

# **Pressure Pulses**

## **Case 3**

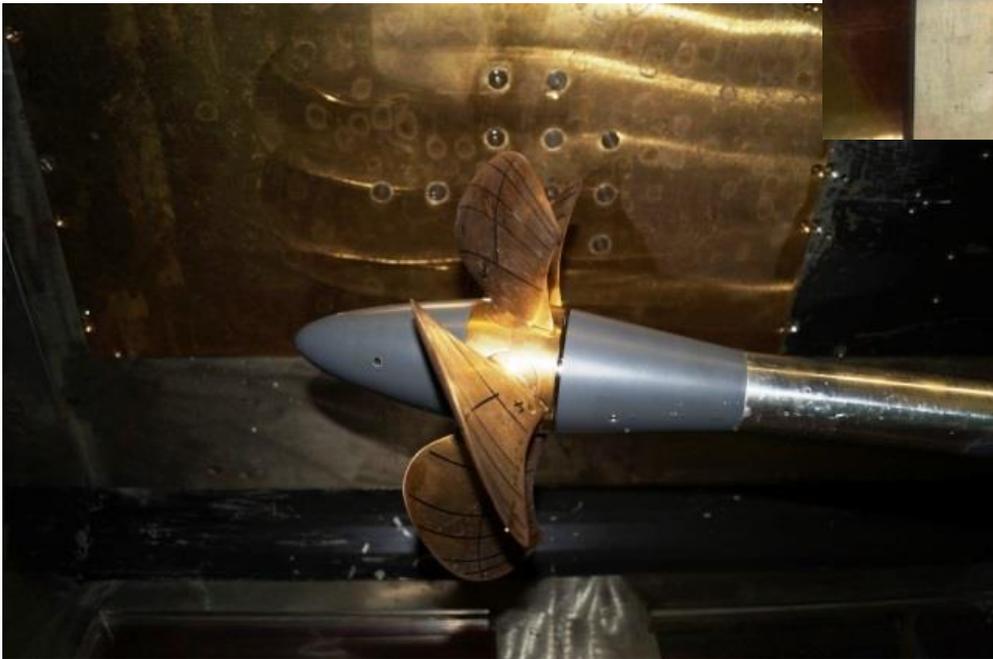
**Ulf Barkmann**

**Potsdam Model Basin (SVA)**



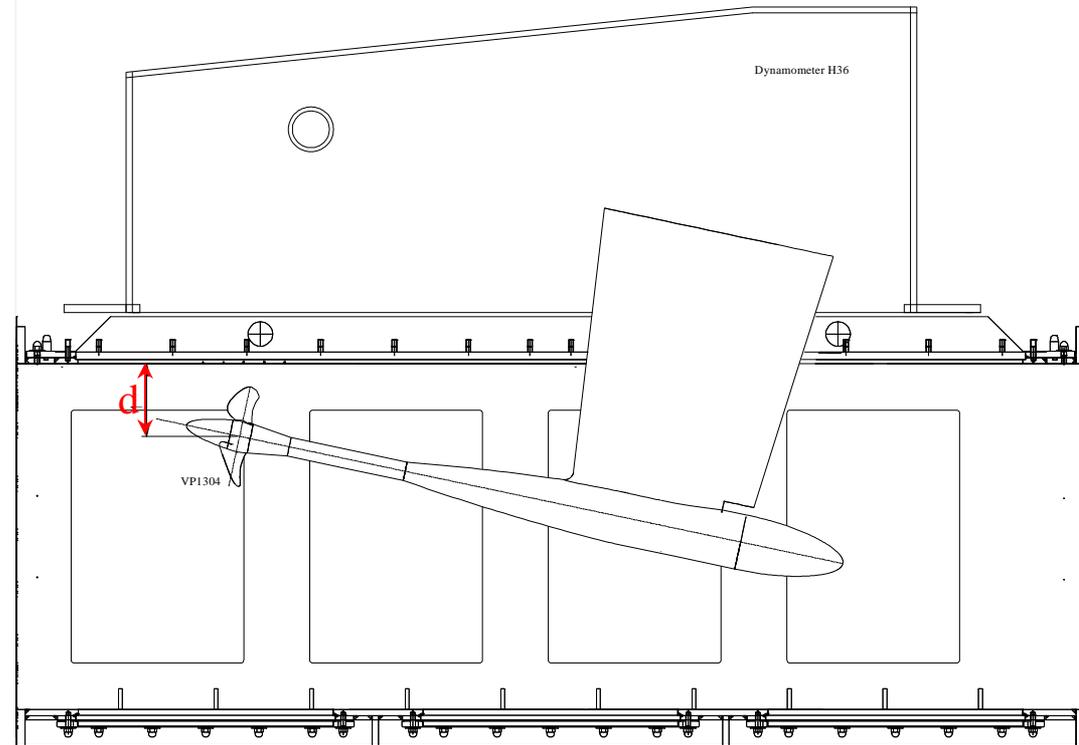
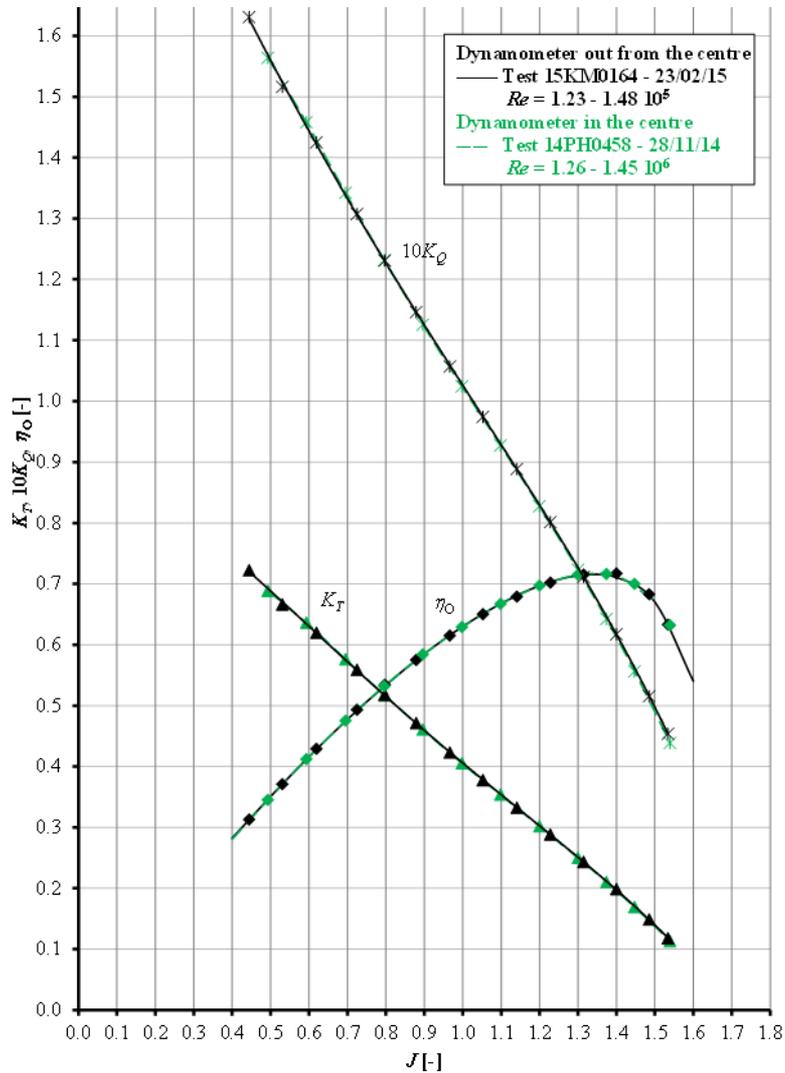
# Cavitation tunnel tests

- Tests were conducted in the cavitation tunnel of the SVA
- Dynamometer mounted behind the propeller with an inclination of  $12^\circ$



- Prior tests with dummy hub were conducted
- Pressure pulses were measured 5 times

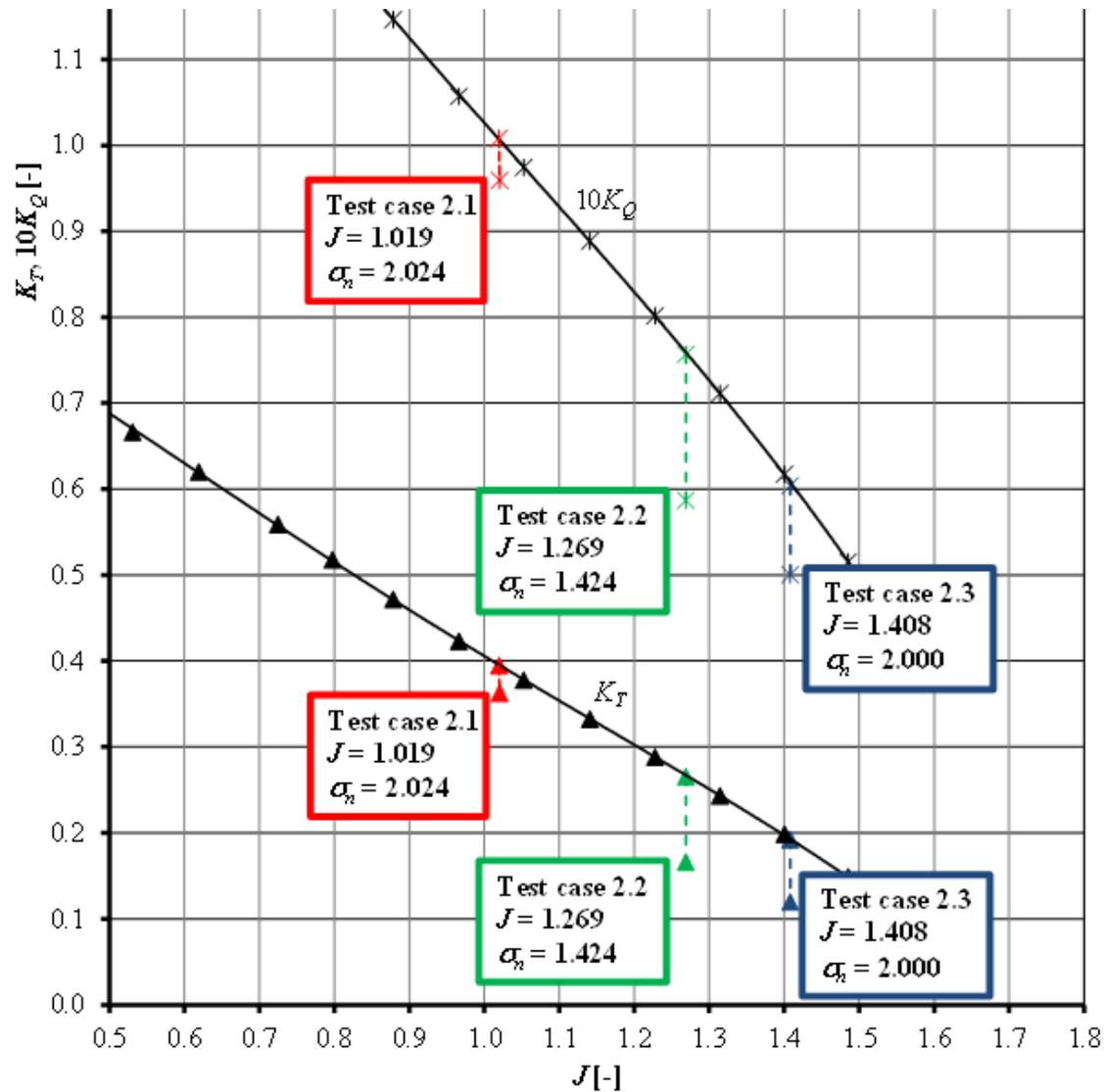
# Cavitation tunnel tests



$d = 175 \text{ mm}$

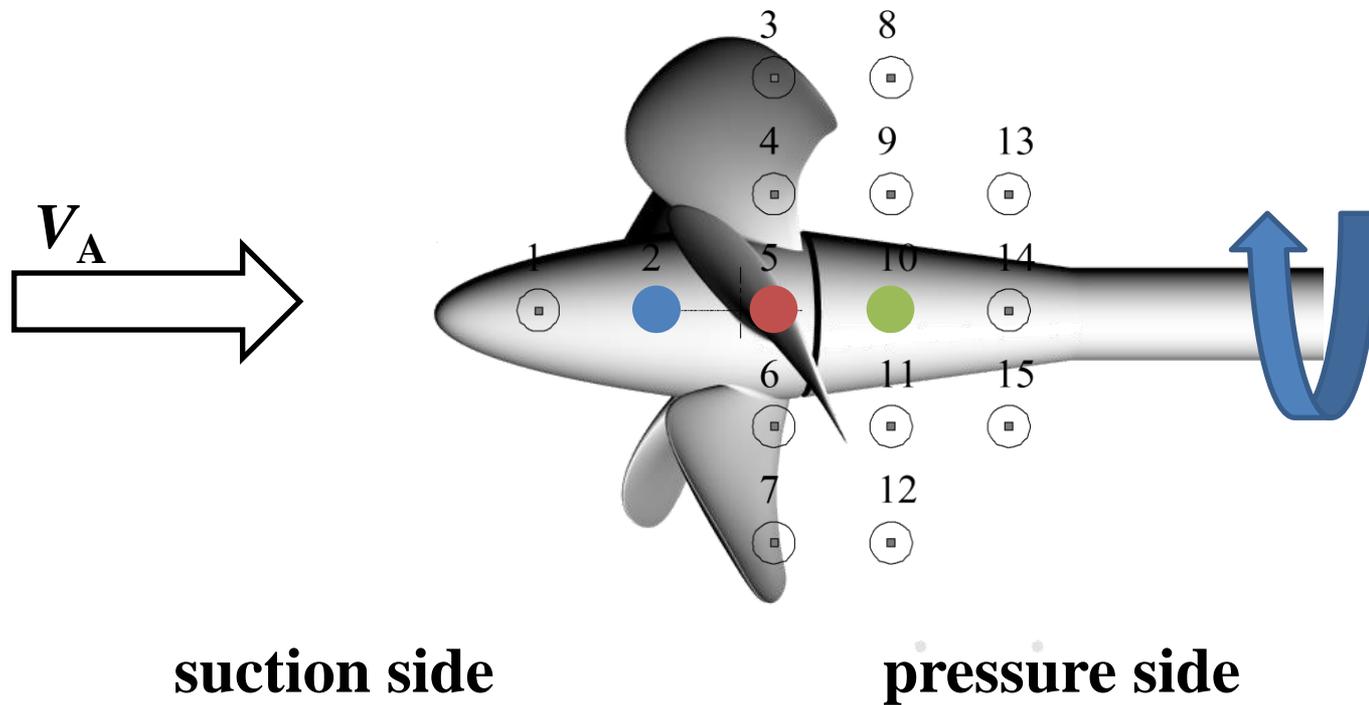
$d = 425 \text{ mm}$

# Cavitation tunnel tests



# Sensor positions

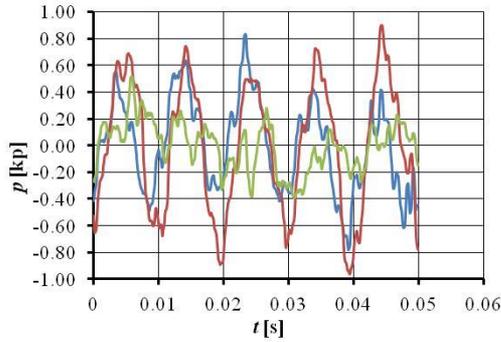
Top view



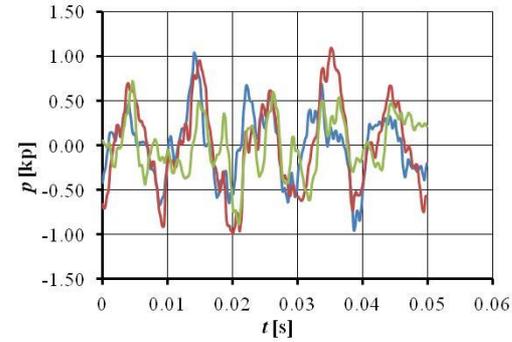
# Measured pressure pulses – case 3.1

wetted

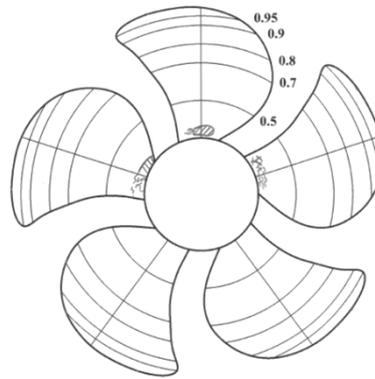
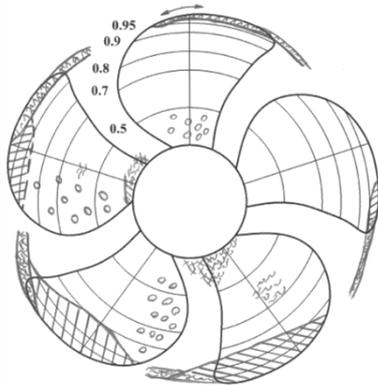
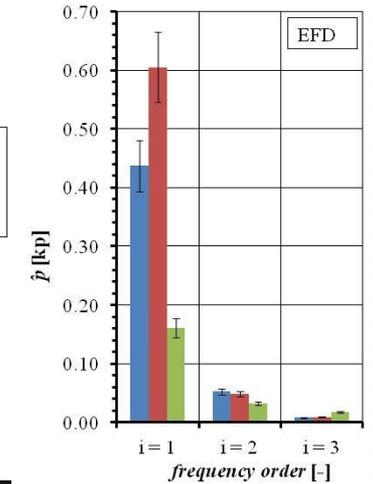
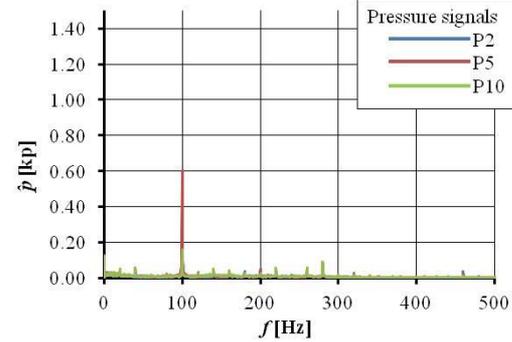
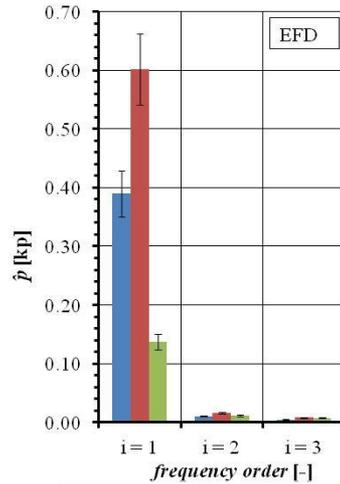
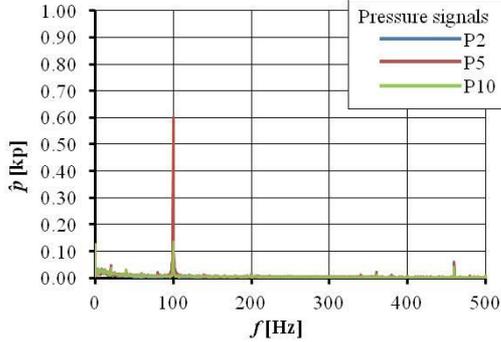
cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.3899	0.0107	0.0047
p5 (mean)	0.6017	0.0159	0.0081
P10 (mean)	0.1373	0.0113	0.0076
p2 ( $\sigma$ )	0.0409	0.0011	0.0005
p5 ( $\sigma$ )	0.0551	0.0015	0.0008
P10 ( $\sigma$ )	0.0148	0.0012	0.0008

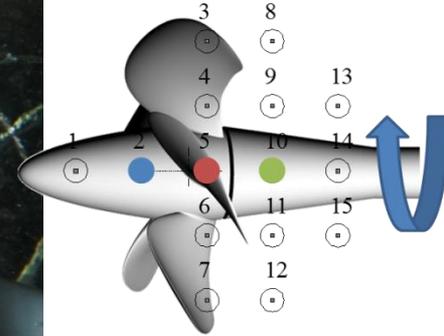
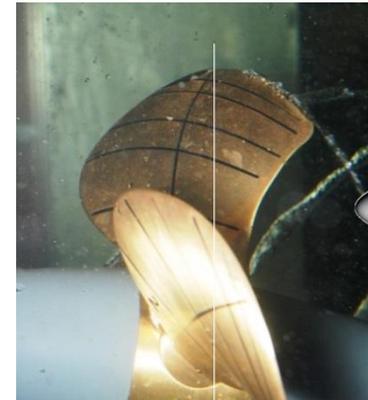


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.4372	0.0525	0.0079
p5 (mean)	0.6053	0.0484	0.0087
P10 (mean)	0.1611	0.0318	0.0178
p2 ( $\sigma$ )	0.0423	0.0055	0.0007
p5 ( $\sigma$ )	0.0659	0.0051	0.0009
P10 ( $\sigma$ )	0.0146	0.0034	0.0016



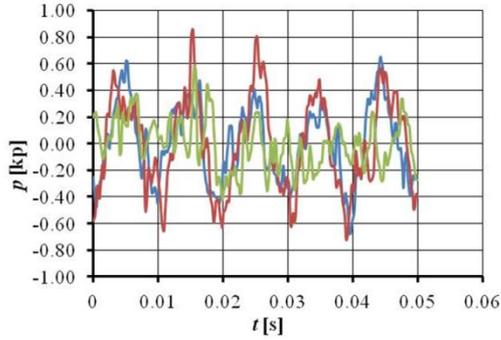
suction side

pressure side

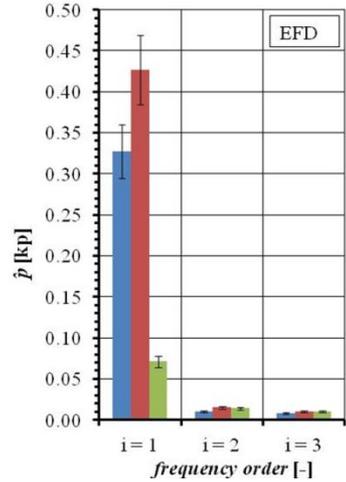
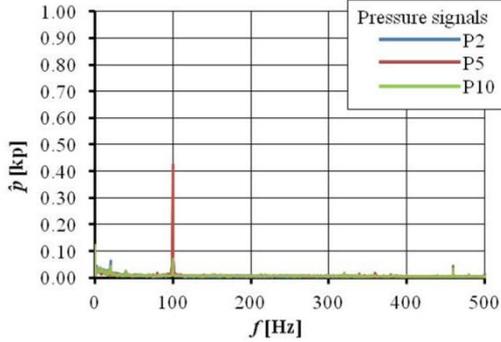


# Measured pressure pulses – case 3.2

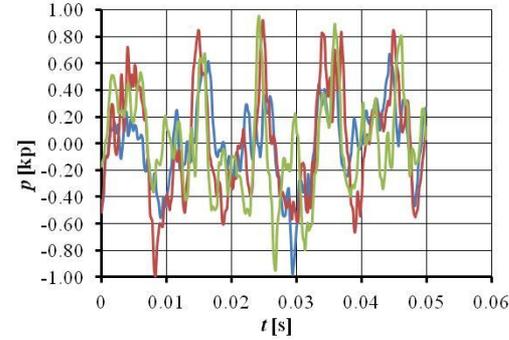
wetted



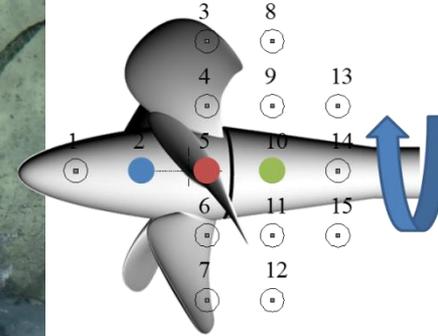
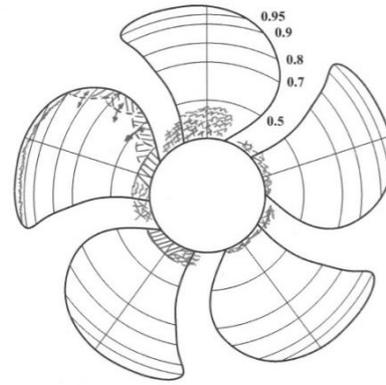
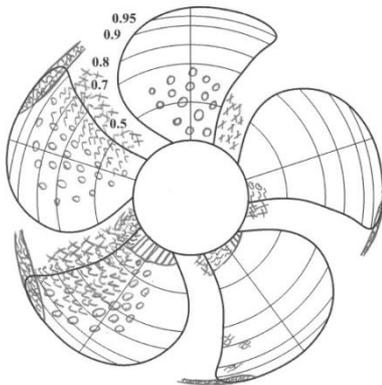
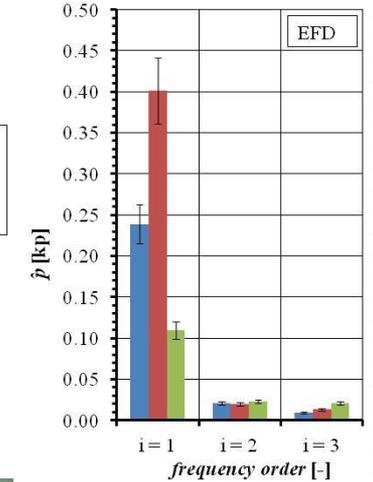
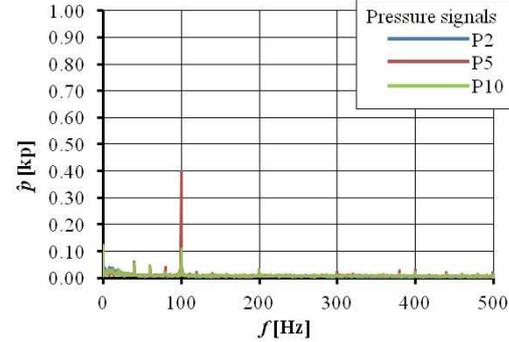
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.3277	0.0103	0.0080
p5 (mean)	0.4266	0.0152	0.0108
P10 (mean)	0.0711	0.0142	0.0104
p2 ( $\sigma$ )	0.0345	0.0010	0.0008
p5 ( $\sigma$ )	0.0431	0.0016	0.0011
P10 ( $\sigma$ )	0.0069	0.0014	0.0010



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.2387	0.0206	0.0091
p5 (mean)	0.4017	0.0196	0.0130
P10 (mean)	0.1096	0.0227	0.0207
p2 ( $\sigma$ )	0.0255	0.0022	0.0009
p5 ( $\sigma$ )	0.0403	0.0019	0.0014
P10 ( $\sigma$ )	0.0107	0.0021	0.0019

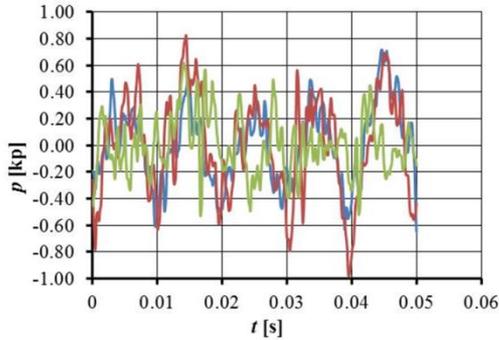


suction side

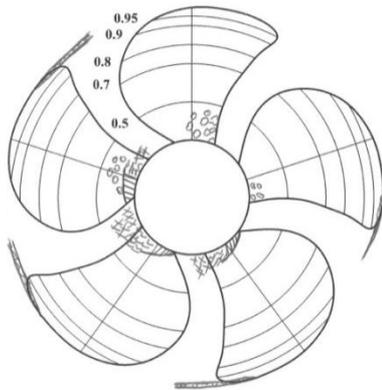
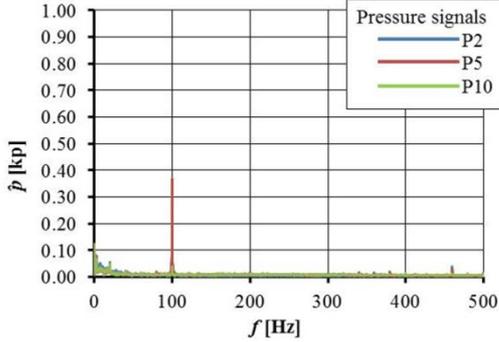
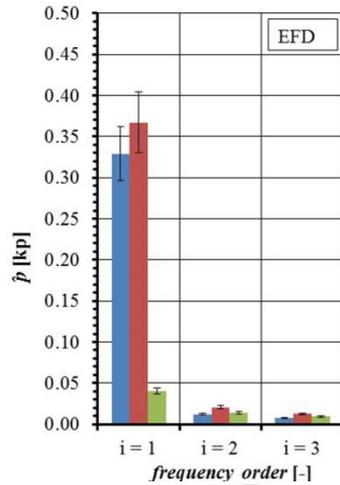
pressure side

# Measured pressure pulses – case 3.3

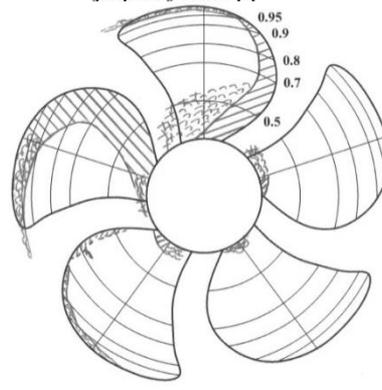
wetted



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.3289	0.0122	0.0077
p5 (mean)	0.3671	0.0204	0.0125
P10 (mean)	0.0404	0.0141	0.0093
p2 ( $\sigma$ )	0.0337	0.0013	0.0007
p5 ( $\sigma$ )	0.0347	0.0020	0.0013
P10 ( $\sigma$ )	0.0040	0.0014	0.0009

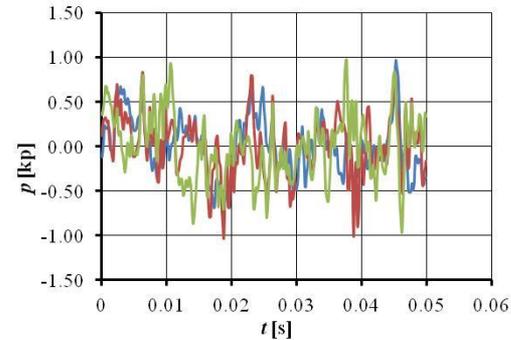


suction side

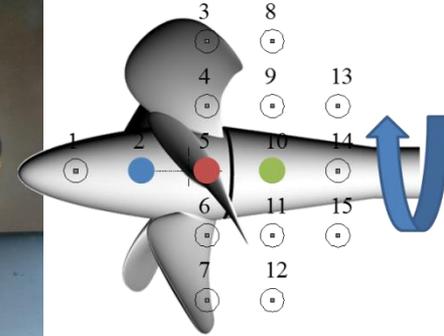
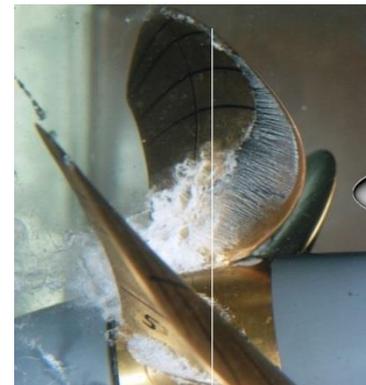
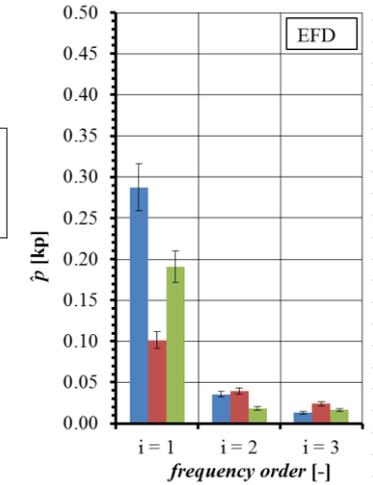
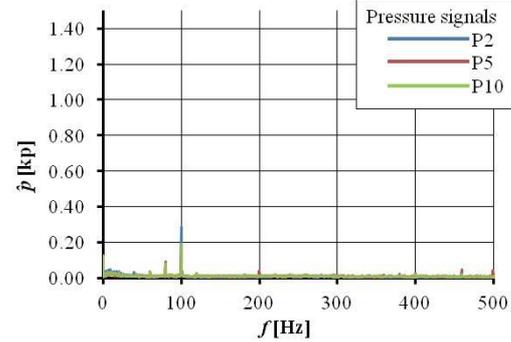


pressure side

cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (mean)	0.2872	0.0355	0.0128
p5 (mean)	0.1014	0.0395	0.0238
P10 (mean)	0.1904	0.0183	0.0162
p2 ( $\sigma$ )	0.0307	0.0038	0.0013
p5 ( $\sigma$ )	0.0095	0.0043	0.0022
P10 ( $\sigma$ )	0.0195	0.0018	0.0016



# Participants

7 groups, 7 solvers, 38 calculations

Group	Solver	Acronym
Cradle	SCTetra	Cradle-SCTetra
MARIN	ReFresco	MARIN-ReFresco
ROTAM	ANSYS	ROTAM-ANSYS
SSPA	FLUENT	SSPA-FLUENT
TUHH	CFX	TUHH-CFX
TUHH	OpenFOAM	TUHH-OpenFOAM
UTAustin	PROPCAV	UTAustin-PROPCAV
VTT	FINFLO	VTT-FINFLO

Number of calculations		Number of calculations	
Case 1	16	wetted	21
Case 2	11	cavitation	17
Case 3	11		

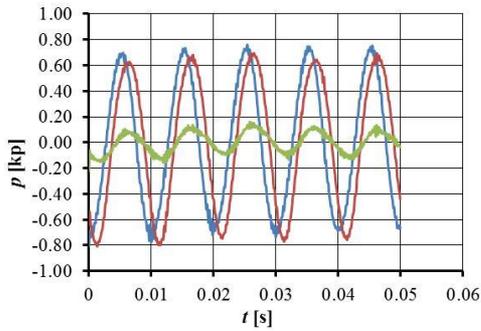
# Case 3.1

Group	Solver	Acronym	Cavitation	N / turn
Cradle	SCTetra	Cradle-SCTetra	wetted	512
Cradle	SCTetra	Cradle-SCTetra	with	1024
MARIN	ReFresco	MARIN-ReFresco	wetted	128
MARIN	ReFresco	MARIN-ReFresco	with	256
ROTAM	ANSYS	ROTAM-ANSYS	wetted	256
SSPA	FLUENT	SSPA-FLUENT	wetted	256
SSPA	FLUENT	SSPA-FLUENT	with	256
SSPA	FLUENT	SSPA-FLUENT	with	256
TUHH	CFX	TUHH-CFX	wetted	256
TUHH	CFX	TUHH-CFX	with	256
TUHH	OpenFOAM	TUHH-OpenFOAM	wetted	256
TUHH	panMARE	TUHH-panMARE	wetted	64
TUHH	panMARE	TUHH-panMARE	with	32
UTAustin	PROPCAV	UTAustin-PROPCAV	wetted	60
UTAustin	PROPCAV	UTAustin-PROPCAV	with	60
VTT	FINFLO	VTT-FINFLO	wetted	256

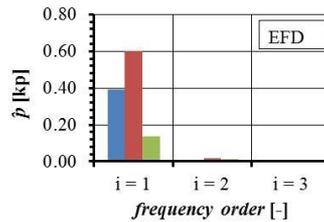
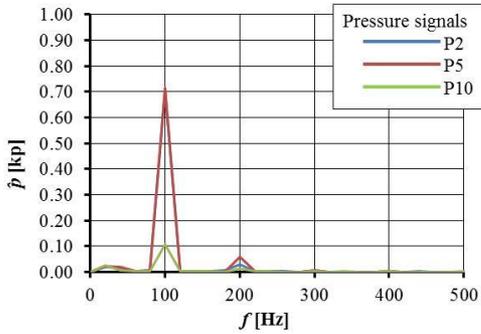
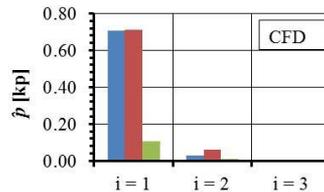


# Case 3.1 – Cradle SCTetra

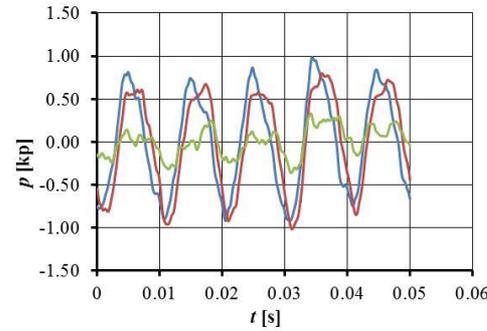
wetted



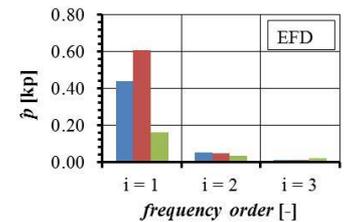
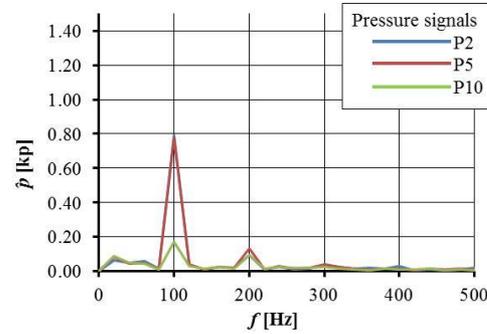
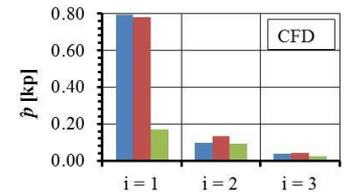
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.7085	0.0294	0.0051
p5 (CFD)	0.7129	0.0582	0.0059
P10 (CFD)	0.1074	0.0116	0.0038
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



cavitating

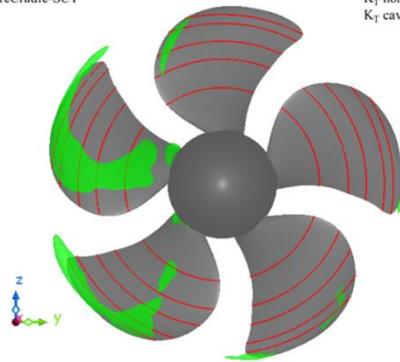


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.7933	0.0948	0.0385
p5 (CFD)	0.7784	0.1337	0.0397
P10 (CFD)	0.1696	0.0941	0.0244
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178



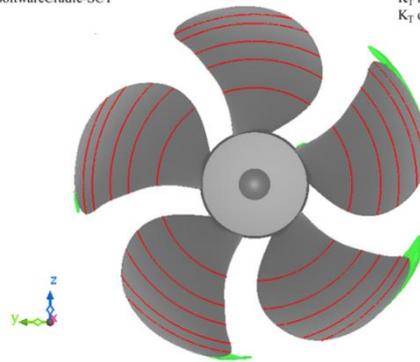
SoftwareCradle-SCT

$K_T$  non-cav = 0.417  
 $K_T$  cav = 0.372

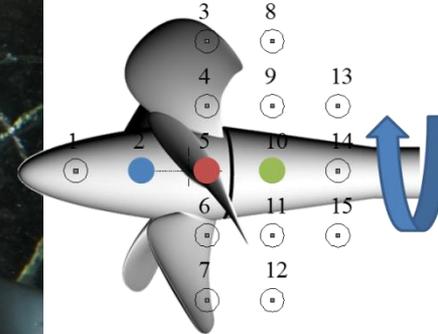
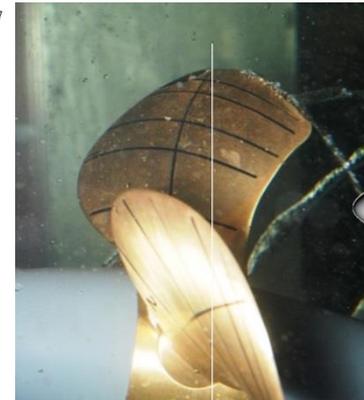


suction side

$K_T$  non-cav = 0.417  
 $K_T$  cav = 0.372

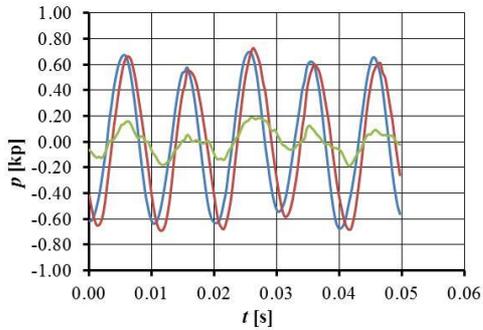


pressure side

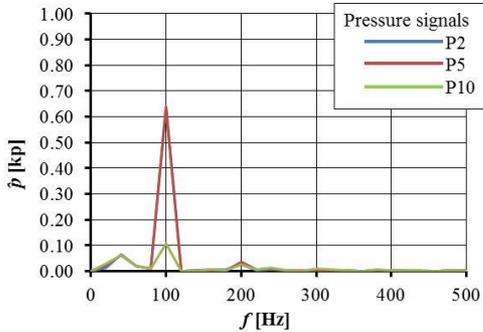
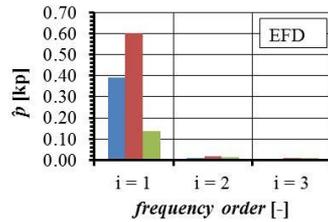
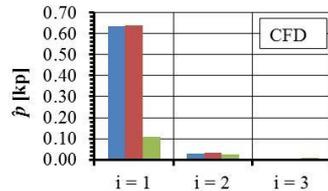


# Case 3.1 – MARIN ReFresco

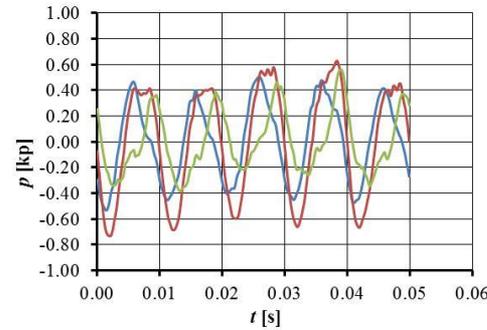
wetted



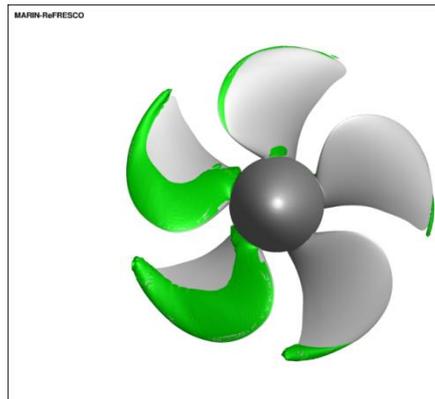
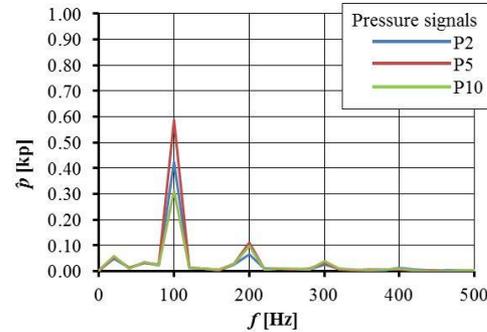
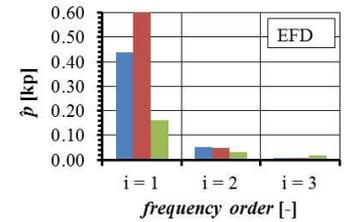
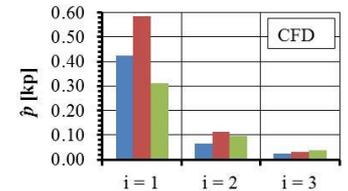
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.6347	0.0269	0.0033
p5 (CFD)	0.6391	0.0347	0.0011
P10 (CFD)	0.1086	0.0254	0.0086
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



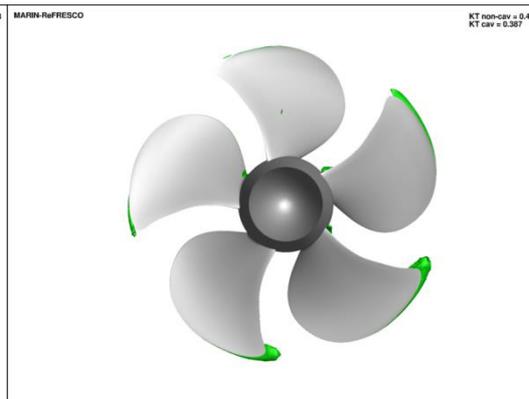
cavitating



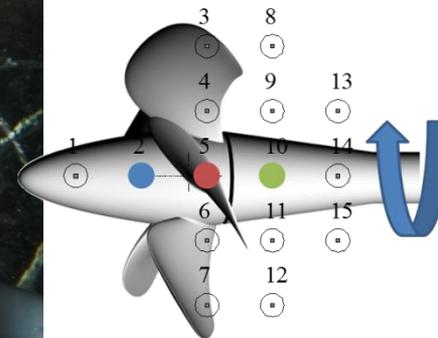
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4243	0.0652	0.0249
p5 (CFD)	0.5855	0.1118	0.0319
P10 (CFD)	0.3130	0.0973	0.0388
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178



suction side

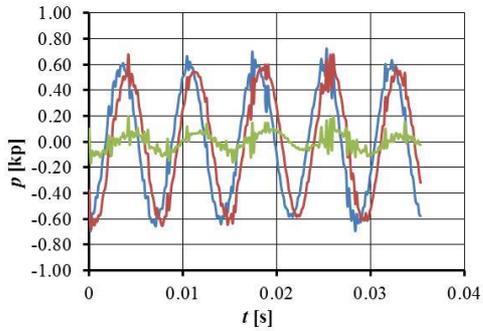


pressure side

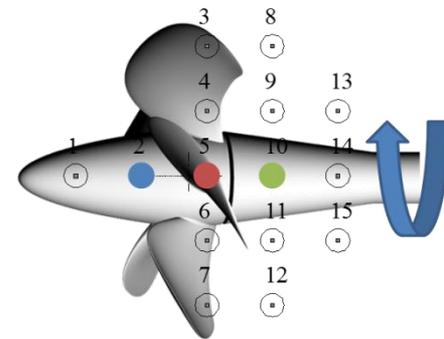
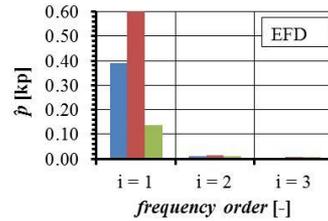
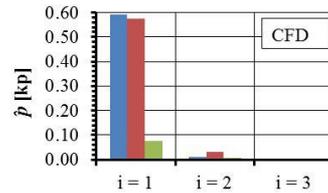
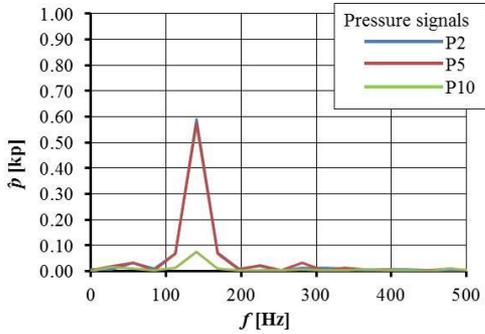


# Case 3.1 – ROTAM ANSYS

wetted

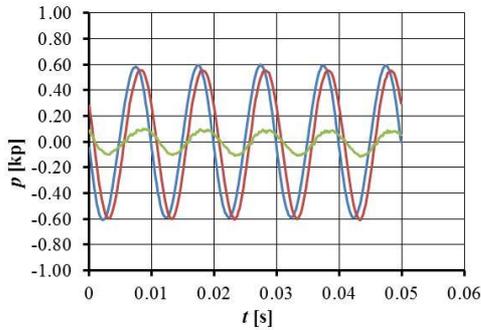


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5896	0.0125	0.0059
p5 (CFD)	0.5734	0.0314	0.0004
P10 (CFD)	0.0761	0.0061	0.0027
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076

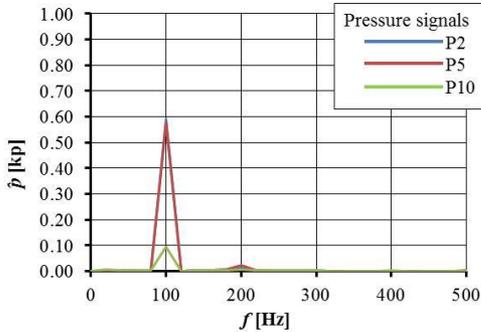
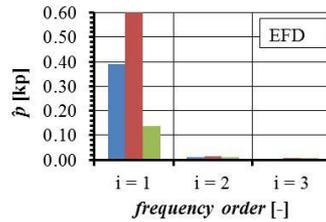
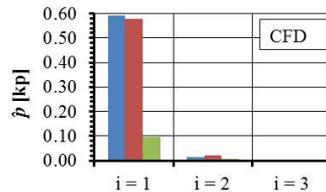


# Case 3.1 – SSPA Fluent (Sauer)

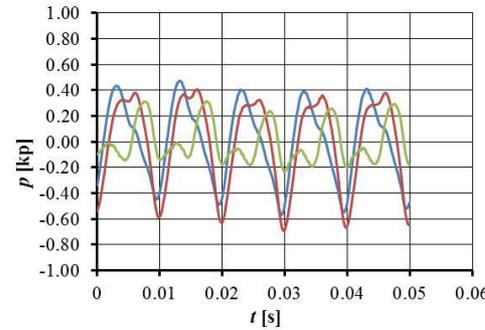
wetted



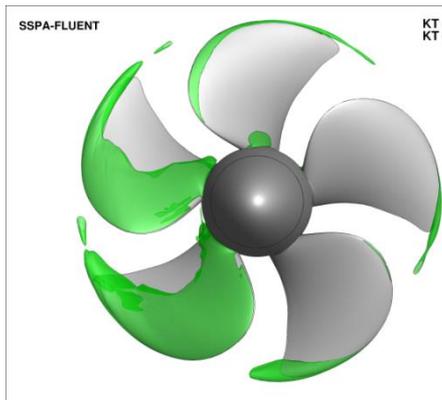
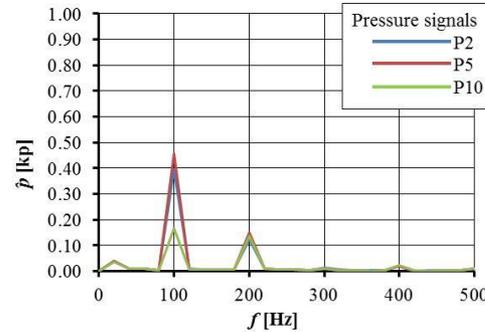
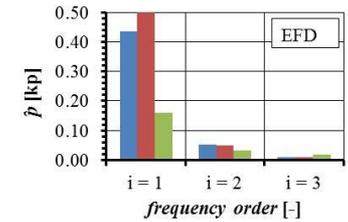
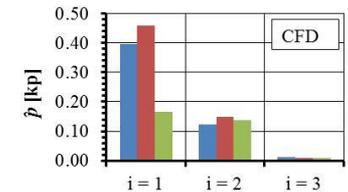
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5907	0.0132	0.0017
p5 (CFD)	0.5778	0.0212	0.0011
P10 (CFD)	0.0955	0.0069	0.0018
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



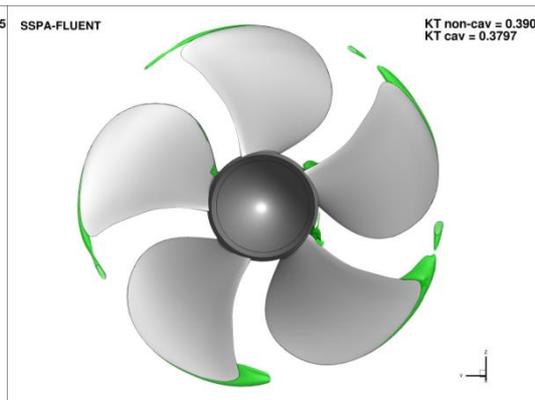
cavitating



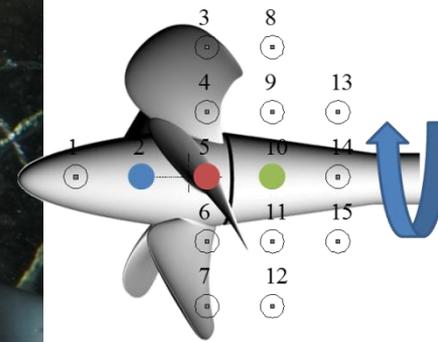
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.3961	0.1238	0.0113
p5 (CFD)	0.4574	0.1483	0.0104
P10 (CFD)	0.1668	0.1360	0.0101
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178



suction side

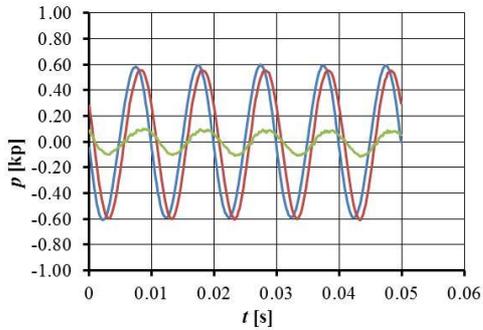


pressure side

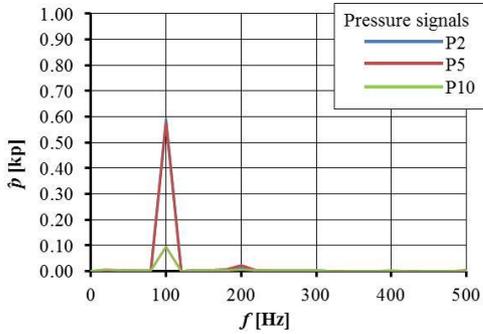
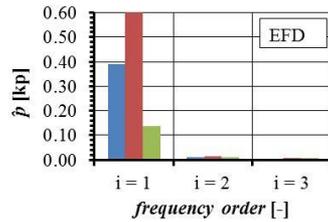
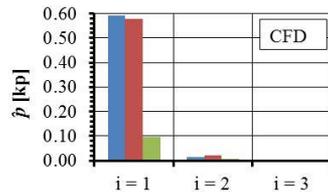


# Case 3.1 – SSPA Fluent (Zwart)

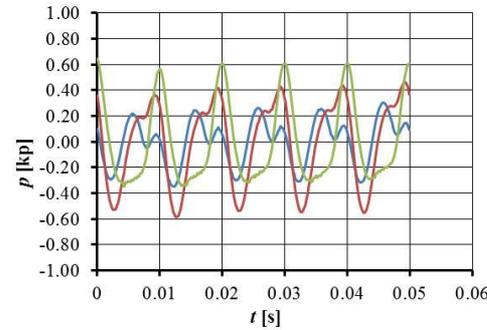
wetted



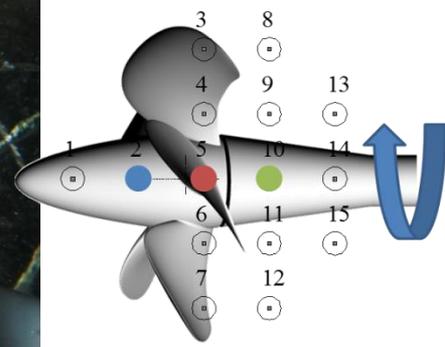
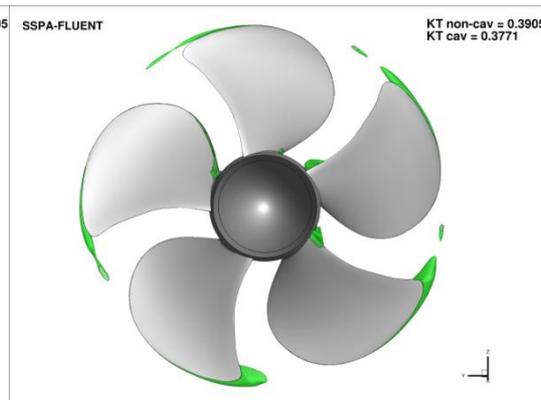
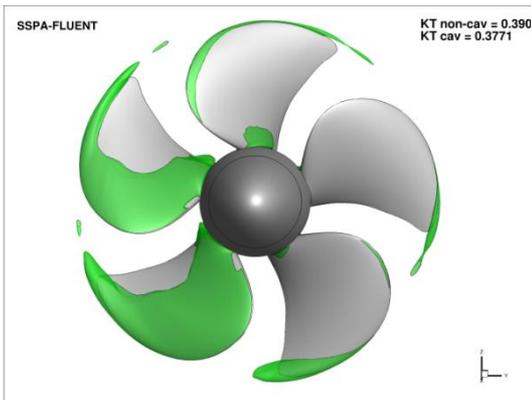
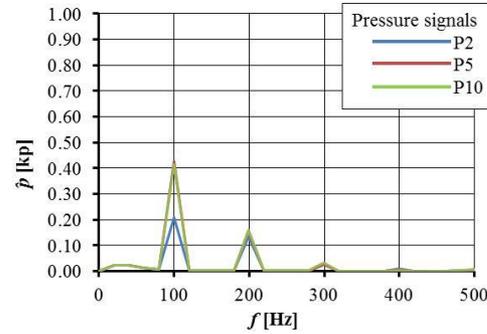
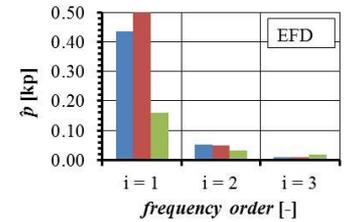
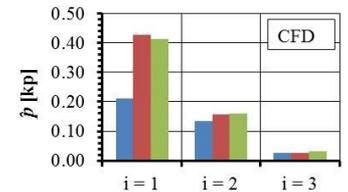
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5907	0.0132	0.0017
p5 (CFD)	0.5778	0.0212	0.0011
P10 (CFD)	0.0955	0.0069	0.0018
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.2100	0.1348	0.0265
p5 (CFD)	0.4285	0.1578	0.0257
P10 (CFD)	0.4144	0.1610	0.0313
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178

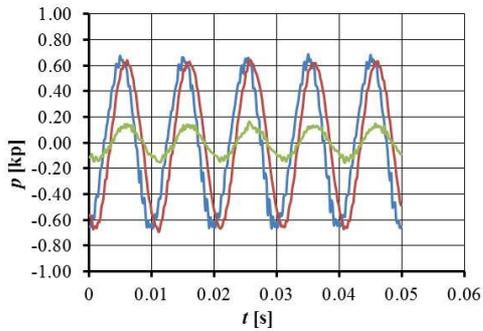


suction side

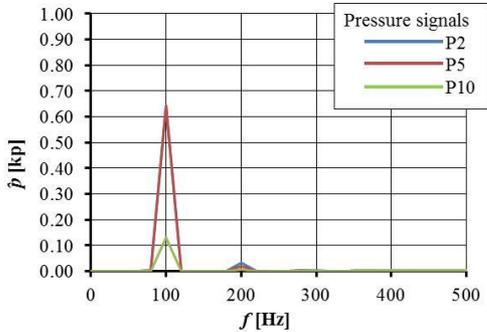
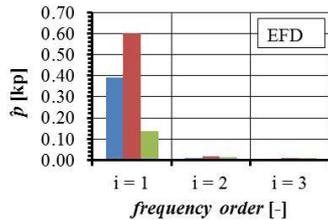
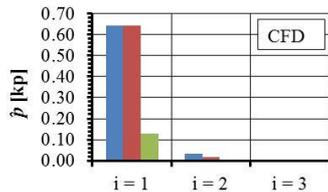
pressure side

# Case 3.1 – TUHH CFX

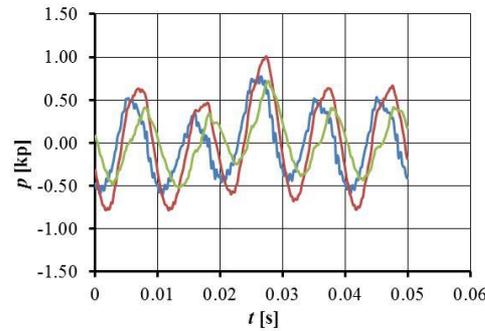
wetted



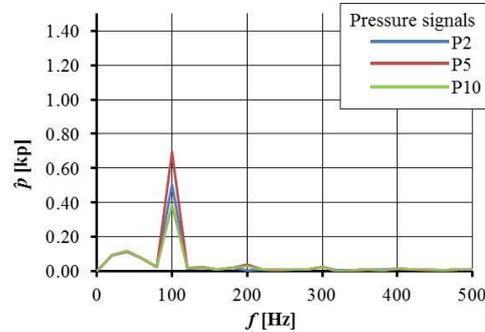
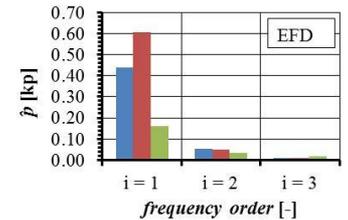
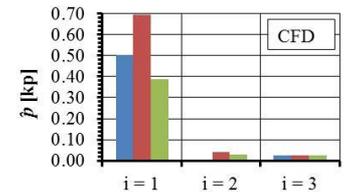
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.6435	0.0308	0.0034
p5 (CFD)	0.6413	0.0178	0.0004
P10 (CFD)	0.1297	0.0047	0.0007
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



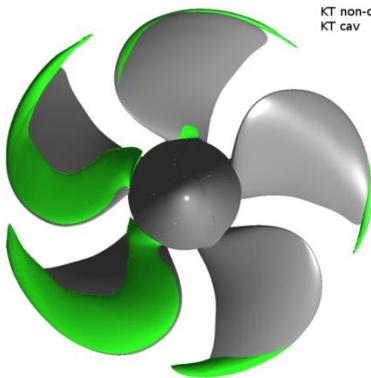
cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5020	0.0023	0.0229
p5 (CFD)	0.6949	0.0406	0.0254
P10 (CFD)	0.3874	0.0283	0.0259
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178

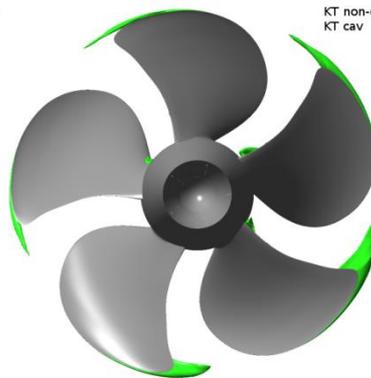


TUHH-CFX

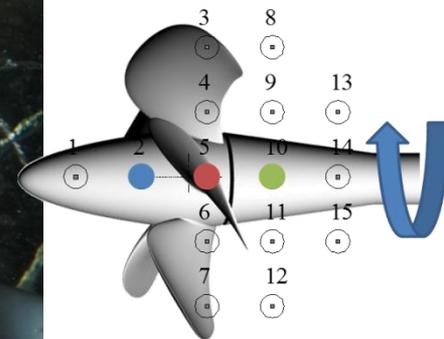
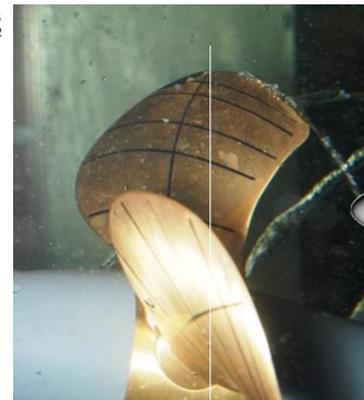


KT non-cav = 0.3946  
KT cav = 0.3862

TUHH-CFX



KT non-cav = 0.3946  
KT cav = 0.3862

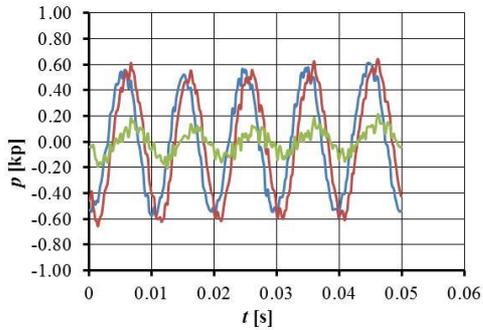


suction side

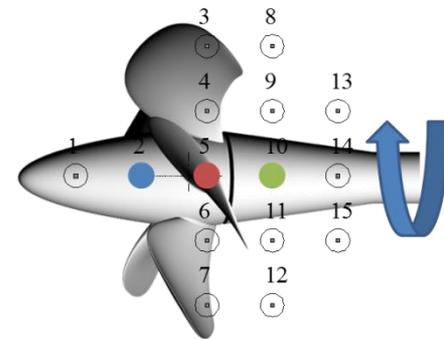
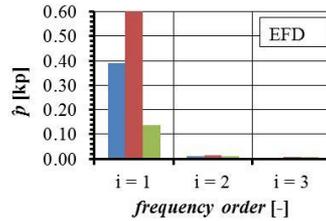
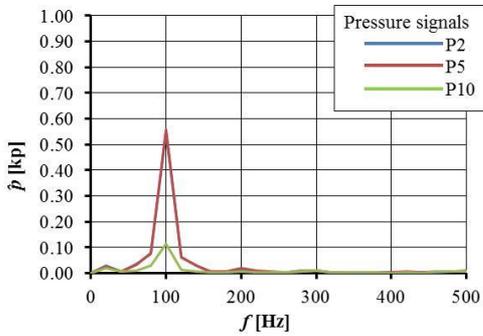
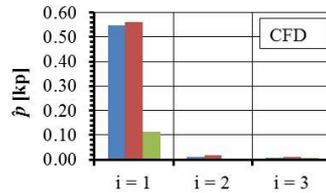
pressure side

# Case 3.1 – TUHH OpenFoam

wetted

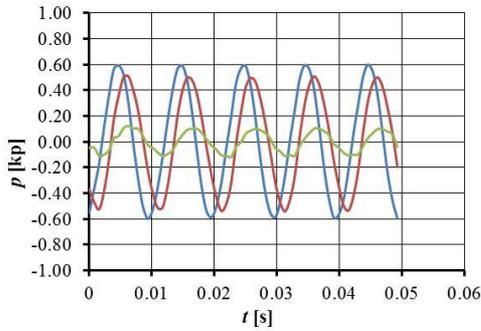


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5471	0.0126	0.0081
p5 (CFD)	0.5591	0.0193	0.0106
P10 (CFD)	0.1134	0.0047	0.0085
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076

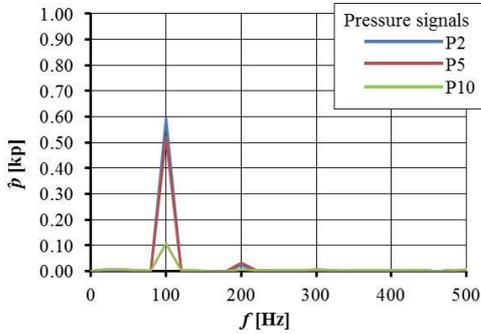
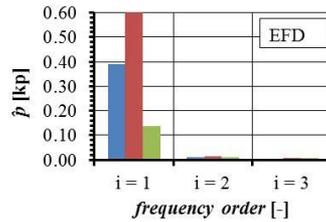
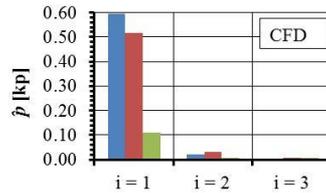


# Case 3.1 – TUHH panMare

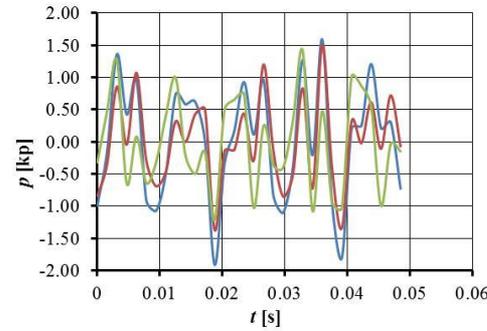
wetted



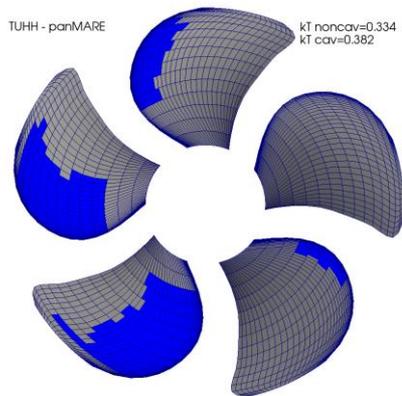
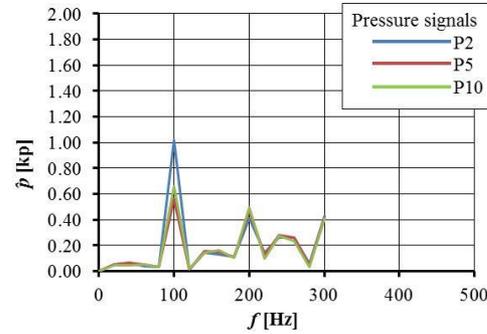
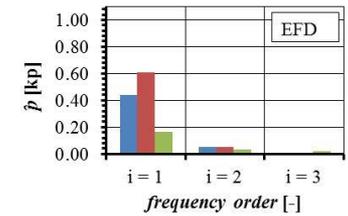
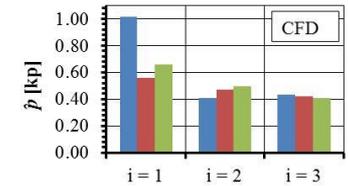
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5941	0.0222	0.0020
p5 (CFD)	0.5170	0.0310	0.0066
P10 (CFD)	0.1085	0.0065	0.0075
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



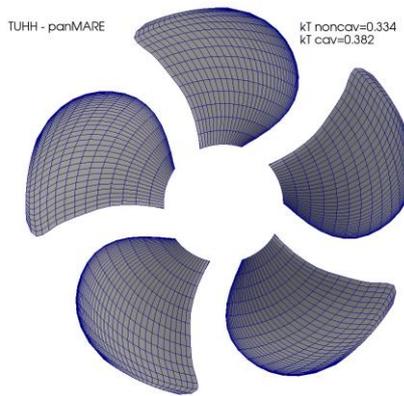
cavitating



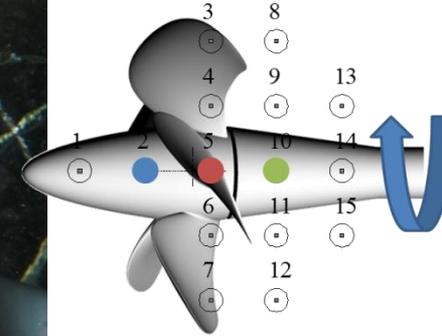
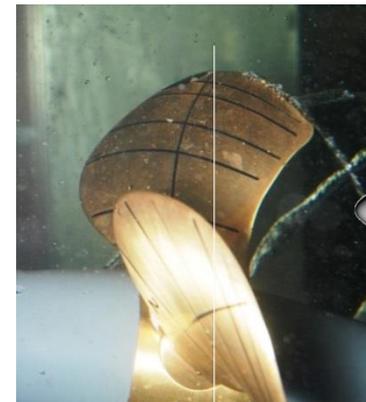
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	1.0153	0.4112	0.4322
p5 (CFD)	0.5582	0.4725	0.4190
P10 (CFD)	0.6599	0.4959	0.4102
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178



suction side

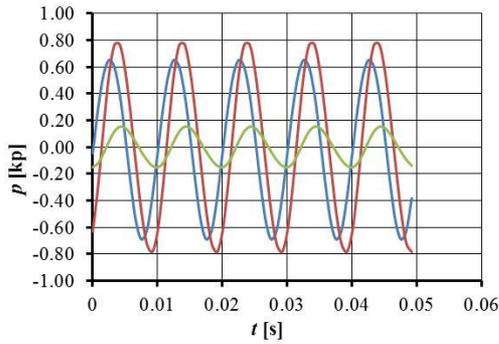


pressure side

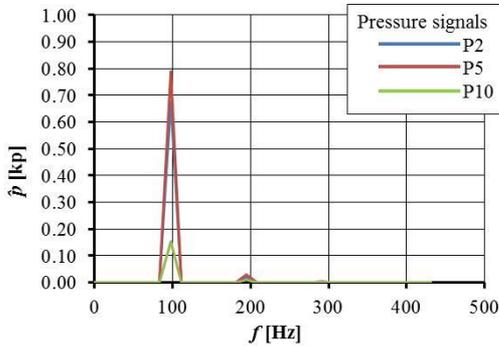
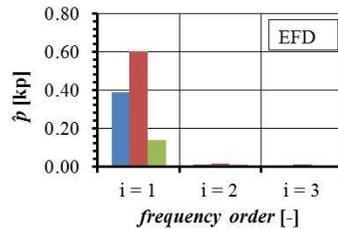
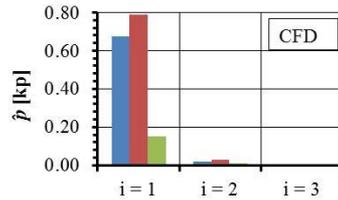


# Case 3.1 – UTAustin PROPCAV

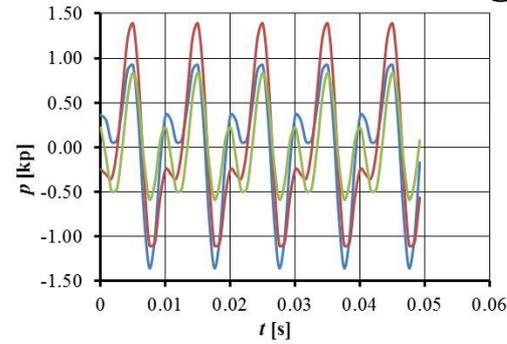
wetted



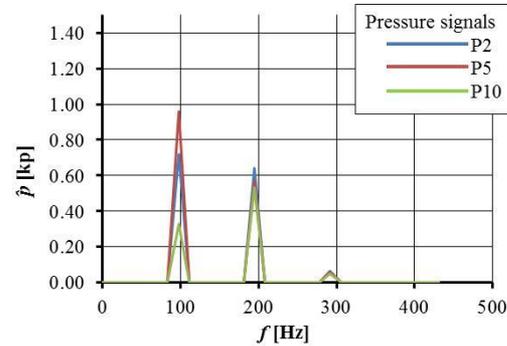
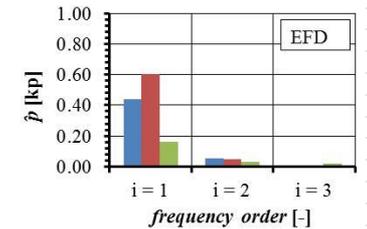
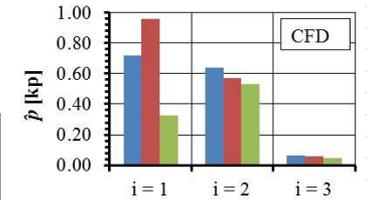
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.6737	0.0193	0.0010
p5 (CFD)	0.7901	0.0293	0.0018
P10 (CFD)	0.1519	0.0108	0.0008
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076



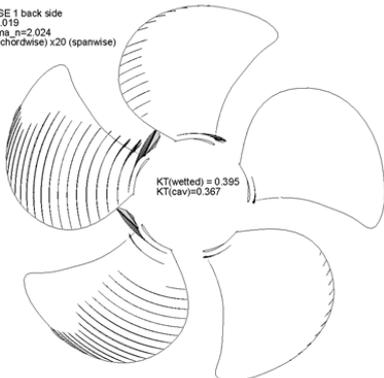
cavitating



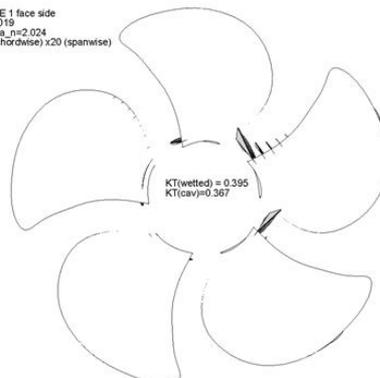
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.7195	0.6388	0.0641
p5 (CFD)	0.9578	0.5697	0.0606
P10 (CFD)	0.3280	0.5310	0.0495
p2 (EFD)	0.4372	0.0525	0.0079
p5 (EFD)	0.6053	0.0484	0.0087
P10 (EFD)	0.1611	0.0318	0.0178



CASE 1 back side  
J=1.019  
 $\sigma_n=2.024$   
60 (chordwise) x20 (spanwise)

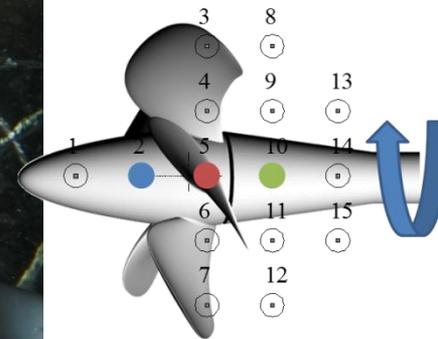
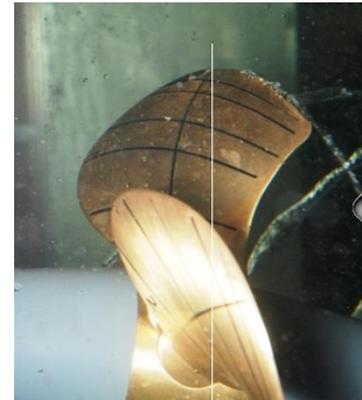


CASE 1 face side  
J=1.019  
 $\sigma_n=2.024$   
60 (chordwise) x20 (spanwise)



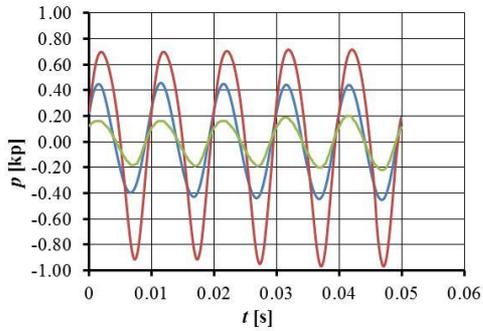
suction side

pressure side

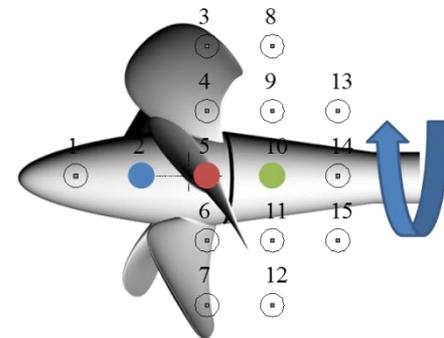
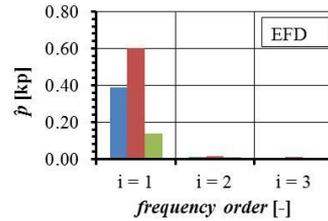
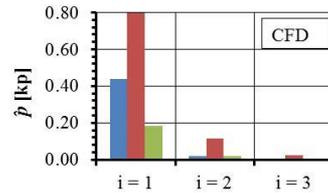
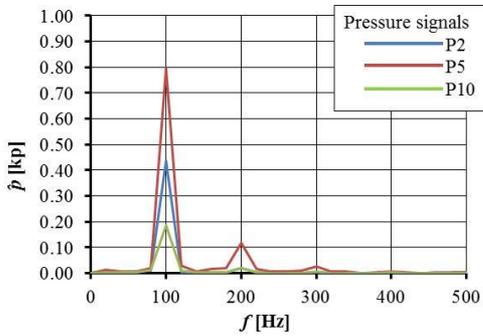


# Case 3.1 – VTT FINFLO

wetted



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4367	0.0180	0.0030
p5 (CFD)	0.7963	0.1161	0.0255
P10 (CFD)	0.1842	0.0182	0.0050
p2 (EFD)	0.3899	0.0107	0.0047
p5 (EFD)	0.6017	0.0159	0.0081
P10 (EFD)	0.1373	0.0113	0.0076

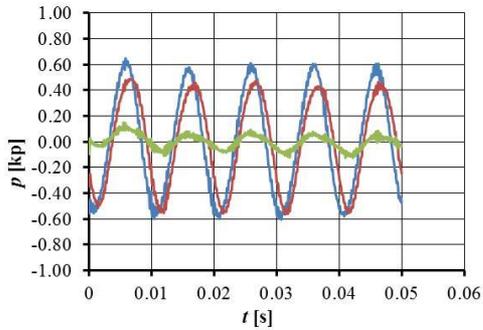


## Case 3.2

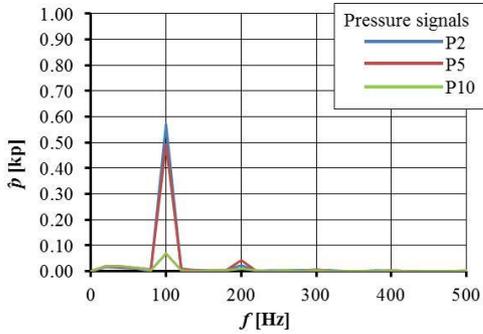
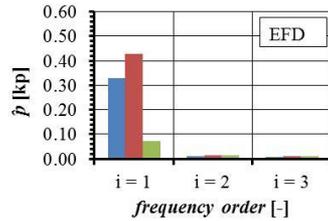
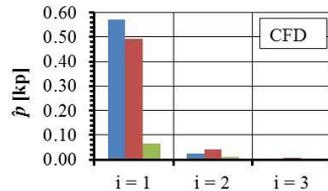
Group	Solver	Acronym	Cavitation	N / turn
Cradle	SCTetra	Cradle-SCTetra	wetted	512
Cradle	SCTetra	Cradle-SCTetra	with	1024
SSPA	FLUENT	SSPA-FLUENT	wetted	256
SSPA	FLUENT	SSPA-FLUENT	with	256
SSPA	FLUENT	SSPA-FLUENT	with	256
TUHH	CFX	TUHH-CFX	wetted	256
TUHH	CFX	TUHH-CFX	with	256
TUHH	OpenFOAM	TUHH-OpenFOAM	wetted	256
TUHH	panMARE	TUHH-panMARE	wetted	64
TUHH	panMARE	TUHH-panMARE	with	16
UTAustin	PROPCAV	UTAustin-PROPCAV	wetted	60

# Case 3.2 – Cradle SCTetra

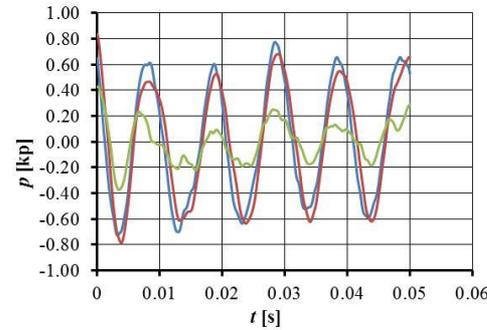
wetted



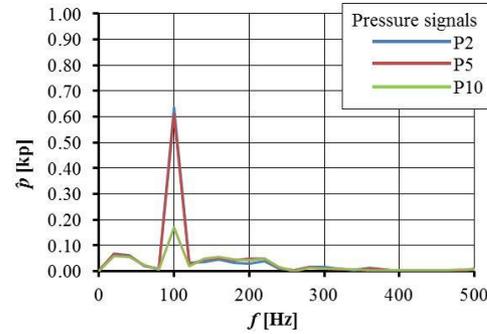
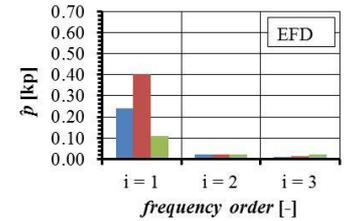
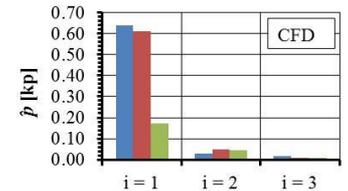
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5701	0.0236	0.0031
p5 (CFD)	0.4918	0.0432	0.0062
P10 (CFD)	0.0672	0.0105	0.0017
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104



cavitating

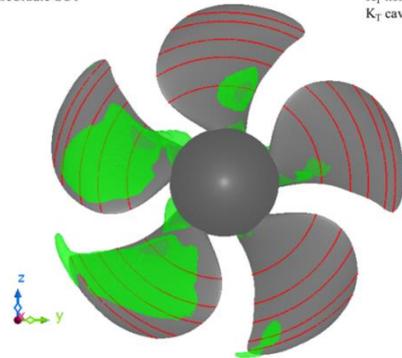


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.6369	0.0280	0.0153
p5 (CFD)	0.6105	0.0499	0.0107
P10 (CFD)	0.1707	0.0435	0.0098
p2 (EFD)	0.2387	0.0206	0.0091
p5 (EFD)	0.4017	0.0196	0.0130
P10 (EFD)	0.1096	0.0227	0.0207



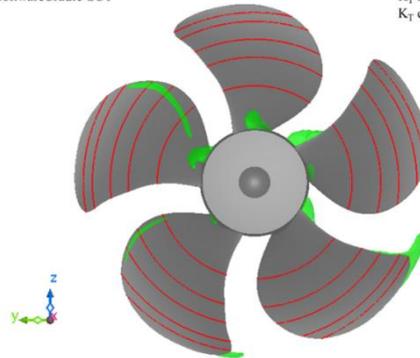
SoftwareCradle-SCT

$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212

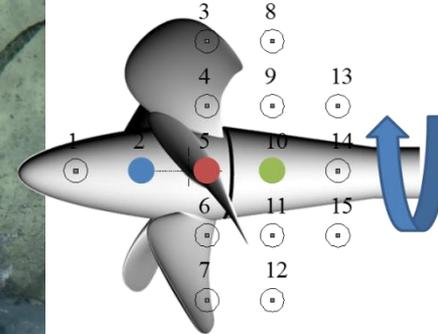


suction side

$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212



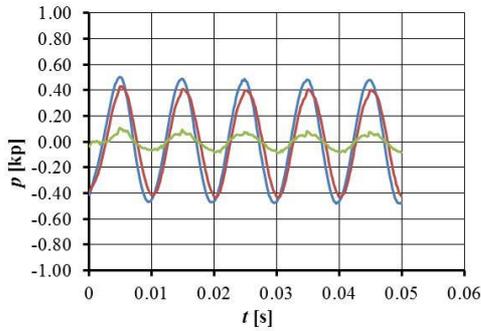
pressure side



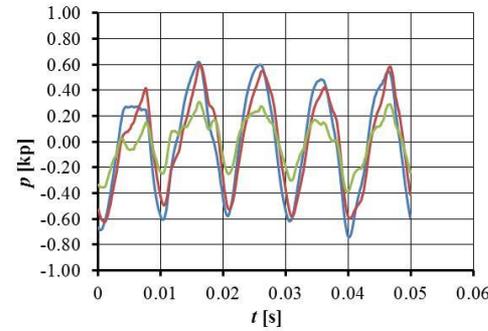
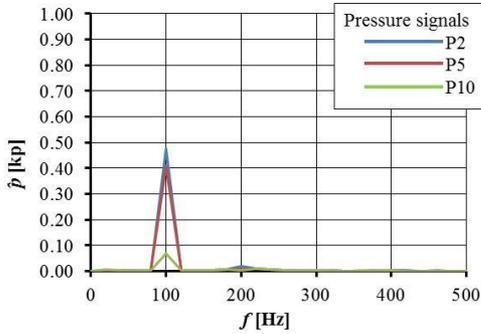
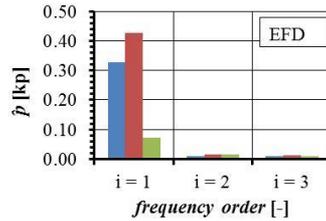
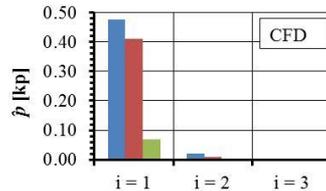
# Case 3.2 – SSPA Fluent (Sauer)

wetted

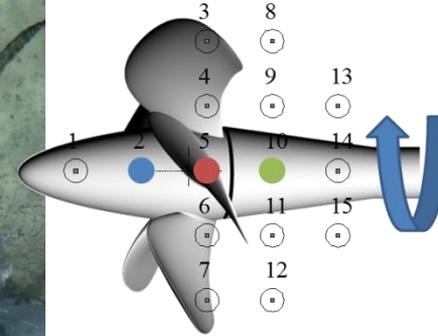
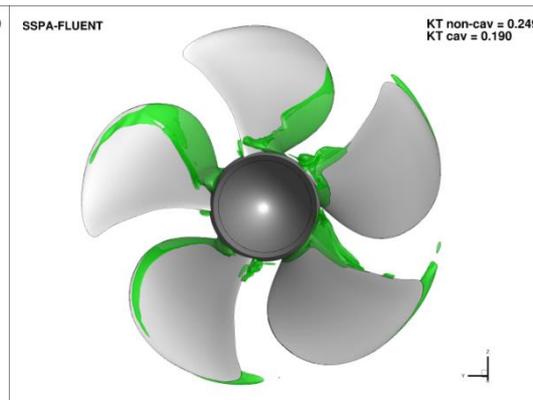
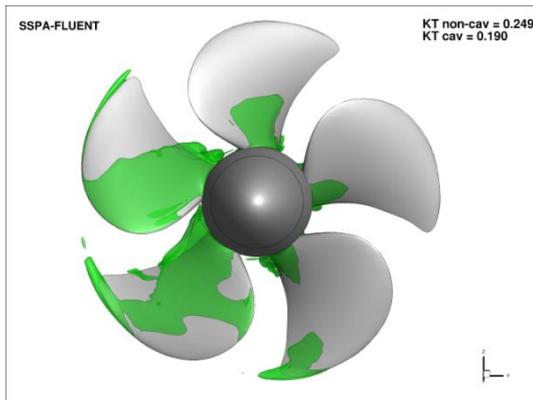
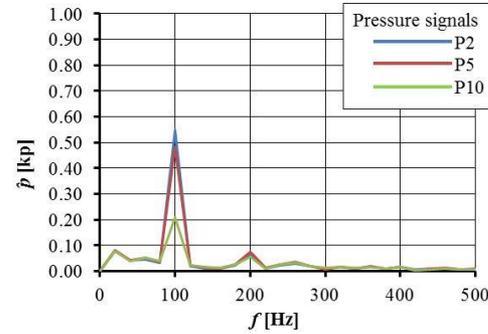
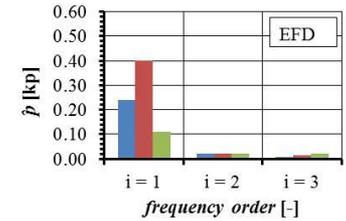
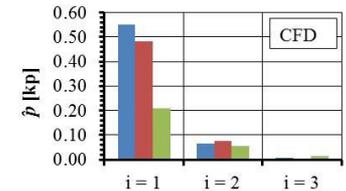
cavitating



Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.4770	0.0205	0.0015
p5 (CFD)	0.4090	0.0097	0.0013
P10 (CFD)	0.0691	0.0031	0.0015
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104



Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.5488	0.0651	0.0092
p5 (CFD)	0.4814	0.0750	0.0050
P10 (CFD)	0.2079	0.0566	0.0132
p2 (EFD)	0.2387	0.0206	0.0091
p5 (EFD)	0.4017	0.0196	0.0130
P10 (EFD)	0.1096	0.0227	0.0207

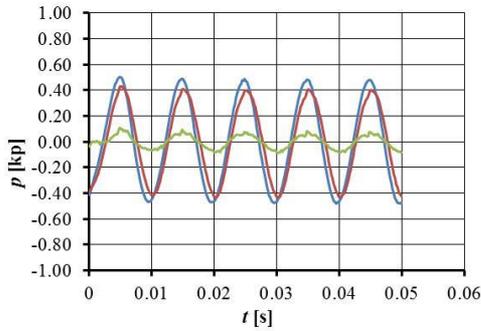


suction side

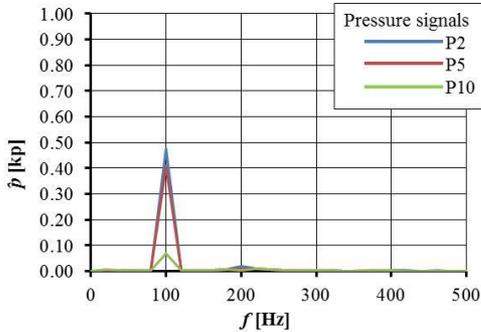
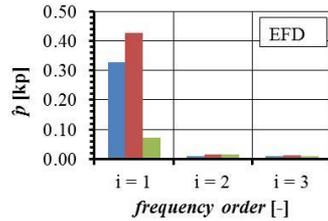
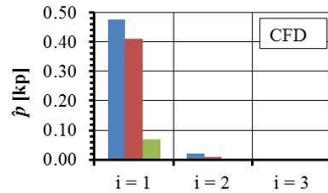
pressure side

# Case 3.2 – SSPA Fluent (Zwart)

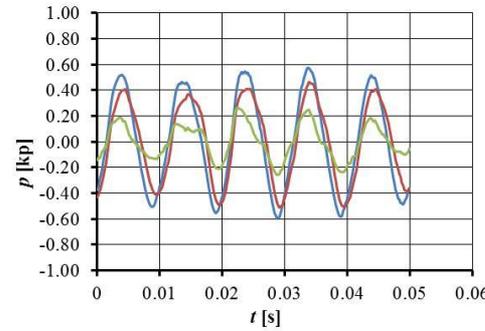
wetted



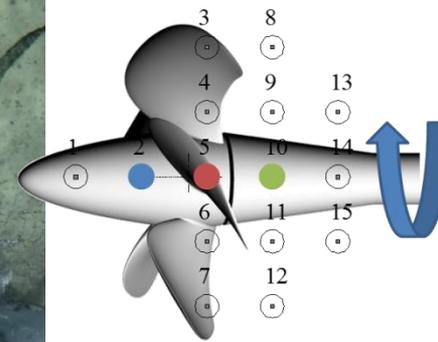
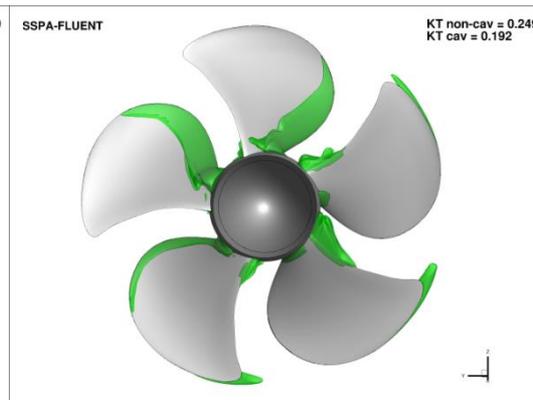
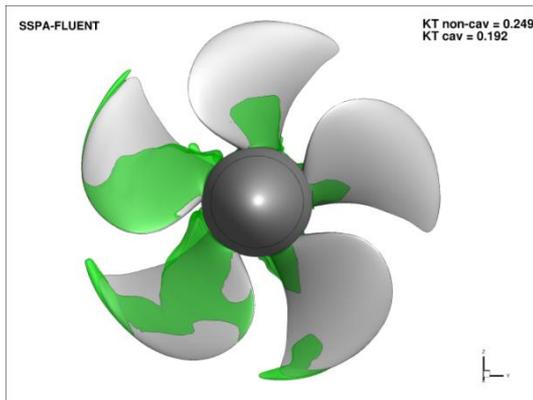
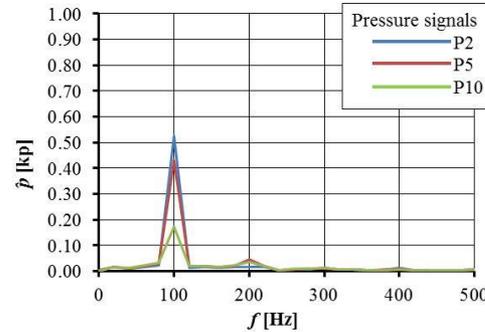
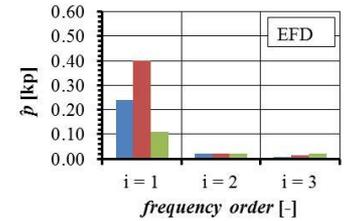
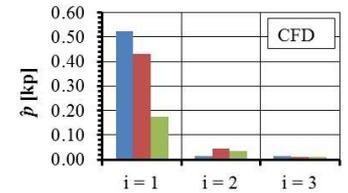
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4770	0.0205	0.0015
p5 (CFD)	0.4090	0.0097	0.0013
P10 (CFD)	0.0691	0.0031	0.0015
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5237	0.0155	0.0138
p5 (CFD)	0.4315	0.0468	0.0100
P10 (CFD)	0.1732	0.0343	0.0124
p2 (EFD)	0.2387	0.0206	0.0091
p5 (EFD)	0.4017	0.0196	0.0130
P10 (EFD)	0.1096	0.0227	0.0207



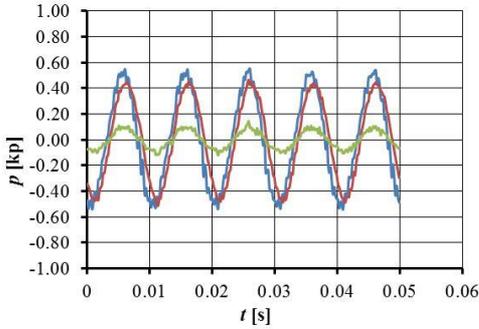
suction side

pressure side

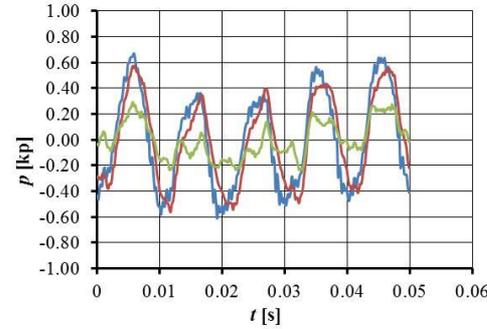
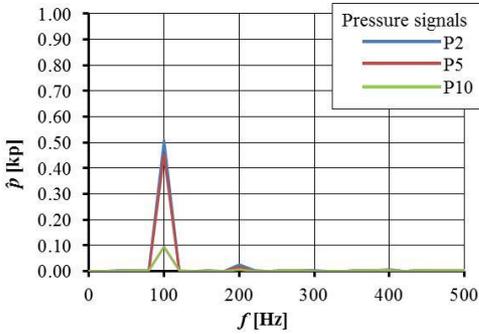
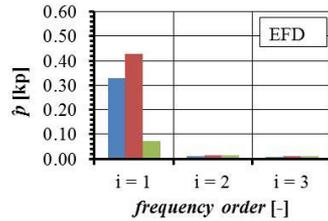
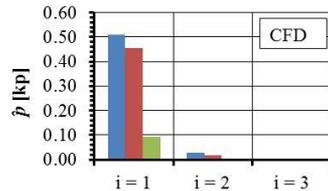
# Case 3.2 – TUHH CFX

wetted

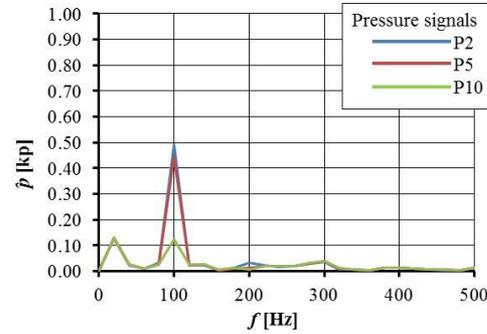
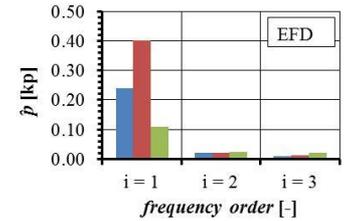
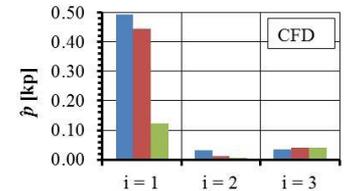
cavitating



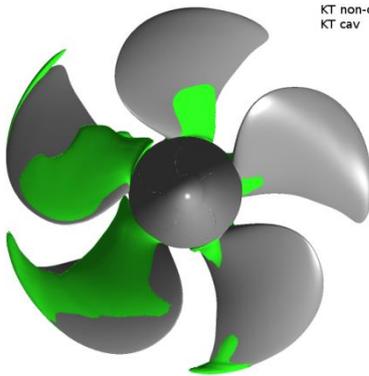
Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.5086	0.0266	0.0036
p5 (CFD)	0.4535	0.0167	0.0005
P10 (CFD)	0.0928	0.0048	0.0006
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104



Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.4925	0.0309	0.0361
p5 (CFD)	0.4445	0.0119	0.0403
P10 (CFD)	0.1229	0.0074	0.0399
p2 (EFD)	0.2387	0.0206	0.0091
p5 (EFD)	0.4017	0.0196	0.0130
P10 (EFD)	0.1096	0.0227	0.0207

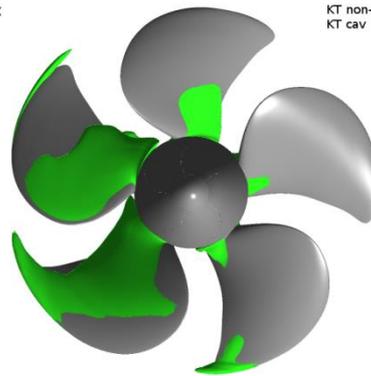


TUHH-CFX

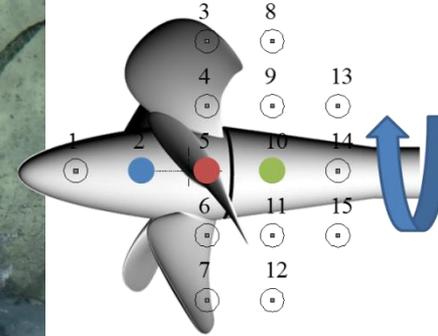


KT non-cav = 0.2584  
KT cav = 0.2045

TUHH-CFX



KT non-cav = 0.2584  
KT cav = 0.2045



suction side

pressure side

PPTC

$J = 1.269, \sigma_n = 1.424$

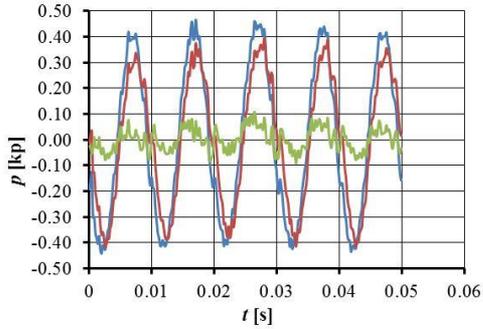
smp'15



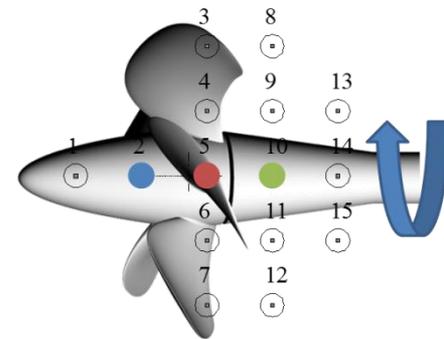
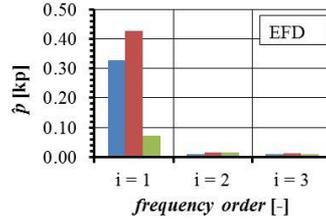
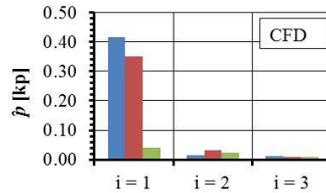
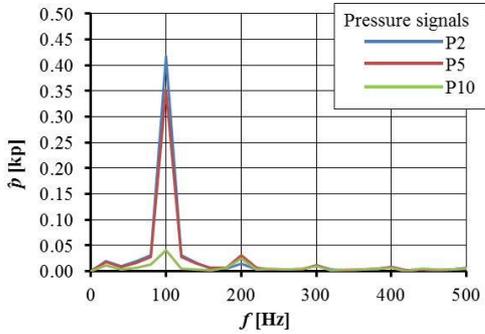
25

# Case 3.2 – TUHH OpenFoam

wetted

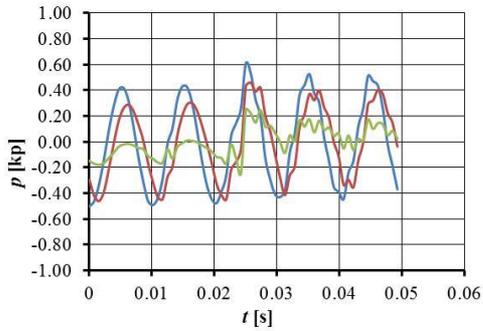


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4168	0.0152	0.0118
p5 (CFD)	0.3517	0.0315	0.0105
P10 (CFD)	0.0408	0.0239	0.0098
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104

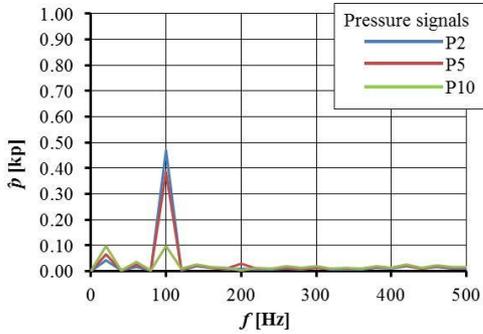
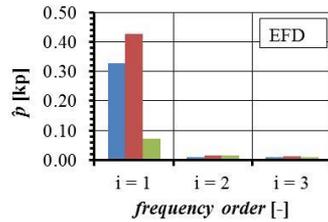
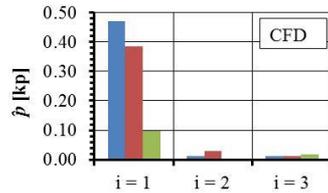


# Case 3.2 – TUHH panMare

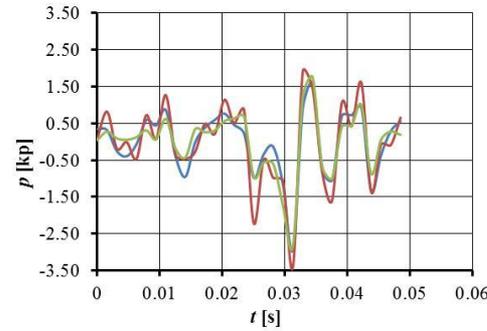
wetted



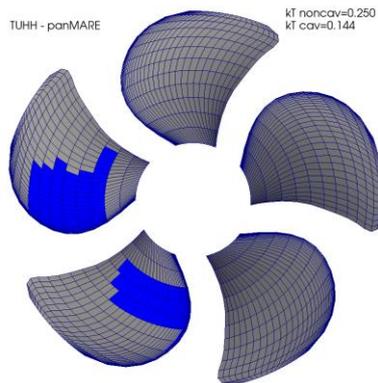
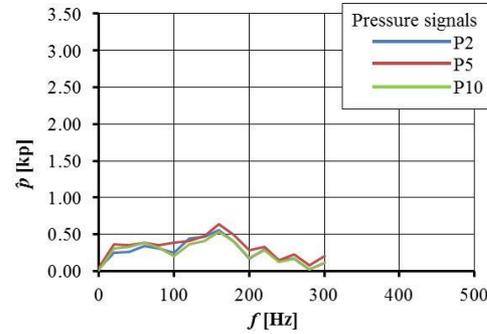
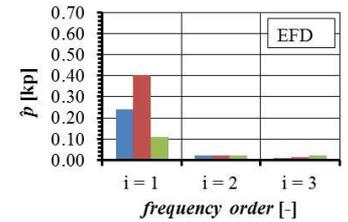
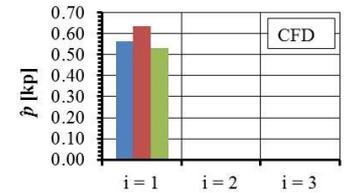
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4699	0.0109	0.0120
p5 (CFD)	0.3841	0.0285	0.0121
P10 (CFD)	0.0985	0.0044	0.0183
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104



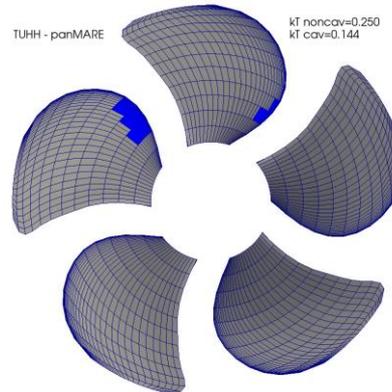
cavitating



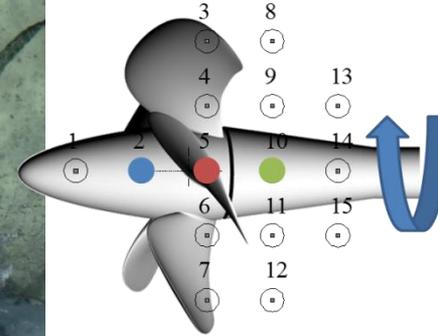
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5619	0.0000	0.0000
p5 (CFD)	0.6338	0.0000	0.0000
P10 (CFD)	0.5303	0.0000	0.0000
p2 (EFD)	0.2387	0.0206	0.0091
p5 (EFD)	0.4017	0.0196	0.0130
P10 (EFD)	0.1096	0.0227	0.0207



suction side

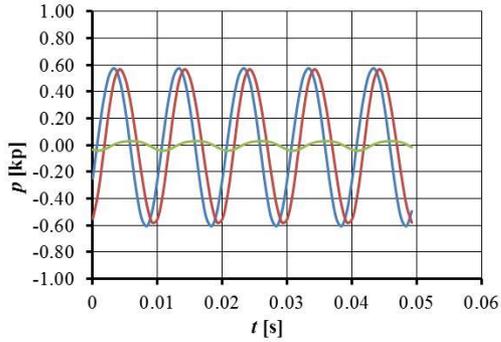


pressure side

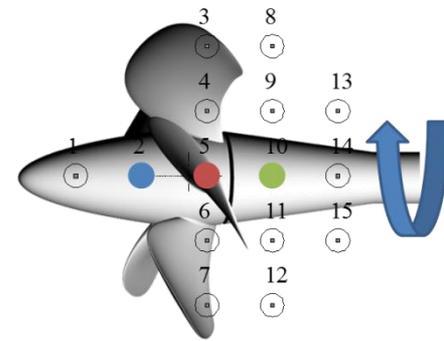
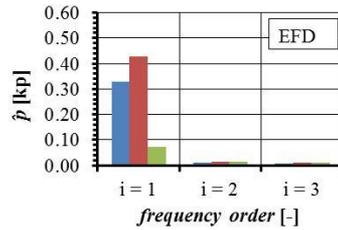
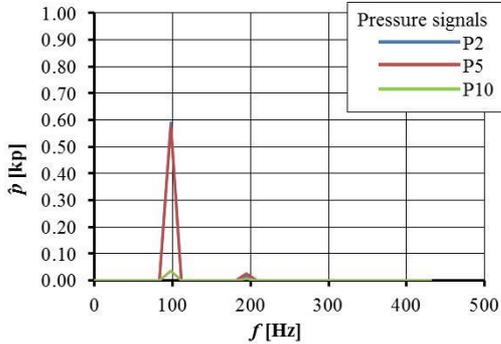
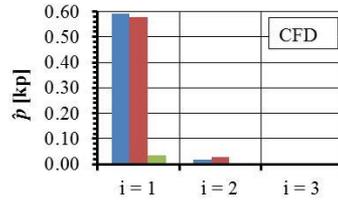


# Case 3.2 – UTAustin PROPCAV

wetted



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5919	0.0162	0.0009
p5 (CFD)	0.5770	0.0266	0.0012
P10 (CFD)	0.0362	0.0058	0.0006
p2 (EFD)	0.3277	0.0103	0.0080
p5 (EFD)	0.4266	0.0152	0.0108
P10 (EFD)	0.0711	0.0142	0.0104

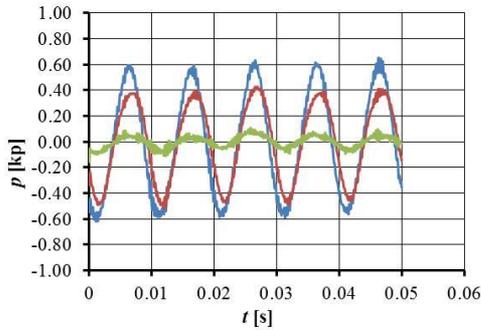


# Case 3.3

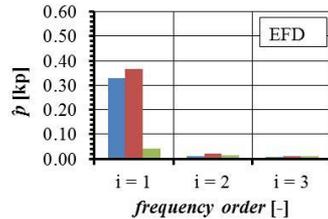
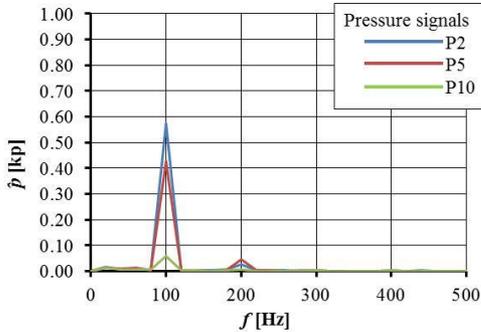
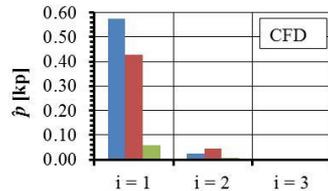
Group	Solver	Acronym	Cavitation	N / turn
Cradle	SCTetra	Cradle-SCTetra	wetted	512
Cradle	SCTetra	Cradle-SCTetra	with	1024
SSPA	FLUENT	SSPA-FLUENT	wetted	256
SSPA	FLUENT	SSPA-FLUENT	with	256
SSPA	FLUENT	SSPA-FLUENT	with	256
TUHH	CFX	TUHH-CFX	wetted	256
TUHH	CFX	TUHH-CFX	with	256
TUHH	OpenFOAM	TUHH-OpenFOAM	wetted	256
TUHH	panMARE	TUHH-panMARE	wetted	64
TUHH	panMARE	TUHH-panMARE	with	16
UTAustin	PROPCAV	UTAustin-PROPCAV	wetted	60

# Case 3.3 – Cradle SCTetra

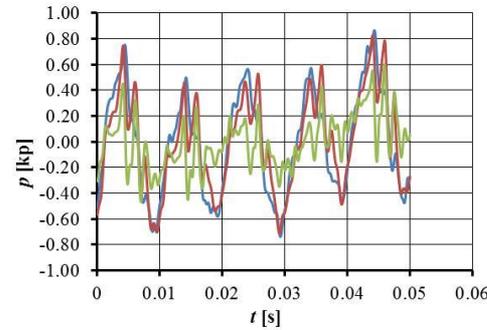
wetted



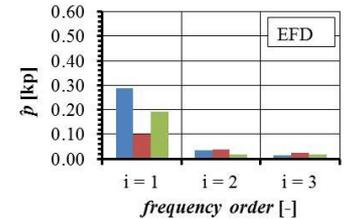
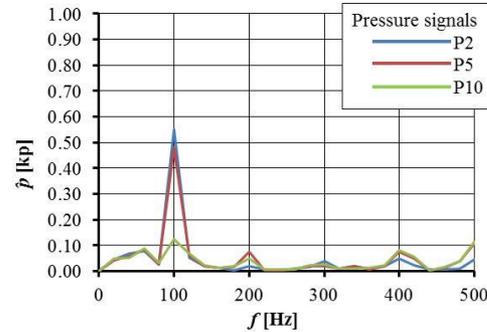
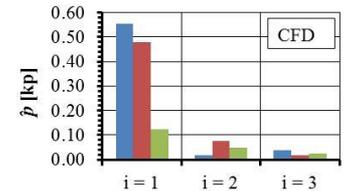
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5727	0.0256	0.0024
p5 (CFD)	0.4275	0.0457	0.0042
P10 (CFD)	0.0580	0.0078	0.0040
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5527	0.0194	0.0380
p5 (CFD)	0.4779	0.0758	0.0194
P10 (CFD)	0.1222	0.0497	0.0258
p2 (EFD)	0.2872	0.0355	0.0128
p5 (EFD)	0.1014	0.0395	0.0238
P10 (EFD)	0.1904	0.0183	0.0162

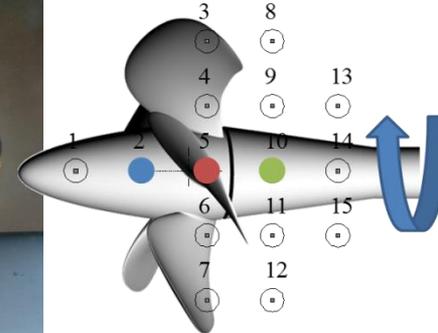
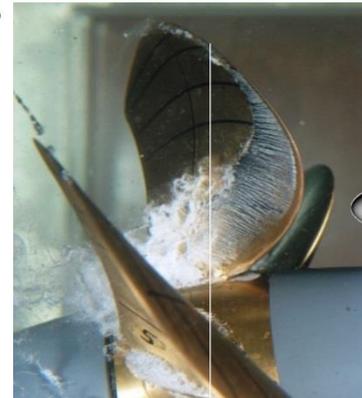
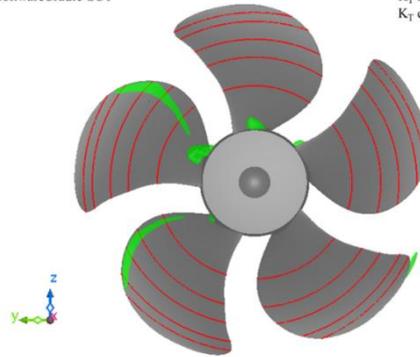
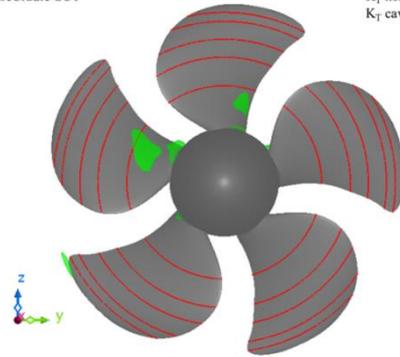


SoftwareCradle-SCT

$K_T$  non-cav = 0.200  
 $K_T$  cav = 0.146

SoftwareCradle-SCT

$K_T$  non-cav = 0.200  
 $K_T$  cav = 0.146

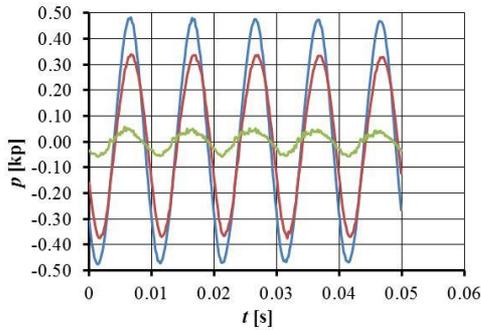


suction side

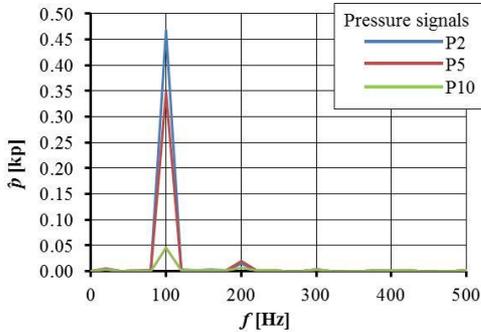
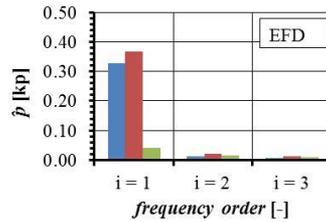
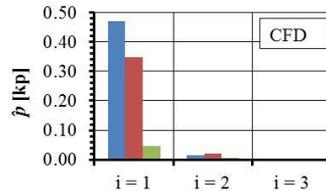
pressure side

# Case 3.3 – SSPA Fluent (Sauer)

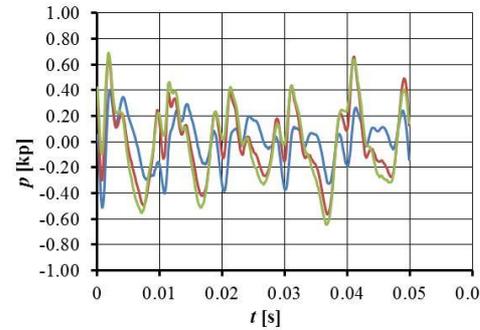
wetted



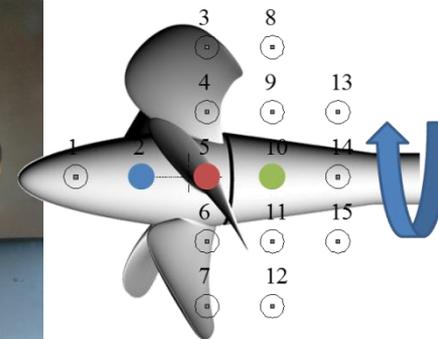
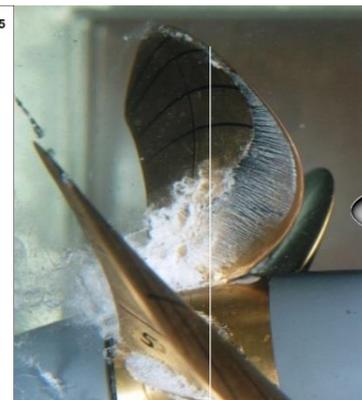
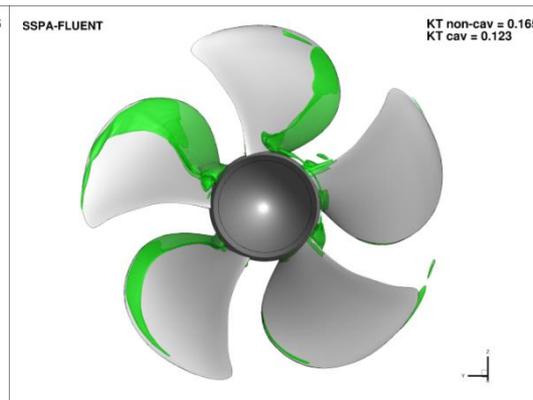
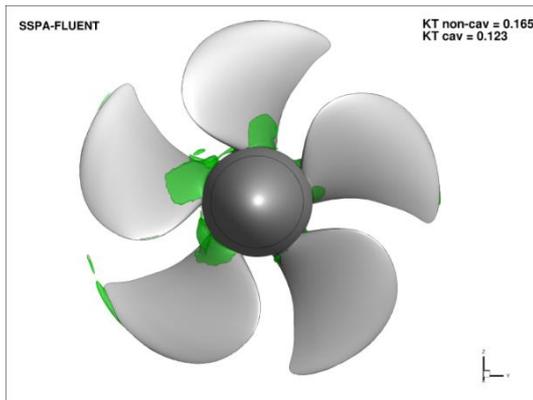
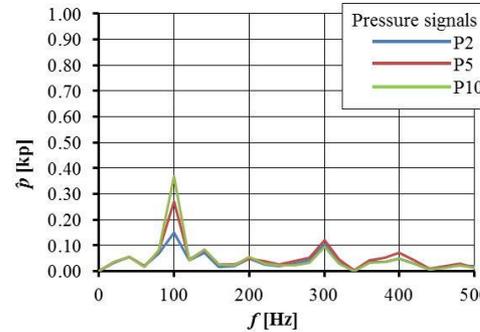
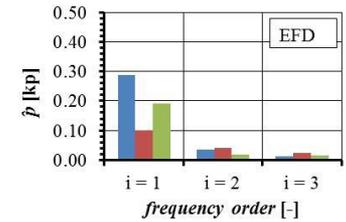
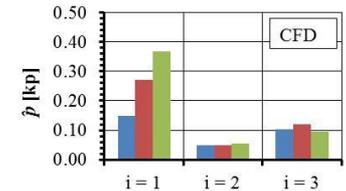
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4686	0.0142	0.0032
p5 (CFD)	0.3478	0.0197	0.0037
P10 (CFD)	0.0463	0.0058	0.0026
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.1492	0.0500	0.1031
p5 (CFD)	0.2719	0.0488	0.1213
P10 (CFD)	0.3690	0.0541	0.0941
p2 (EFD)	0.2872	0.0355	0.0128
p5 (EFD)	0.1014	0.0395	0.0238
P10 (EFD)	0.1904	0.0183	0.0162

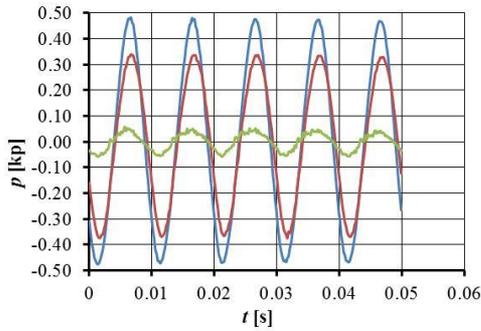


suction side

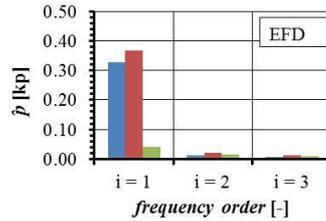
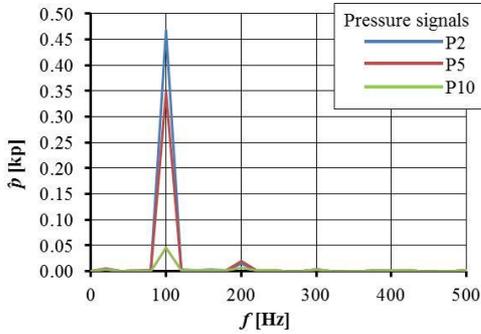
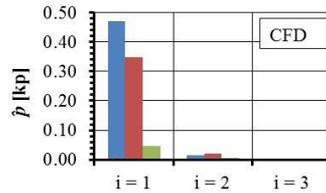
pressure side

# Case 3.3 – SSPA Fluent (Zwart)

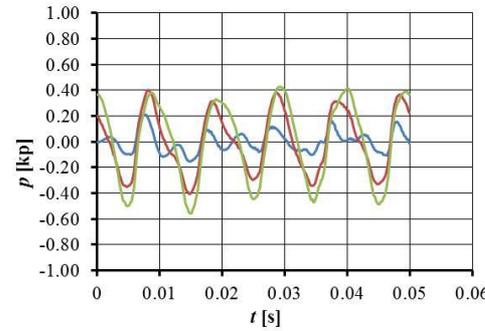
wetted



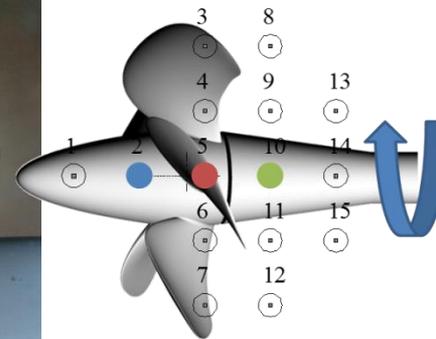
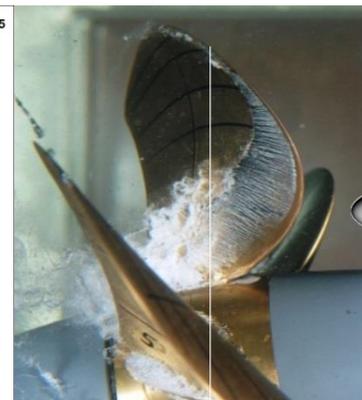
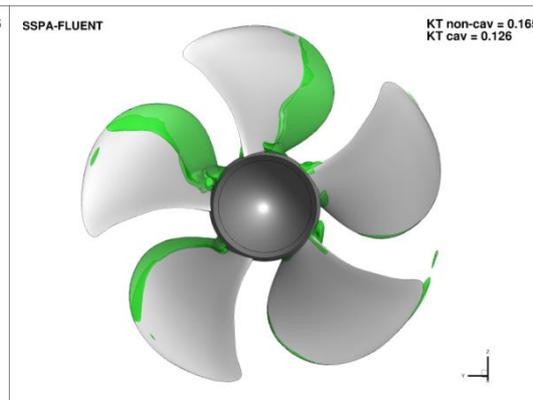
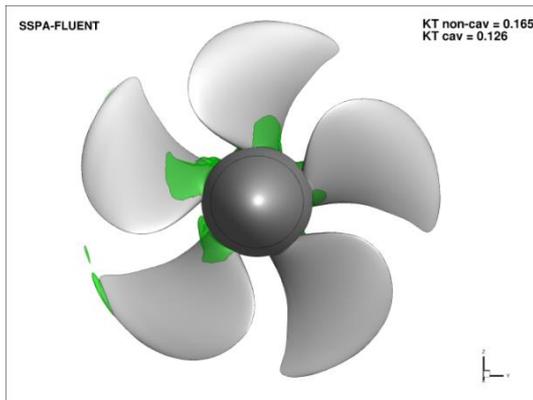
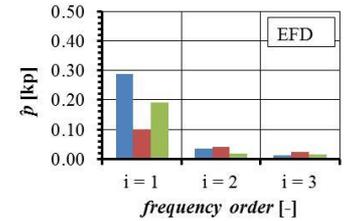
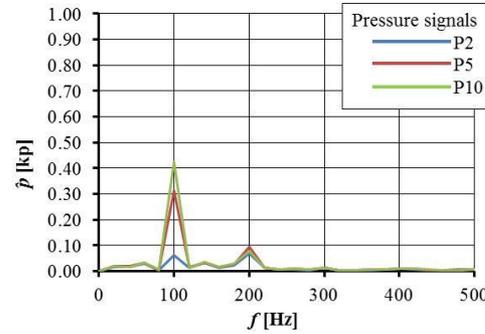
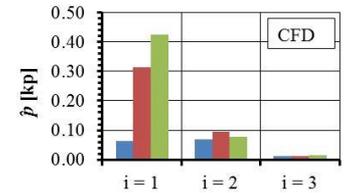
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4686	0.0142	0.0032
p5 (CFD)	0.3478	0.0197	0.0037
P10 (CFD)	0.0463	0.0058	0.0026
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



cavitating



Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.0620	0.0689	0.0122
p5 (CFD)	0.3128	0.0937	0.0120
P10 (CFD)	0.4232	0.0765	0.0141
p2 (EFD)	0.2872	0.0355	0.0128
p5 (EFD)	0.1014	0.0395	0.0238
P10 (EFD)	0.1904	0.0183	0.0162



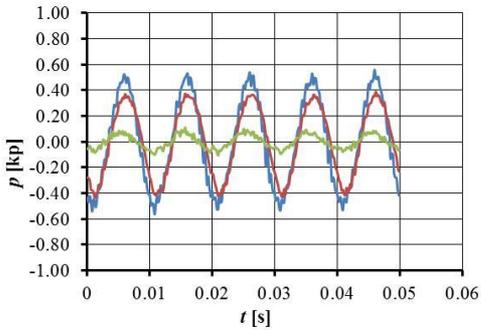
suction side

pressure side

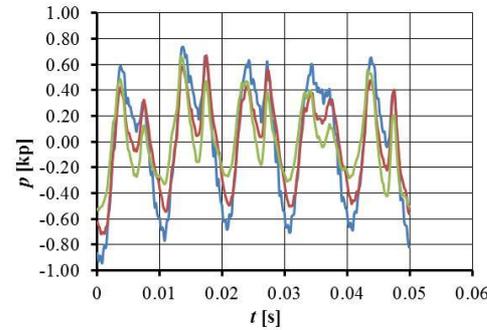
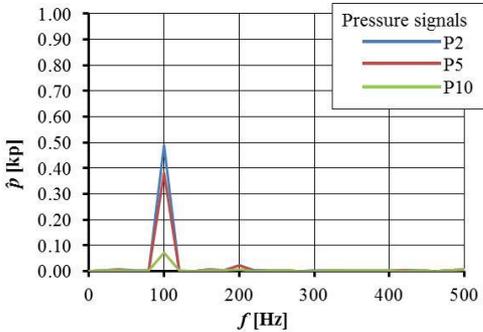
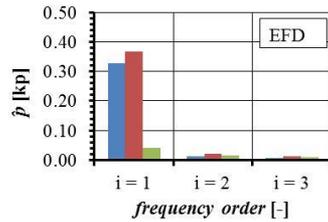
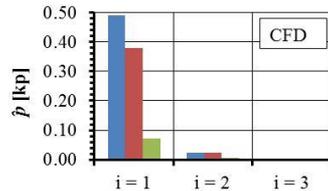
# Case 3.3 – TUHH CFX

wetted

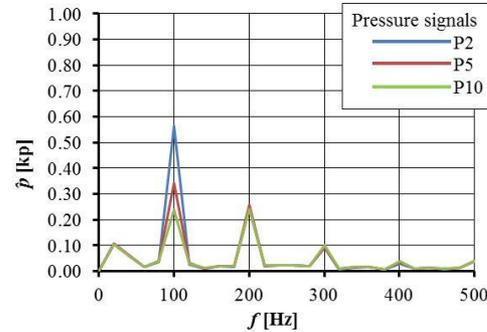
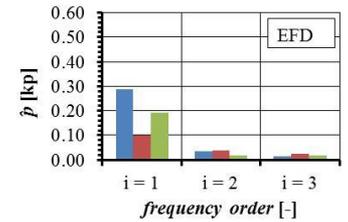
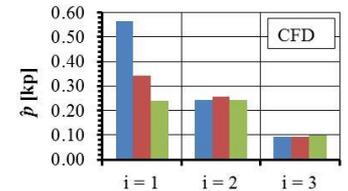
cavitating



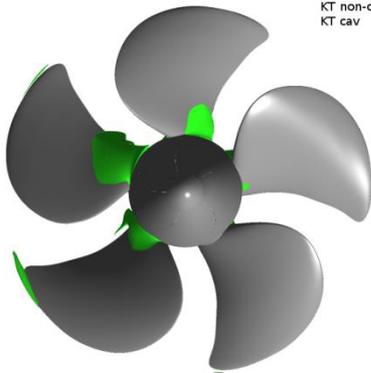
Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.4894	0.0230	0.0035
p5 (CFD)	0.3802	0.0227	0.0006
P10 (CFD)	0.0705	0.0065	0.0003
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



Sensor	i = 1	i = 2	i = 3
p2 (CFD)	0.5653	0.2435	0.0914
p5 (CFD)	0.3419	0.2576	0.0939
P10 (CFD)	0.2392	0.2422	0.1004
p2 (EFD)	0.2872	0.0355	0.0128
p5 (EFD)	0.1014	0.0395	0.0238
P10 (EFD)	0.1904	0.0183	0.0162

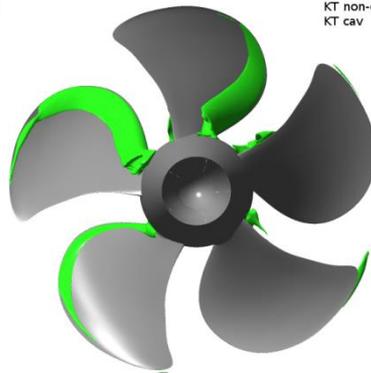


TUHH-CFX

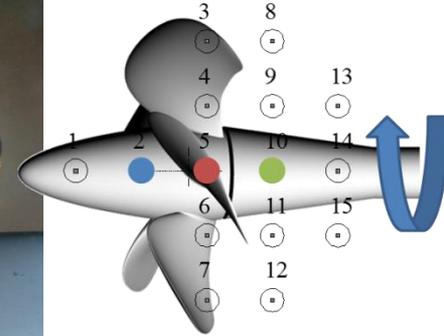
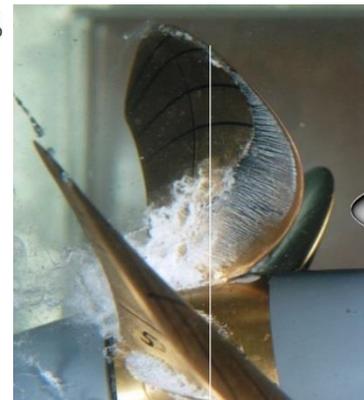


KT non-cav = 0.1847  
KT cav = 0.1470

TUHH-CFX



KT non-cav = 0.1847  
KT cav = 0.1470



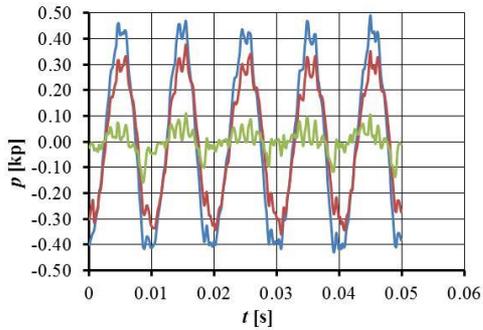
suction side

pressure side

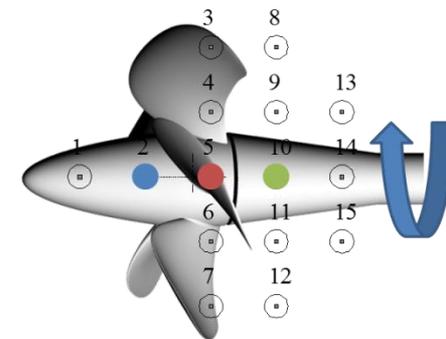
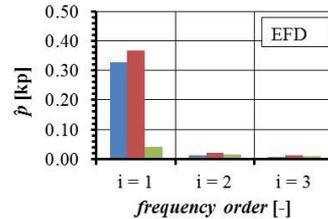
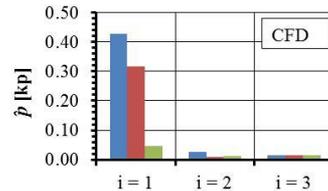
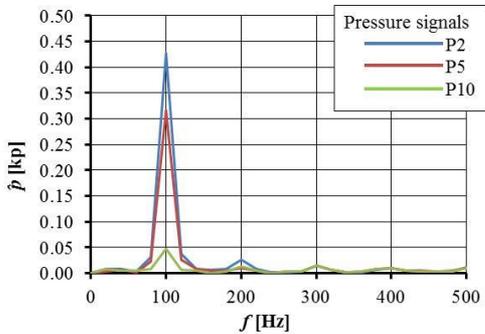
# Case 3.3 – TUHH OpenFoam

wetted

cavitating

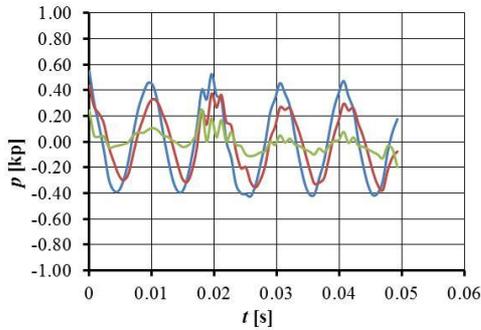


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4281	0.0267	0.0141
p5 (CFD)	0.3169	0.0101	0.0144
P10 (CFD)	0.0470	0.0125	0.0139
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093

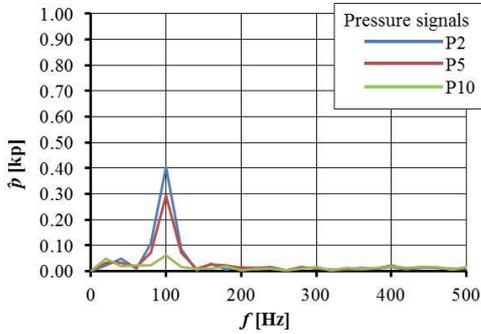
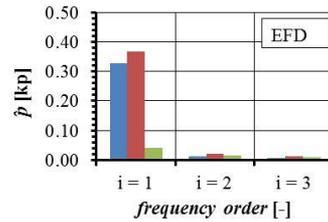
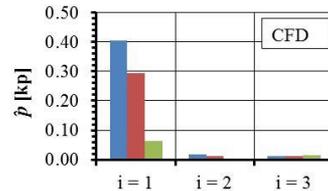


# Case 3.3 – TUHH panMare

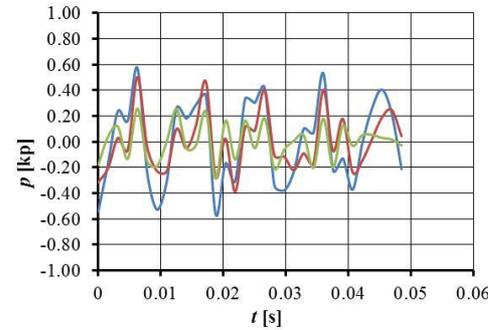
wetted



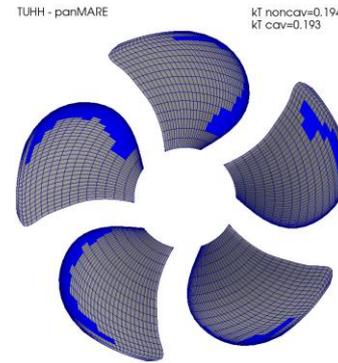
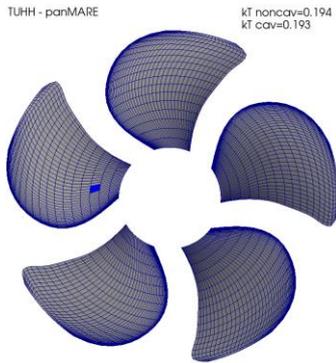
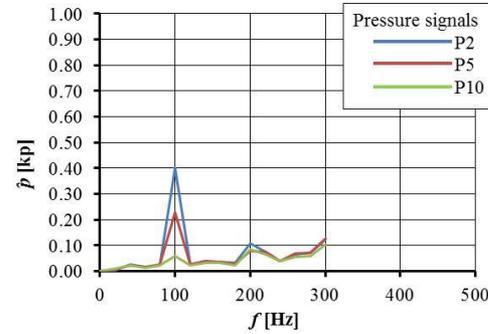
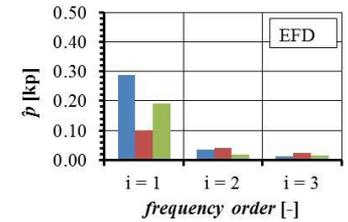
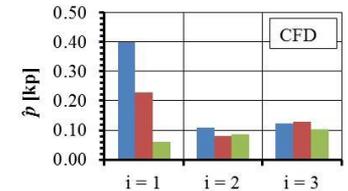
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4050	0.0177	0.0118
p5 (CFD)	0.2946	0.0122	0.0109
P10 (CFD)	0.0630	0.0046	0.0155
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



cavitating

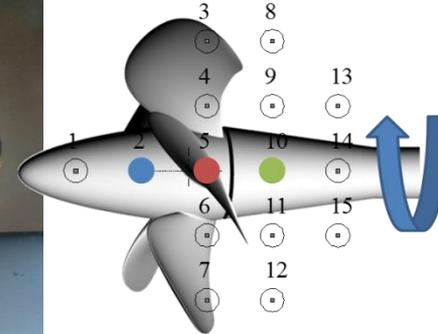
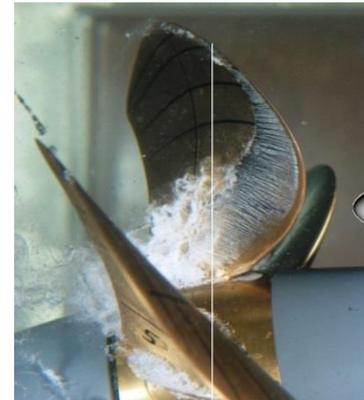


Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.4002	0.1084	0.1224
p5 (CFD)	0.2290	0.0792	0.1273
P10 (CFD)	0.0596	0.0856	0.1033
p2 (EFD)	0.2872	0.0355	0.0128
p5 (EFD)	0.1014	0.0395	0.0238
P10 (EFD)	0.1904	0.0183	0.0162



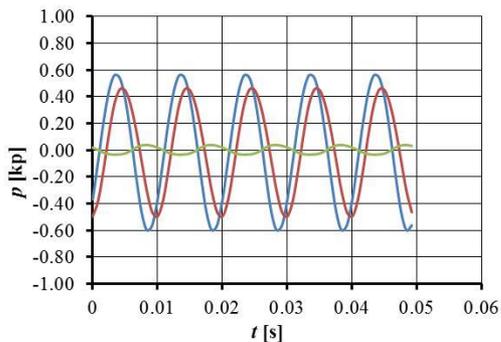
suction side

pressure side

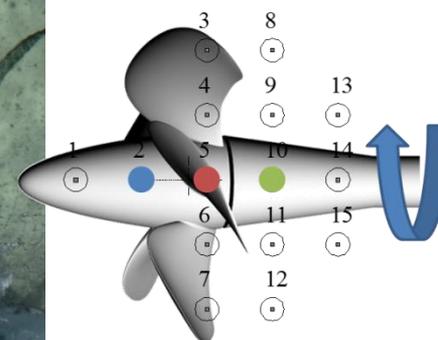
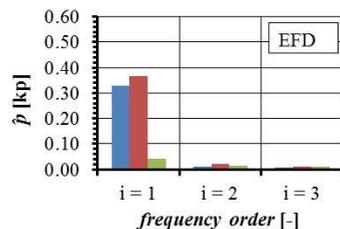
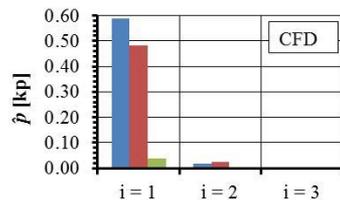
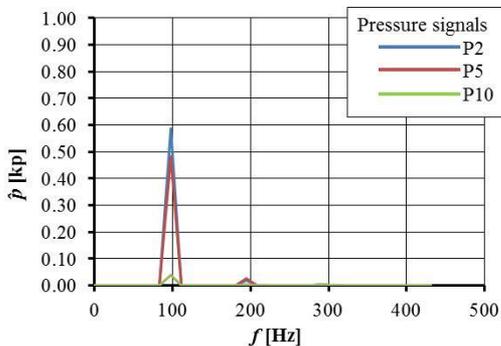


# Case 3.3 – UTAustin PROPCAV

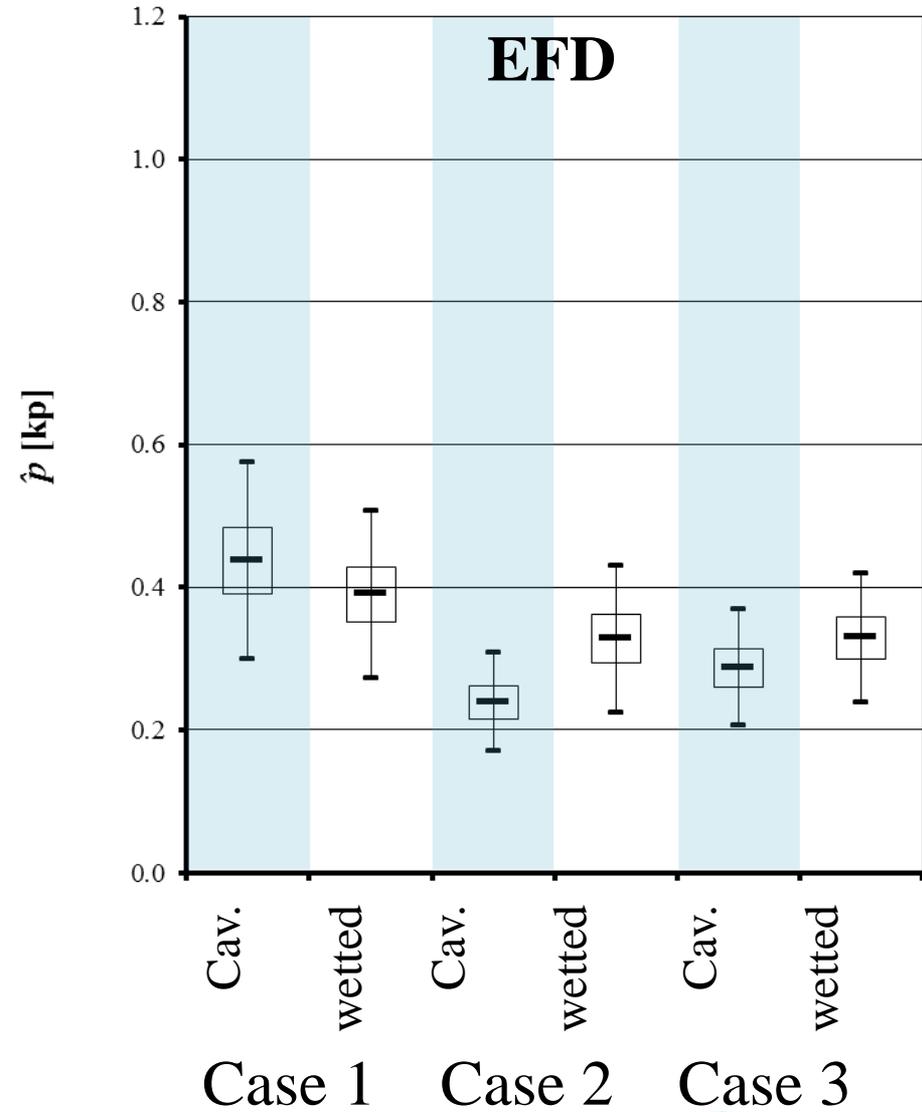
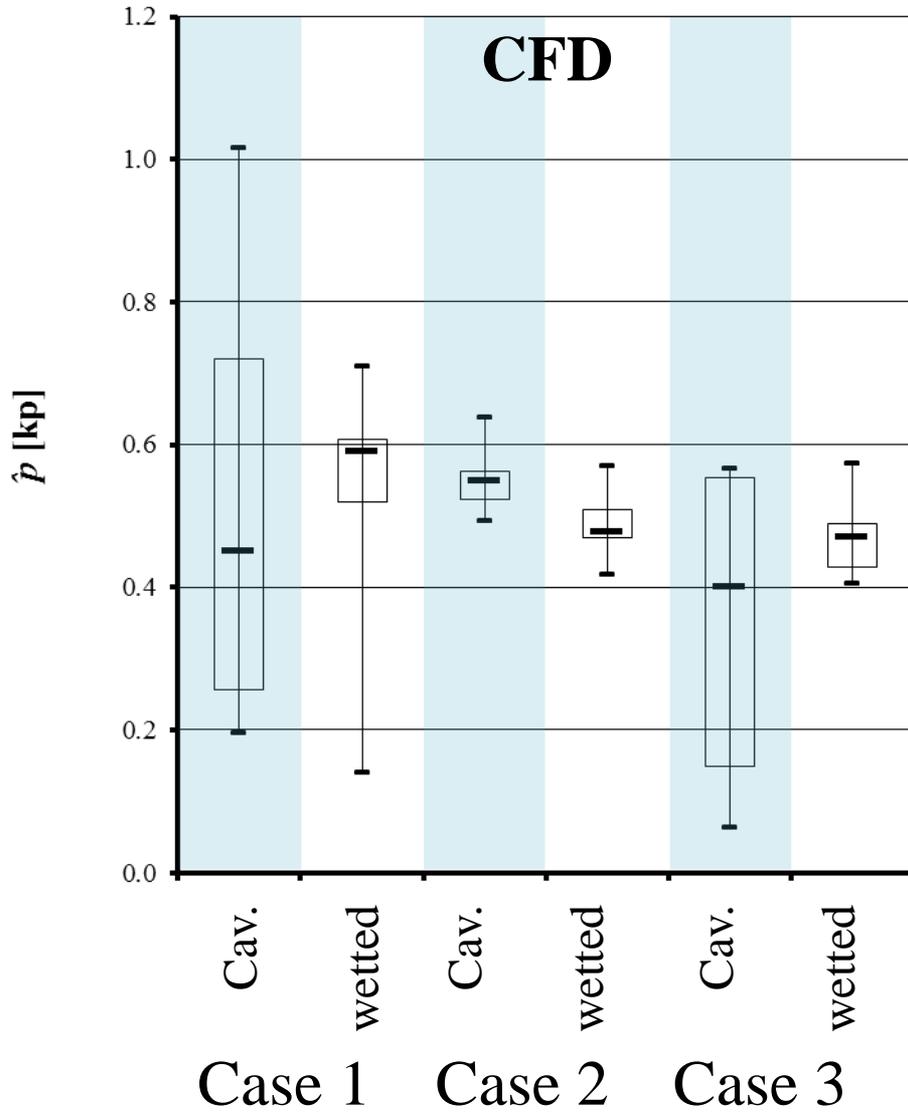
wetted



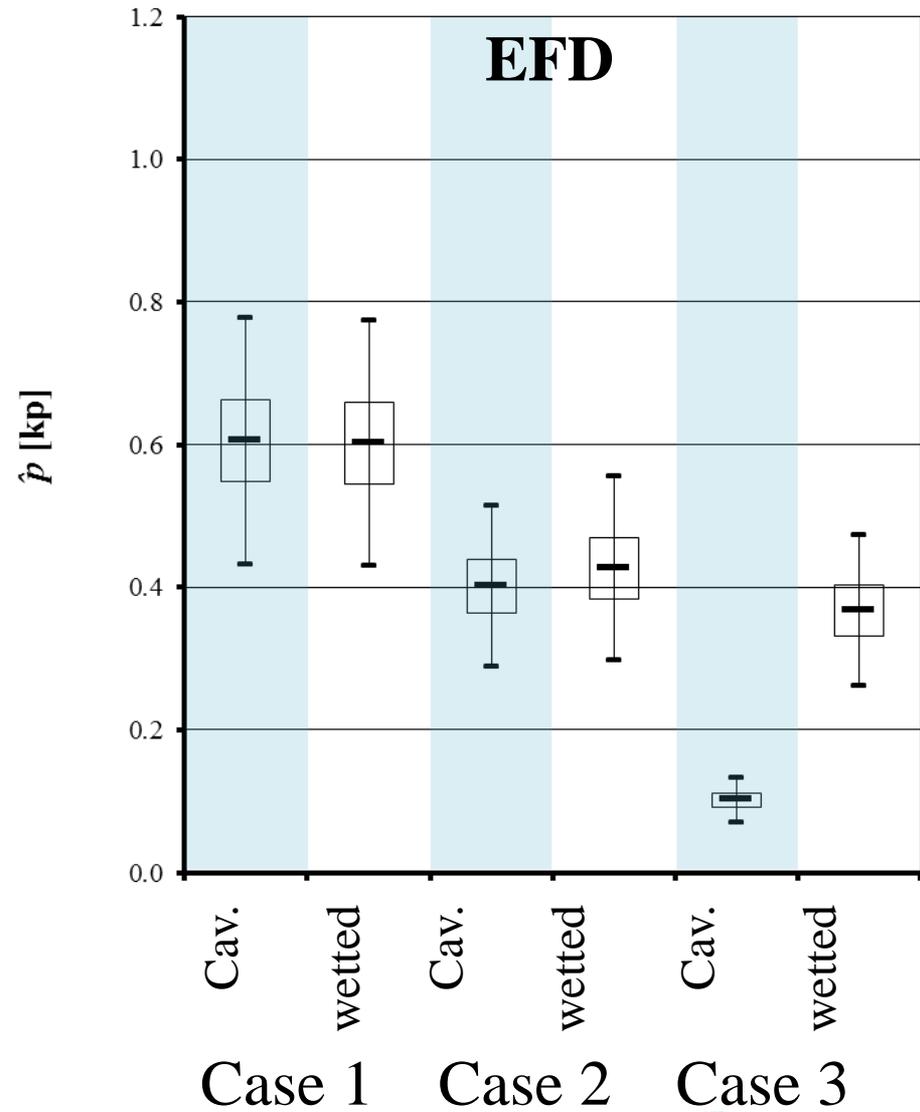
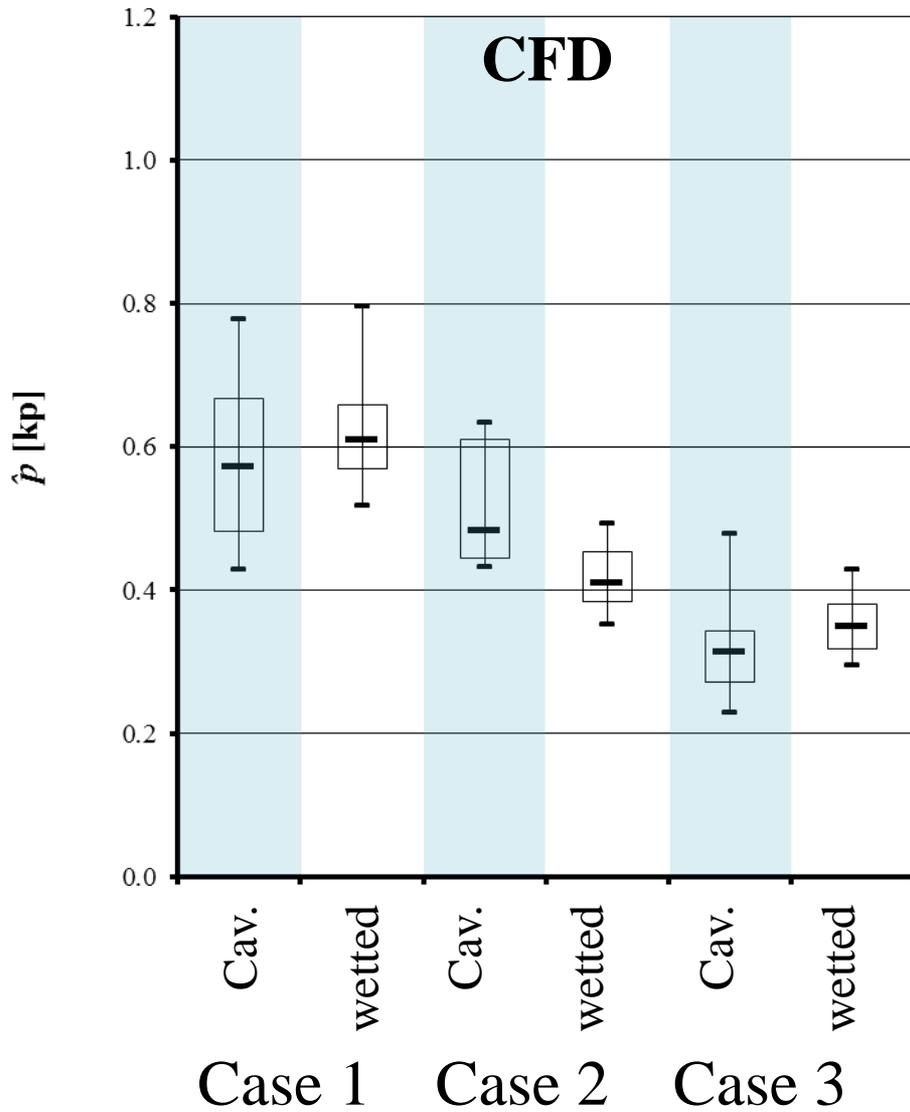
Sensor	$i = 1$	$i = 2$	$i = 3$
p2 (CFD)	0.5873	0.0192	0.0014
p5 (CFD)	0.4831	0.0257	0.0018
P10 (CFD)	0.0377	0.0031	0.0019
p2 (EFD)	0.3289	0.0122	0.0077
p5 (EFD)	0.3671	0.0204	0.0125
P10 (EFD)	0.0404	0.0141	0.0093



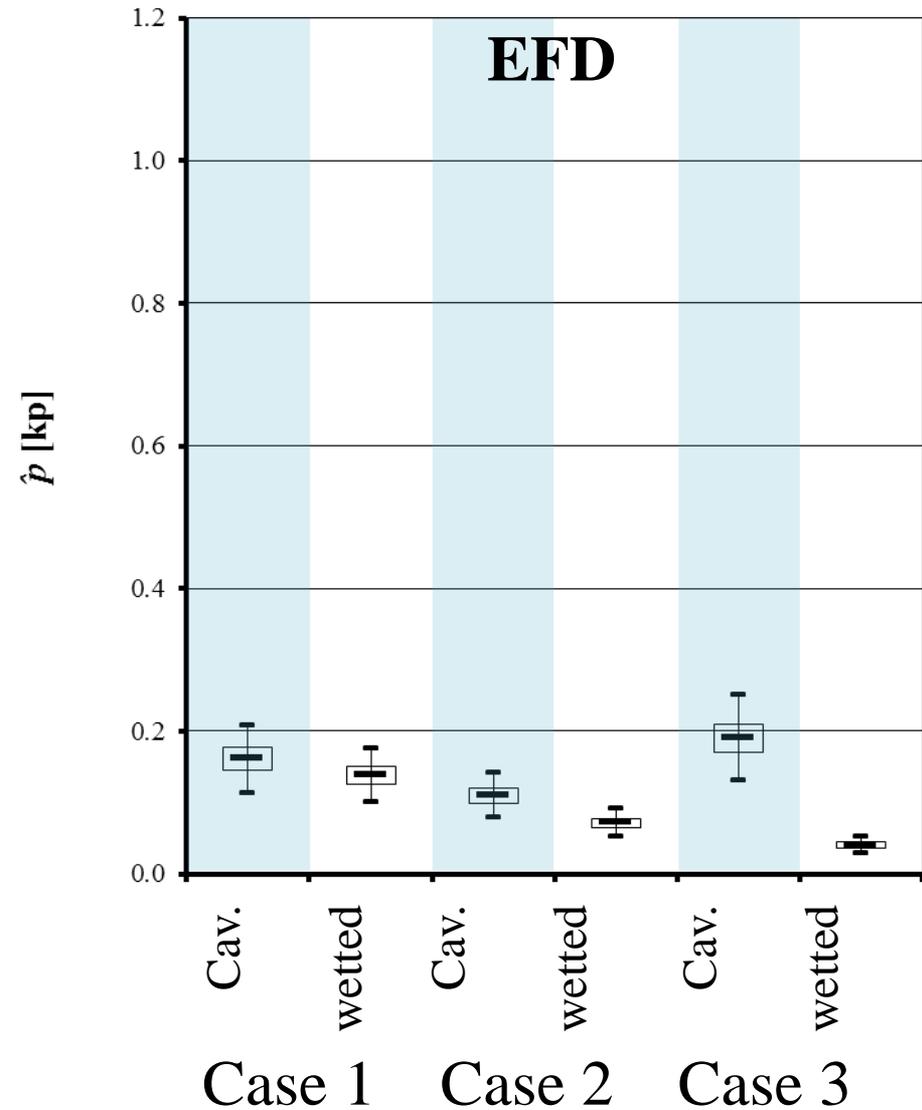
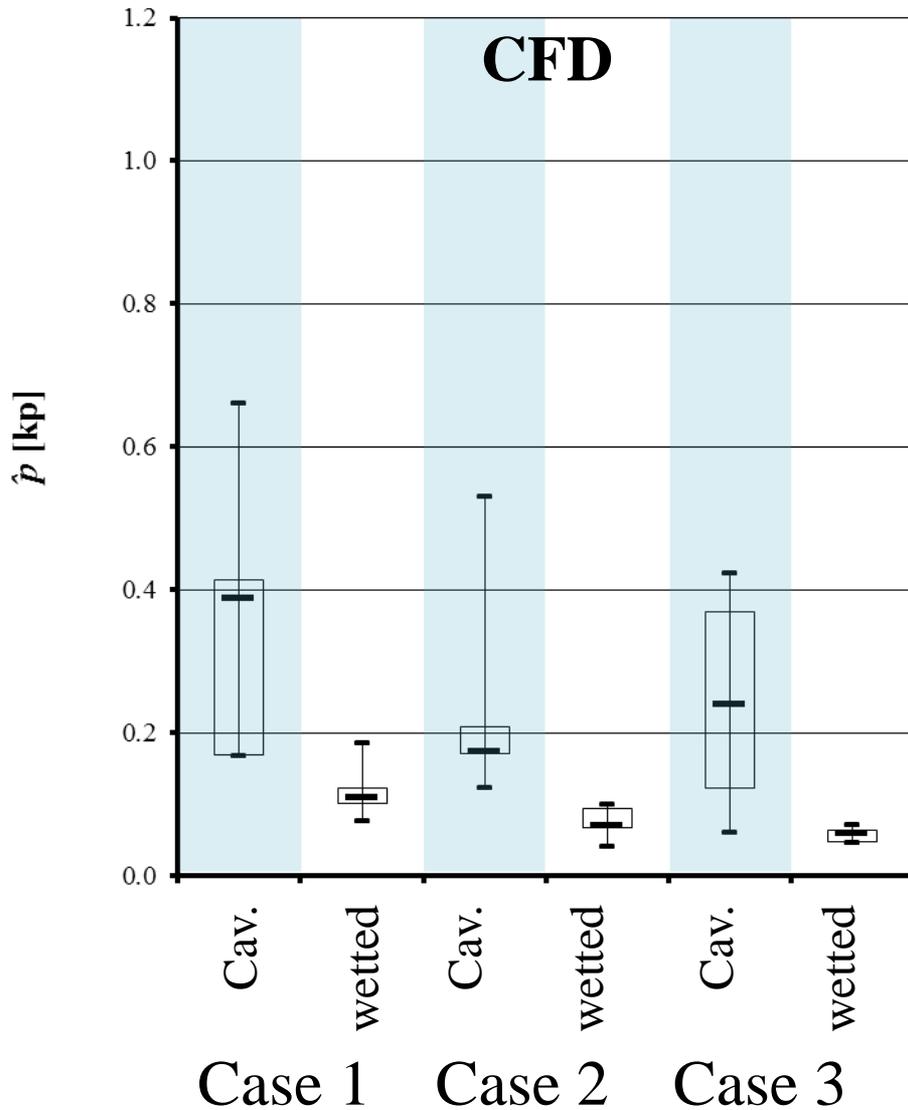
# Results sensor P2 (suction side)



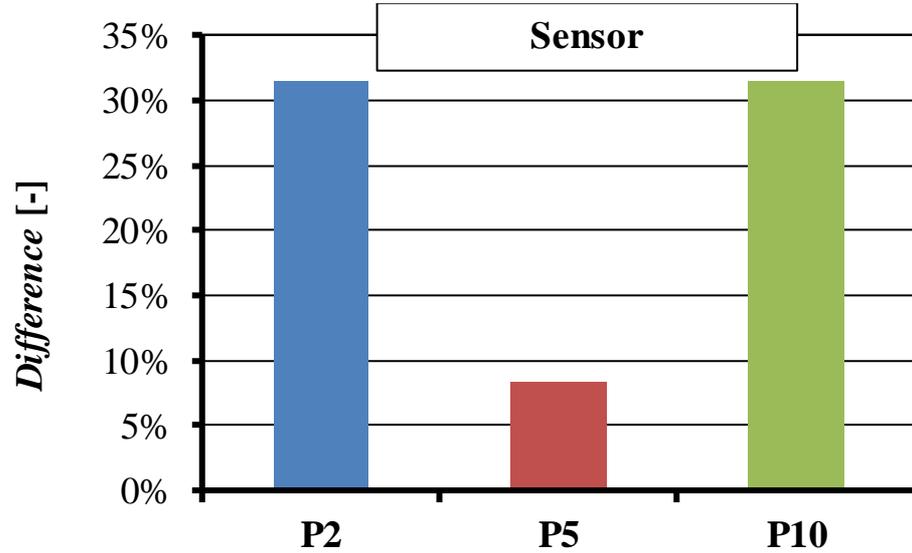
# Results sensor P5 (top)



# Results sensor P10 (pressure side)

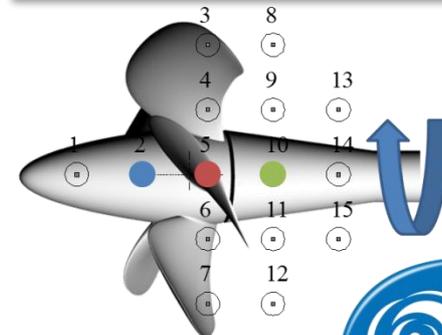


# Difference of CFD and EFD



Difference of CFD and EFD

$$Difference = 1 - \frac{\bar{p}_{EFD}^1}{\bar{p}_{CFD}^1}$$



# Potsdam Propeller Test Case

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**Thank You!**

