. The test arrangement and the measuring positions are shown below:

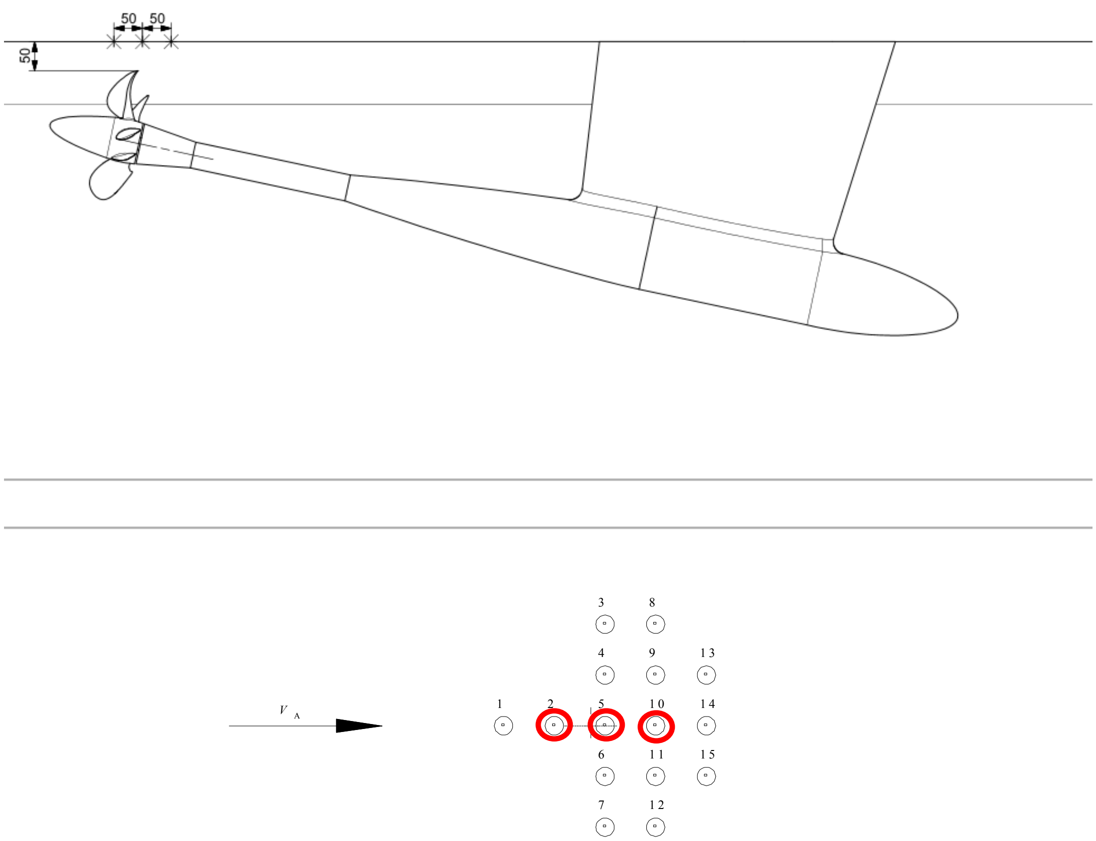

Fig. 1: Test arrangement and measuring positions

In order to identify the effect of cavitation on the pressure pulses it is requested to calculate three operation points (case3.1, case3.2 and case3.3) without and with cavitation.

The time history of the pressure at the position of the pressure sensors will be evaluated by the SVA, with the intention to apply the same procedure for all calculations. The harmonic frequencies and the corresponding amplitudes will be evaluated by means of a Fourier transformation.

In order to impose as little error as possible it is requested to conduct the simulations with a time step size which resolves one propeller revolution with 256 (2^8) steps. In case this is somehow not possible, please always use a time step which divides one propeller revolution by 2^m steps (e.g. m = 9, giving a time step of $t = 1/(n*2^m) = 1/(20*512)$ s, with n being the number of revolutions)

It is requested to hand in the time history of **8** propeller revolutions. To limit the amount of computational time however, everybody is free to extent there time history to the requested number of rotations. Please check for a smooth transition between the time series.

Please provide the time history of the pressure pulses in Seconds [s] and in kilo-Pascal [kPa].

Requested computations:

Case 3.1:

Cavitation number based on n	σ_n	[-]	2.024
Number of revolutions	n	[1/s]	20.000
Advance coefficient	J	[-]	1.019
Water density (for t_w = 23.7°C)	ρ	[kg/m^3]	997.38
Kinematic viscosity of water (for t_w = 23.7°C)	ν	[m²/s]	9.199e-7
Vapour pressure (for t_w = 23.7°C)	p_v	[Pa]	2929
Oxygen saturation	α/α_s	[%]	55
Inclination angle	Ψ^{bP}	[°]	12

- Evaluation of the pressure time history for 3 measuring positions with and without cavitation
- Time history of 8 entire revolutions
- Requested time step size for the simulations: $t = 1/(n*256)$ or $1/(n\, z^m)$ in [s]
- Data format:
  The data shall be provided in ASCII-format, with blanks or tabs as separator. The column descriptors should have a preceding hash key. The time should be given in the first, the pressure of sensor **p2** in the second, the pressure of sensor **p5** in the third and the pressure of sensor **p10** in the fourth column.

  Example:
  ```
  # t[s]   p2[kPa]   p5[kPa]   p10[kPa]
  1.0      1.000       1.000      1.000
  2.0      2.000       2.000      2.000
  …
  10      10.000      10.000     10.000
  ```

- File name: [identifier1]_case3-1_[identifier2].dat
  The first identifier should be [Institute Name]-[Solver Name]. The second identifier [cav or nocav] should indicate whether the calculations were carried out with or without cavitation model. For the SVA Potsdam using the CFX solver and providing data for the simulations without cavitation it would be:
  SVA-CFX_case3-1_nocav.dat

Case 3.2:

Cavitation number based on *n*	σ_n	[-]	1.424
Number of revolutions	n	[1/s]	20.000
Advance coefficient	J	[-]	1.269
Water density (for t_w = 23.7°C)	ρ	[kg/m^3]	997.38
Kinematic viscosity of water (for t_w = 23.7°C)	ν	[m²/s]	9.199e-7
Vapour pressure (for t_w = 23.7°C)	p_v	[Pa]	2929
Oxygen saturation	α/α_s	[%]	55
Inclination angle	Ψ^{bP}	[°]	12

- Evaluation of the pressure time history for 3 measuring positions with and without cavitation
- Time history of 8 entire revolutions
- Requested time step size for the simulations: $t = 1/(n*256)$ or $1/(n\, z^{m})$ in [s]
- Data format:
  The data shall be provided in ASCII-format, with blanks or tabs as separator. The column descriptors should have a preceding hash key. The time should be given in the first, the pressure of sensor **p2** in the second, the pressure of sensor **p5** in the third and the pressure of sensor **p10** in the fourth column.

  Example:
  ```
  # t[s]   p2[kPa]   p5[kPa]   p10[kPa]
  1.0      1.000       1.000      1.000
  2.0      2.000       2.000      2.000
  …
  10      10.000      10.000     10.000
  ```

- File name: [identifier1]_case3-2_[identifier2].dat
  The first identifier should be [Institute Name]-[Solver Name]. The second identifier [cav or nocav] should indicate whether the calculations were carried out with or without cavitation model. For the SVA Potsdam using the CFX solver and providing data for the simulations without cavitation it would be:
  SVA-CFX_case3-2_nocav.dat

Case 3.3

Cavitation number based on *n*	σ_n	[-]	2.000
Number of revolutions	n	[1/s]	20.000
Advance coefficient	J	[-]	1.408
Water density (for t_w = 23.7°C)	ρ	[kg/m^3]	997.38
Kinematic viscosity of water (for t_w = 23.7°C)	ν	[m²/s]	9.199e-7
Vapour pressure (for t_w = 23.7°C)	p_v	[Pa]	2929
Oxygen saturation	α/α_s	[%]	55
Inclination angle	Ψ^{bP}	[°]	12

- Evaluation of the pressure time history for 3 measuring positions (p with and without cavitation
- Time history of 8 entire revolutions
- Requested time step size for the simulations: $t = 1/(n*256)$ or $1/(n\, z^m)$ in [s]
- Data format:
  The data shall be provided in ASCII-format, with blanks or tabs as separator. The column descriptors should have a preceding hash key. The time should be given in the first, the pressure of sensor **p2** in the second, the pressure of sensor **p5** in the third and the pressure of sensor **p10** in the fourth column.

  Example:
  ```
  # t[s]   p2[kPa]   p5[kPa]   p10[kPa]
  1.0      1.000       1.000      1.000
  2.0      2.000       2.000      2.000
  …
  10      10.000      10.000     10.000
  ```

- File name: [identifier1]_case3-3_[identifier2].dat
  The first identifier should be [Institute Name]-[Solver Name]. The second identifier [cav or nocav] should indicate whether the calculations were carried out with or without cavitation model. For the SVA Potsdam using the CFX solver and providing data for the simulations without cavitation it would be:
  SVA-CFX_case3-3_nocav.dat

Formula:

Advance coefficient: $$J = \frac{V}{n \cdot D_P}$$

Thrust coefficient: $$K_{Tx} = \frac{T_x}{\rho \cdot n^2 \cdot D_P^4}$$

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

Cavitation number with respect to *n* $$\sigma_n = \frac{(p - p_v)}{0.5 \cdot \rho \cdot (n \cdot D_P)^2}$$

With D_P being the propeller diameter, *Tx* the propeller thrust along the shaft axis (PCS), *Q* the propeller torque, *p* the tunnel pressure and p_v the vapour pressure.

Propeller coordinate system (PCS)

An orthogonal coordinate system is used for the propeller, with the x-axis pointing upstream against the flow direction and the z-axis upwards.

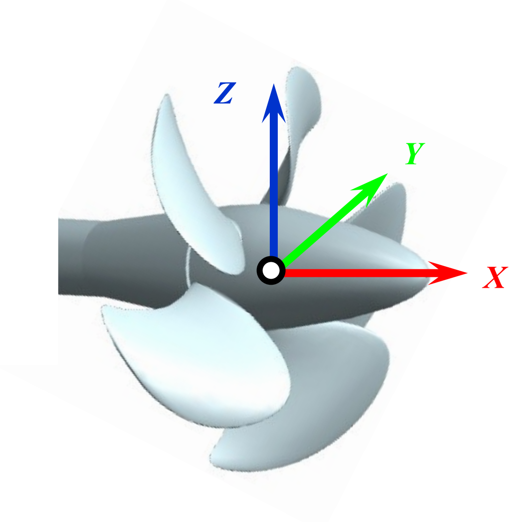

Fig. 2: Propeller coordinate system