Second International Symposium on Marine Propulsors 2011

Workshop:
Propeller Performance

Potsdam Propeller Test Case (PPTC)

Cavitation Tests with the Model Propeller VP1304

Case 2.3

Potsdam, May 2011

Case 2.3

Cavitation Test

Test Description

Content

1 Introduction

In the intention to offer research groups the possibility to test and validate their numerical tools the SVA Potsdam GmbH (SVA) investigated the controllable pitch propeller VP1304. The test results are published in course of the propeller workshop of the Second International Symposium on Marine Propulsors 2011 (smp'11). The geometry and results of the propeller are presented by the name PPTC, an acronym for "Potsdam Propeller Test Case".

In the following the cavitation tests with the propeller VP1304 are presented. Also the comparison between the measured data with the corresponding computational results is carried out.

A more detailed description of the cavitation tests conducted in the cavitation tunnel of the SVA is presented in the SVA report 3753 [1], which can be found on the website www.sva-potsdam.de.

2 Model propeller VP1304

The propeller is a controllable pitch propeller. This affects the propeller blade design near the hub and results in a 0.3 mm gap between hub and propeller blade near the leading and trailing edge of the propeller. In Table 1 the main data of the propeller is given.

Table 1: Main data of model propeller VP1304

			VP1304
Diameter	D	[m]	0.250
Pitch ratio $r/R = 0.7$	$P_{0.7}/D$	[–]	1.635
Area ratio	A_E/A_0	[–]	0.77896
Chord length $r/R = 0.7$	$c_{0.7}$	[m]	0.10417
Skew	θ_{EXT}	[°]	18.837
Hub ratio	d_h/D	[–]	0.300
Number of blades	Z	[–]	5
Sense of rotation		[–]	right
Type		[–]	controllable pitch propeller

3 Cavitation tests

The cavitation tests were conducted in the cavitation tunnel K 15 A (Kempf & Remmers) of the SVA Potsdam. For the tests a test section with the length of 2600 mm and a cross section of 600 x 600 mm was used. The dynamometer J25 from Kempf & Remmers was arranged in front of the propeller model. The shaft inclination was zero degrees.

The propeller characteristic in the cavitation tunnel had been measured at the numbers of revolutions n = 15, 20 and 25 s^{-1}. Cavitation buckets were measured with the number of revolutions $n = 25\ s^{-1}$. Two blades had been selected for the cavitation tests.

The cavitation behaviour of the propeller was observed in three working points, corresponding to the test conditions required for test case 2.3.1-2.3.3.

4 Requested computations

It was requested to calculate the propeller cavitation for three working point, given in Table 2.

Table 2: Working points for the cavitation tests

			Case 2.3.1	Case 2.3.2	Case 2.3.3
Advanced coefficient	J	[-]	1.019	1.269	1.408
Cavitation number based on n	σ_n	[-]	2.024	1.424	2.000
Thrust coefficient (non-cavitating!)	K_T	[-]	0.387	0.245	0.167
Number of revolutions	n	[1/s]	24.987	24.986	25.014
Water density (for t_w = 23.2°C)	ρ	[kg/m^3]	997.44	997.44	997.37
Kinematic viscosity water (for t_w = 23.2°C)	ν	[m²/s]	$9.337 \cdot 10^{-7}$	$9.337 \cdot 10^{-7}$	$9.272 \cdot 10^{-7}$
Vapour pressure (for t_w = 23.2°C)	p_v	[Pa]	2818	2818	2869
Air content	α/α_s	[%]	53.5	53.5	58.50

The calculation shall be conducted according to the thrust identity.

For the three working points it was requested to visualize the cavity surface for vapor fractions of 20, 50 and 80%. For case 2.3.1 and case 2.3.2 it was requested to look upon the suction side, while for case 2.3.3 on the pressure side of the propeller.

In order to quantify the thrust deduction it was additionally requested to provide the thrust coefficient of the propeller in cavitating condition.

It was also requested to provide the pressure distribution, made dimensionless with the section advance speed, on the propeller radii r/R = 0.7, 0.97 and 1.00 with and without cavitation.

The data is made dimensionless as follows:

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

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

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

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

Pressure coefficient: $$c_P = \frac{(p - p_0)}{0.5 \cdot \rho \cdot \left(V^2 + (2 \cdot \pi \cdot n \cdot r)^2\right)}$$

with D_P being the propeller diameter, T the propeller thrust, Q the propeller torque, p the tunnel pressure, p_v the vapour pressure, p_0 the static pressure and r the radius.

5 Reference

[1] Heinke, H.-J.
Potsdam Propeller Test Case (PPTC), Cavitation Tests with the Model Propeller VP1304,
Report 3753, Schiffbau-Versuchsanstalt Potsdam, April 2011

Case 2.3

Cavitation Test

Evaluation

6 Evaluation

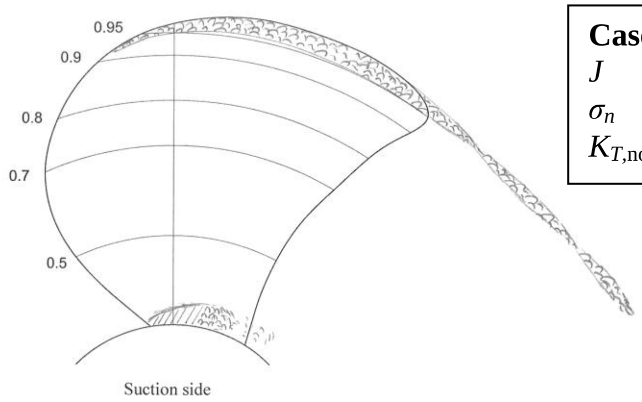
Calculations from 11 different groups were obtained for the evaluation of the cavitating propeller, employing 12 different solvers and submitting 15 calculations. Among these are submissions of different cavitation models and settings. In the following all participants of the case 2.3 and the used solvers are listed:

Group	Solver	Acronym
Berg-Propulsion	Procal	Berg-Procal
Cradle	SC/Tetra	Cradle-SC/Tetra
CSSRC	ANSYS Fluent	CSSRC-Fluent
HSVA	QCM	HSVA-QCM
	PPB	HSVA-PPB
INSEAN	PFC	INSEAN-PFC
SSPA	ANSYS Fluent	SSPA-Fluent
TUHH	FreSCO+	TUHH-FreSCO
University of Genua	Panel	UniGenua-Panel
	StarCCM+	UniGenua-StarCCM
University of Triest	ANSYS CFX(FCM)	UniTriest-CFX(FCM)
	ANSYS CFX(Kunz)	UniTriest-CFX(Kunz)
	ANSYS CFX(Zwart)	UniTriest-CFX(Zwart)
VOITH	Comet	VOITH-Comet
VTT	FinFlo	VTT-FinFlo

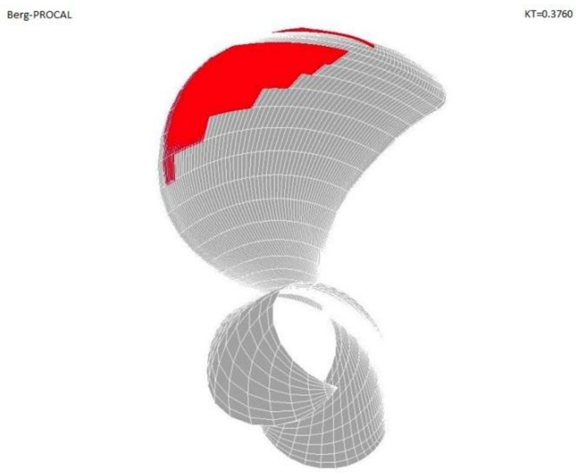
At first the cavity surface for different vapour fractions are evaluated, followed by a summary of the computed thrust coefficient for the cavitating propeller. At the end the pressure distribution on different radii are given for the cavitating and non-cavitating propeller.

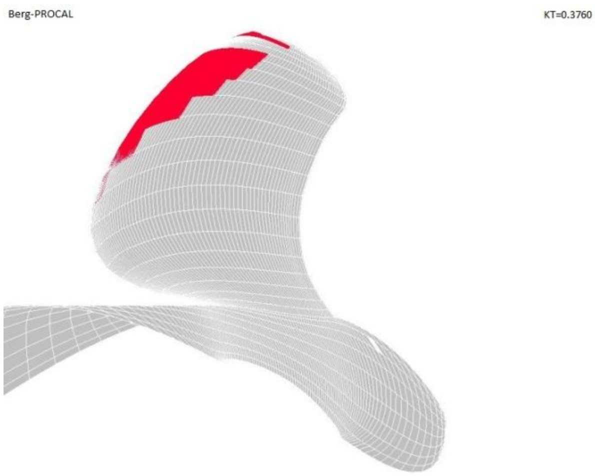
6.1 Case2.3.1, Cavity surface

Berg-Procal



Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387

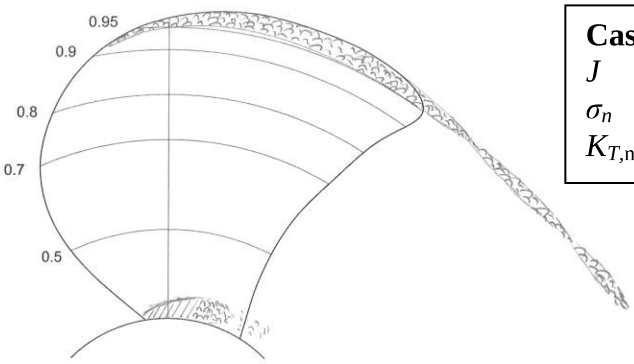




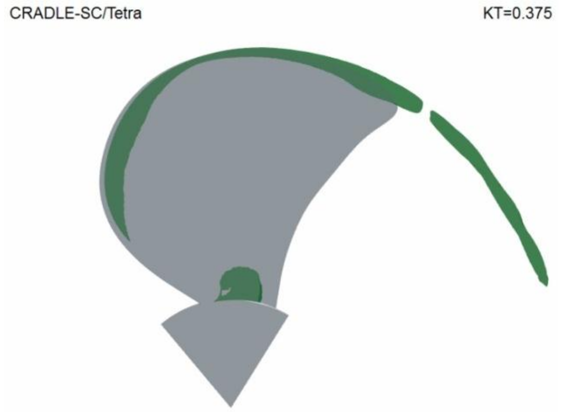
Vapour volume fraction 50%

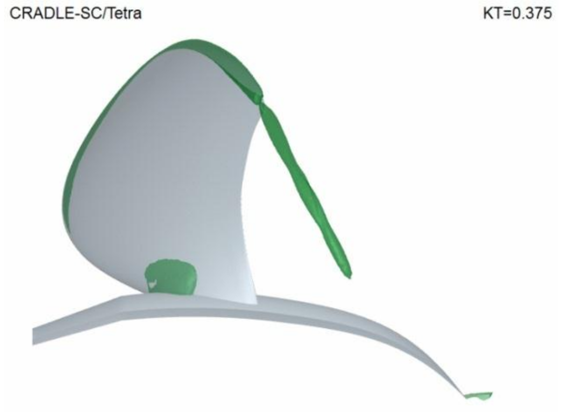
Cradel-SC/Tetra

Case 2.3.1
J = 1.019
σ_n = 2.024
$K_{T,\text{no cav.}}$ = 0.387

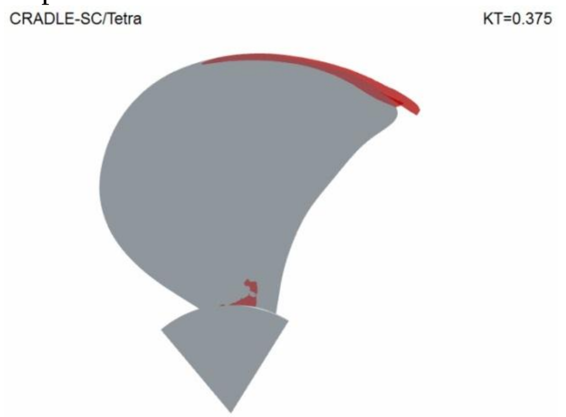


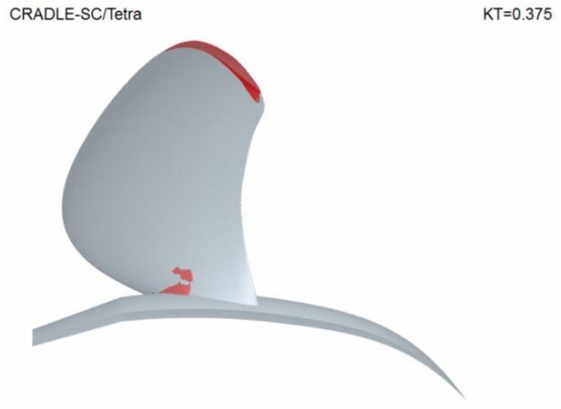
Suction side



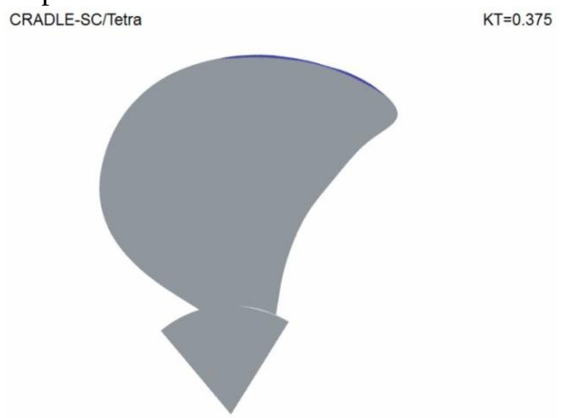


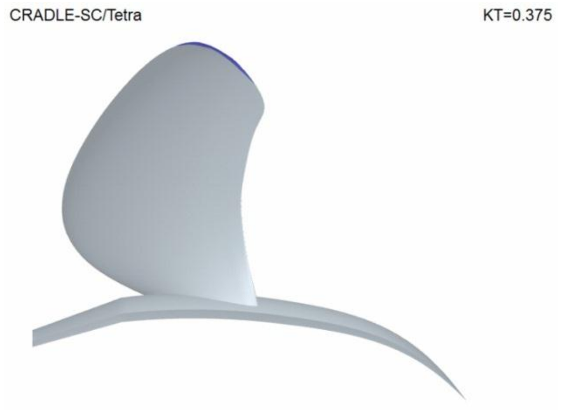
Vapour volume fraction 20%





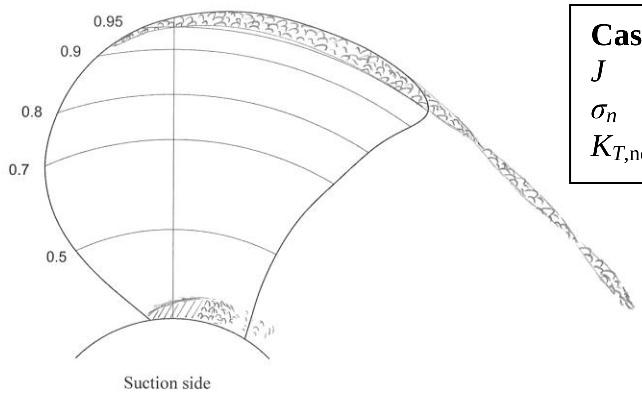
Vapour volume fraction 50%



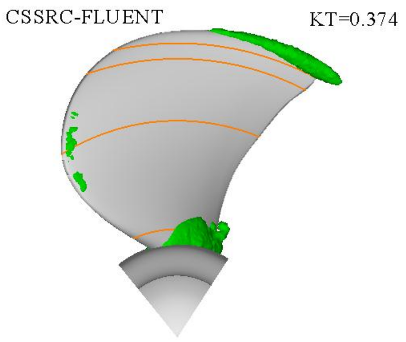


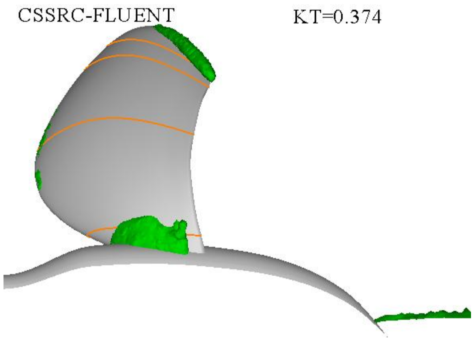
Vapour volume fraction 80%

CSSRC-Fluent

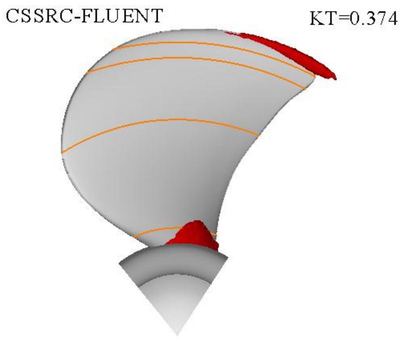


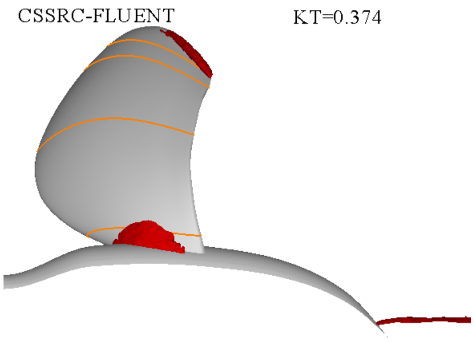
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



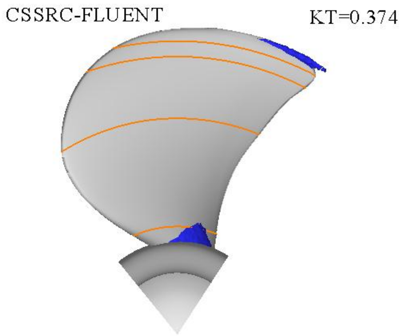


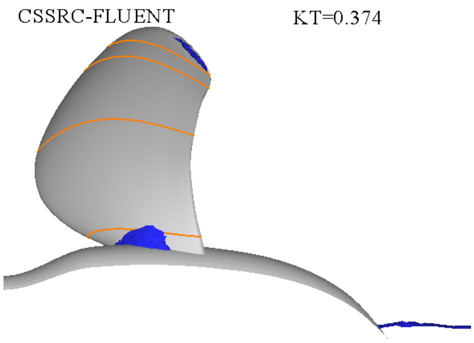
Vapour volume fraction 20%





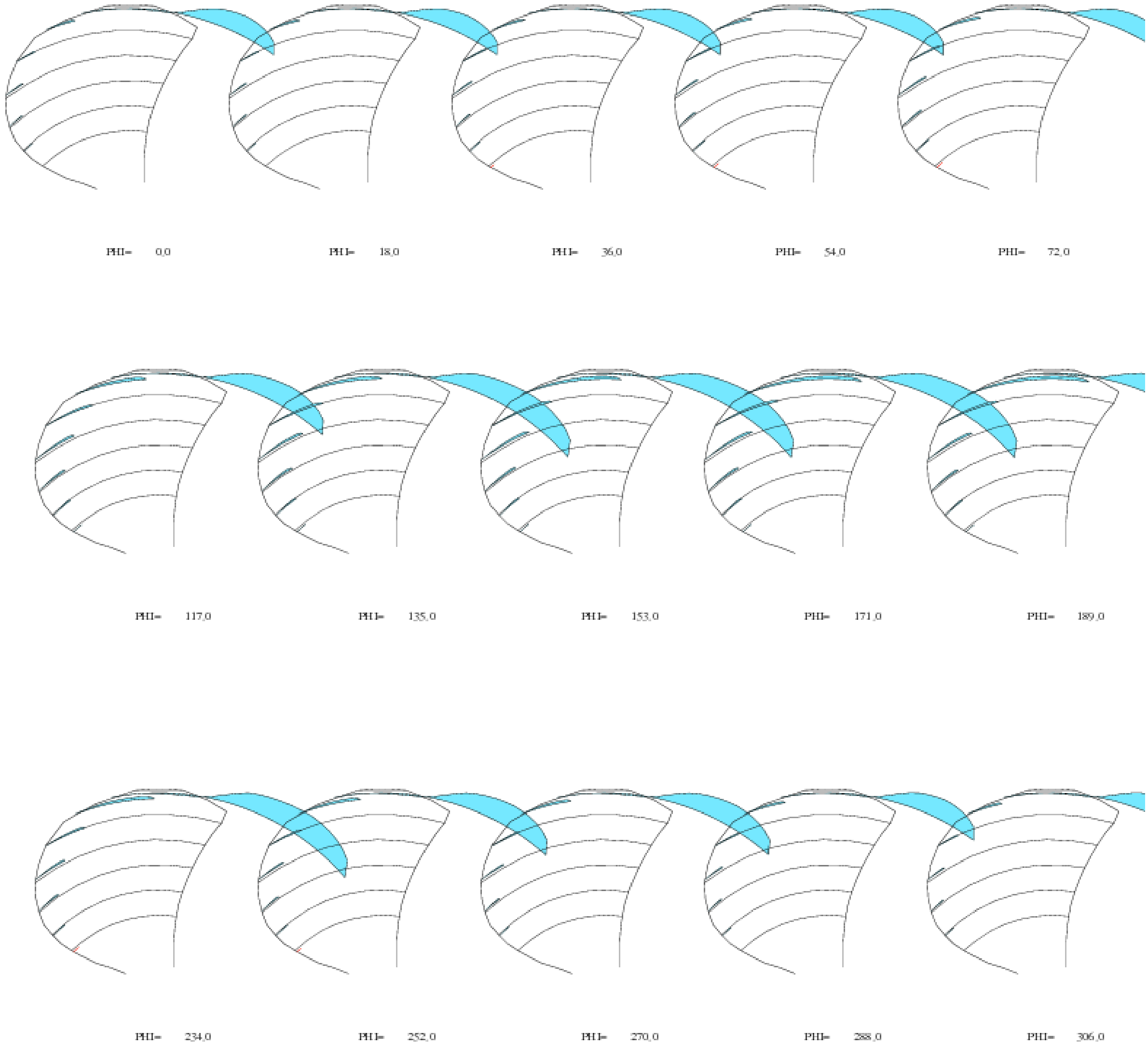
Vapour volume fraction 50%





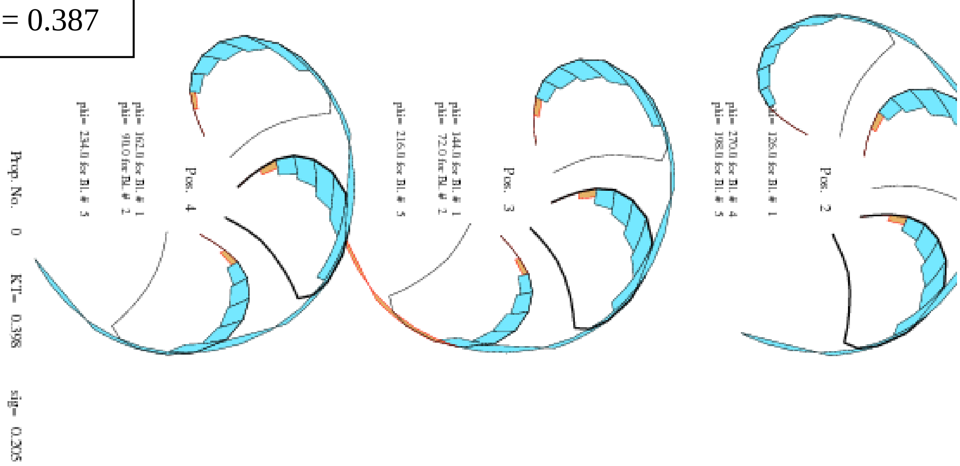
Vapour volume fraction 80%

HSVA-QCM

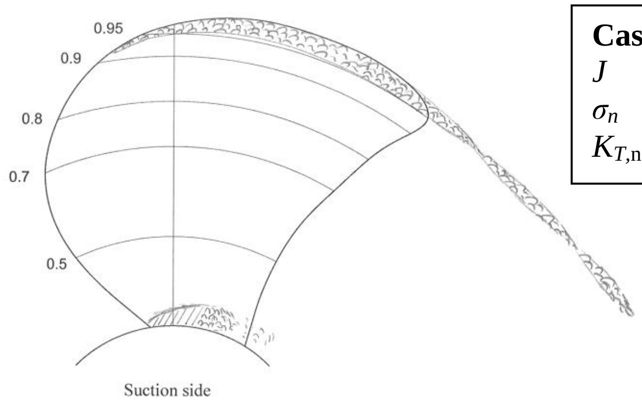


Case 2.3.1

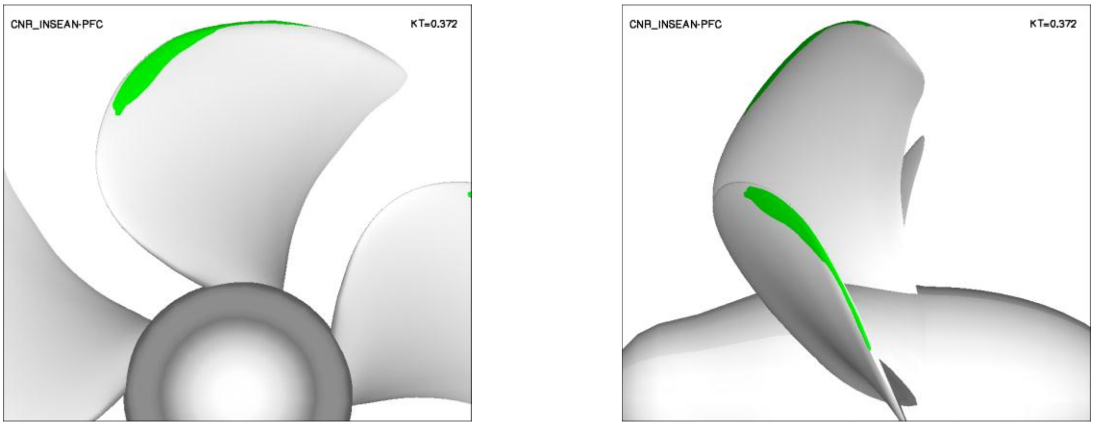
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



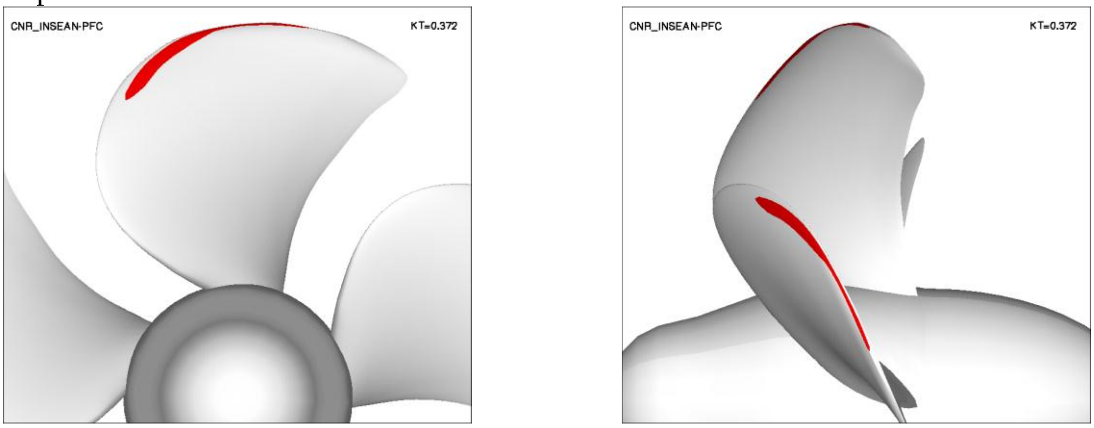
INSEAN-PFC



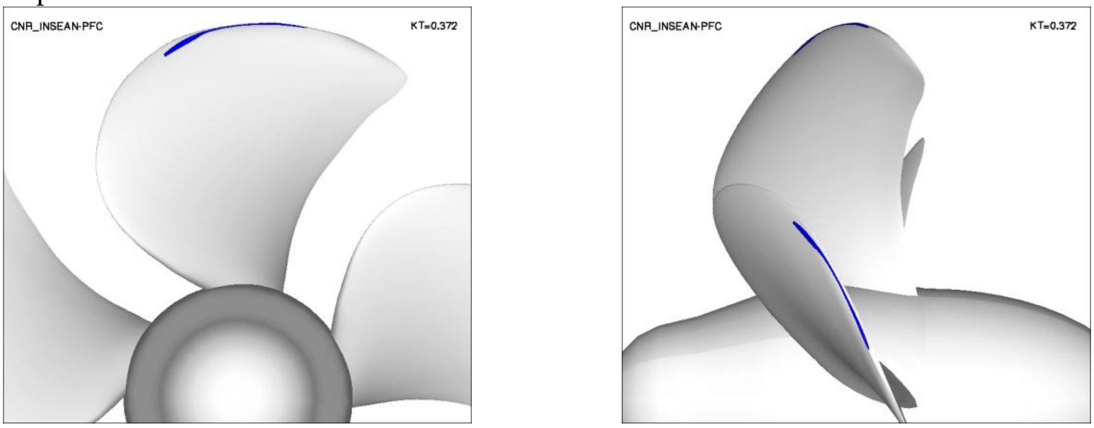
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



Vapour volume fraction 20%

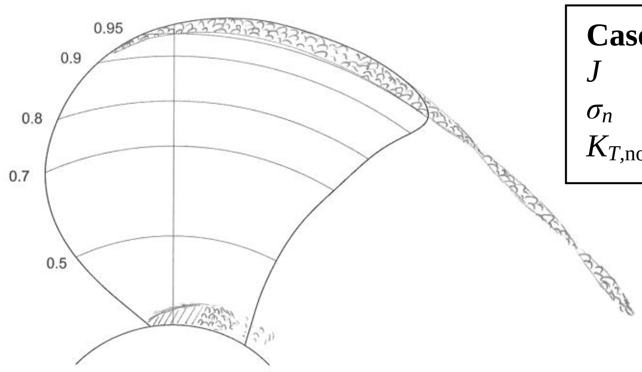


Vapour volume fraction 50%



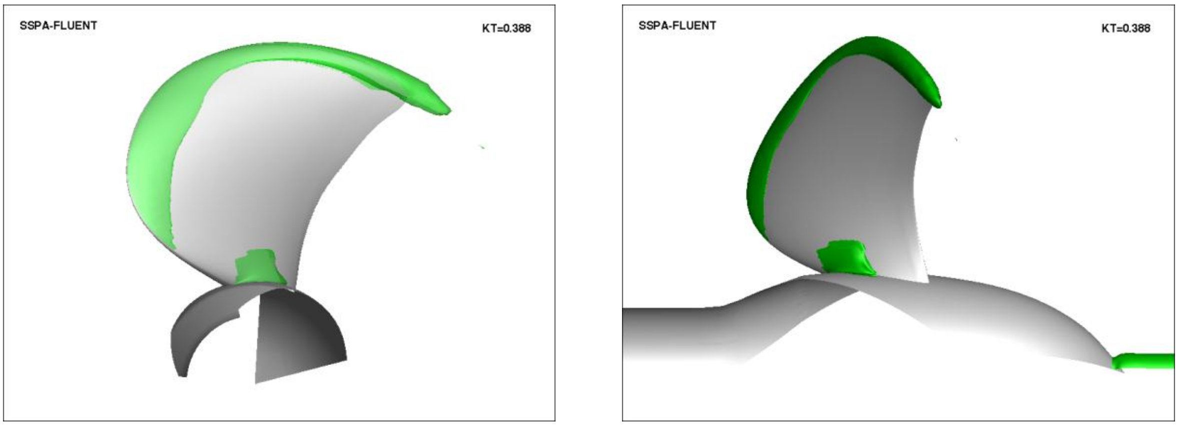
Vapour volume fraction 80%

SSPA-Fluent

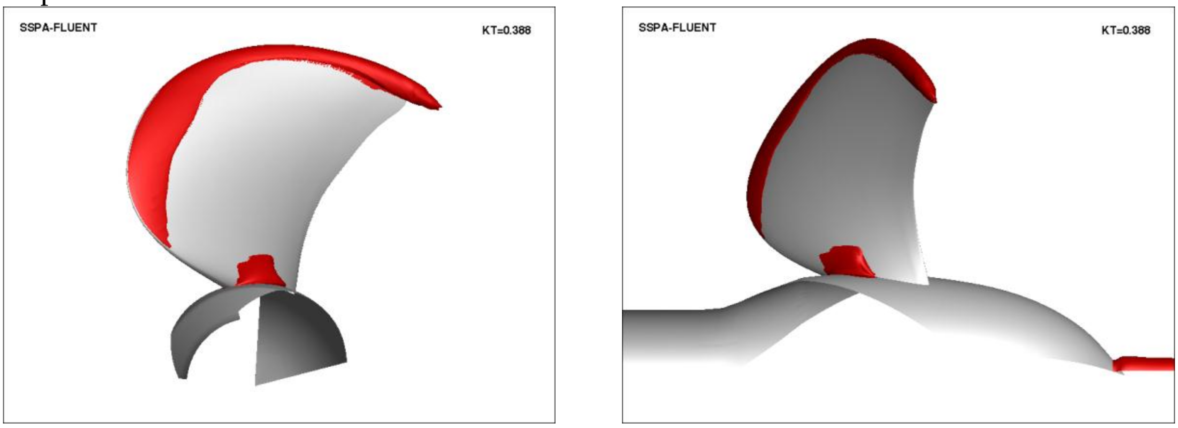


Suction side

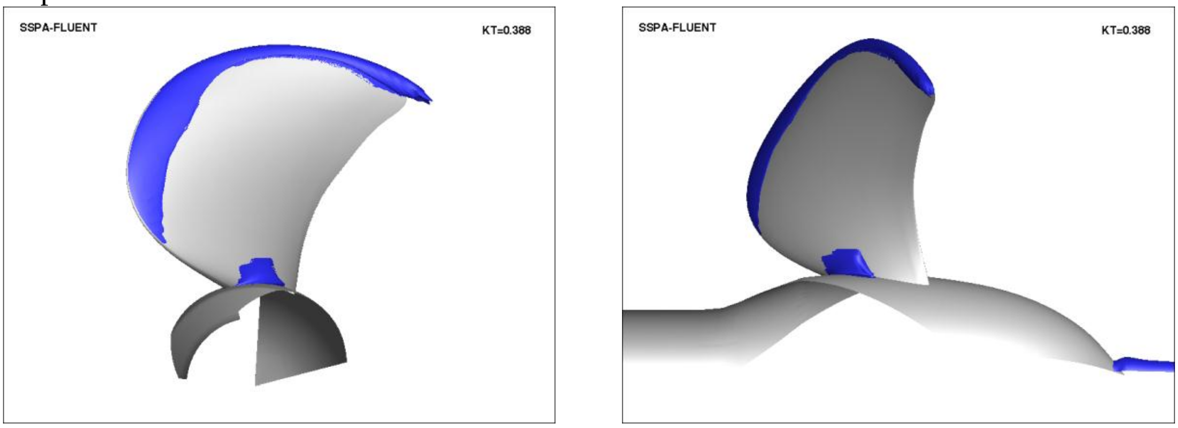
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



Vapour volume fraction 20%



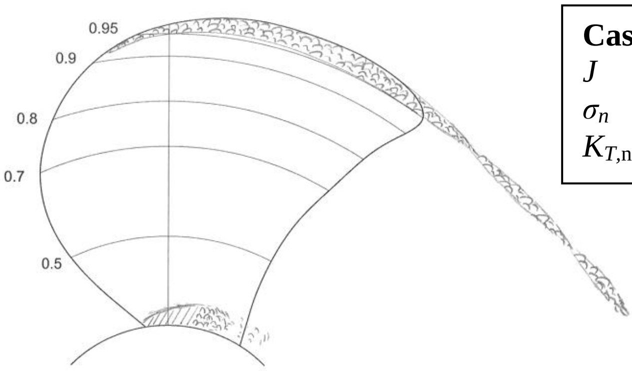
Vapour volume fraction 50%



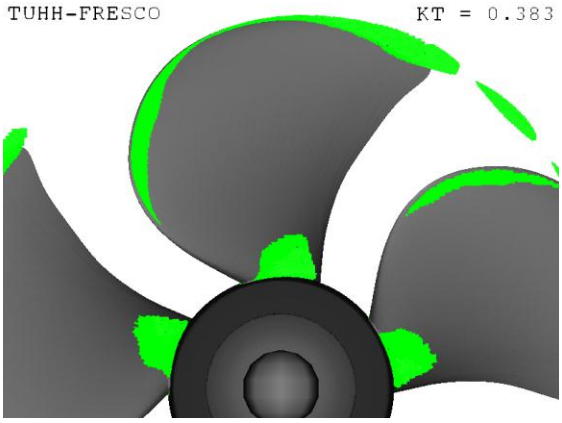
Vapour volume fraction 80%

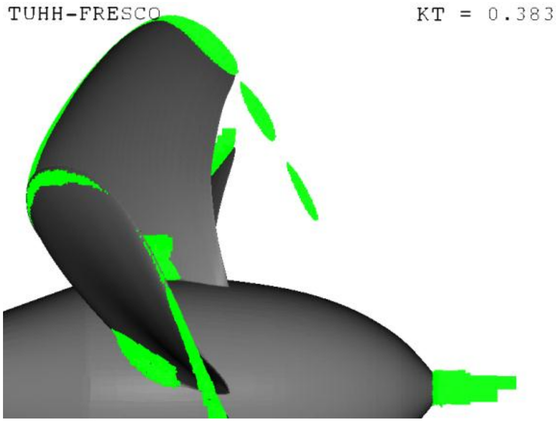
TUHH-FreSCO+

Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387

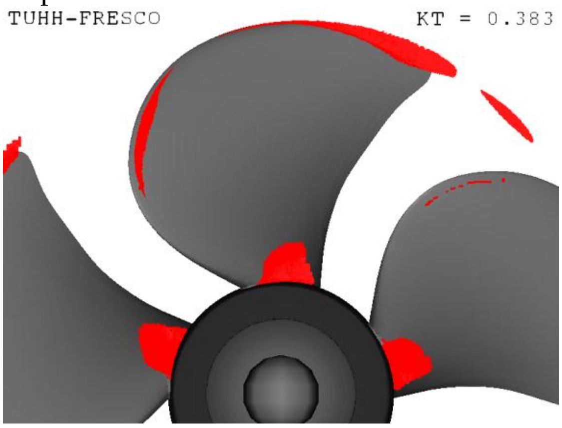


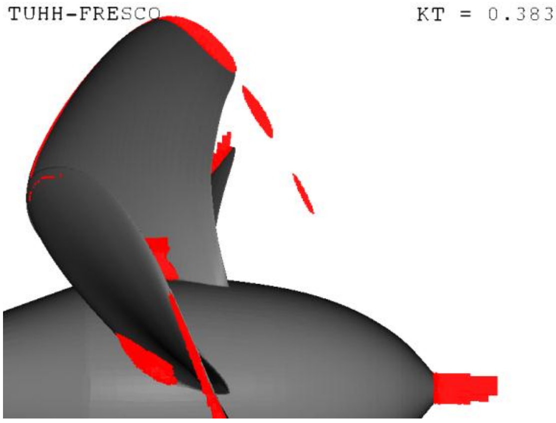
Suction side



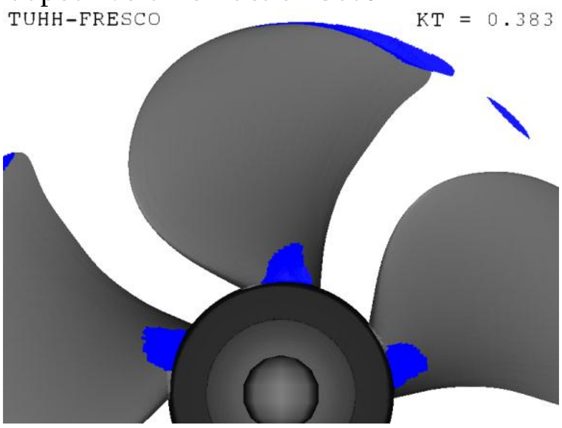


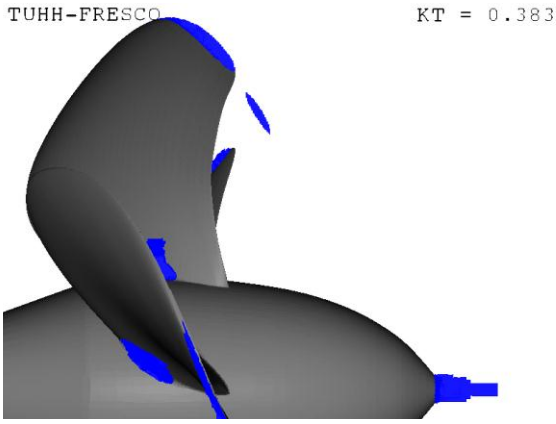
Vapour volume fraction 20%





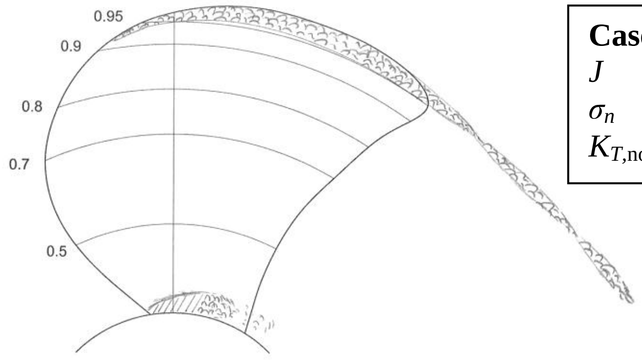
Vapour volume fraction 50%





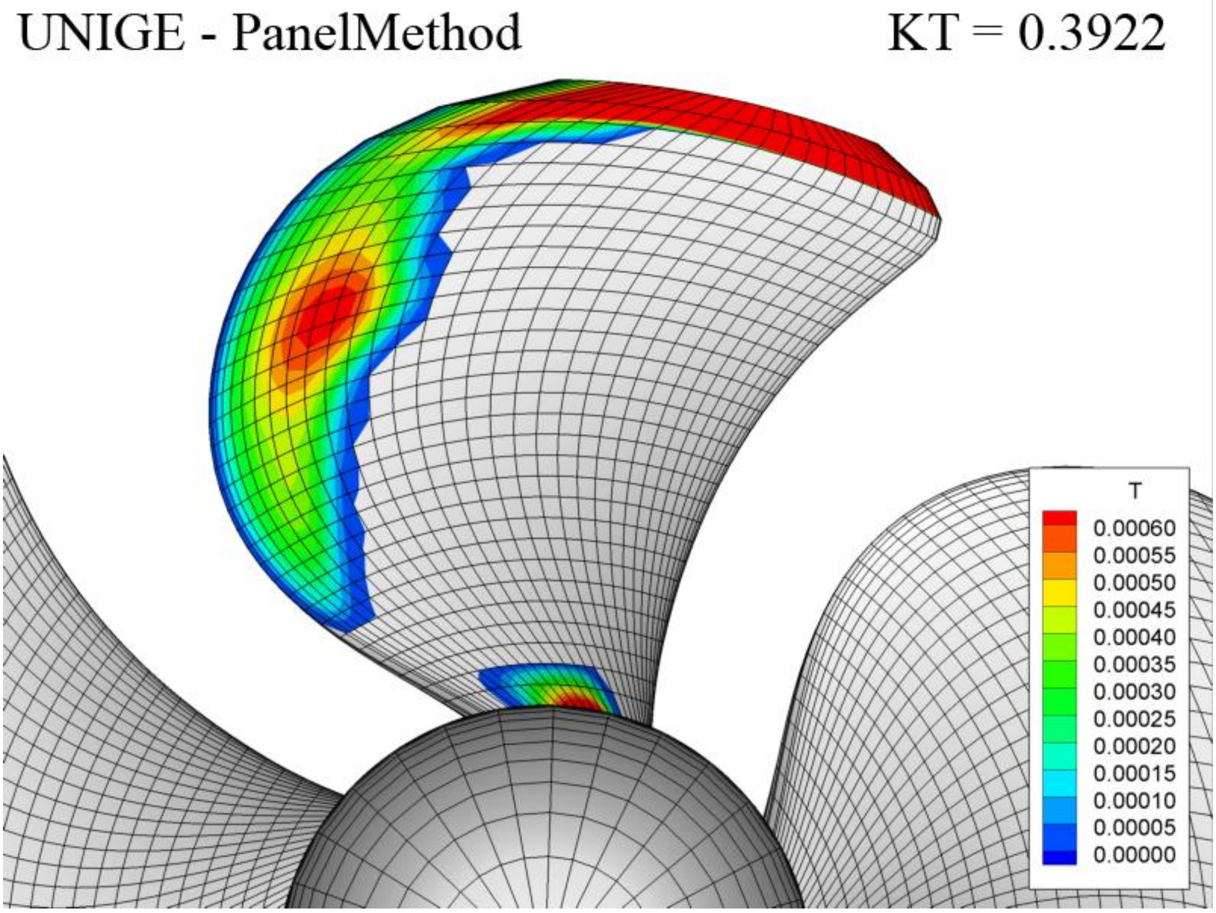
Vapour volume fraction 80%

UniGenua-Panel

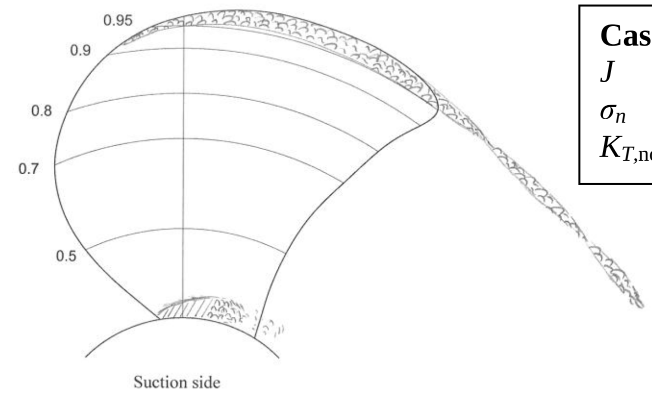


Suction side

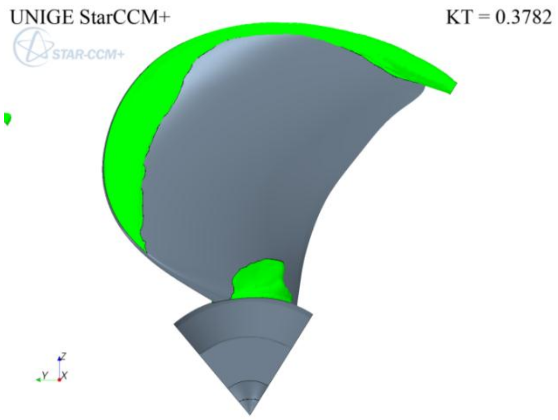
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387

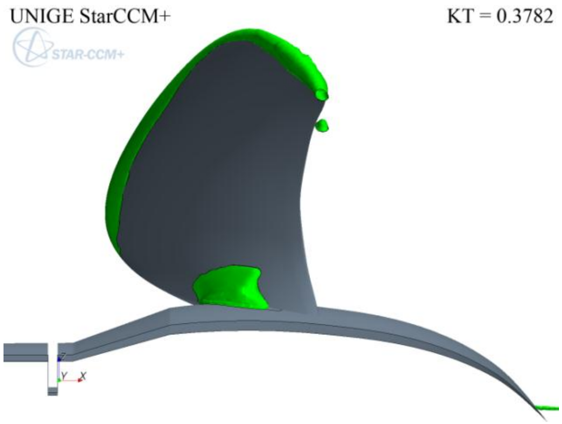


UniGenua-StarCCM+

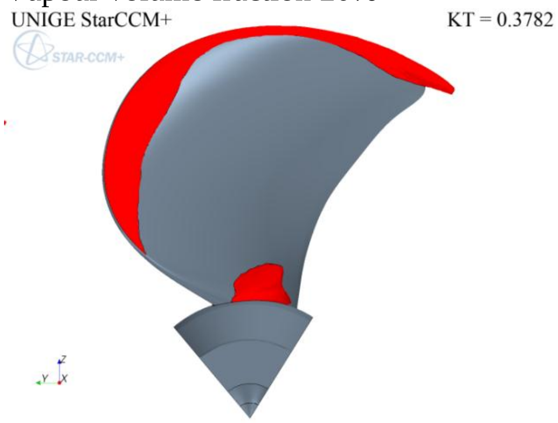


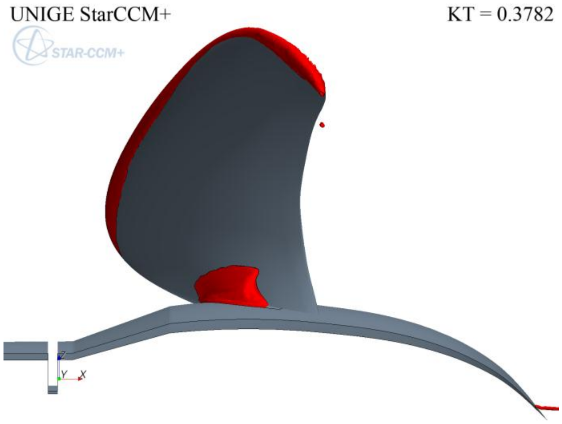
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



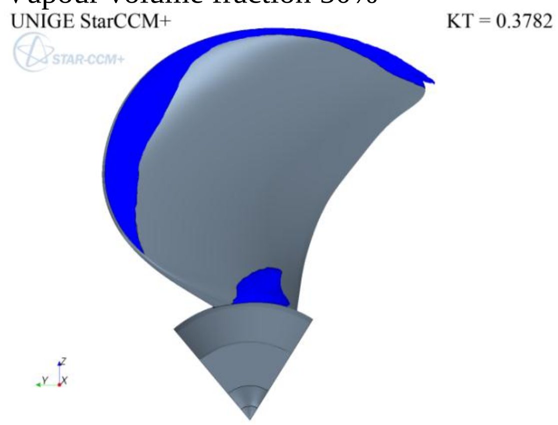


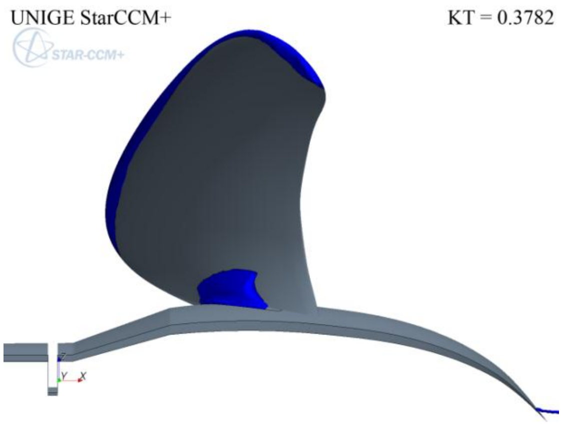
Vapour volume fraction 20%





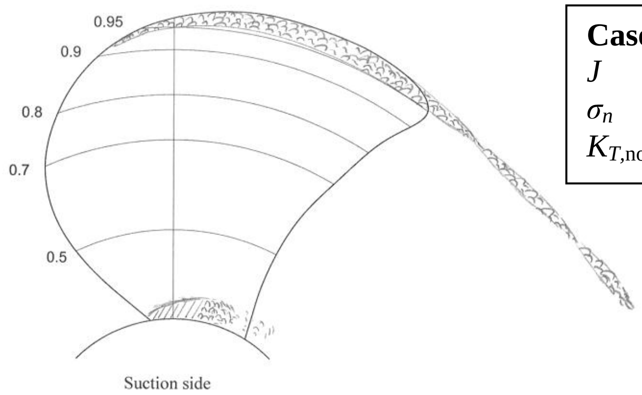
Vapour volume fraction 50%



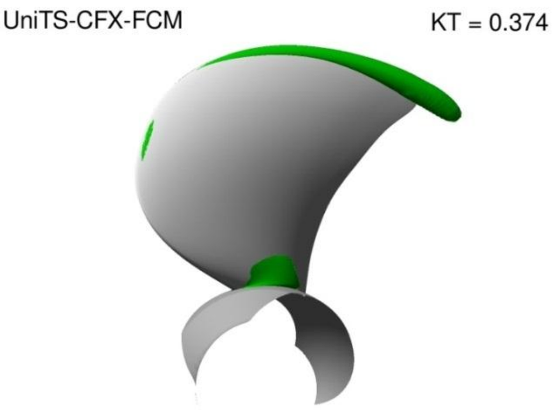


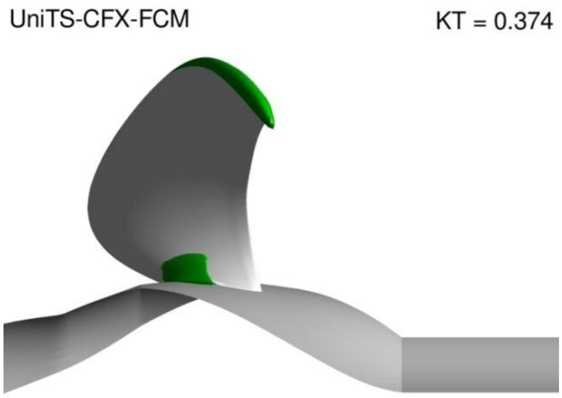
Vapour volume fraction 80%

UniTriest-CFX(FCM)

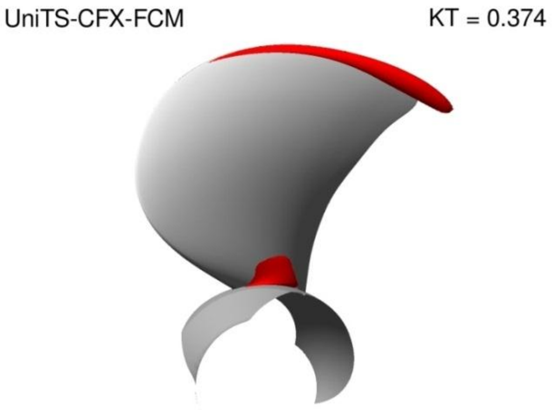


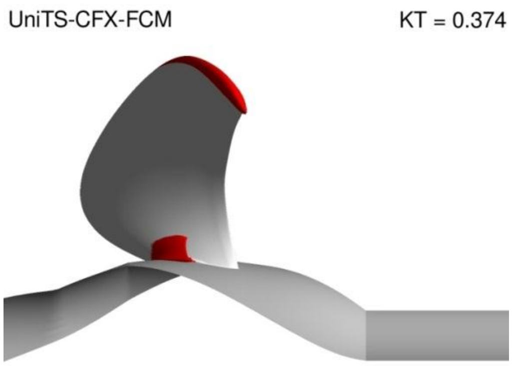
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



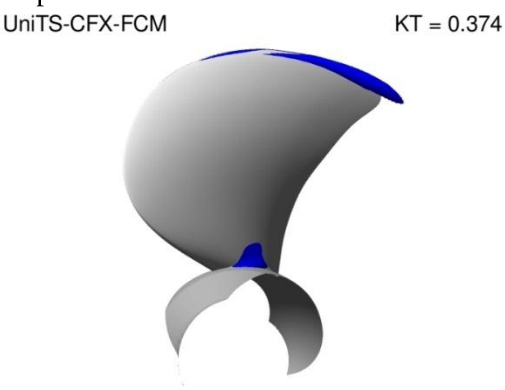


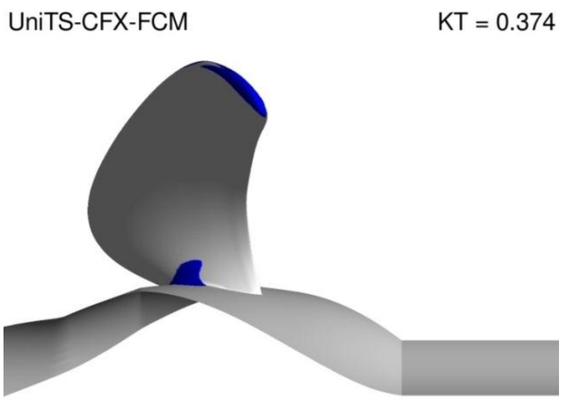
Vapour volume fraction 20%





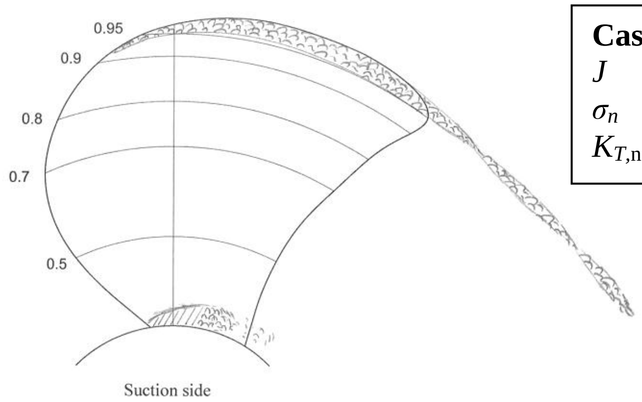
Vapour volume fraction 50%





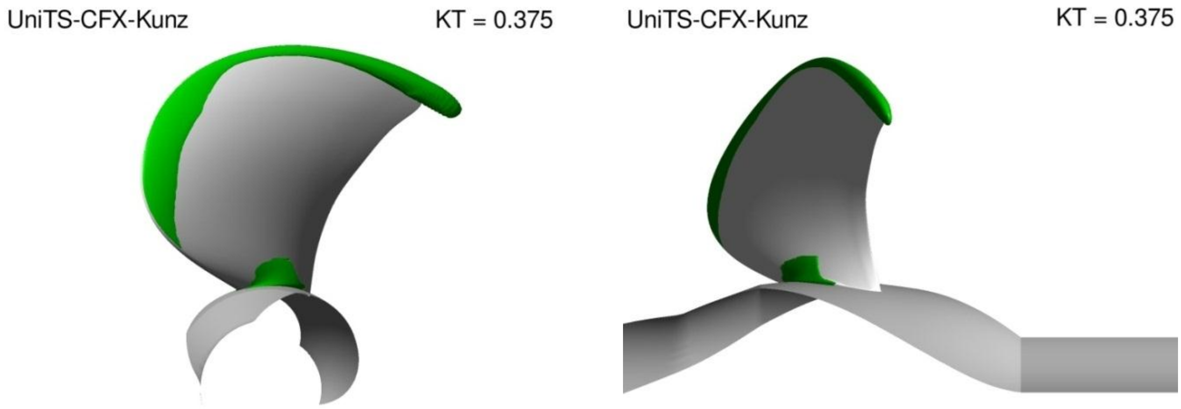
Vapour volume fraction 80%

UniTriest-CFX(Kunz)

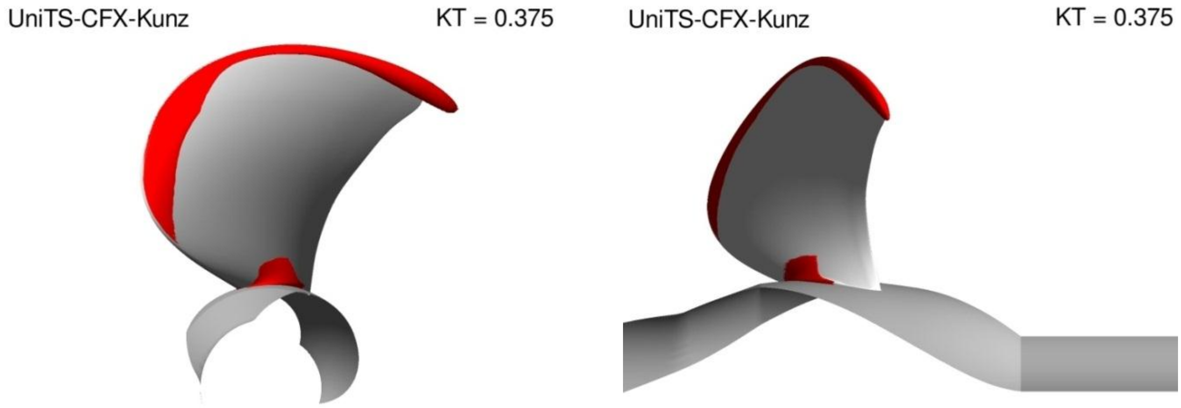


Case 2.3.1

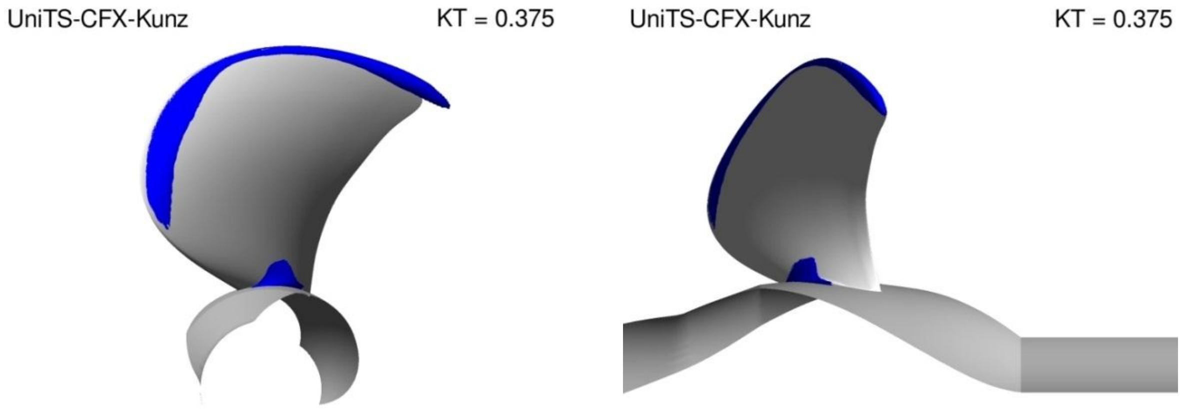
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



Vapour volume fraction 20%



Vapour volume fraction 50%

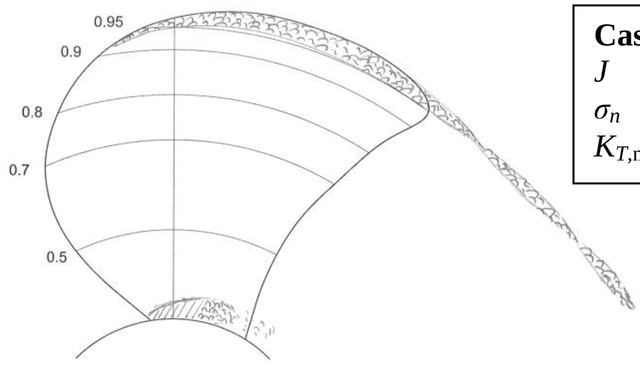


Vapour volume fraction 80%

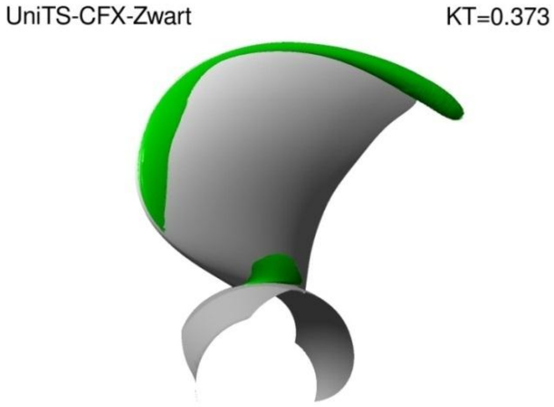
UniTriest-CFX(Zwart)

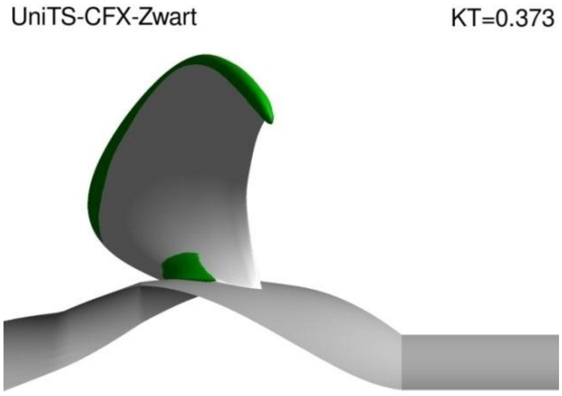
Case 2.3.1

J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387

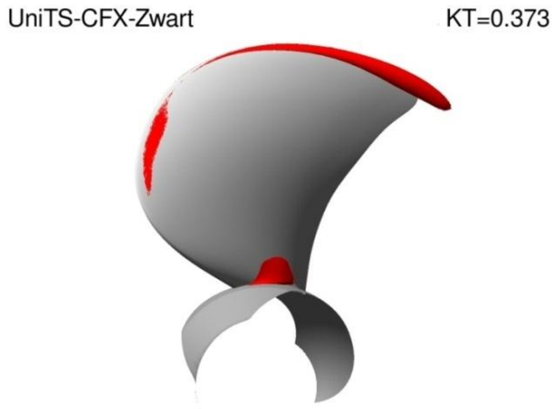


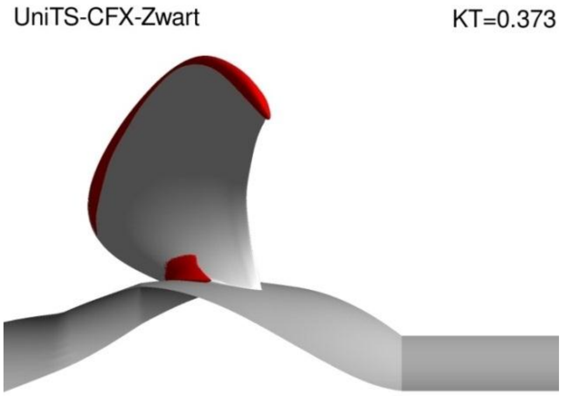
Suction side



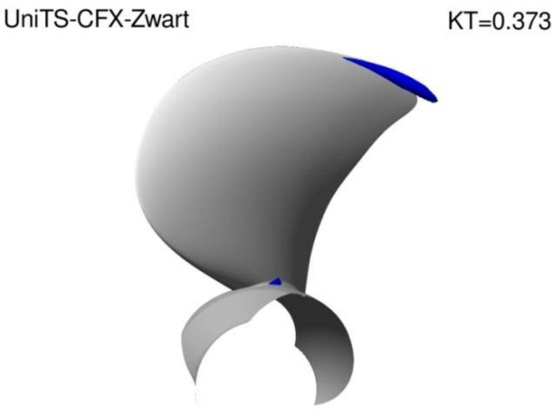


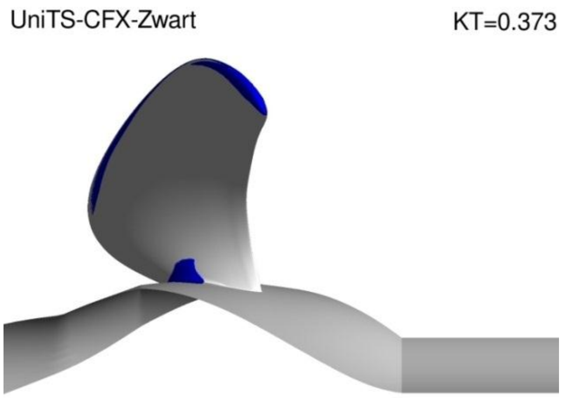
Vapour volume fraction 20%





Vapour volume fraction 50%

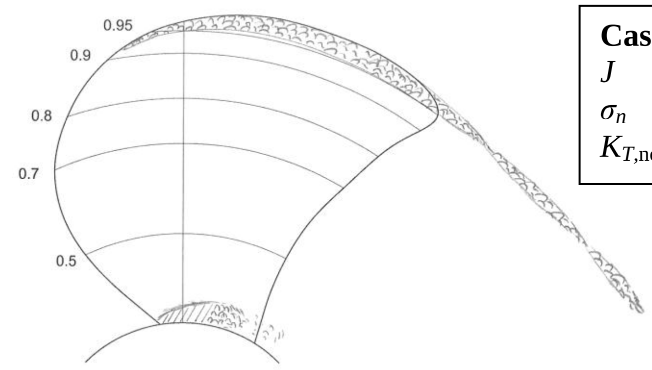




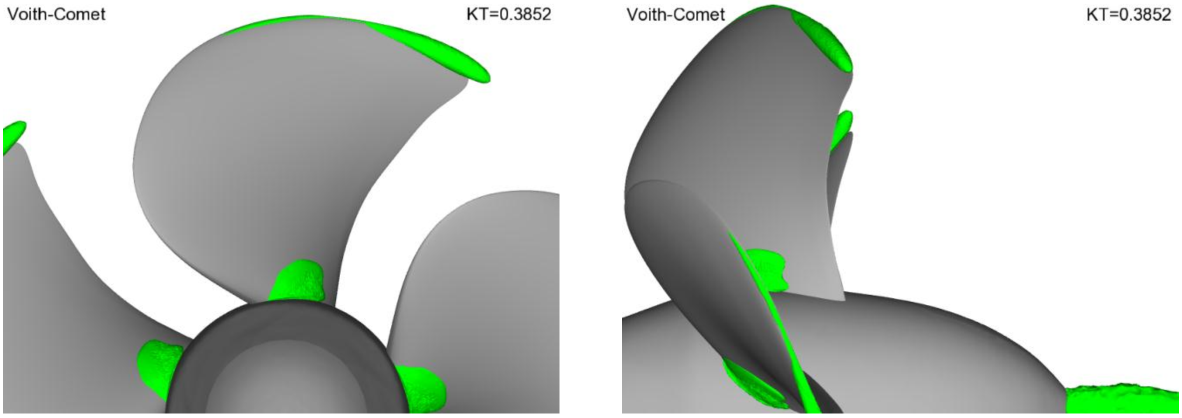
Vapour volume fraction 80%

VOITH-Comet

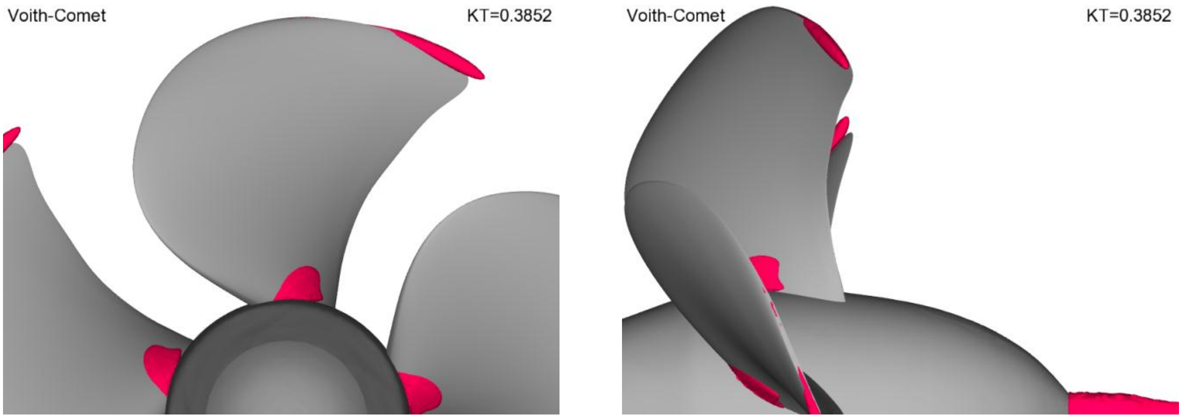
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



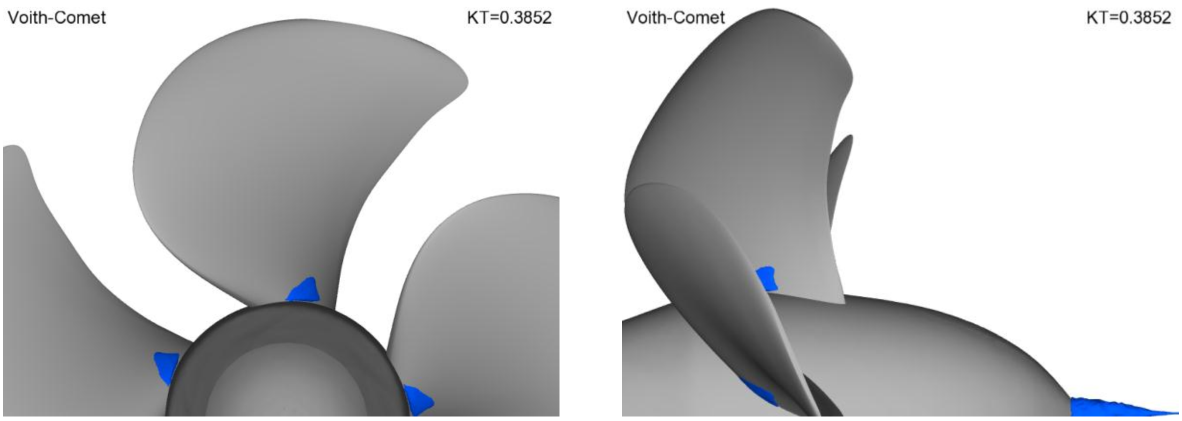
Suction side



Vapour volume fraction 20%



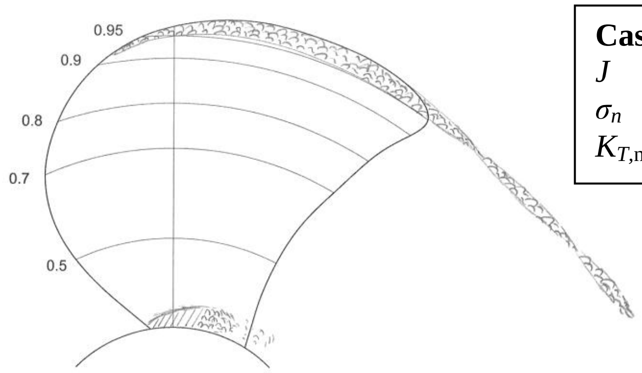
Vapour volume fraction 50%



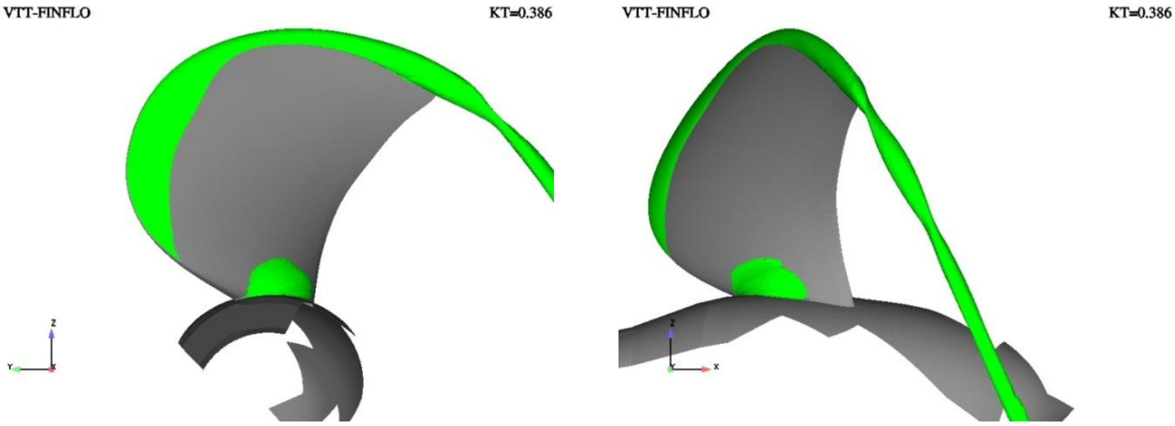
Vapour volume fraction 80%

VTT-FinFlo

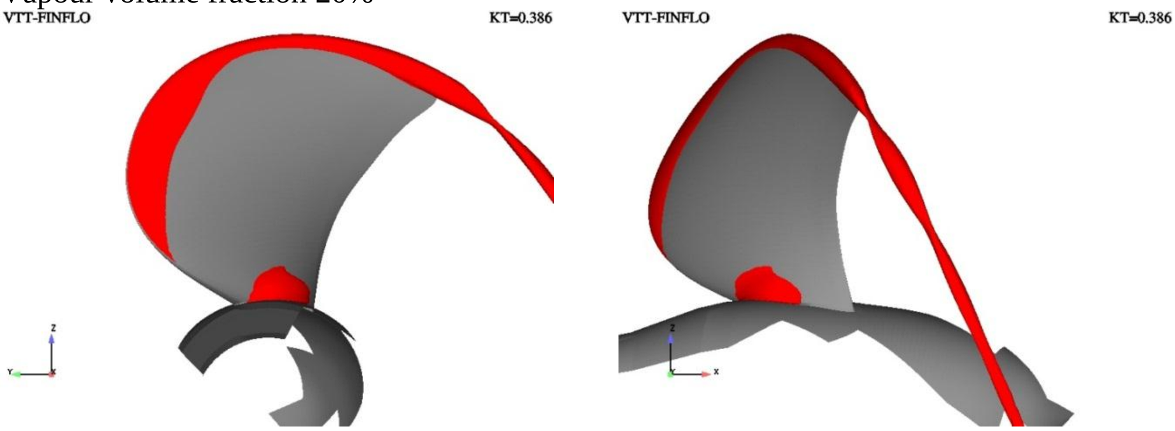
Case 2.3.1	
J	= 1.019
σ_n	= 2.024
$K_{T,\text{no cav.}}$	= 0.387



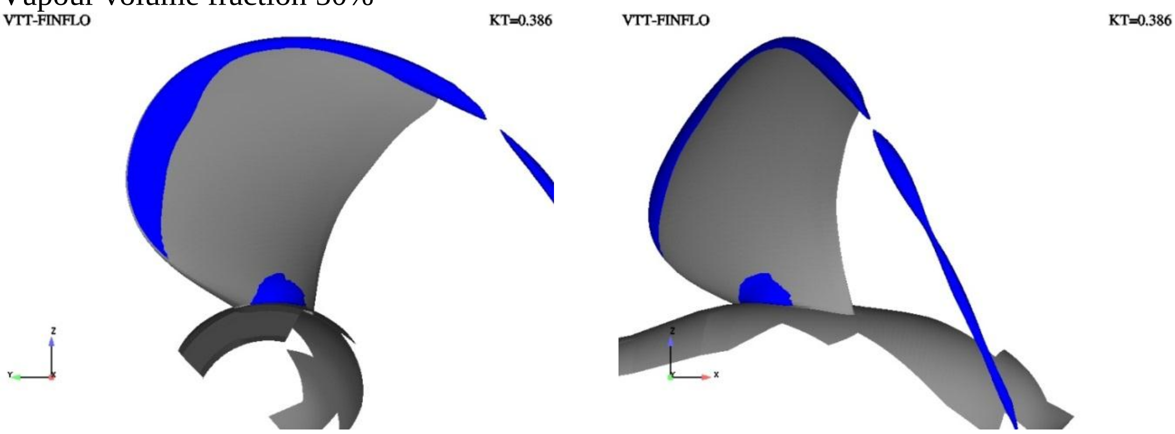
Suction side



Vapour volume fraction 20%



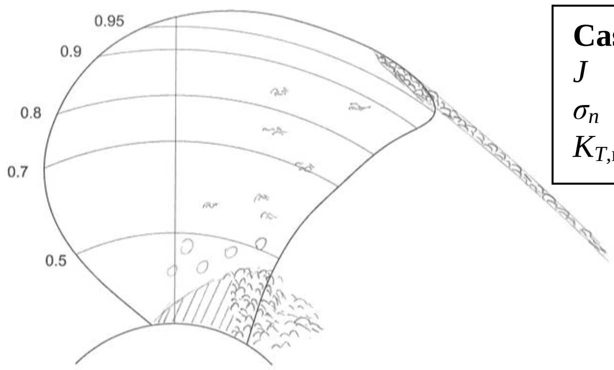
Vapour volume fraction 50%



Vapour volume fraction 80%

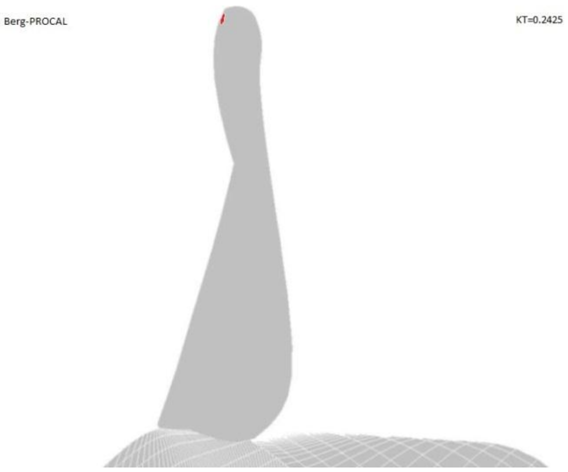
6.2 Case2.3.2, Cavity surface

Berg-Procal



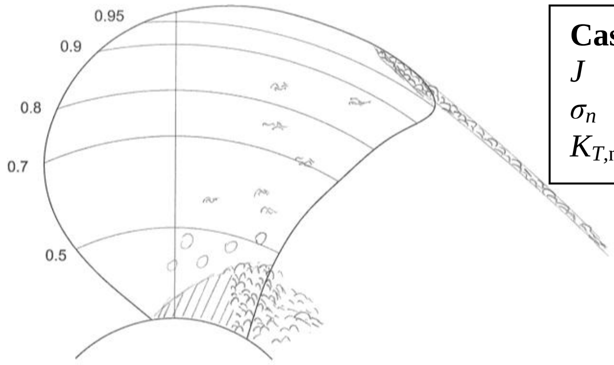
Suction side

Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



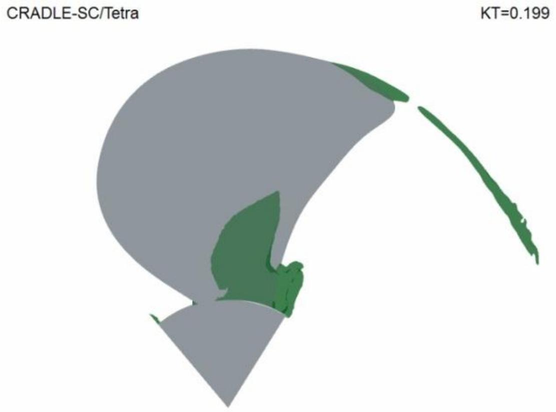
Vapour volume fraction 50%

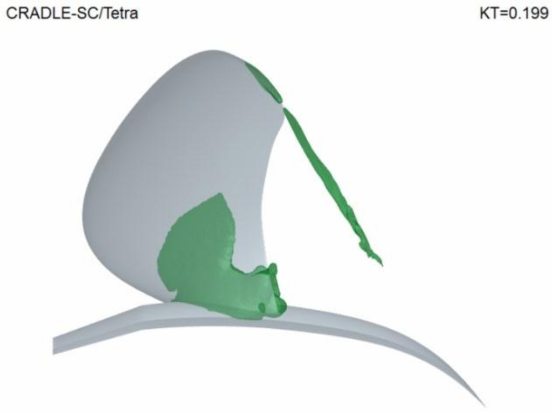
Cradle-SC/Tetra



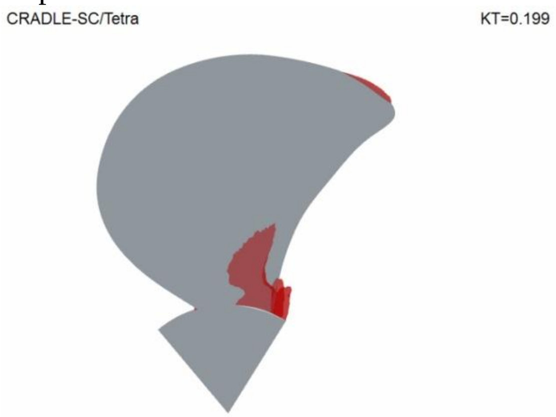
Suction side

Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245

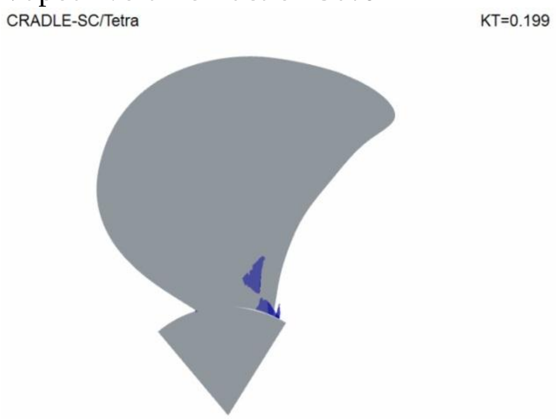


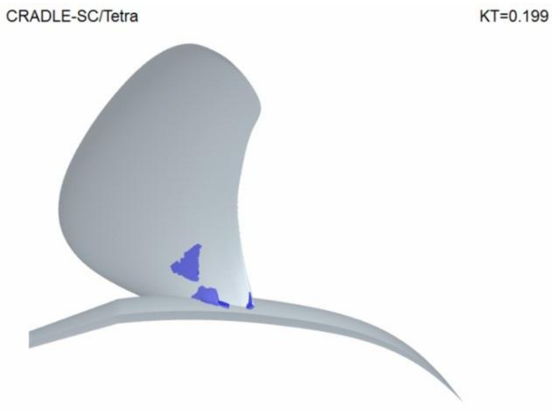


Vapour volume fraction 20%



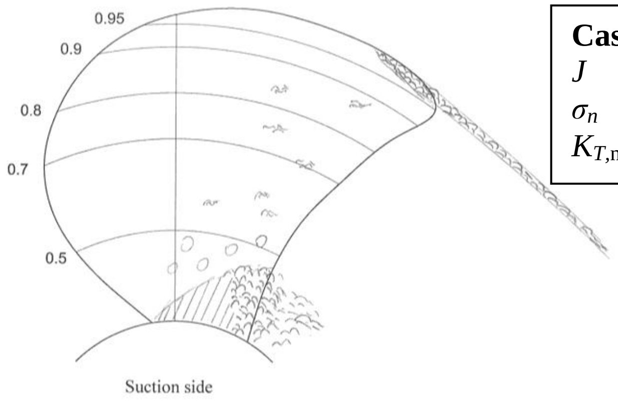
Vapour volume fraction 50%





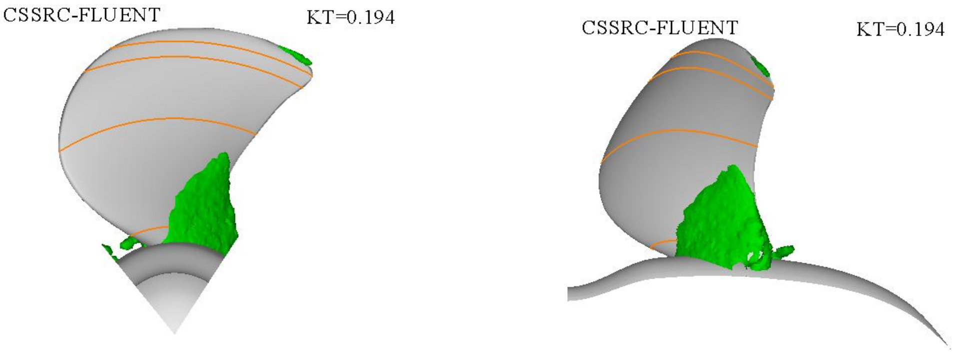
Vapour volume fraction 80%

CSSRC-Fluent

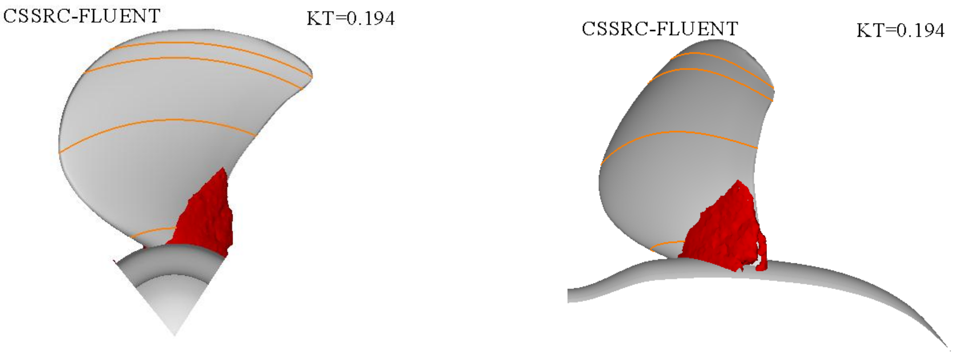


Case 2.3.2

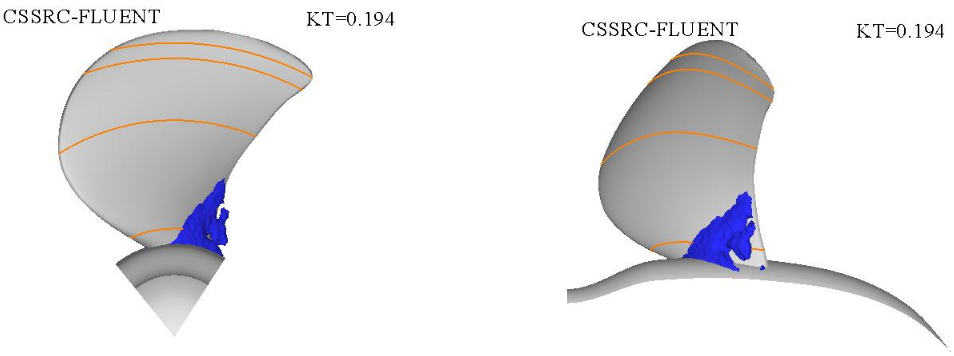
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Vapour volume fraction 20%

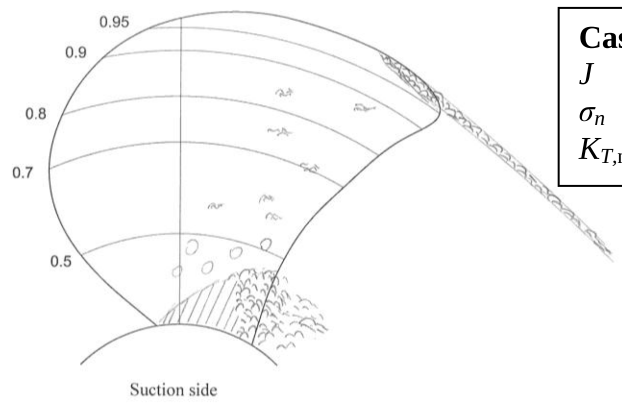


Vapour volume fraction 50%



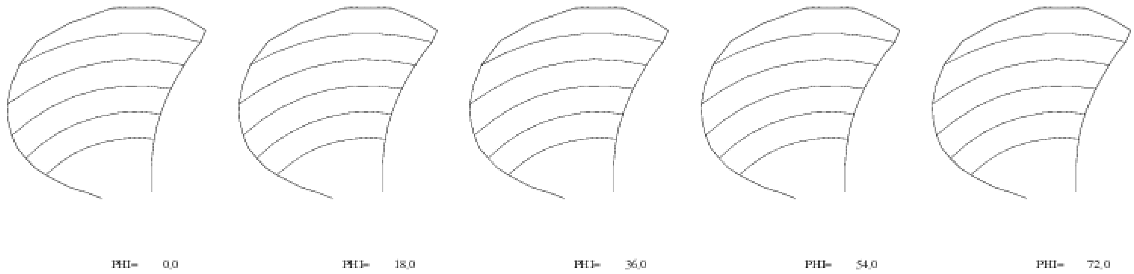
Vapour volume fraction 80%

HSVA-QCM

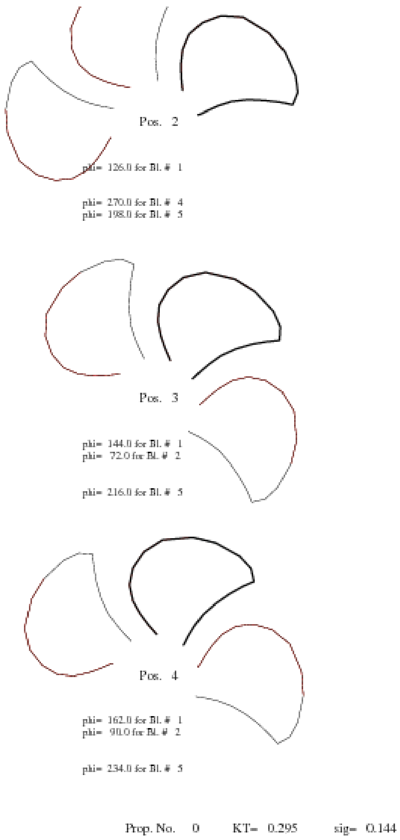


Case 2.3.2

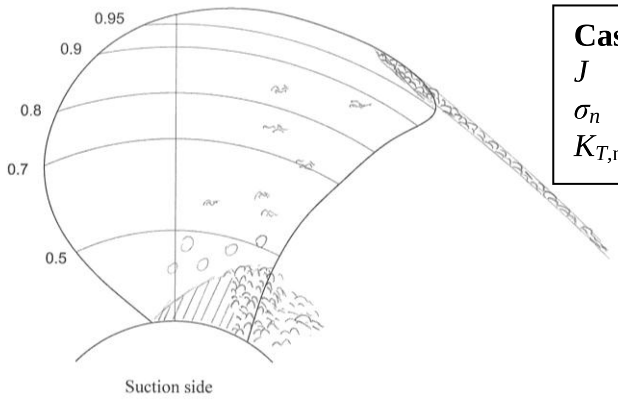
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



(for all angular positions)

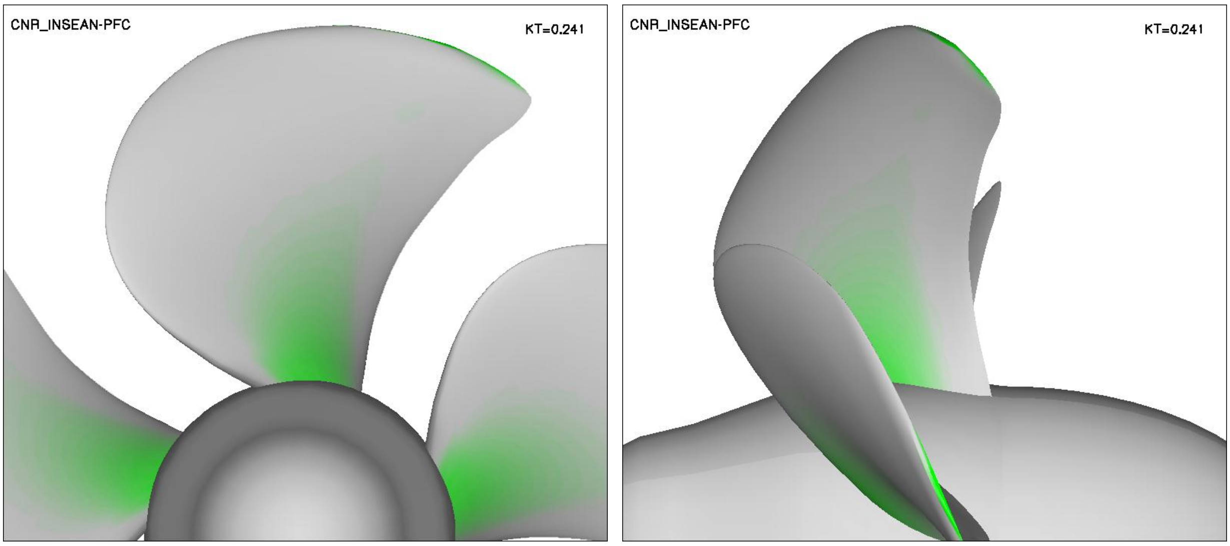


INSEAN-PFC



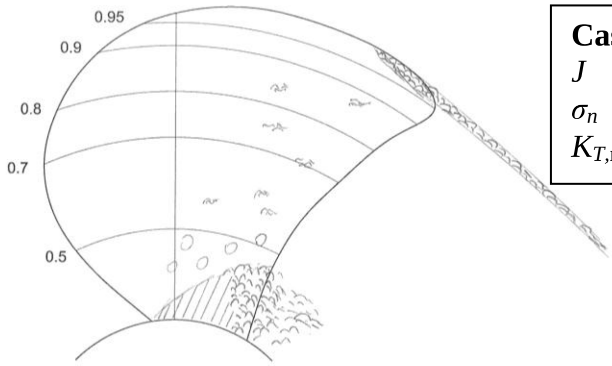
Case 2.3.2

J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Blade surface region $p \leq p_v$

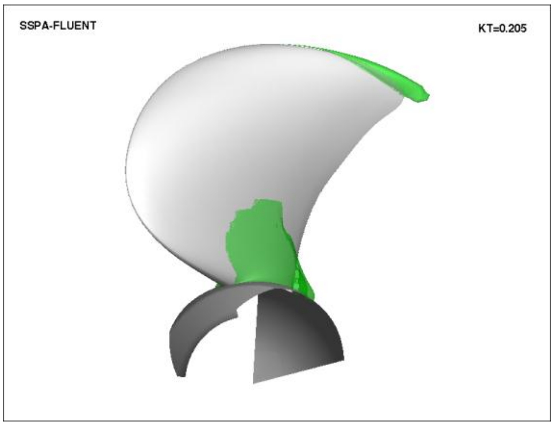
SSPA-Fluent

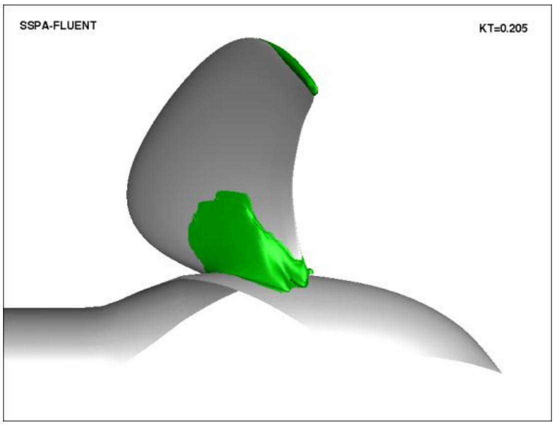


Suction side

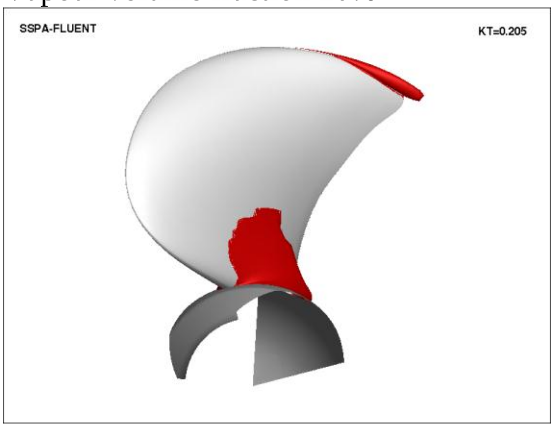
Case 2.3.2

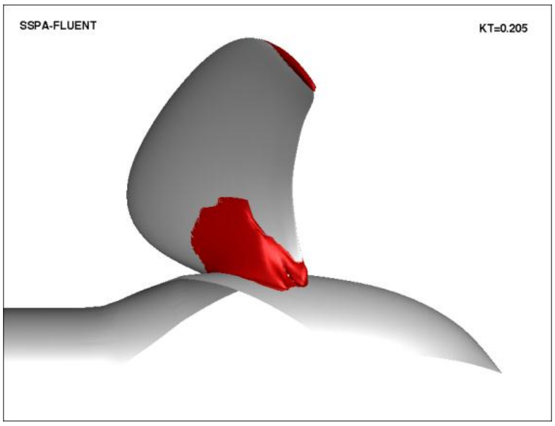
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



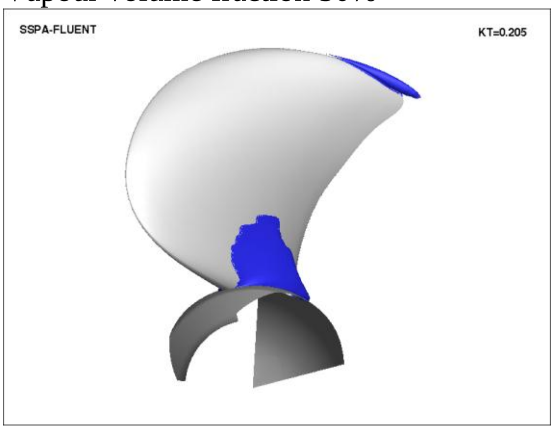


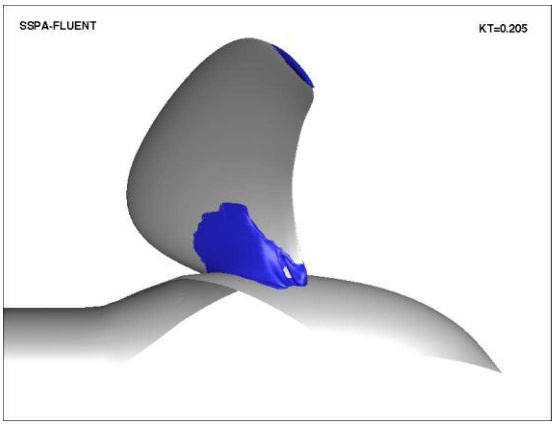
Vapour volume fraction 20%





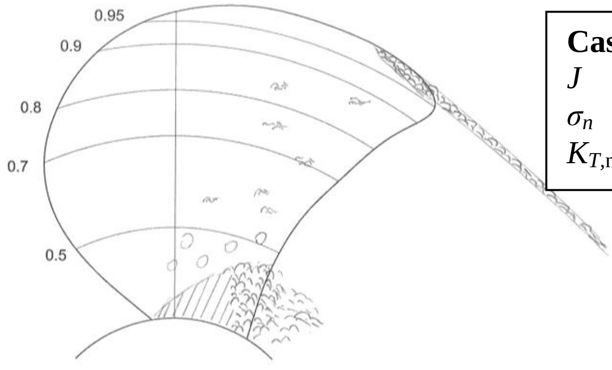
Vapour volume fraction 50%



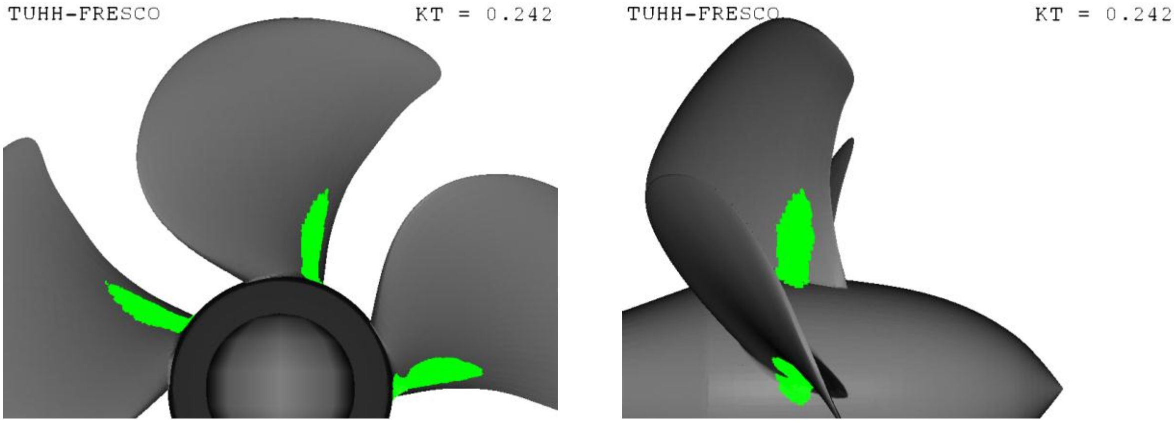


Vapour volume fraction 80%

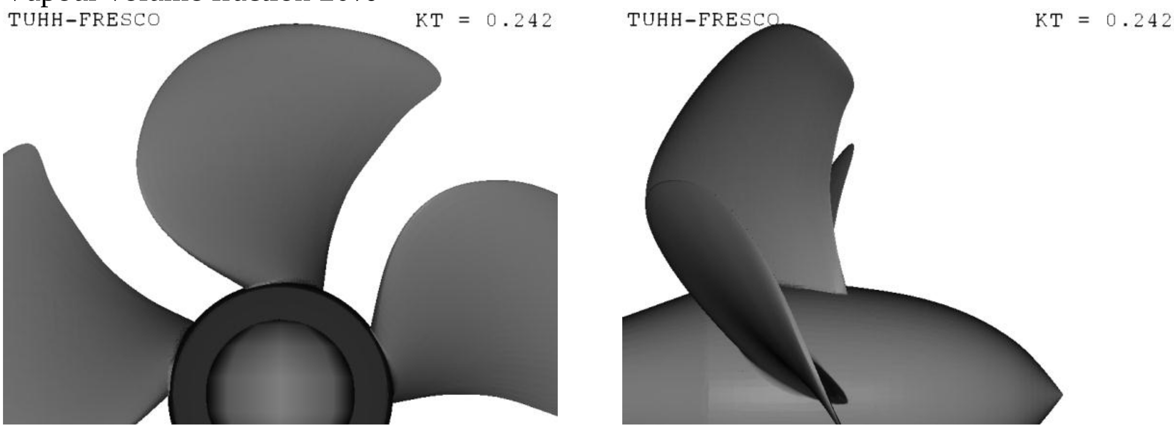
TUHH-FreSCO+(small coeff.)



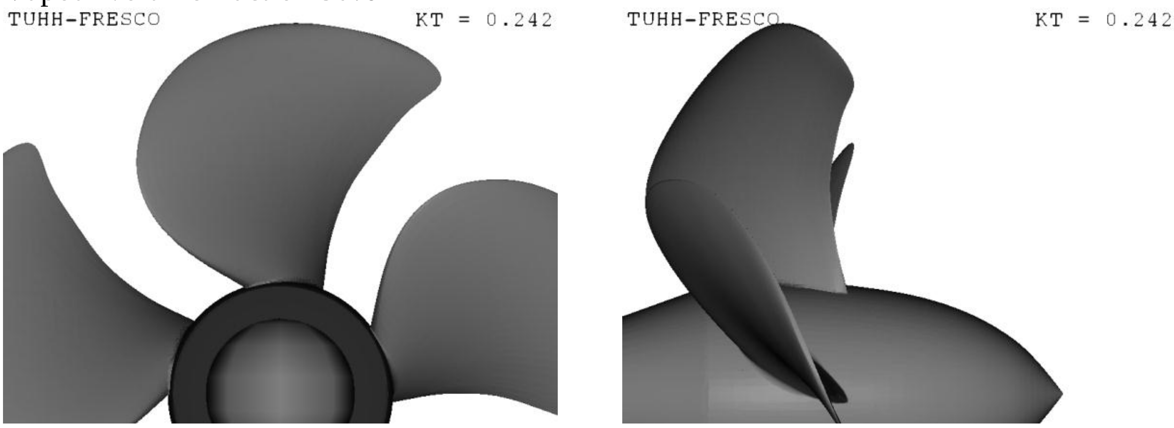
Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Vapour volume fraction 20%

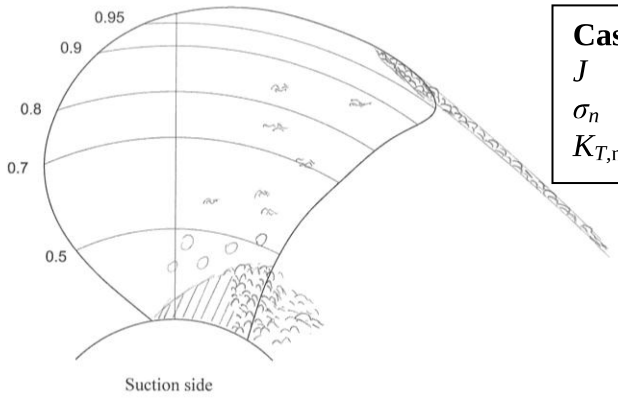


Vapour volume fraction 50%

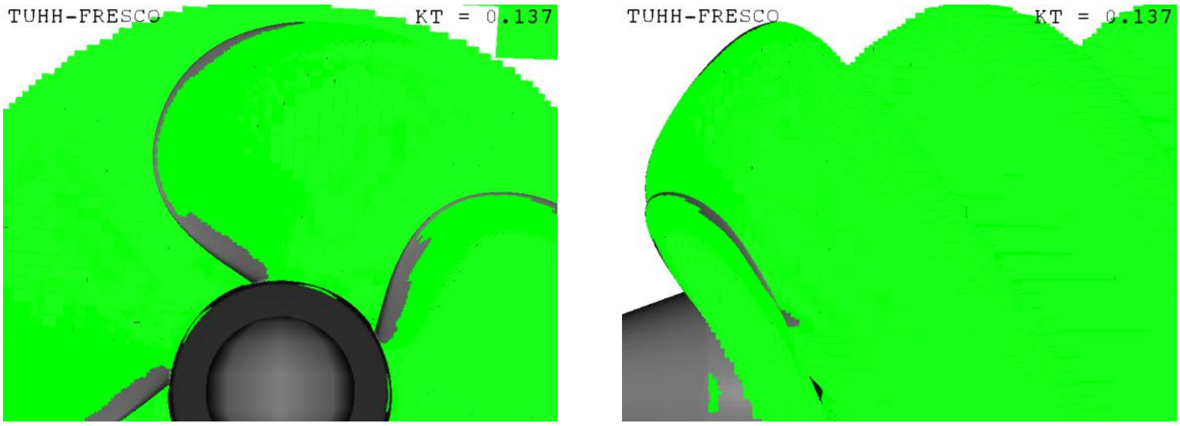


Vapour volume fraction 80%

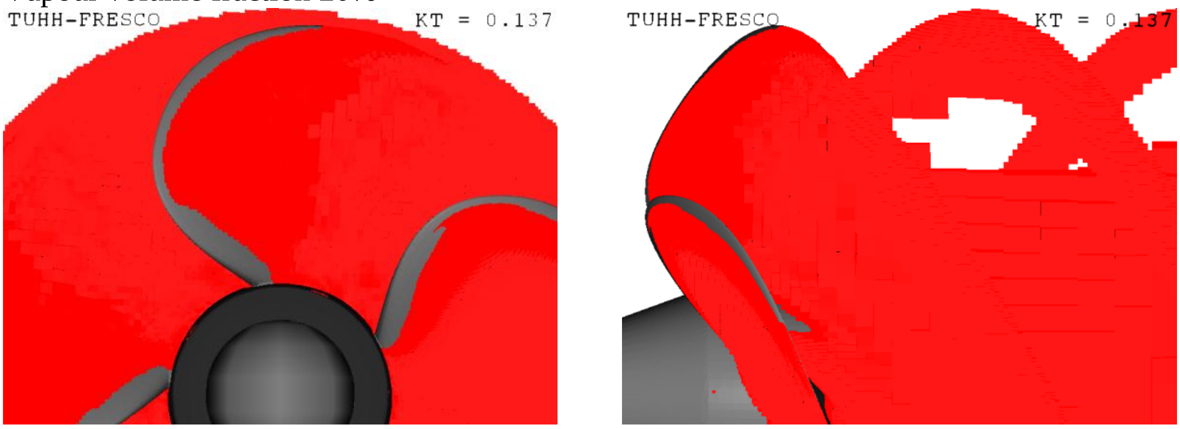
TUHH-FreSCO+(large coeff.)



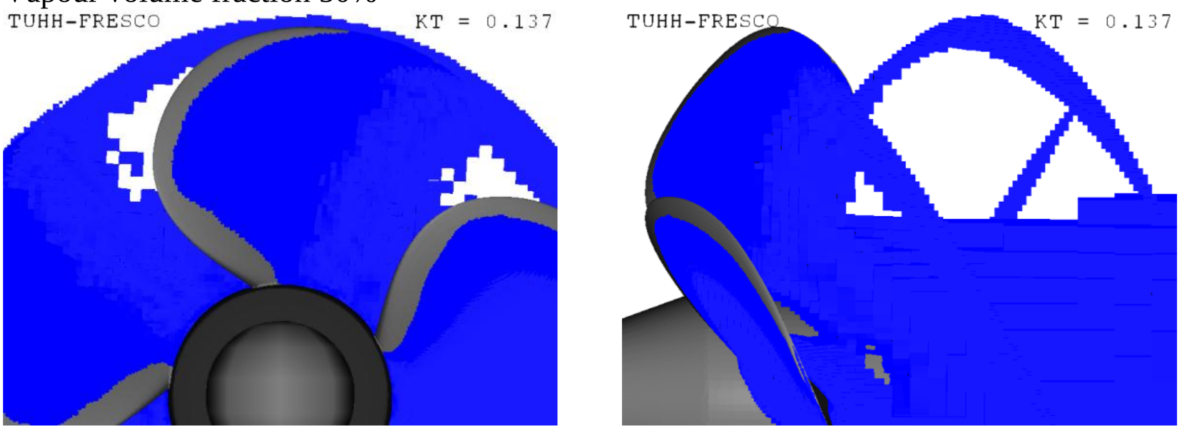
Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Vapour volume fraction 20%

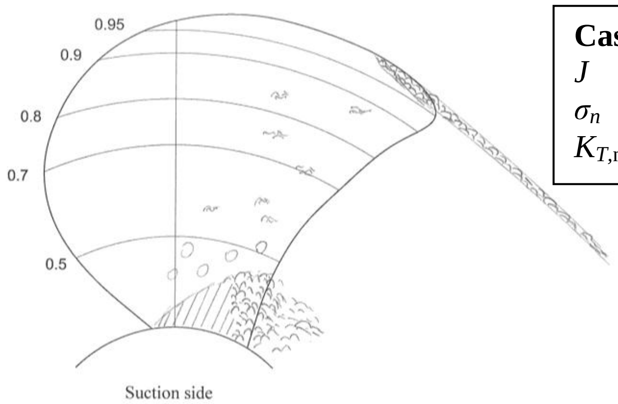


Vapour volume fraction 50%

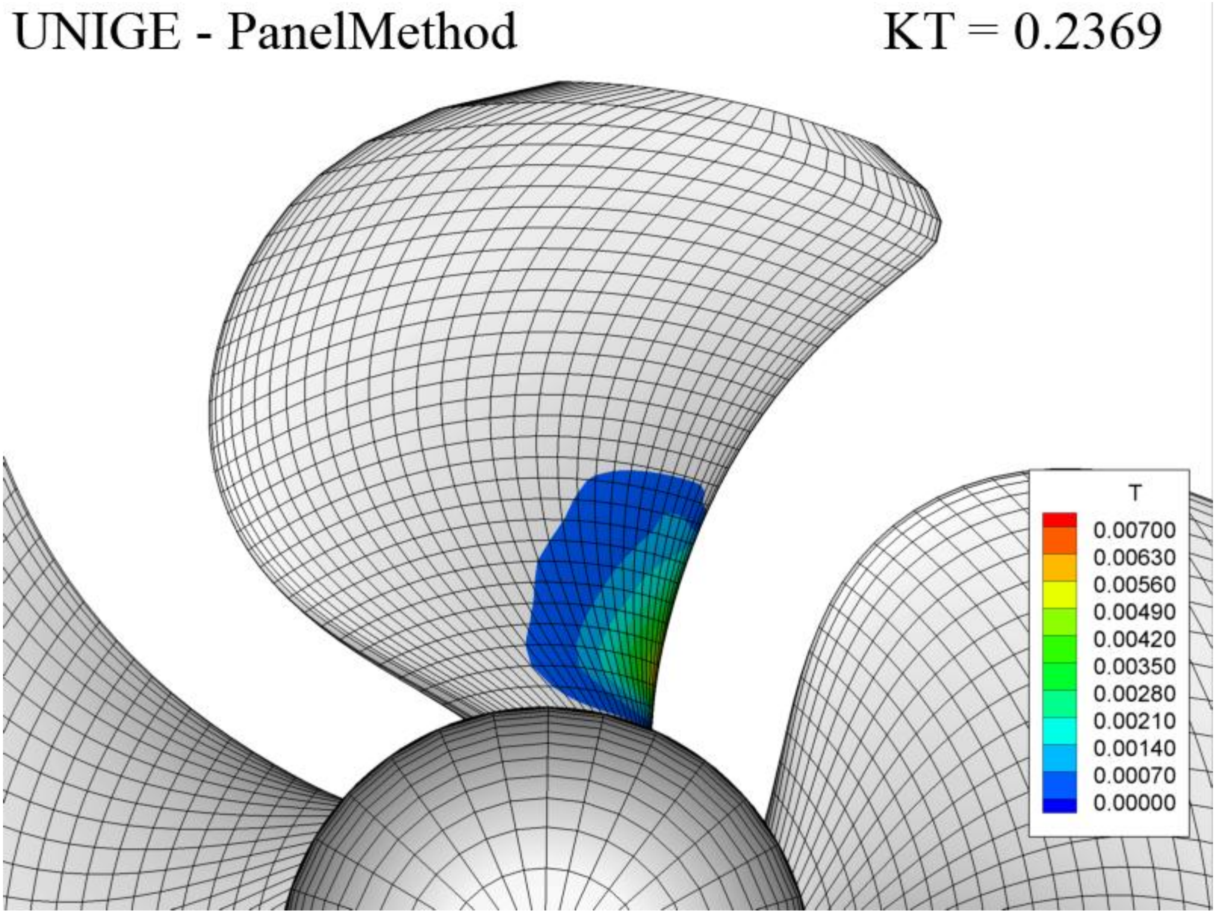


Vapour volume fraction 80%

UniGenua-Panel

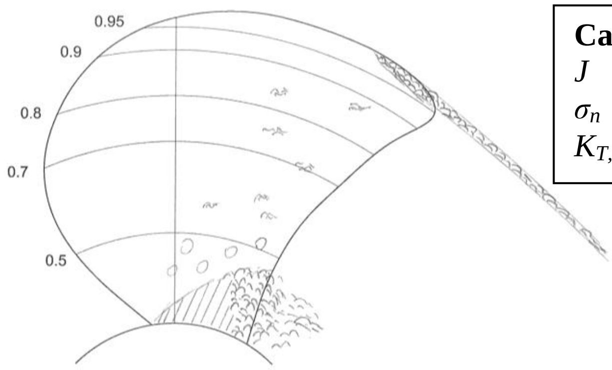


Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



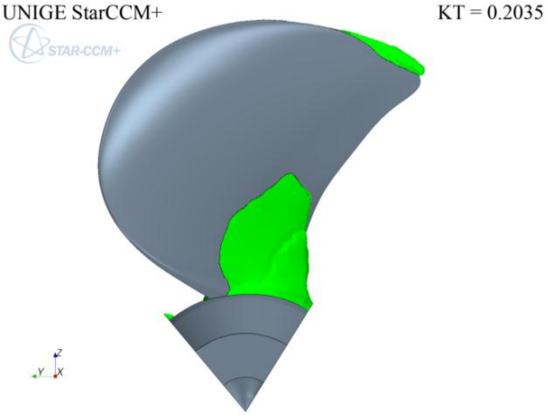
Vapour volume fraction

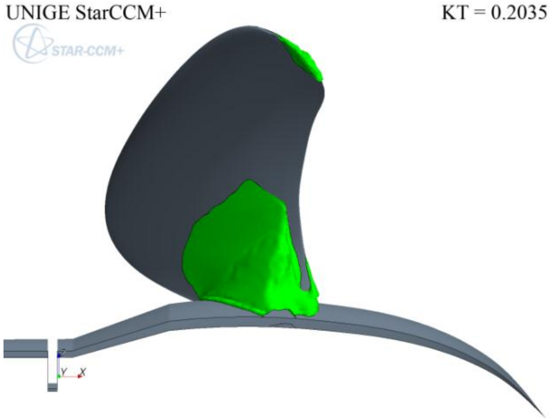
UniGenua-StarCCM+



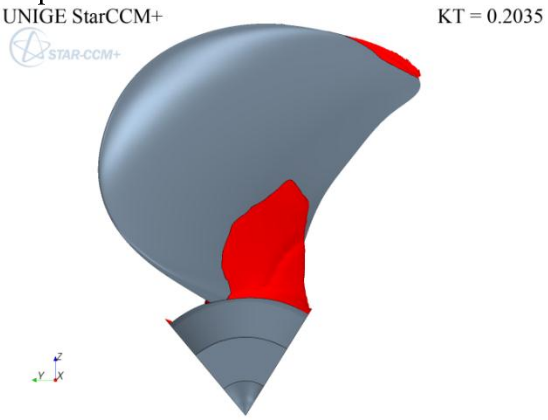
Suction side

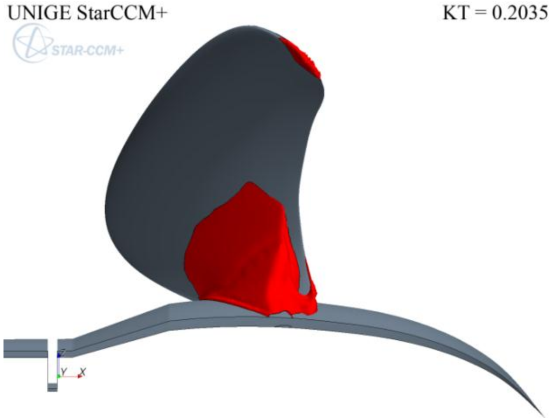
Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



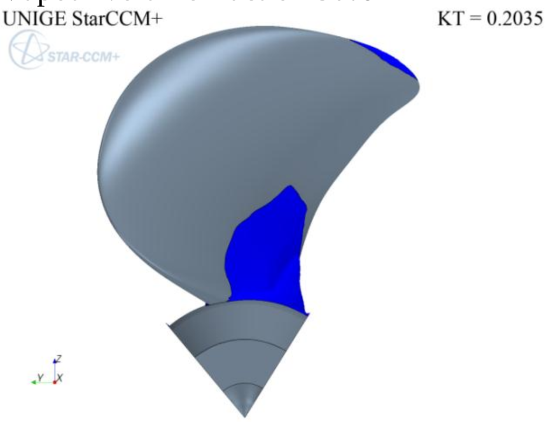


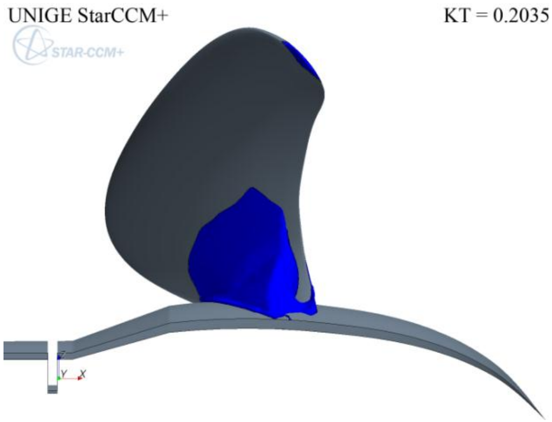
Vapour volume fraction 20%





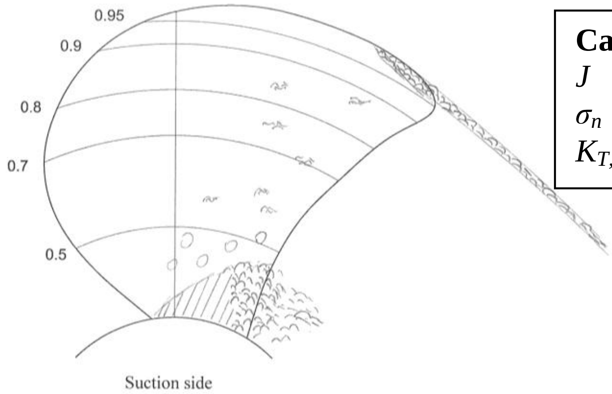
Vapour volume fraction 50%





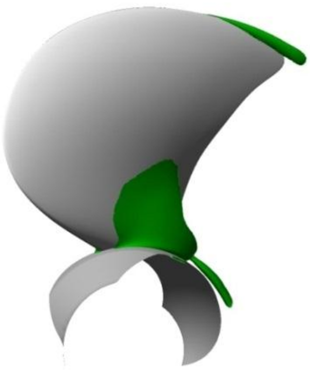
Vapour volume fraction 80%

UniTriest-CFX(FCM)

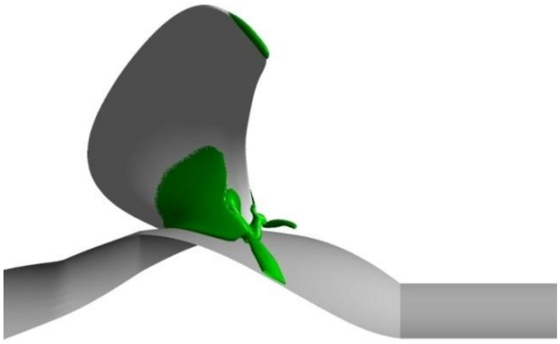


Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245

UniTS-CFX-FCM KT=0.203

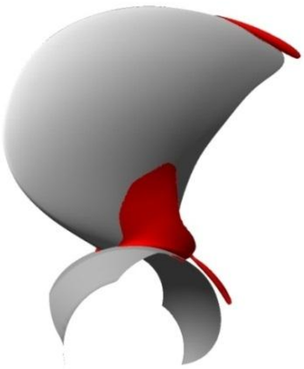


UniTS-CFX-FCM KT=0.203

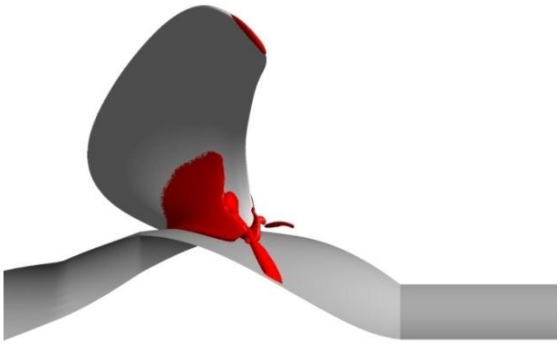


Vapour volume fraction 20%

UniTS-CFX-FCM KT=0.203

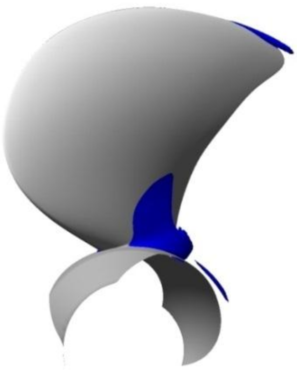


UniTS-CFX-FCM KT=0.203

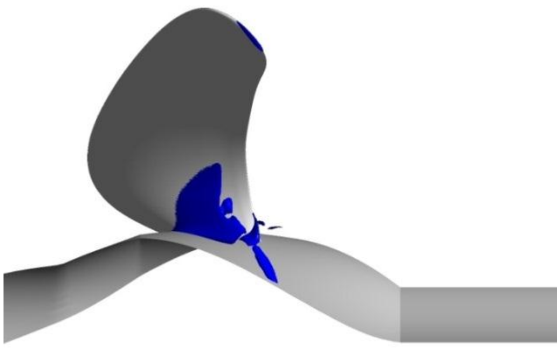


Vapour volume fraction 50%

UniTS-CFX-FCM KT=0.203

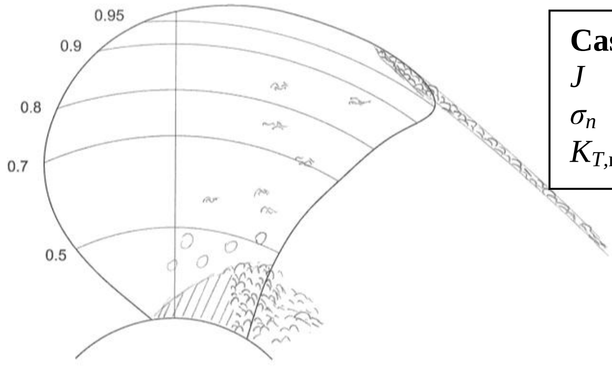


UniTS-CFX-FCM KT=0.203



Vapour volume fraction 80%

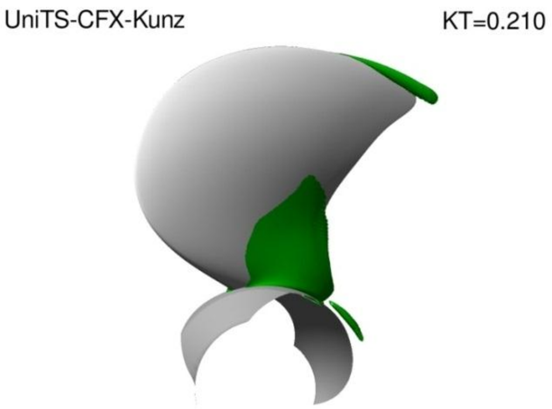
UniTriest-CFX(Kunz)

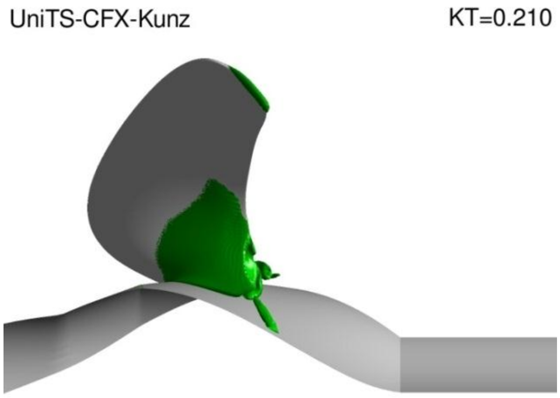


Suction side

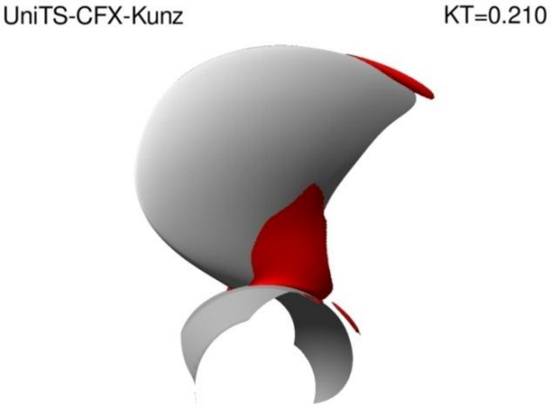
Case 2.3.2

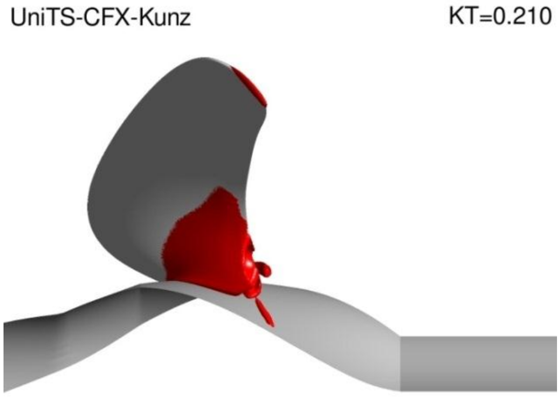
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



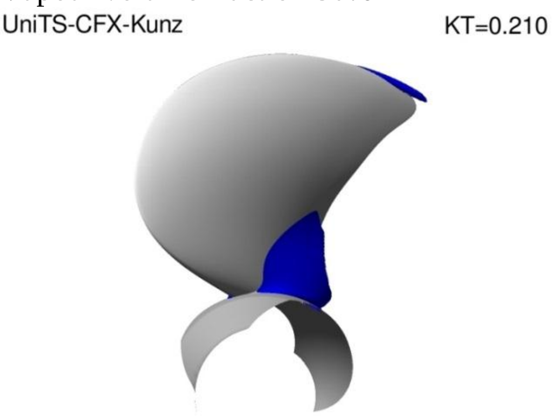


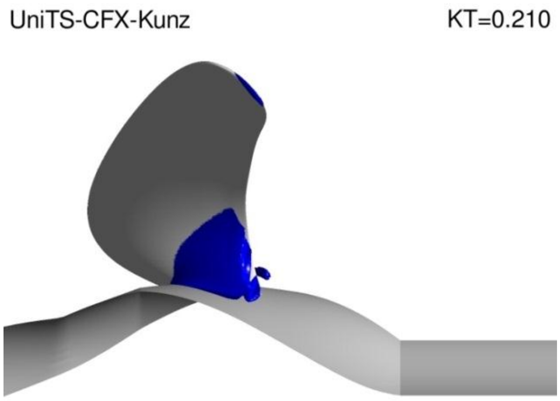
Vapour volume fraction 20%





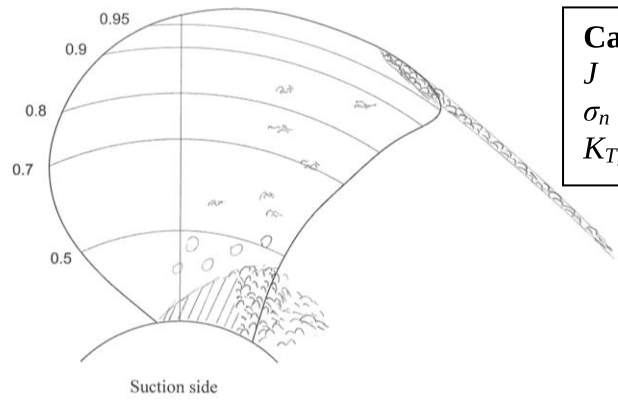
Vapour volume fraction 50%



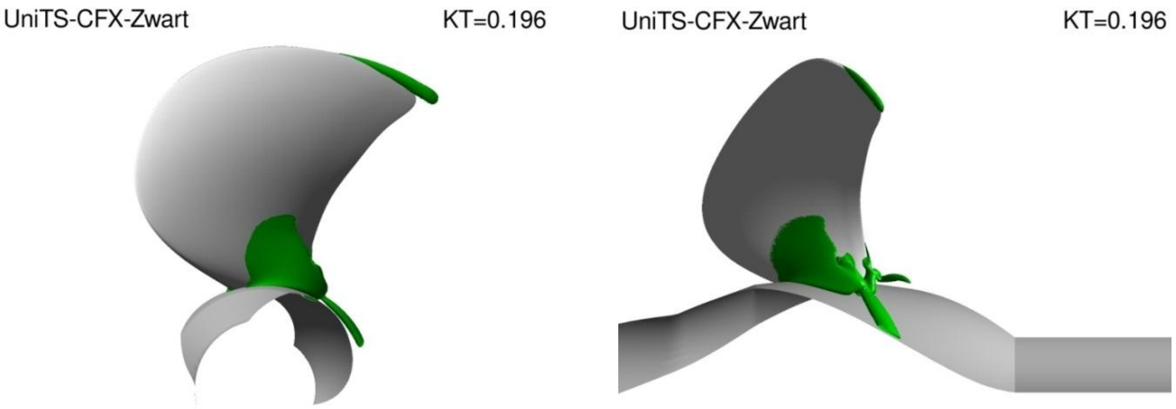


Vapour volume fraction 80%

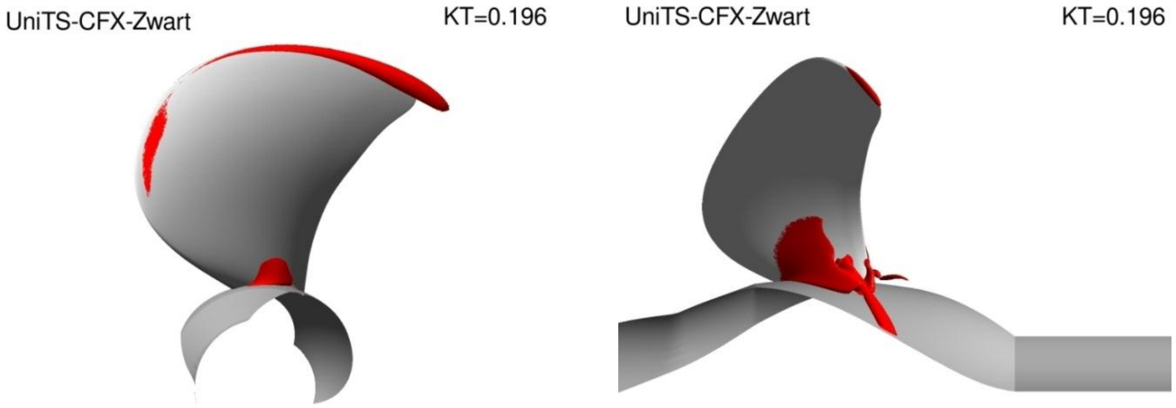
UniTriest-CFX(Zwart)



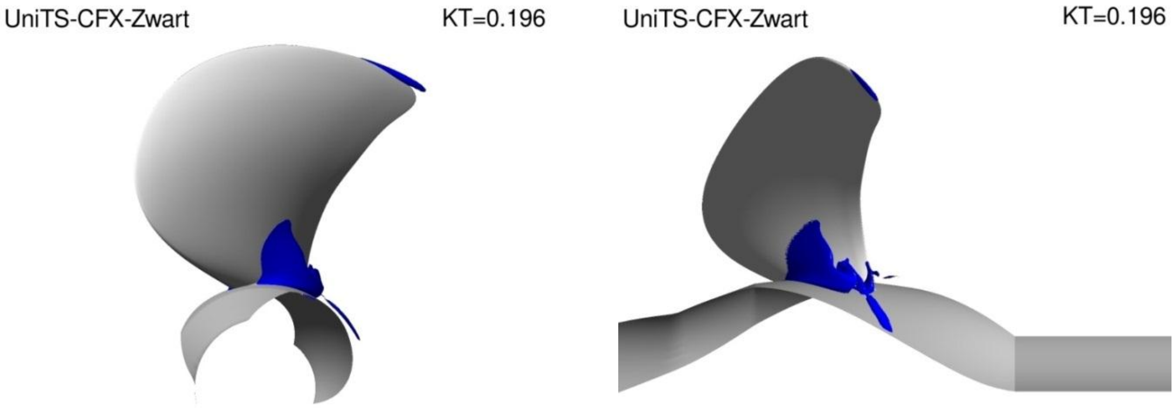
Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Vapour volume fraction 20%

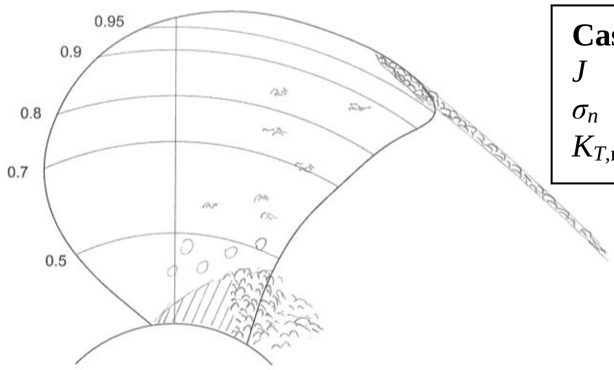


Vapour volume fraction 50%



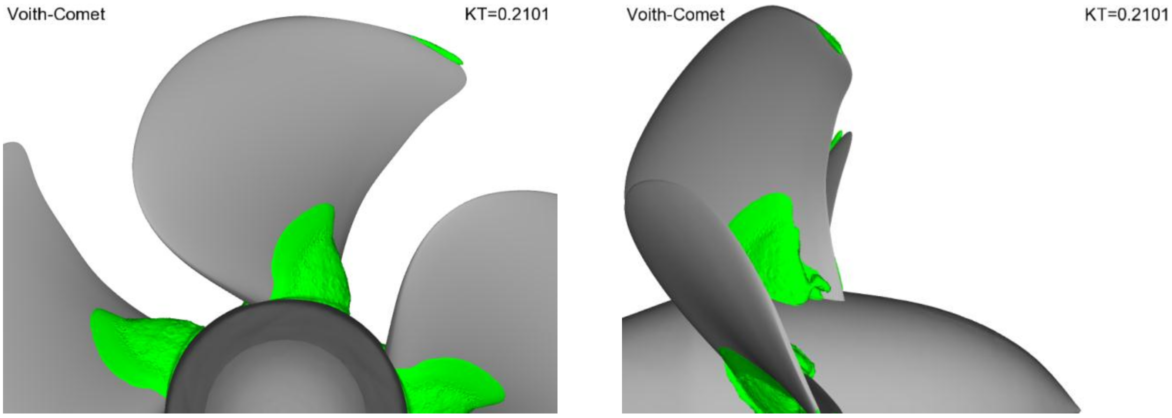
Vapour volume fraction 80%

VOITH-Comet

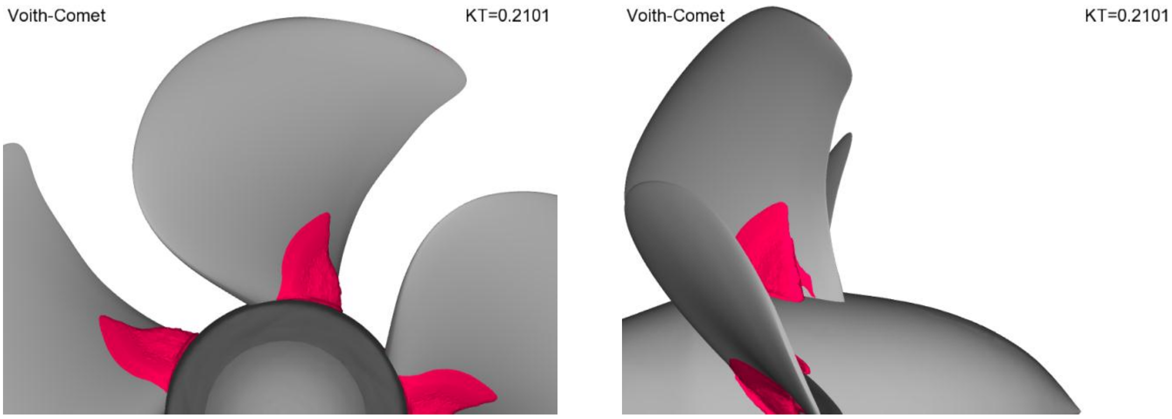


Suction side

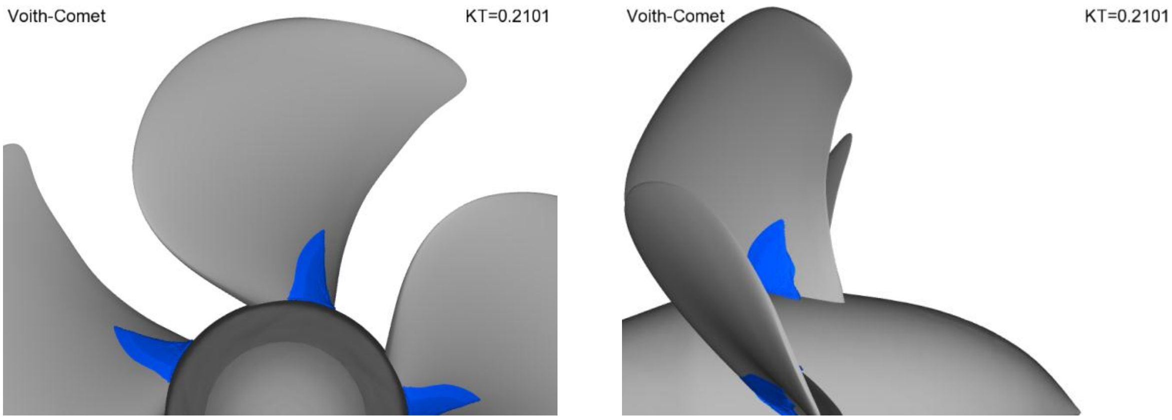
Case 2.3.2	
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



Vapour volume fraction 20%



Vapour volume fraction 50%

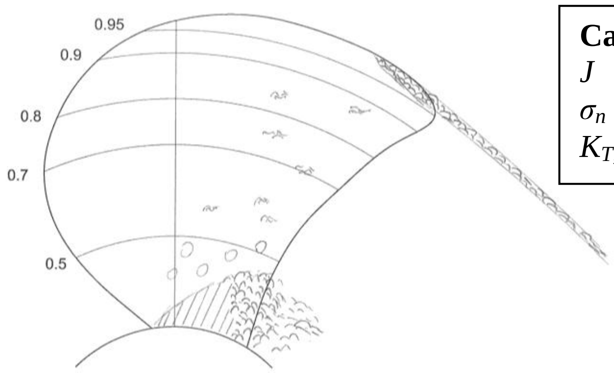


Vapour volume fraction 80%

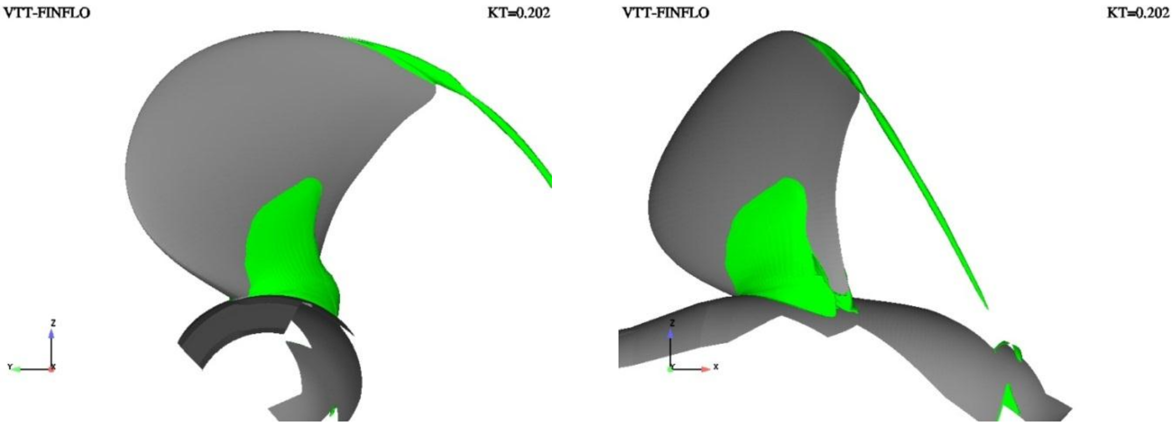
VTT-FinFlo

Case 2.3.2

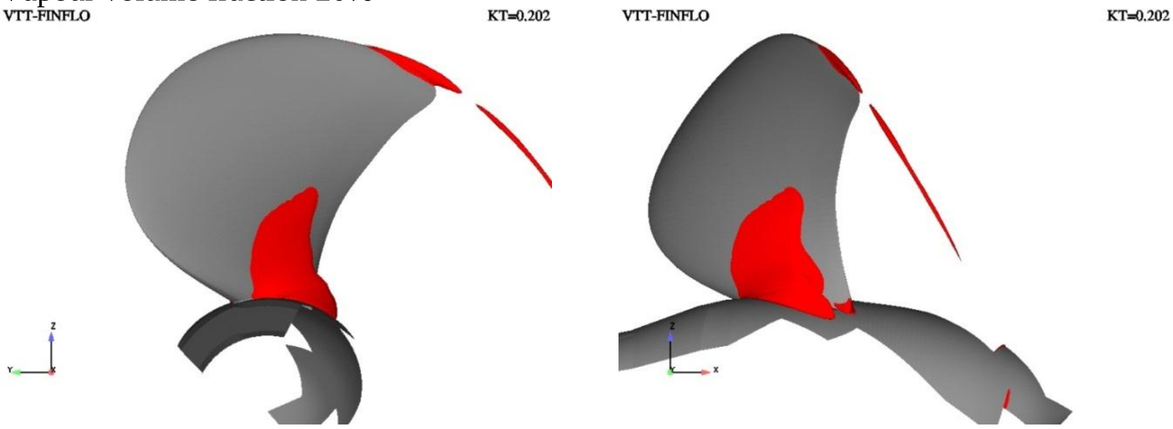
J	= 1.269
σ_n	= 1.424
$K_{T,\text{no cav.}}$	= 0.245



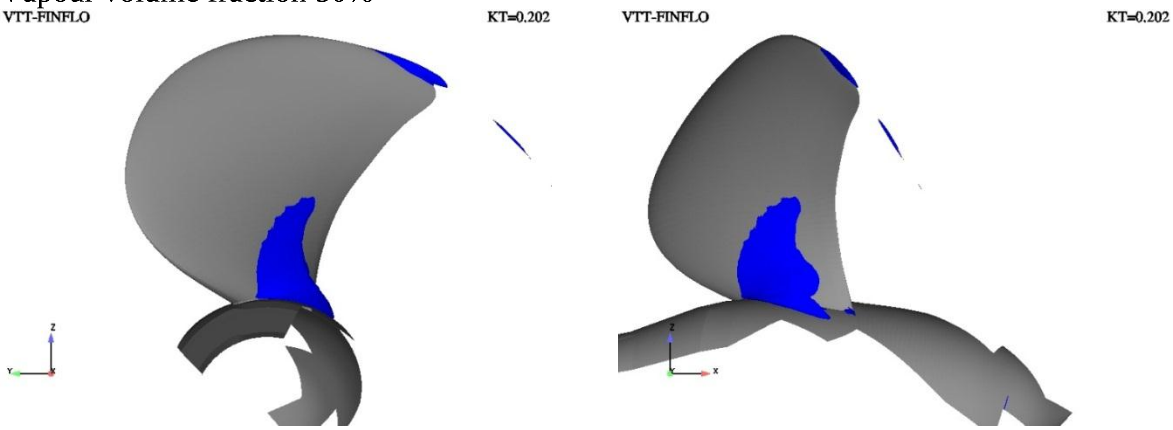
Suction side



Vapour volume fraction 20%



Vapour volume fraction 50%

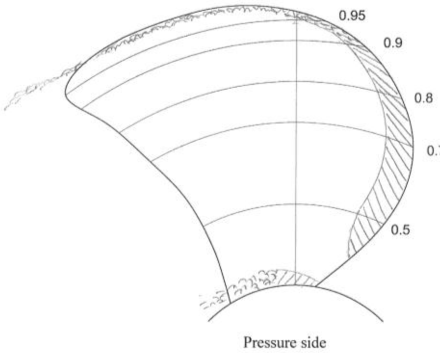


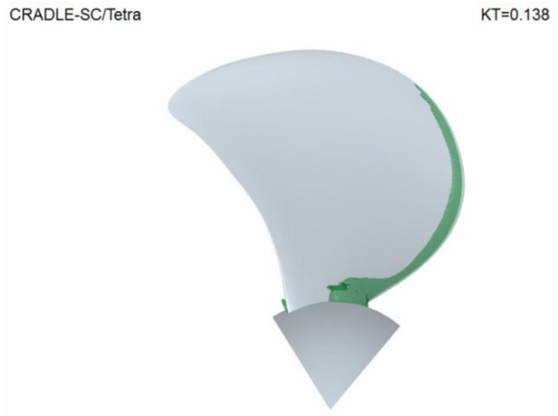
Vapour volume fraction 80%

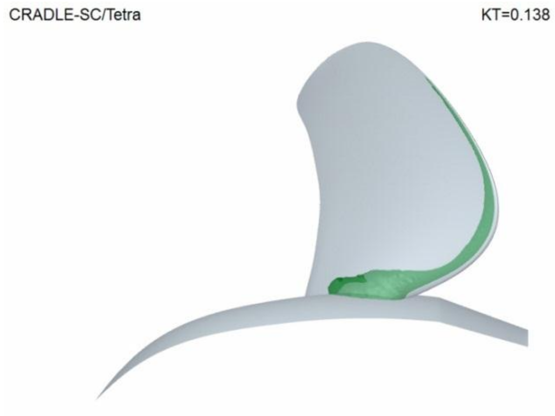
6.3 Cavity surface, Case 2.3.3

Cradle-SC/Tetra

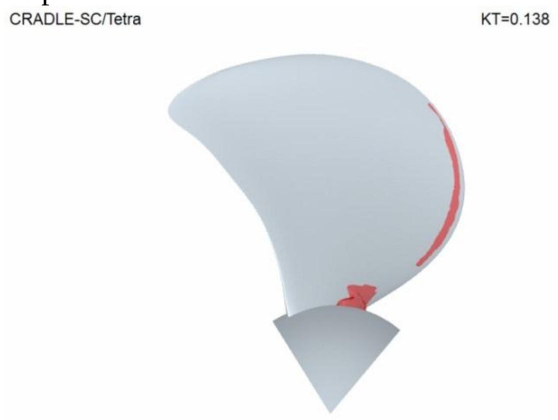
Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167

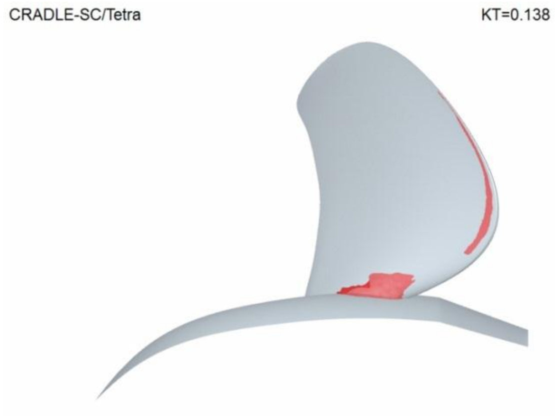




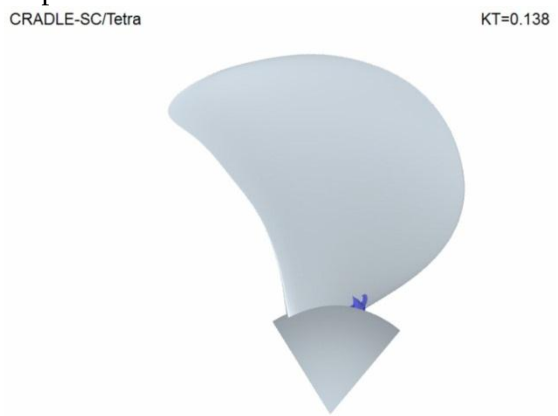


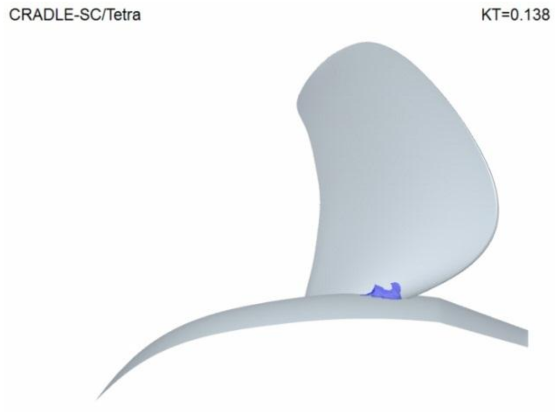
Vapour volume fraction 20%





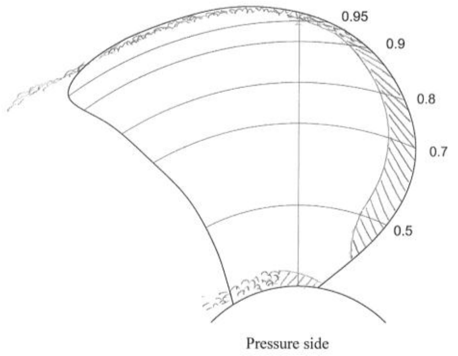
Vapour volume fraction 50%



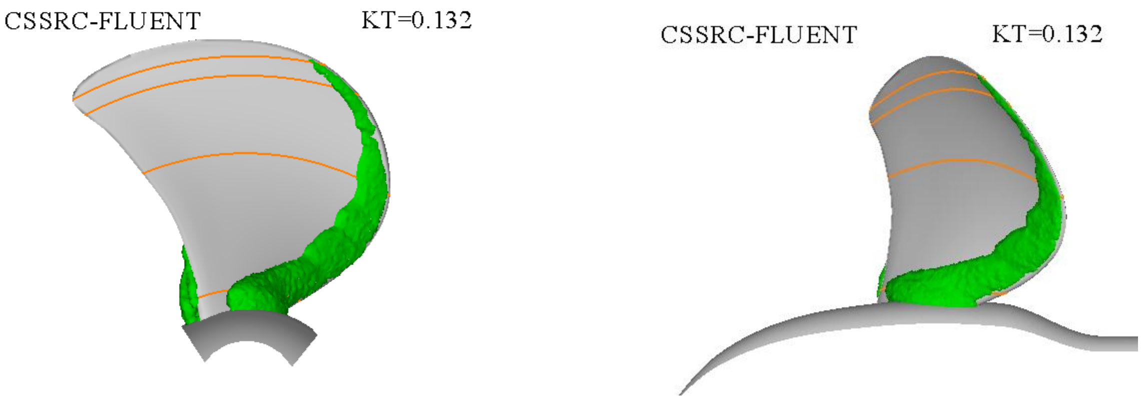


Vapour volume fraction 80%

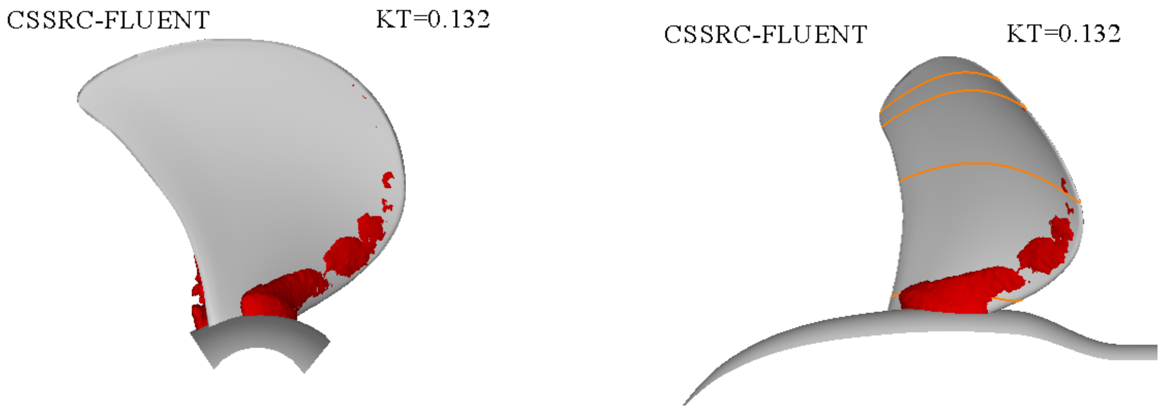
CSSRC-Fluent



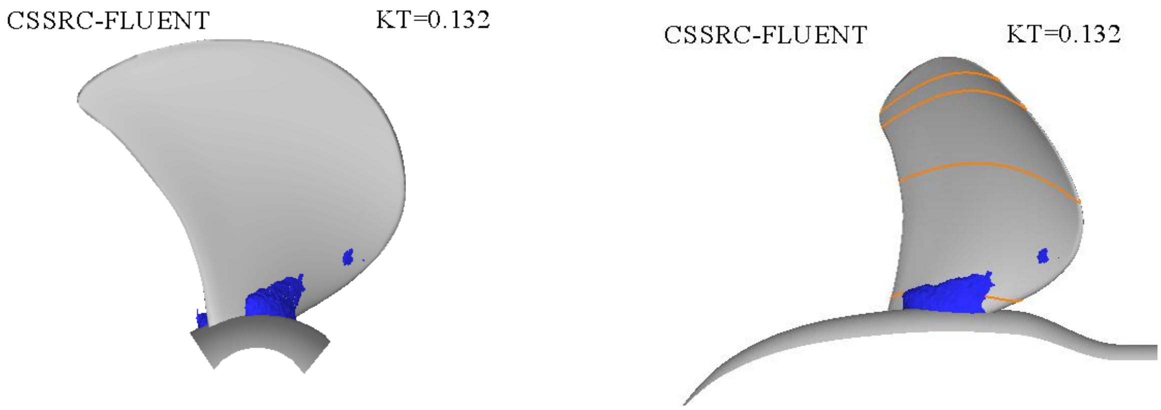
Case 2.3.3	
J	$= 1.408$
σ_n	$= 2.000$
$K_{T,\text{no cav.}}$	$= 0.167$



Vapour volume fraction 20%



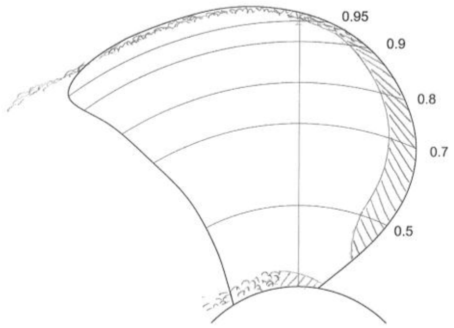
Vapour volume fraction 50%



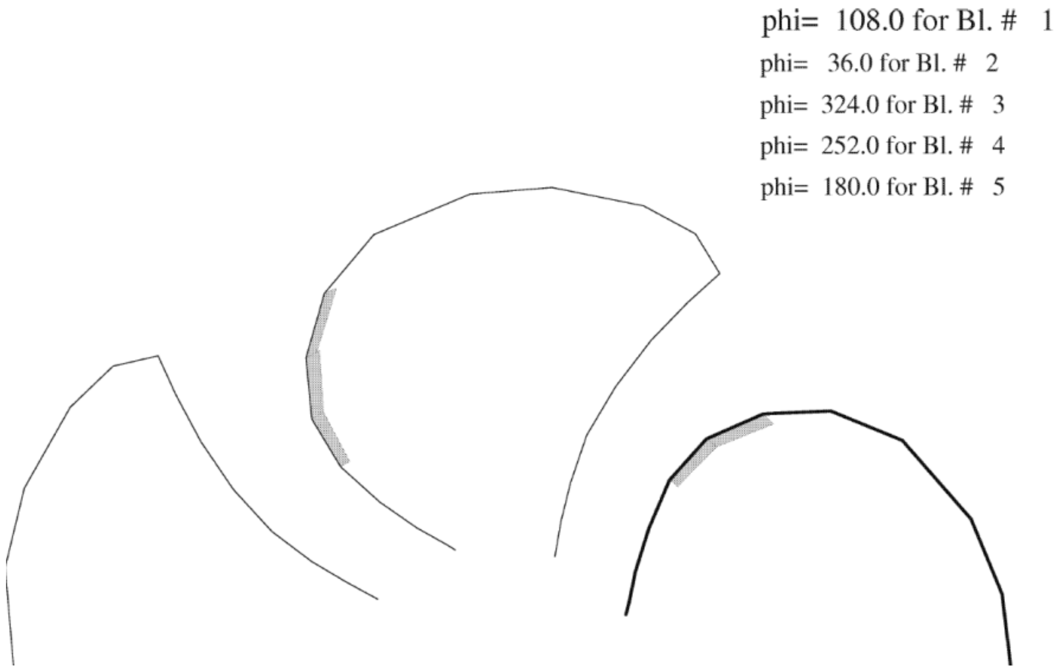
Vapour volume fraction 80%

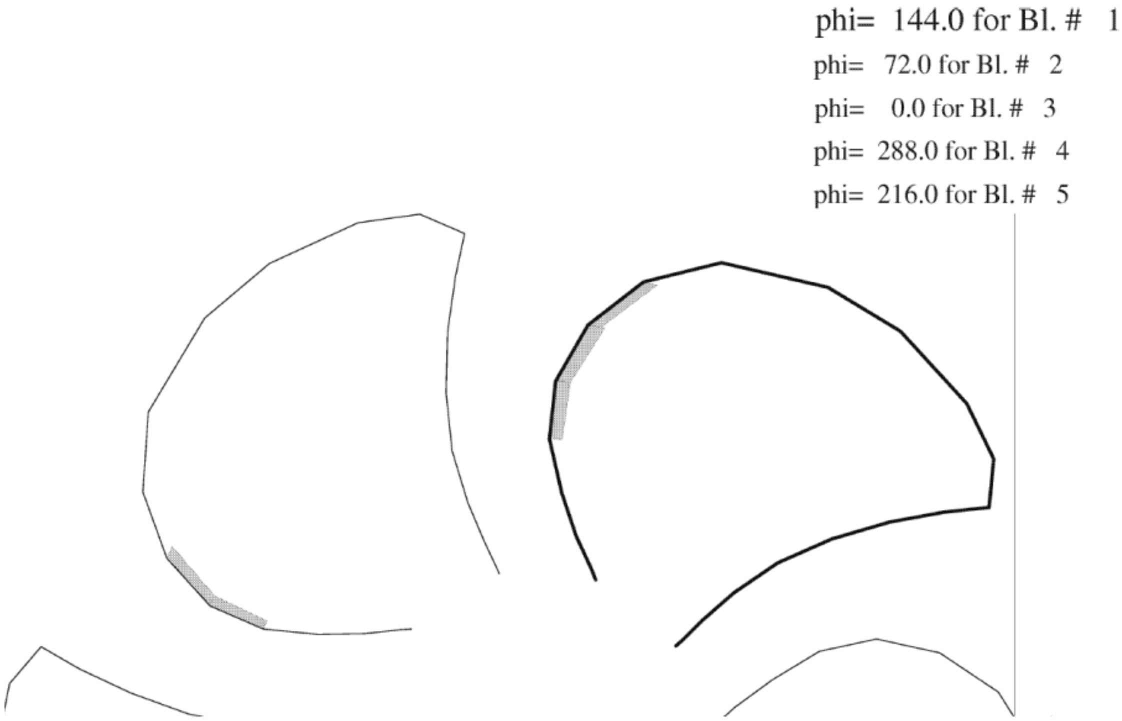
HSVA-QCM/PPB

Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



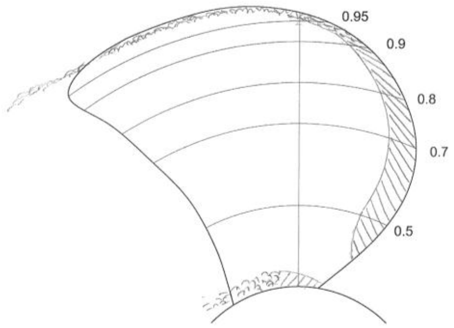
Pressure side



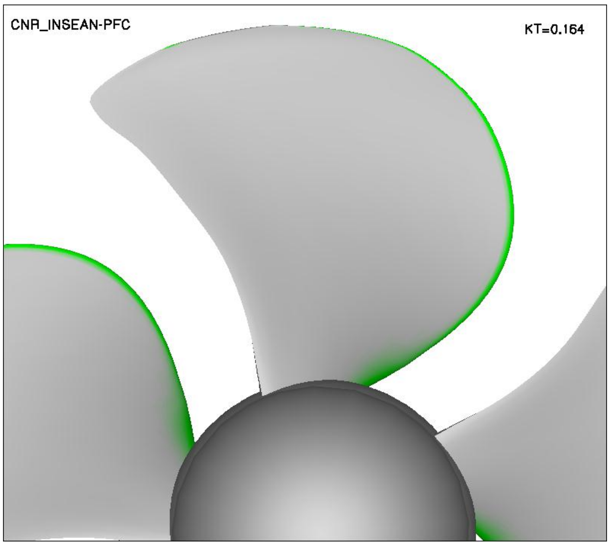


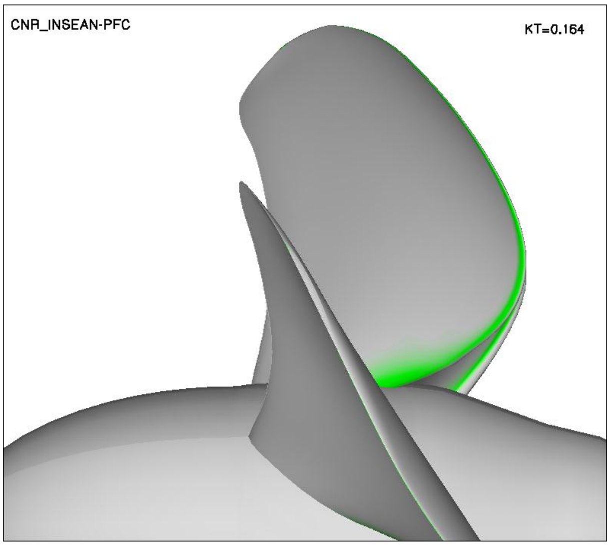
INSEAN-PFC

Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



Pressure side

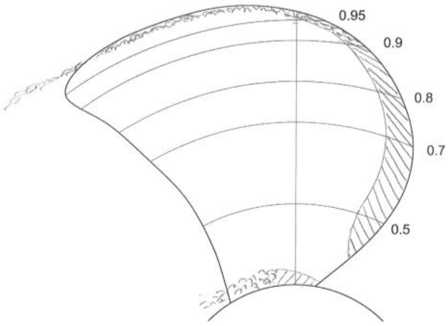




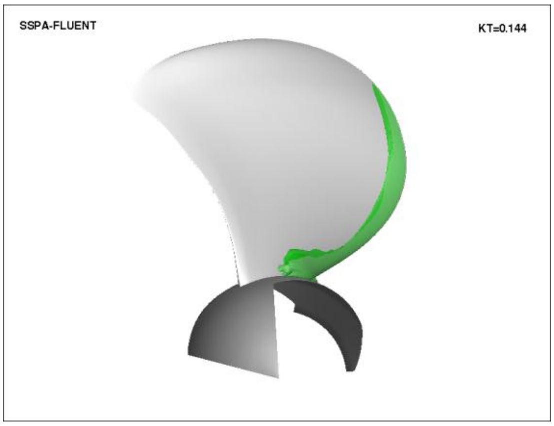
Blade surface region $p \leq p_v$

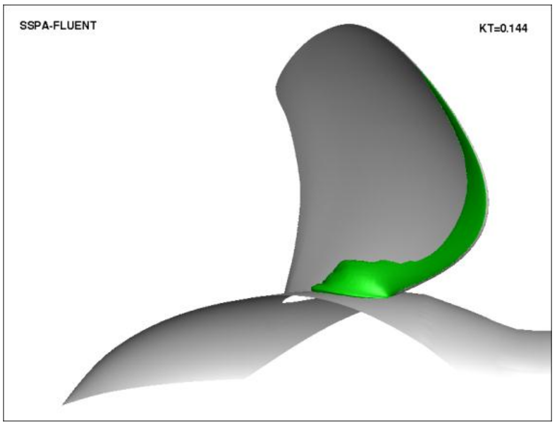
SSPA-Fluent

Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167

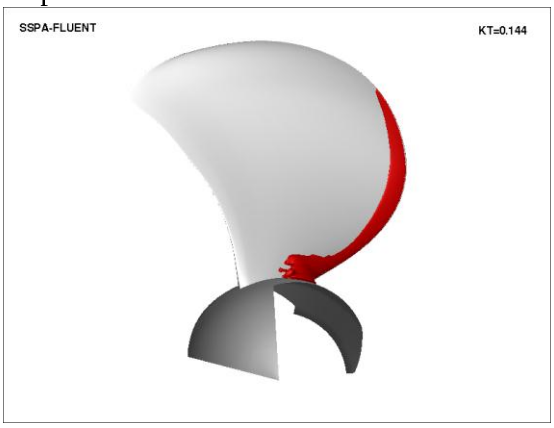


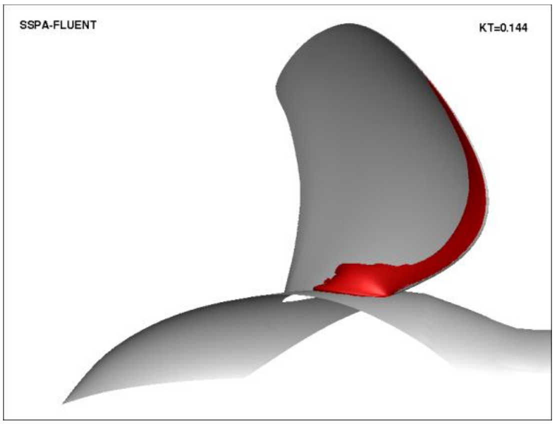
Pressure side



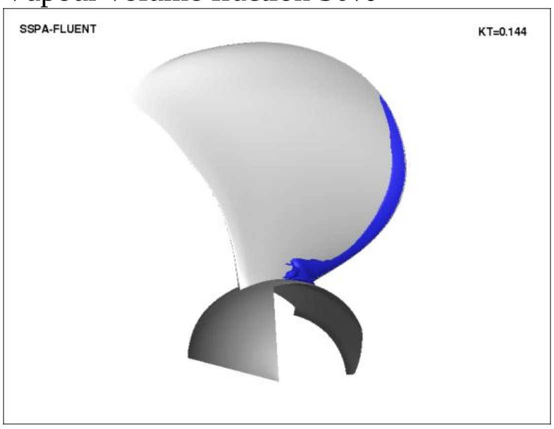


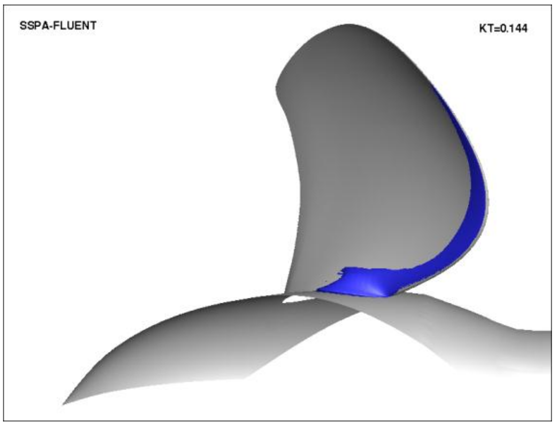
Vapour volume fraction 20%





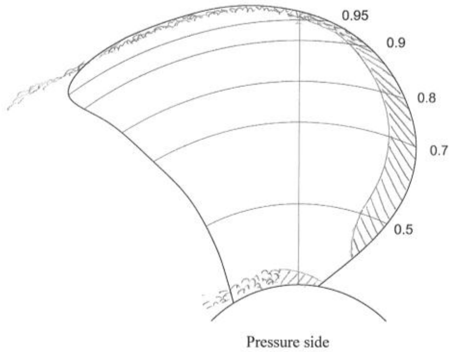
Vapour volume fraction 50%



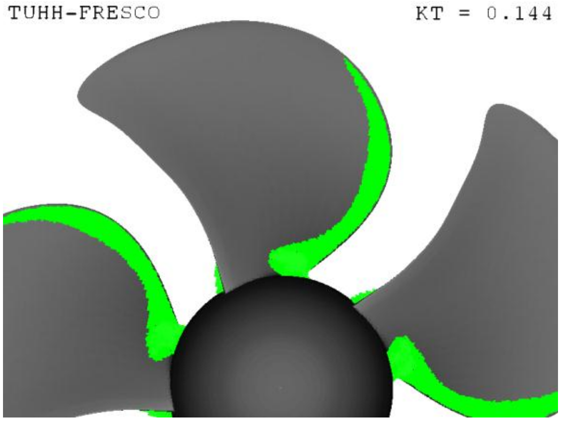


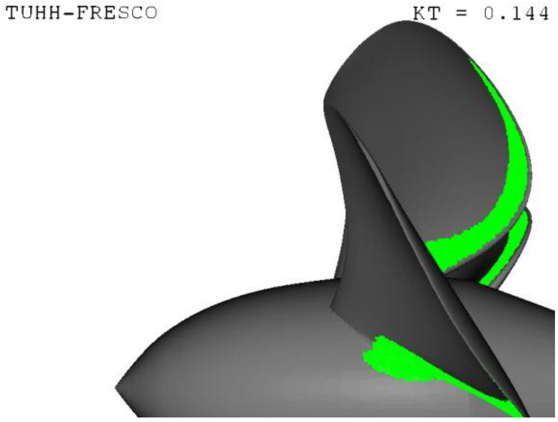
Vapour volume fraction 80%

TUHH-FreSCO+

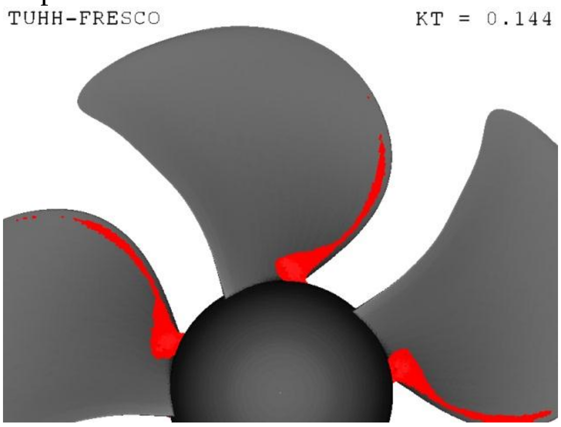


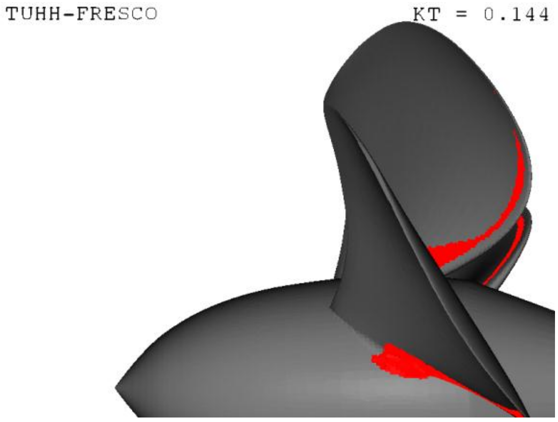
Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



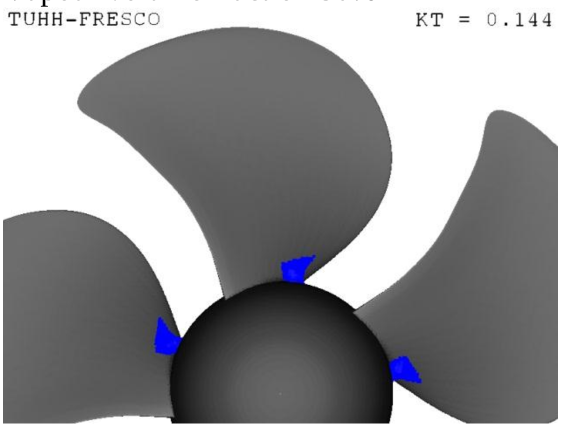


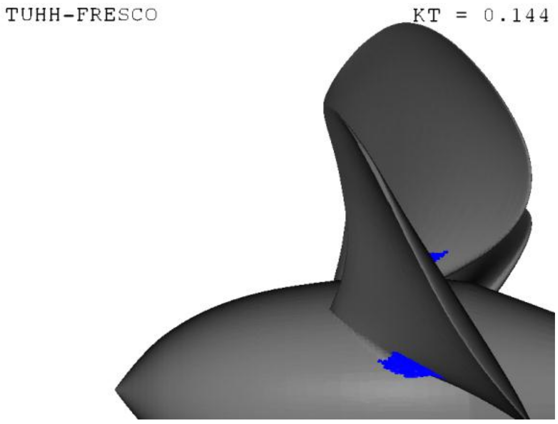
Vapour volume fraction 20%





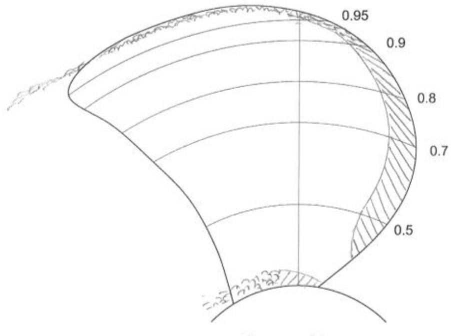
Vapour volume fraction 50%



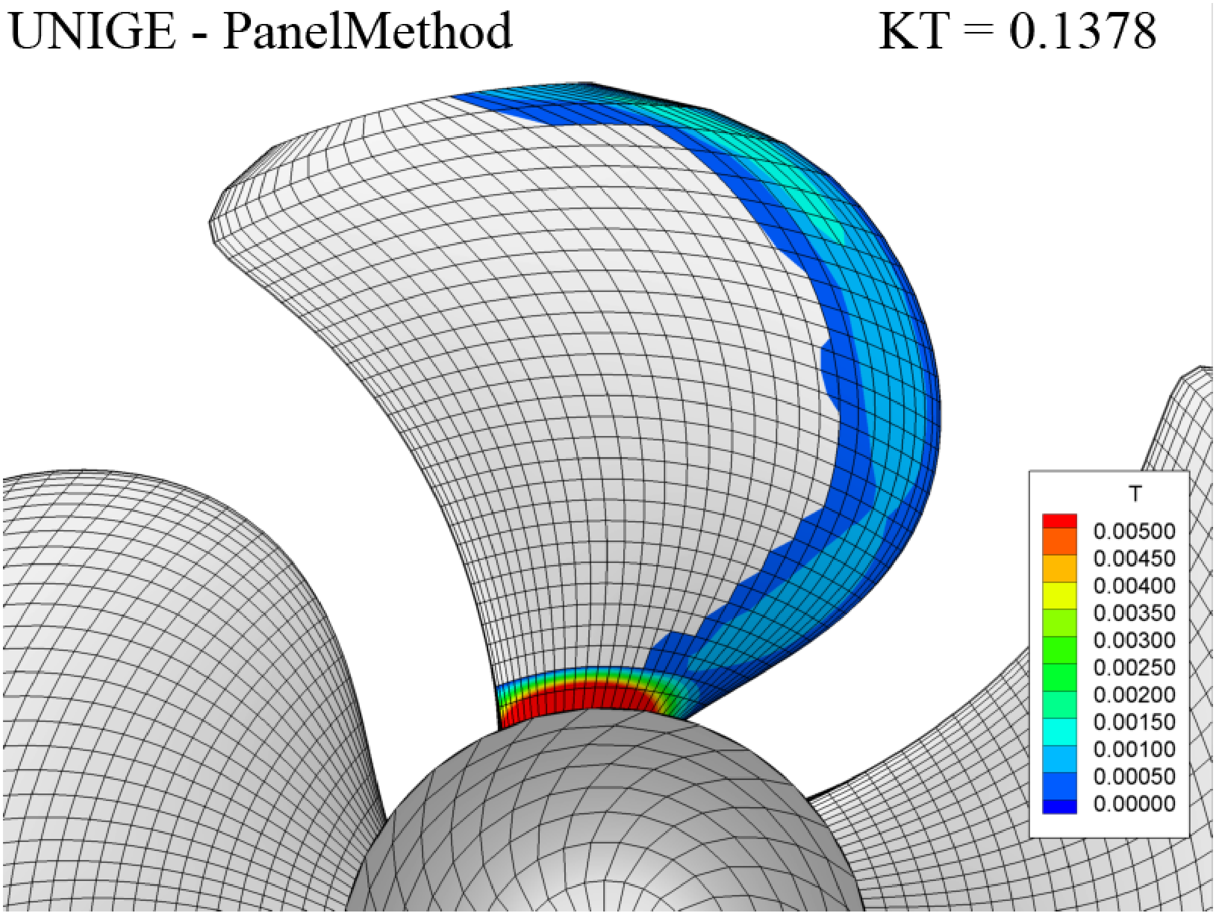


Vapour volume fraction 80%

UniGenua-Panel



Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167

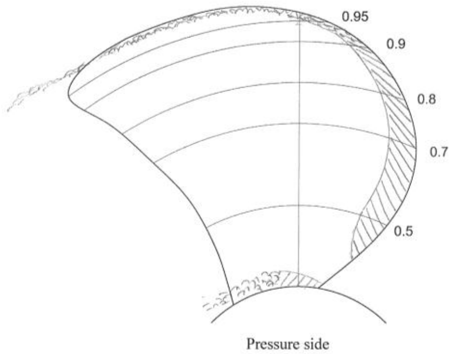


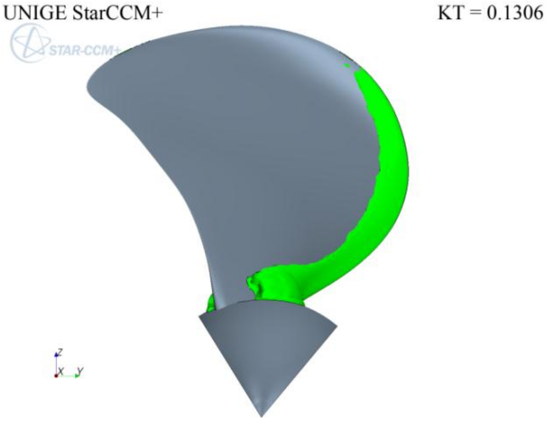
Vapour volume fraction

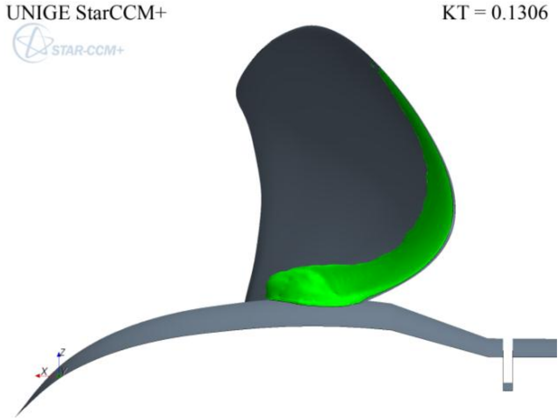
UniGenua-StarCCM+

Case 2.3.3

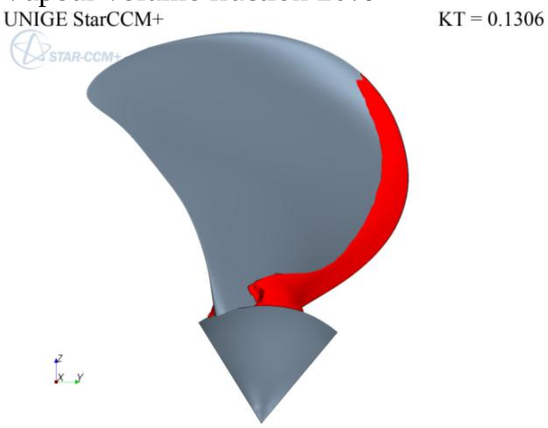
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167

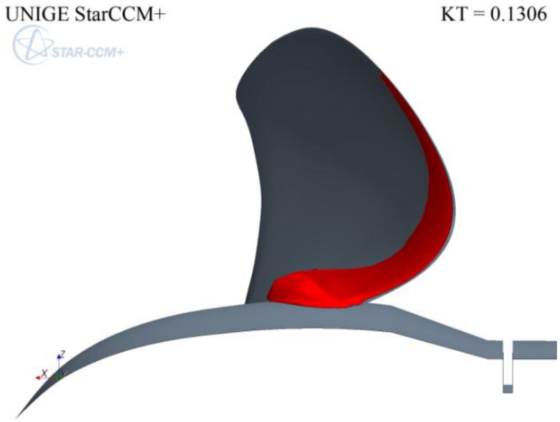




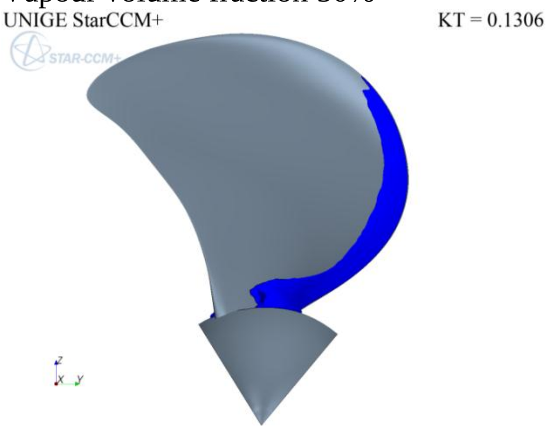


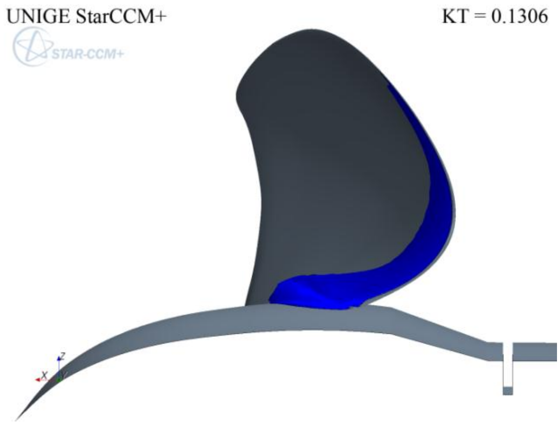
Vapour volume fraction 20%





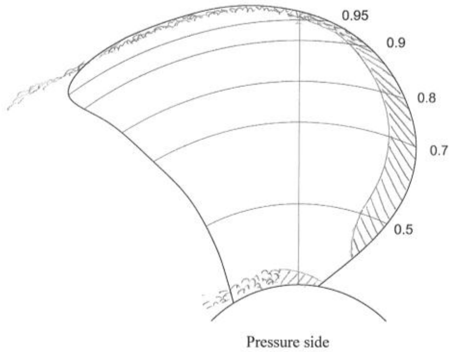
Vapour volume fraction 50%



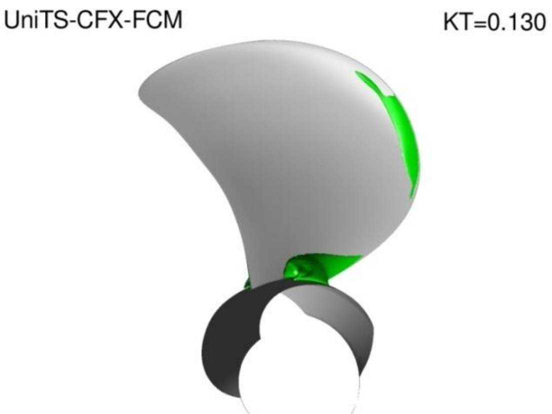


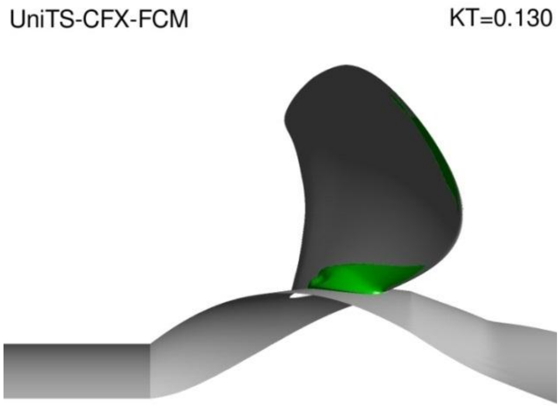
Vapour volume fraction 80%

UniTriest-CFX(FCM)

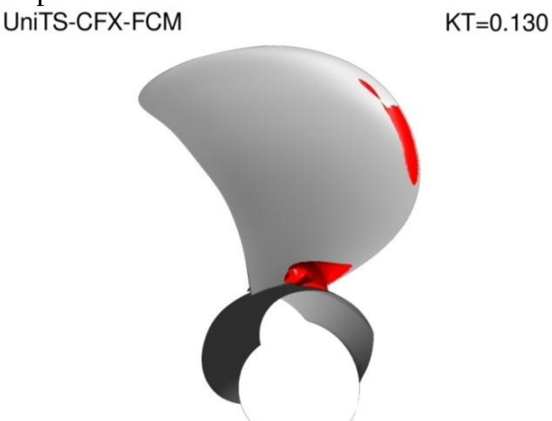


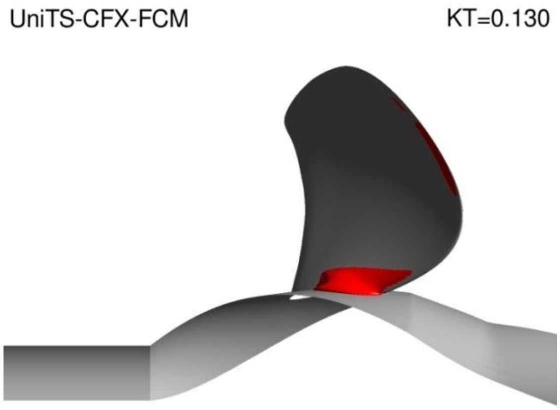
Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



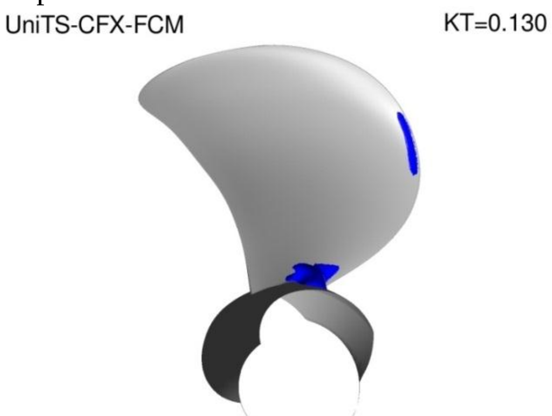


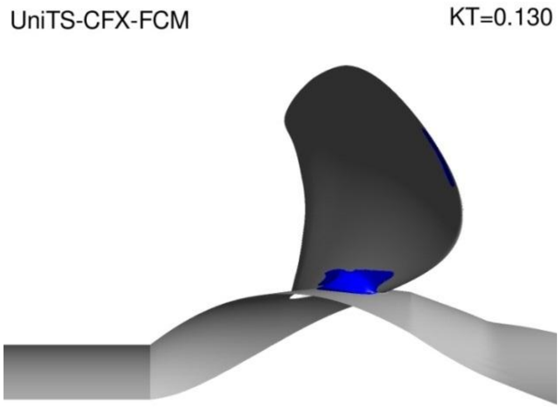
Vapour volume fraction 20%





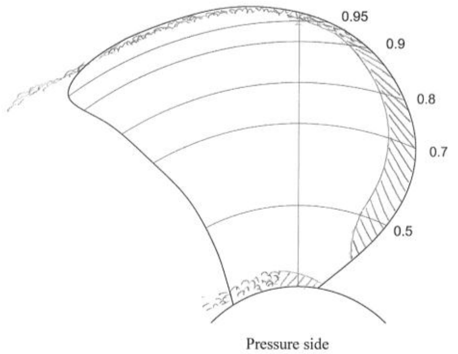
Vapour volume fraction 50%



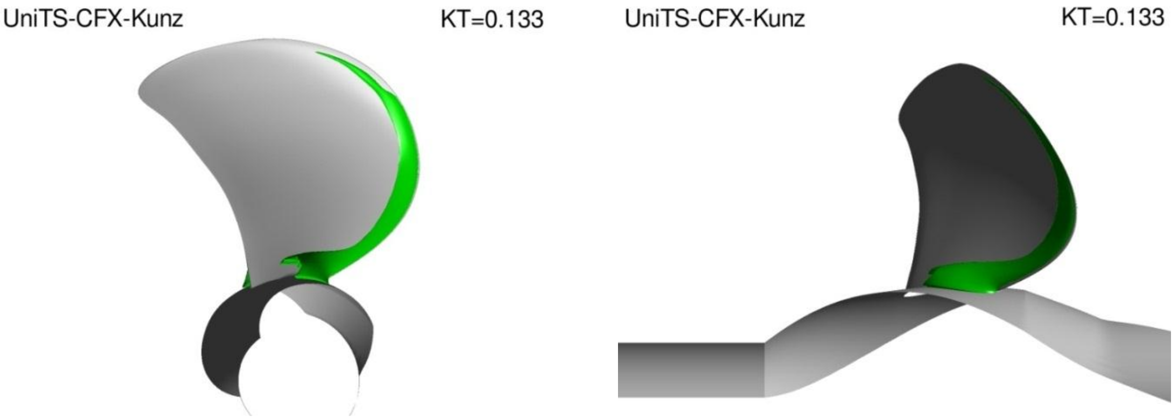


Vapour volume fraction 80%

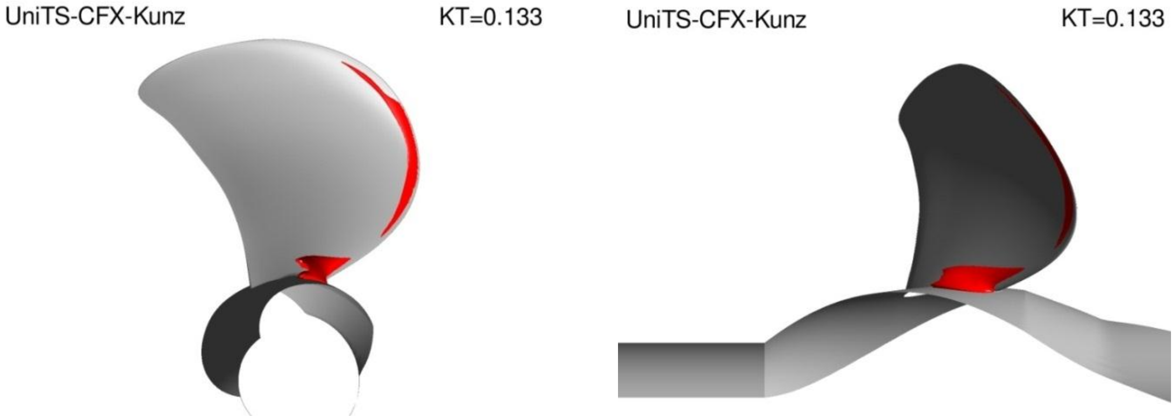
UniTriest-CFX(Kunz)



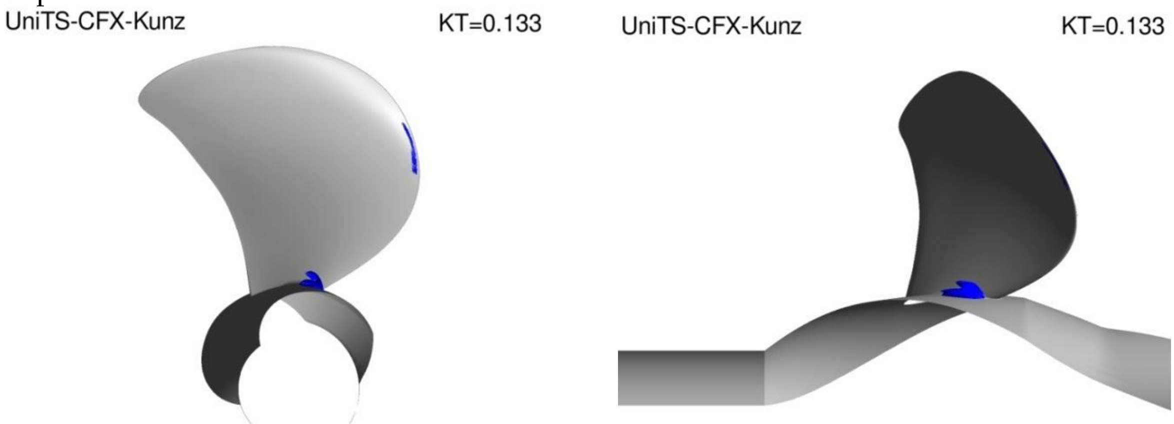
Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



Vapour volume fraction 20%

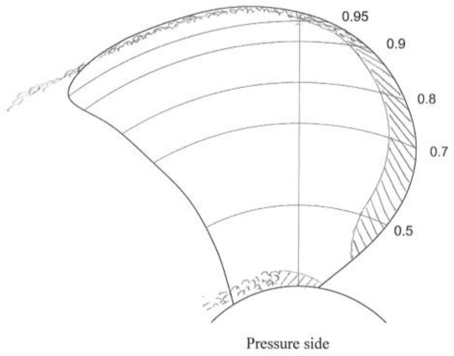


Vapour volume fraction 50%



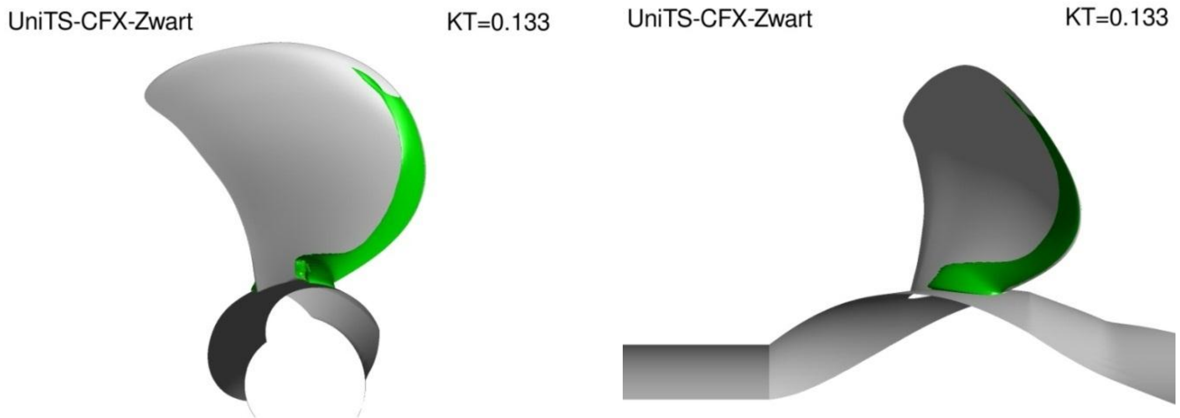
Vapour volume fraction 80%

UniTriest-CFX(Zwart)

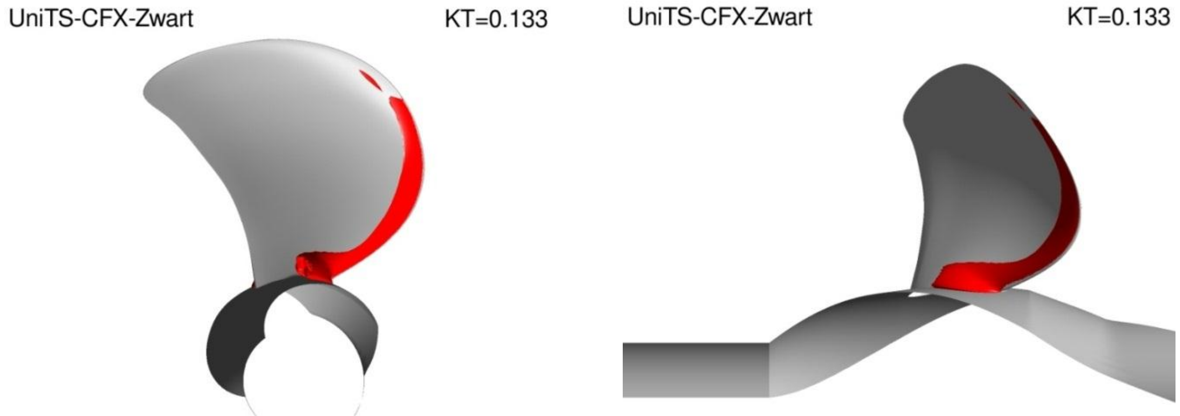


Case 2.3.3

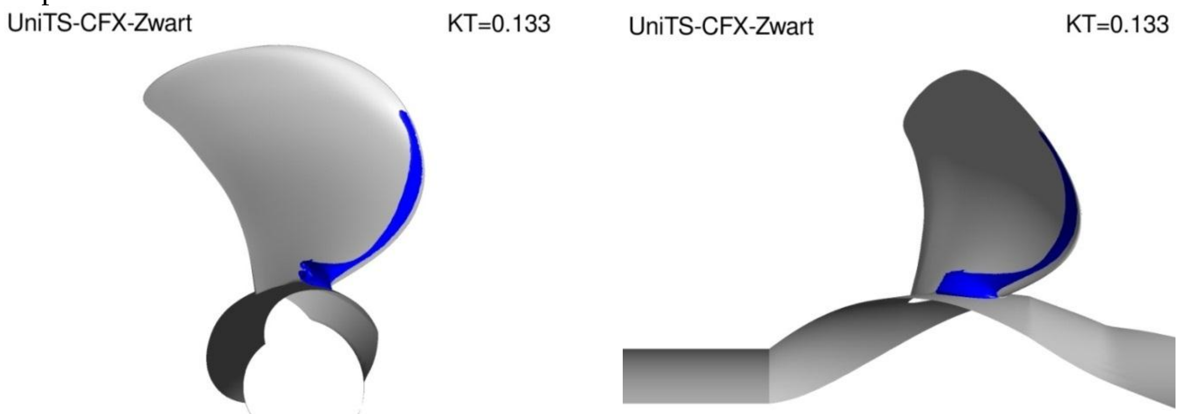
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



Vapour volume fraction 20%

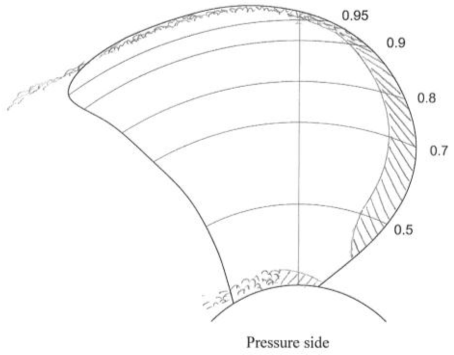


Vapour volume fraction 50%

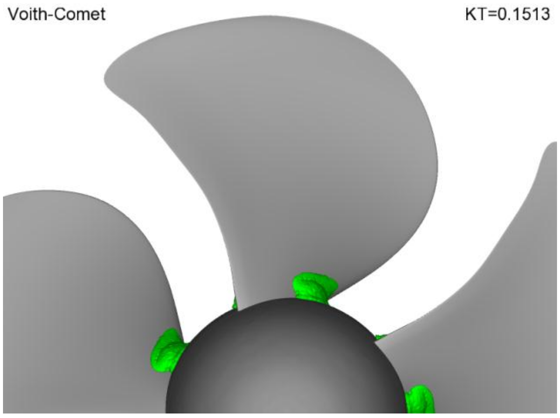


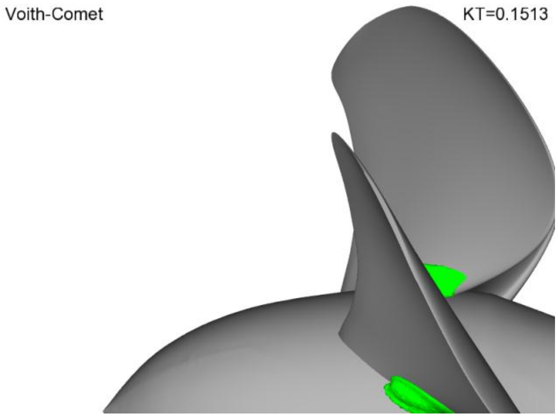
Vapour volume fraction 80%

VOITH-Comet

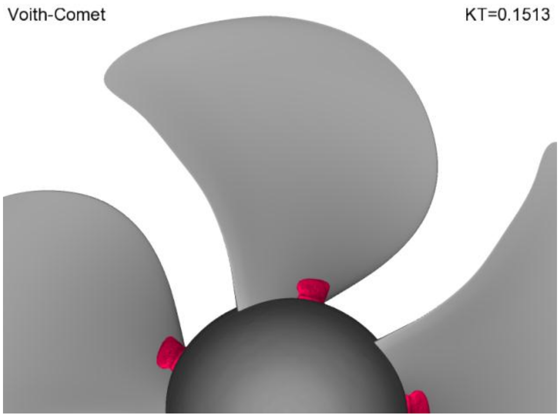


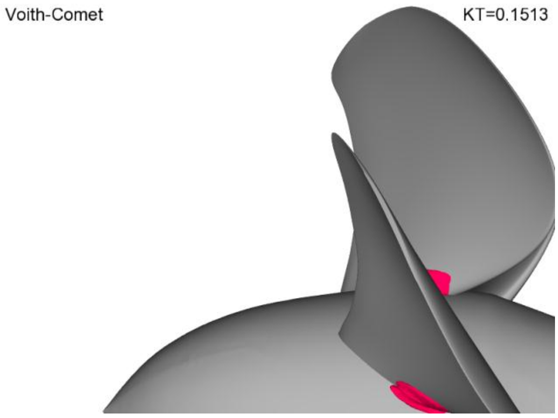
Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167



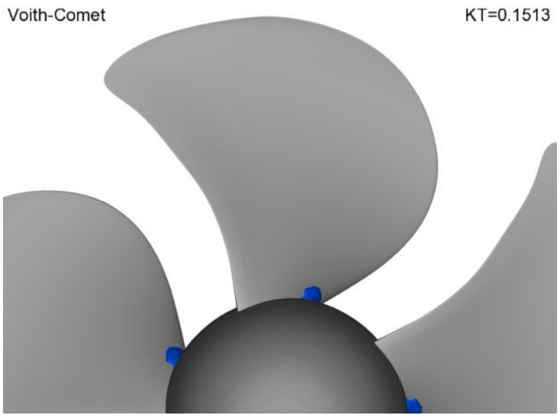


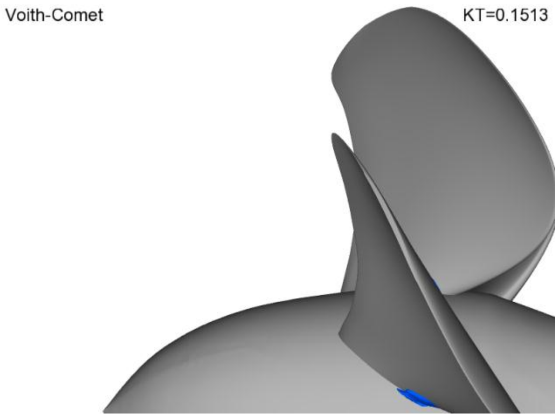
Vapour volume fraction 20%





Vapour volume fraction 50%

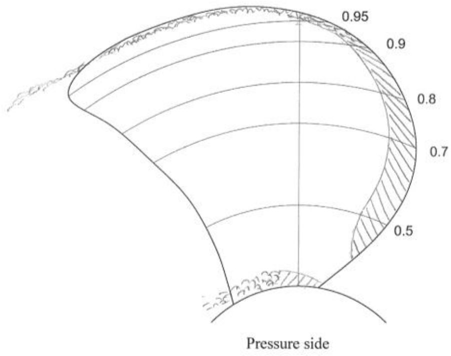


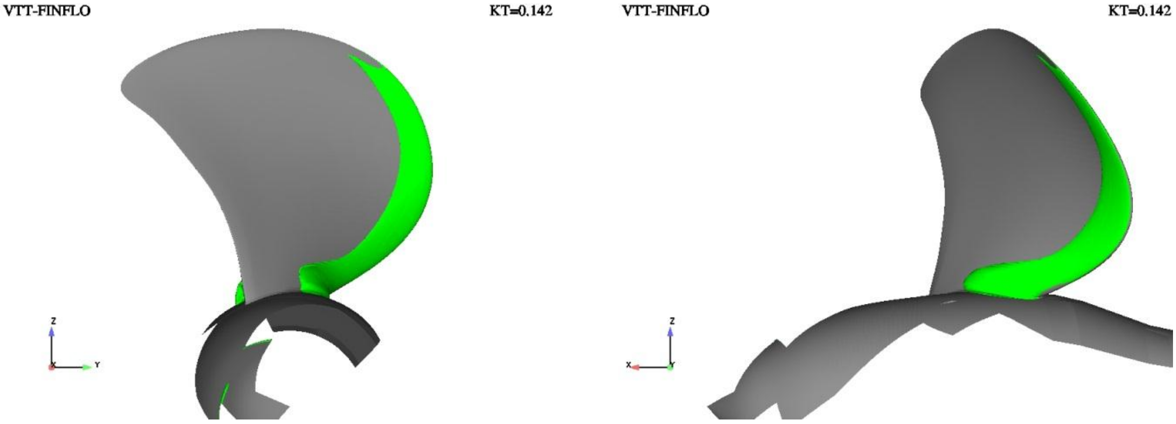


Vapour volume fraction 80%

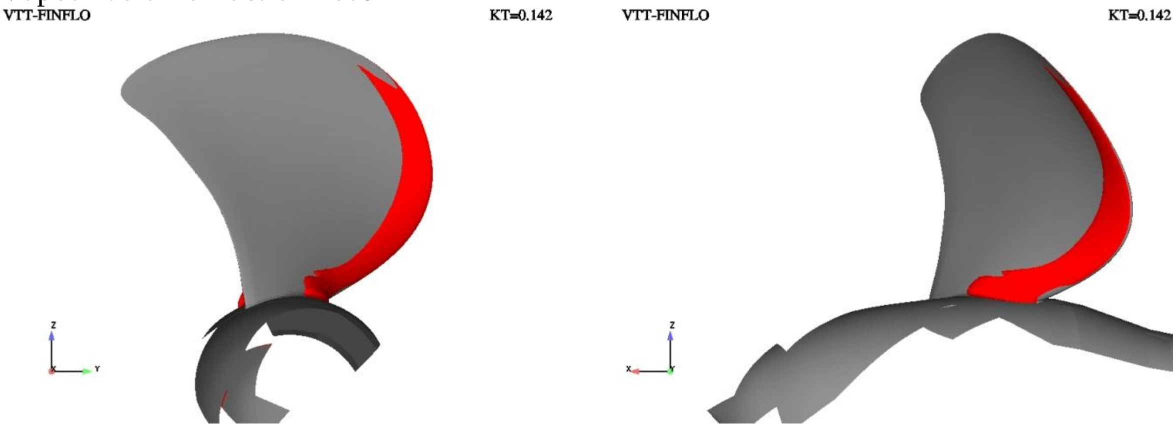
VTT-FinFlo

Case 2.3.3	
J	= 1.408
σ_n	= 2.000
$K_{T,\text{no cav.}}$	= 0.167

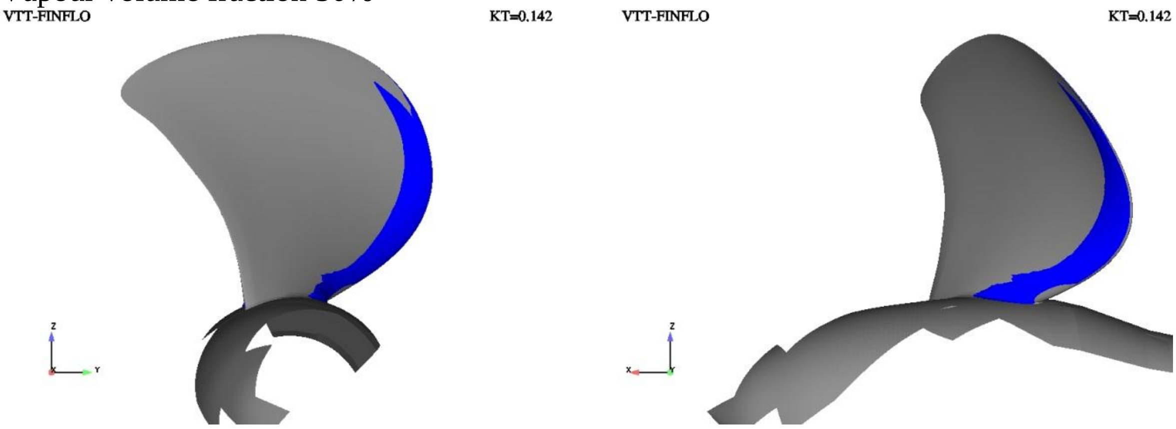




Vapour volume fraction 20%



Vapour volume fraction 50%



Vapour volume fraction 80%

6.4 Comparison of thrust coefficient

Table 3: Thrust coefficients of cavitating propeller

	case 2.3.1	case 2.3.2	case 2.3.3
	K_T [-]	K_T [-]	K_T [-]
Exp. (non-cavitating)	**0.3870**	**0.2450**	**0.1670**
Exp. (cavitating)	**0.3725**	**0.2064**	**0.1362**
Berg-Procal	0.3760		
Cradle-SC/Tetra	0.3750	0.1990	0.1380
CSSRC-Fluent	0.3740	0.1940	0.1320
INSEAN-PFC	0.3570	0.2330	0.1610
SSPA-Fluent	0.3880	0.2050	0.1440
TUHH-FreSCO+	0.3830		0.1440
TUHH-FreSCO+ (small-large coef.)		0.2420 - 0.1370	
UniGenua-Panel	0.3922	0.2369	0.1378
UniGenua-StarCCM	0.3782	0.2035	0.1306
UniTriest-CFX(FCM)	0.3740	0.2030	0.1300
UniTriest-CFX(Kunz)	0.3750	0.2100	0.1330
UniTriest-CFX(Zwart)	0.3730	0.1960	0.1330
VOITH-Comet	0.3852	0.2101	0.1513
VTT-FinFlo	0.3860	0.2020	0.1420

Table 4: Difference between computed and measured thrust of cavitating propeller

	case 2.3.1	case 2.3.2	case 2.3.3
	ΔK_T [%]	ΔK_T [%]	ΔK_T [%]
Berg-Procal	0.94		
Cradle-SC/Tetra	0.67	-3.59	1.32
CSSRC-Fluent	0.40	-6.01	-3.08
INSEAN-PFC	-4.16	12.89	18.21
SSPA-Fluent	4.16	-0.68	5.73
TUHH-FreSCO+	2.82		5.73
TUHH-FreSCO+ (small-large coef.)		17.25 - -33.62	
UniGenua-Panel	5.29	14.78	1.17
UniGenua-StarCCM	1.53	-1.41	-4.11
UniTriest-CFX(FCM)	0.40	-1.65	-4.55
UniTriest-CFX(Kunz)	0.67	1.74	-2.35
UniTriest-CFX(Zwart)	0.13	-5.04	-2.35
VOITH-Comet	3.41	1.79	11.09
VTT-FinFlo	3.62	-2.13	4.26

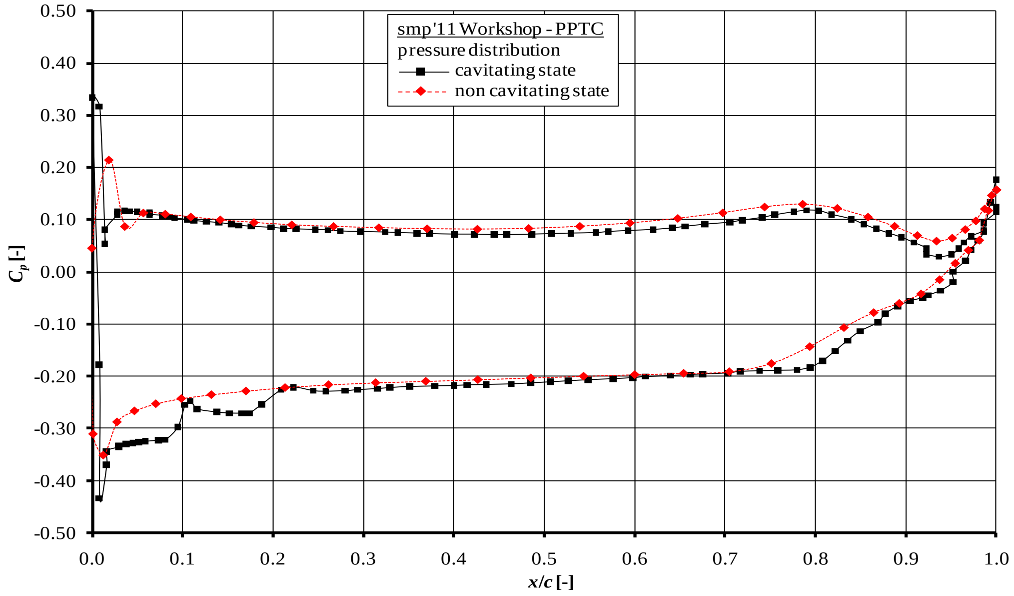
Case 2.3.1

Cavitation Test
Pressure distribution

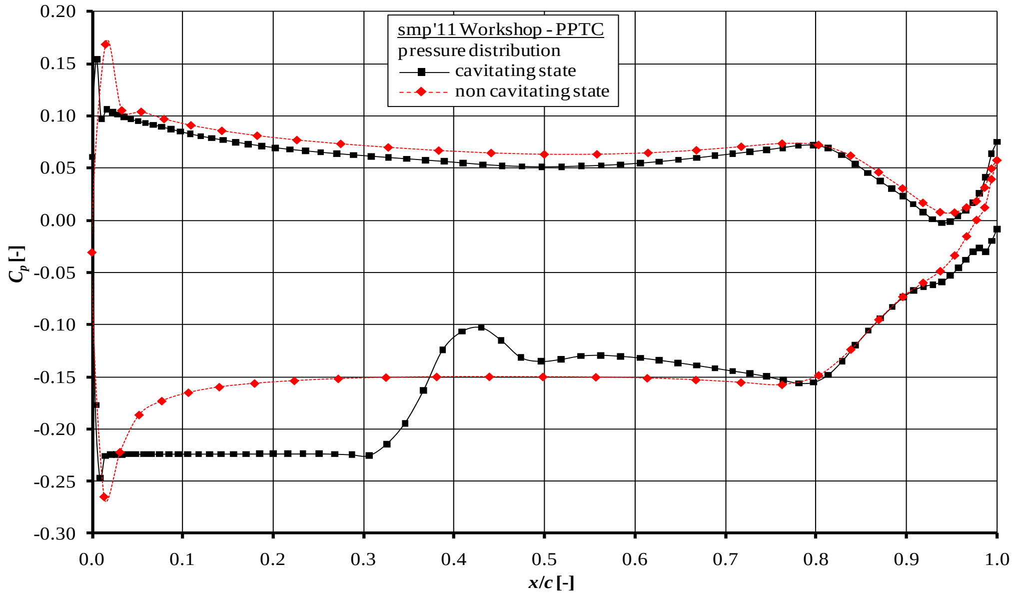
Evaluation

Berg-OpenFOAM **Case 2.3.1**

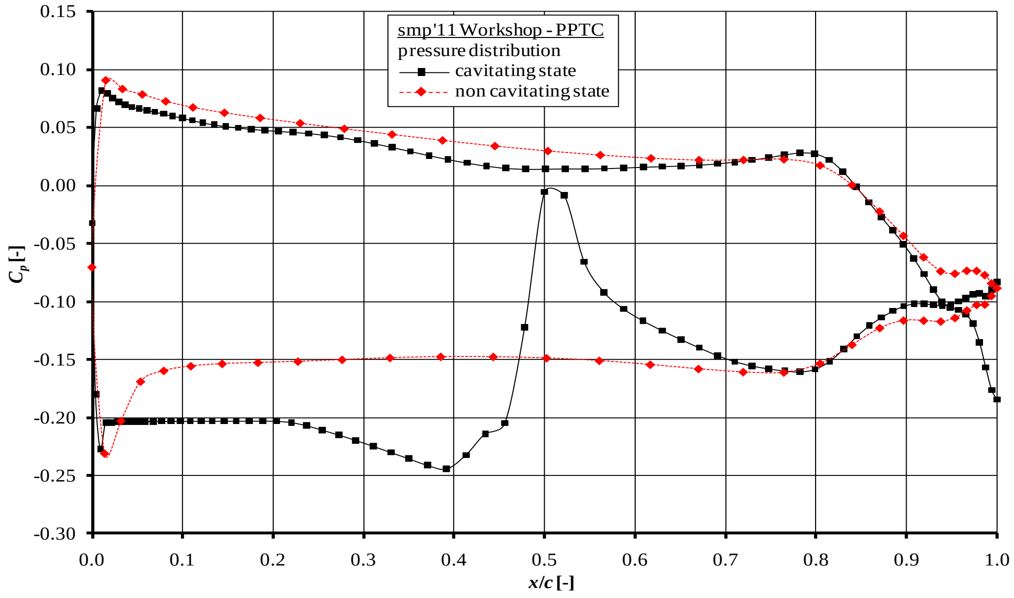
***r*/*R* = 0.70**



***r*/*R* = 0.90**

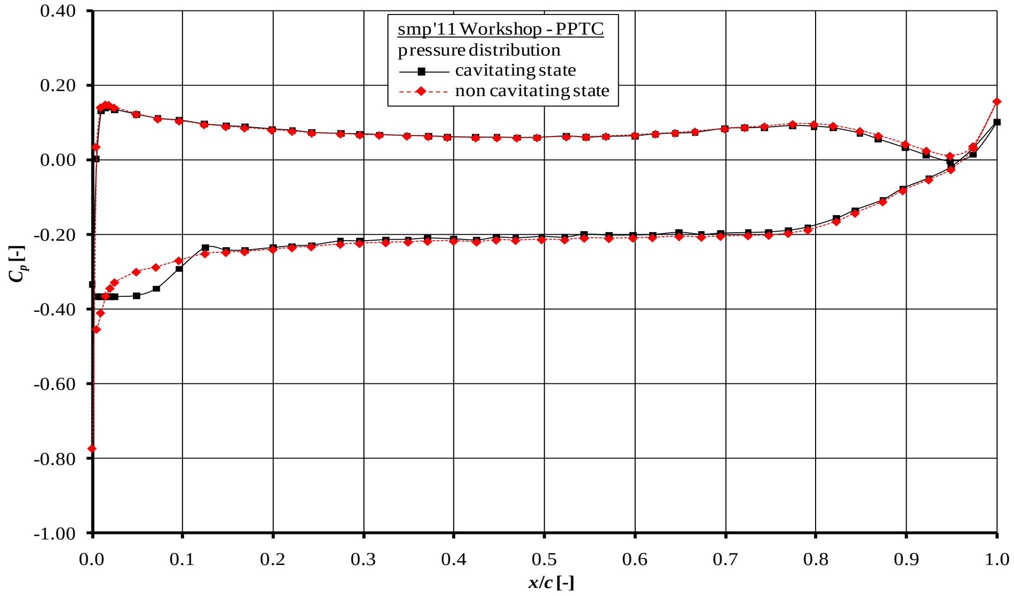


***r*/*R* = 0.95**

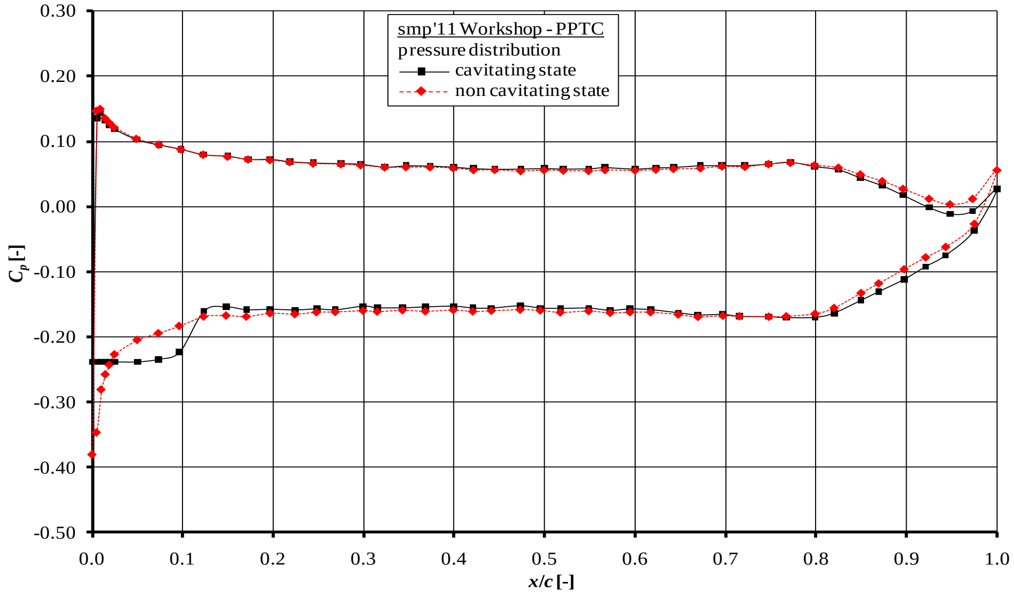


Cradle-SC/Tetra **Case 2.3.1**

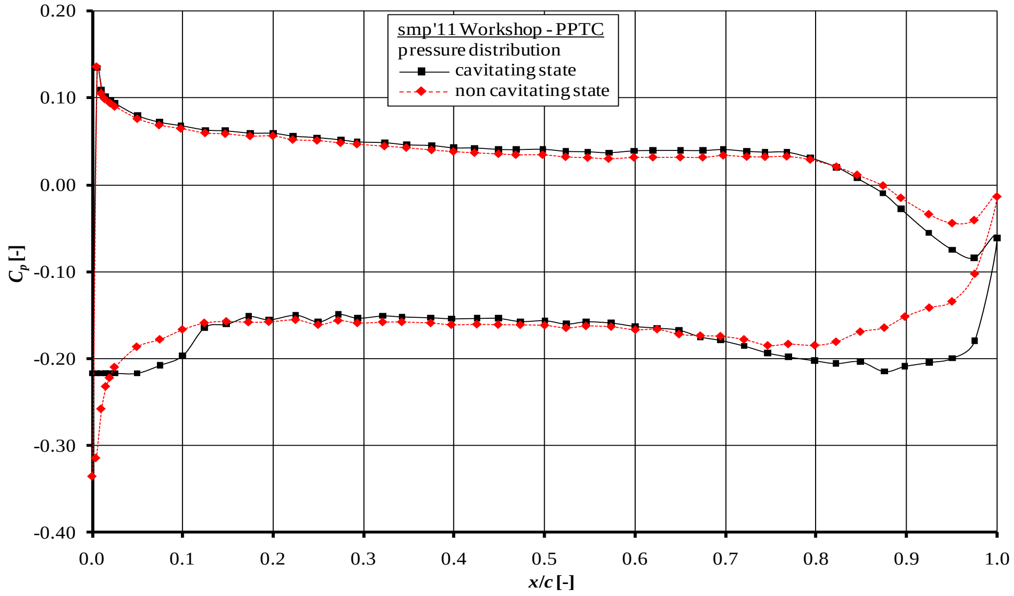
r/R = 0.70



r/R = 0.90

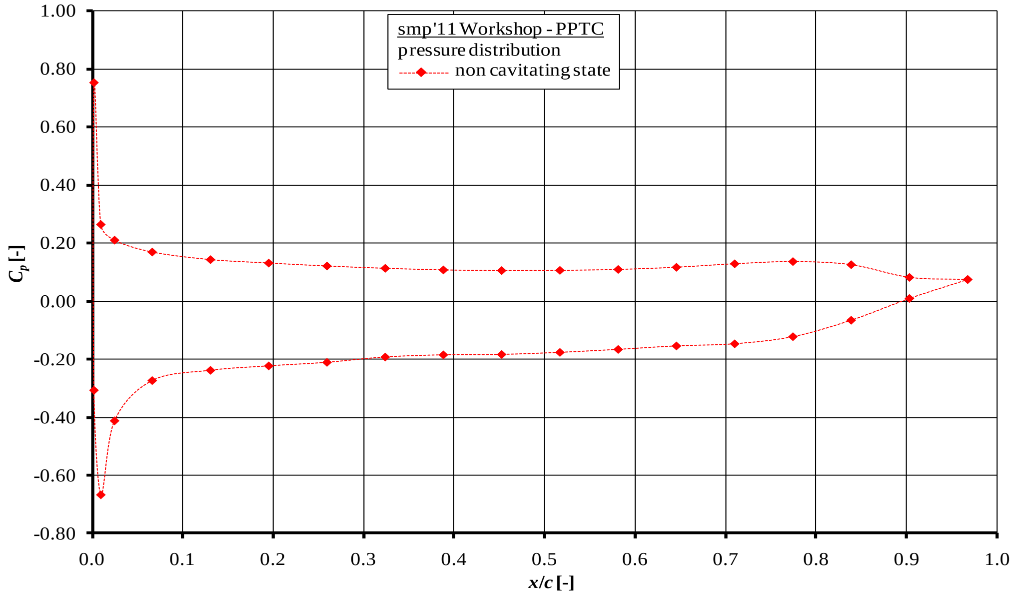


r/R = 0.95

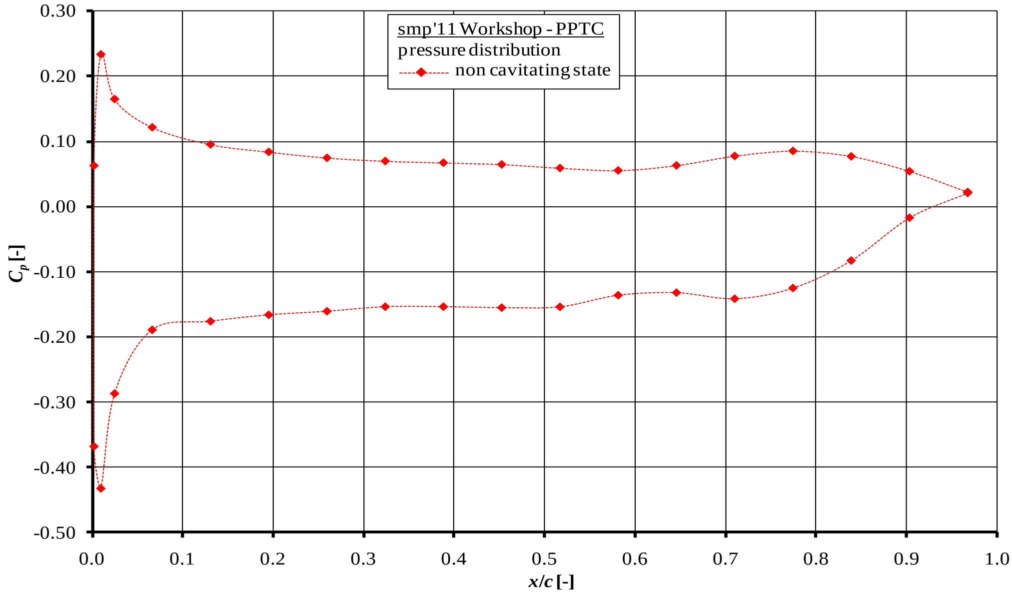


HSVA-PPB **Case 2.3.1**

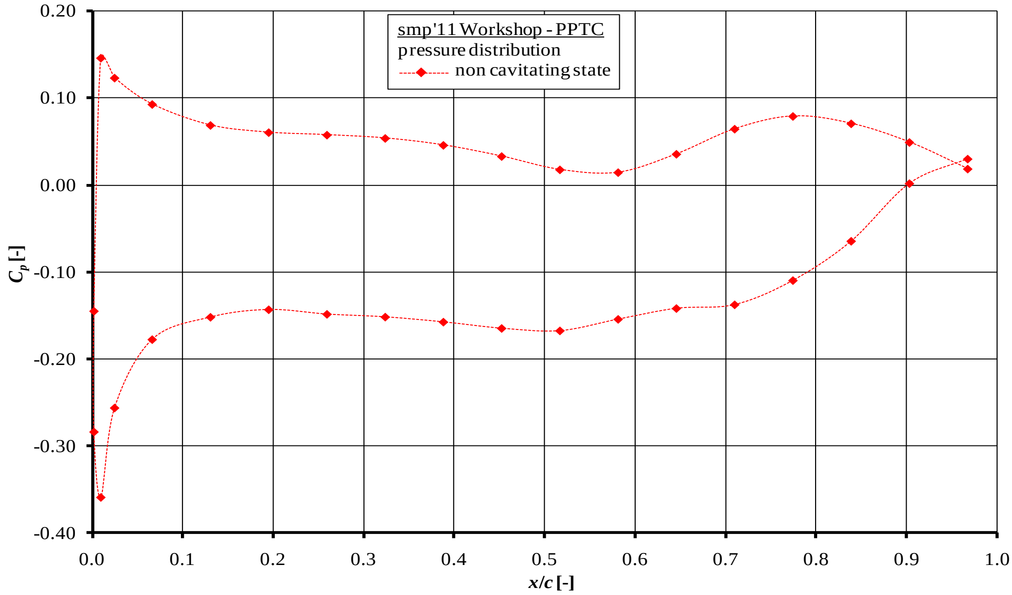
r/R = 0.70



r/R = 0.90

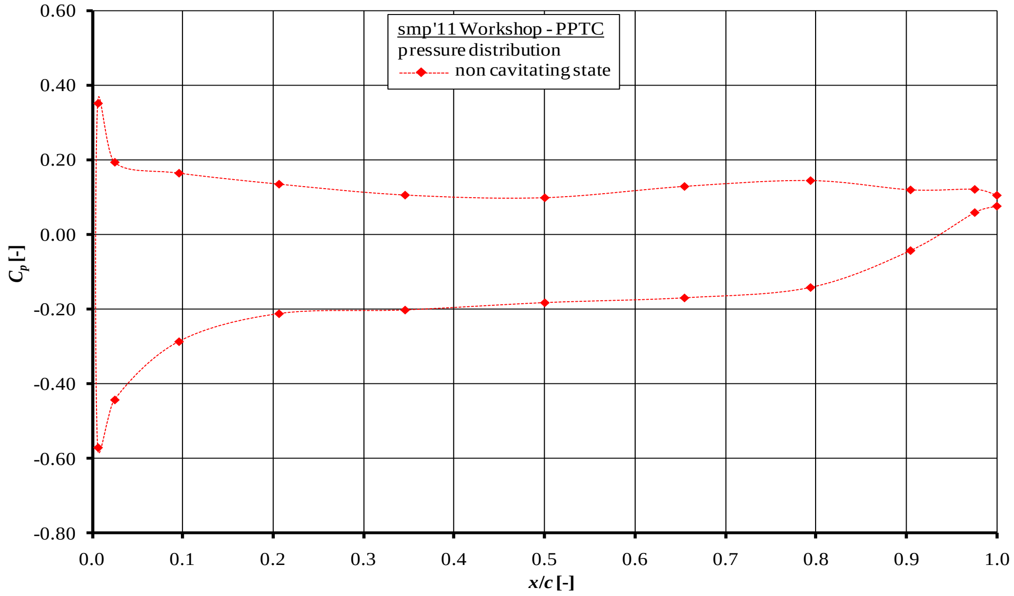


r/R = 0.95

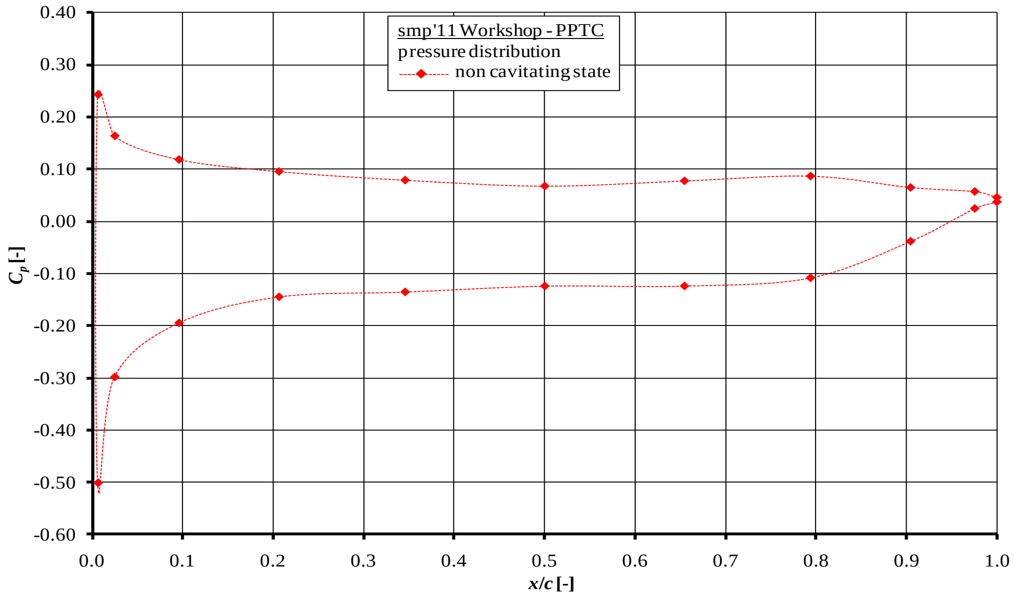


HSVA-QCM **Case 2.3.1**

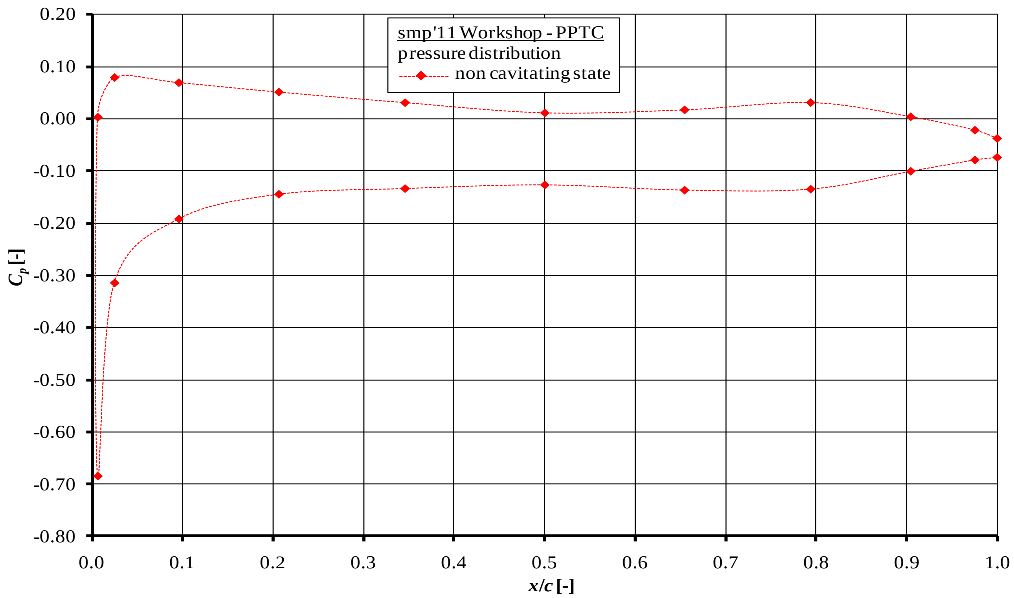
r/R = 0.70



r/R = 0.90

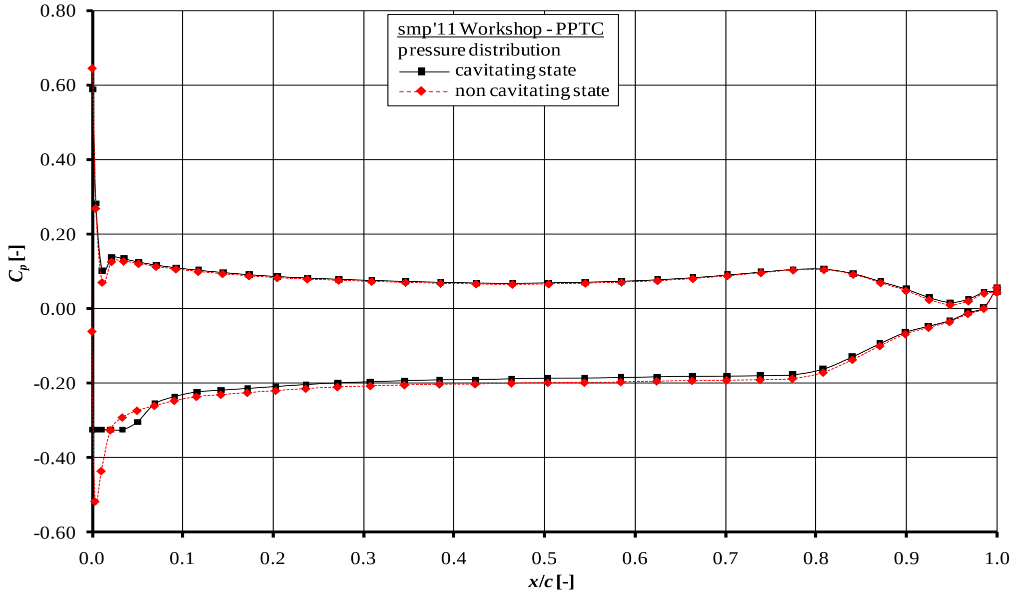


r/R = 0.95

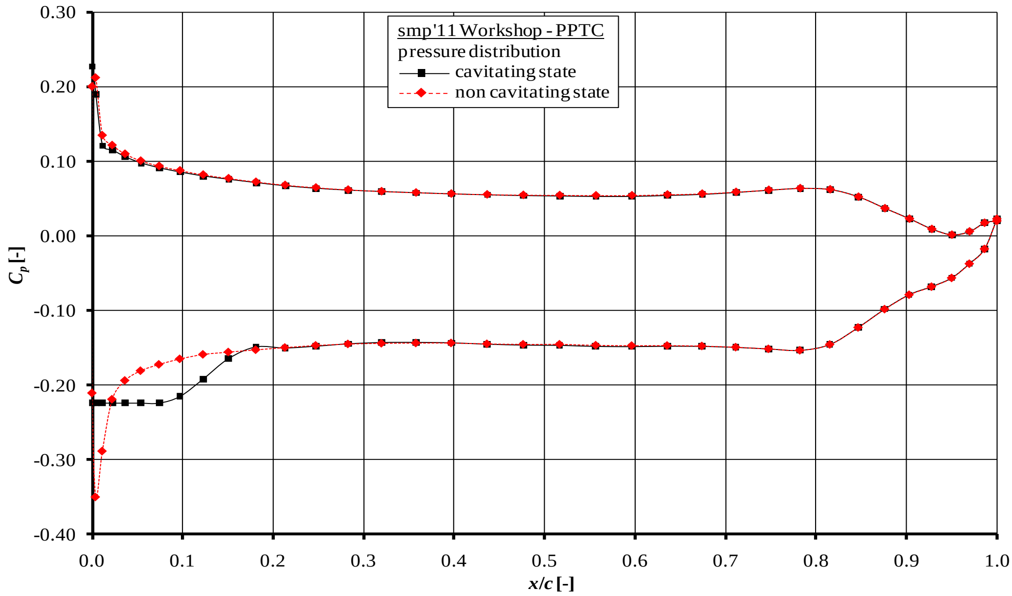


INSEAN-PFC **Case 2.3.1**

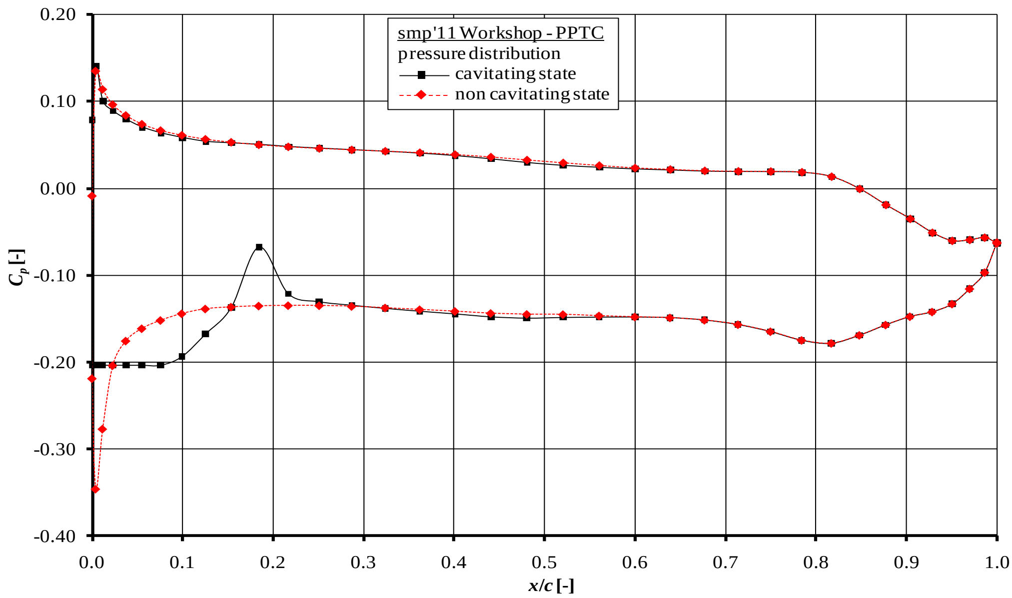
r/R = 0.70



r/R = 0.90

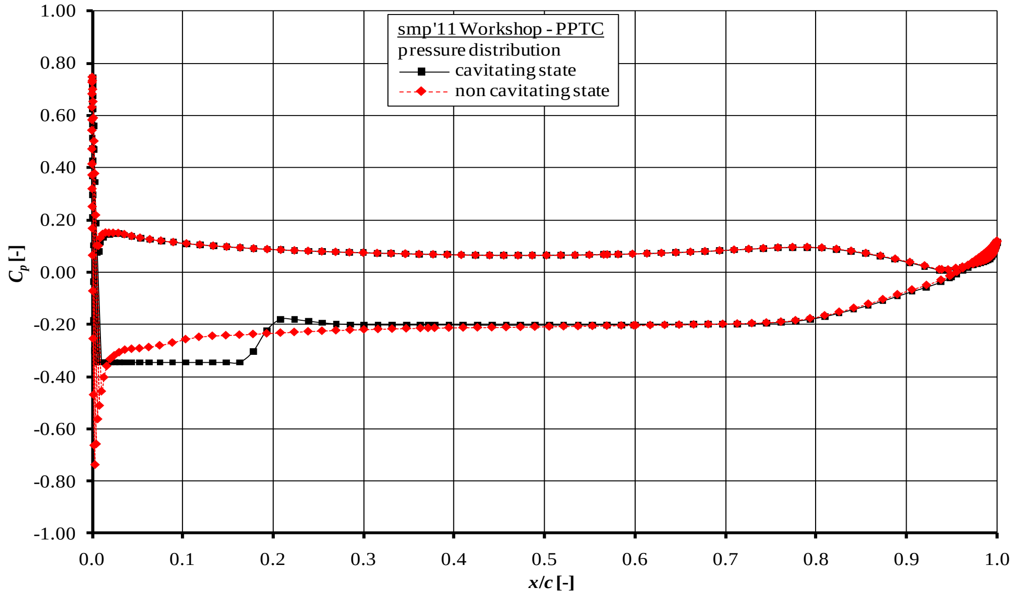


r/R = 0.95

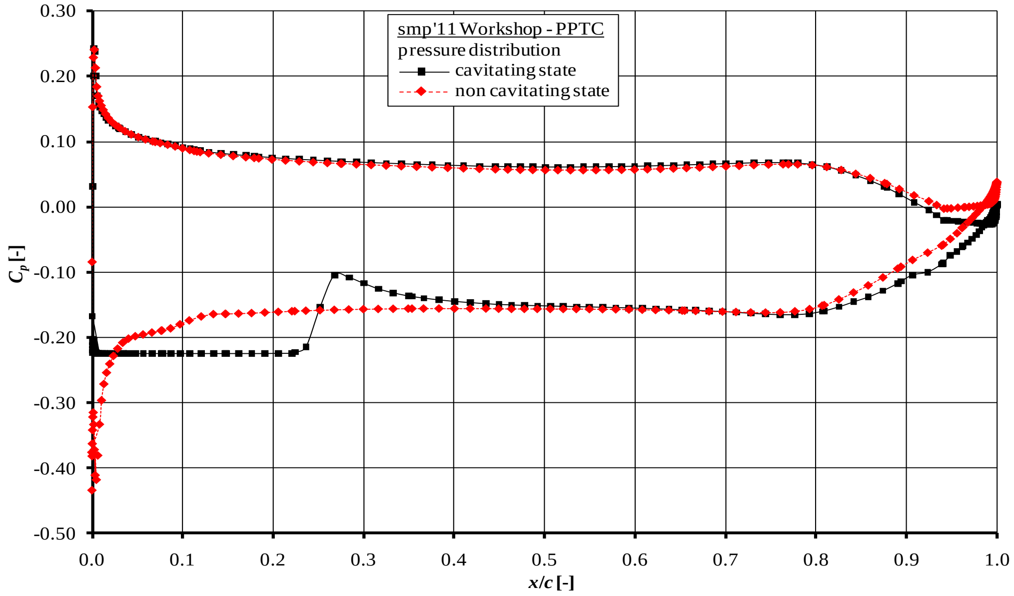


SSPA-Fluent **Case 2.3.1**

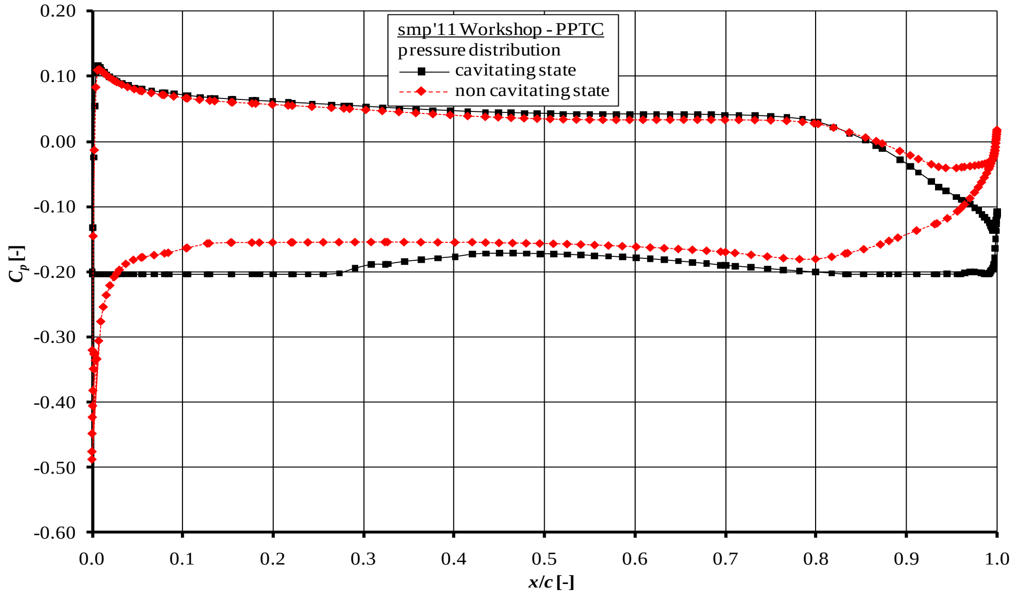
r/R = 0.70



r/R = 0.90

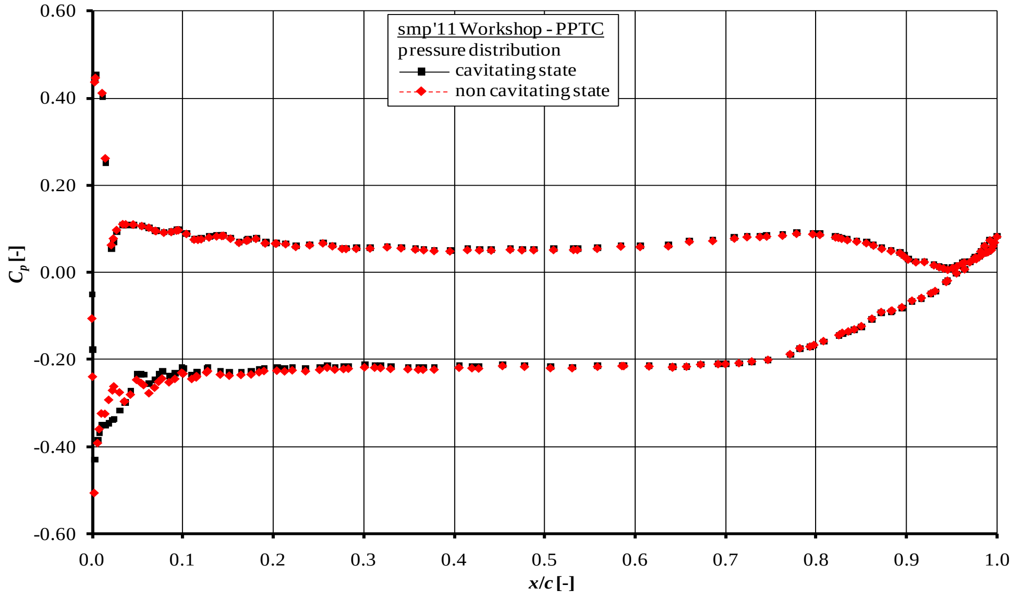


r/R = 0.95

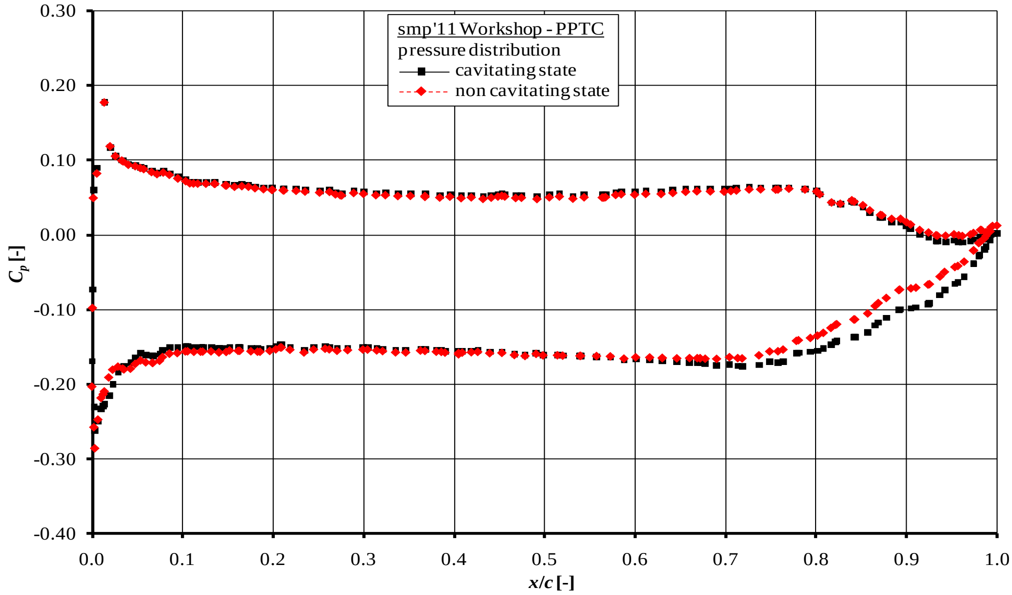


TUHH-Fresco+ **Case 2.3.1**

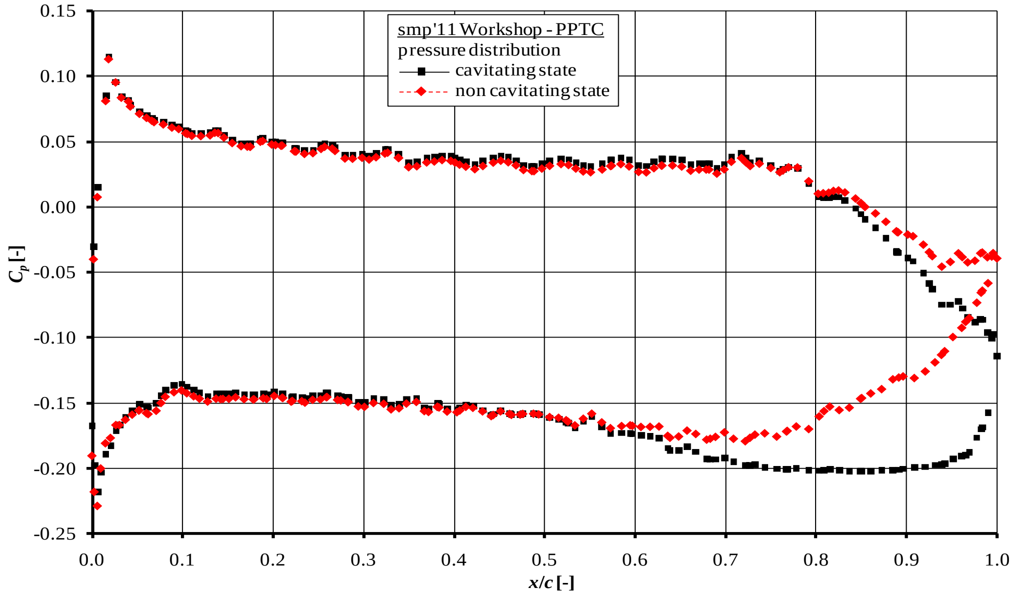
r/R = 0.70



r/R = 0.90

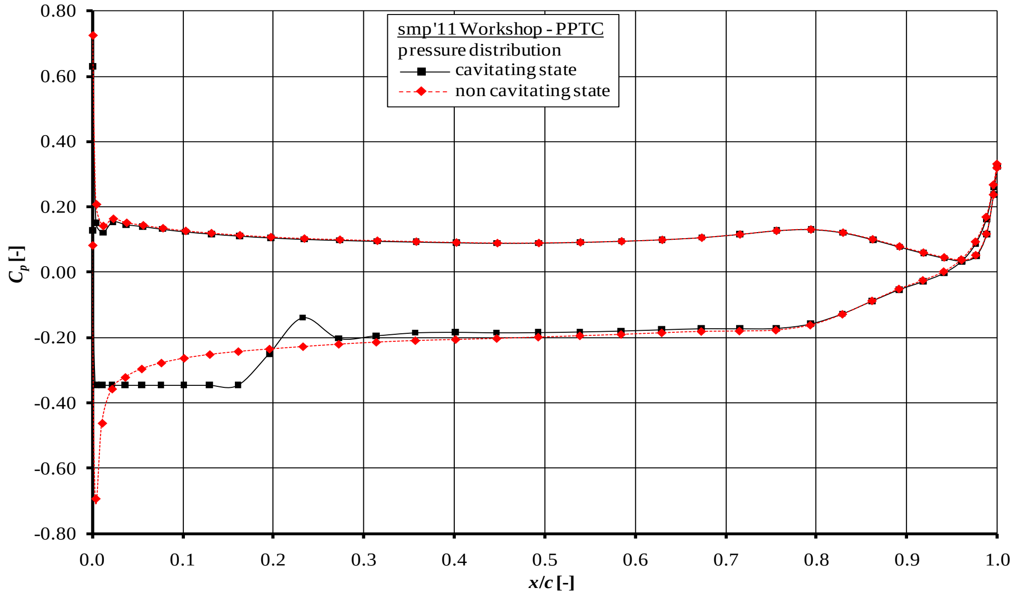


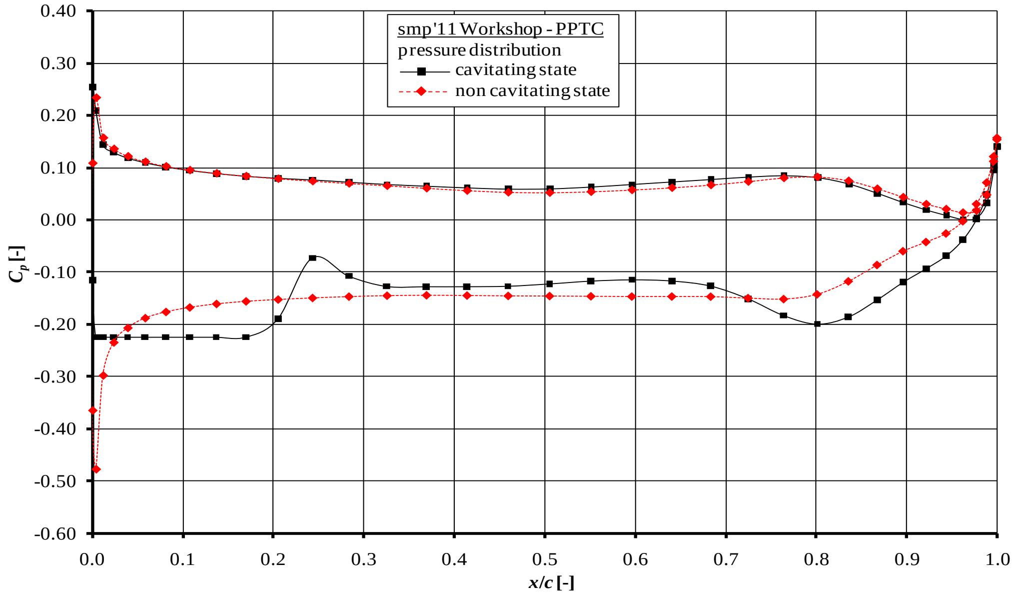
r/R = 0.95



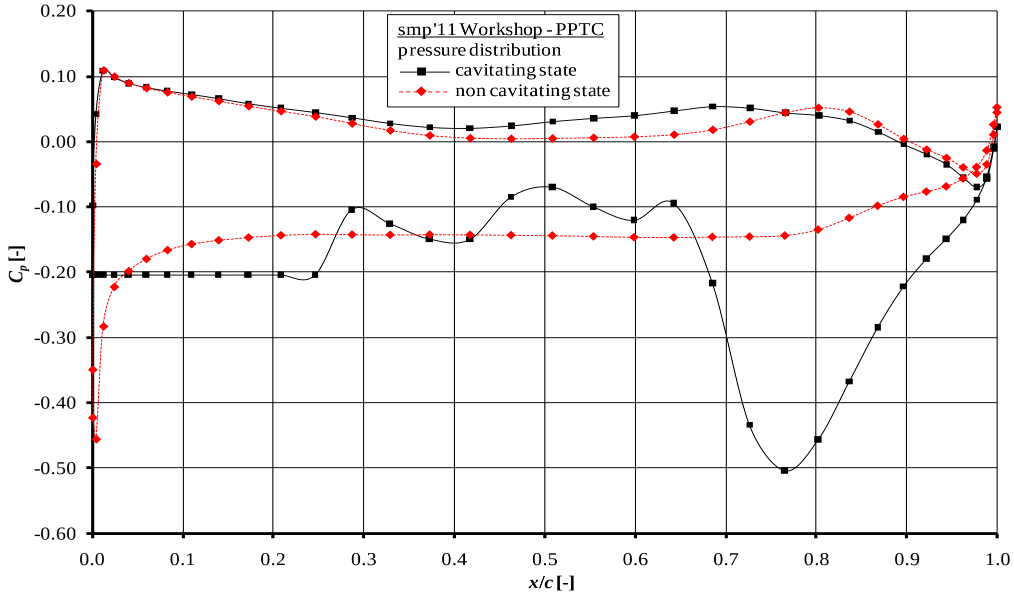
UniGenua-Panel **Case 2.3.1**

r/R = 0.70





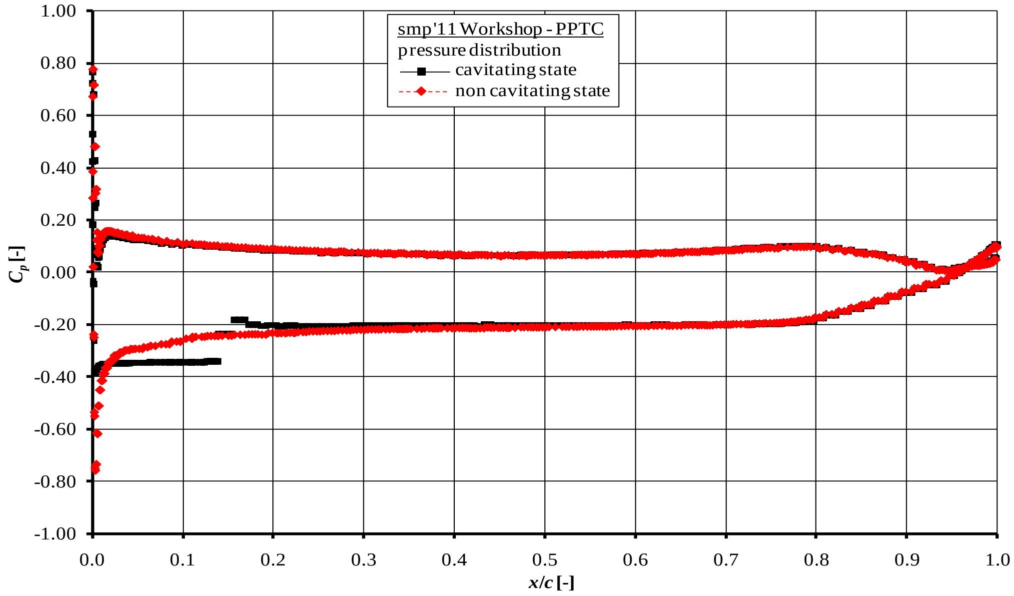
r/R = 0.95



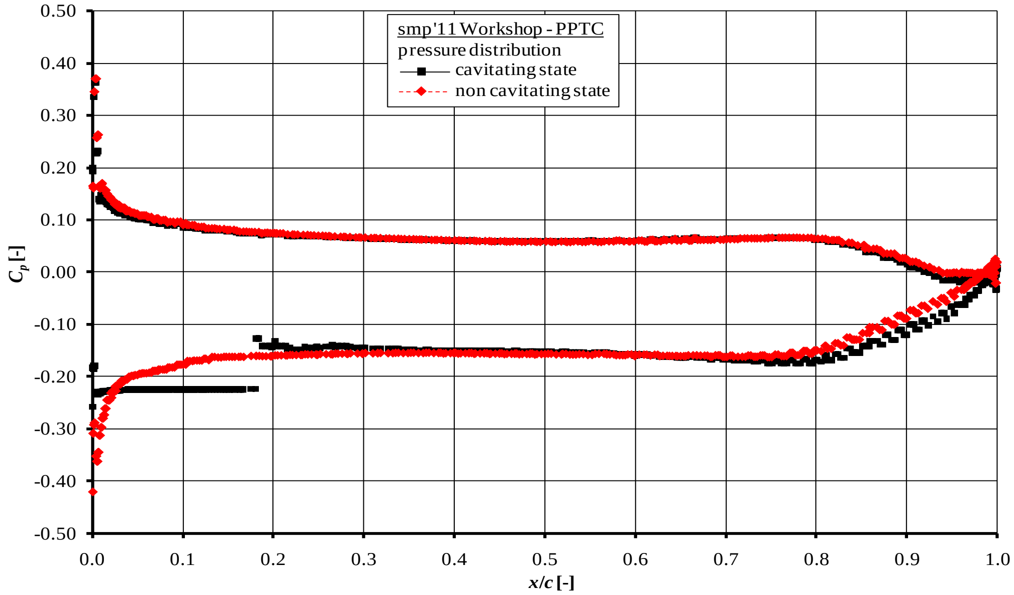
.90

UniGenua-StarCCM(kw) **Case 2.3.1**

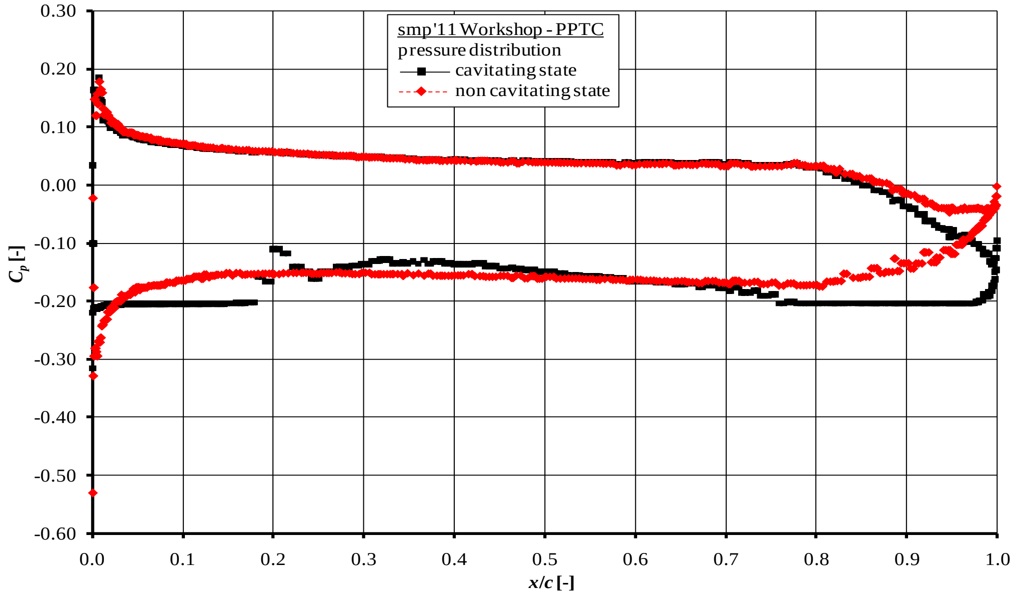
r/R = 0.70



r/R = 0.90

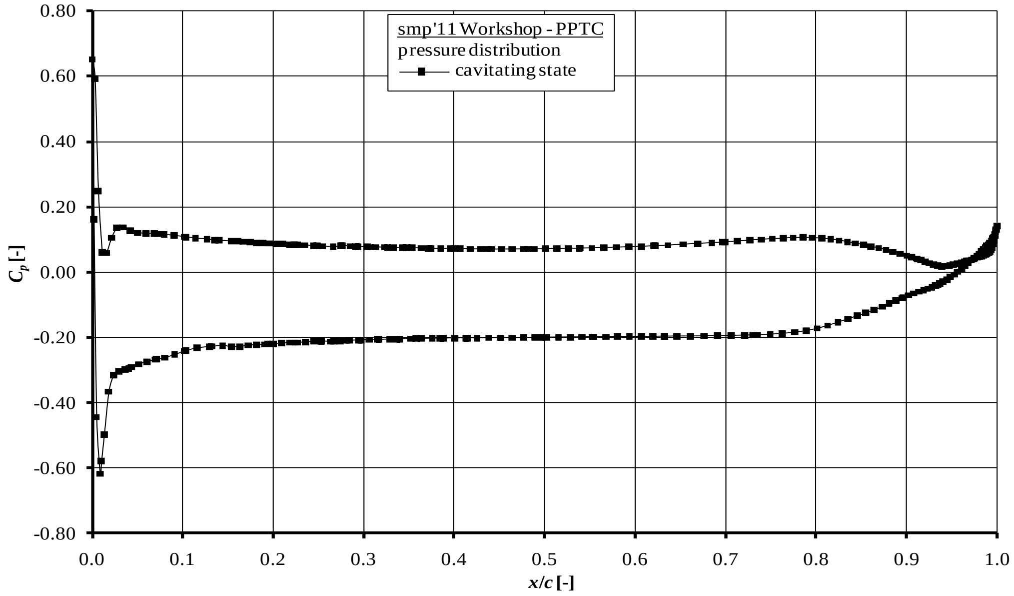


r/R = 0.95

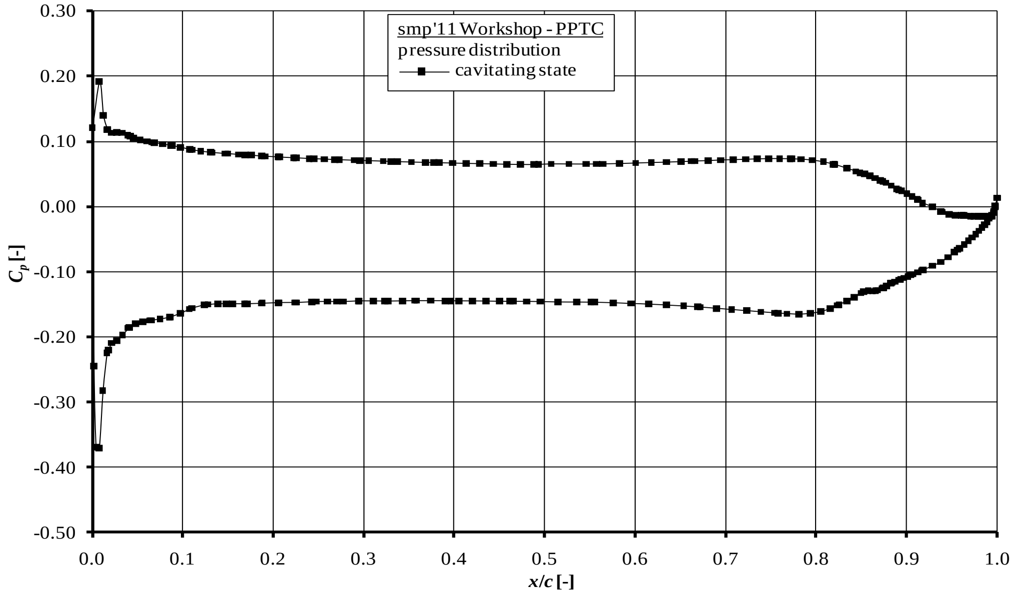


UniTriest-CFX-FCM **Case 2.3.1**

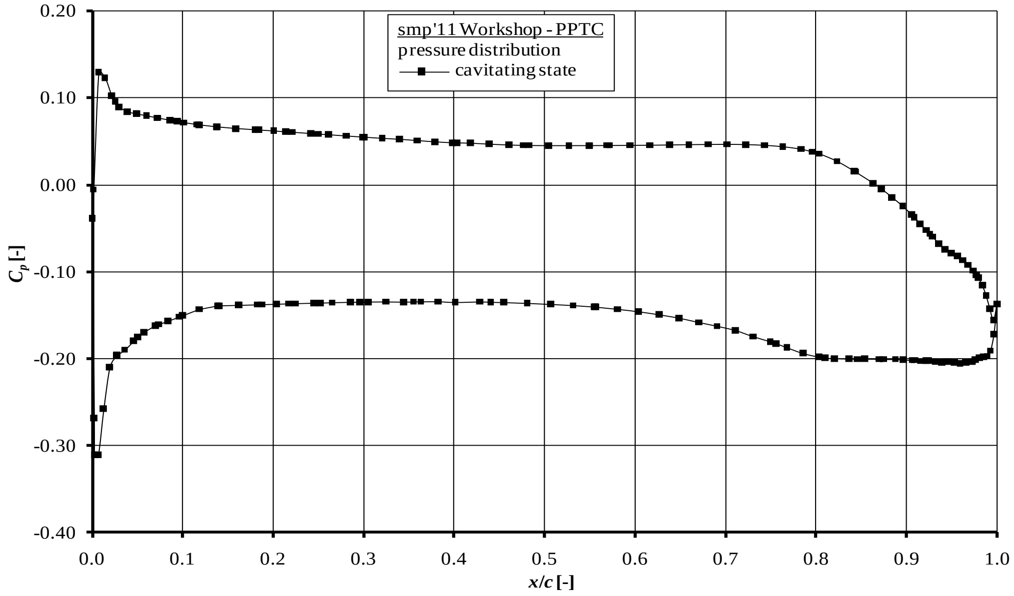
r/R = 0.70



r/R = 0.90

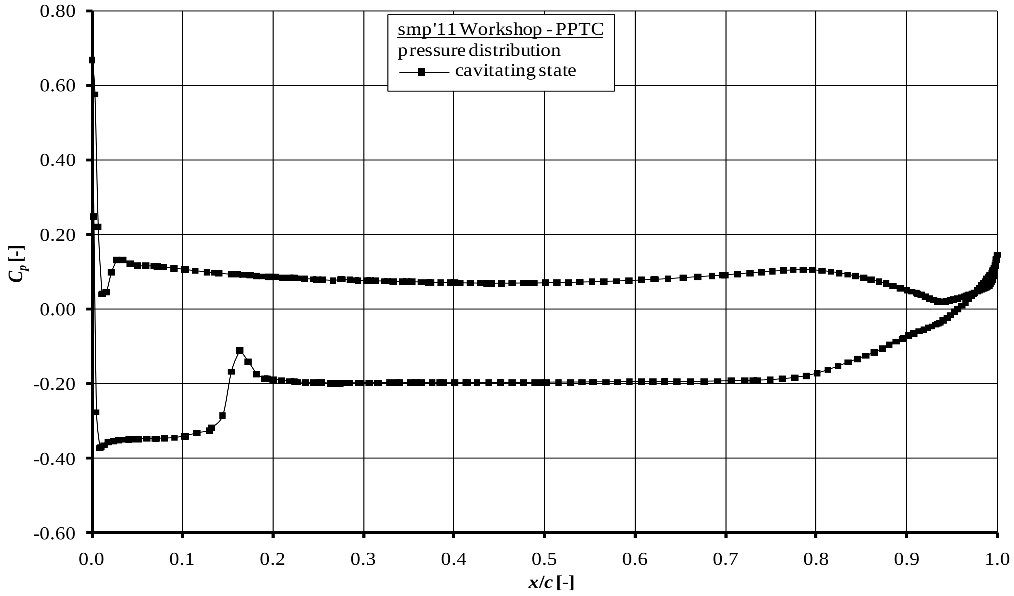


r/R = 0.95

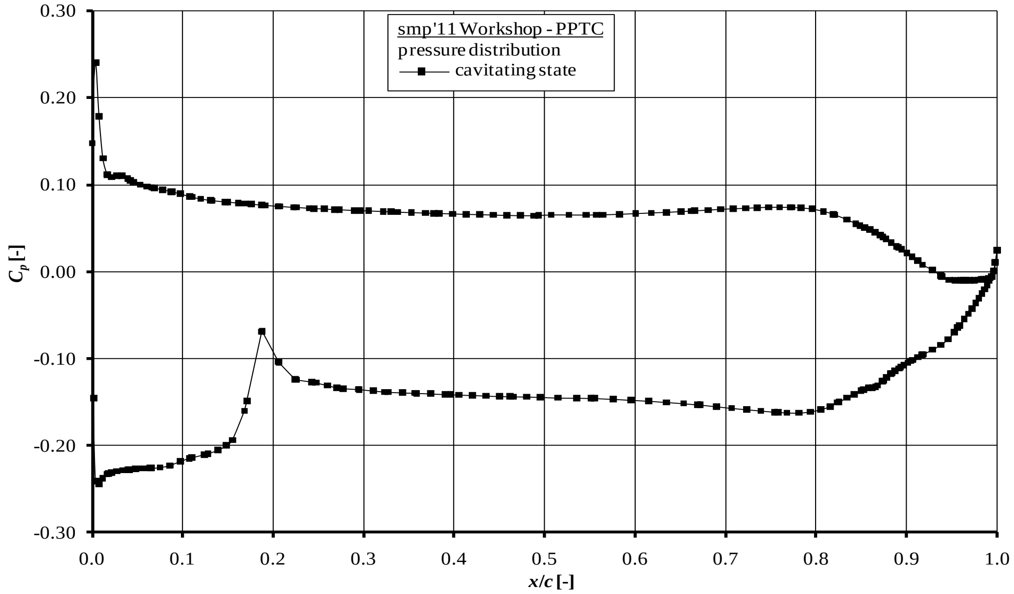


UniTriest-CFX-Kunz **Case 2.3.1**

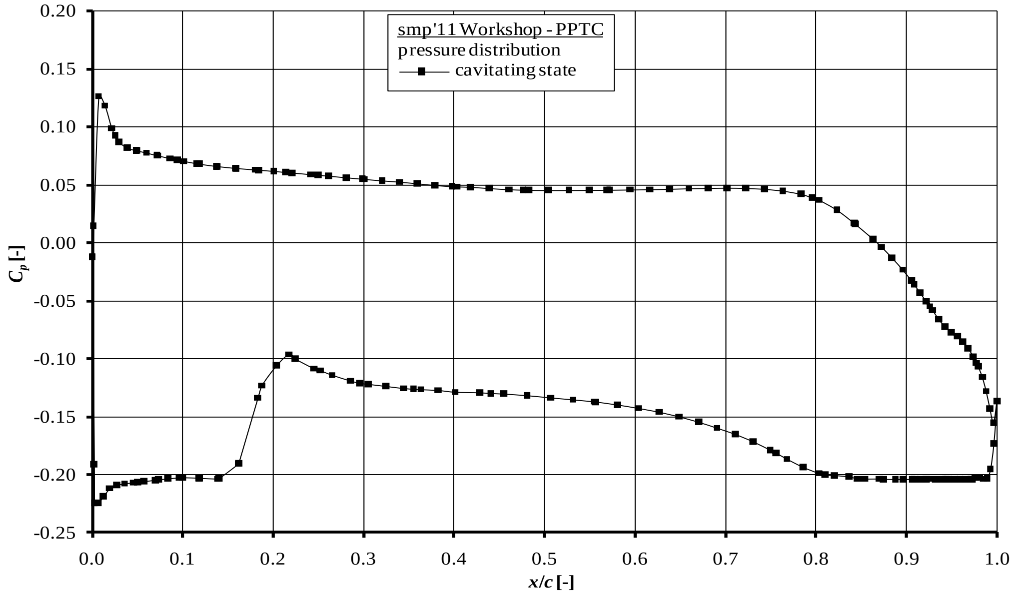
r/R = 0.70



r/R = 0.90

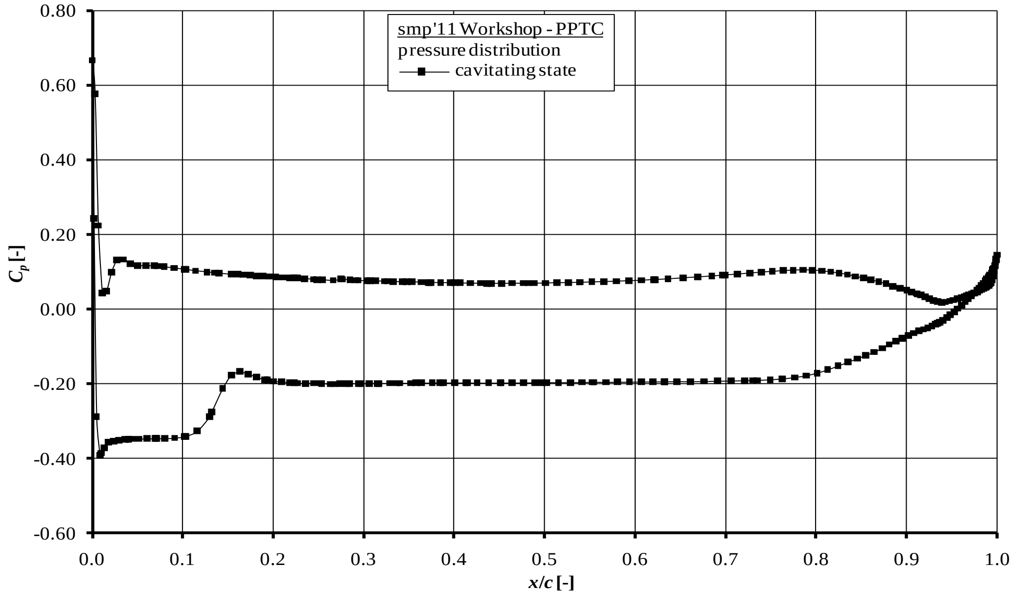


r/R = 0.95

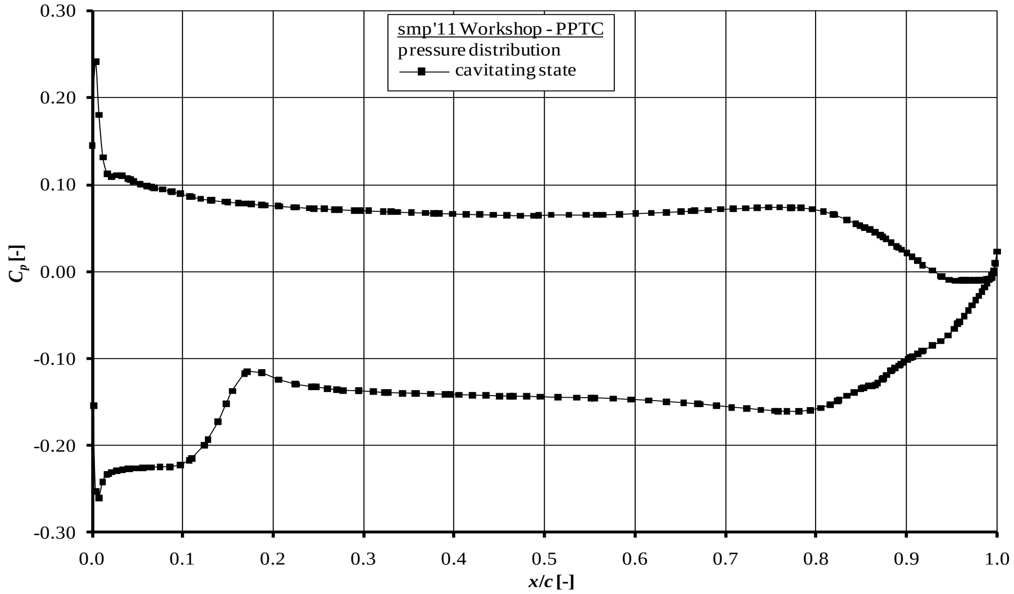


UniTriest-CFX-Zwart **Case 2.3.1**

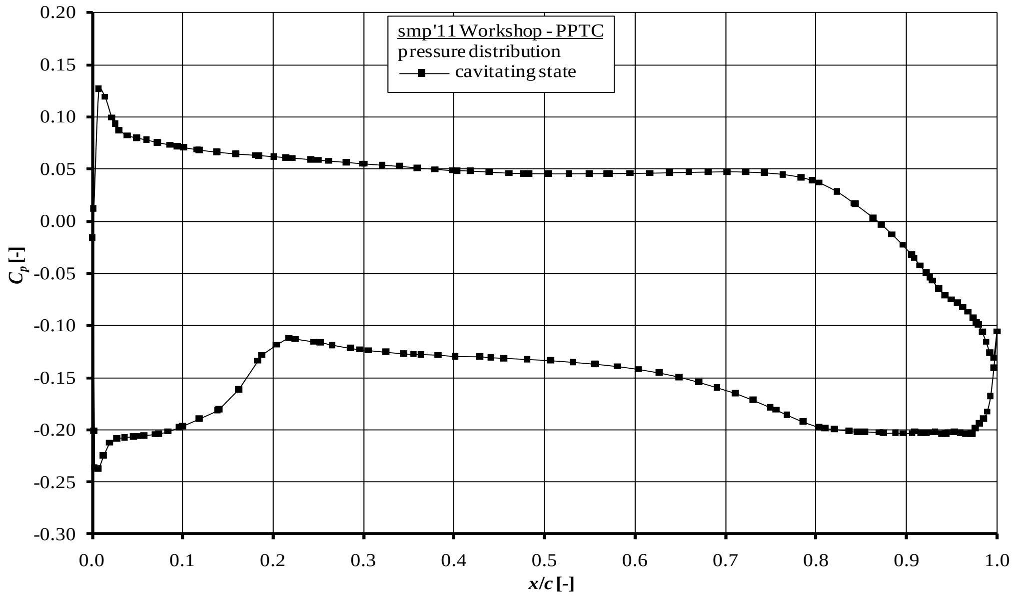
r/R = 0.70



r/R = 0.90

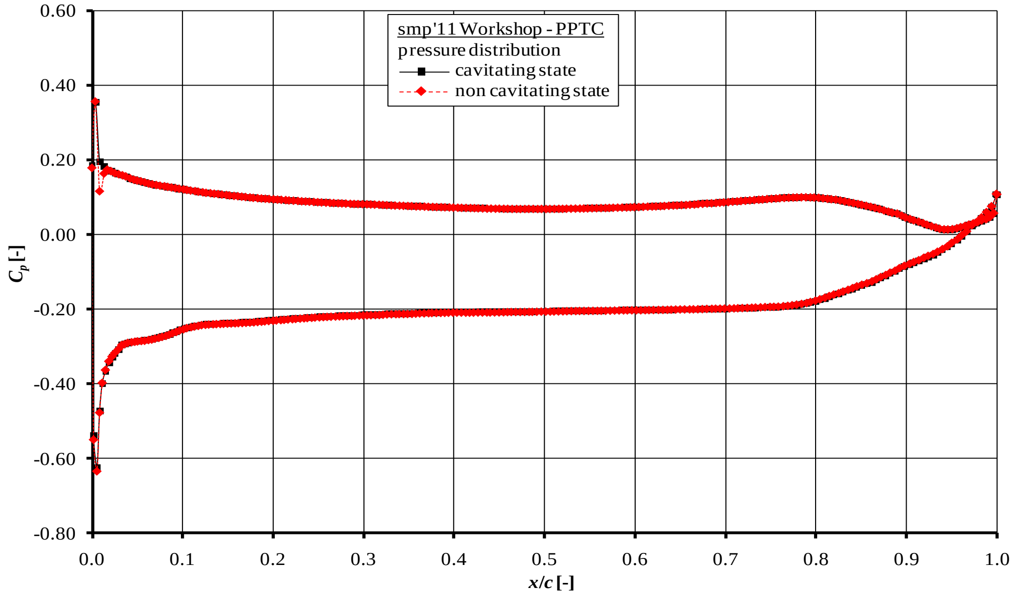


r/R = 0.95

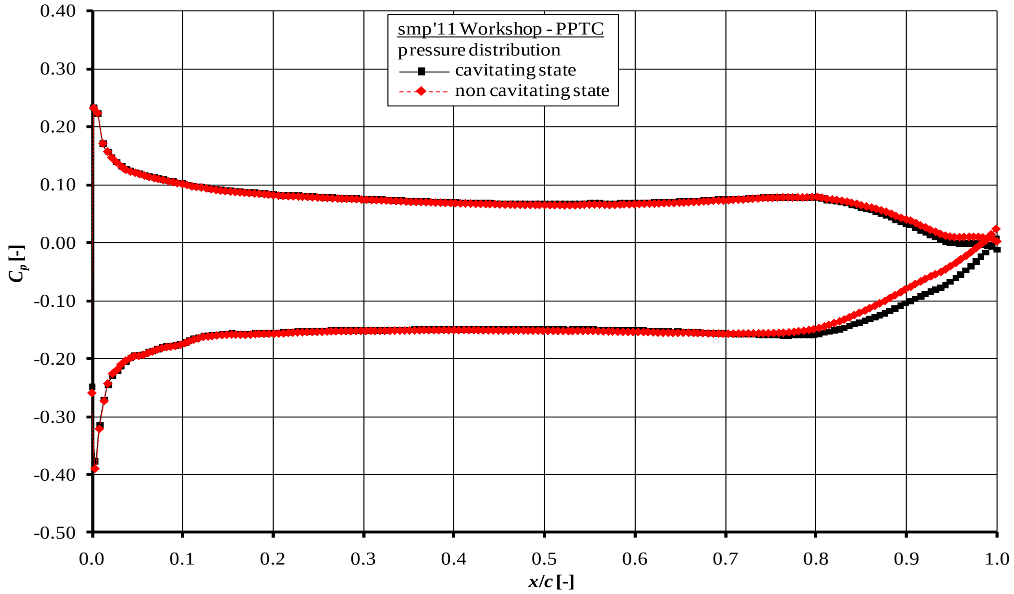


VOITH-Comet **Case 2.3.1**

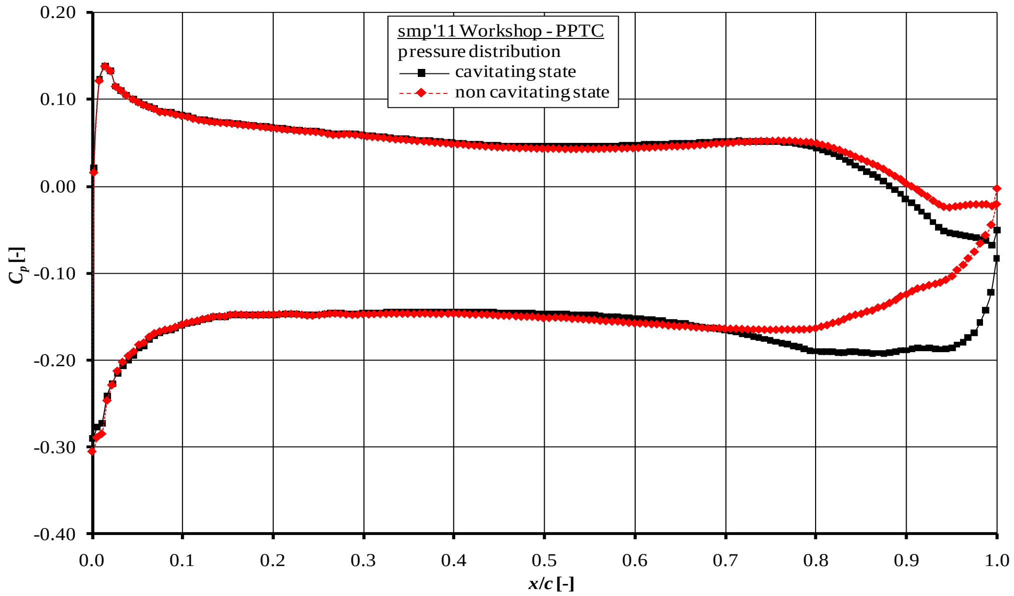
r/R = 0.70



r/R = 0.90

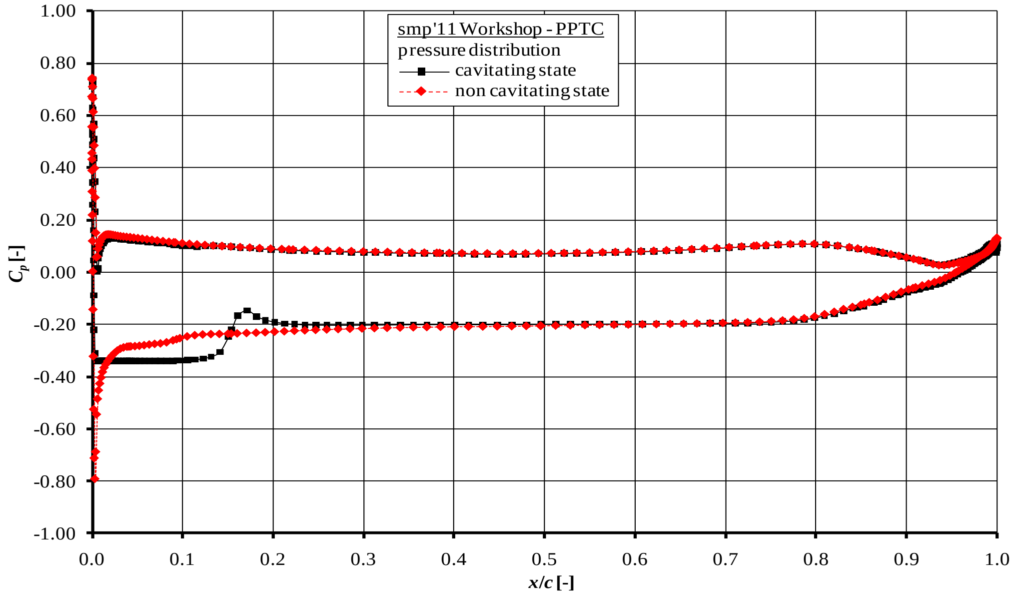


r/R = 0.95

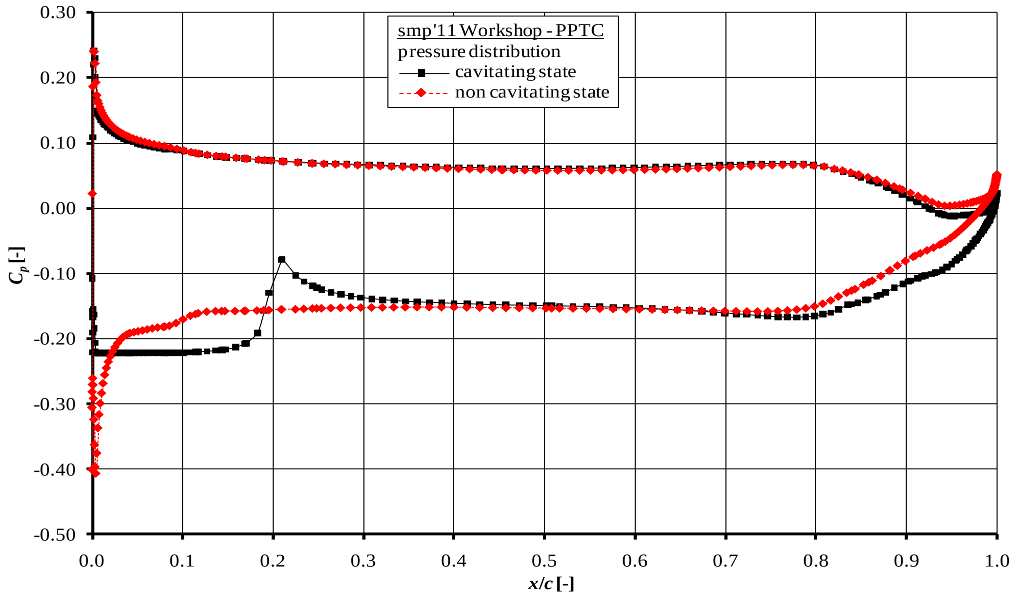


VTT-FinFlo **Case 2.3.1**

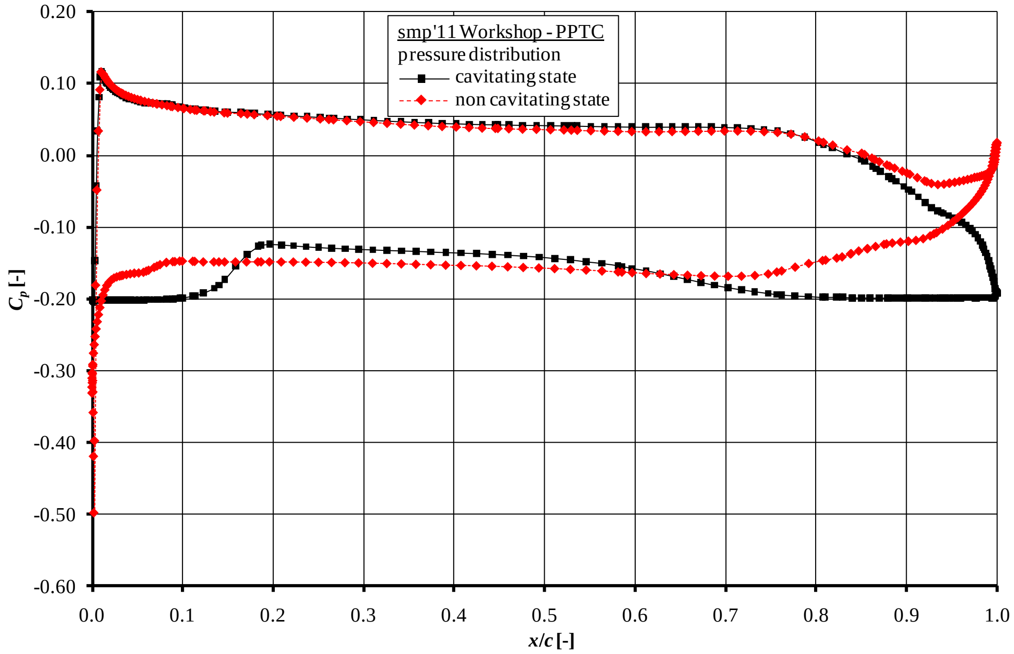
r/R = 0.70



r/R = 0.90



r/R = 0.95



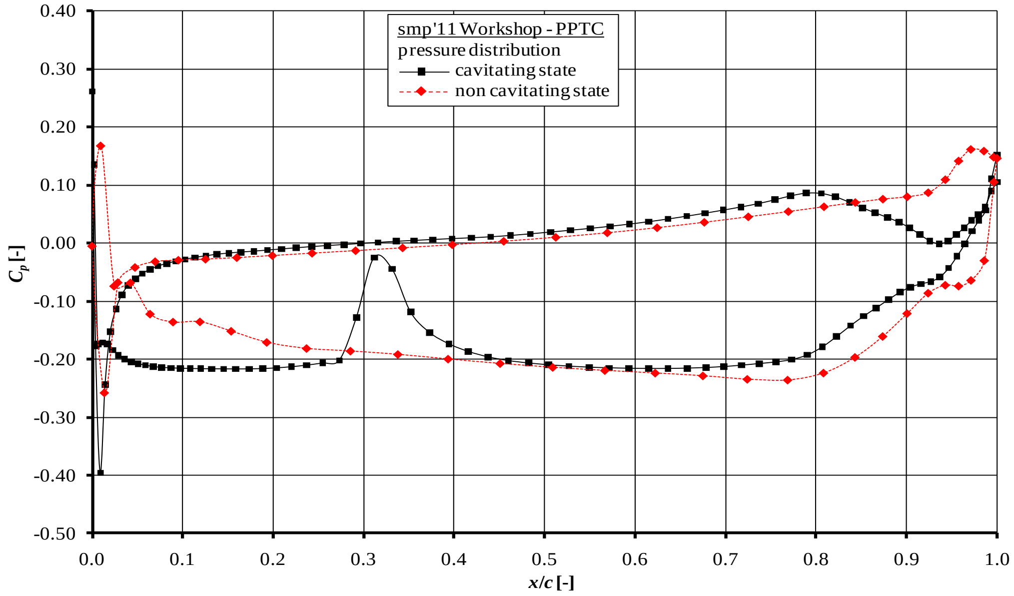
Case 2.3.2

Cavitation Test
Pressure distribution

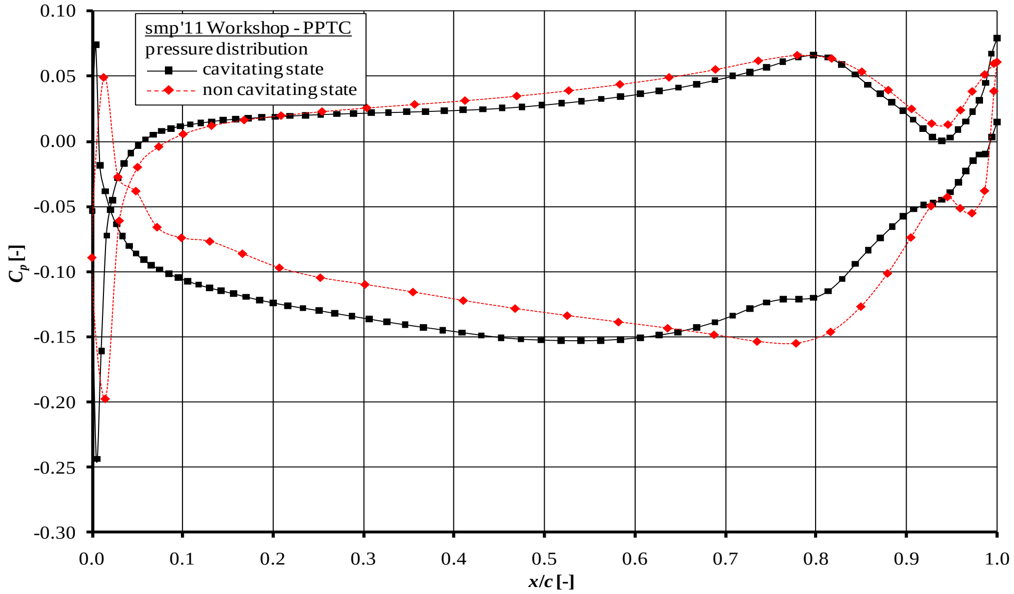
Evaluation

Berg-OpenFOAM **Case 2.3.2**

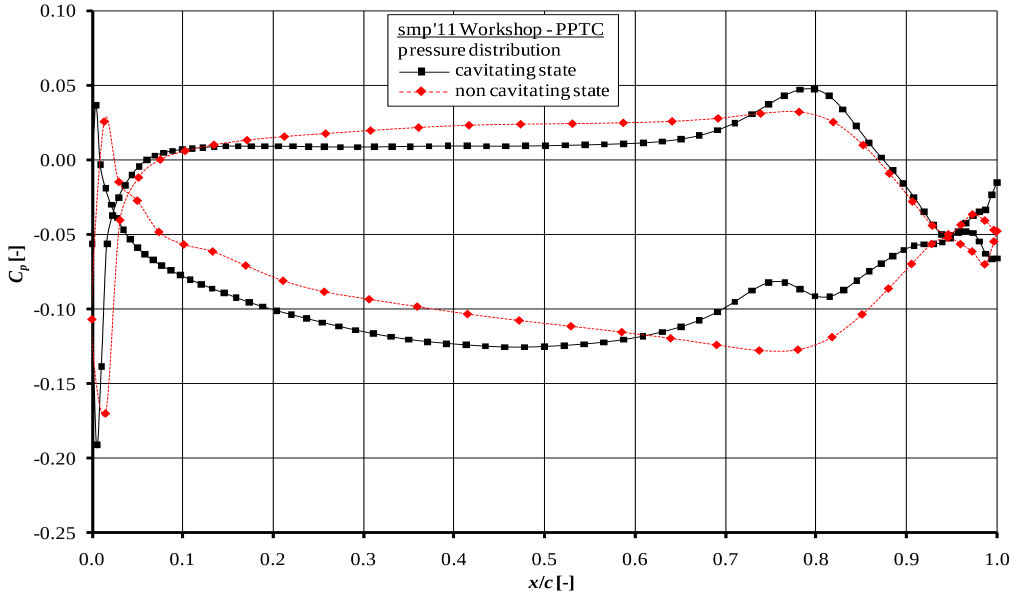
r/R = 0.70



r/R = 0.90

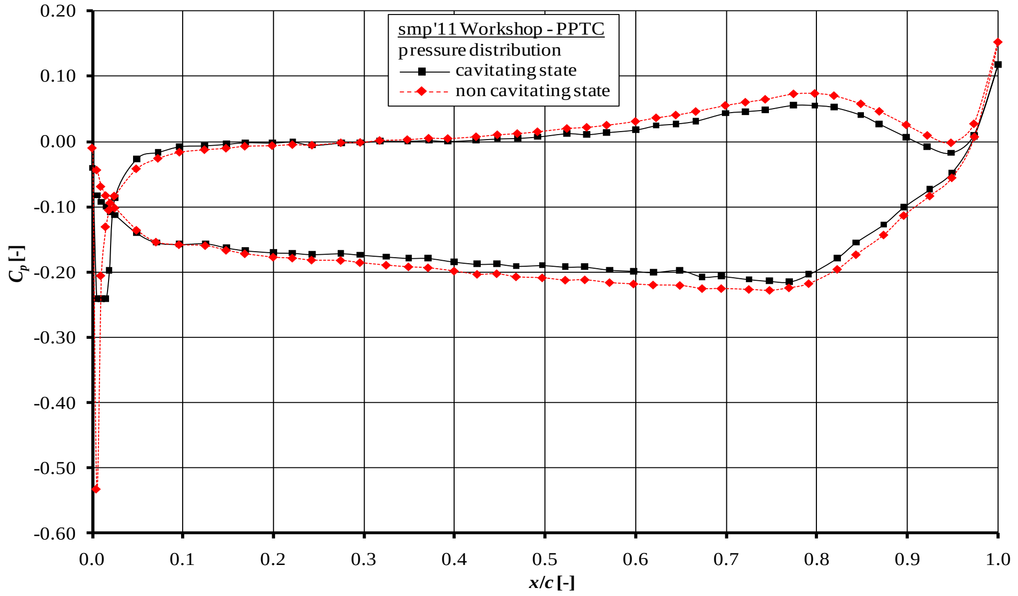


r/R = 0.95

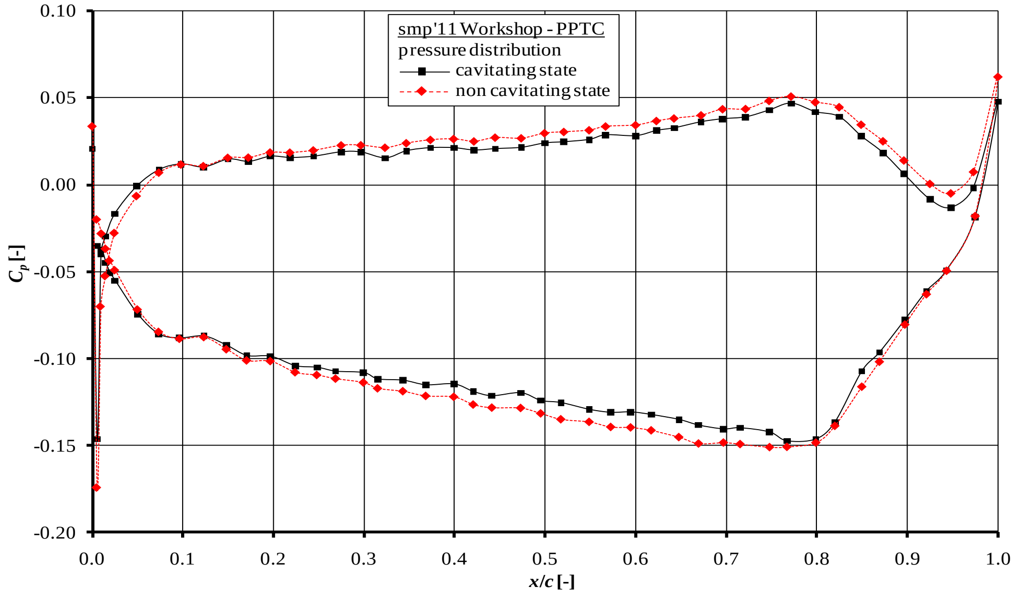


Cradle-SC/Tetra **Case 2.3.2**

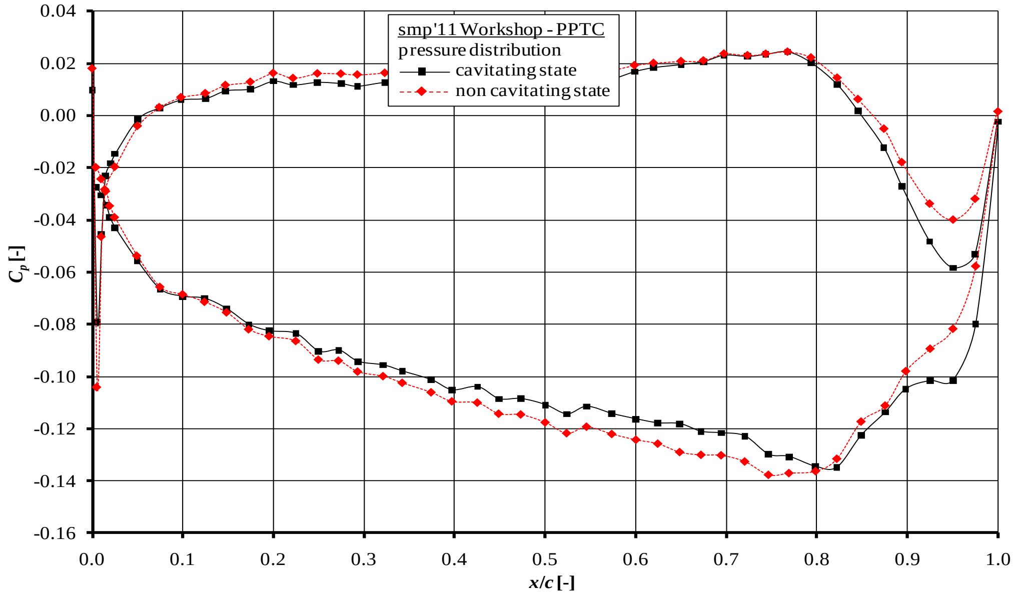
r/R = 0.70



r/R = 0.90

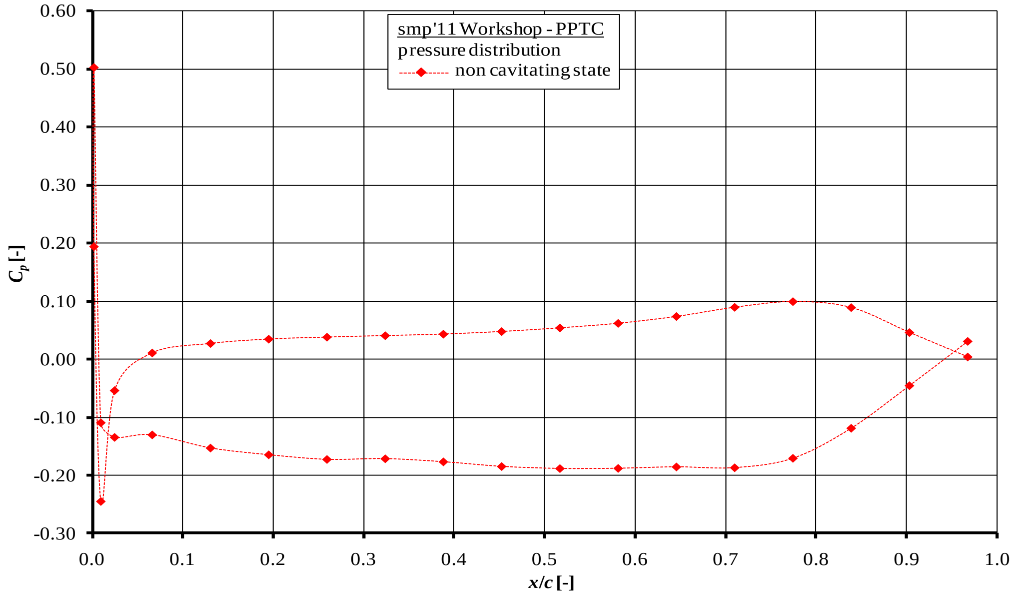


r/R = 0.95

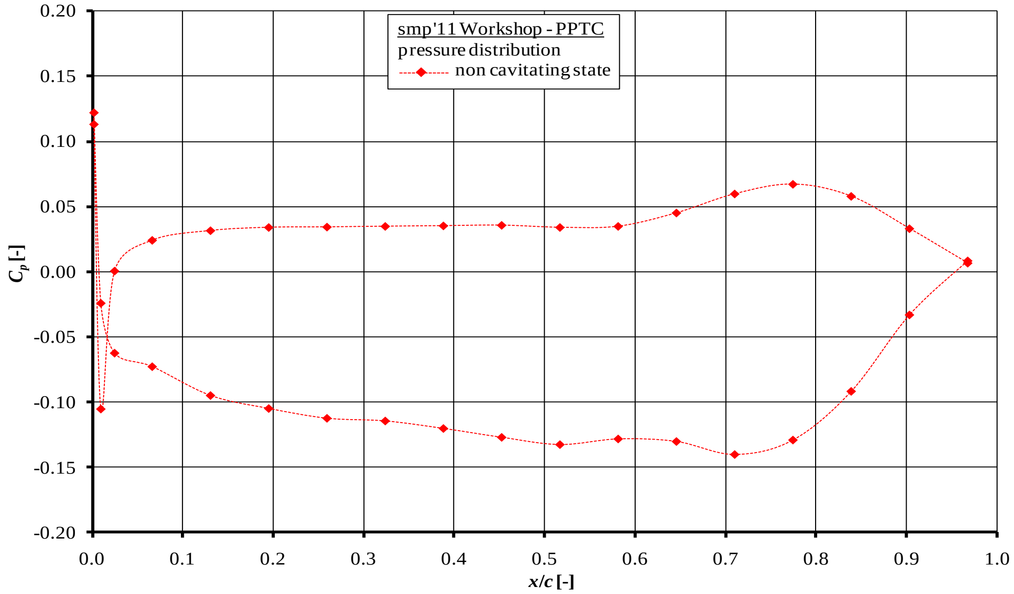


HSVA-PPB **Case 2.3.2**

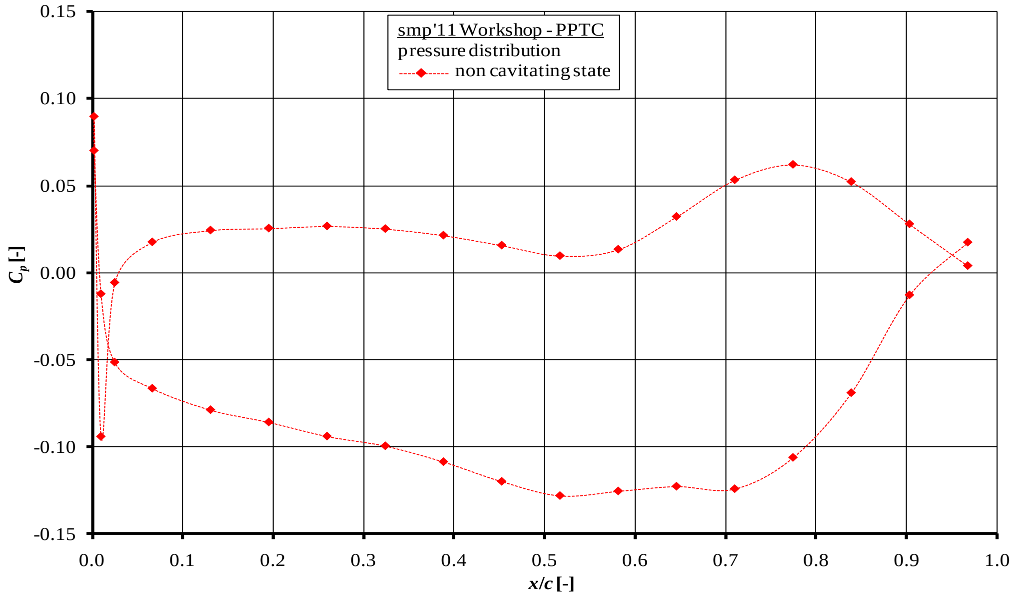
r/R = 0.70



r/R = 0.90

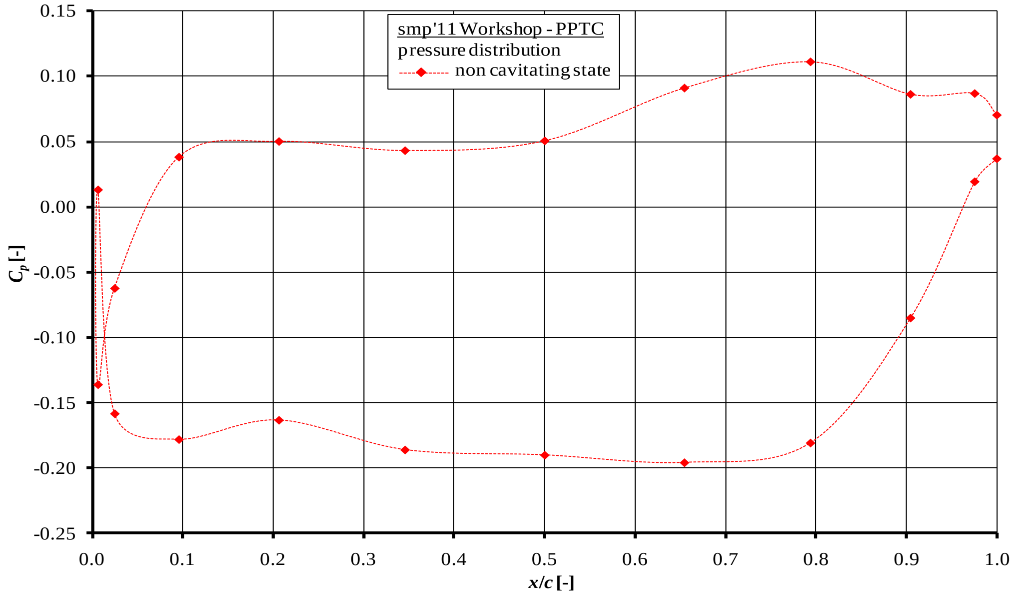


r/R = 0.95

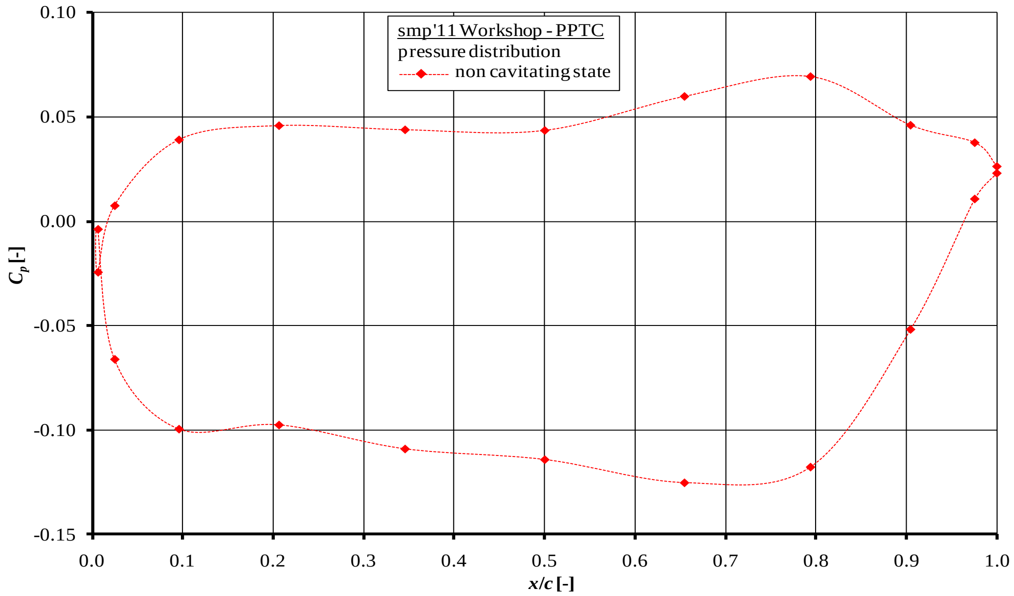


HSVA-QCM **Case 2.3.2**

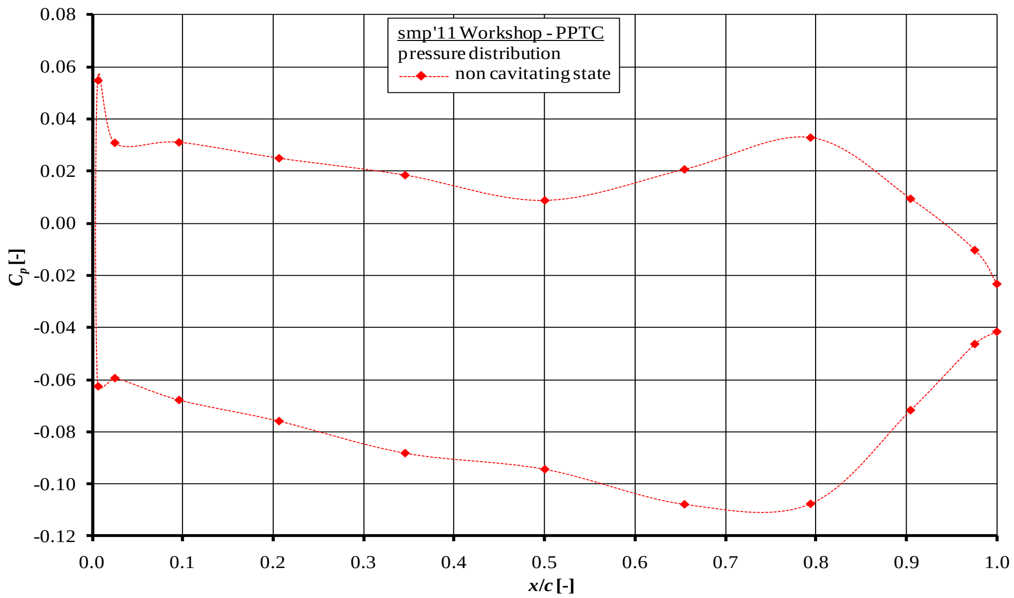
r/R = 0.70



r/R = 0.90

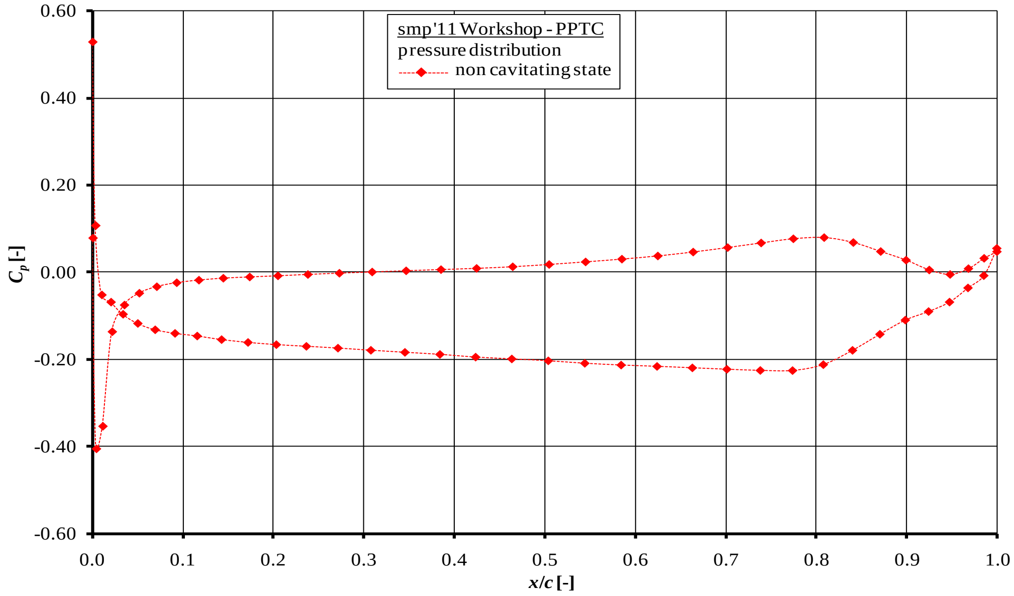


r/R = 0.95

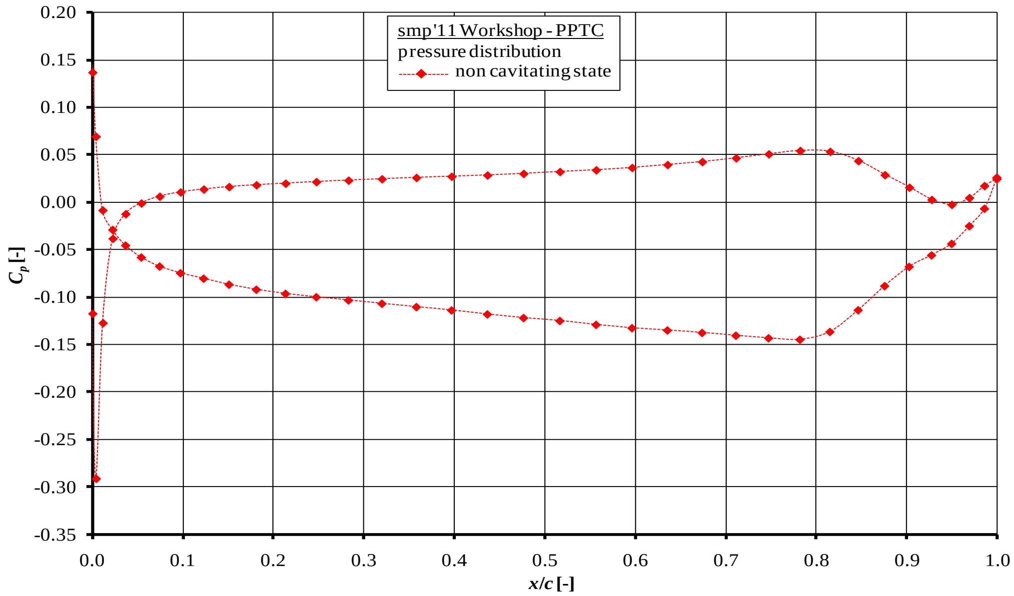


INSEAN-PFC **Case 2.3.2**

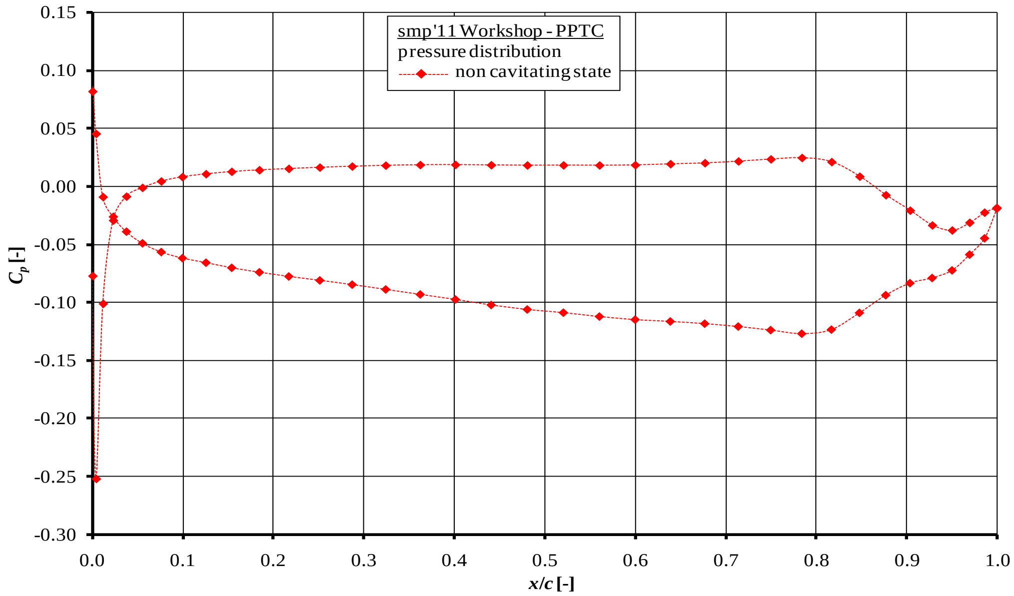
***r/R* = 0.70**



***r/R* = 0.90**

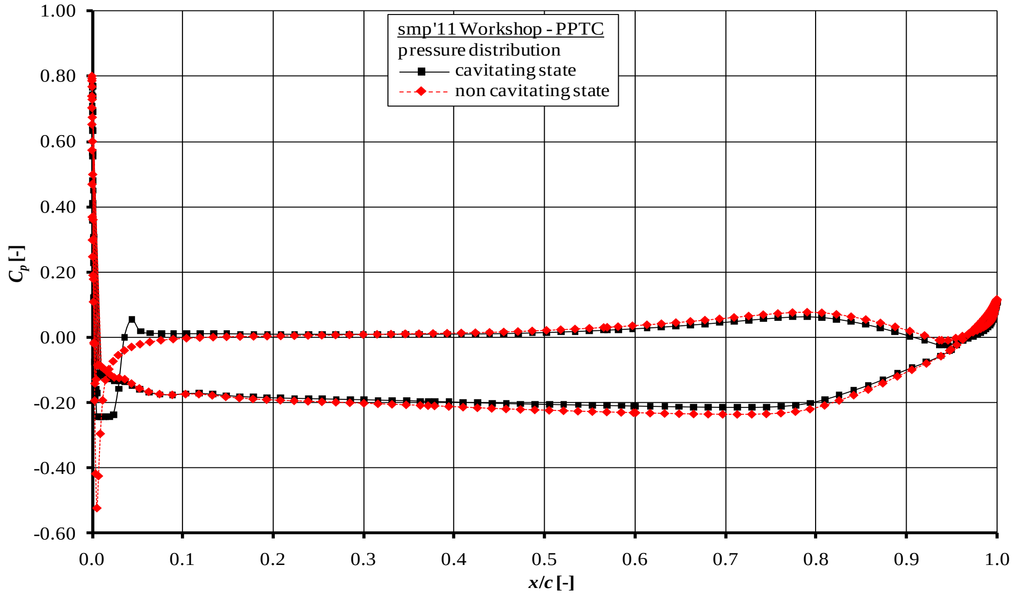


***r/R* = 0.95**

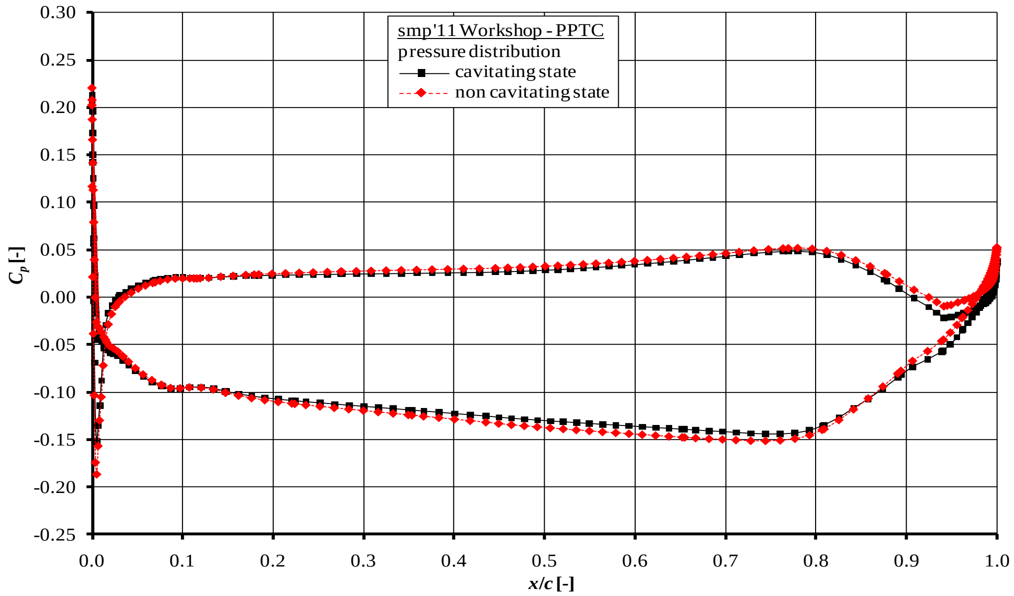


SSPA-Fluent **Case 2.3.2**

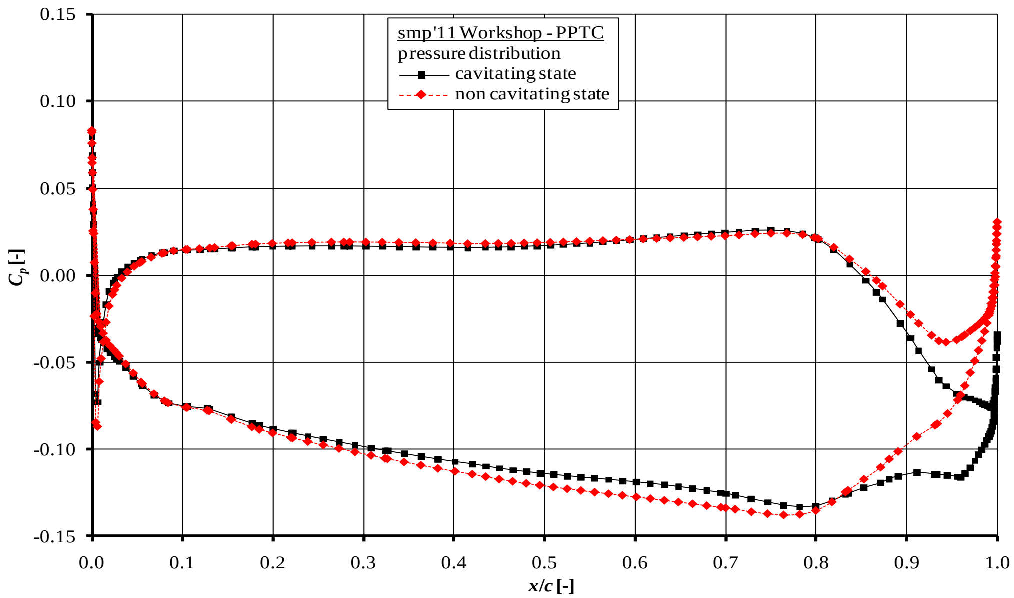
r/R = 0.70



r/R = 0.90

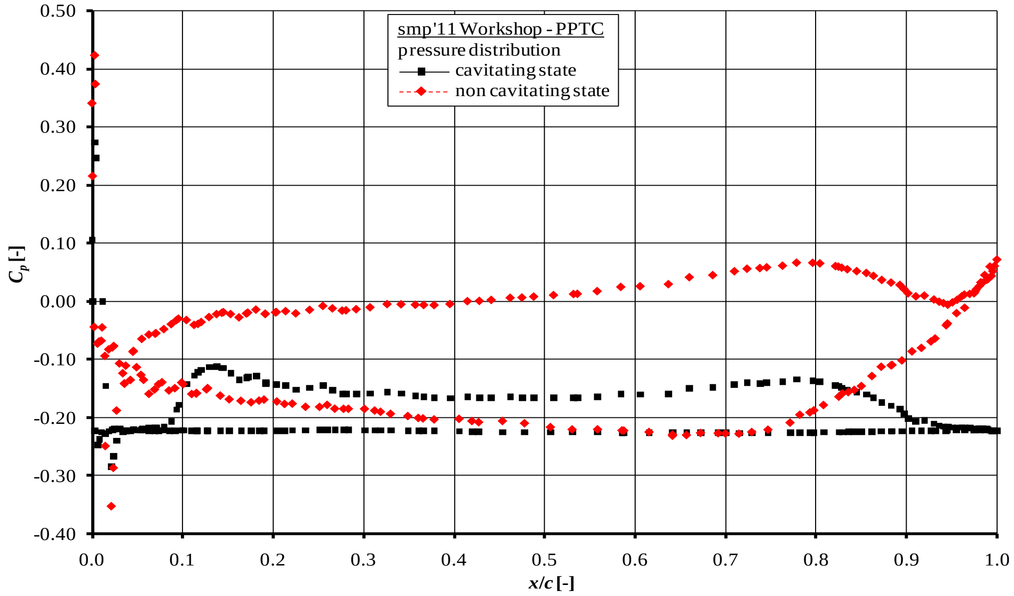


r/R = 0.95

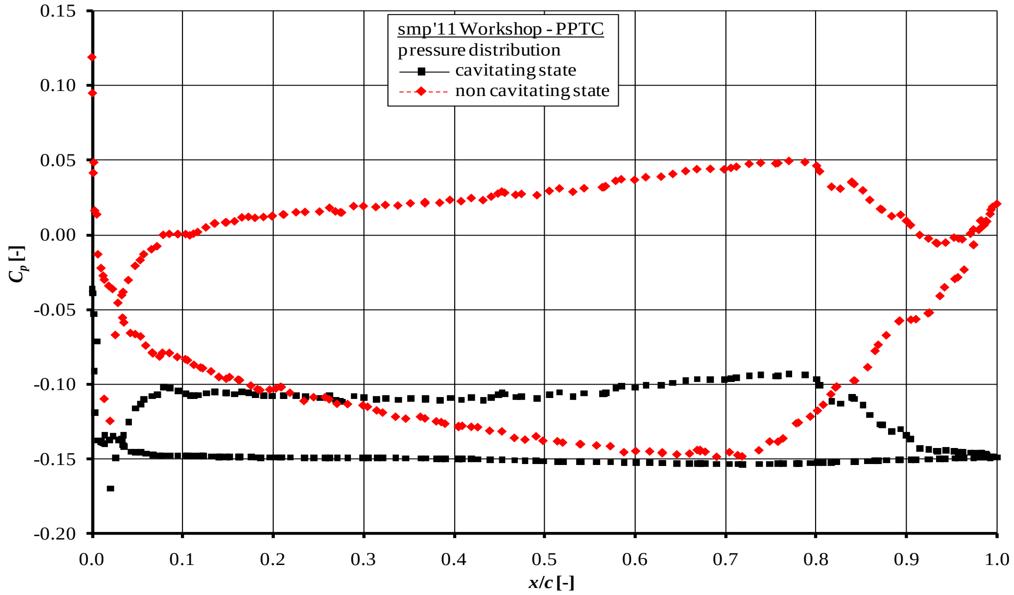


TUHH-Fresco+ (large coefficient) **Case 2.3.2**

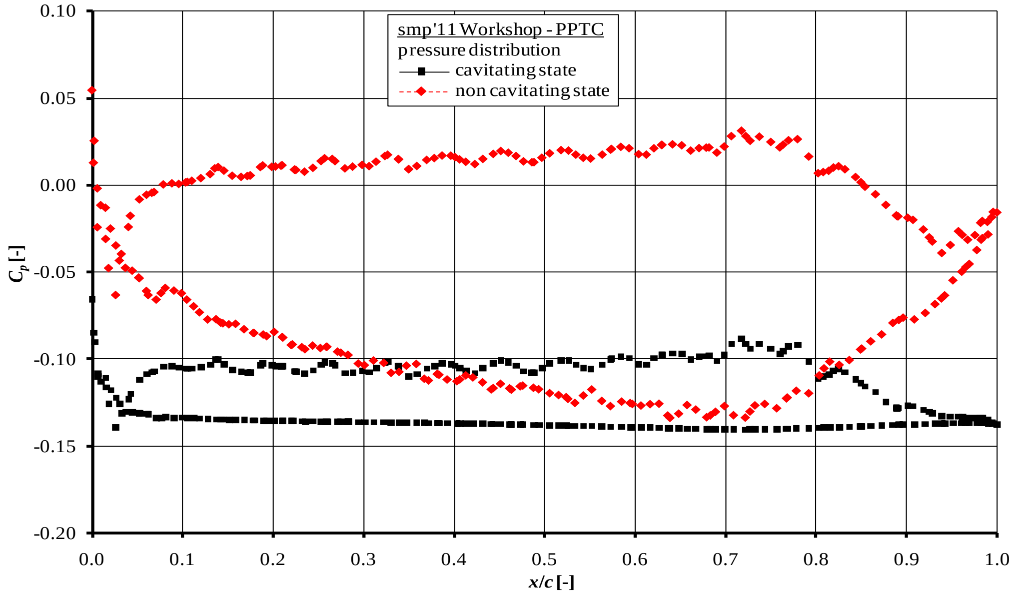
r/R = 0.70



r/R = 0.90

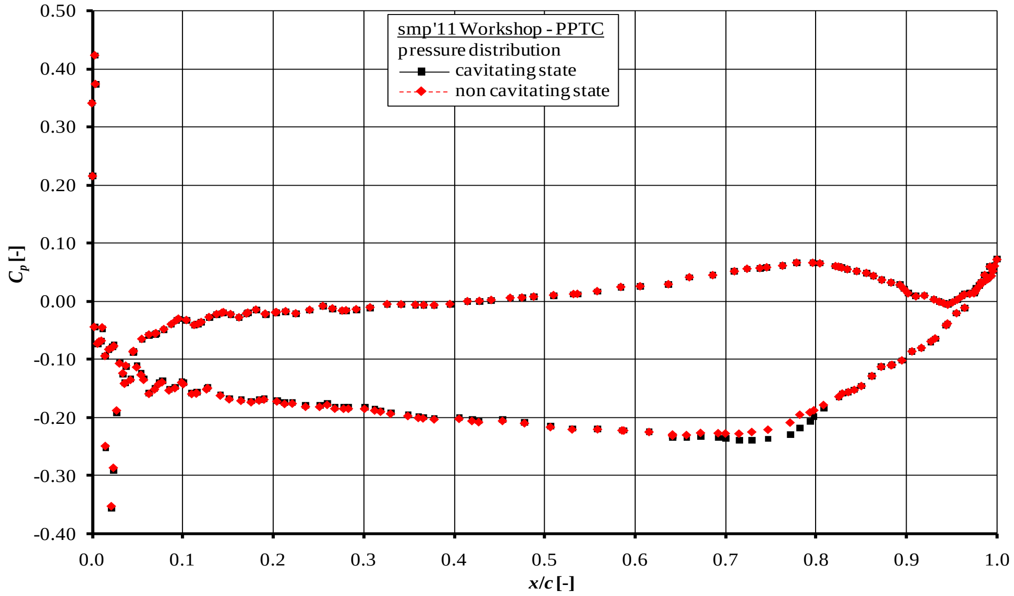


r/R = 0.95

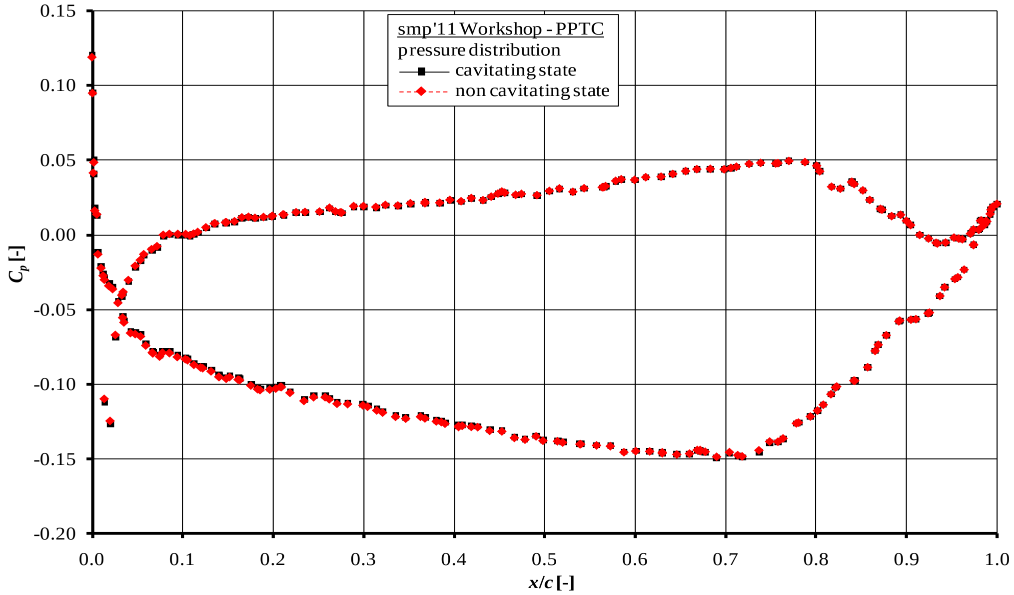


TUHH-Fresco+ (small coefficient) **Case 2.3.2**

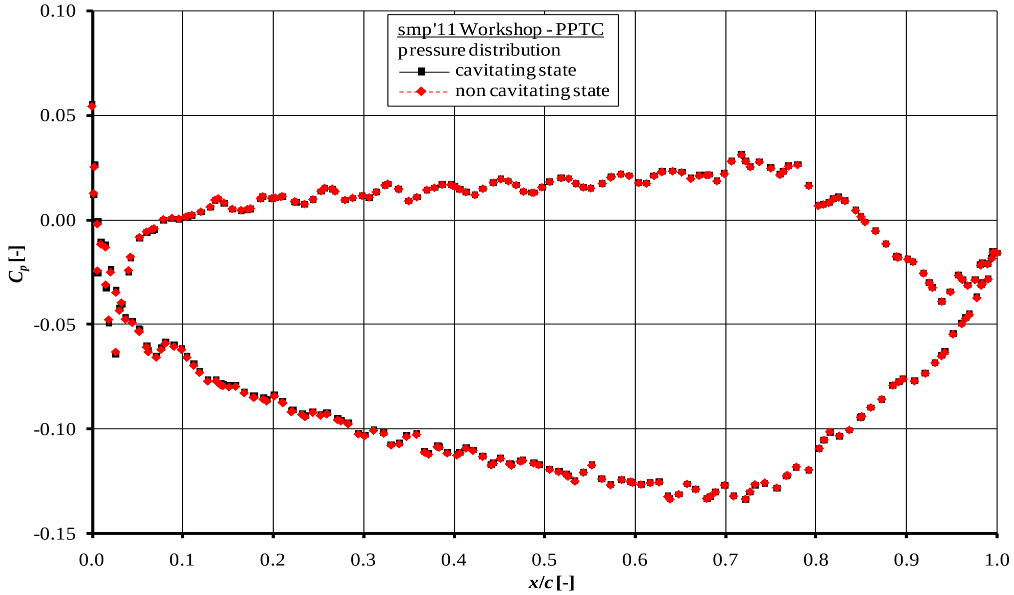
r/R = 0.70



r/R = 0.90

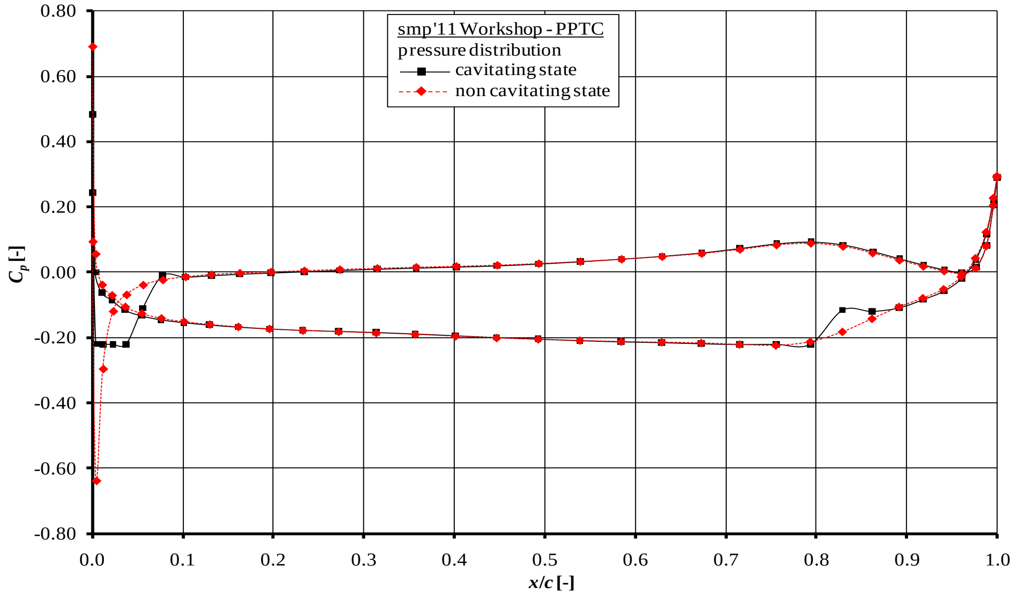


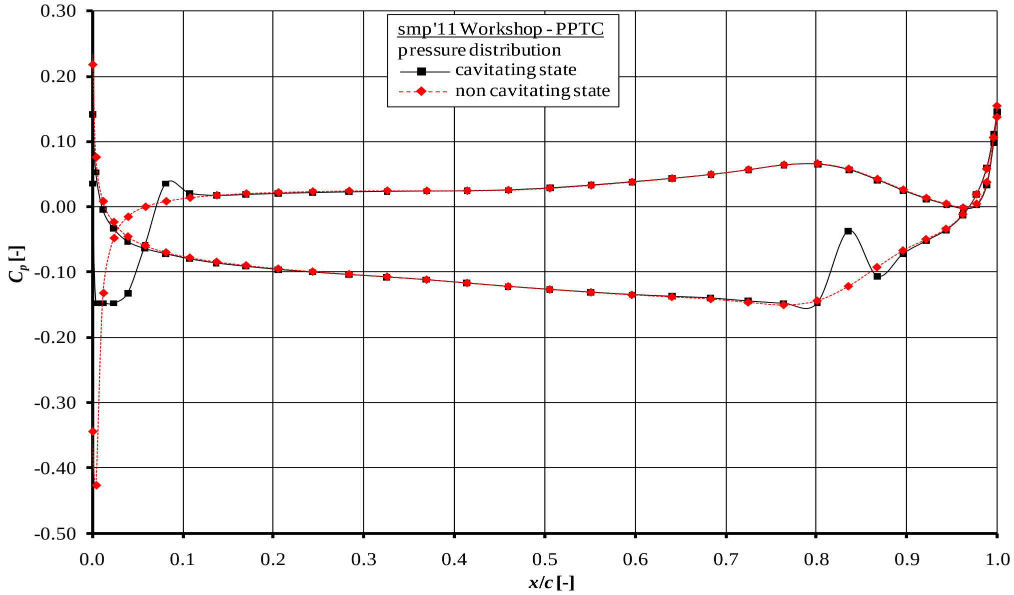
r/R = 0.95



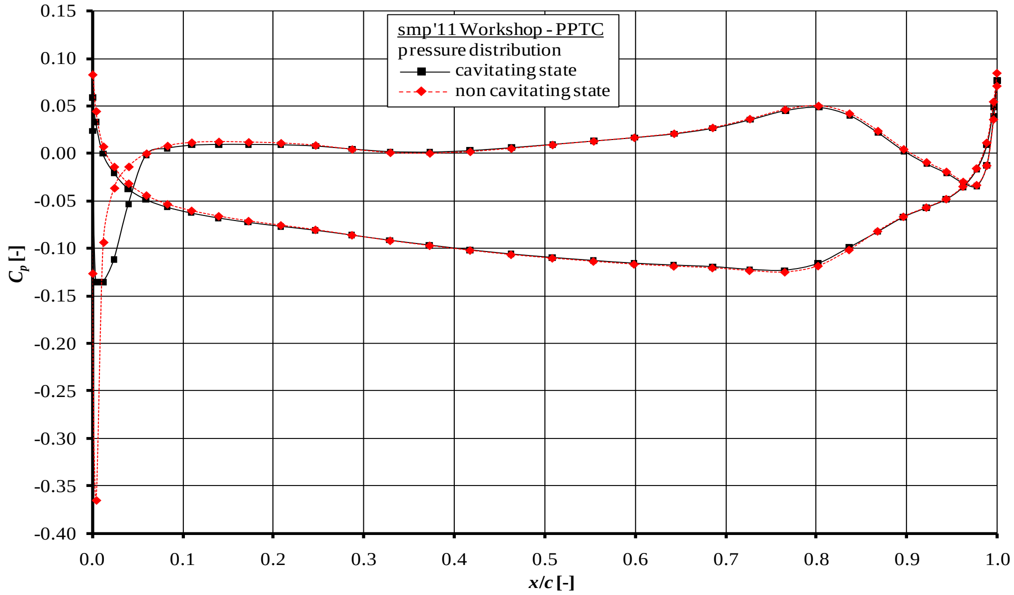
UniGenua-Panel **Case 2.3.2**

r/R = 0.70





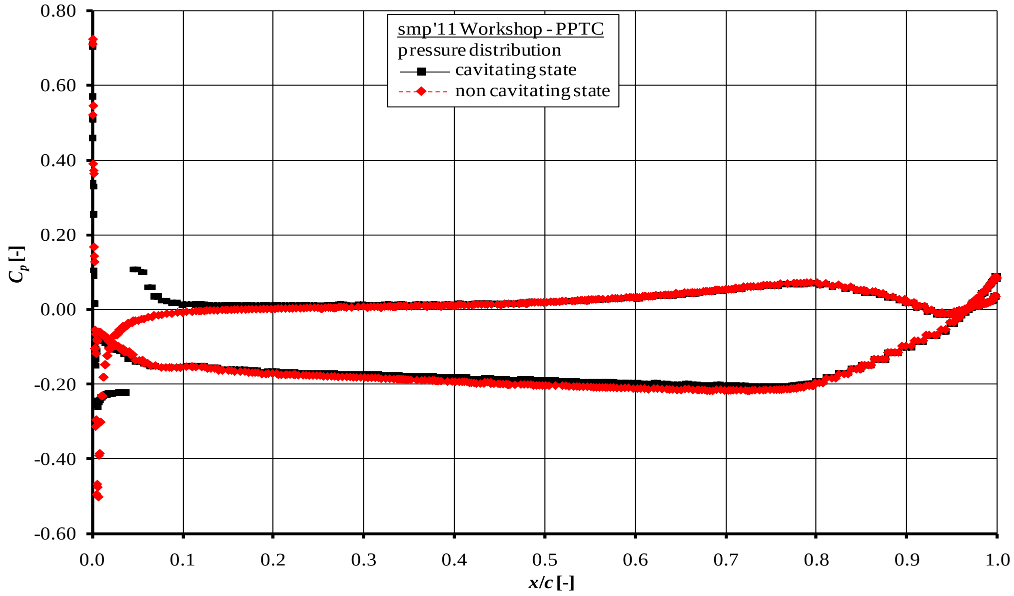
r/R = 0.95



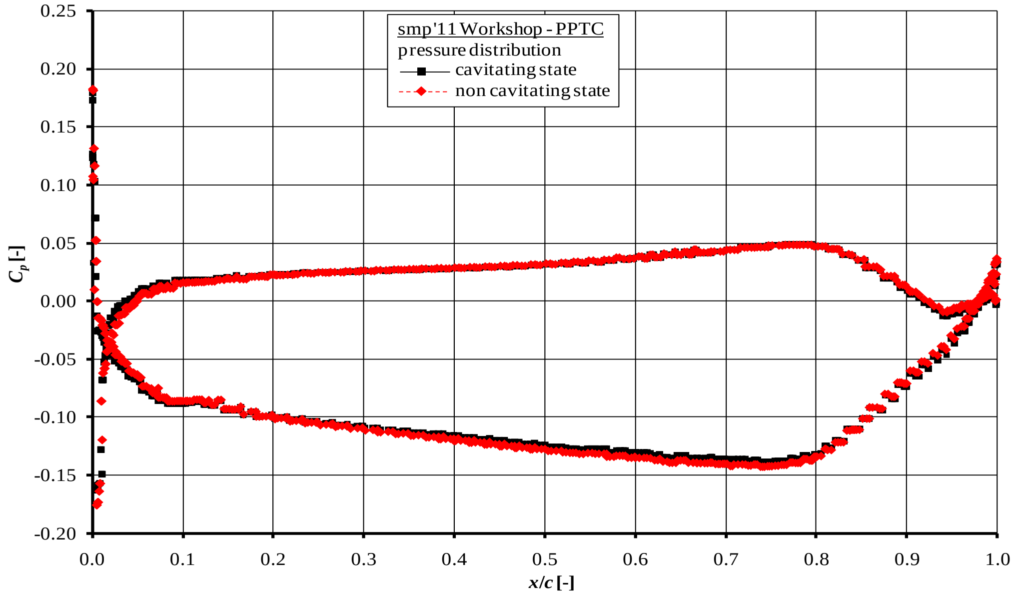
.90

UniGenua-StarCCM(kw) **Case 2.3.2**

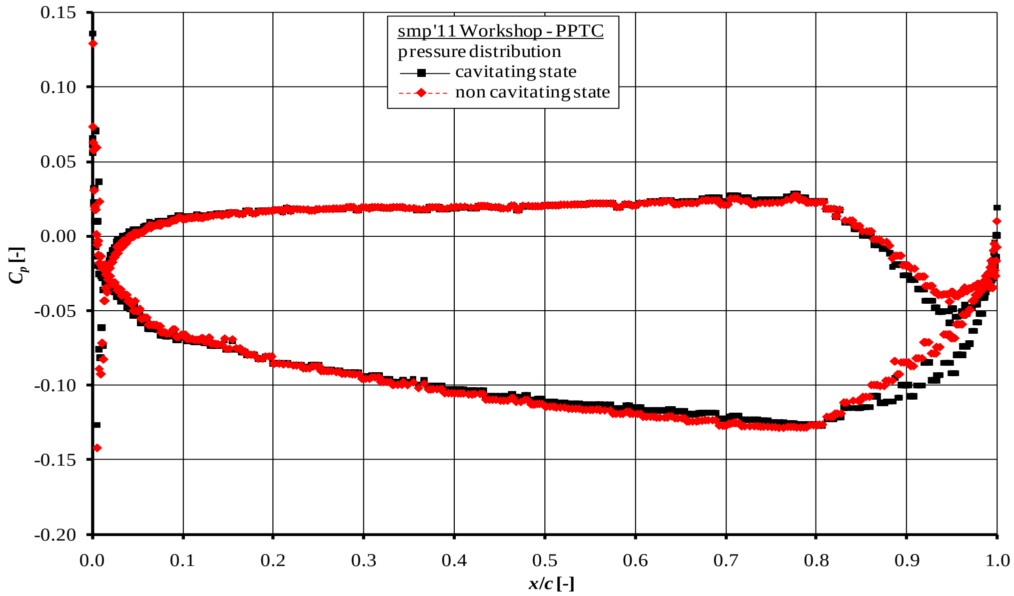
r/R = 0.70



r/R = 0.90

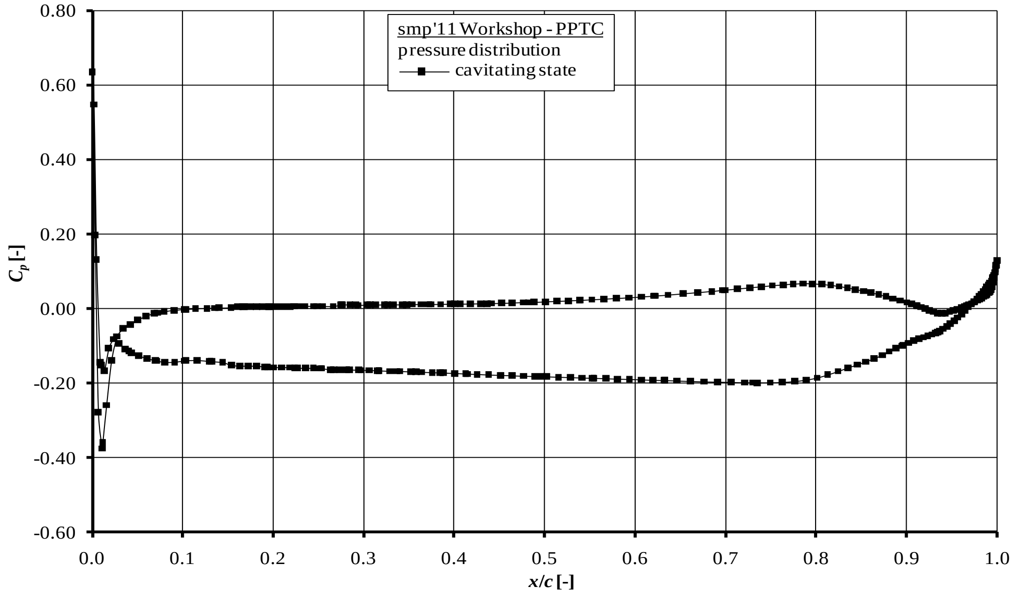


r/R = 0.95

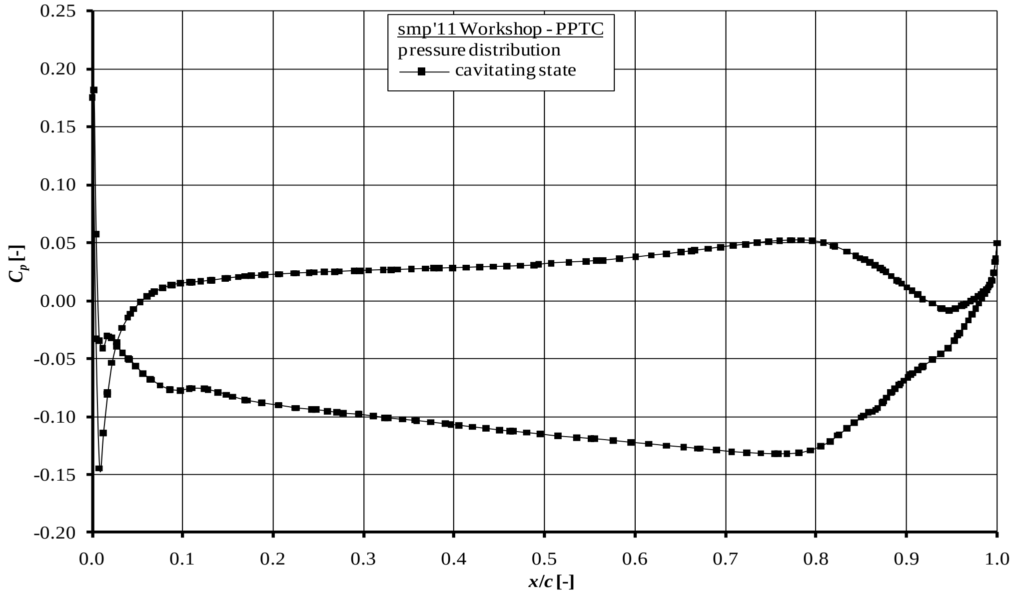


UniTriest-CFX-FCM **Case 2.3.2**

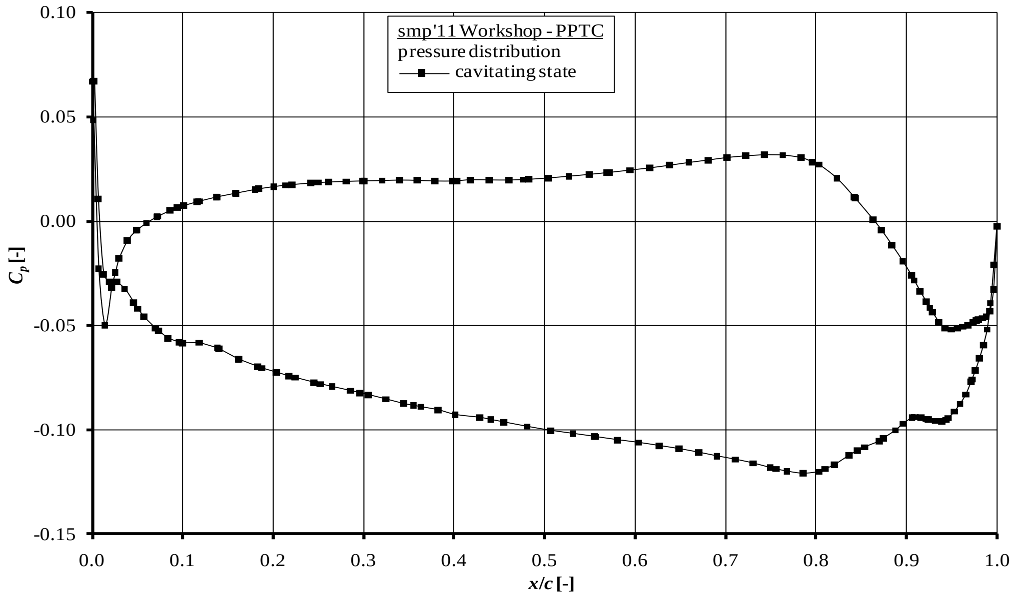
r/R = 0.70



r/R = 0.90

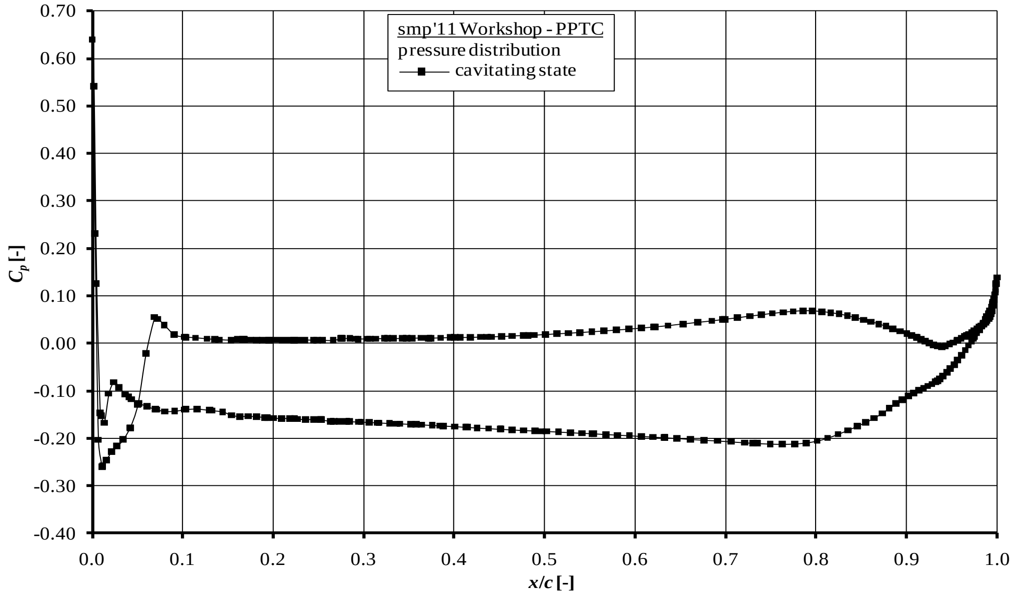


r/R = 0.95

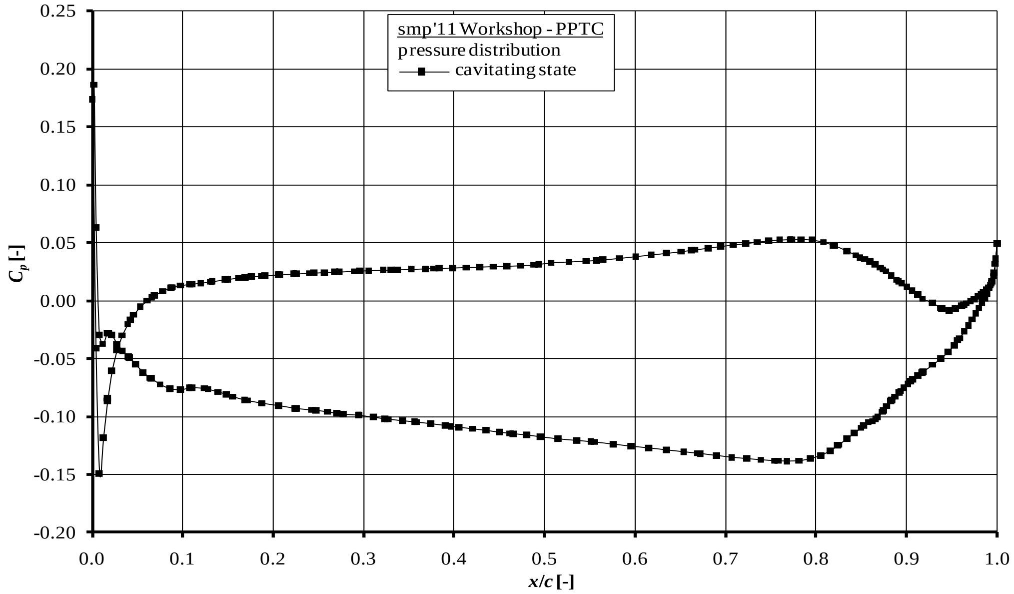


UniTriest-CFX-Kunz **Case 2.3.2**

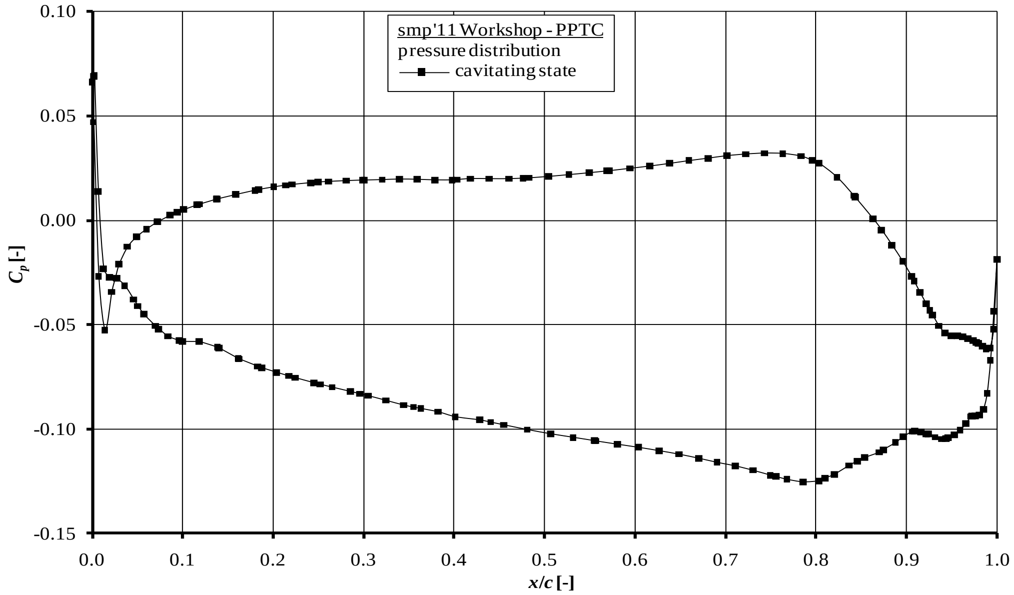
r/R = 0.70



r/R = 0.90

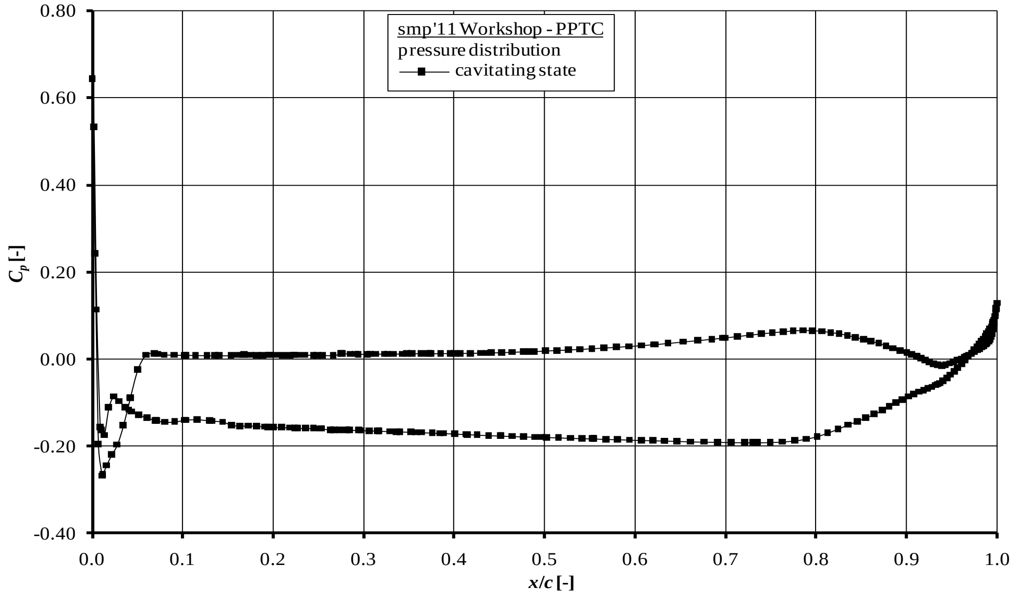


r/R = 0.95

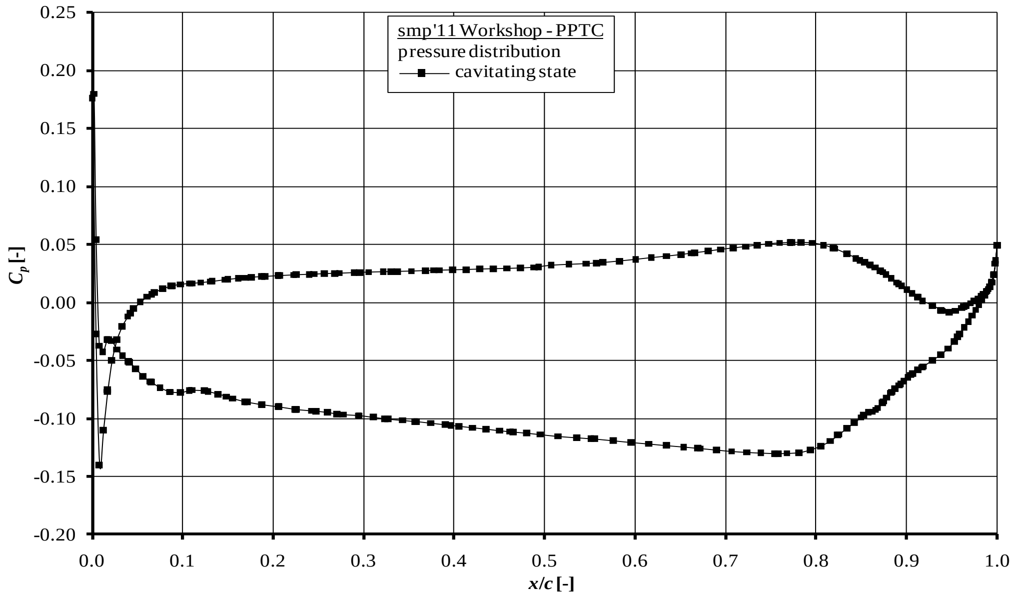


UniTriest-CFX-Zwart **Case 2.3.2**

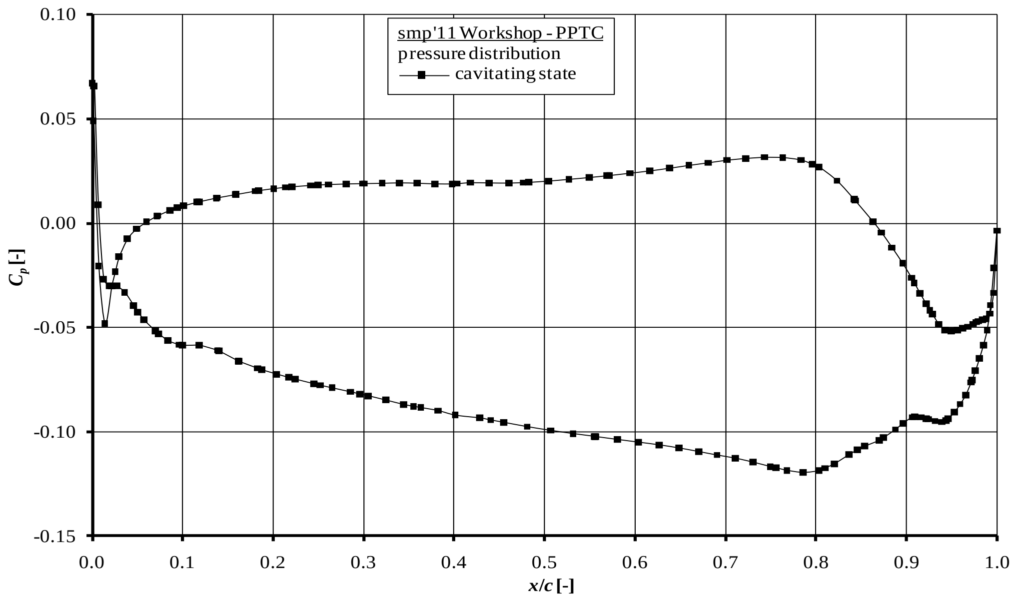
r/R = 0.70



r/R = 0.90

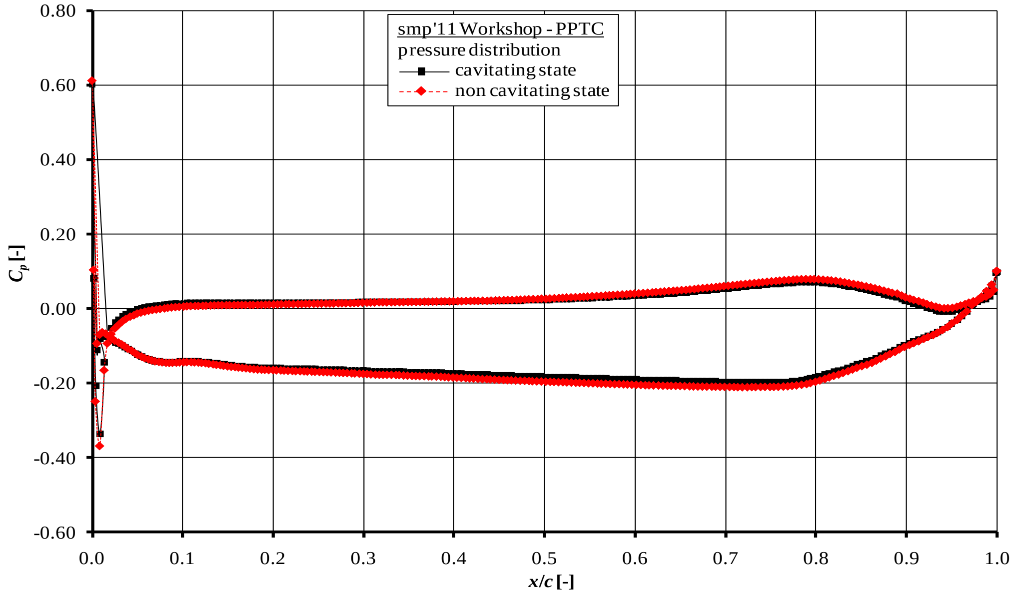


r/R = 0.95

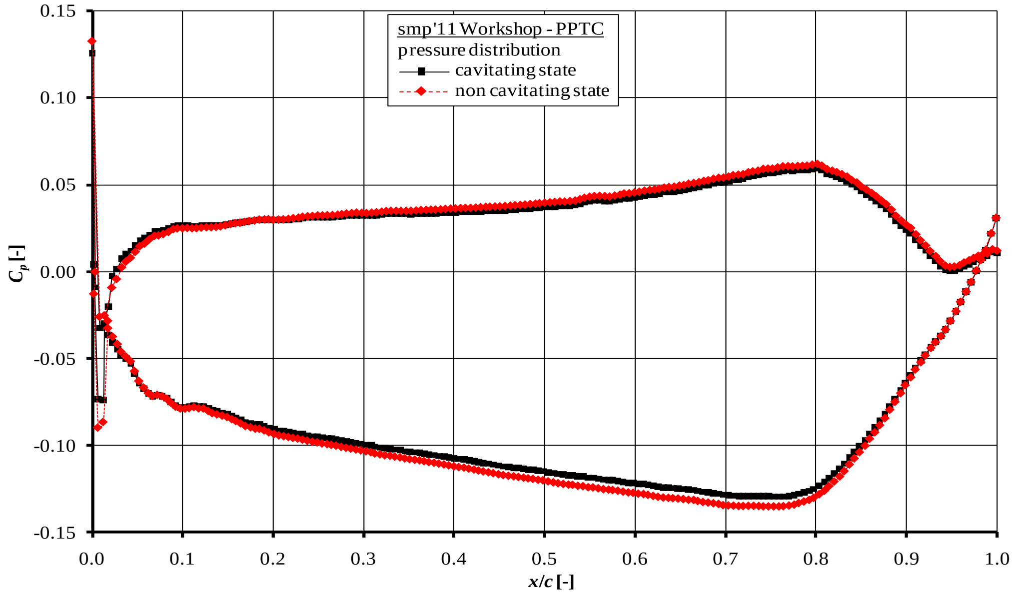


VOITH-Comet **Case 2.3.2**

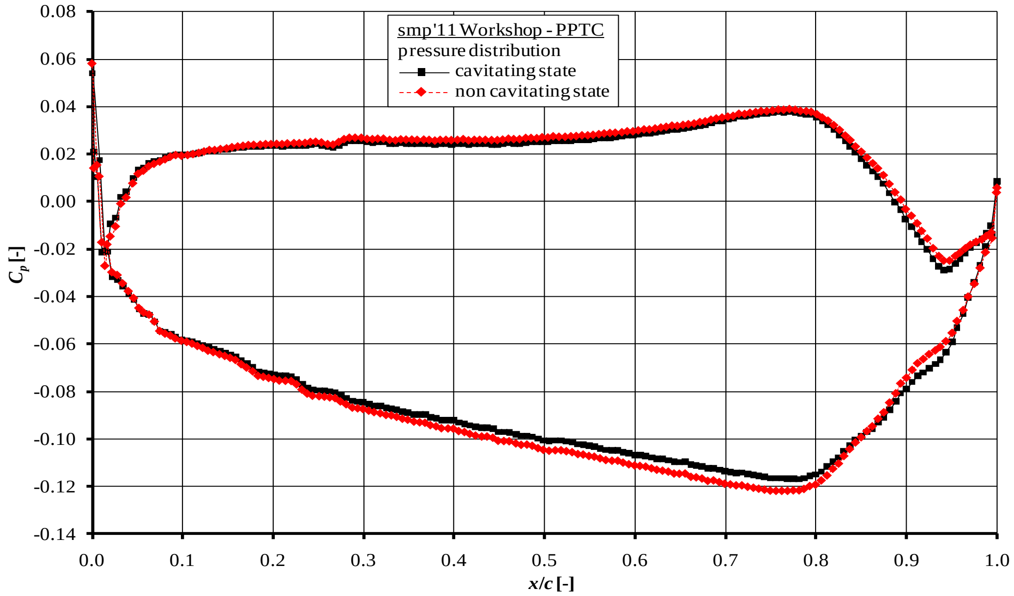
r/R = 0.70



r/R = 0.90

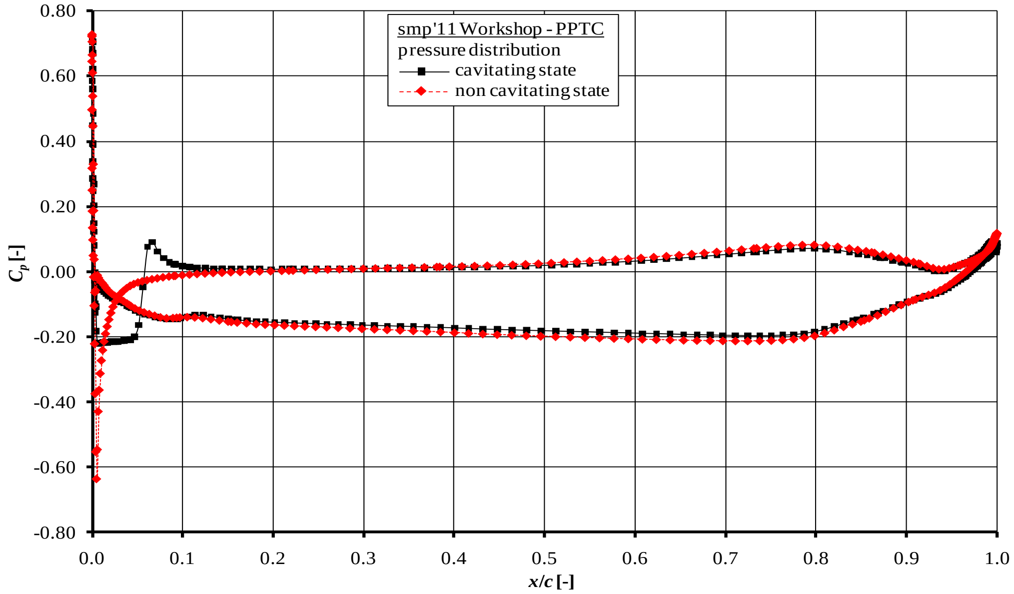


r/R = 0.95

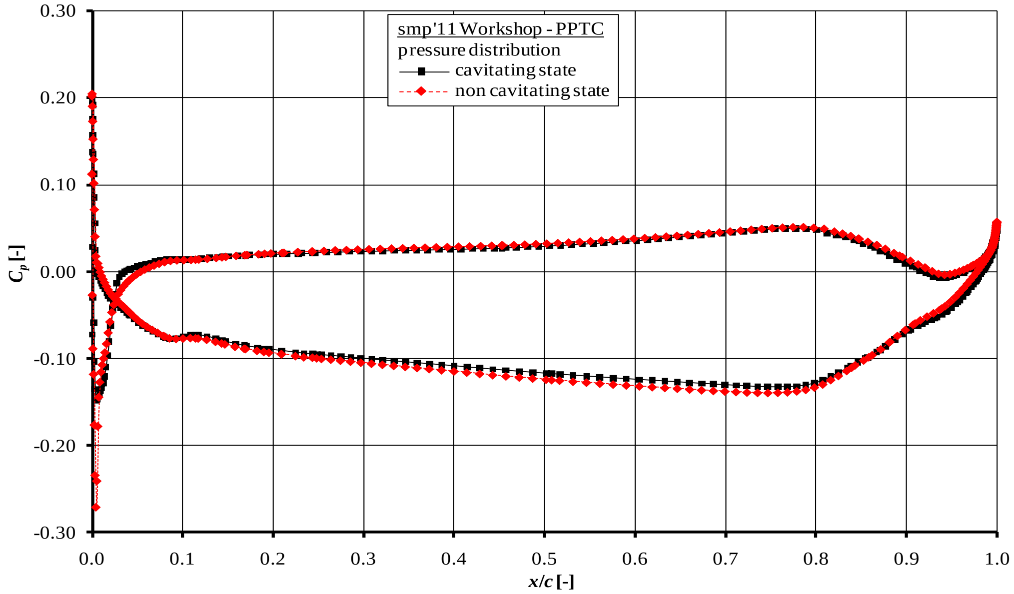


VTT-FinFlo **Case 2.3.2**

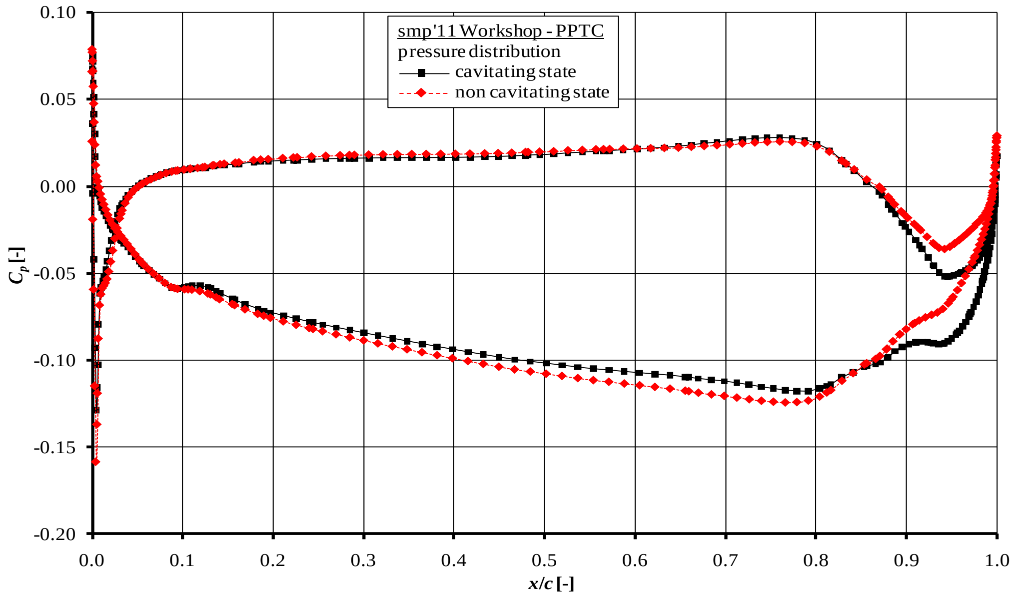
r/R = 0.70



r/R = 0.90



r/R = 0.95



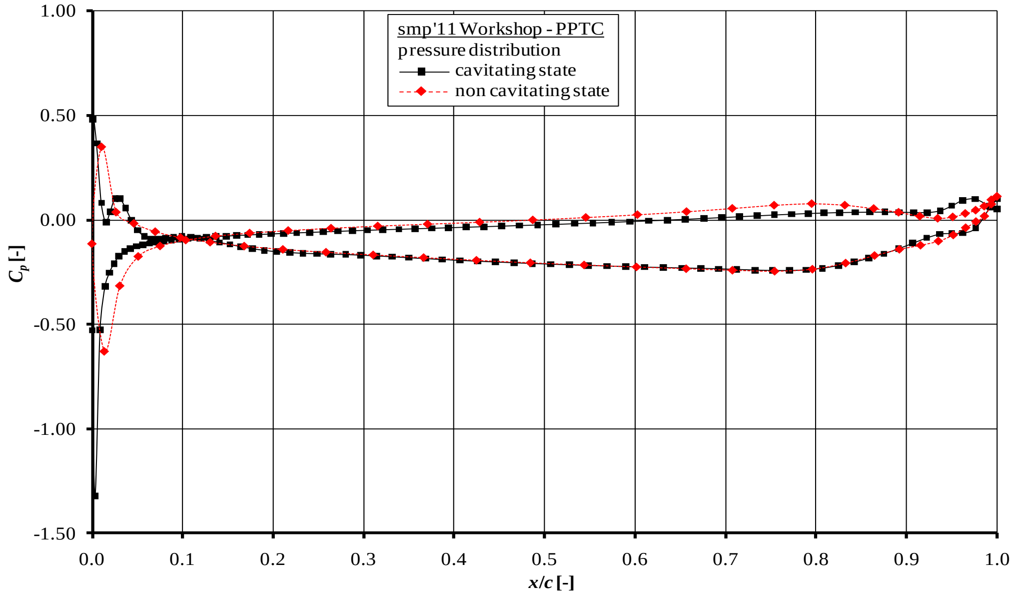
Case 2.3.3

Cavitation Test
Pressure distribution

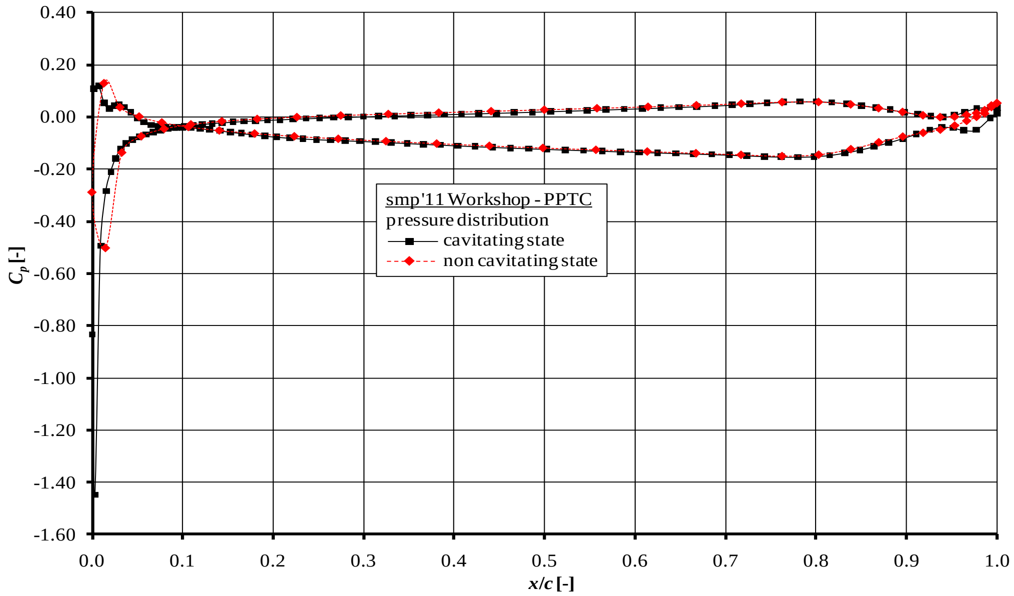
Evaluation

Berg-OpenFOAM **Case 2.3.3**

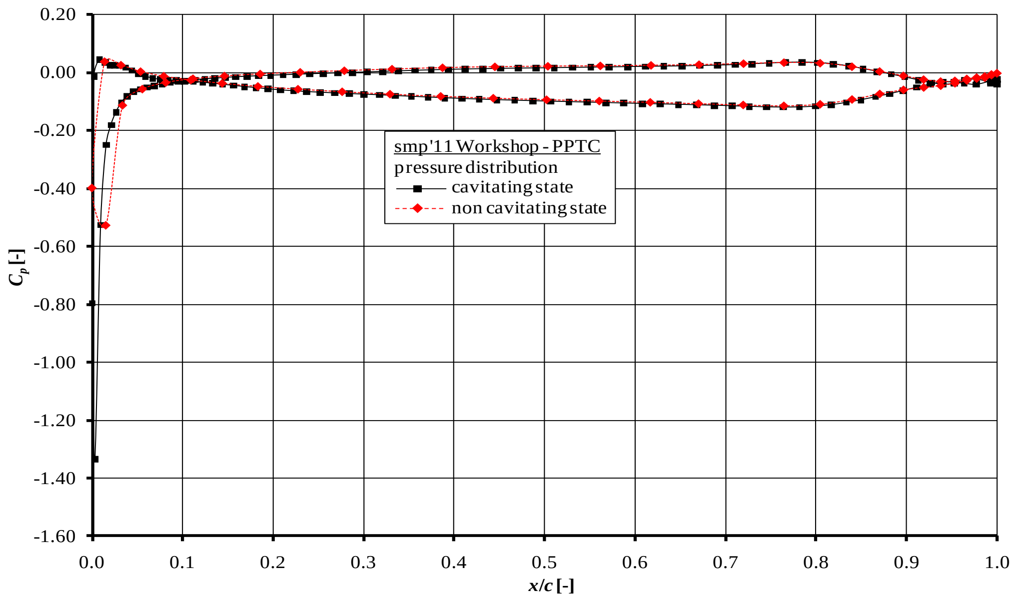
r/R = 0.70



r/R = 0.90

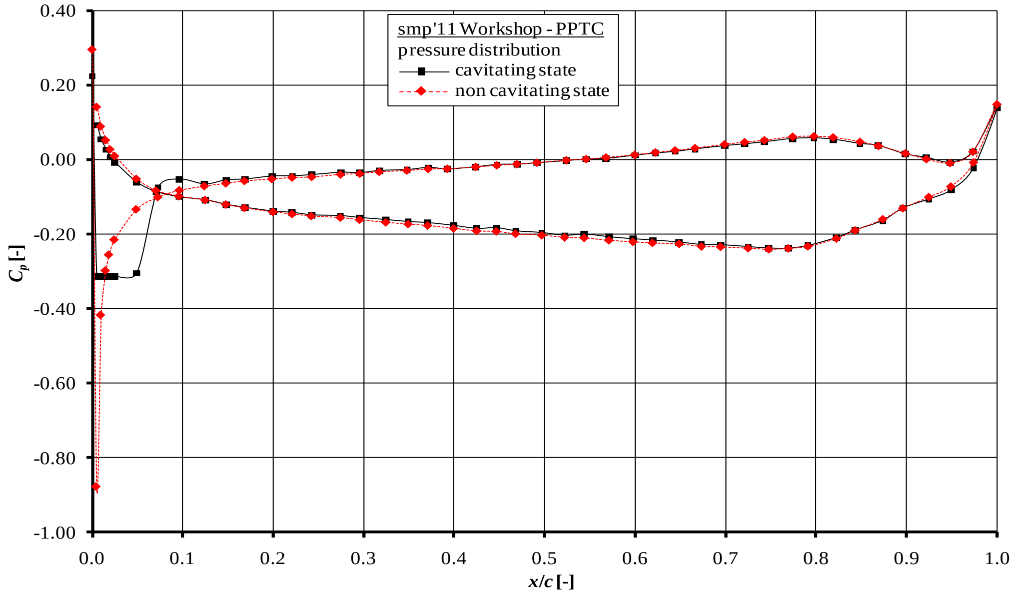


r/R = 0.95

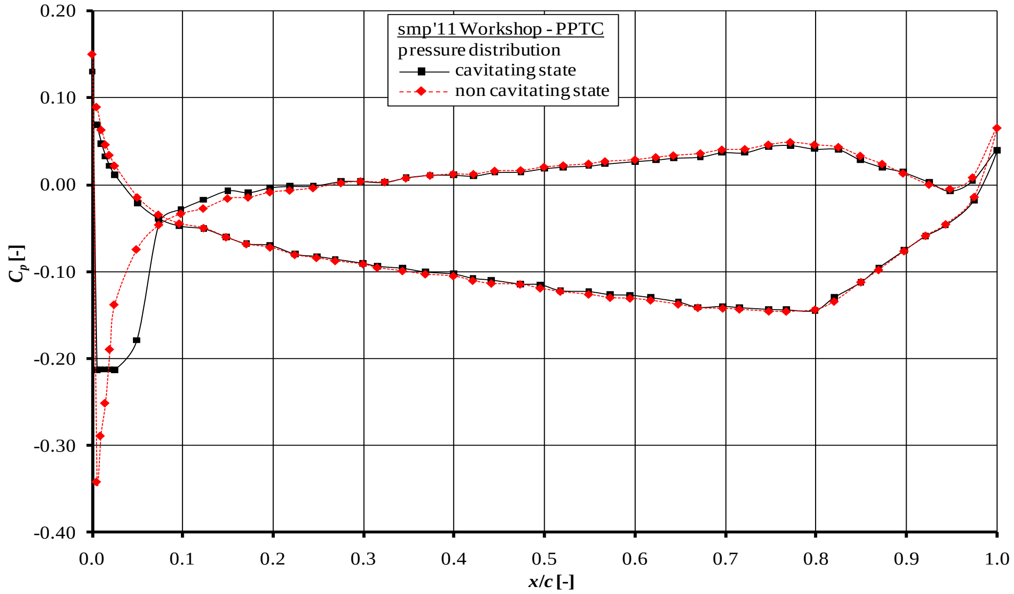


Cradle-SC/Tetra **Case 2.3.3**

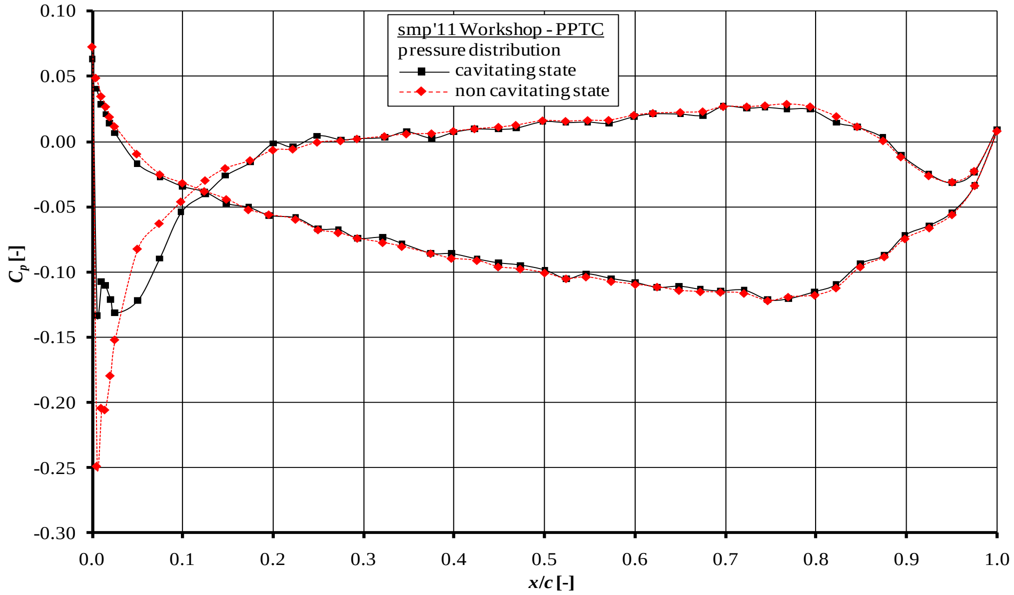
r/R = 0.70



r/R = 0.90

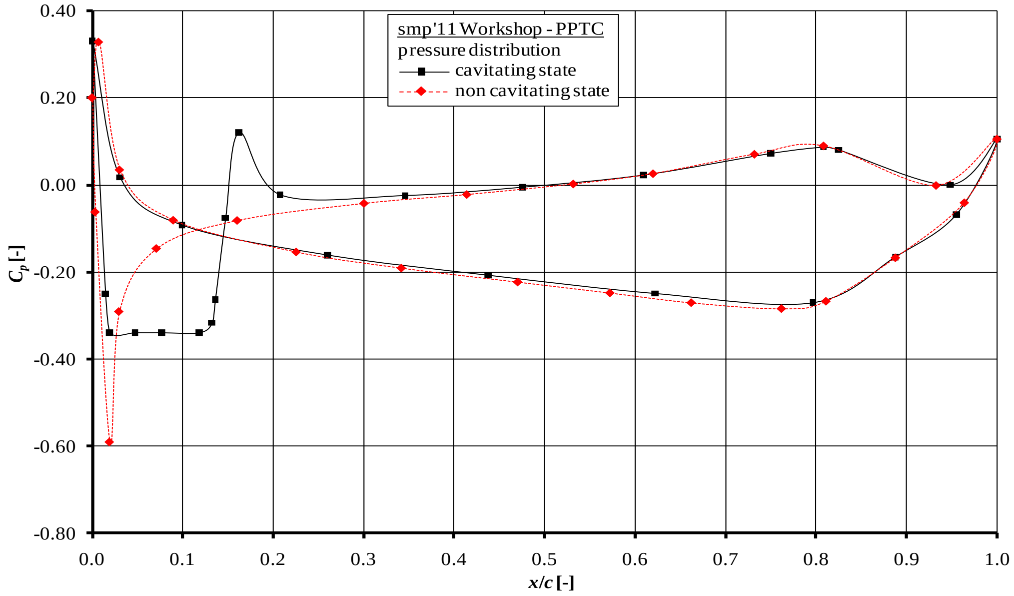


r/R = 0.95

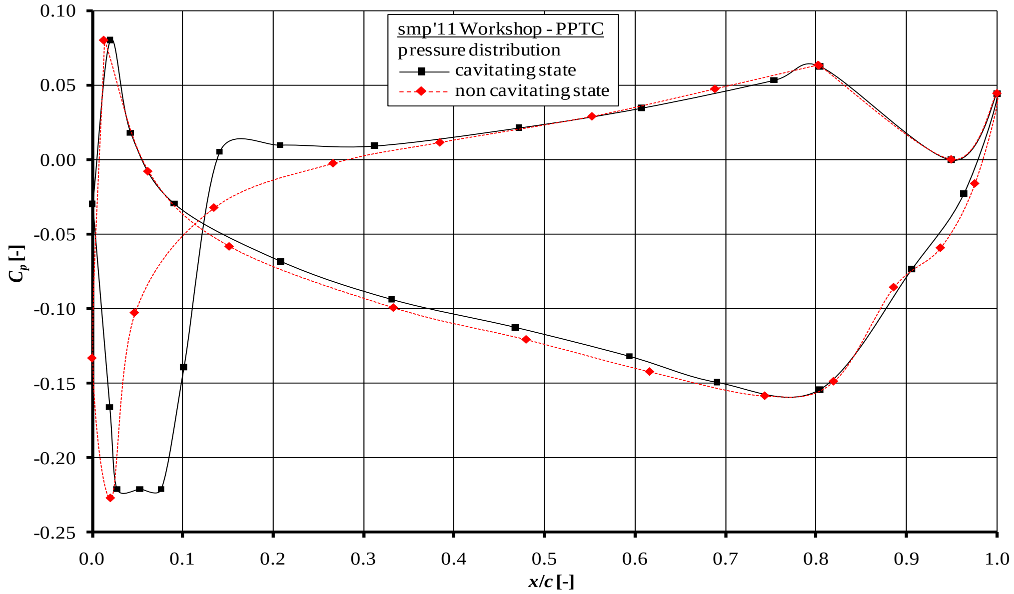


CSSRC-Fluent **Case 2.3.3**

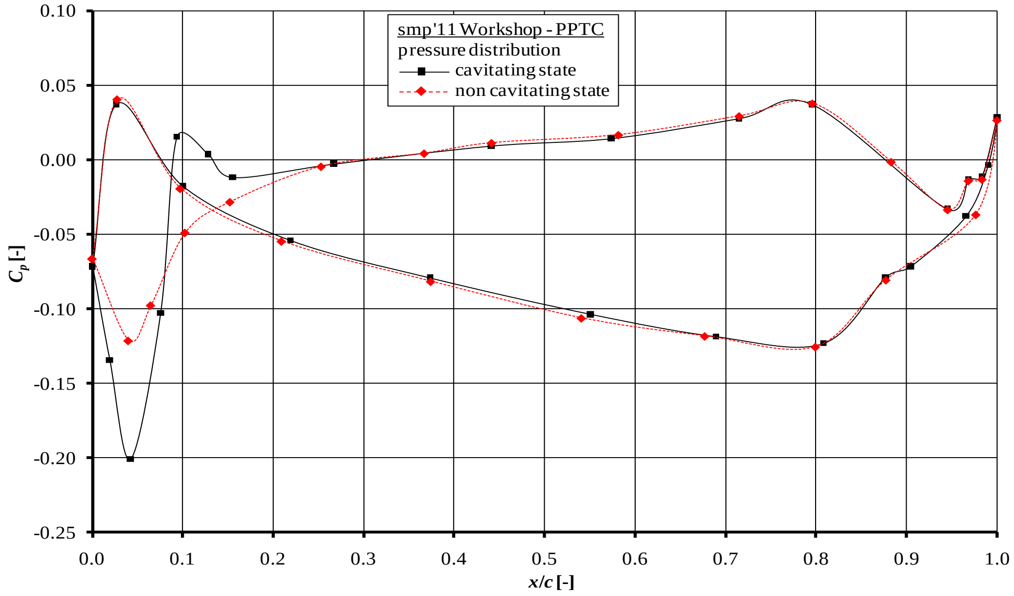
r/R = 0.70



r/R = 0.90

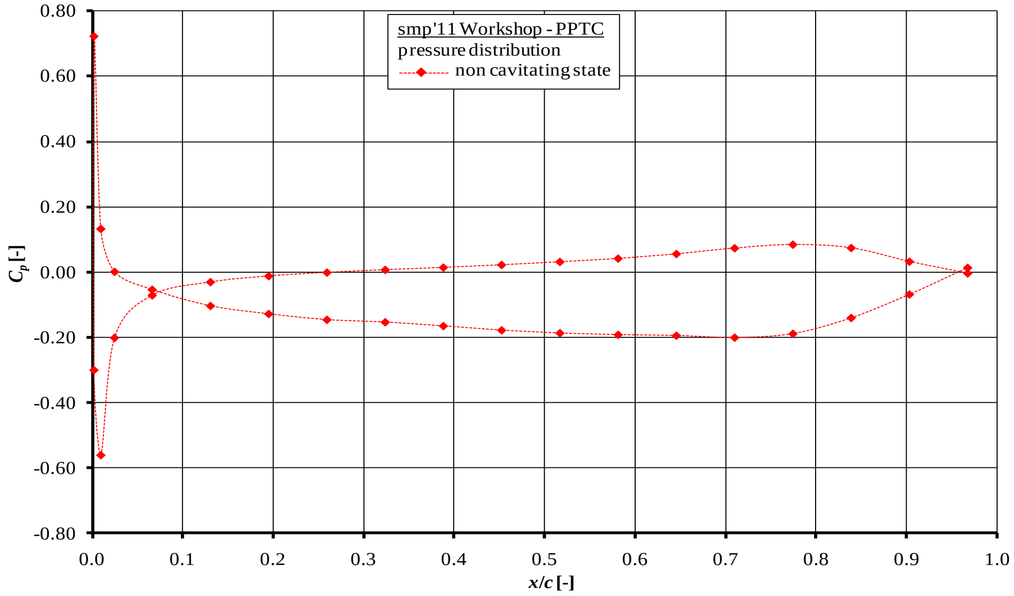


r/R = 0.95

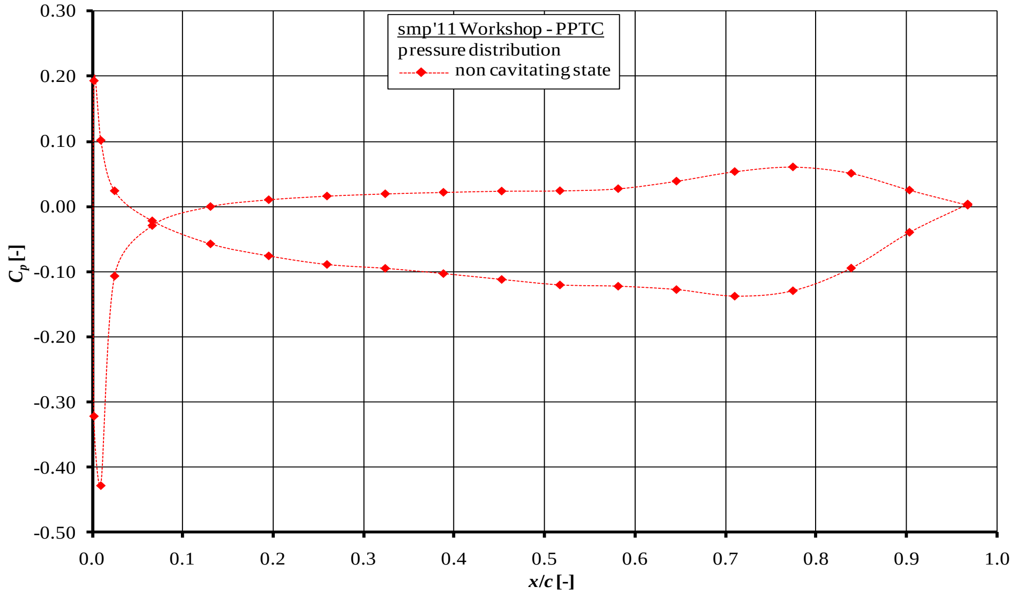


HSVA-PPB **Case 2.3.3**

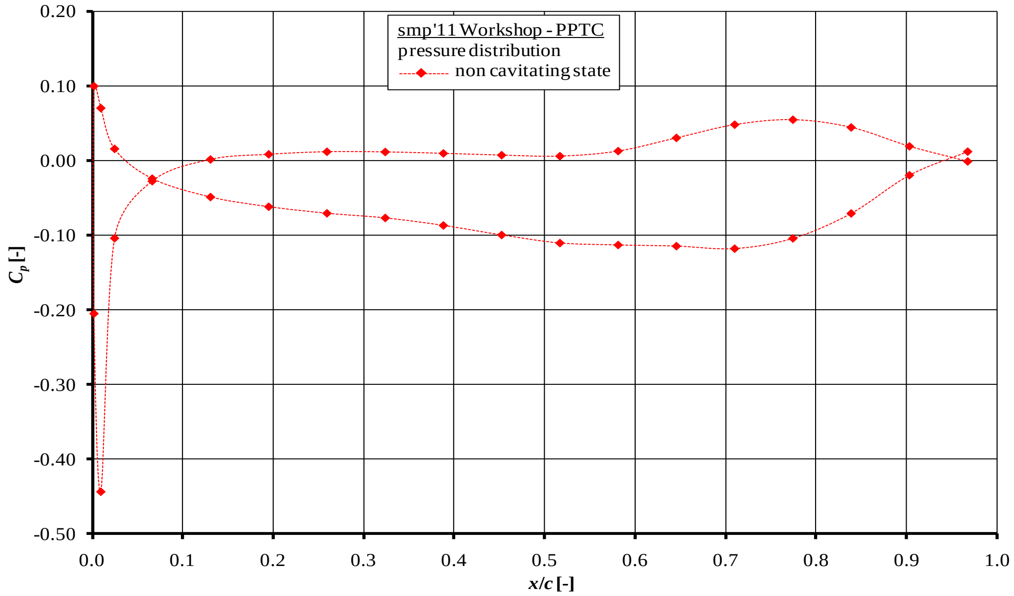
r/R = 0.70



r/R = 0.90

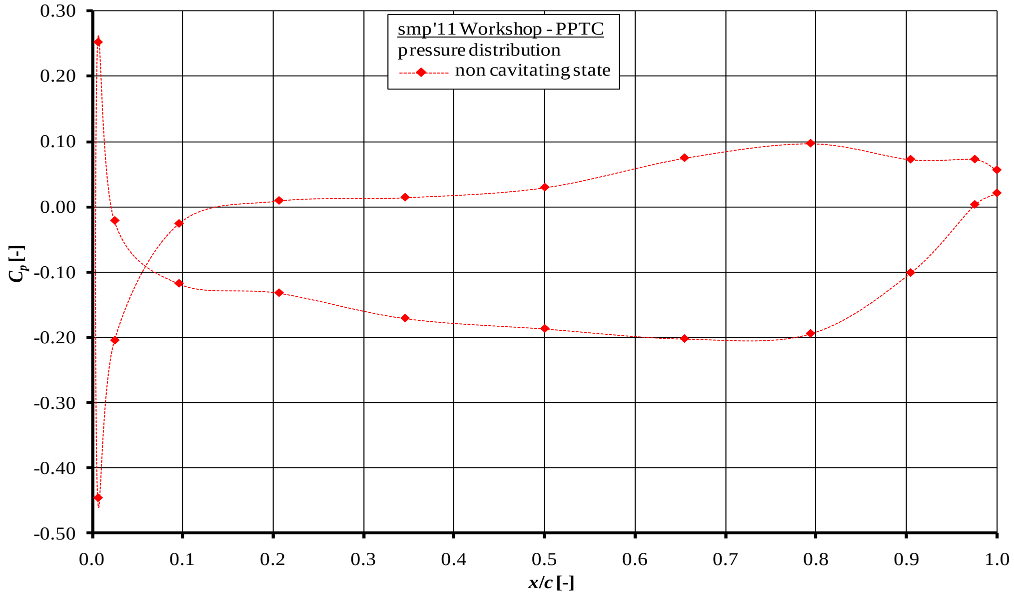


r/R = 0.95

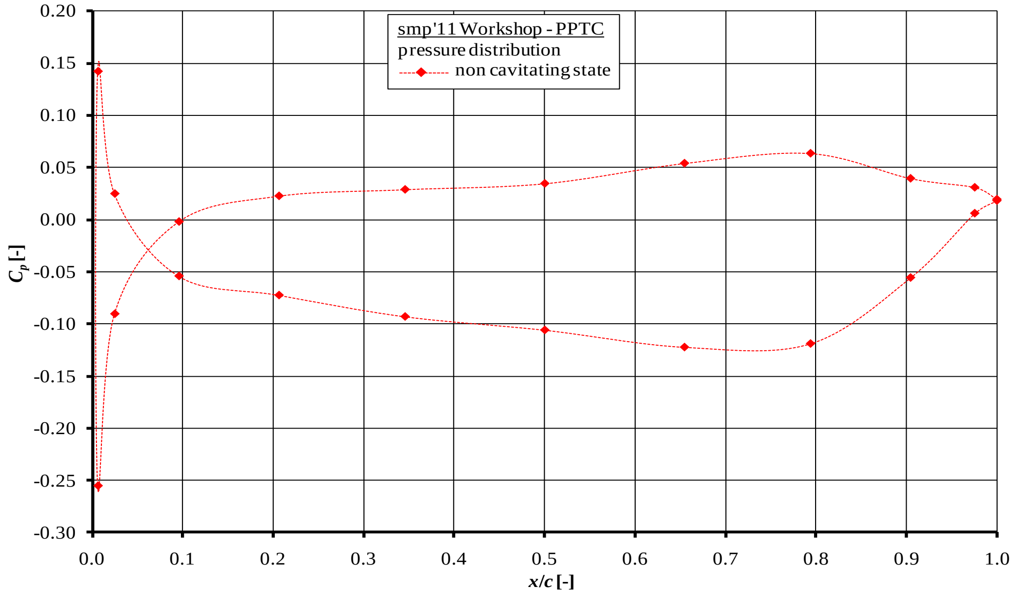


HSVA-QCM **Case 2.3.3**

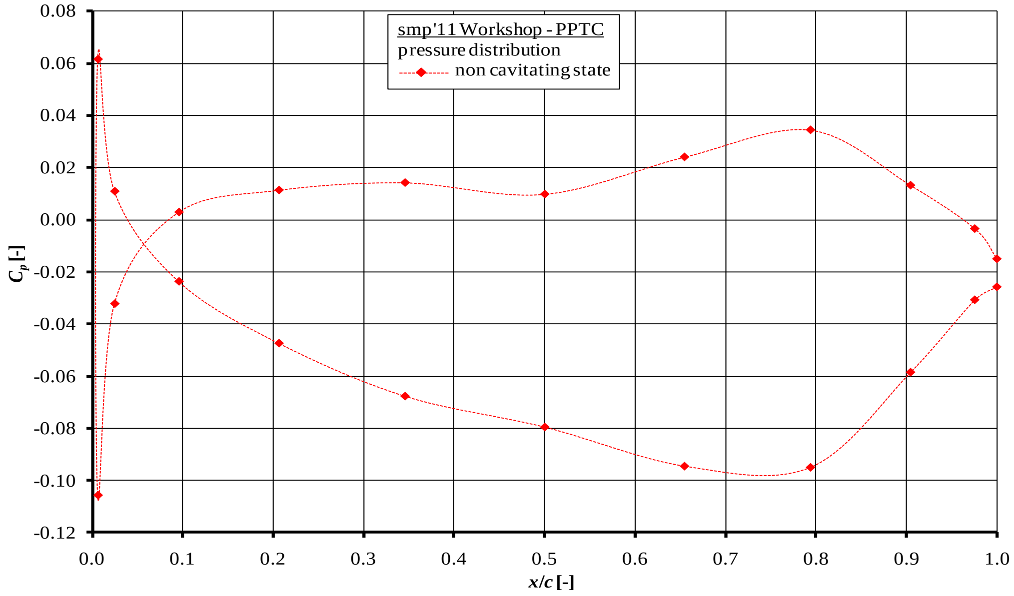
r/R = 0.70



r/R = 0.90

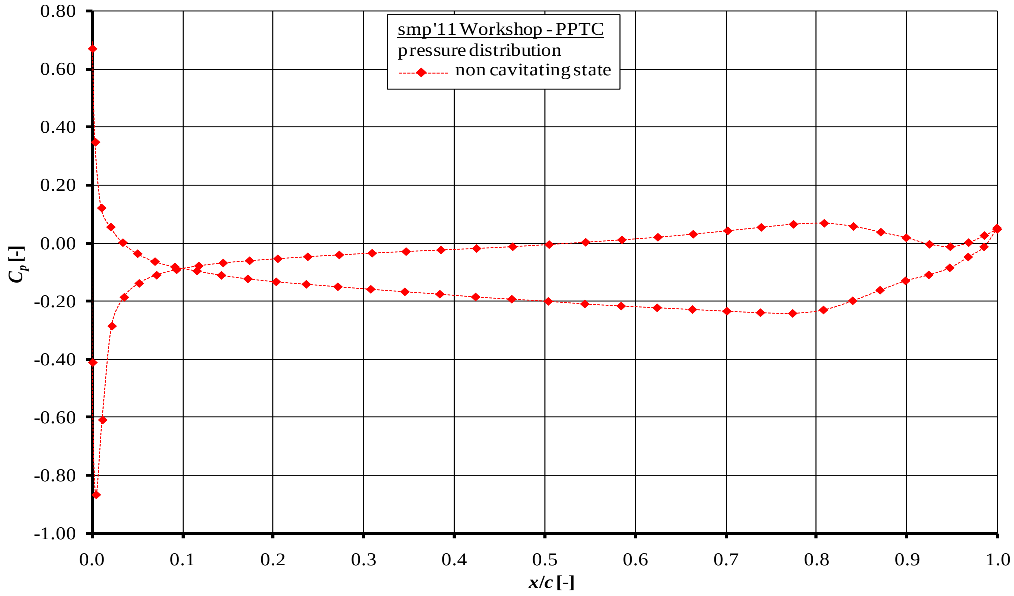


r/R = 0.95

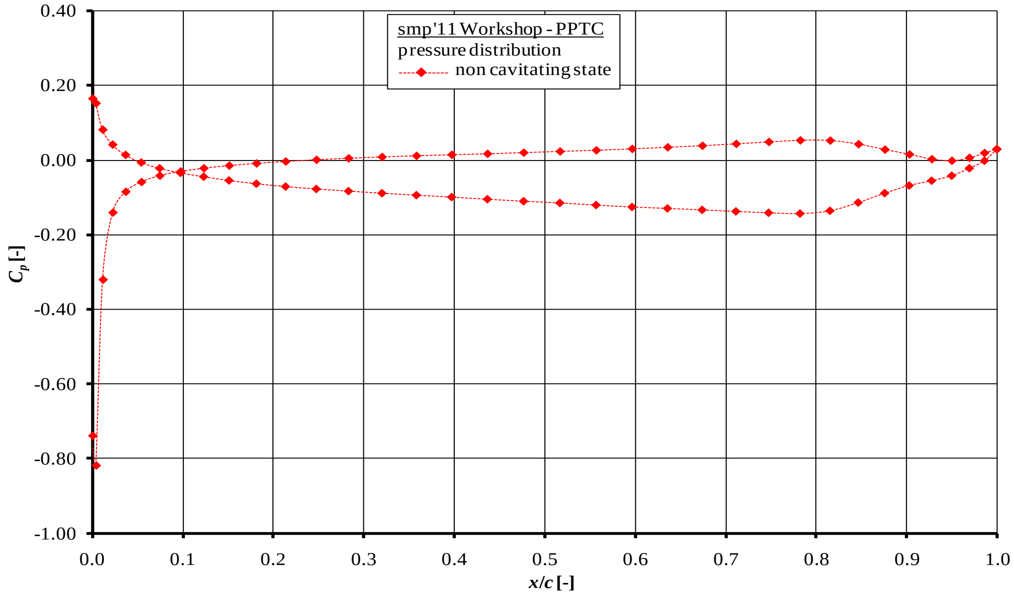


INSEAN-PFC **Case 2.3.3**

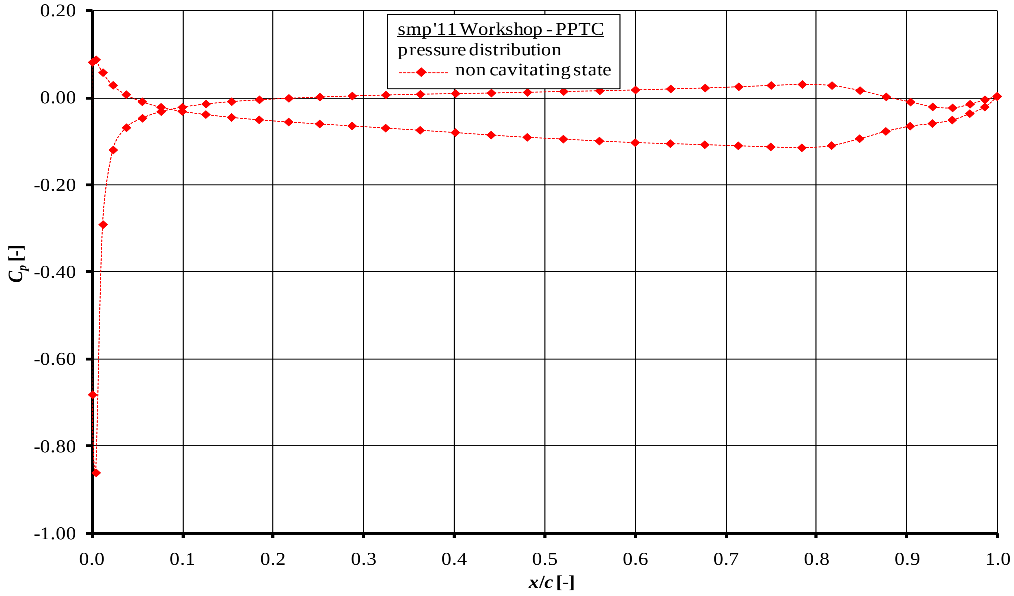
r/R = 0.70



r/R = 0.90

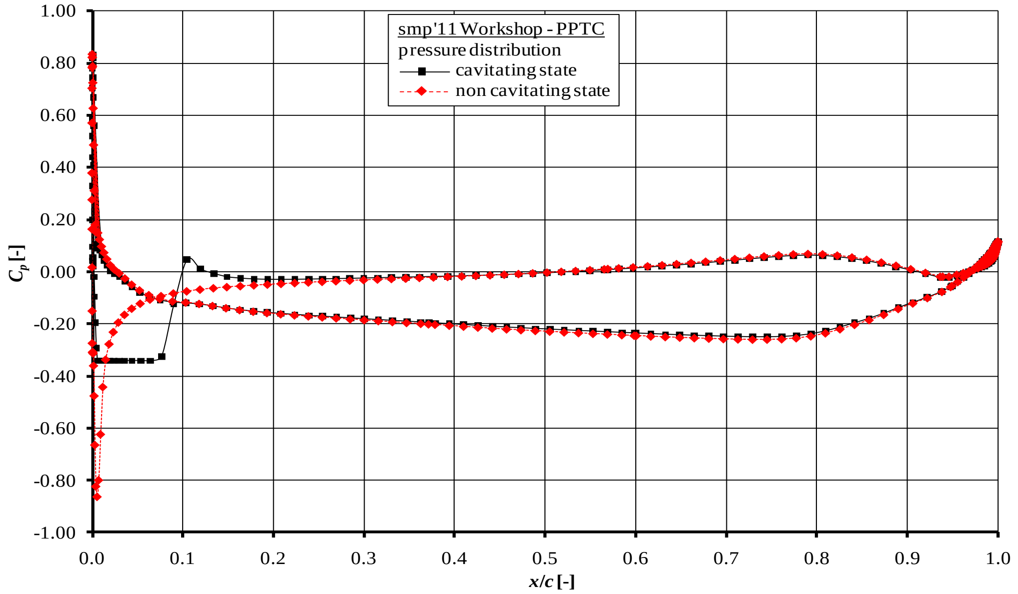


r/R = 0.95

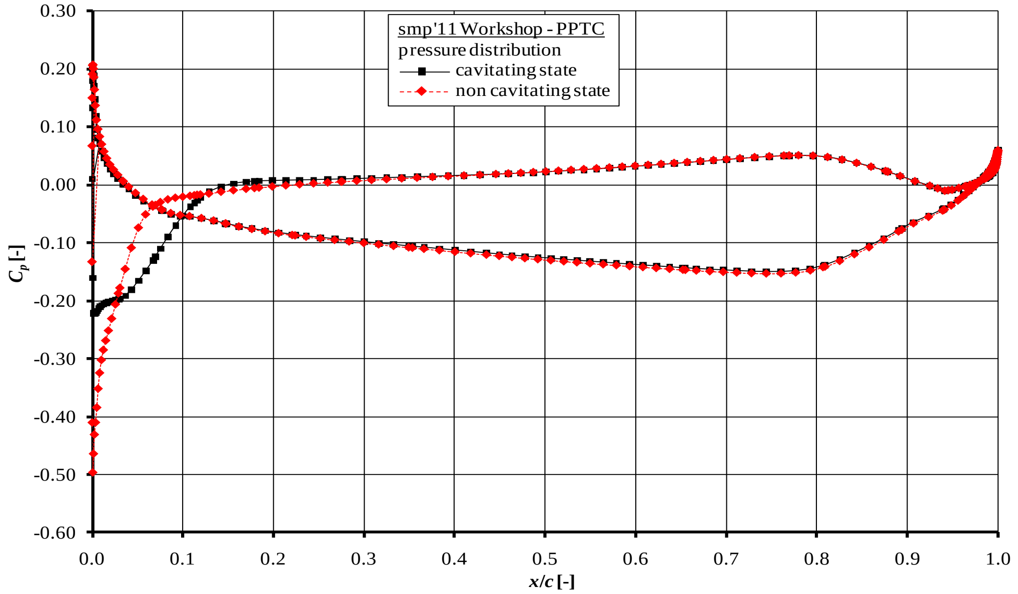


SSPA-Fluent **Case 2.3.3**

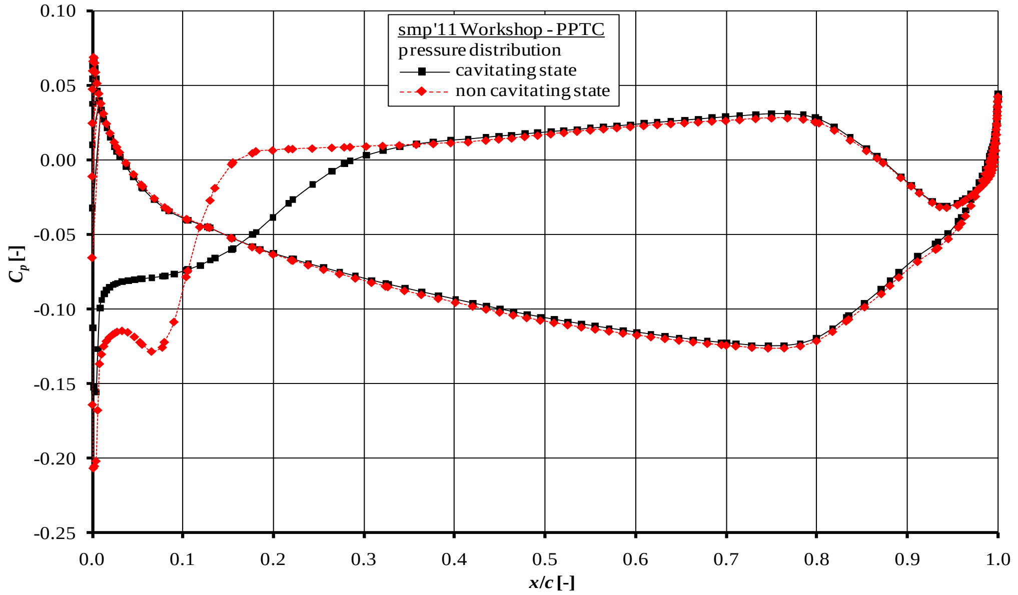
r/R = 0.70



r/R = 0.90

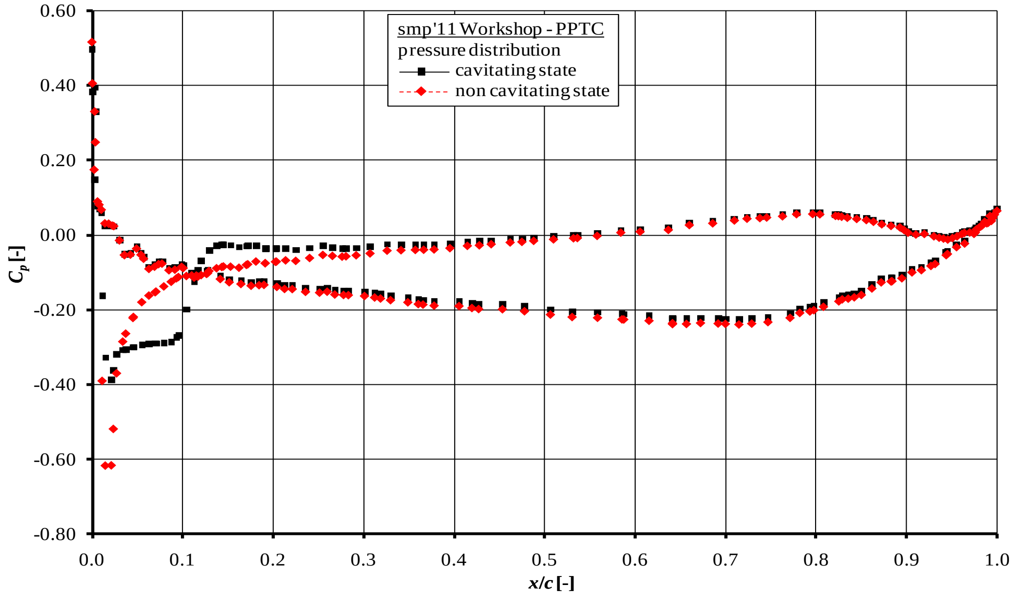


r/R = 0.95

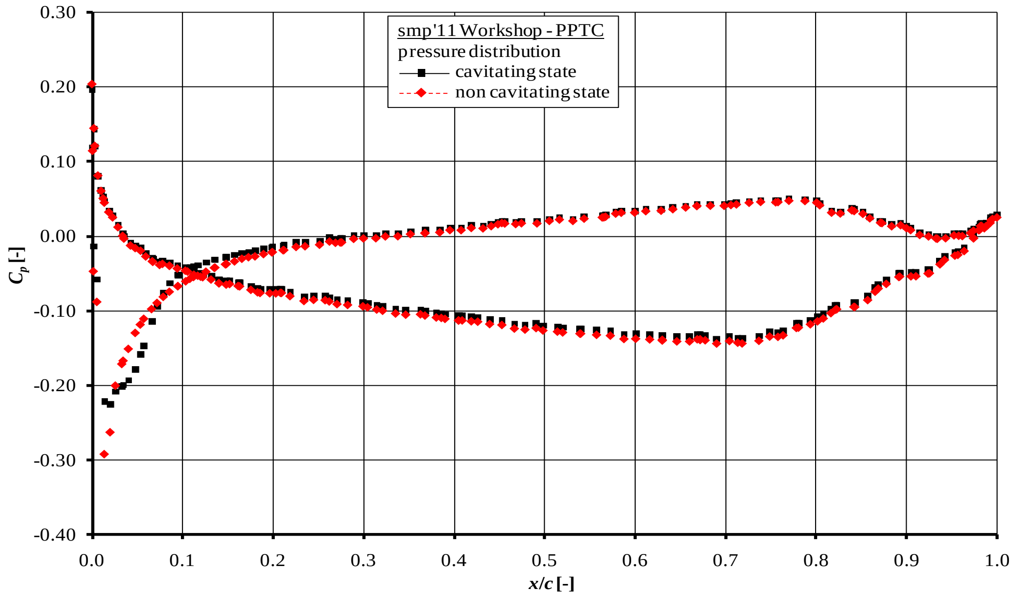


TUHH-Fresco+ **Case 2.3.3**

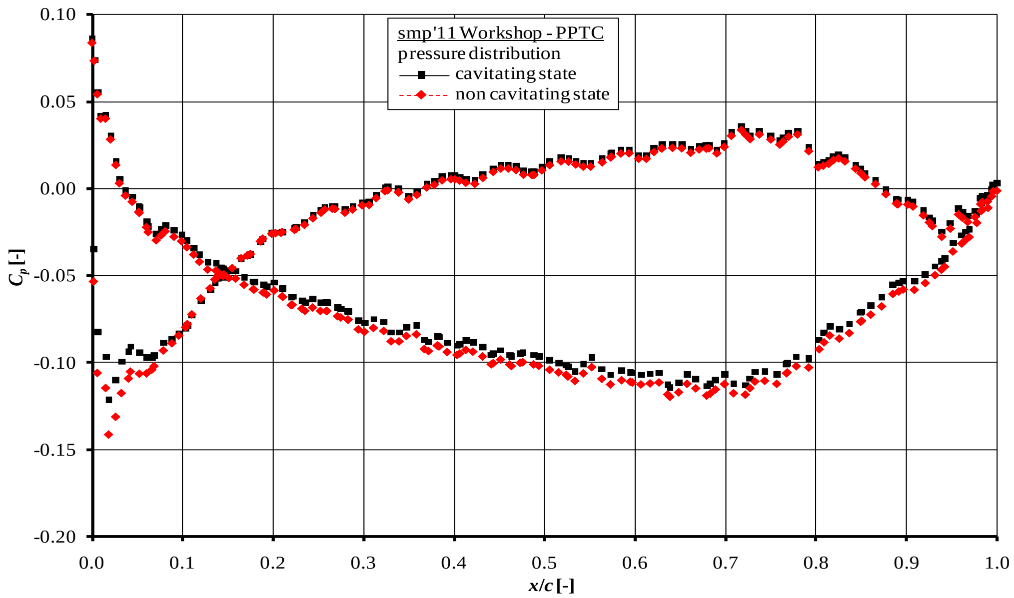
r/R = 0.70



r/R = 0.90

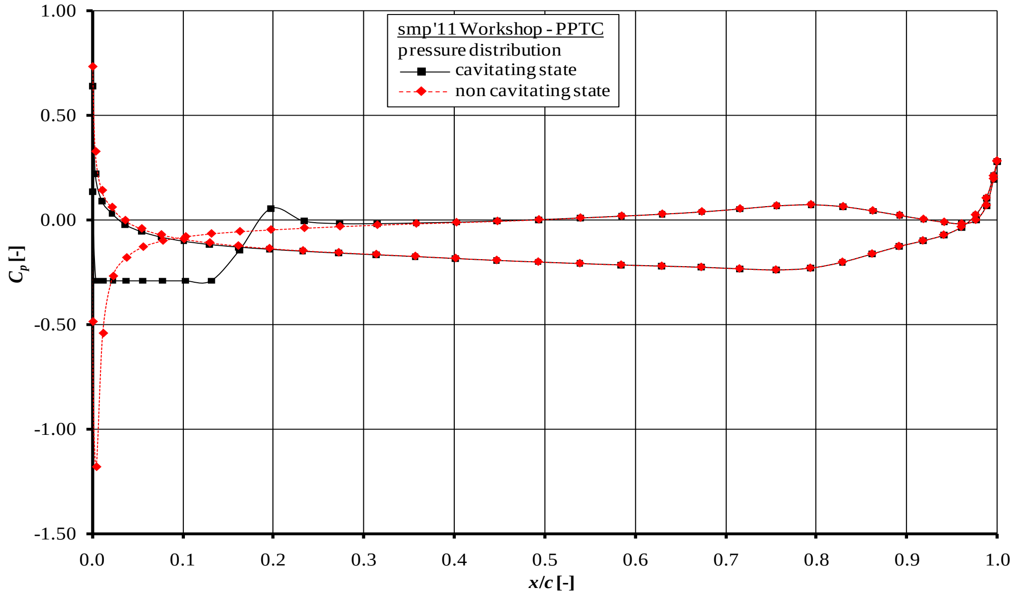


r/R = 0.95

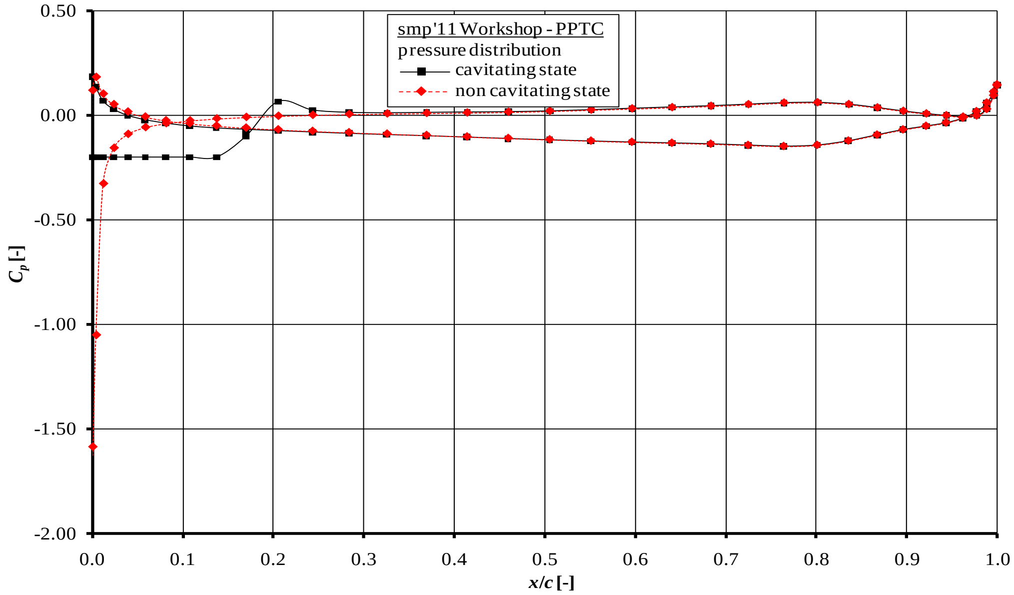


UniGenua-Panel **Case 2.3.3**

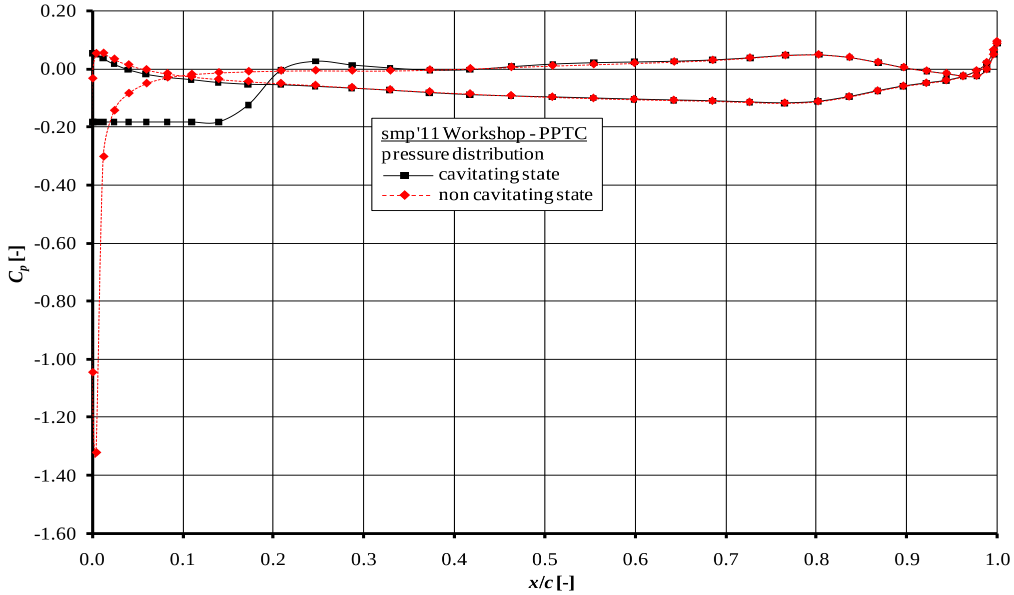
r/R = 0.70



r/R = 0.90

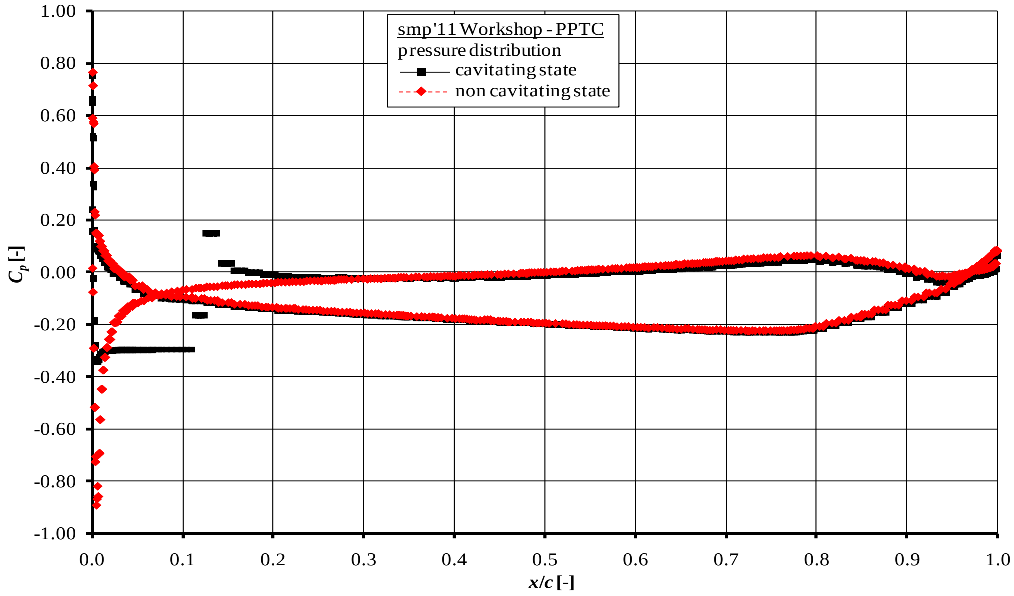


r/R = 0.95

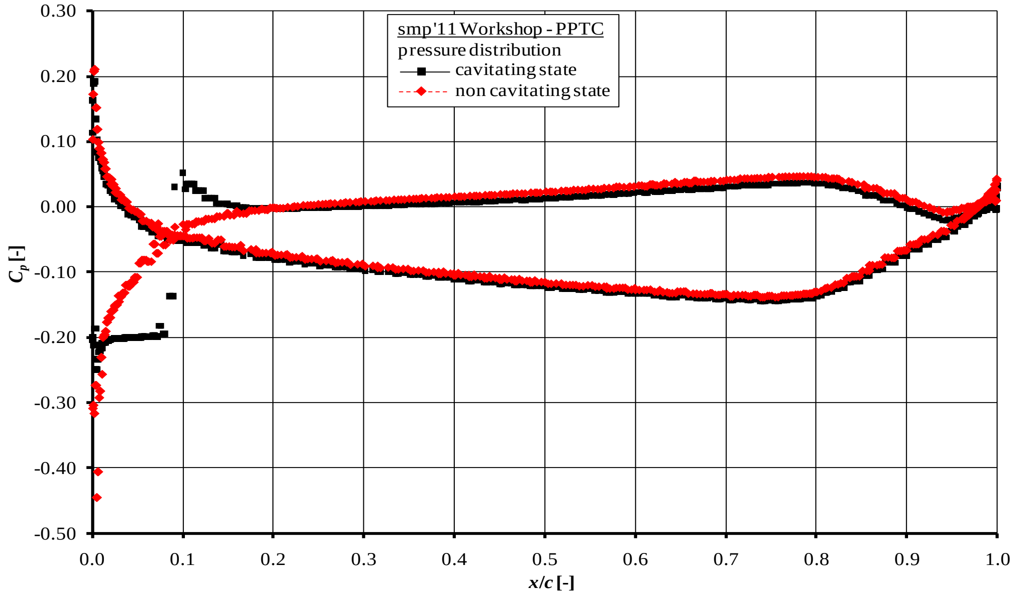


UniGenua-StarCCM(kw) **Case 2.3.3**

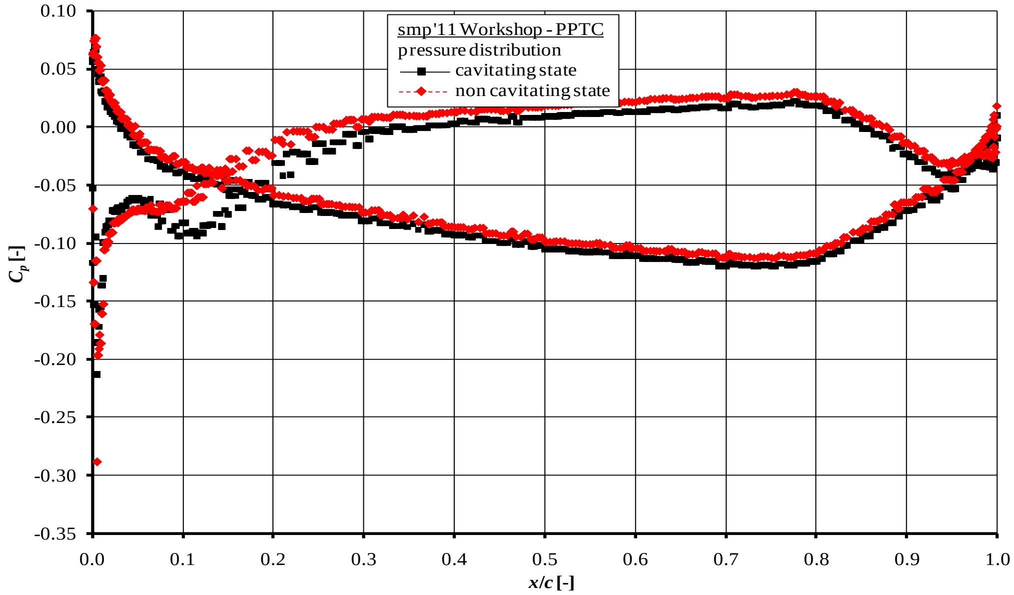
r/R = 0.70



r/R = 0.90

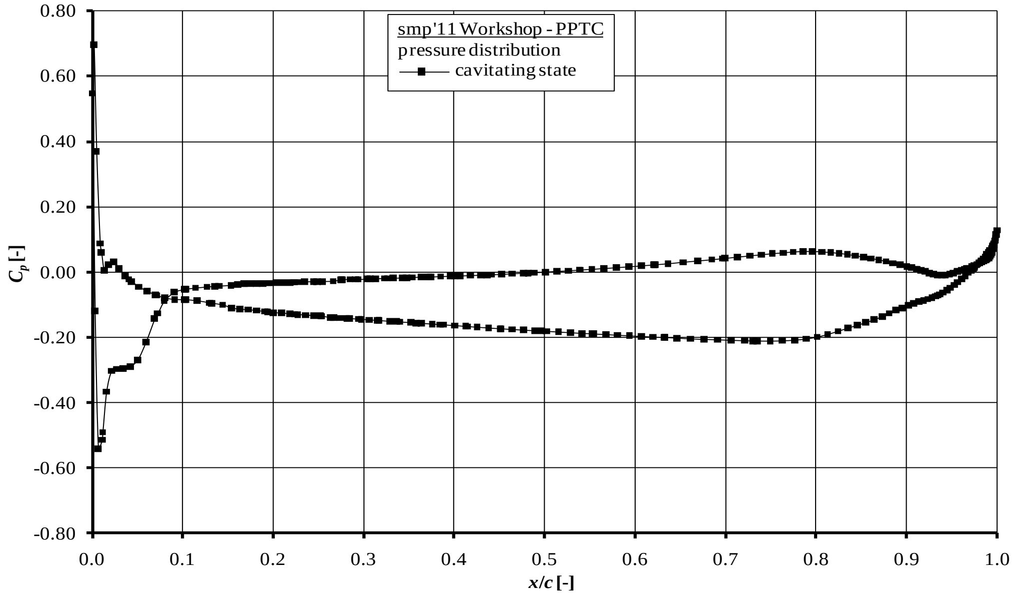


r/R = 0.95

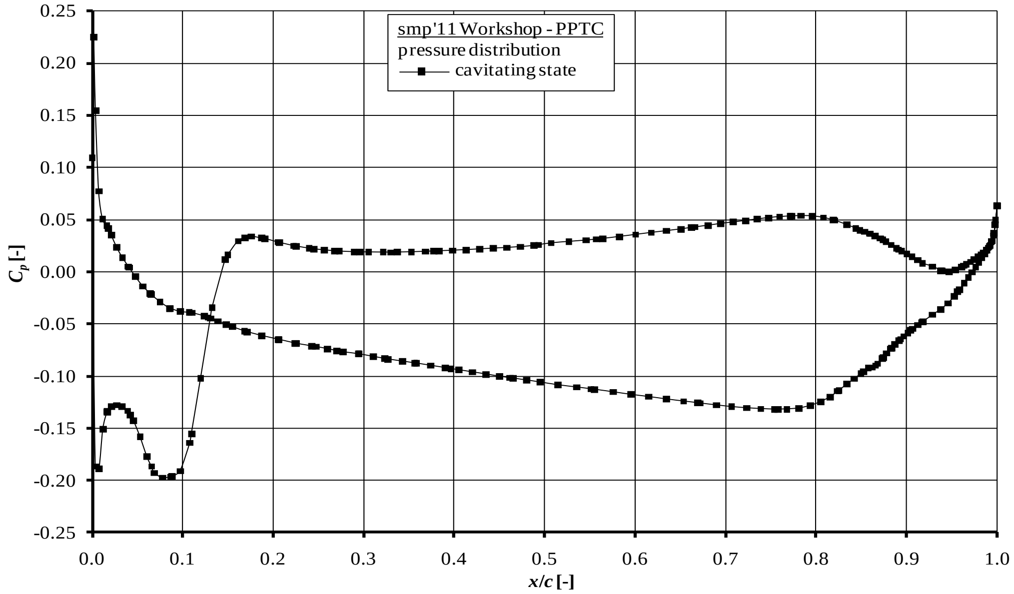


UniTriest-CFX-FCM **Case 2.3.3**

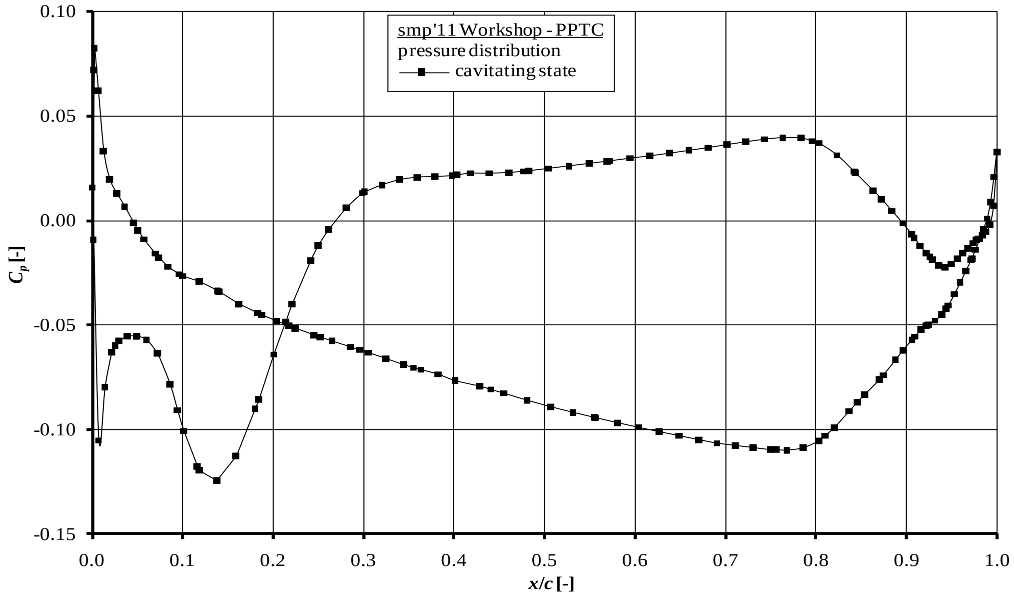
r/R = 0.70



r/R = 0.90

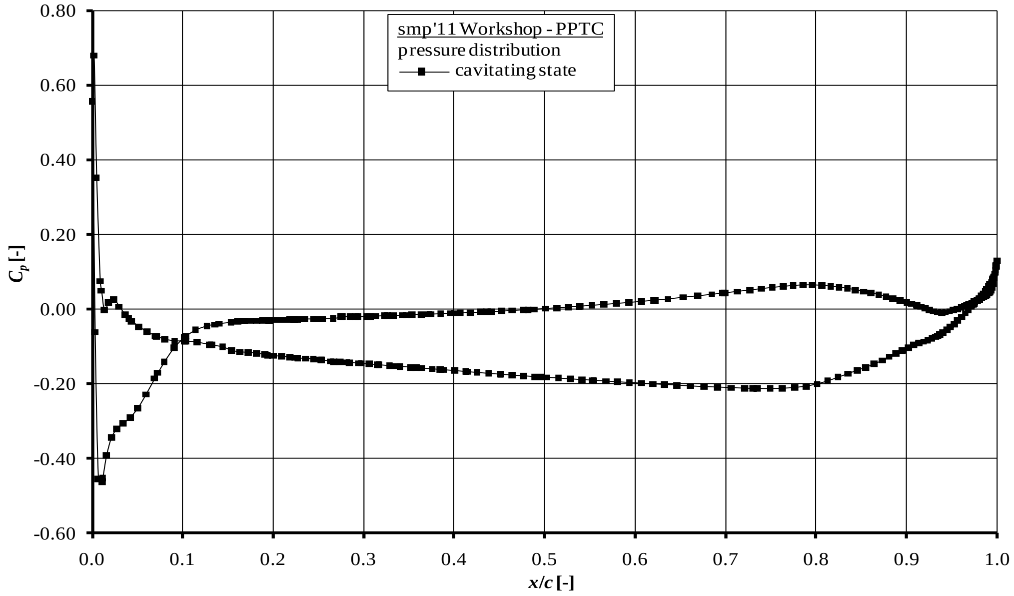


r/R = 0.95

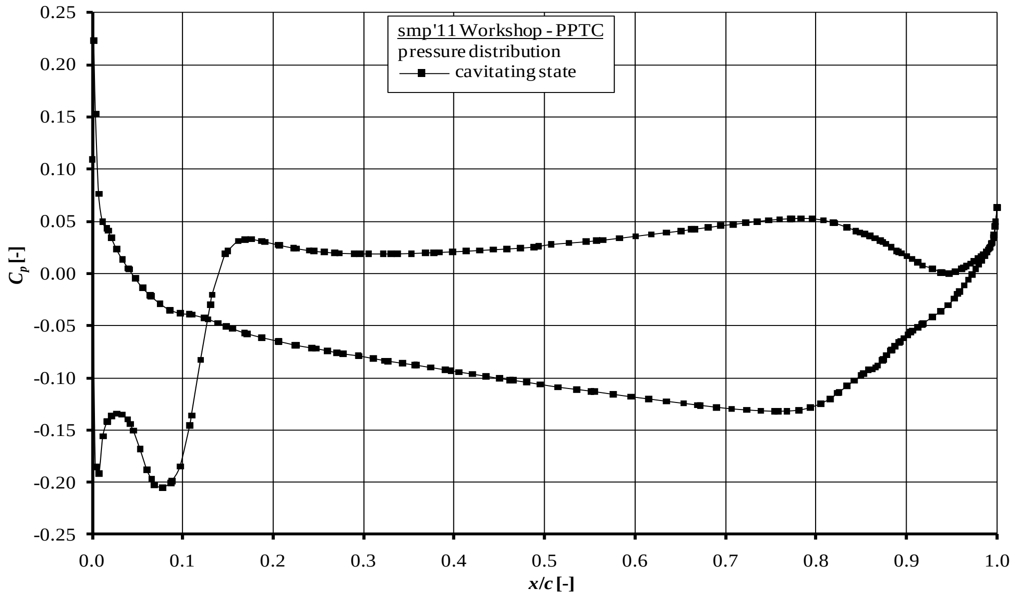


UniTriest-CFX-Kunz **Case 2.3.3**

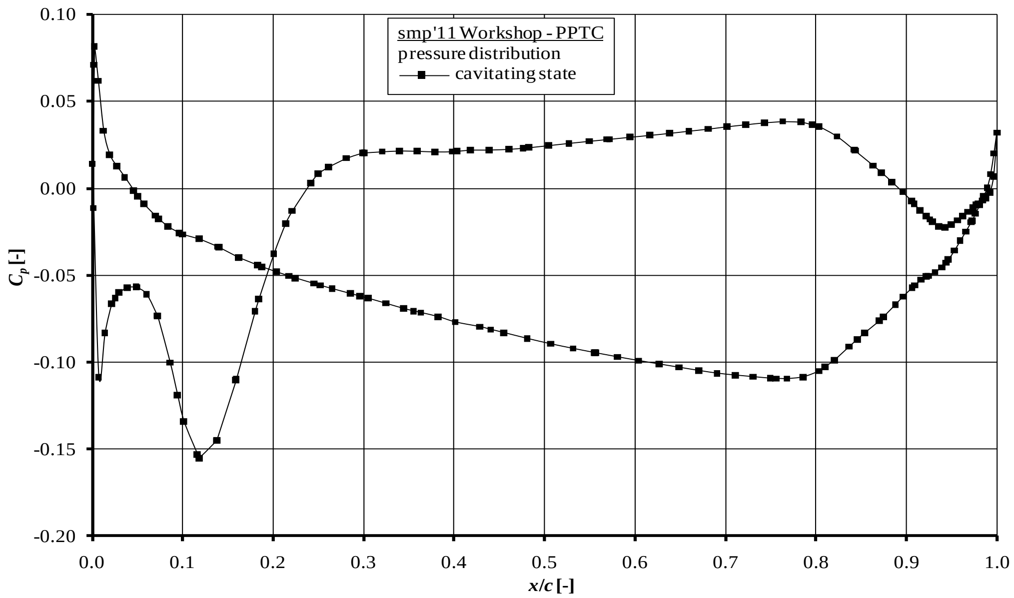
r/R = 0.70



r/R = 0.90

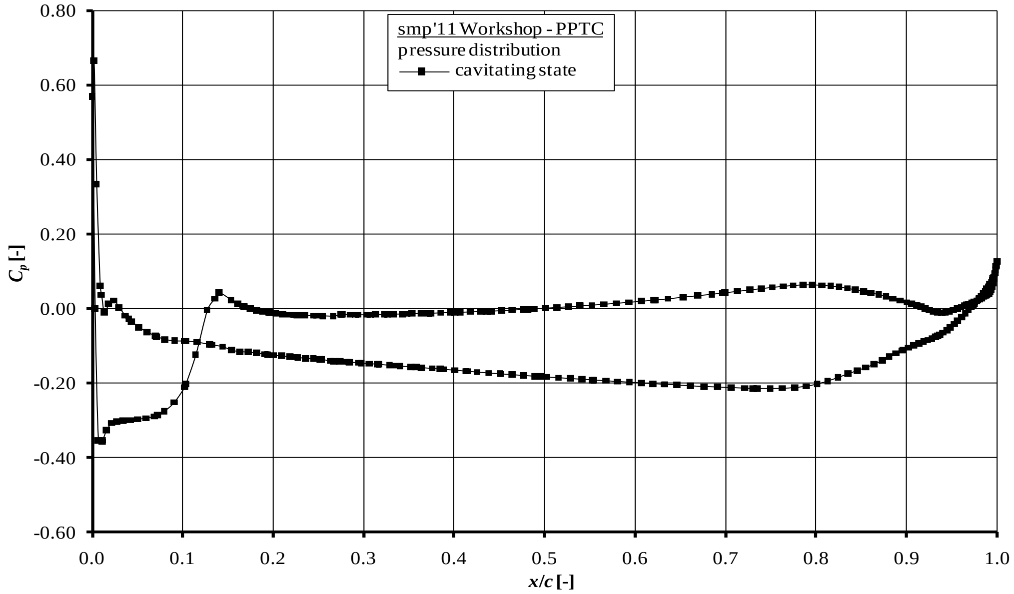


r/R = 0.95

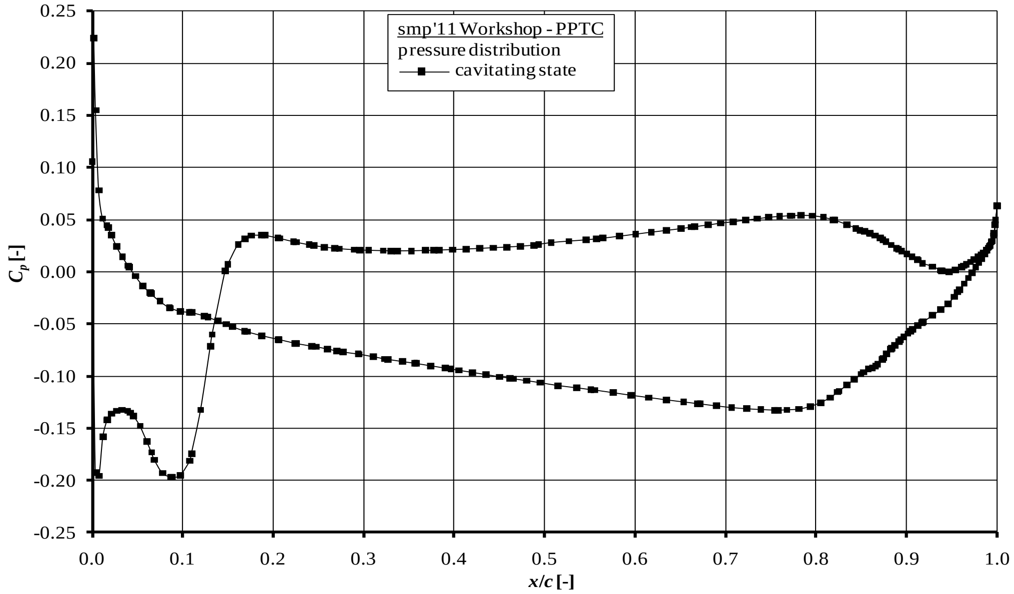


UniTriest-CFX-Zwart **Case 2.3.3**

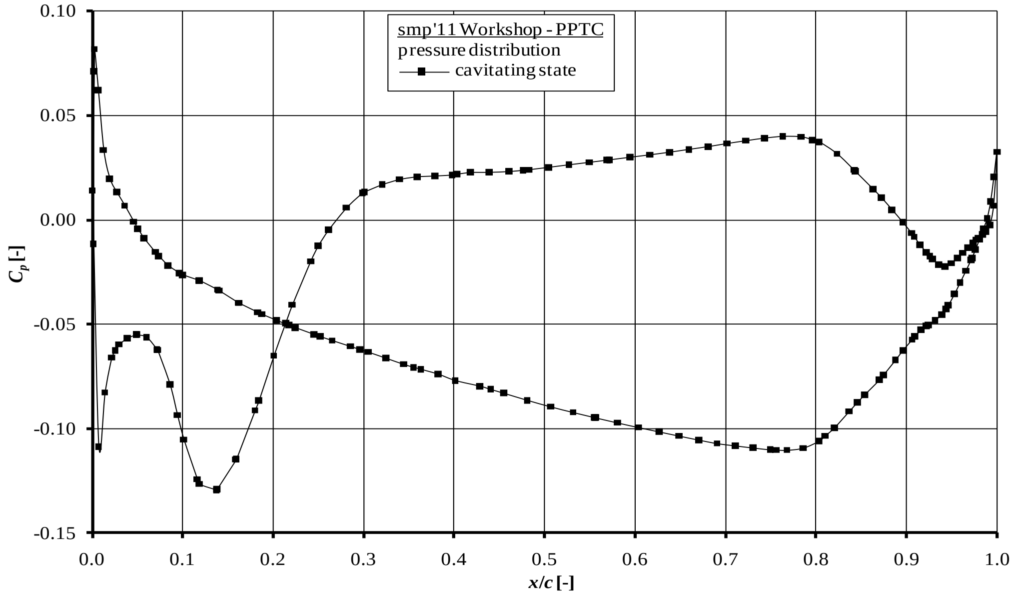
r/R = 0.70



r/R = 0.90

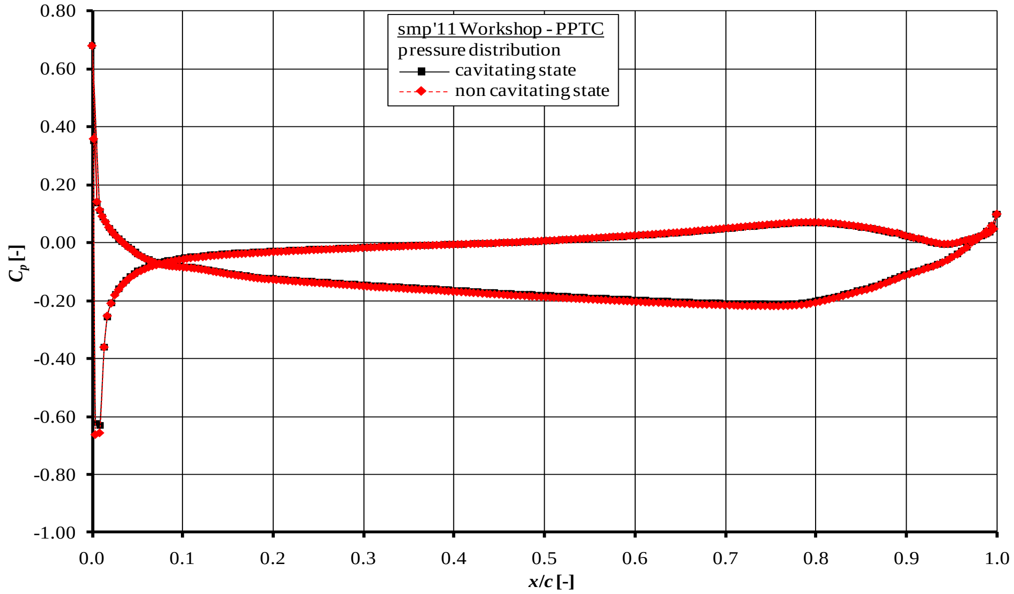


r/R = 0.95

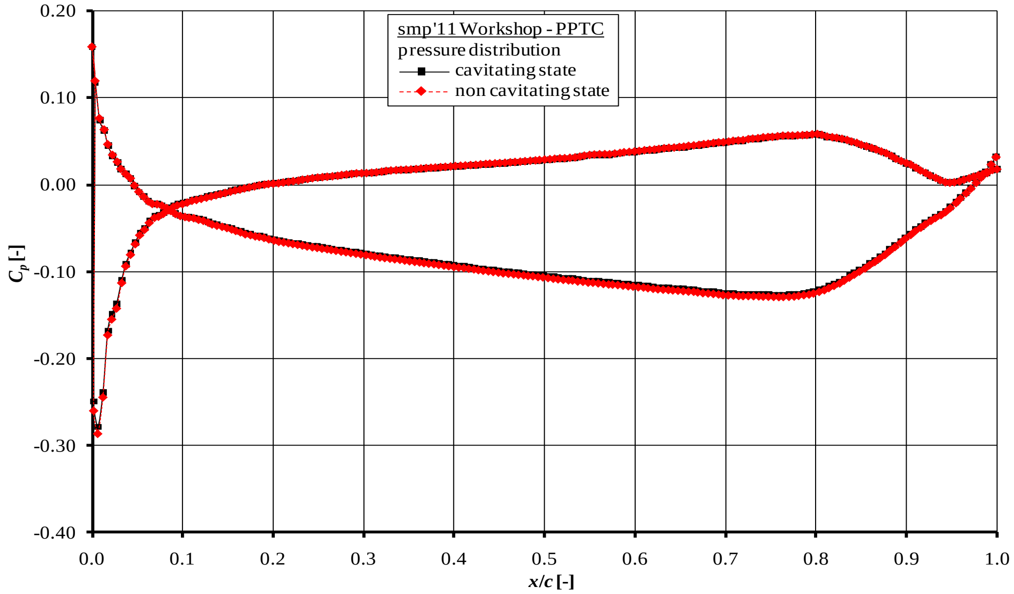


VOITH-Comet **Case 2.3.3**

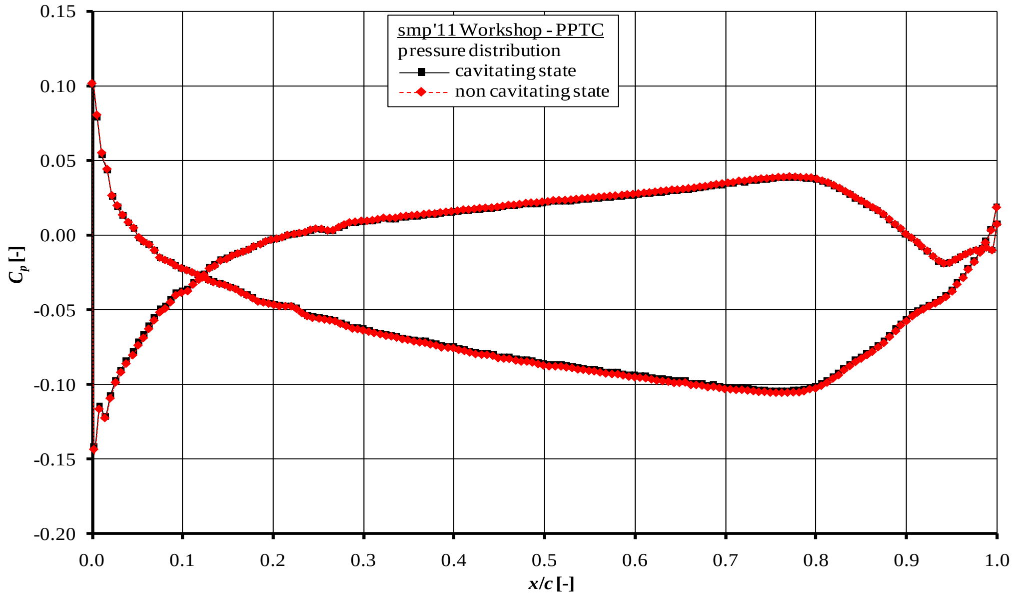
r/R = 0.70



r/R = 0.90

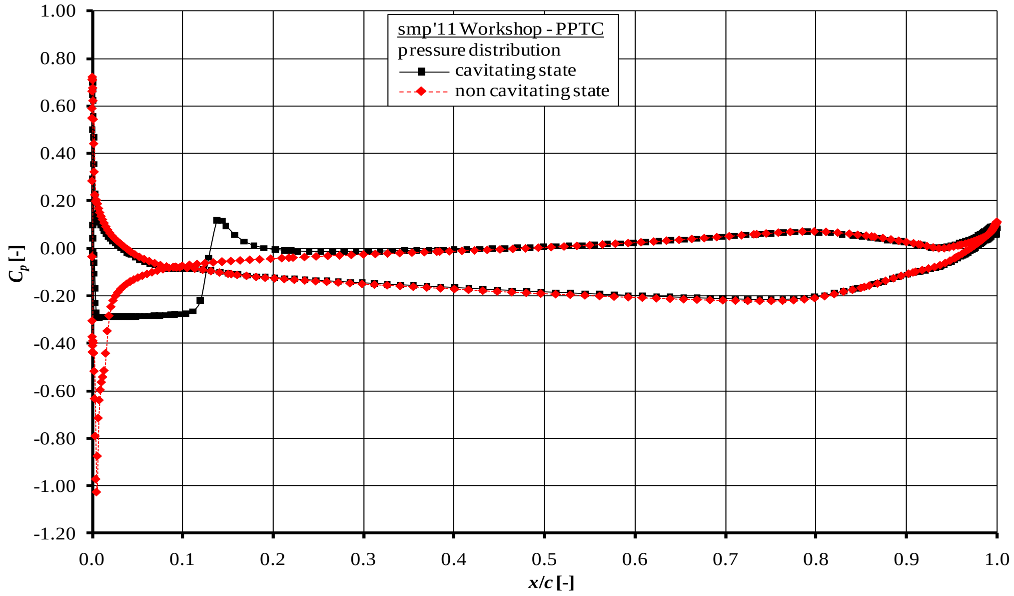


r/R = 0.95

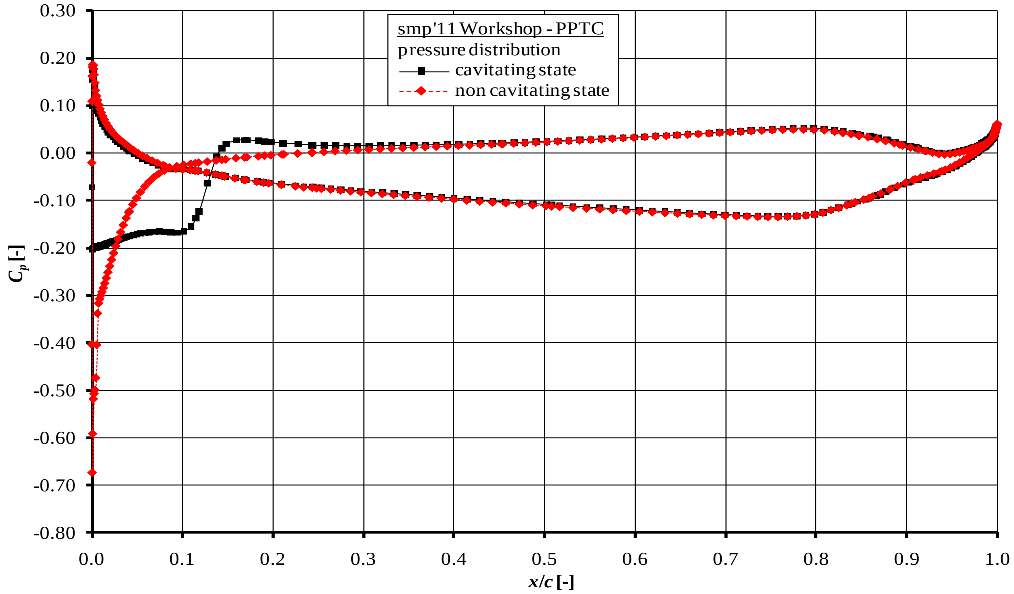


VTT-FinFlo **Case 2.3.3**

r/R = 0.70



r/R = 0.90



r/R = 0.95