

## **Case 2**

### **Cavitation Test in Oblique Flow**

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## 1 Participants

The following institutes have participated:

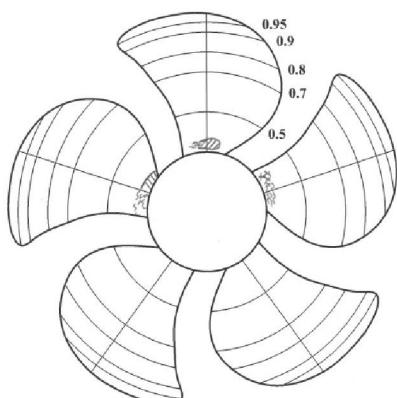
Group	Solver	Acronym
ACCUSIM	ANSYS-CFX, FCM cav. model	ACCUSIM-CFX-FCM
	ANSYS-CFX, Kunz cav. model	ACCUSIM-CFX-Kunz
	ANSYS-CFX, Zwart cav. model	ACCUSIM-CFX-Zwart
CAT-Propulsion	OpenFOAM	CAT-OF
Chalmers	OpenFOAM	Chalmers-OF
CNRS-ECN	ISIS	CNRS-ISIS
CRADLE	SC-Tetra	CRADLE-SCTetra
CSSRC	ANSYS-Fluent	CSSRC-Fluent
MARIN	ReFRECSCO	MARIN-ReFRESCO
ROTAM	ANSYS-Fluent	ROTAM-Fluent
SSPA	ANSYS-Fluent	SSPA-Fluent-Sauer
	ANSYS-Fluent	SSPA-Fluent-Zwart1
	ANSYS-Fluent	SSPA-Fluent-Zwart2
TUHH	ANSYS-CFX	TUHH-CFX
	panMARE	TUHH-panMARE
University of Genoa	BEM	UniGenoa-BEM
	StarCCM+	UniGenoa-StarCCM+
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 and non-cavitating propeller.

## 2 Case 2.1

### 2.1 Case 2.1, ACCUSIM-CFX-FCM

Pressure side

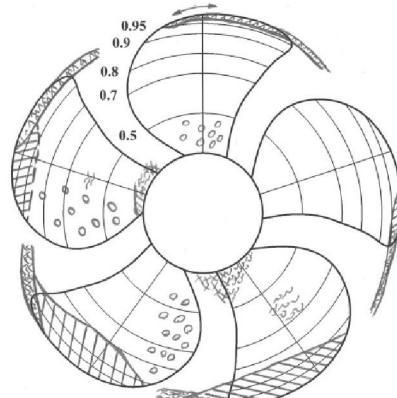


ACCUSIM-CFX-FCM

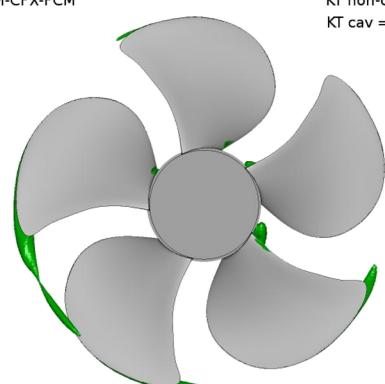
#### Case 2.1

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

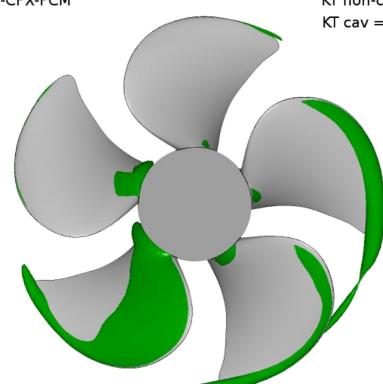
Suction side



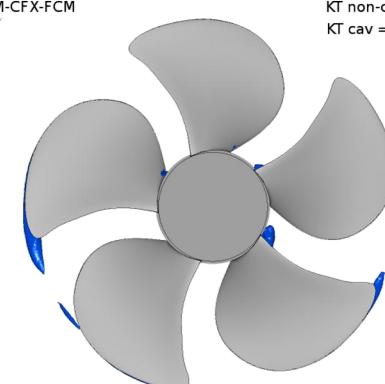
KT non-cav = 0.392  
 KT cav = 0.365



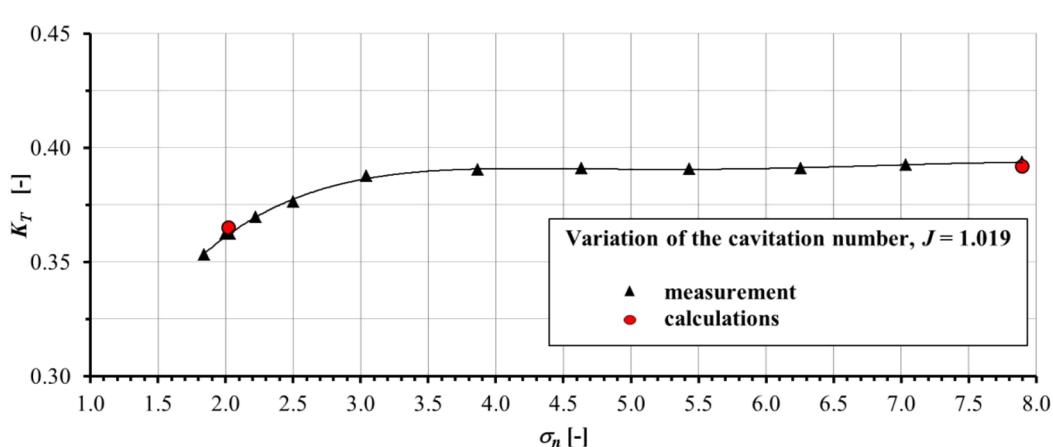
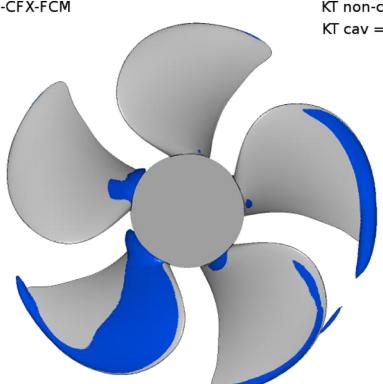
40 %  
 vapour  
 fraction



KT non-cav = 0.392  
 KT cav = 0.365

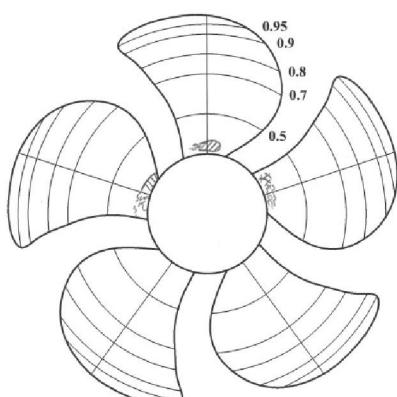


60 %  
 vapour  
 fraction



## 2.2 Case 2.1, ACCUSIM-CFX-Kunz

Pressure side

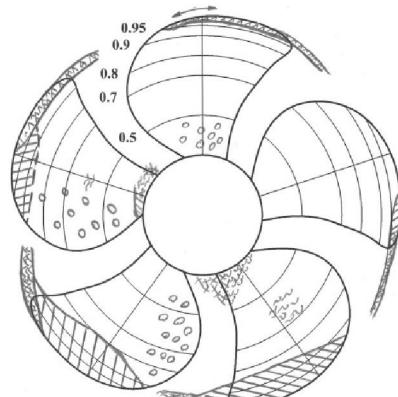


ACCUSIM-CFX-KUNZ

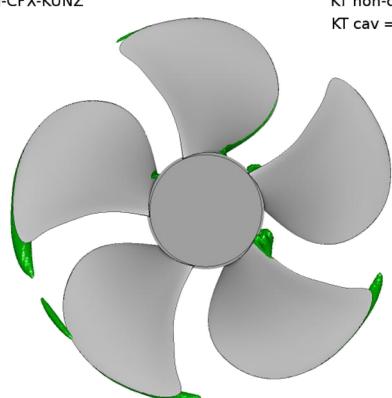
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



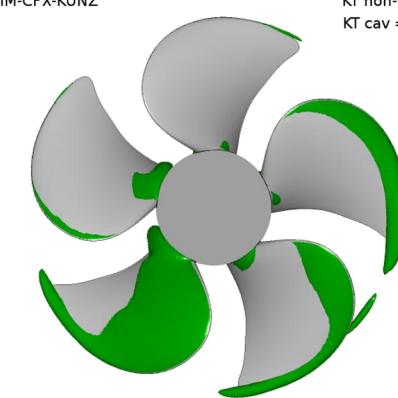
KT non-cav = 0.392  
 KT cav = 0.368



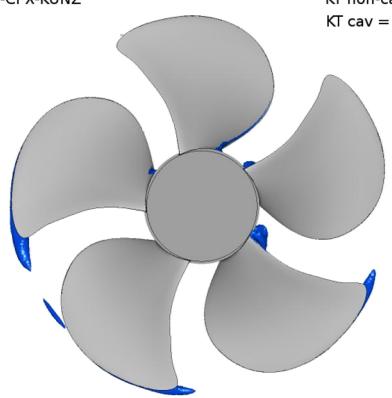
40 %  
 vapour  
 fraction

ACCUSIM-CFX-KUNZ

KT non-cav = 0.392  
 KT cav = 0.368

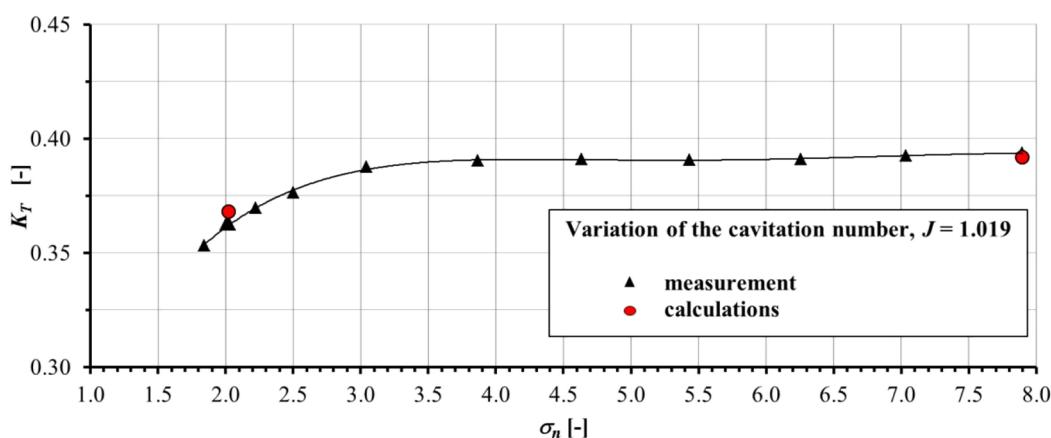
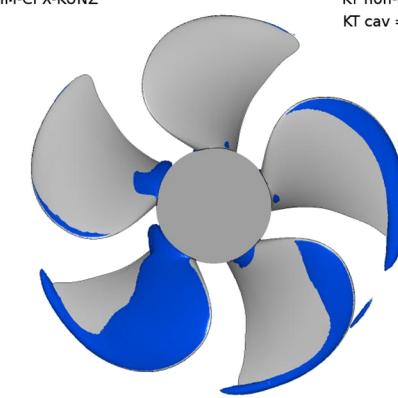


KT non-cav = 0.392  
 KT cav = 0.368



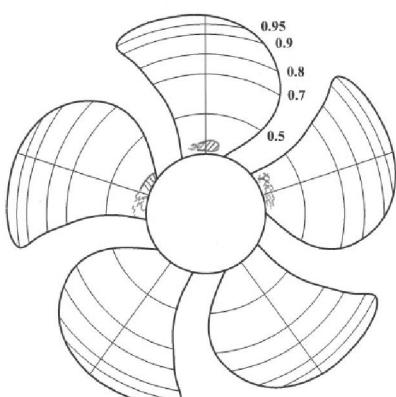
60 %  
 vapour  
 fraction

ACCUSIM-CFX-KUNZ



### 2.3 Case 2.1, ACCUSIM-CFX-Zwart

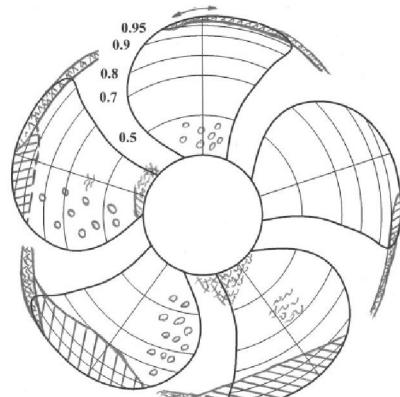
Pressure side



ACCUSIM-CFX-ZWART

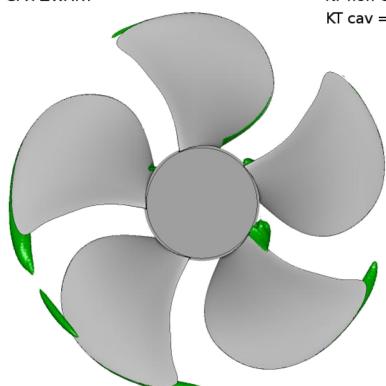
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

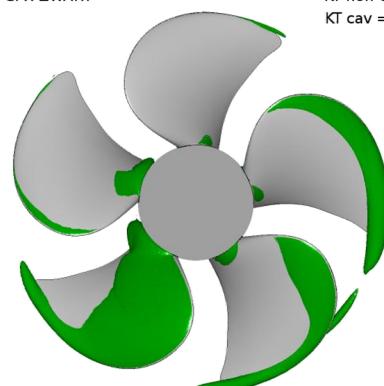


ACCUSIM-CFX-ZWART

$$\begin{aligned} \text{KT non-cav} &= 0.392 \\ \text{KT cav} &= 0.365 \end{aligned}$$

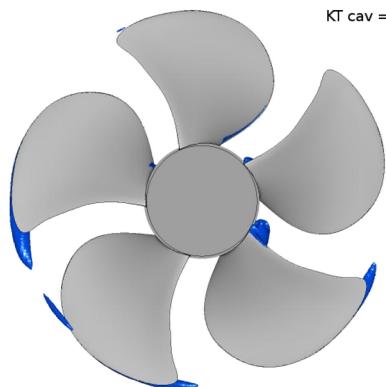


40 %  
vapour  
fraction

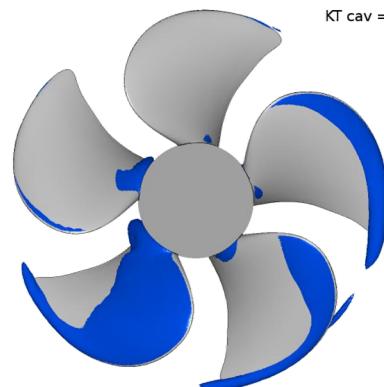


ACCUSIM-CFX-ZWART

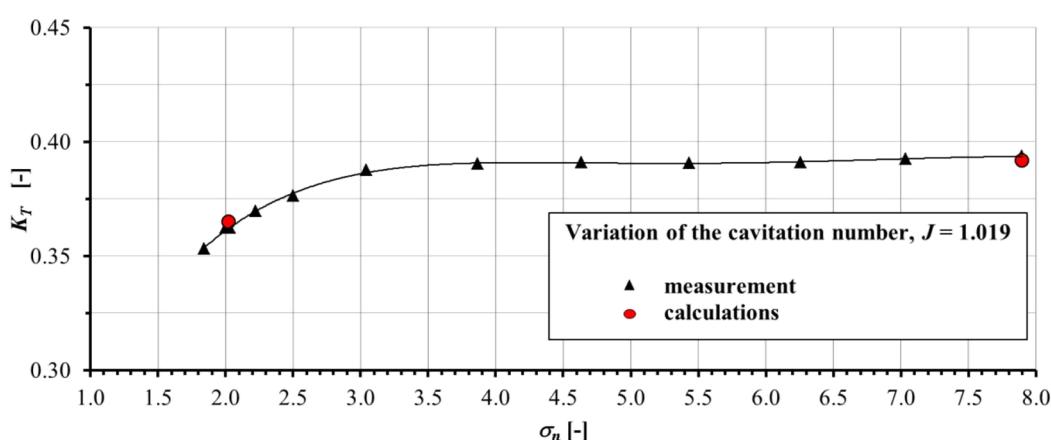
$$\begin{aligned} \text{KT non-cav} &= 0.392 \\ \text{KT cav} &= 0.365 \end{aligned}$$



60 %  
vapour  
fraction

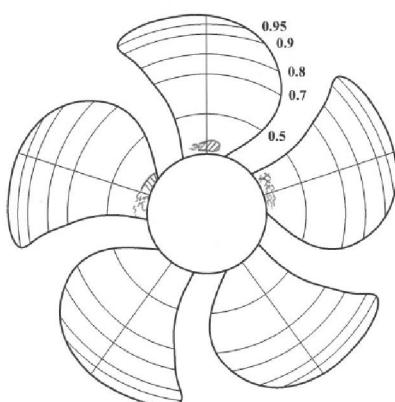


$$\begin{aligned} \text{KT non-cav} &= 0.392 \\ \text{KT cav} &= 0.365 \end{aligned}$$



## 2.4 Case 2.1, CAT-OF

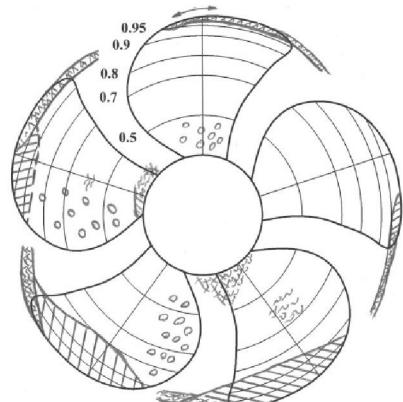
Pressure side



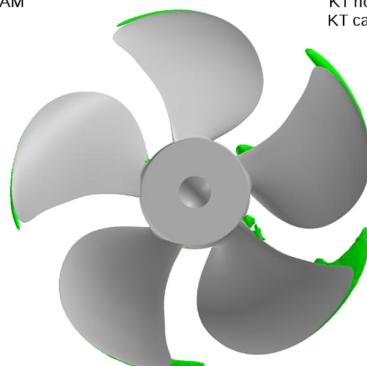
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

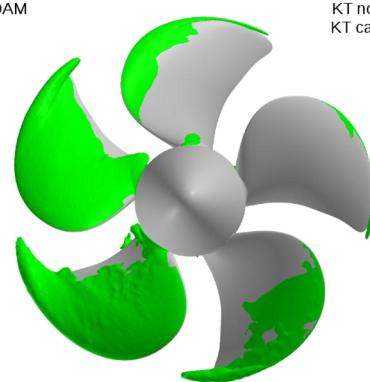


CAT-OpenFOAM



KT non-cav = 0.385  
 KT cav = 0.349

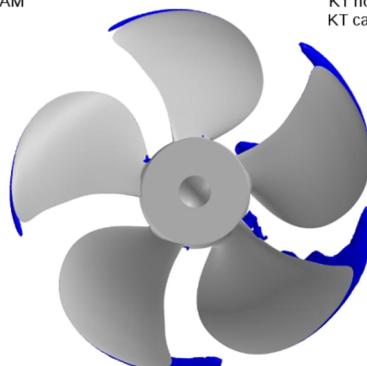
CAT-OpenFOAM



KT non-cav = 0.385  
 KT cav = 0.349

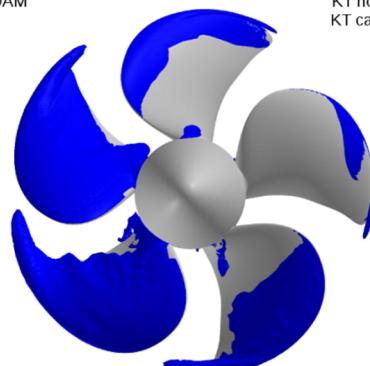
40 %  
 vapour  
 fraction

CAT-OpenFOAM



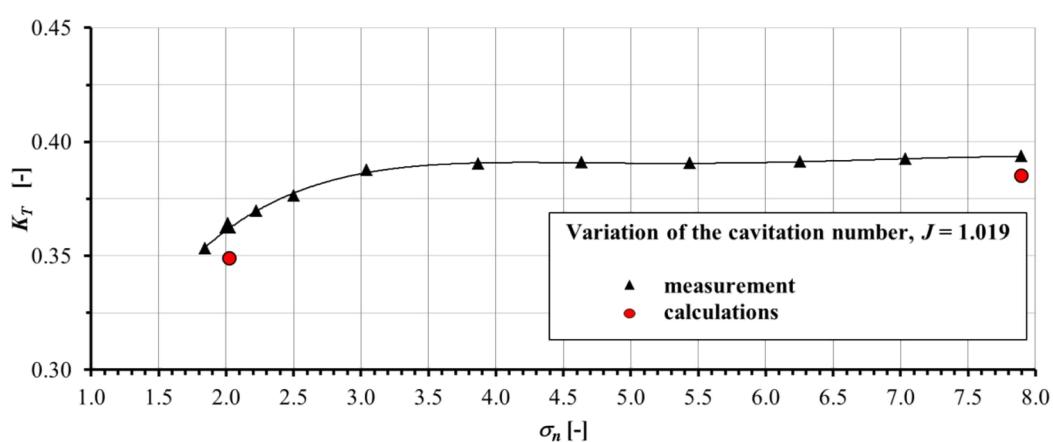
KT non-cav = 0.385  
 KT cav = 0.349

CAT-OpenFOAM



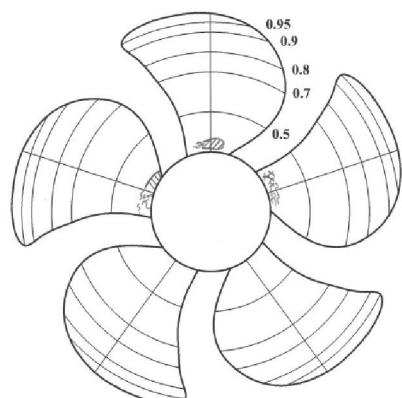
KT non-cav = 0.385  
 KT cav = 0.349

60 %  
 vapour  
 fraction



## 2.5 Case 2.1, Chalmers-OF

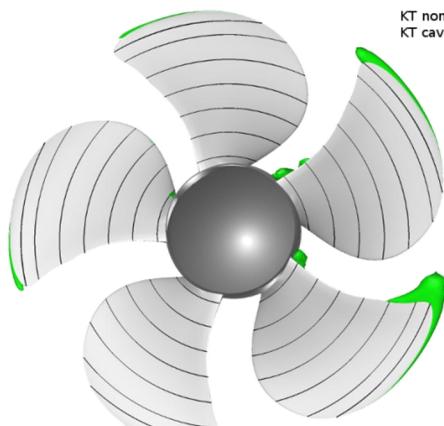
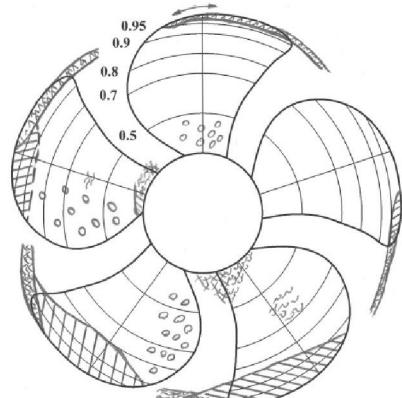
Pressure side



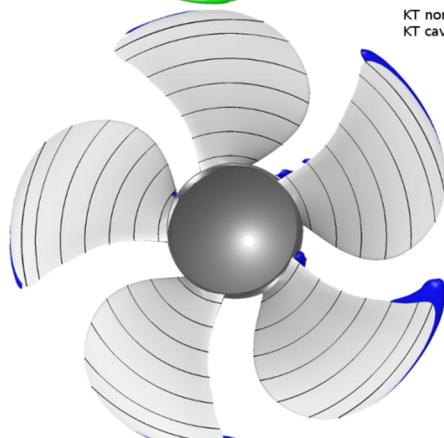
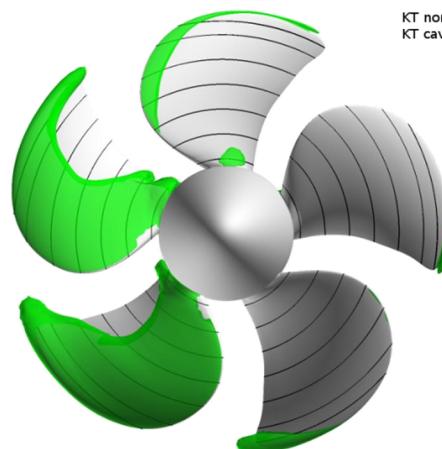
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

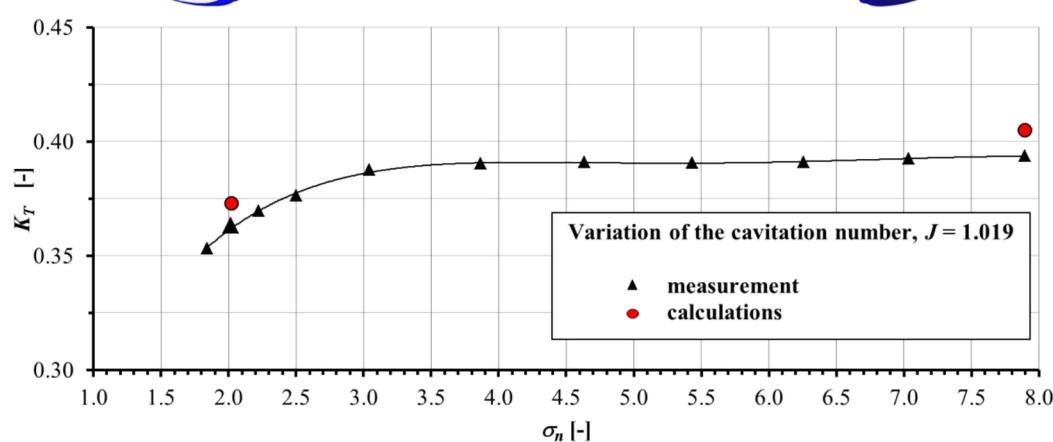
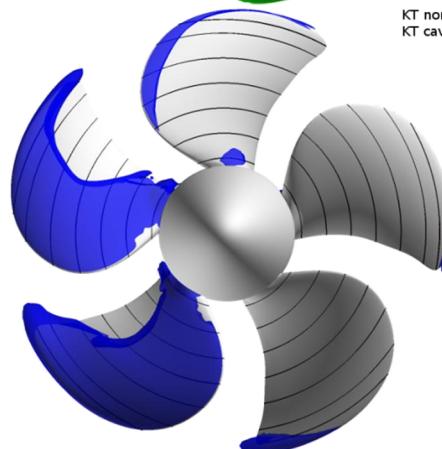
Suction side



40 %  
vapour  
fraction

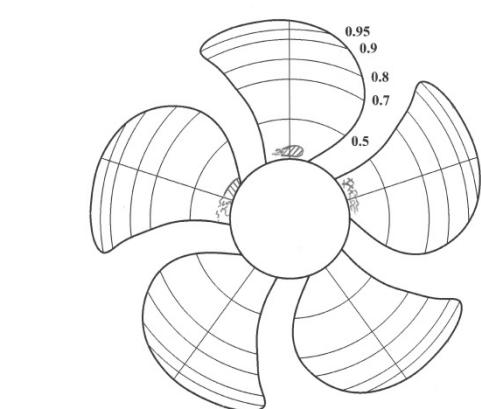


60 %  
vapour  
fraction



## 2.6 Case 2.1, CNRS-ISIS

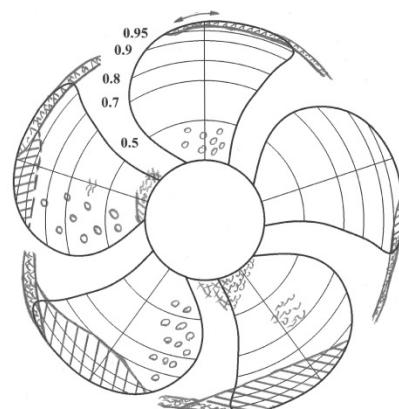
Pressure side



CNRS-ECN ISIS-CFD

**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

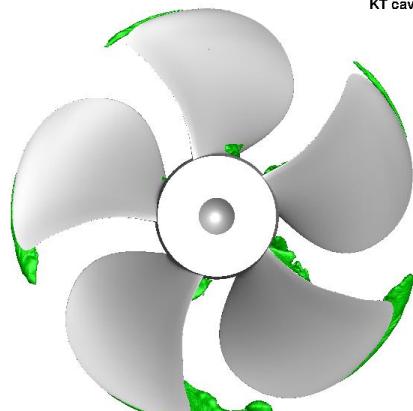


Suction side

KT non-cav = 0.402  
 KT cav = 0.353

CNRS-ECN ISIS-CFD

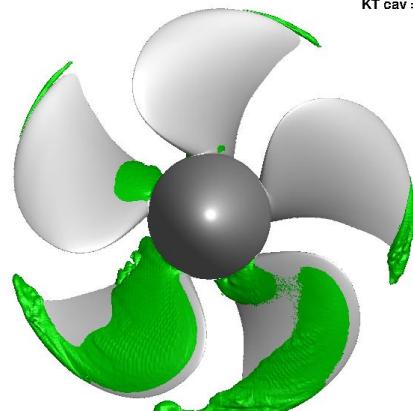
KT non-cav = 0.402  
 KT cav = 0.353



40 %  
 vapour  
 fraction

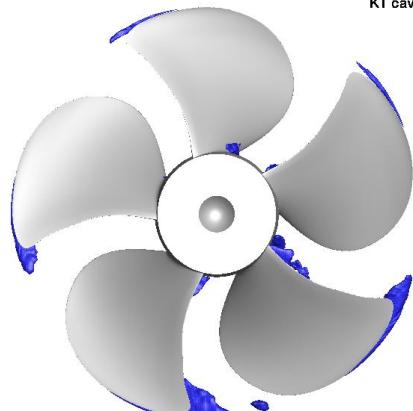
CNRS-ECN ISIS-CFD

KT non-cav = 0.402  
 KT cav = 0.353

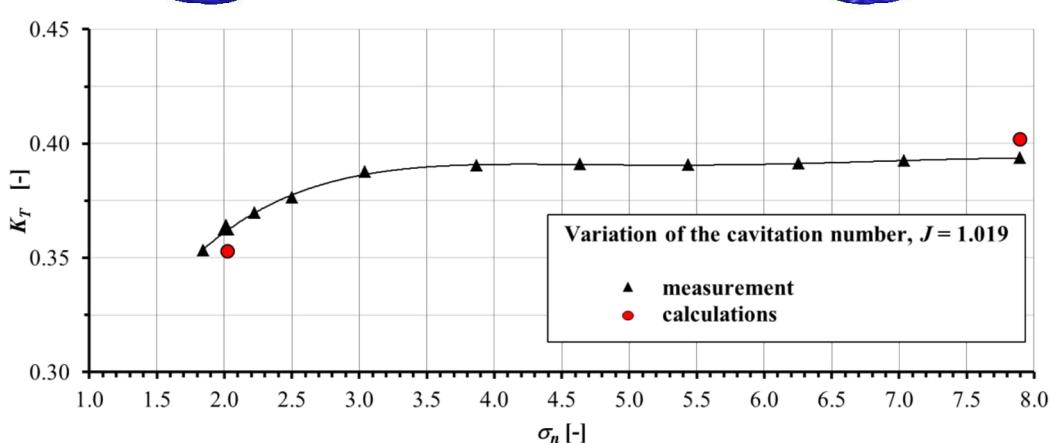
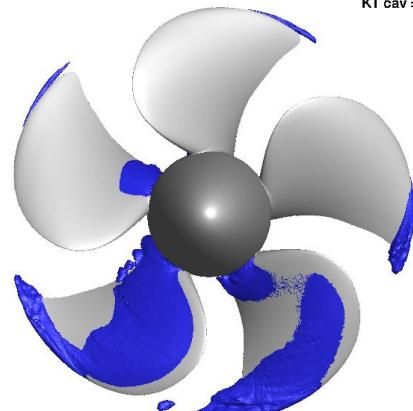


CNRS-ECN ISIS-CFD

KT non-cav = 0.402  
 KT cav = 0.353

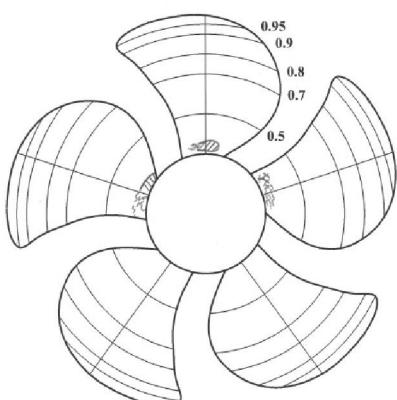


60 %  
 vapour  
 fraction



## 2.7 Case 2.1, CRADLE-SCTetra

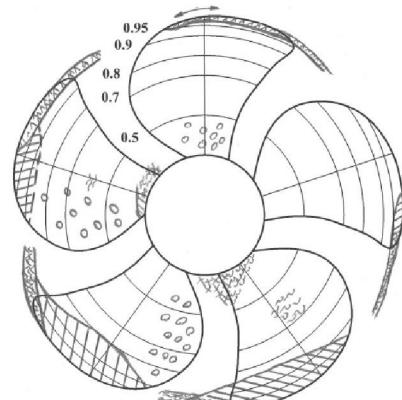
Pressure side



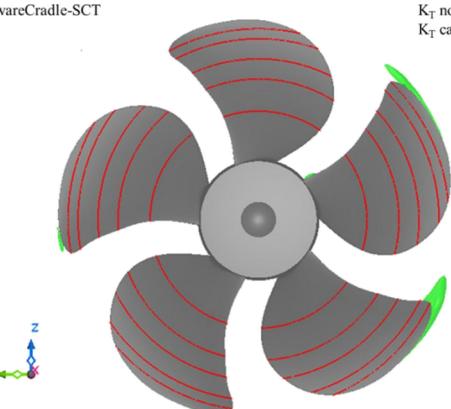
SoftwareCradle-SCT

### Case 2.1

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

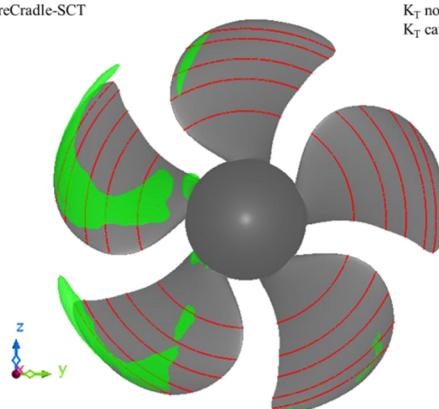


Suction side



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

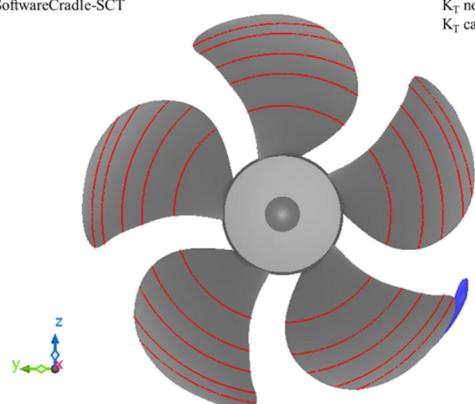
40 %  
vapour  
fraction



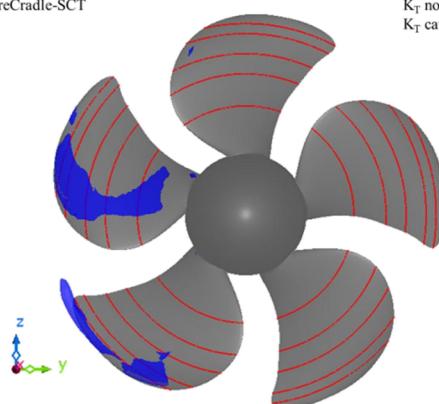
$K_T$  non-cav = 0.417  
 $K_T$  cav = 0.372

SoftwareCradle-SCT

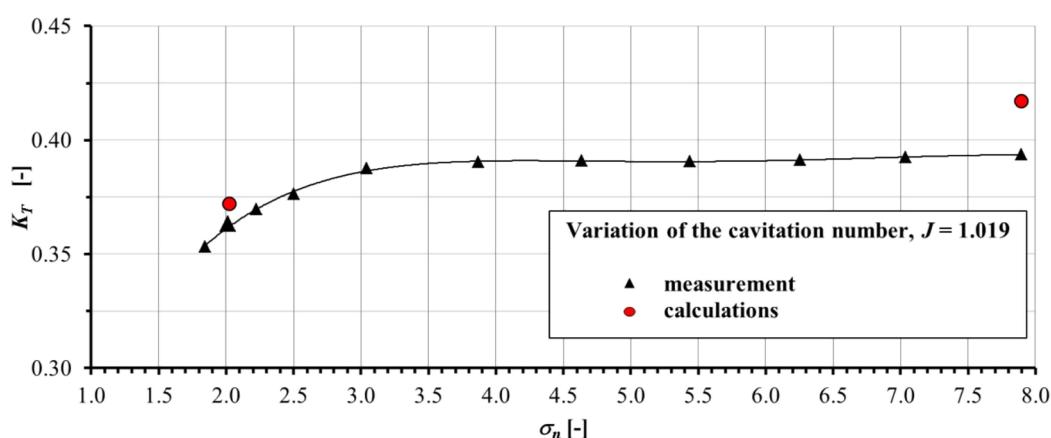
$K_T$  non-cav = 0.417  
 $K_T$  cav = 0.372



60 %  
vapour  
fraction

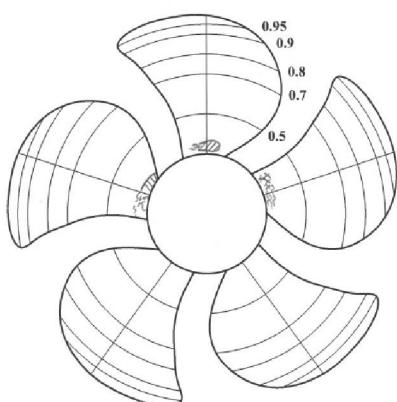


$K_T$  non-cav = 0.417  
 $K_T$  cav = 0.372



## 2.8 Case 2.1, CSSRC-Fluent

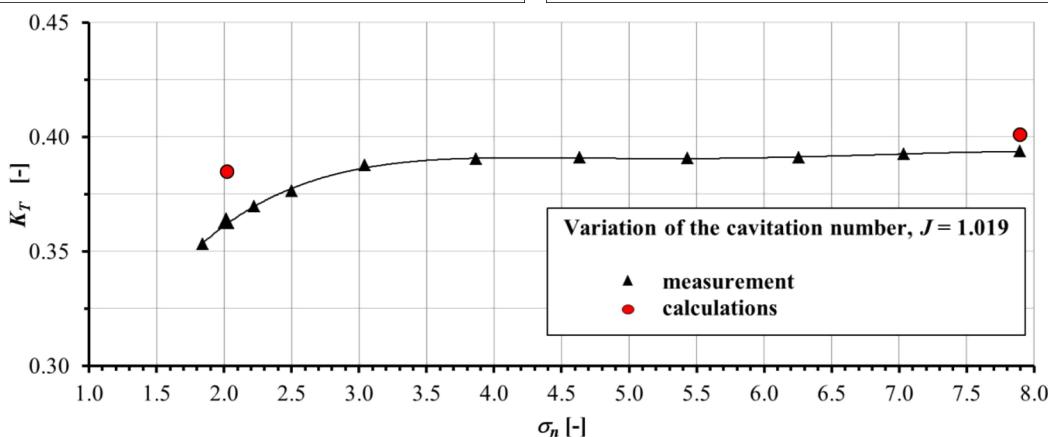
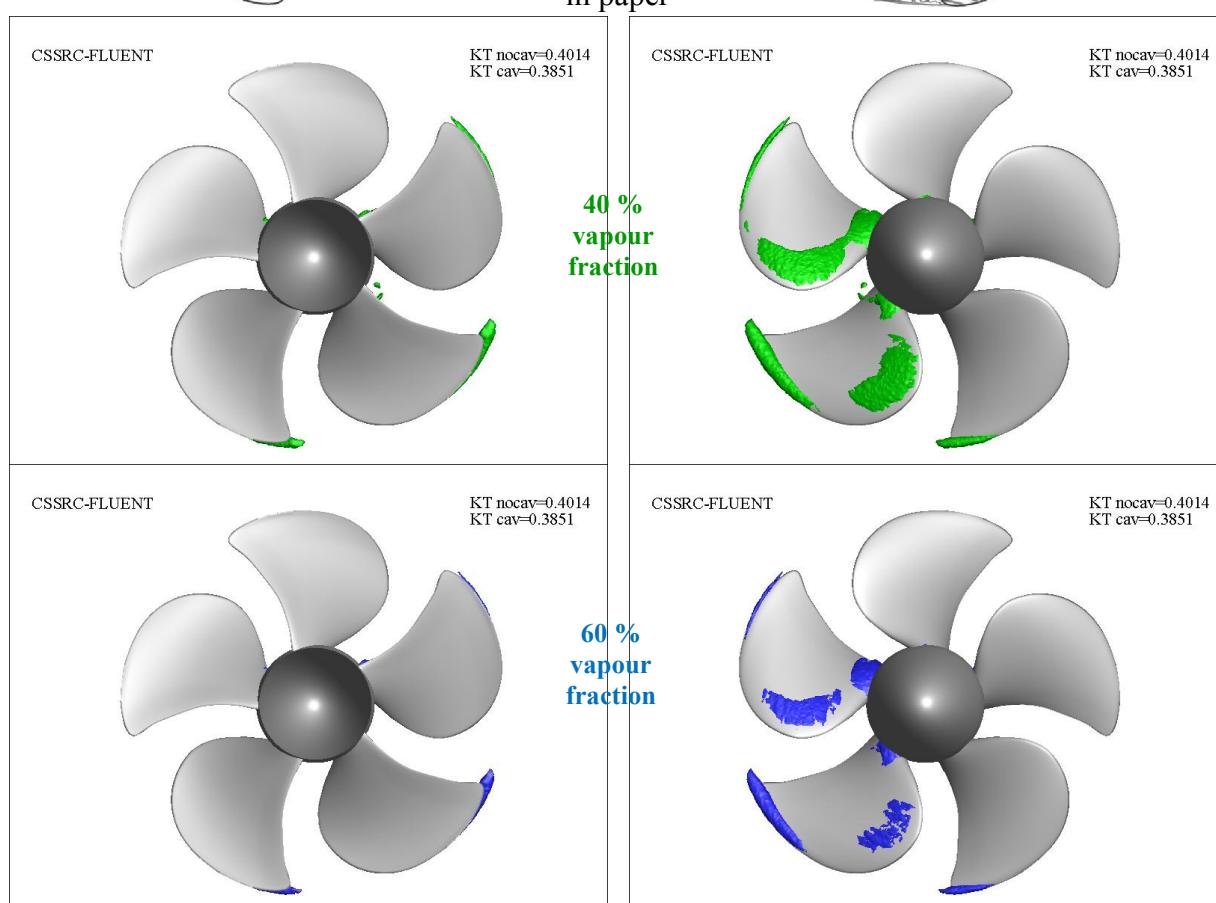
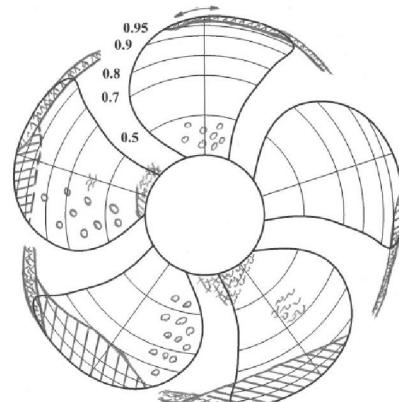
Pressure side



**Case 2.1**

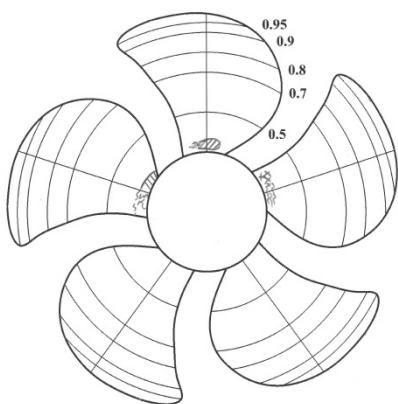
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



## 2.9 Case 2.1, MARIN-ReFRESCO

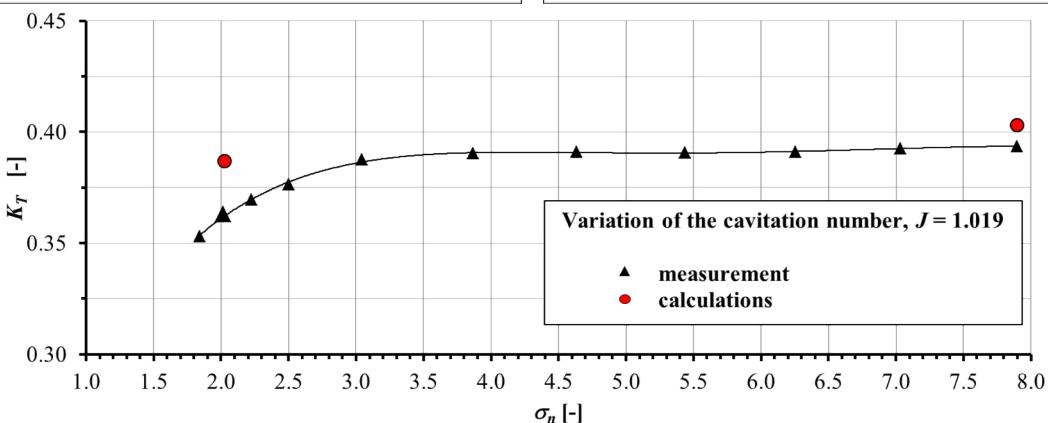
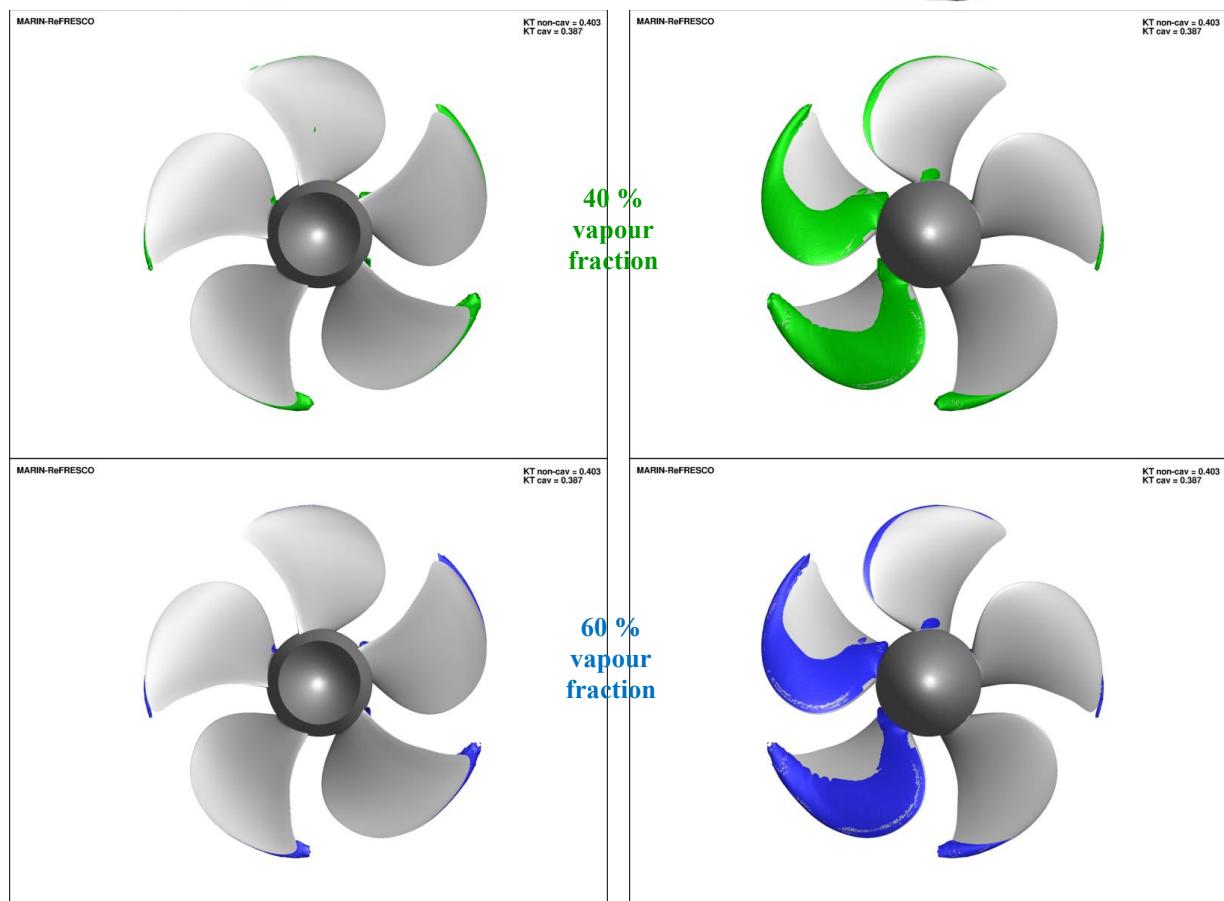
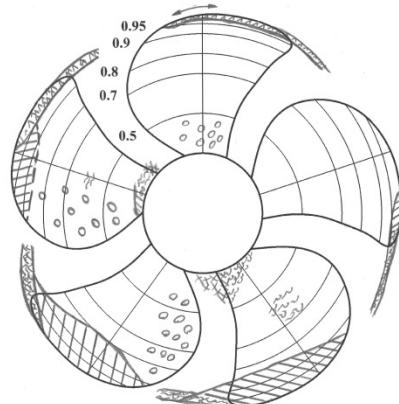
Pressure side



**Case 2.1**

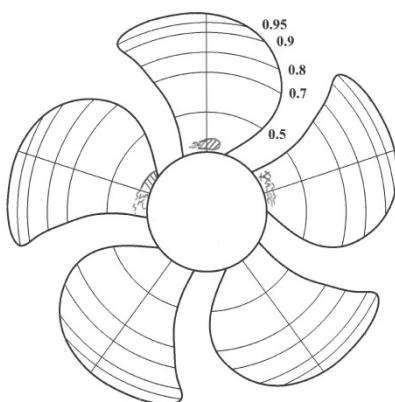
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



## 2.10 Case 2.1, ROTAM-Fluent

Pressure side

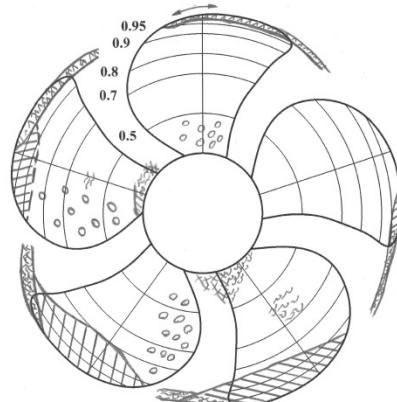


ROTAM-ANSYS

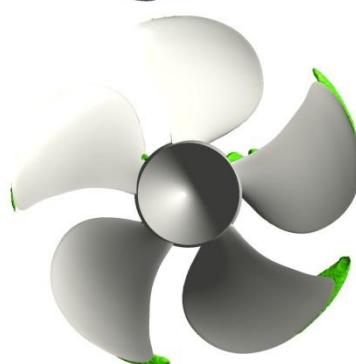
### Case 2.1

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

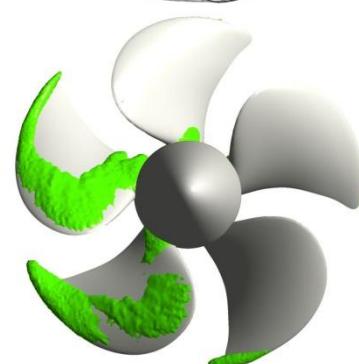


KT non-cav = 0.420  
 KT cav = 0.385



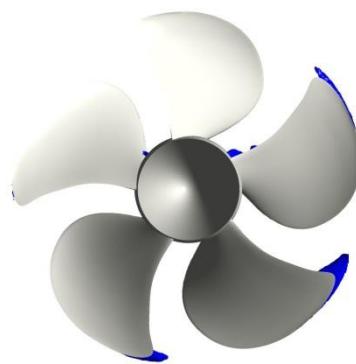
40 %  
 vapour  
 fraction

ROTAM-ANSYS  
 KT non-cav = 0.420  
 KT cav = 0.385



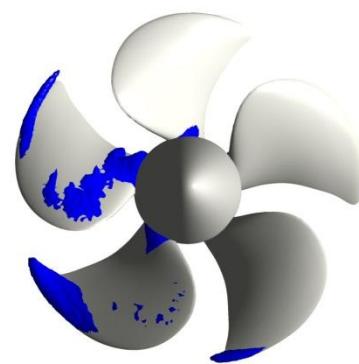
KT non-cav = 0.420  
 KT cav = 0.385

ROTAM-ANSYS

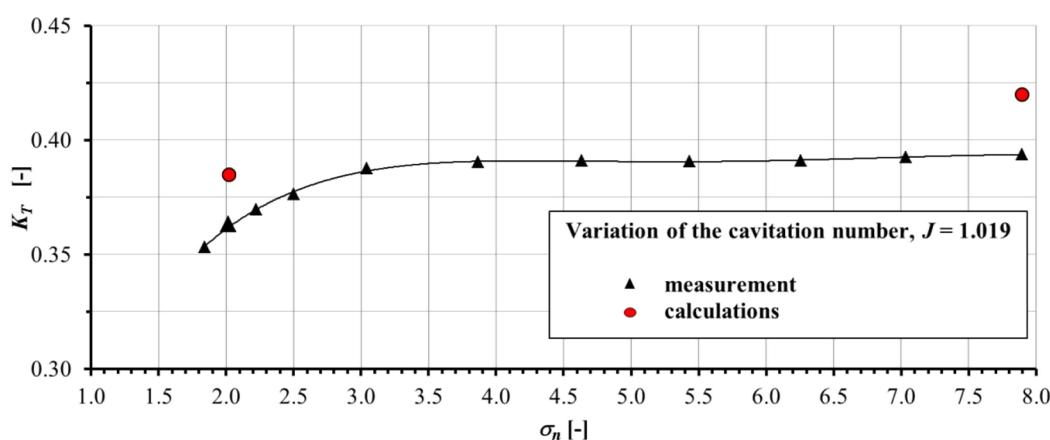


60 %  
 vapour  
 fraction

ROTAM-ANSYS  
 KT non-cav = 0.420  
 KT cav = 0.385

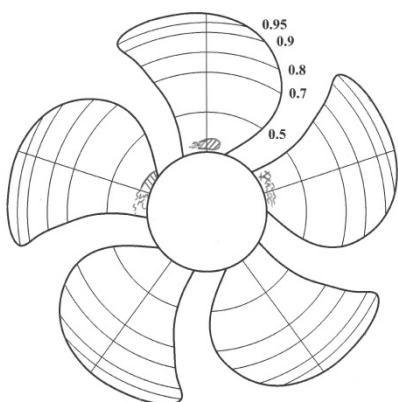


KT non-cav = 0.420  
 KT cav = 0.385



## 2.11 Case 2.1, SSPA-Fluent-Sauer

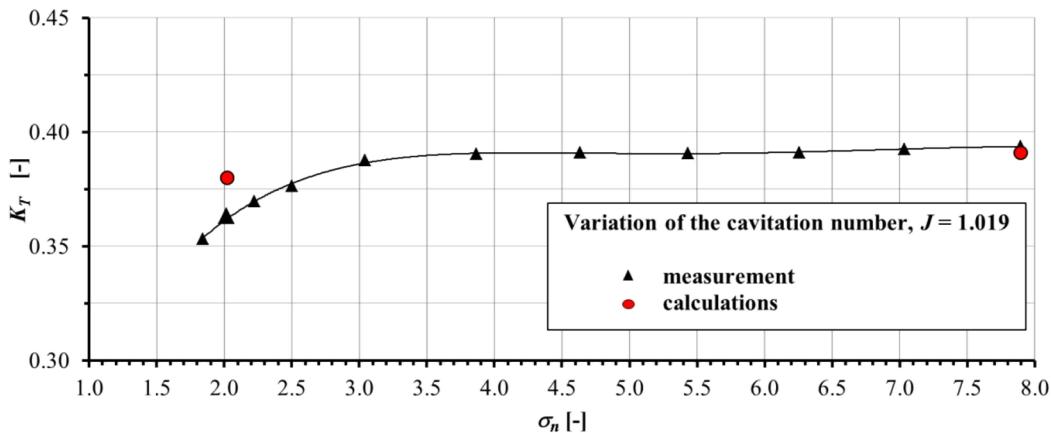
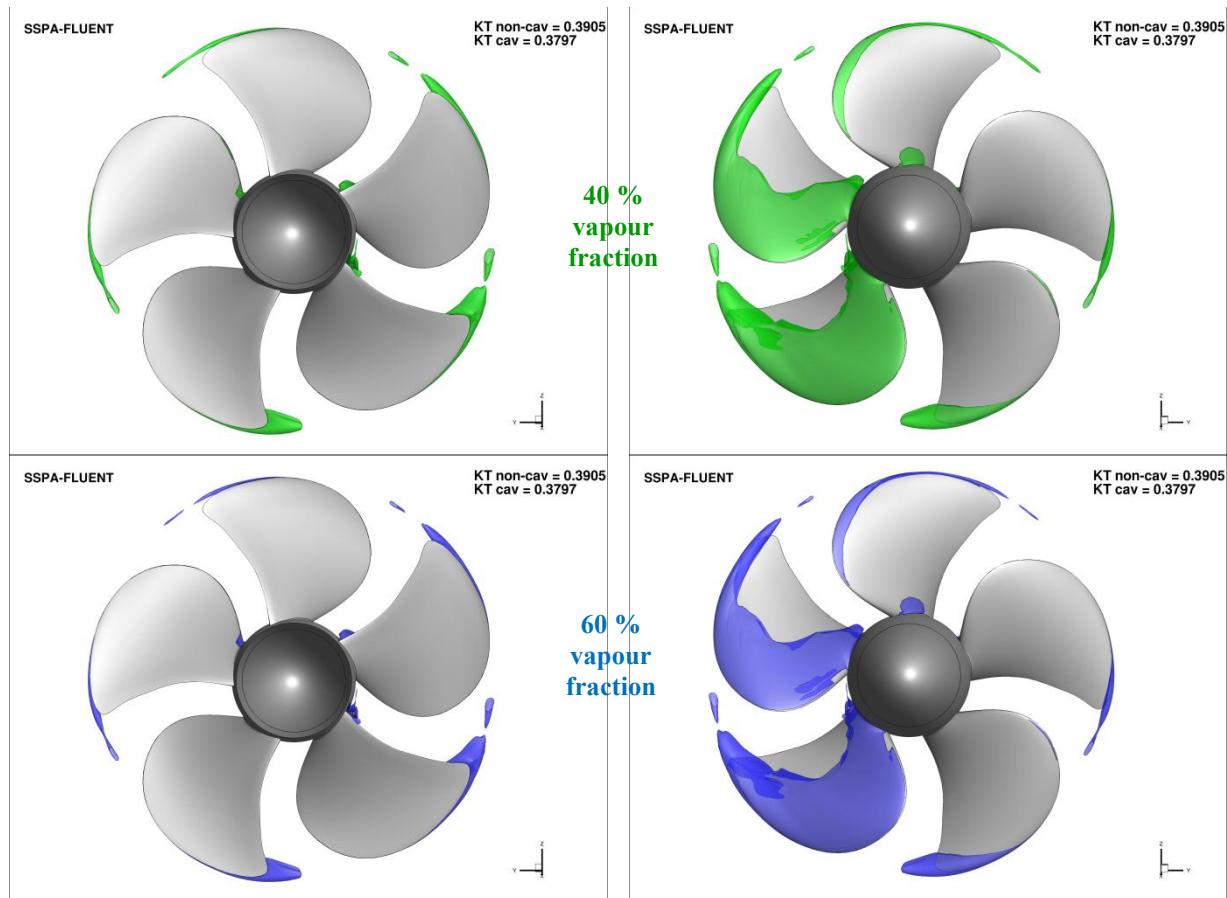
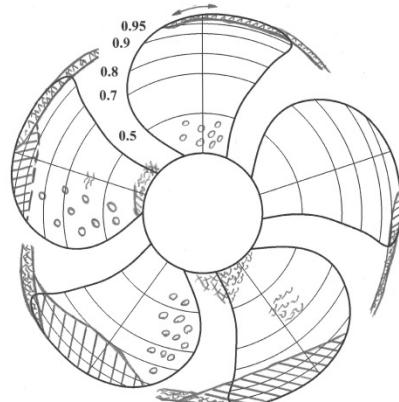
Pressure side



**Case 2.1**

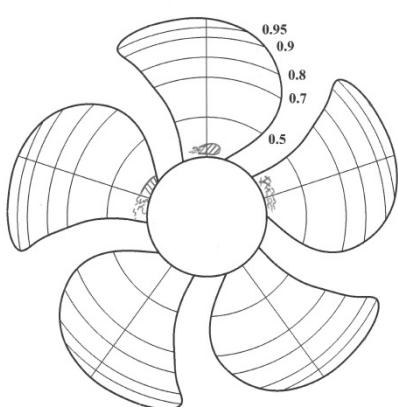
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



## 2.12 Case 2.1, SSPA-Fluent-Zwart1

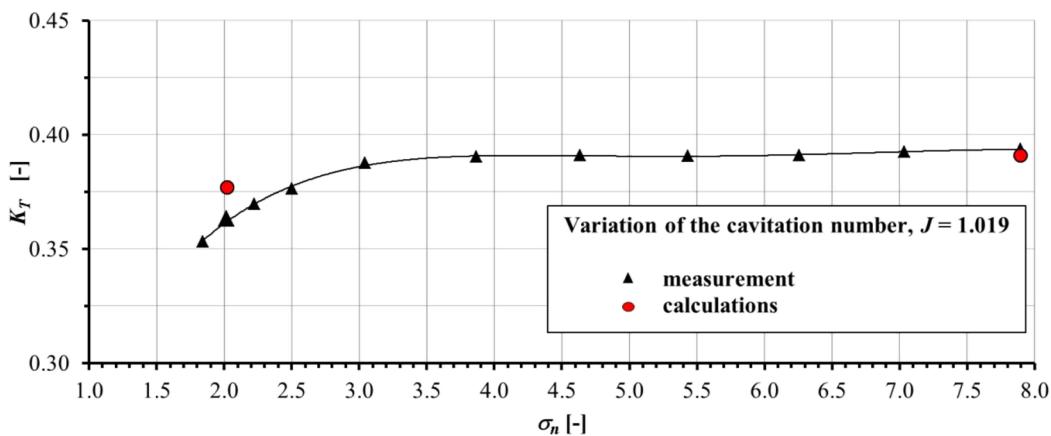
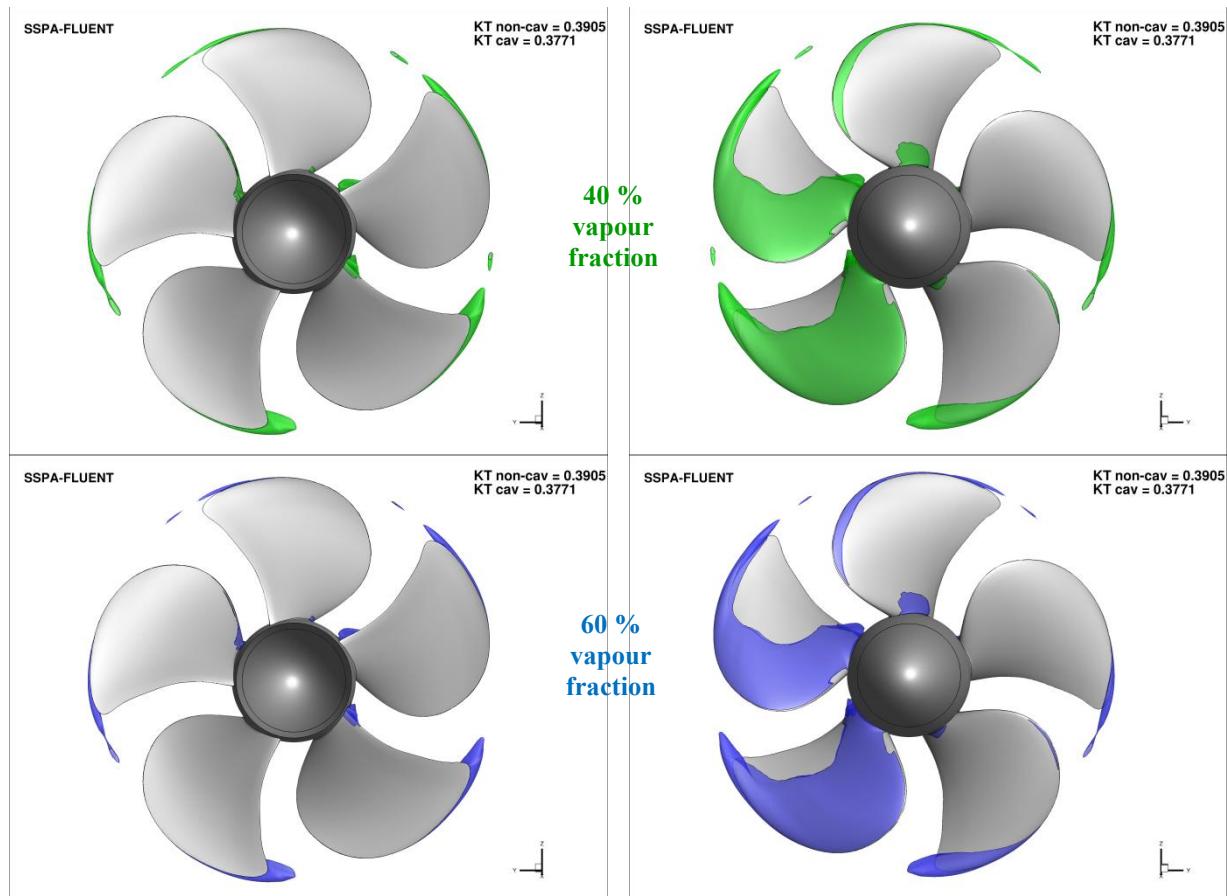
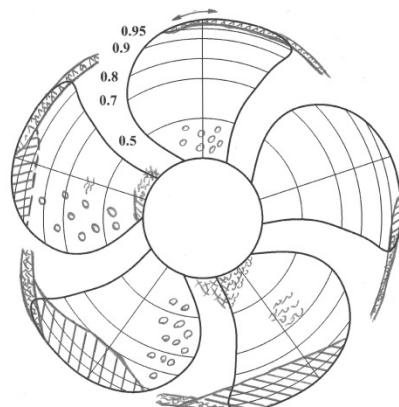
Pressure side



**Case 2.1**

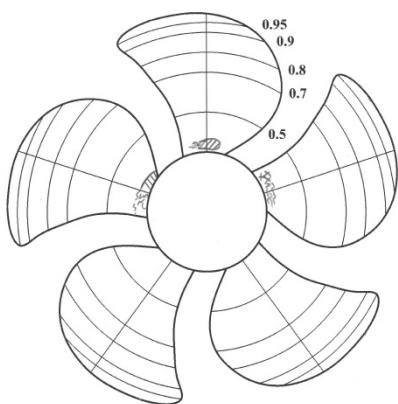
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



### 2.13 Case 2.1, SSPA-Fluent-Zwart2

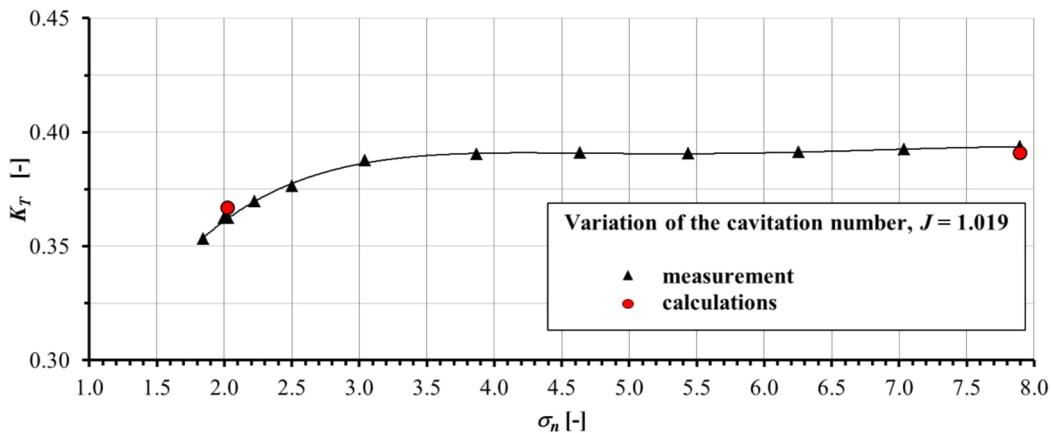
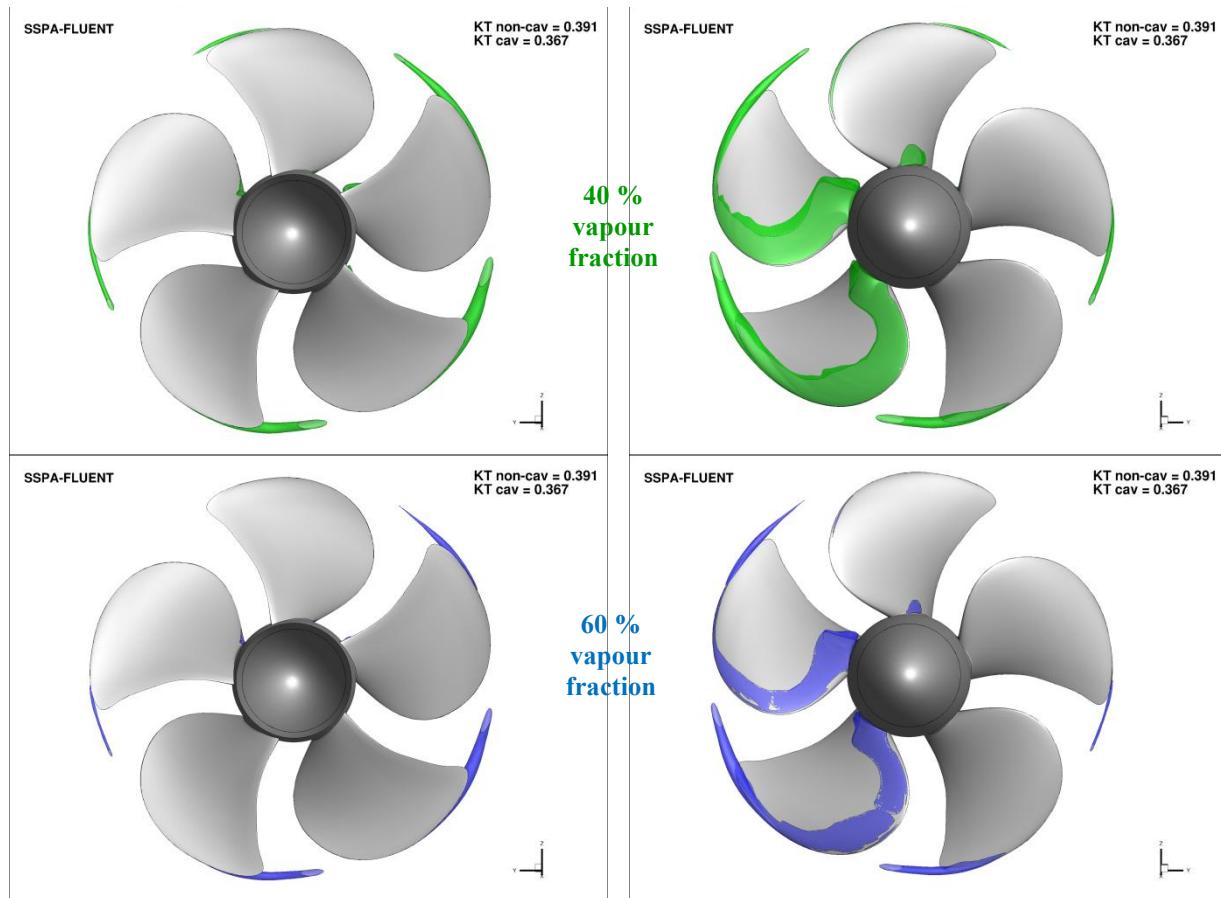
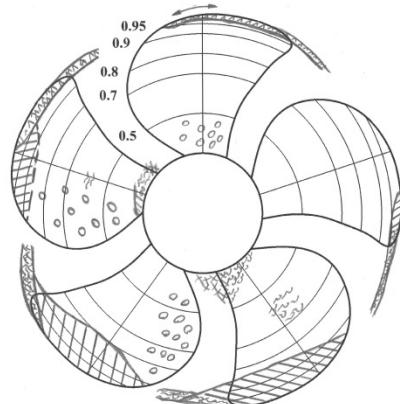
Pressure side



**Case 2.1**

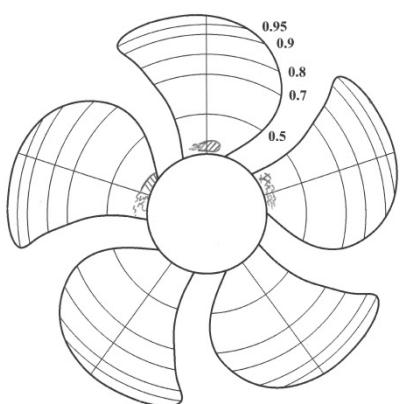
$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



## 2.14 Case 2.1, TUHH-CFX

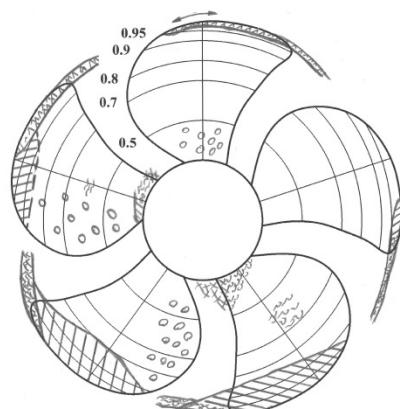
Pressure side



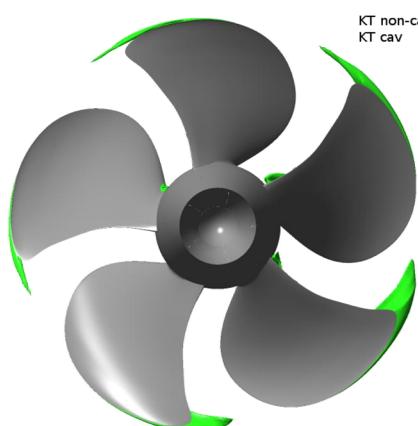
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

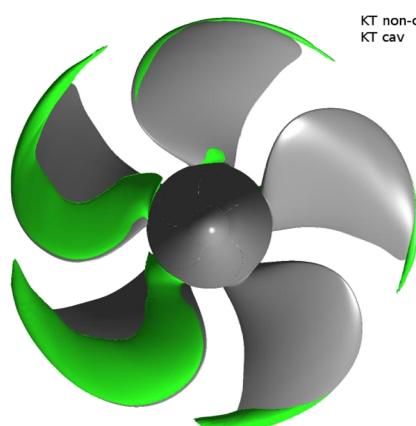


TUHH-CFX



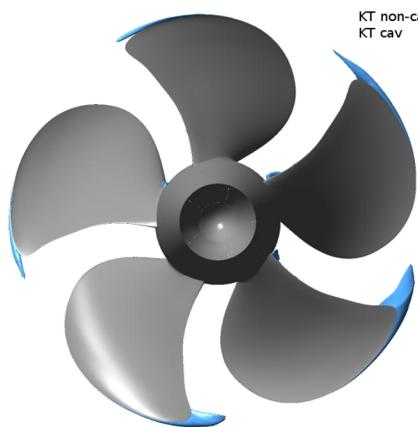
TUHH-CFX

40 %  
vapour  
fraction



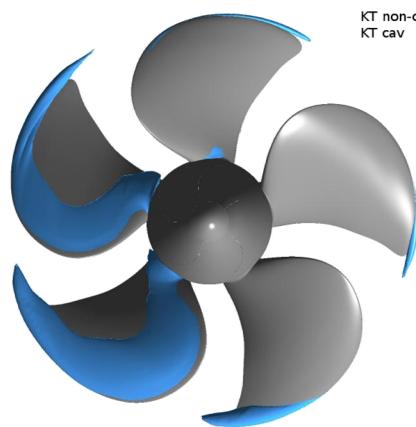
KT non-cav = 0.3946  
 KT cav = 0.3862

TUHH-CFX

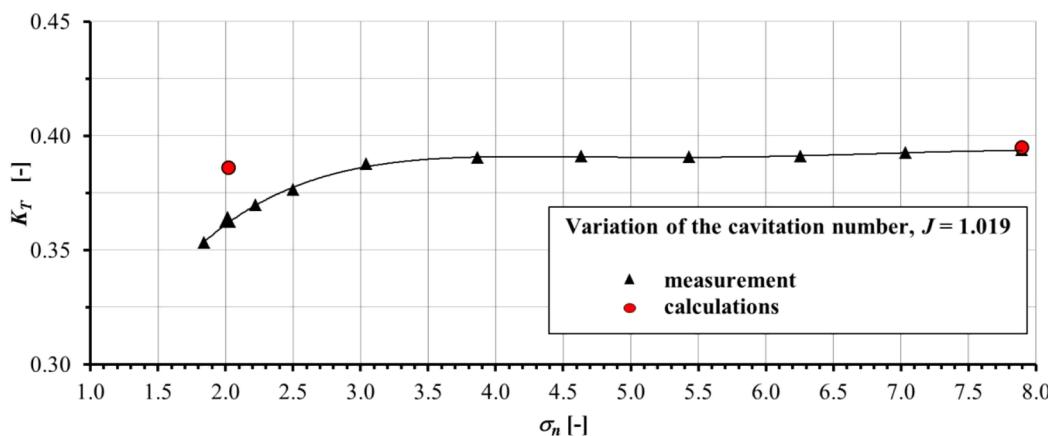


TUHH-CFX

60 %  
vapour  
fraction

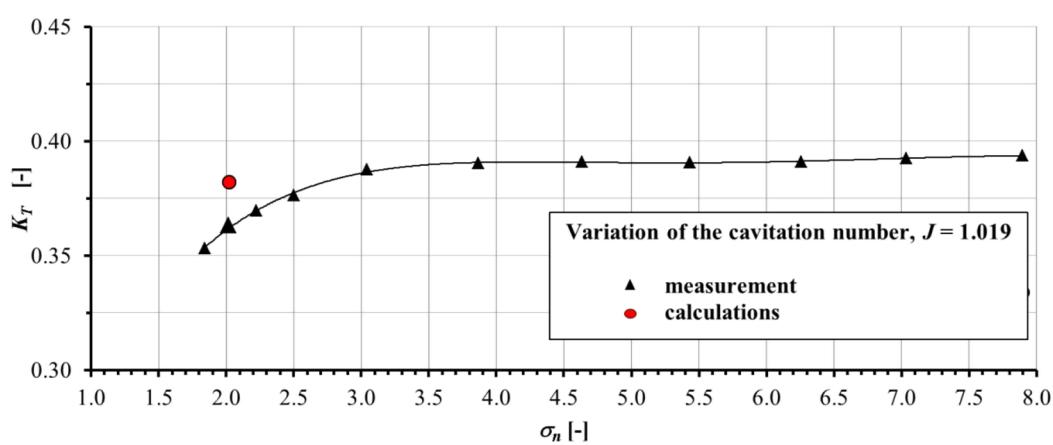
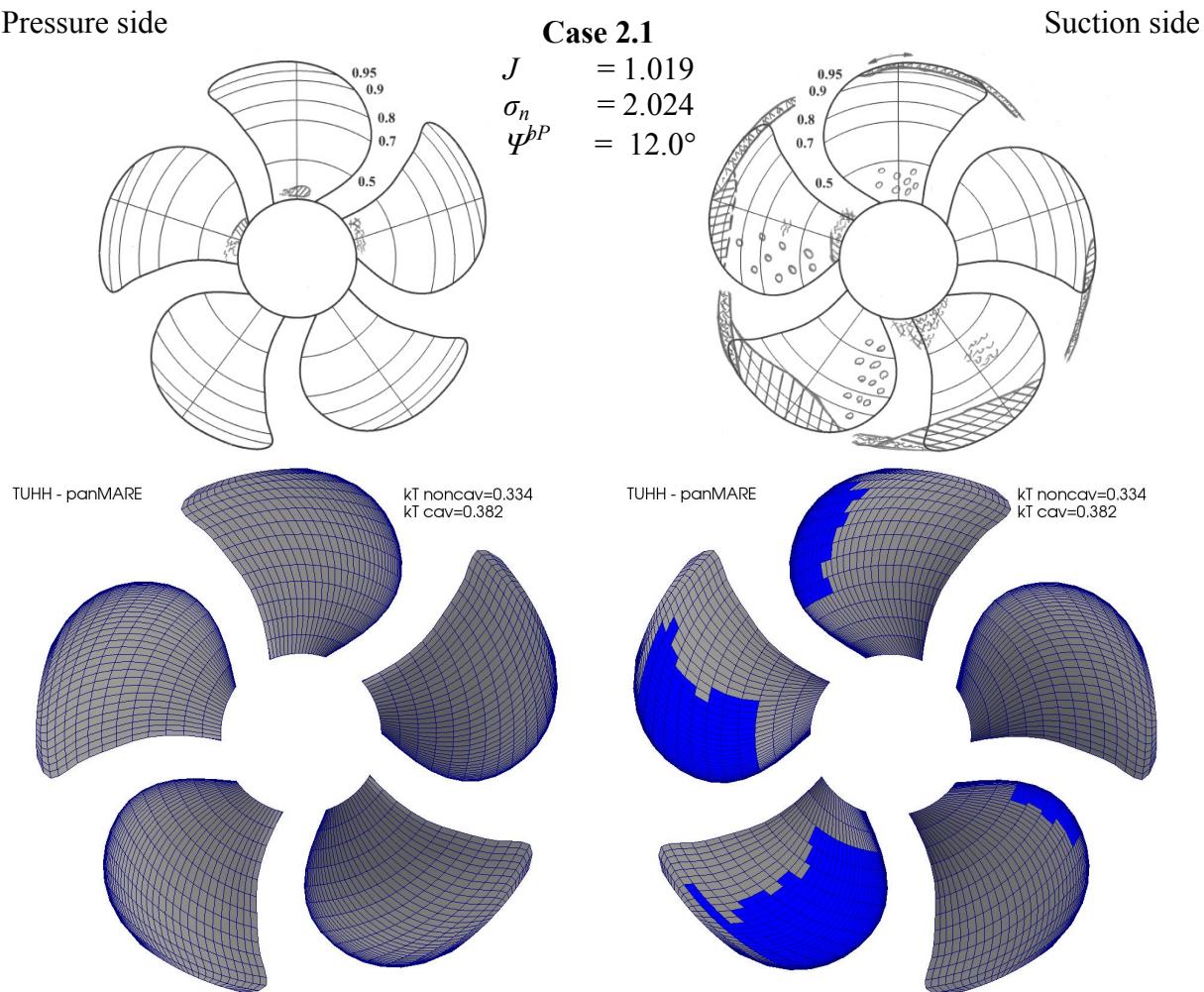


KT non-cav = 0.3946  
 KT cav = 0.3862



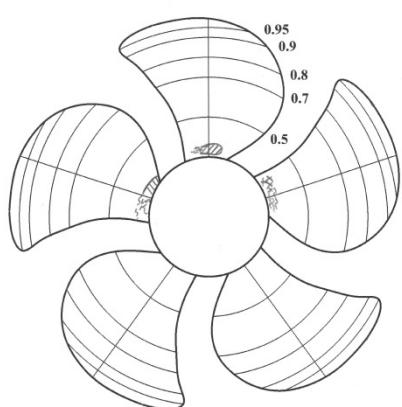
## 2.15 Case 2.1, TUHH-panMARE

## Pressure side



## 2.16 Case 2.1, UniGenoa-BEM

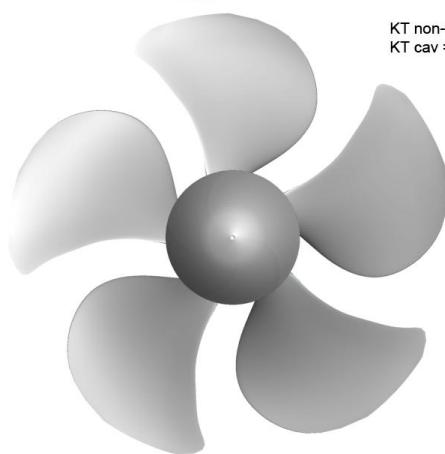
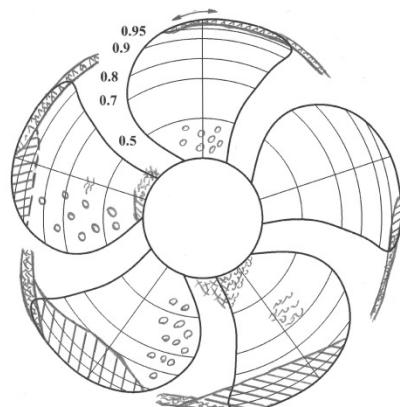
Pressure side



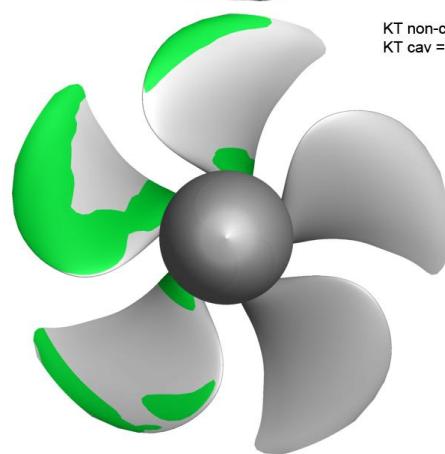
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

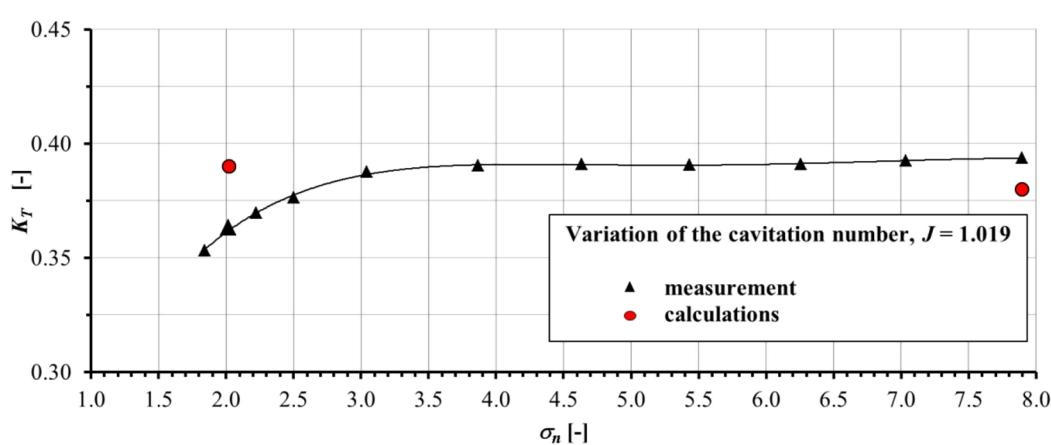
Suction side



40 %  
vapour  
fraction

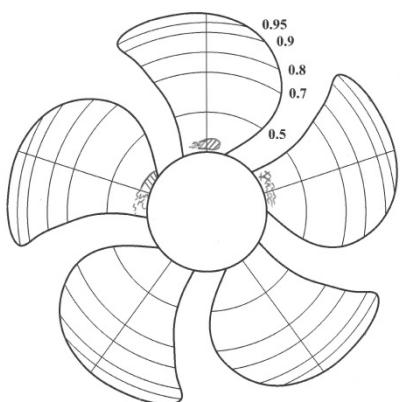


KT non-cav = 0.380  
 KT cav = 0.390



## 2.17 Case 2.1, UniGenoa-StarCCM+

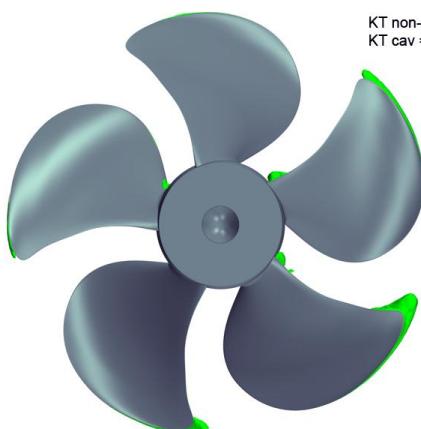
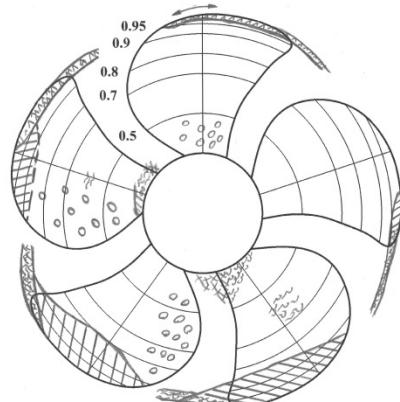
Pressure side



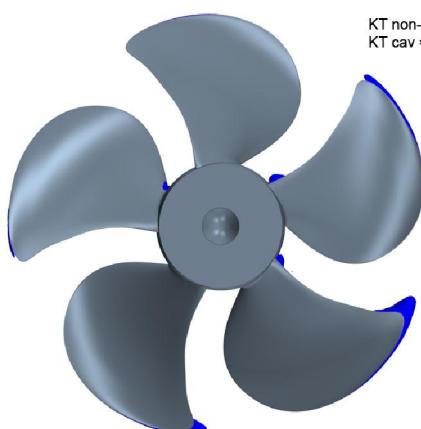
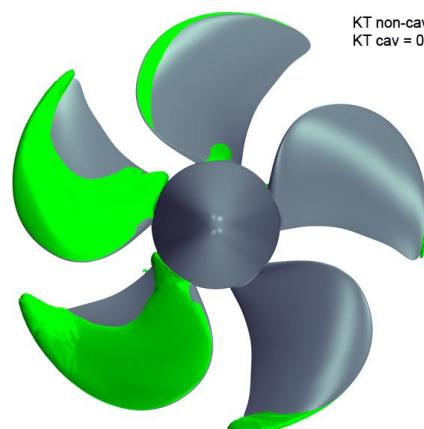
**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

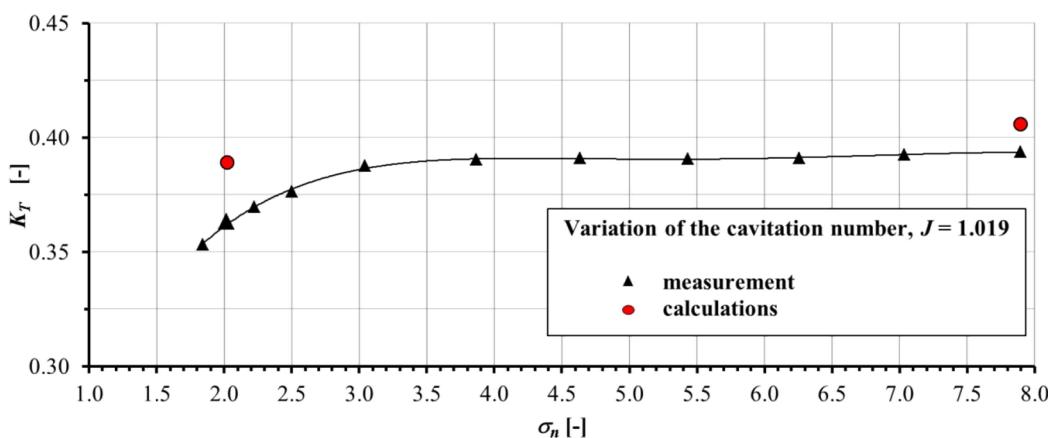
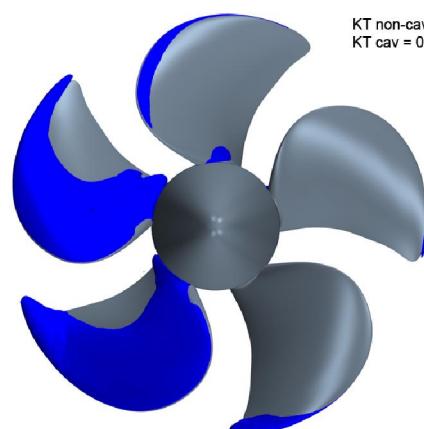
Suction side



40 %  
vapour  
fraction

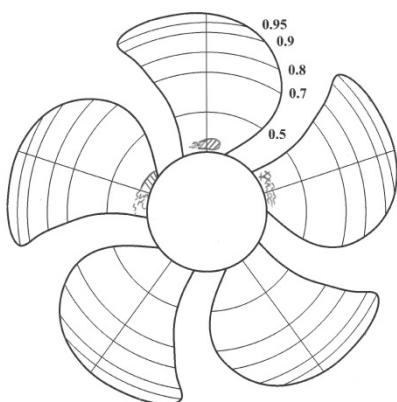


60 %  
vapour  
fraction



## 2.18 Case 2.1, VTT-FinFlo

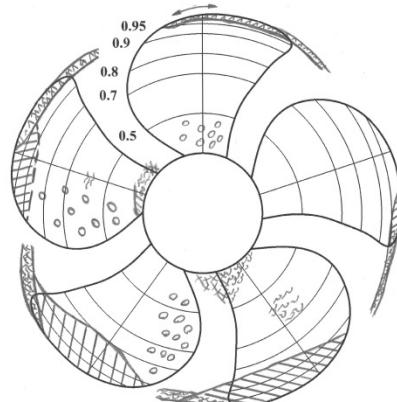
Pressure side



**Case 2.1**

$$\begin{aligned} J &= 1.019 \\ \sigma_n &= 2.024 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



VTT-FINFLO

KT non-cav = 0.401  
 KT cav = 0.375

40 %  
 vapour  
 fraction

VTT-FINFLO

KT non-cav = 0.401  
 KT cav = 0.375

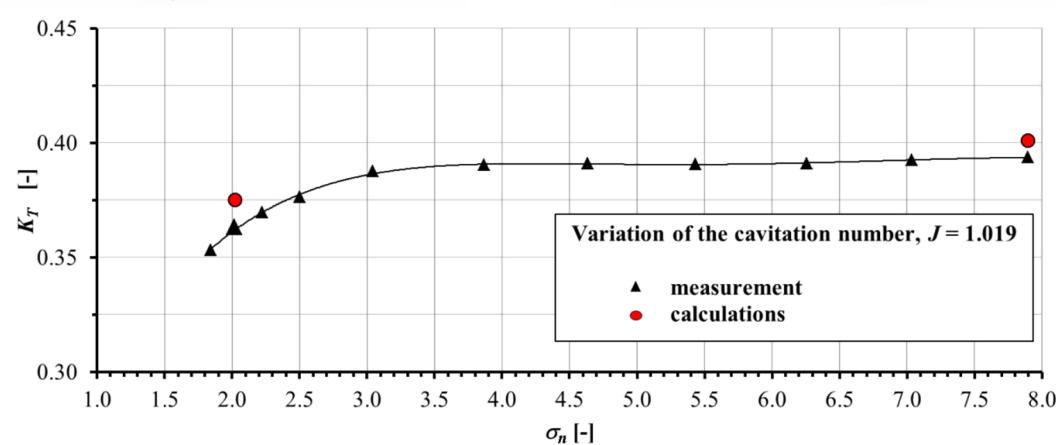
VTT-FINFLO

KT non-cav = 0.401  
 KT cav = 0.375

60 %  
 vapour  
 fraction

VTT-FINFLO

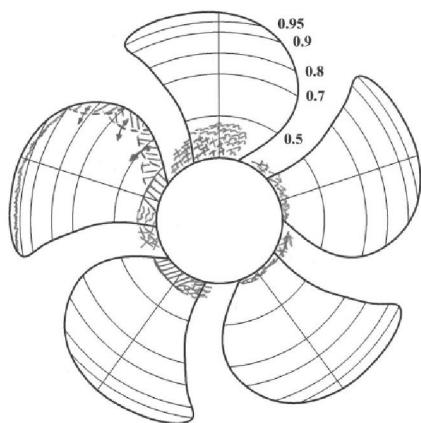
KT non-cav = 0.401  
 KT cav = 0.375



### 3 Case 2.2

#### 3.1 Case 2.2, ACCUSIM-CFX-FCM

Pressure side

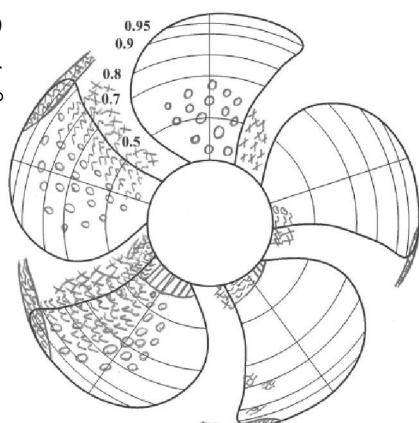


ACCUSIM-CFX-FCM

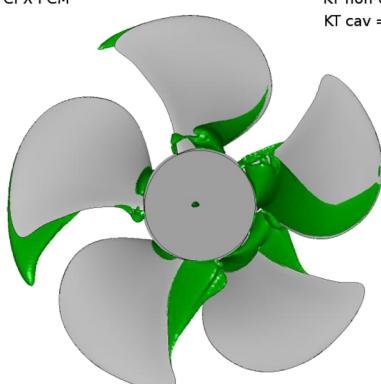
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

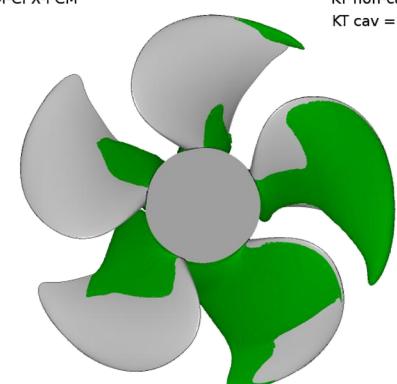
Suction side



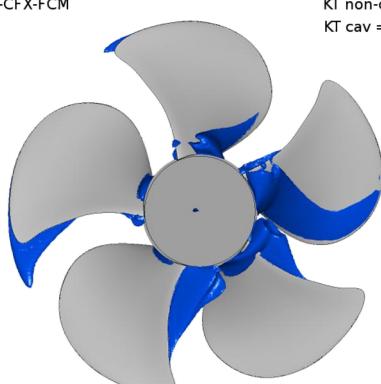
KT non-cav = 0.255  
 KT cav = 0.173



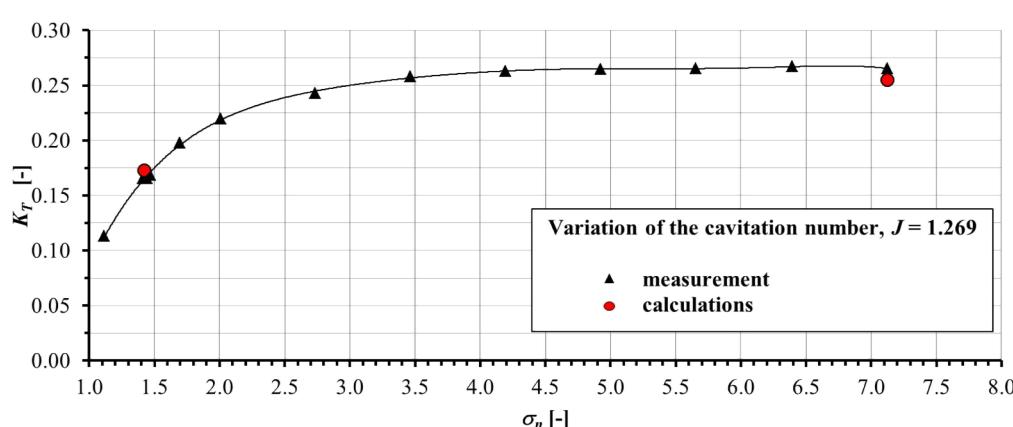
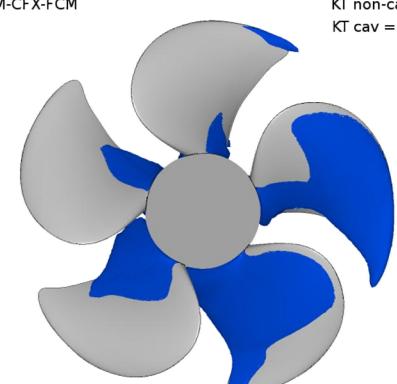
40 %  
 vapour  
 fraction



KT non-cav = 0.255  
 KT cav = 0.173

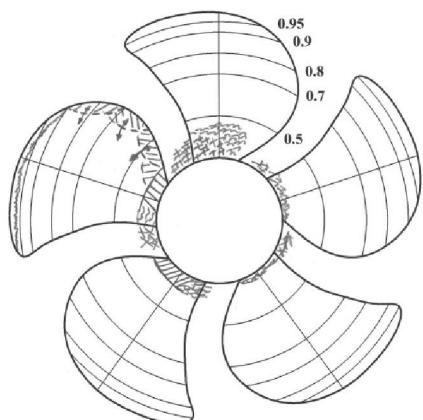


60 %  
 vapour  
 fraction



### 3.2 Case 2.2, ACCUSIM-CFX-Kunz

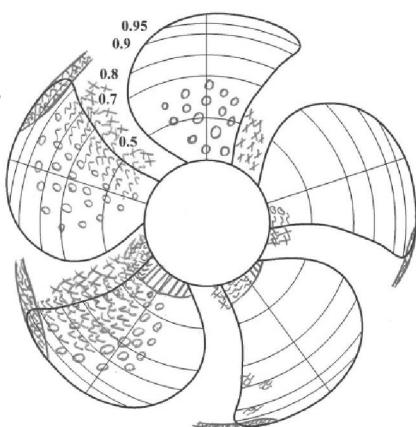
Pressure side



ACCUSIM-CFX-KUNZ

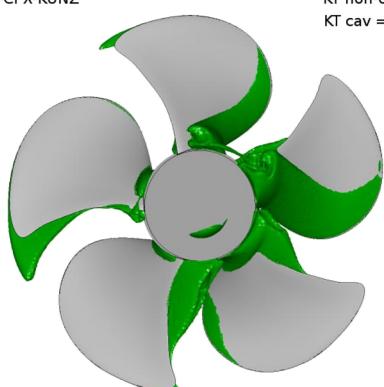
$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

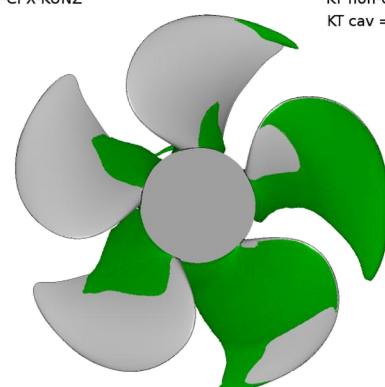


ACCUSIM-CFX-KUNZ

$$\begin{aligned} \text{KT non-cav} &= 0.255 \\ \text{KT cav} &= 0.166 \end{aligned}$$

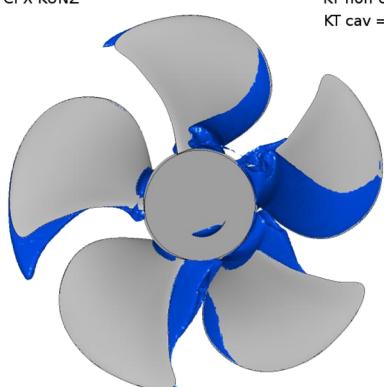


40 %  
vapour  
fraction



ACCUSIM-CFX-KUNZ

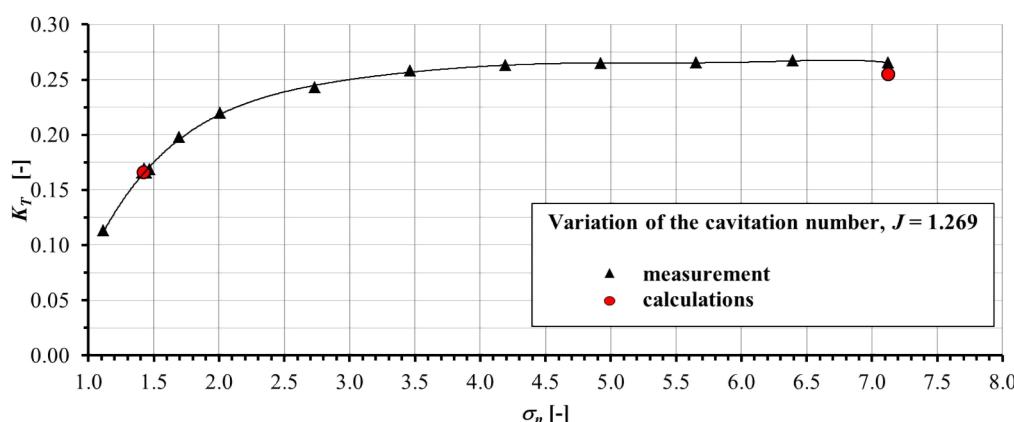
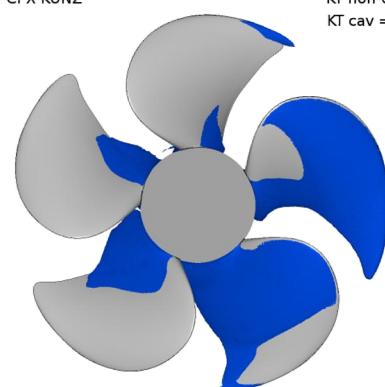
$$\begin{aligned} \text{KT non-cav} &= 0.255 \\ \text{KT cav} &= 0.166 \end{aligned}$$



60 %  
vapour  
fraction

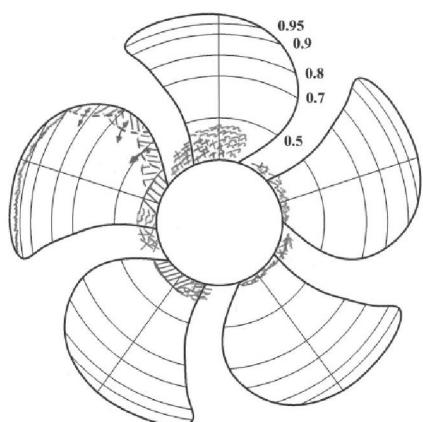
ACCUSIM-CFX-KUNZ

$$\begin{aligned} \text{KT non-cav} &= 0.255 \\ \text{KT cav} &= 0.166 \end{aligned}$$



### 3.3 Case 2.2, ACCUSIM-CFX-Zwart

Pressure side

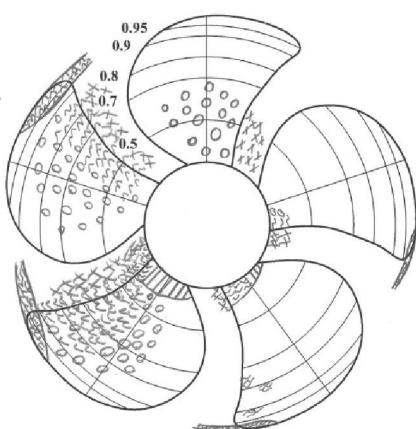


ACCUSIM-CFX-ZWART

**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

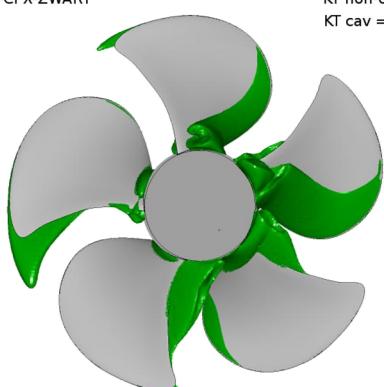
Suction side



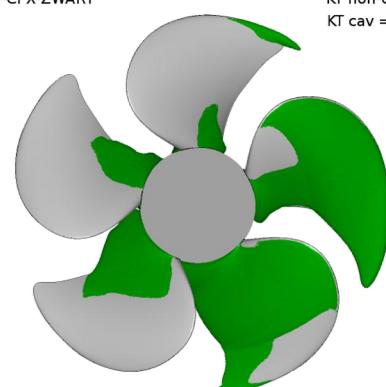
ACCUSIM-CFX-ZWART

KT non-cav = 0.255

KT cav = 0.166



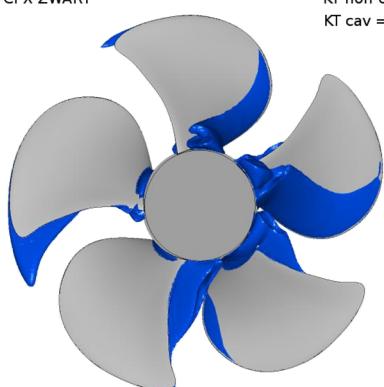
40 %  
vapour  
fraction



ACCUSIM-CFX-ZWART

KT non-cav = 0.255

KT cav = 0.166

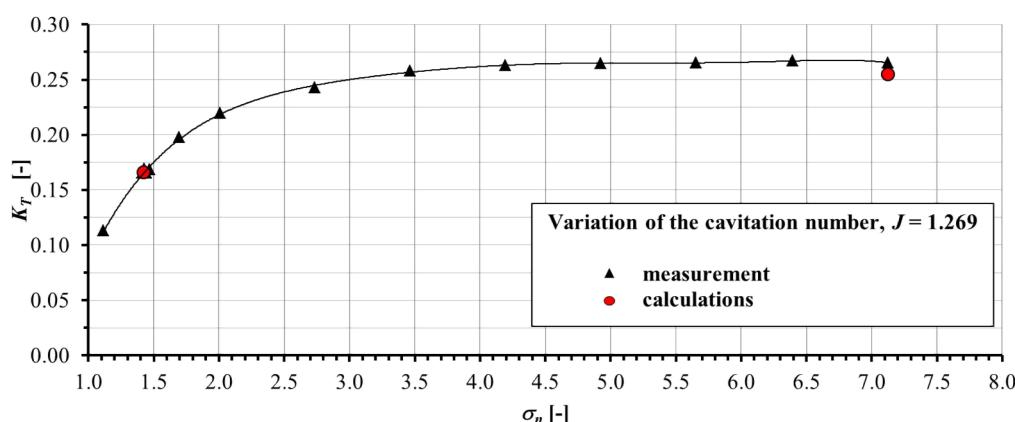
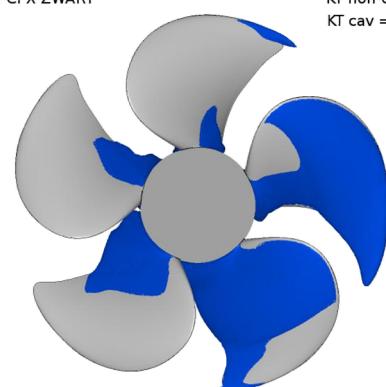


60 %  
vapour  
fraction

ACCUSIM-CFX-ZWART

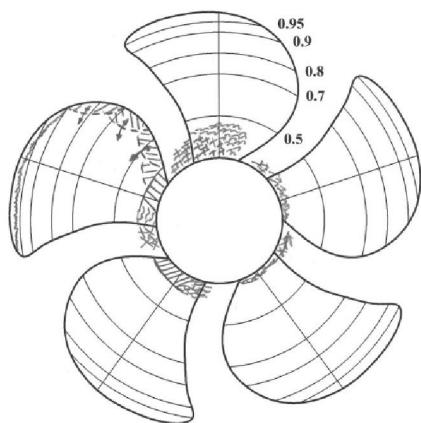
KT non-cav = 0.255

KT cav = 0.166



### 3.4 Case 2.2, CAT-OF

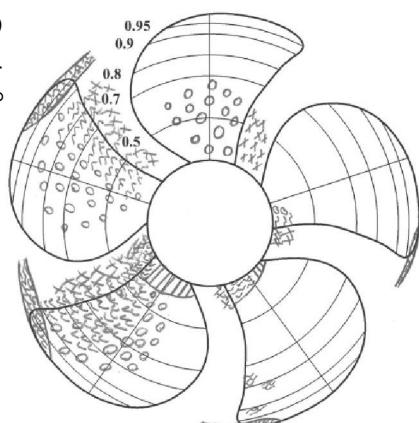
Pressure side



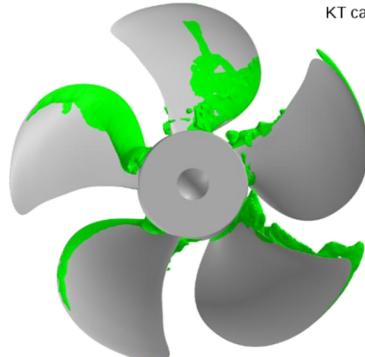
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

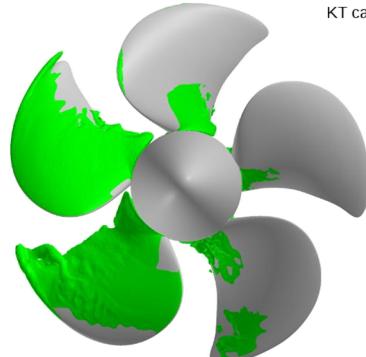


CAT-OpenFOAM



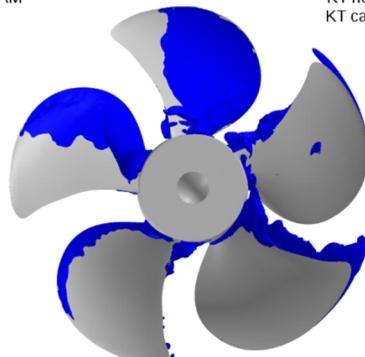
40 %  
vapour  
fraction

CAT-OpenFOAM



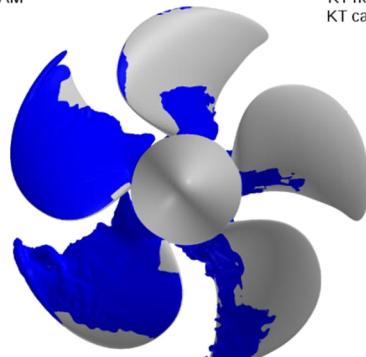
KT non-cav = 0.287  
 KT cav = 0.157

CAT-OpenFOAM

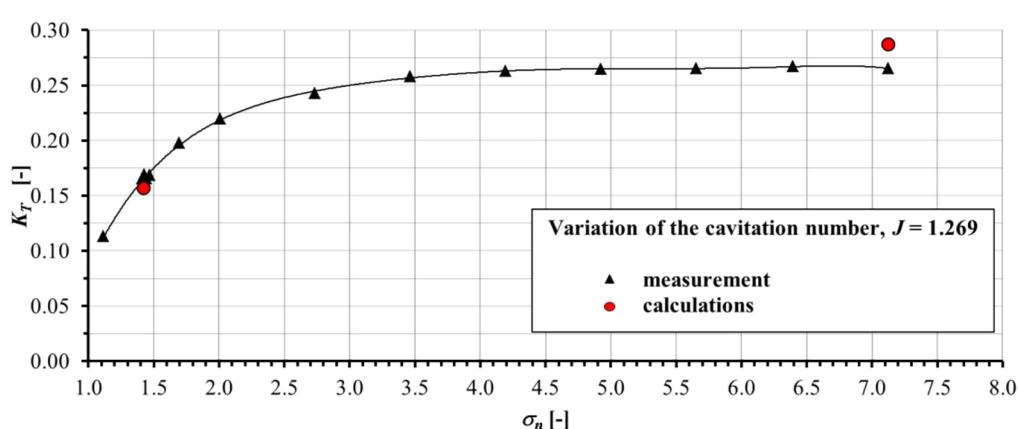


60 %  
vapour  
fraction

CAT-OpenFOAM

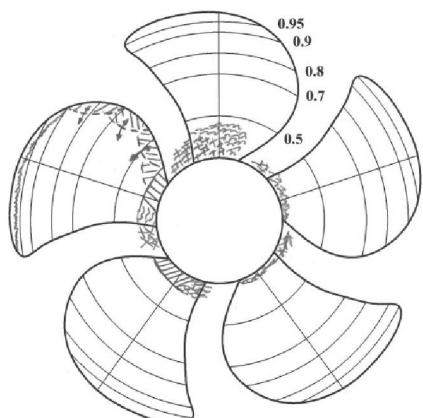


KT non-cav = 0.287  
 KT cav = 0.157



### 3.5 Case 2.2, Chalmers-OF

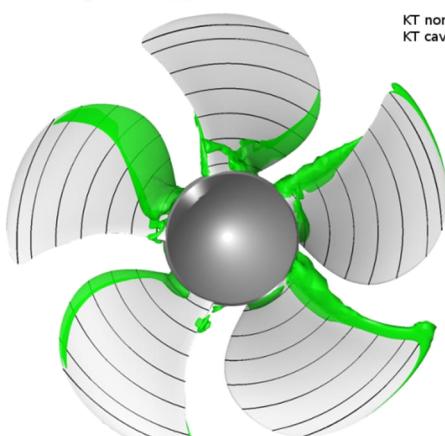
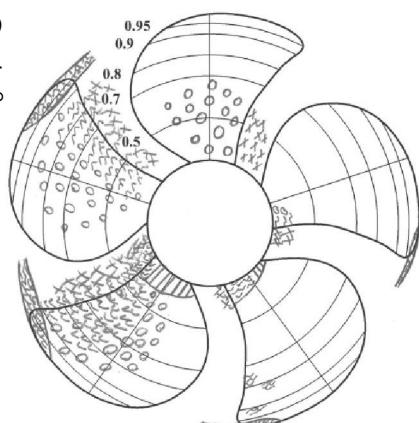
Pressure side



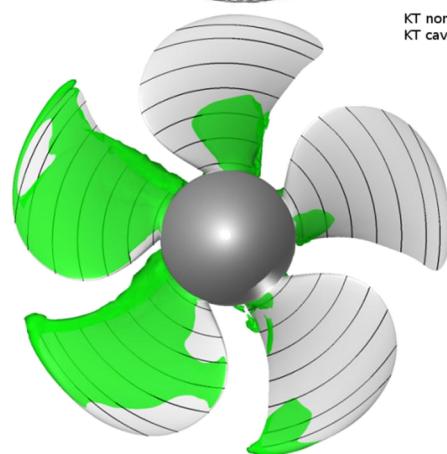
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

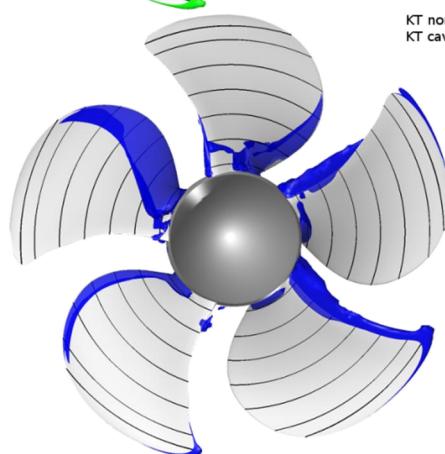
Suction side



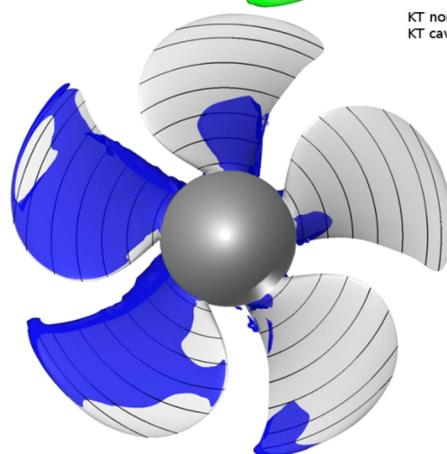
40 %  
vapour  
fraction



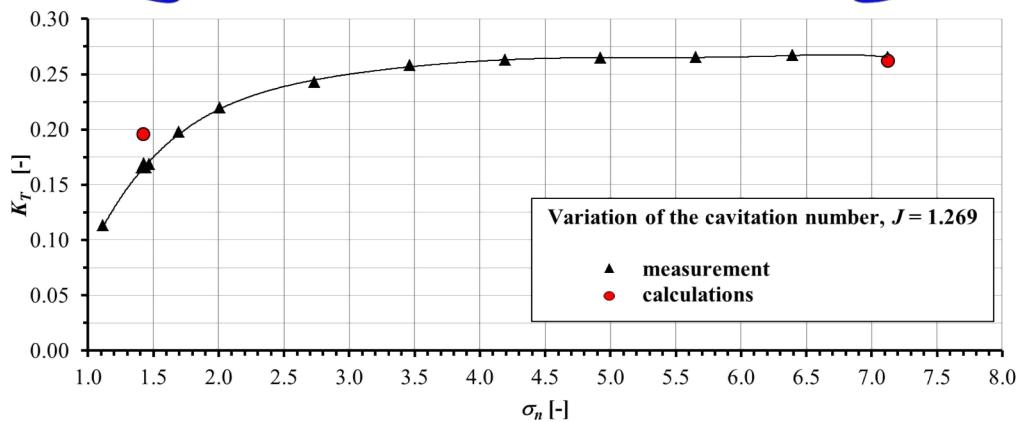
KT non-cav=0.262  
 KT cav=0.196



60 %  
vapour  
fraction

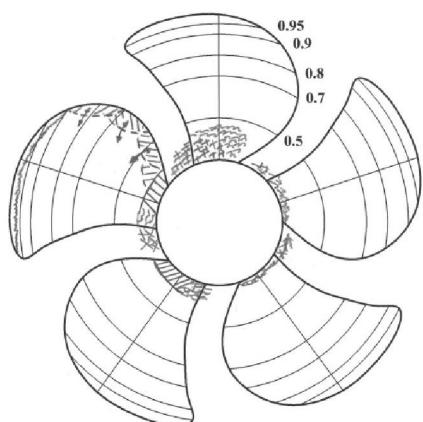


KT non-cav=0.262  
 KT cav=0.196



### 3.6 Case 2.2, CNRS-ISIS

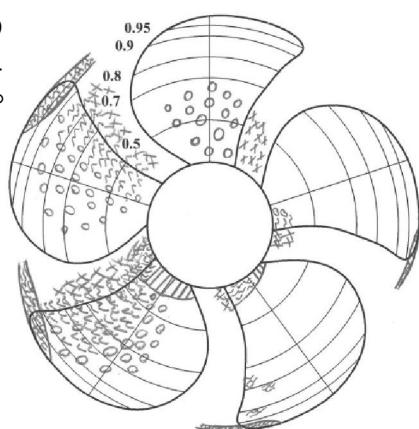
Pressure side



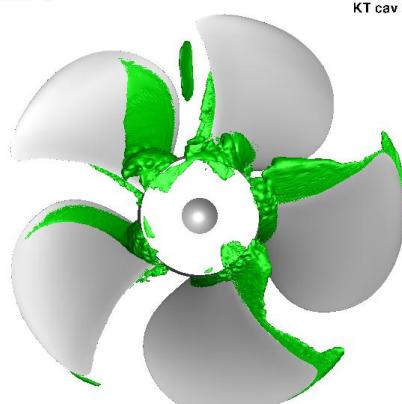
CNRS-ECN ISIS-CFD

**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

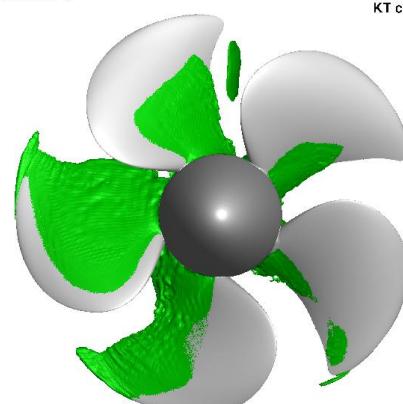


Suction side

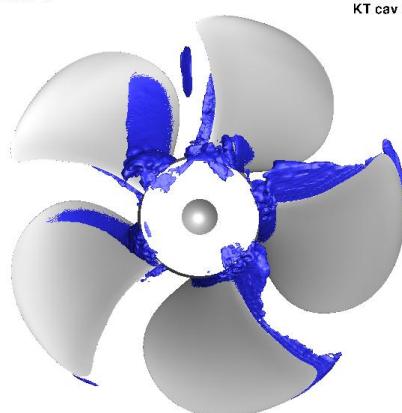


CNRS-ECN ISIS-CFD

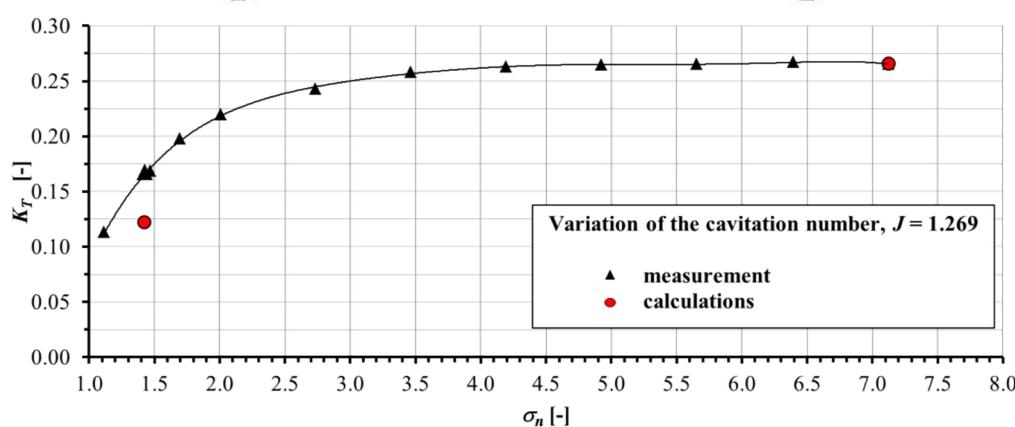
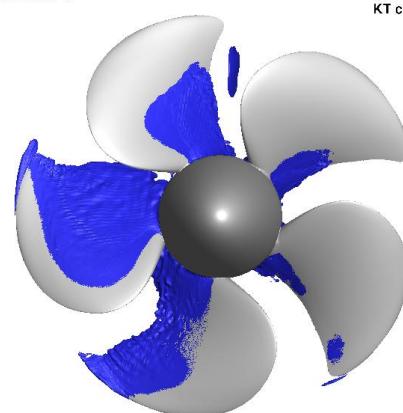
40 %  
vapour  
fraction



KT non-cav = 0.266  
 KT cav = 0.122

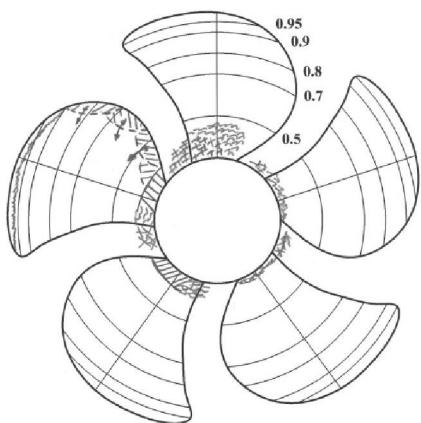


60 %  
vapour  
fraction



### 3.7 Case 2.2, CRADLE-SCTetra

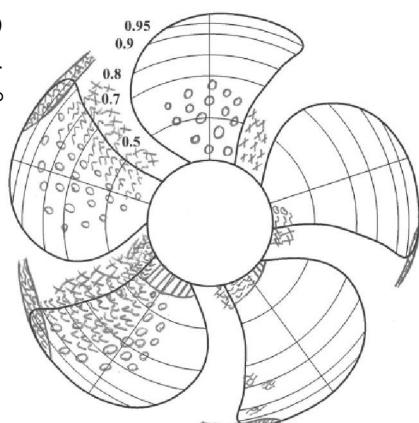
Pressure side



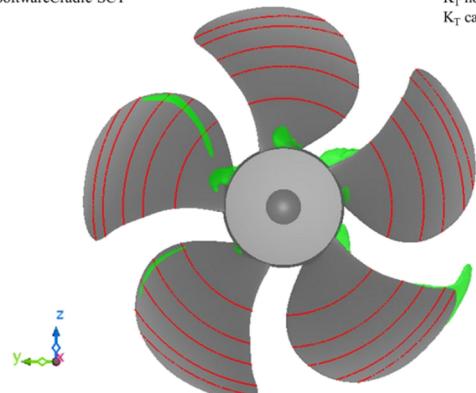
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

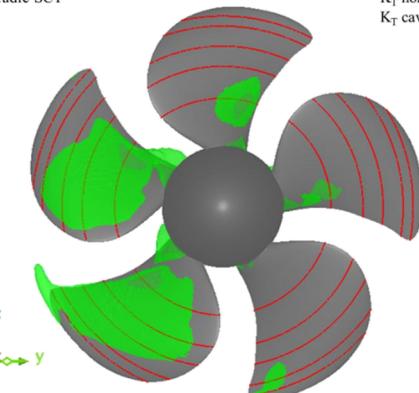


SoftwareCradle-SCT



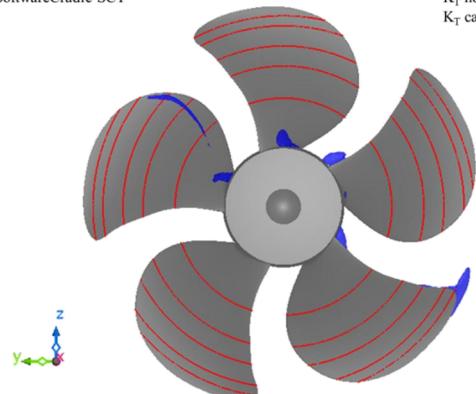
$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212

SoftwareCradle-SCT



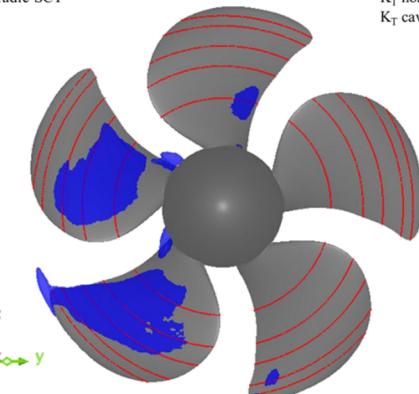
$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212

SoftwareCradle-SCT

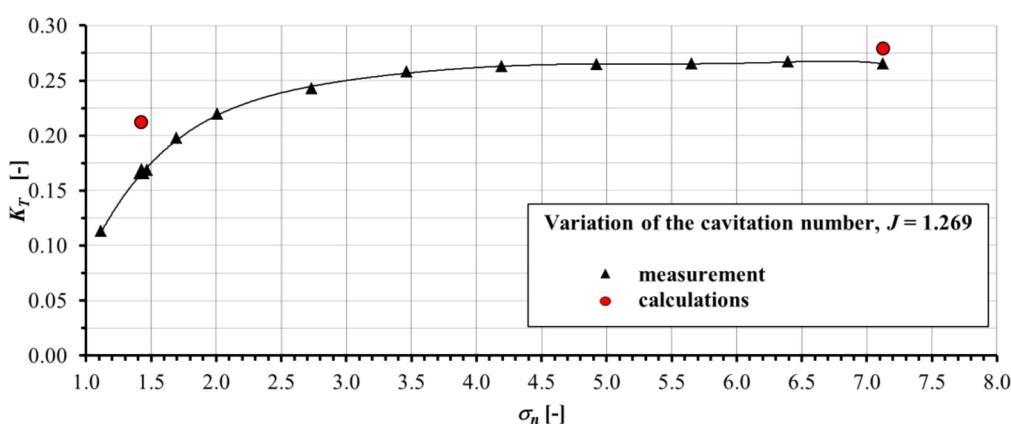


$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212

SoftwareCradle-SCT

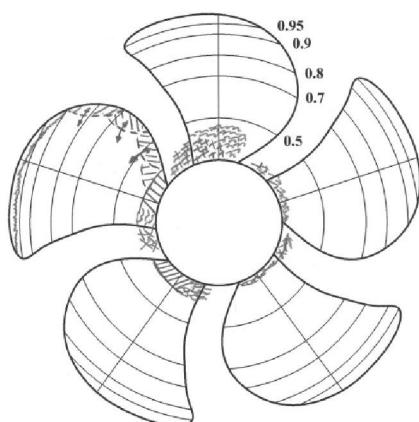


$K_T$  non-cav = 0.279  
 $K_T$  cav = 0.212



### 3.8 Case 2.2, CSSRC-Fluent

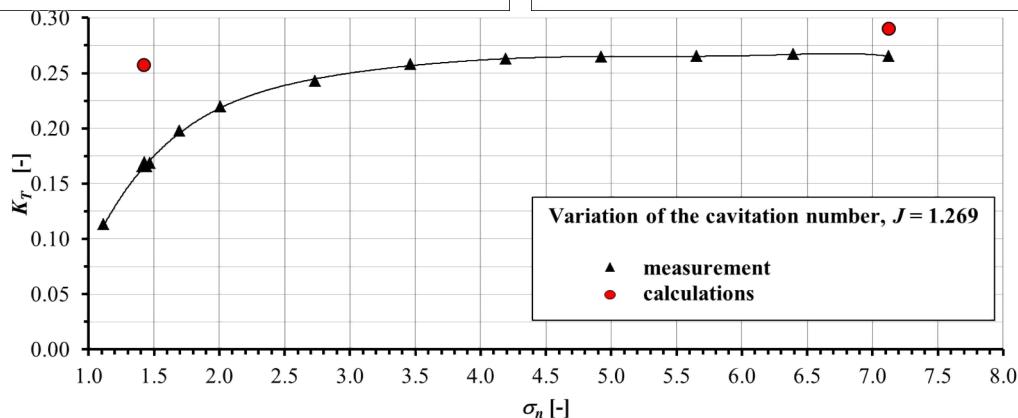
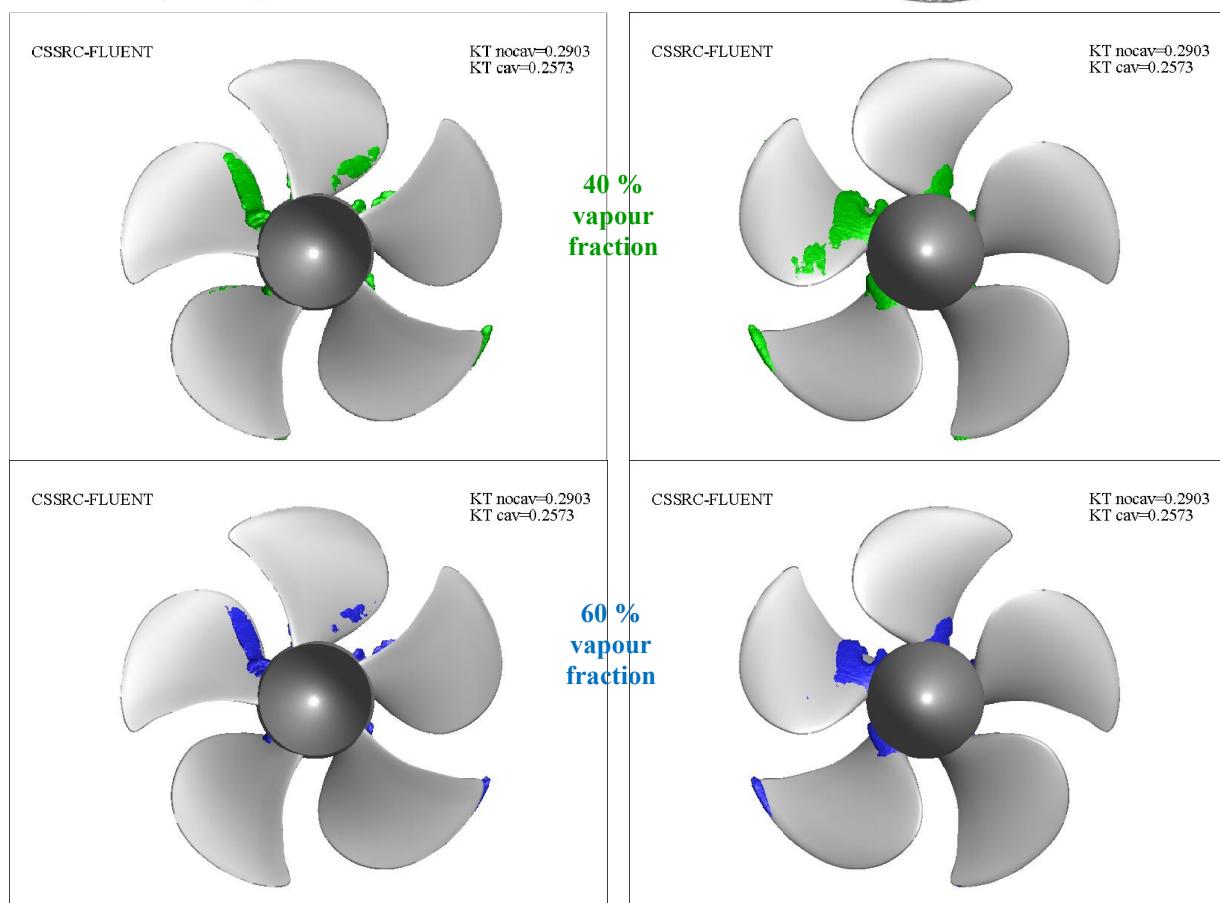
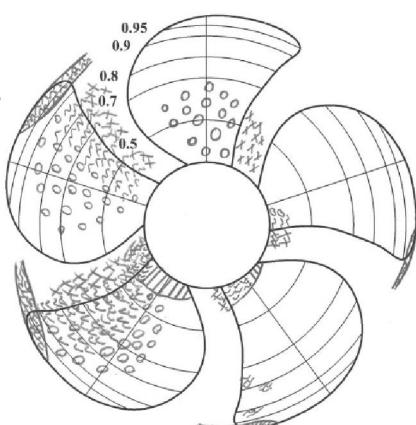
Pressure side



**Case 2.2**

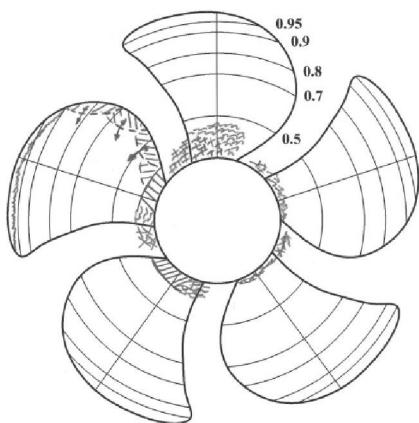
$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



### 3.9 Case 2.2, ROTAM-Fluent

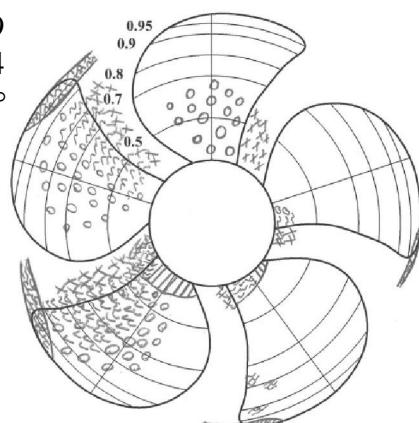
Pressure side



ROTAM-ANSYS

**Case 2.2**

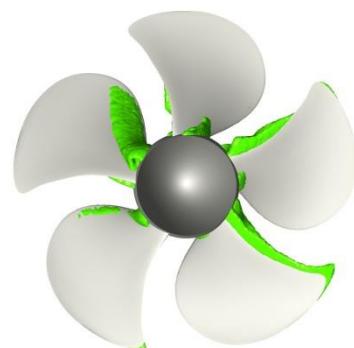
$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$



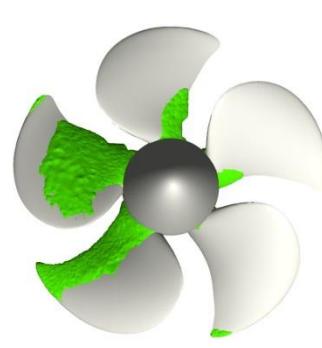
Suction side

KT non-cav = 0.293    ROTAM-ANSYS  
 KT cav = 0.218

KT non-cav = 0.293  
 KT cav = 0.218



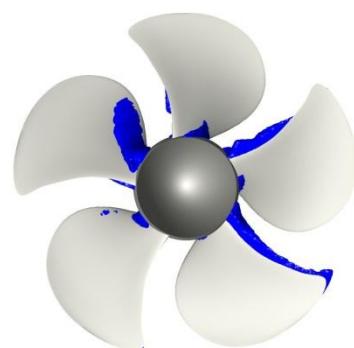
40 %  
vapour  
fraction



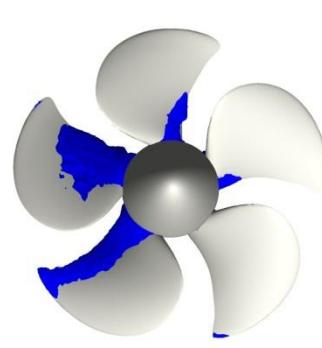
Z  
Y  
X

ROTAM-ANSYS

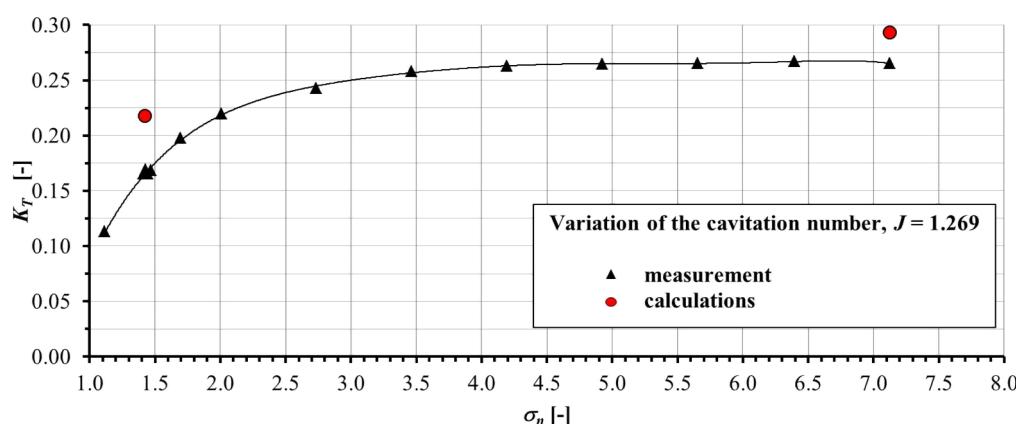
KT non-cav = 0.293    ROTAM-ANSYS  
 KT cav = 0.218



60 %  
vapour  
fraction

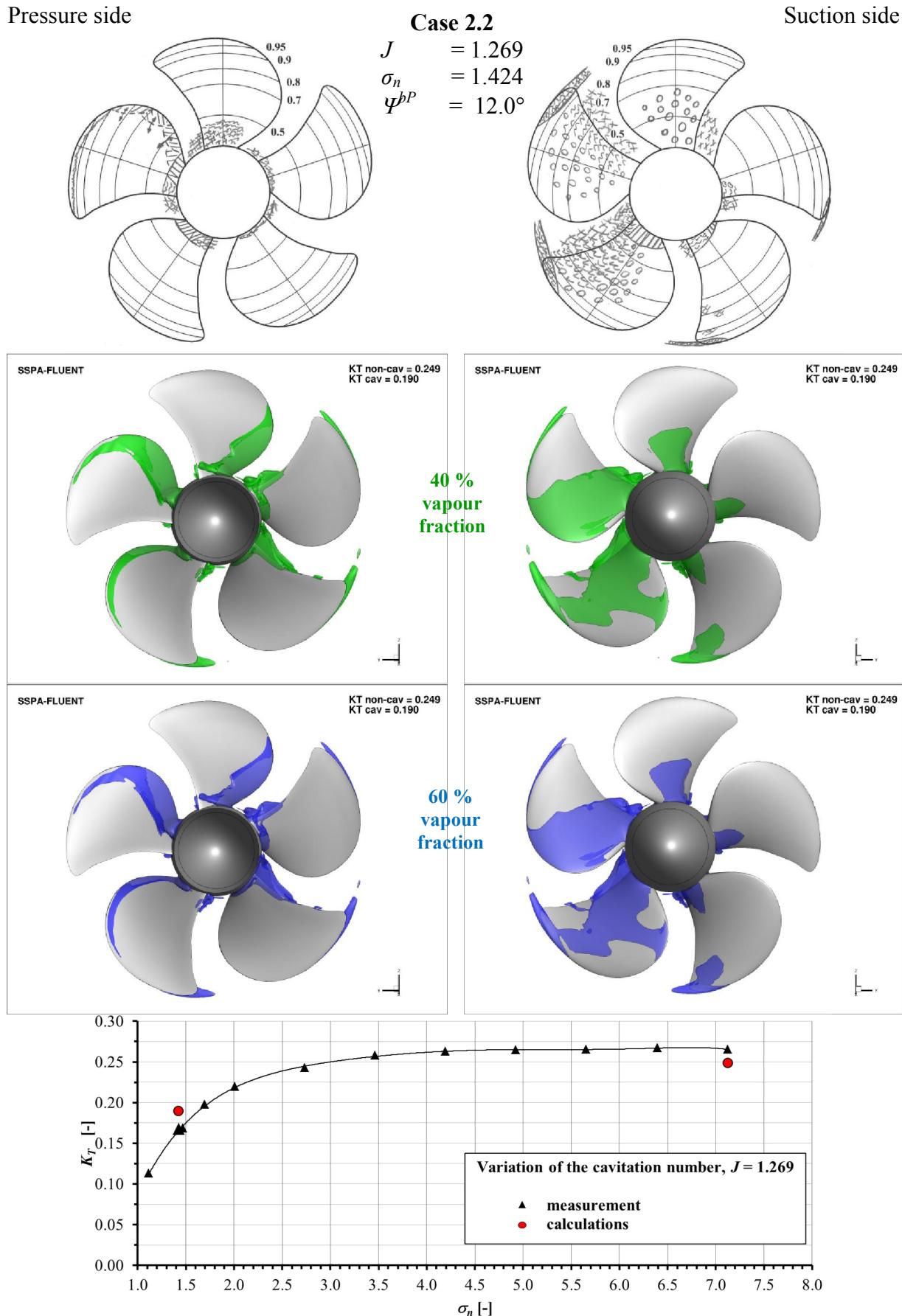


Z  
Y  
X



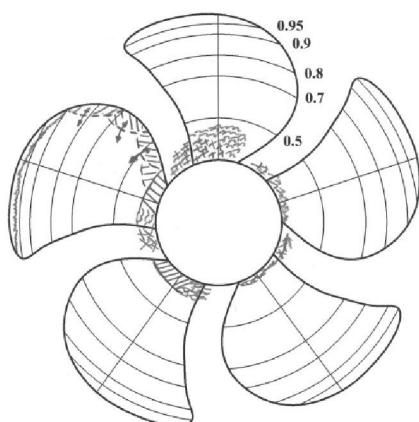
### 3.10 Case 2.2, SSPA-Fluent-Sauer

## Pressure side



### 3.11 Case 2.2, SSPA-Fluent-Zwart1

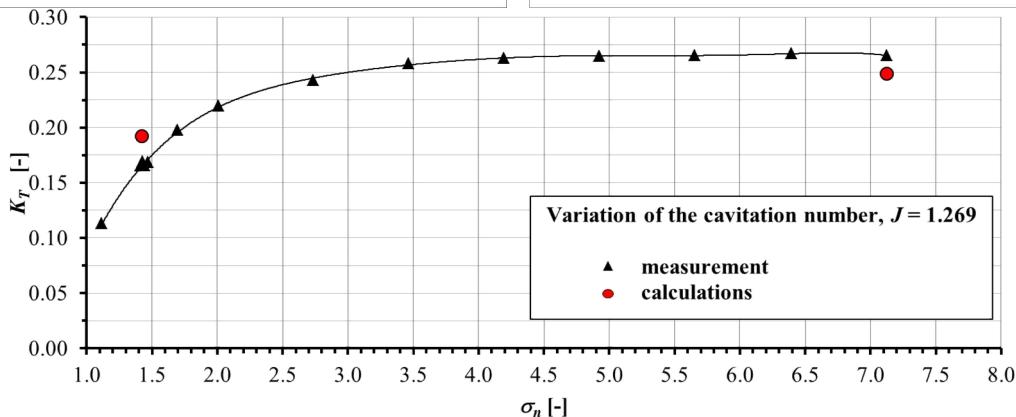
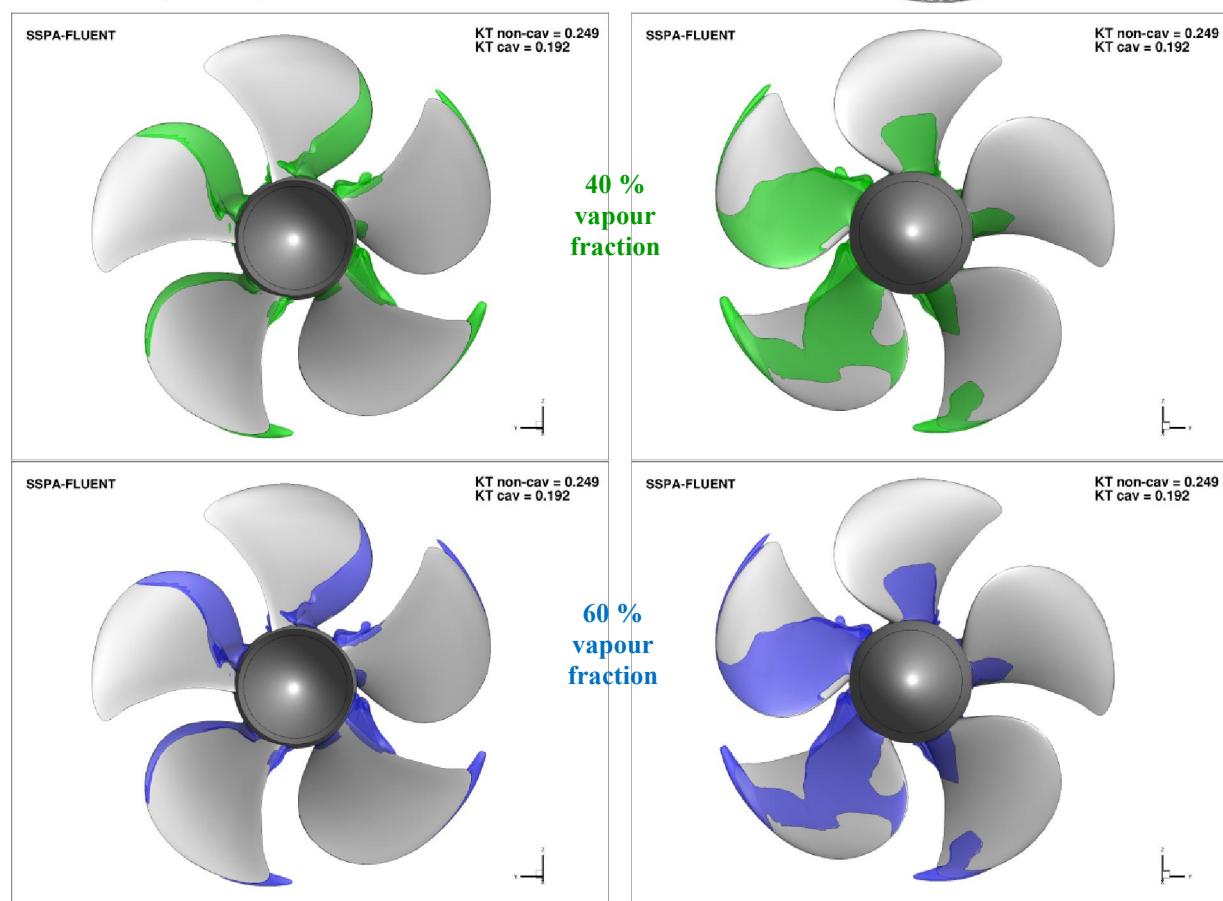
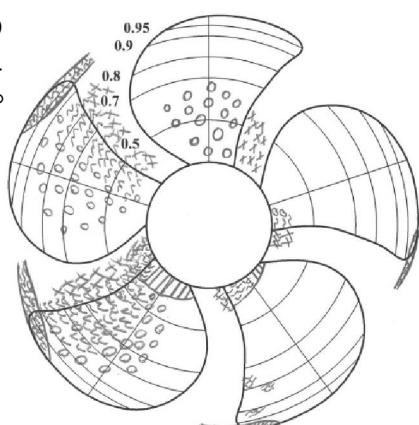
Pressure side



**Case 2.2**

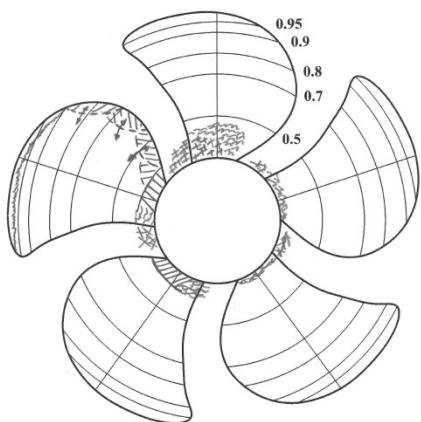
$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



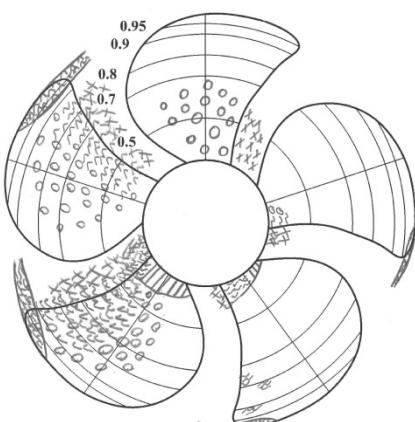
### 3.12 Case 2.2, TUHH-CFX

Pressure side



$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

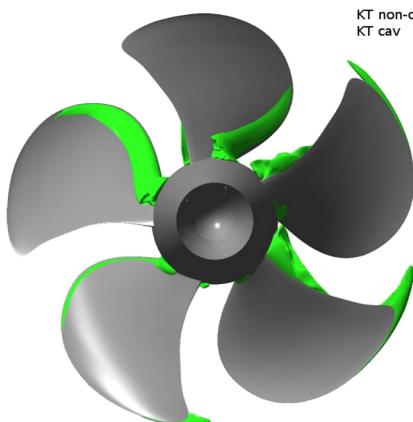


TUHH-CFX

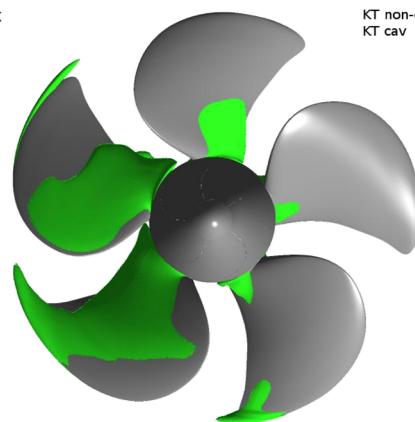
$K_T$  non-cav = 0.2584  
 $K_T$  cav = 0.2045

TUHH-CFX

$K_T$  non-cav = 0.2584  
 $K_T$  cav = 0.2045



40 %  
vapour  
fraction

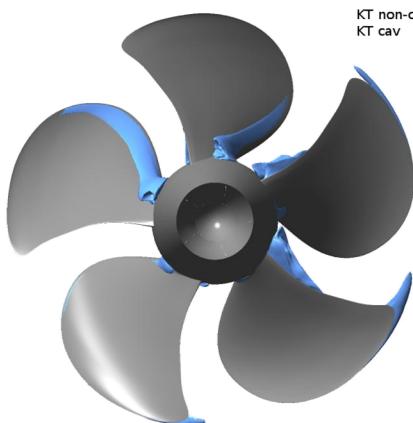


TUHH-CFX

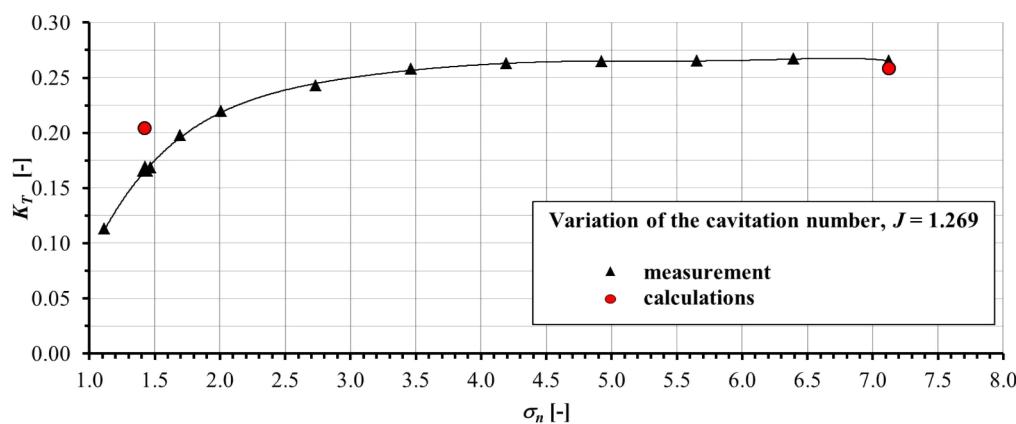
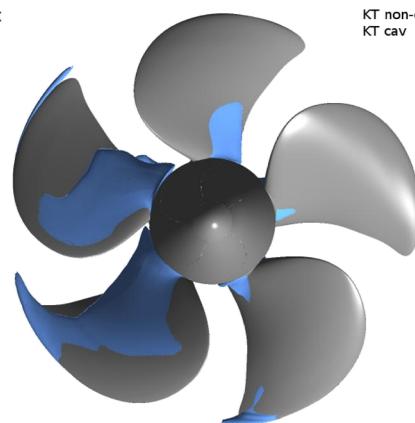
$K_T$  non-cav = 0.2584  
 $K_T$  cav = 0.2045

TUHH-CFX

$K_T$  non-cav = 0.2584  
 $K_T$  cav = 0.2045

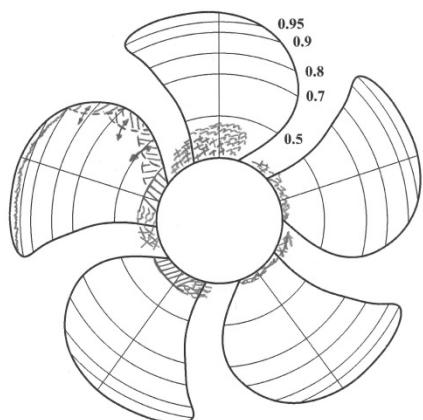


60 %  
vapour  
fraction



### 3.13 Case 2.2, TUHH-panMARE

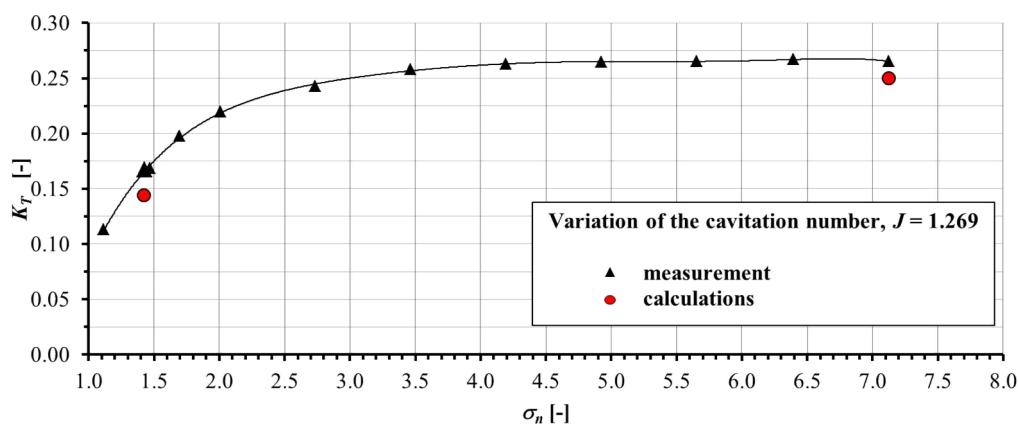
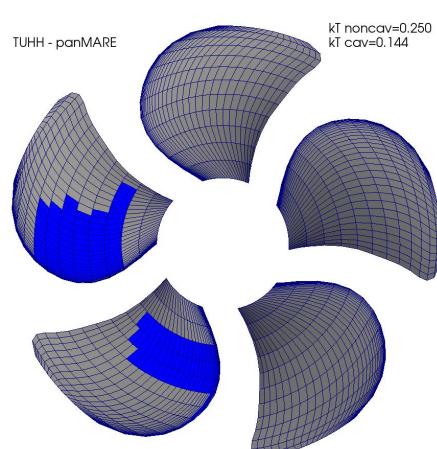
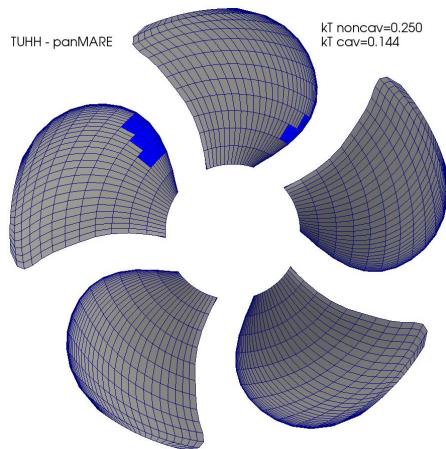
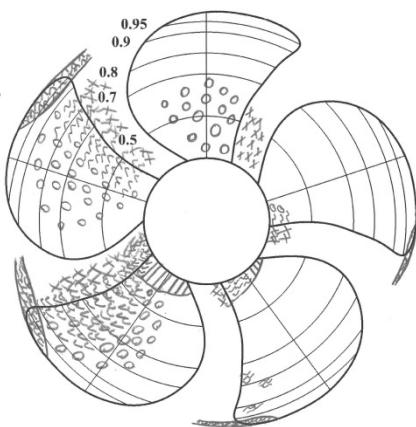
Pressure side



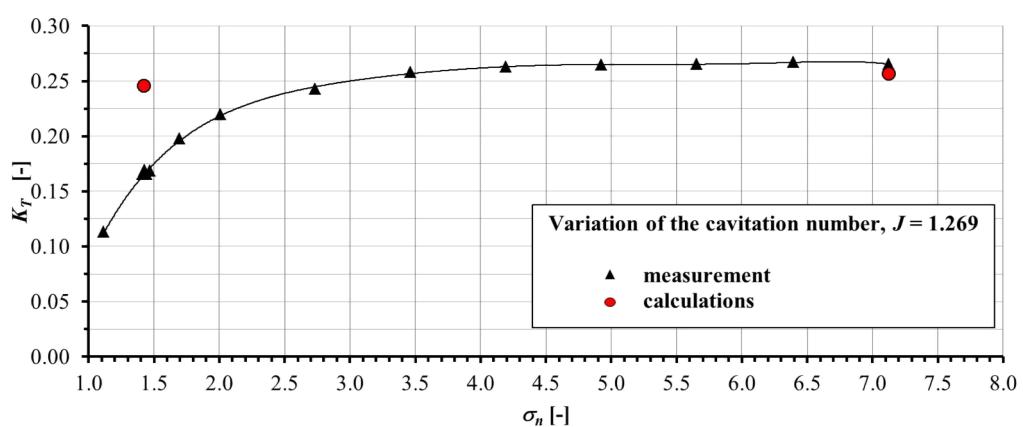
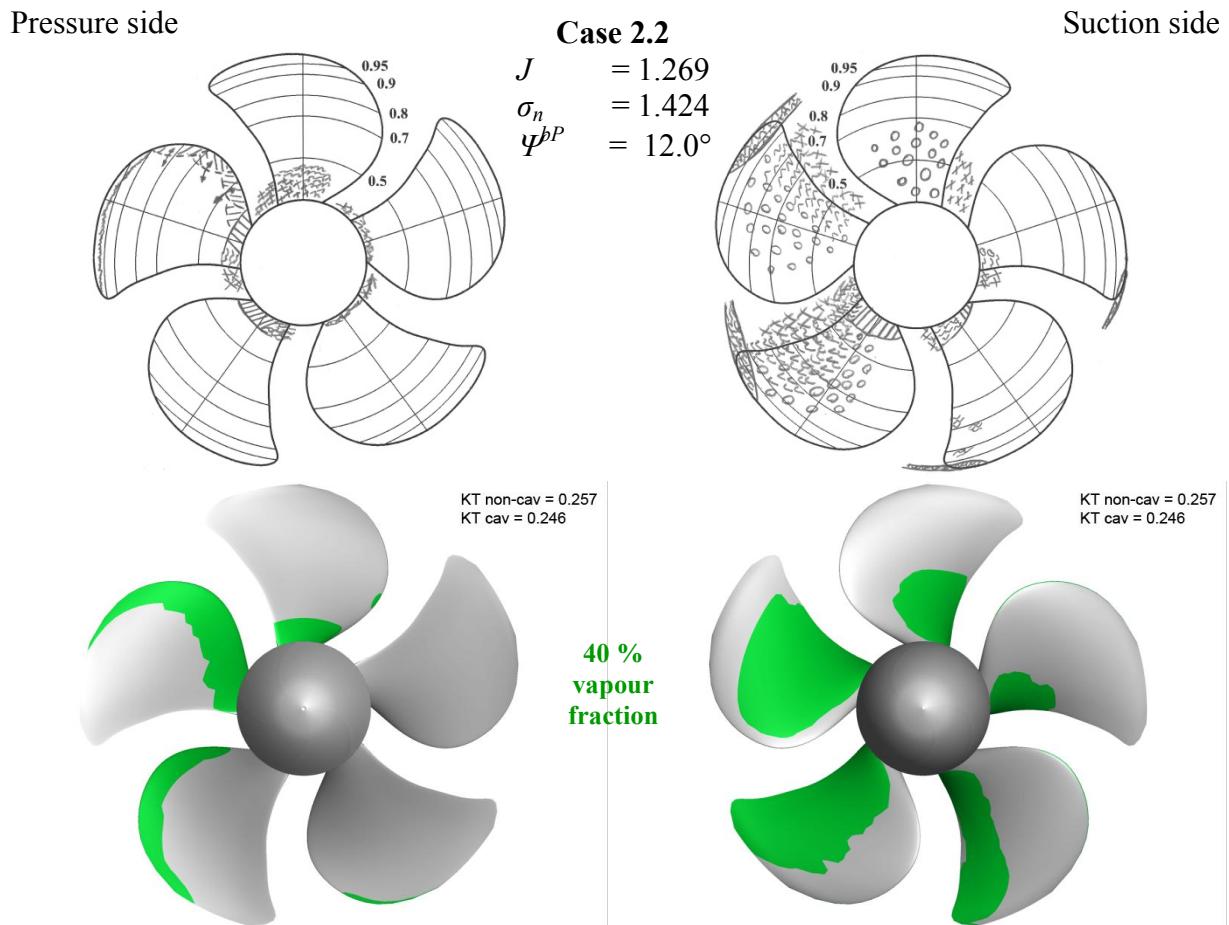
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

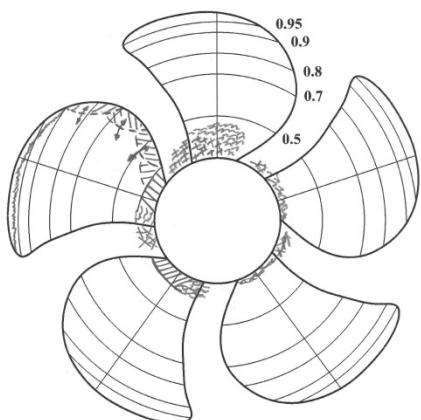


### 3.14 Case 2.2, UniGenoa-BEM



### 3.15 Case 2.2, UniGenoa-StarCCM+

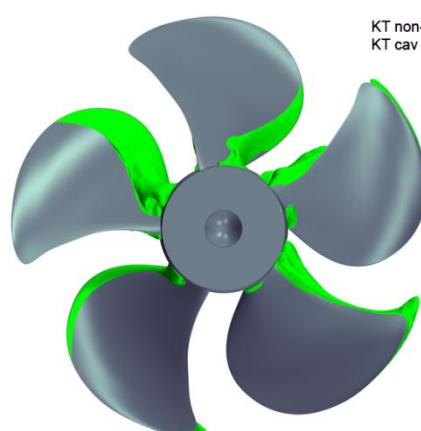
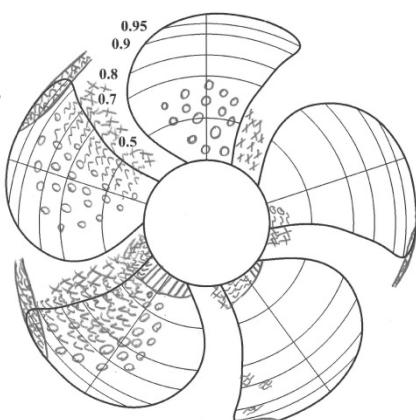
Pressure side



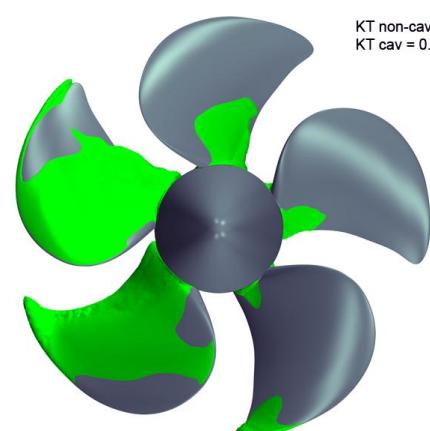
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

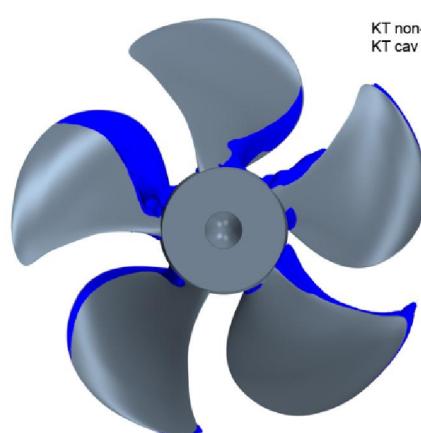
Suction side



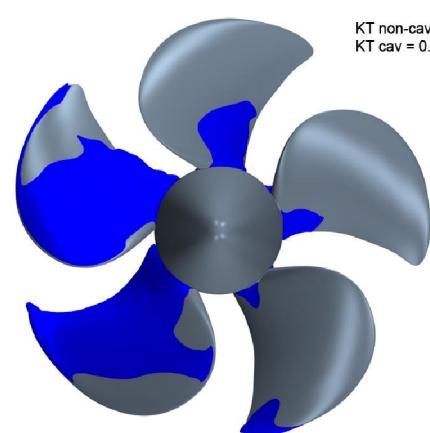
40 %  
vapour  
fraction



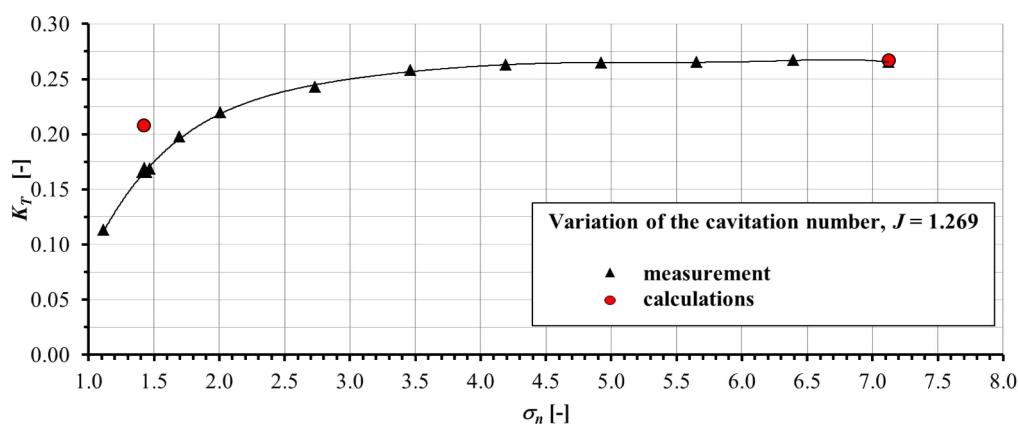
KT non-cav = 0.2673  
 KT cav = 0.2078



60 %  
vapour  
fraction

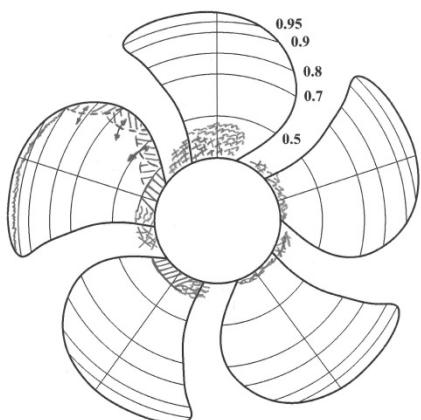


KT non-cav = 0.2673  
 KT cav = 0.2078



### 3.16 Case 2.2, VTT-FinFlo

Pressure side

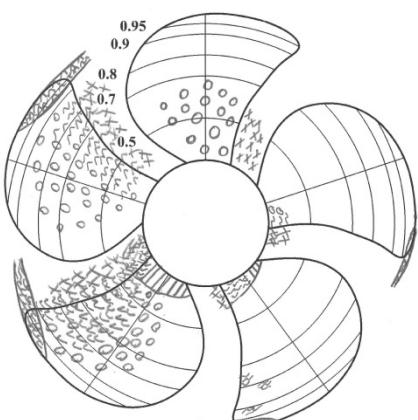


VTT-FINFLO

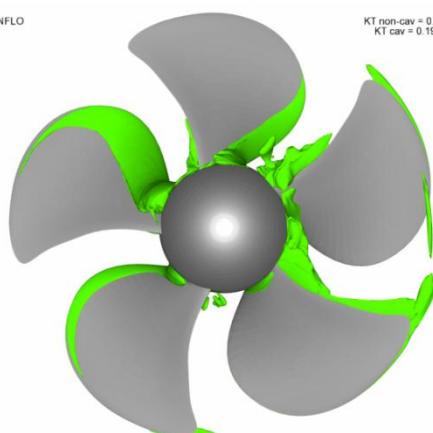
**Case 2.2**

$$\begin{aligned} J &= 1.269 \\ \sigma_n &= 1.424 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

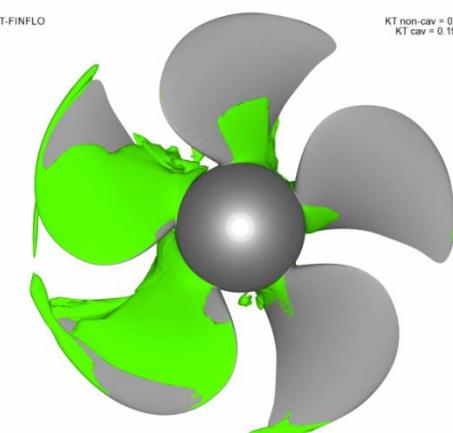
Suction side



VTT-FINFLO

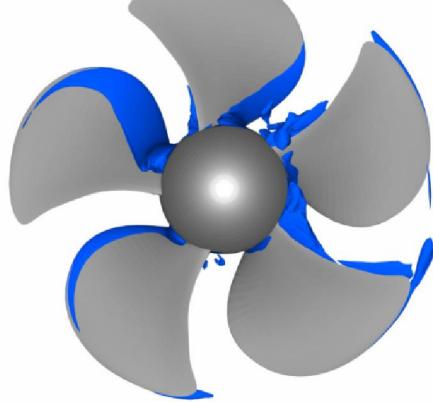


40 %  
vapour  
fraction

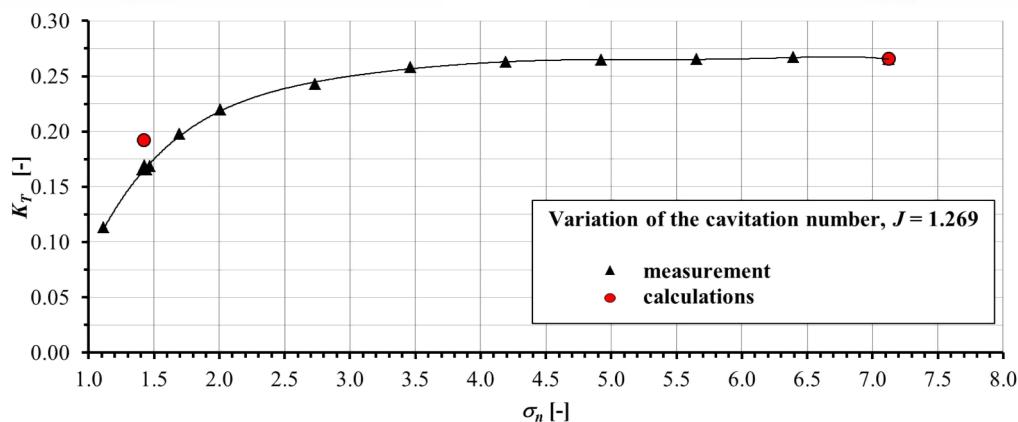
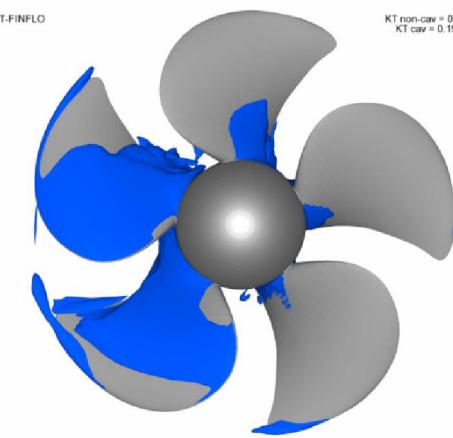


VTT-FINFLO

KT non-cav = 0.286  
 KT cav = 0.192



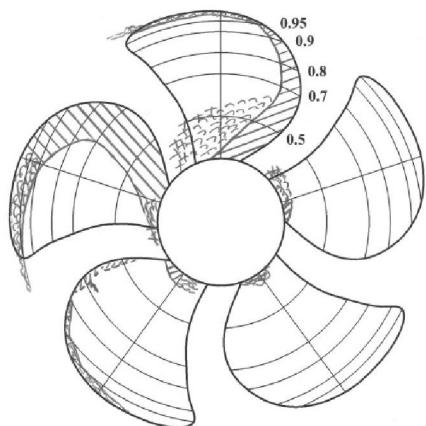
60 %  
vapour  
fraction



## 4 Case 2.3

### 4.1 Case 2.3, ACCUSIM-CFX-FCM

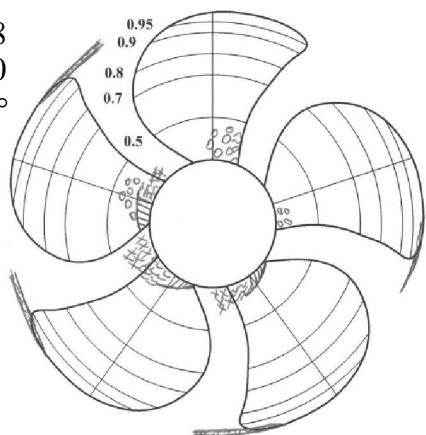
Pressure side



**Case 2.3**

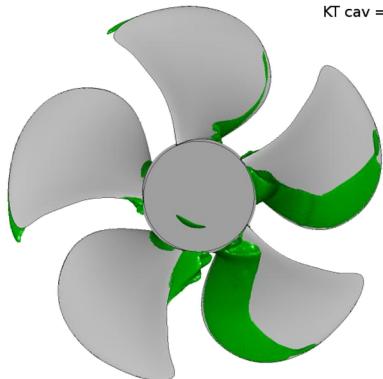
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side



ACCUSIM-CFX-FCM

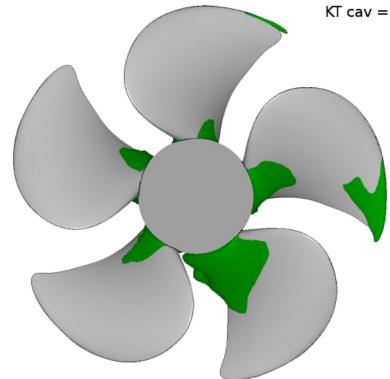
KT non-cav = 0.181  
 KT cav = 0.131



40 %  
 vapour  
 fraction

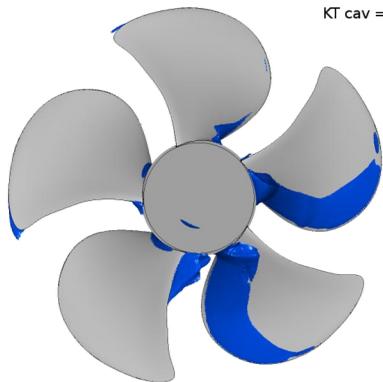
ACCUSIM-CFX-FCM

KT non-cav = 0.181  
 KT cav = 0.131



ACCUSIM-CFX-FCM

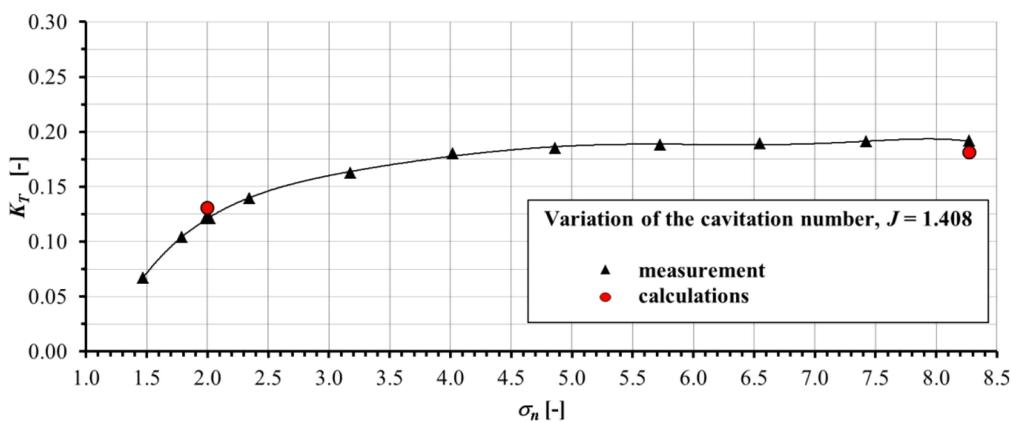
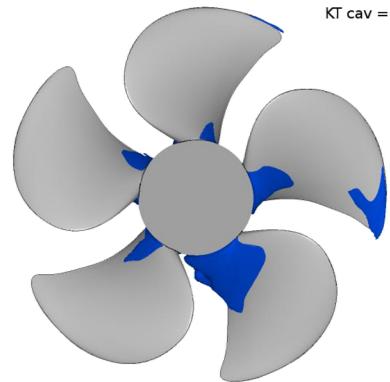
KT non-cav = 0.181  
 KT cav = 0.131



60 %  
 vapour  
 fraction

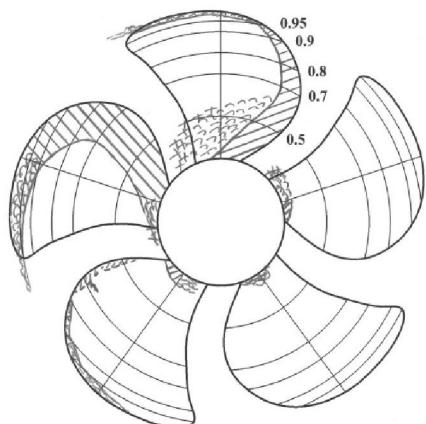
ACCUSIM-CFX-FCM

KT non-cav = 0.181  
 KT cav = 0.131



## 4.2 Case 2.3, ACCUSIM-CFX-Kunz

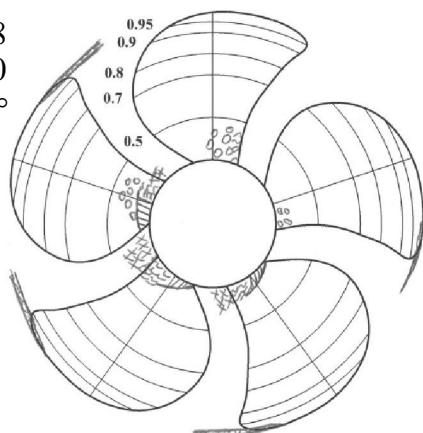
Pressure side



**Case 2.3**

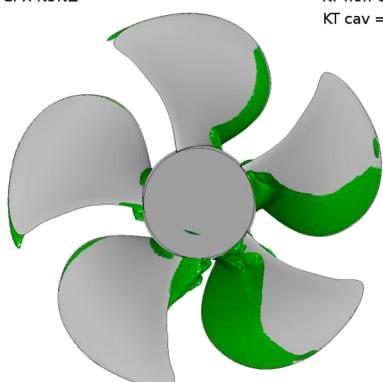
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



ACCUSIM-CFX-KUNZ

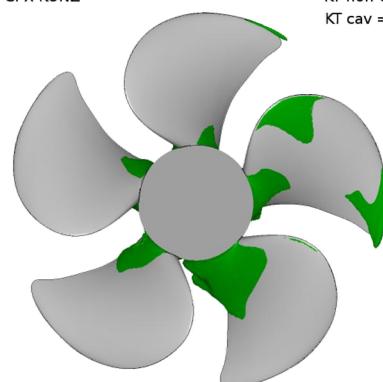
$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.128 \end{aligned}$$



40 %  
vapour  
fraction

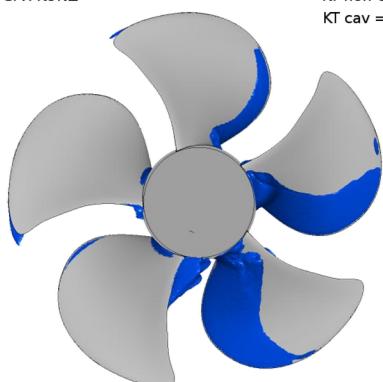
ACCUSIM-CFX-KUNZ

$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.128 \end{aligned}$$



ACCUSIM-CFX-KUNZ

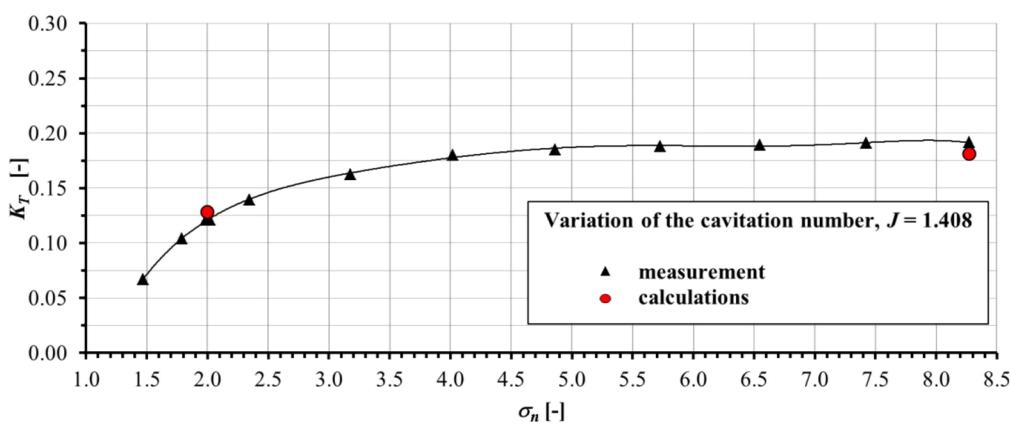
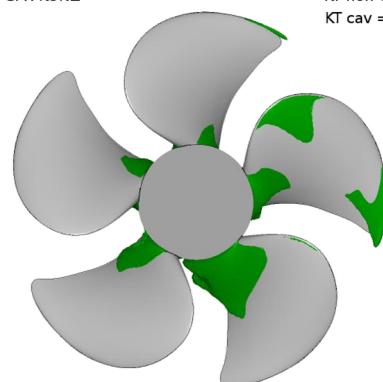
$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.128 \end{aligned}$$



60 %  
vapour  
fraction

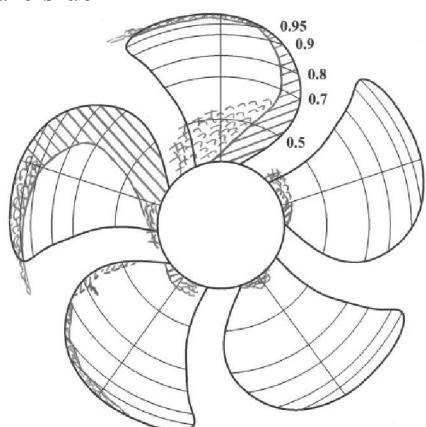
ACCUSIM-CFX-KUNZ

$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.128 \end{aligned}$$



### 4.3 Case 2.3, ACCUSIM-CFX-Zwart

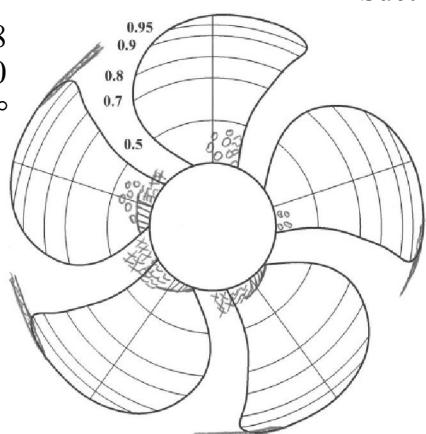
Pressure side



**Case 2.3**

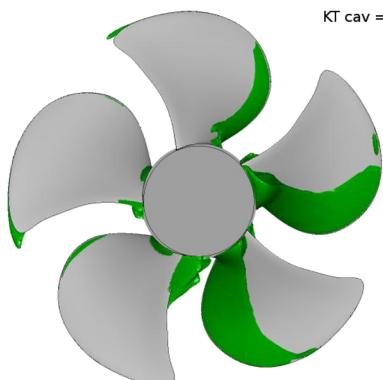
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



ACCUSIM-CFX-ZWART

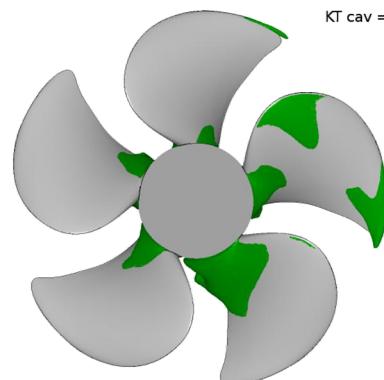
$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.130 \end{aligned}$$



40 %  
vapour  
fraction

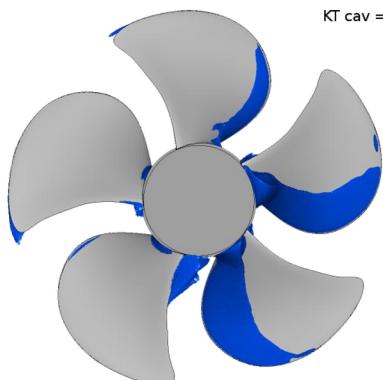
ACCUSIM-CFX-ZWART

$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.130 \end{aligned}$$



ACCUSIM-CFX-ZWART

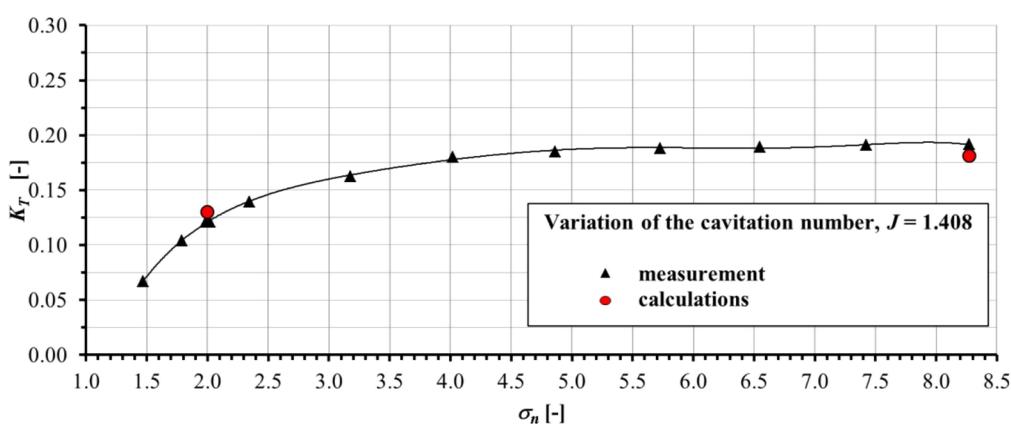
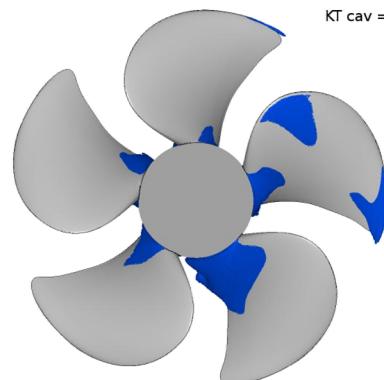
$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.130 \end{aligned}$$



60 %  
vapour  
fraction

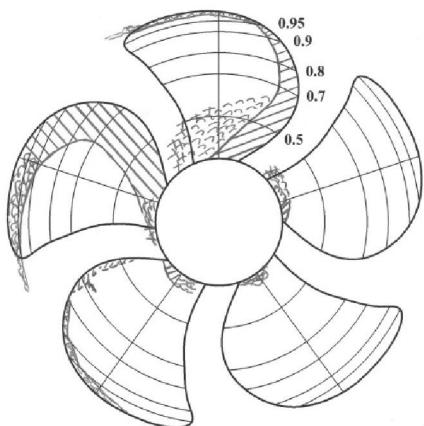
ACCUSIM-CFX-ZWART

$$\begin{aligned} KT \text{ non-cav} &= 0.181 \\ KT \text{ cav} &= 0.130 \end{aligned}$$

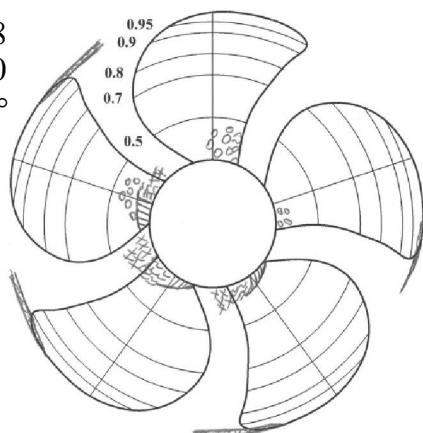


#### 4.4 Case 2.3, CAT-OF

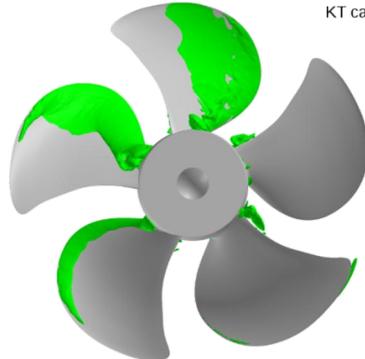
Pressure side



Suction side

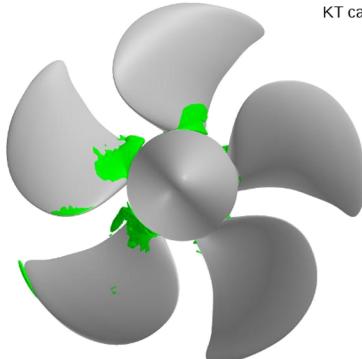


CAT-OpenFOAM



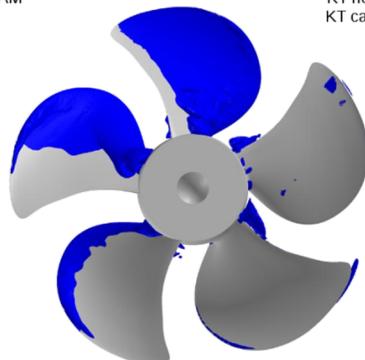
KT non-cav = 0.208  
 KT cav = 0.084

CAT-OpenFOAM



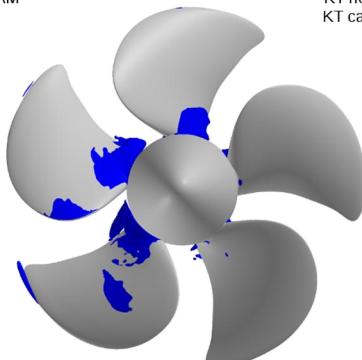
KT non-cav = 0.208  
 KT cav = 0.084

CAT-OpenFOAM

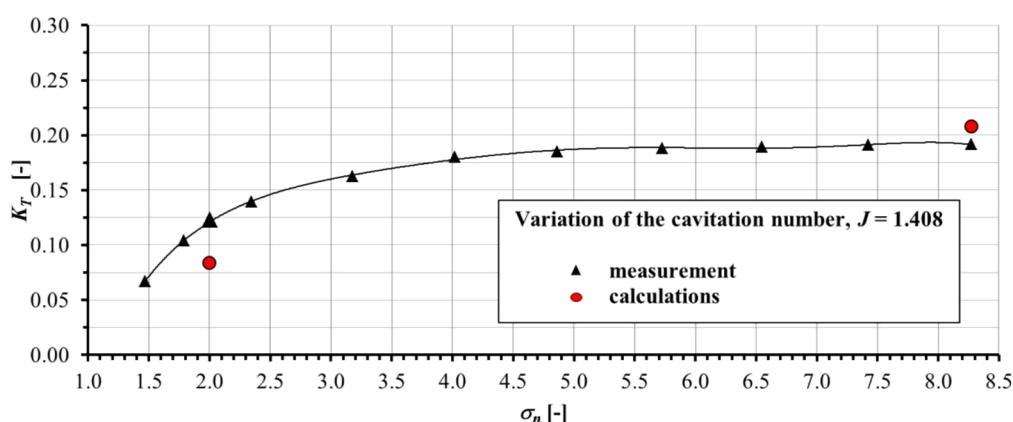


KT non-cav = 0.208  
 KT cav = 0.084

CAT-OpenFOAM

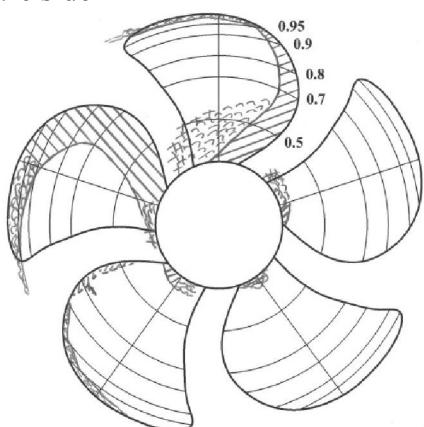


KT non-cav = 0.208  
 KT cav = 0.084



#### 4.5 Case 2.3, Chalmers-OF

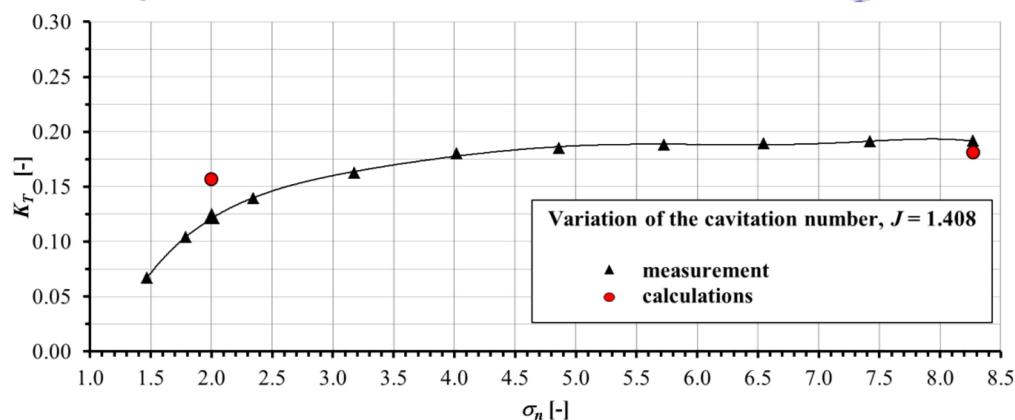
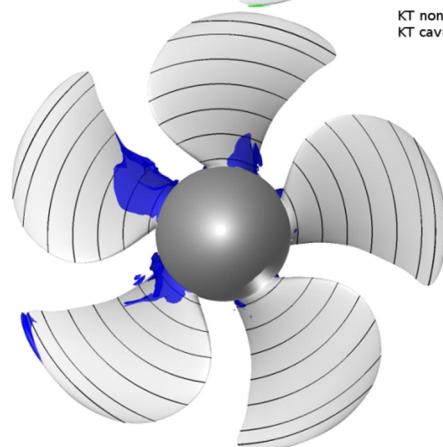
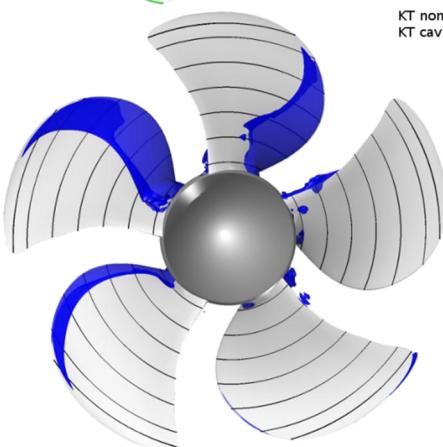
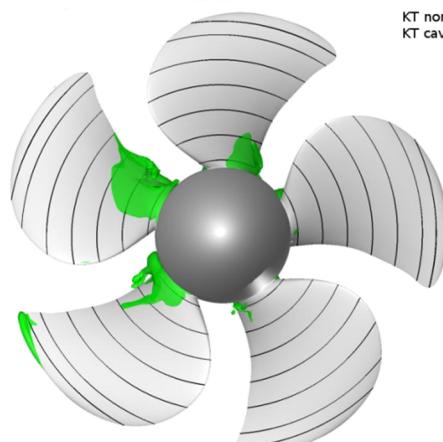
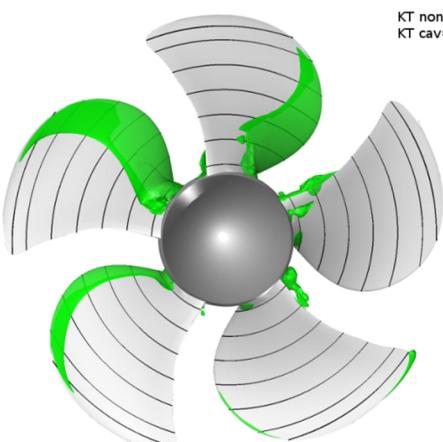
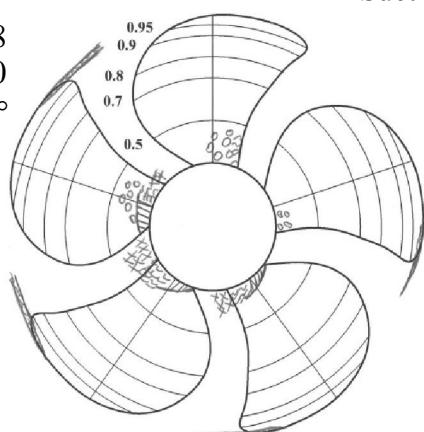
Pressure side



**Case 2.3**

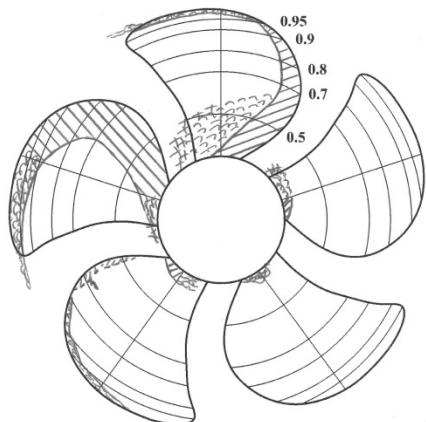
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



#### 4.6 Case 2.3, CNRS-ISIS

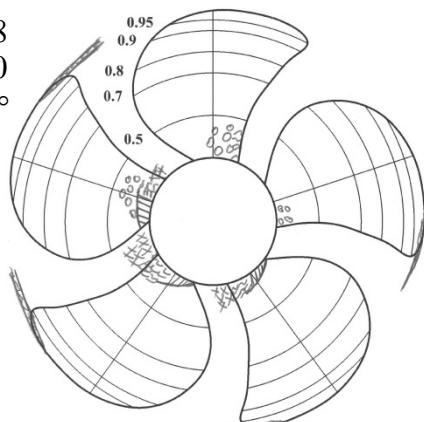
Pressure side



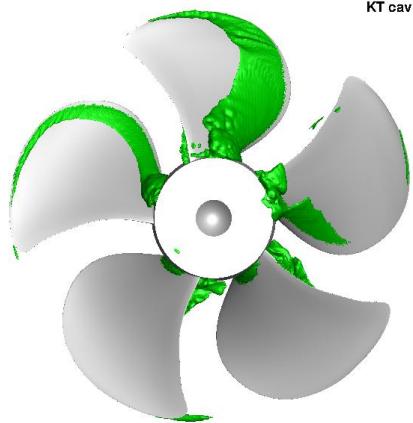
**Case 2.3**

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bP} &= 12.0^\circ \end{aligned}$$

Suction side

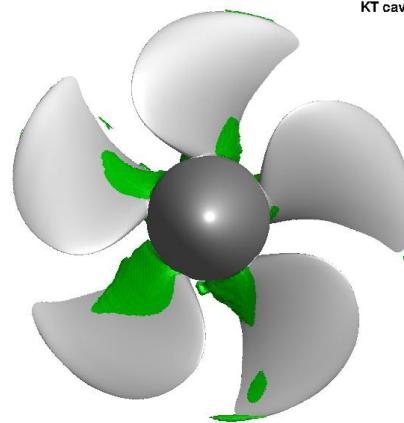


CNRS-ECN ISIS-CFD



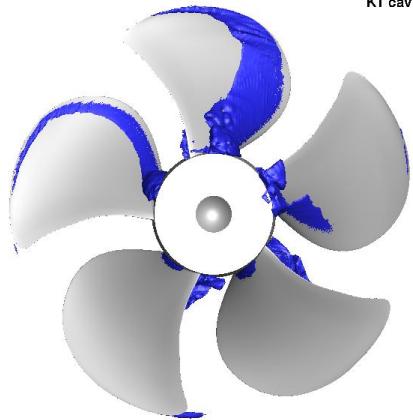
KT non-cav = 0.182  
 KT cav = 0.084

CNRS-ECN ISIS-CFD



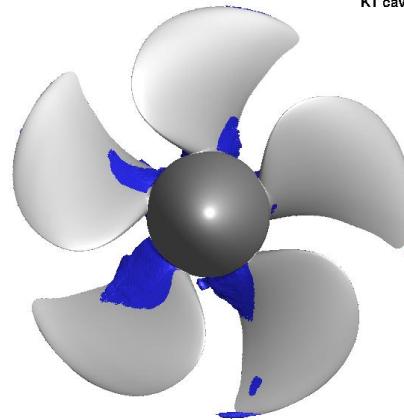
KT non-cav = 0.182  
 KT cav = 0.084

CNRS-ECN ISIS-CFD

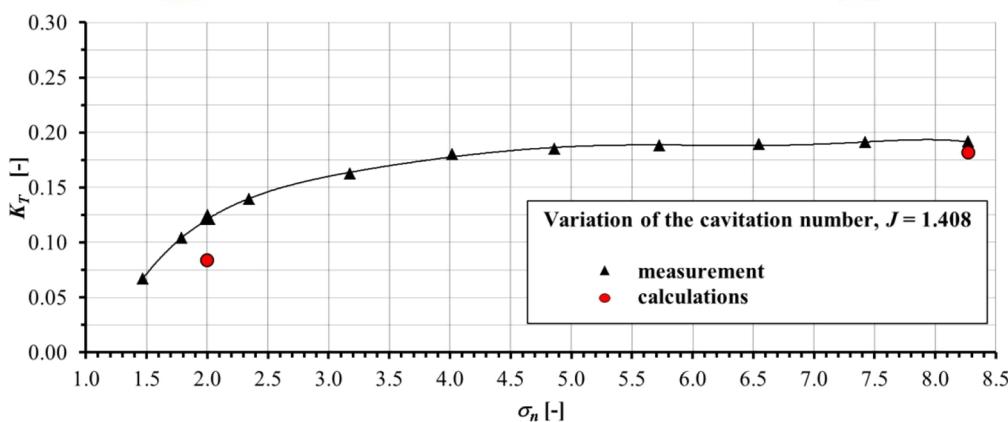


KT non-cav = 0.182  
 KT cav = 0.084

CNRS-ECN ISIS-CFD

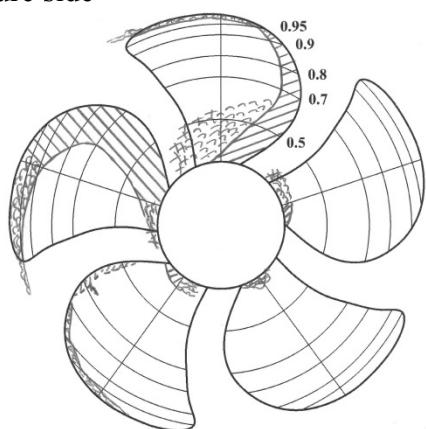


KT non-cav = 0.182  
 KT cav = 0.084



#### 4.7 Case 2.3, CRADLE-SCTetra

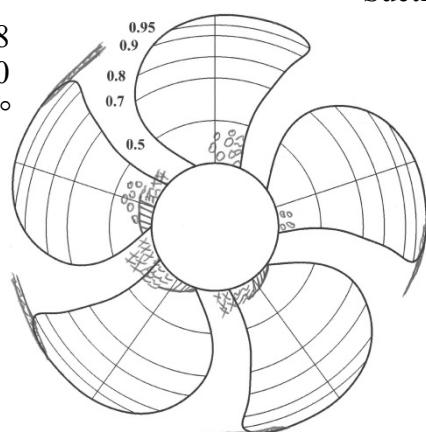
Pressure side



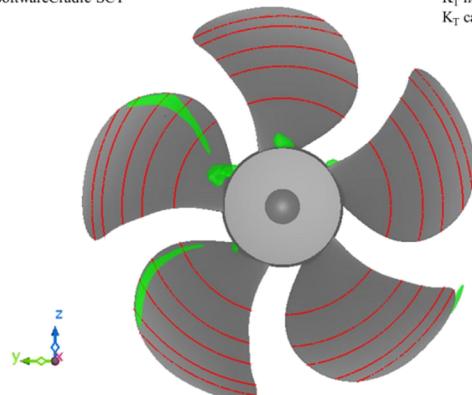
**Case 2.3**

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

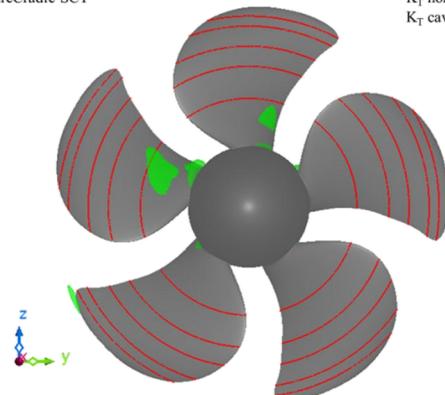


SoftwareCradle-SCT



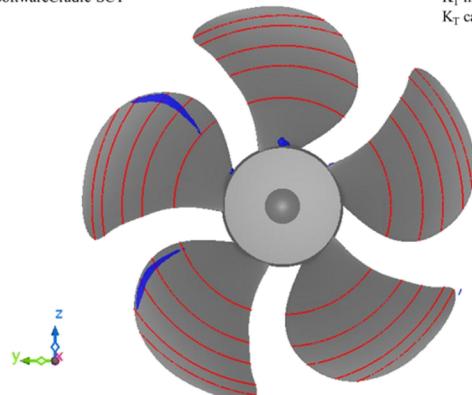
$$\begin{aligned} K_T \text{ non-cav} &= 0.200 \\ K_T \text{ cav} &= 0.146 \end{aligned}$$

SoftwareCradle-SCT



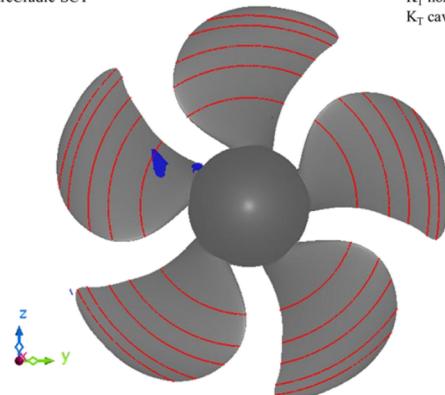
$$\begin{aligned} K_T \text{ non-cav} &= 0.200 \\ K_T \text{ cav} &= 0.146 \end{aligned}$$

SoftwareCradle-SCT

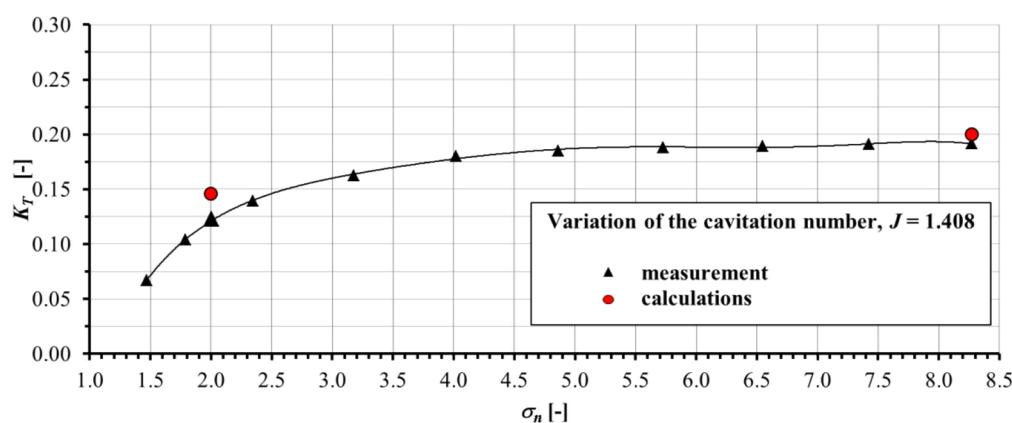


$$\begin{aligned} K_T \text{ non-cav} &= 0.200 \\ K_T \text{ cav} &= 0.146 \end{aligned}$$

SoftwareCradle-SCT

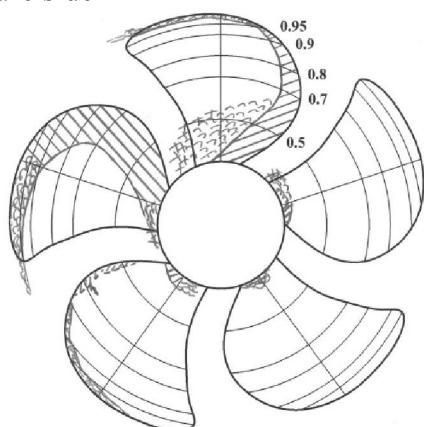


$$\begin{aligned} K_T \text{ non-cav} &= 0.200 \\ K_T \text{ cav} &= 0.146 \end{aligned}$$



#### 4.8 Case 2.3, CSSRC-Fluent

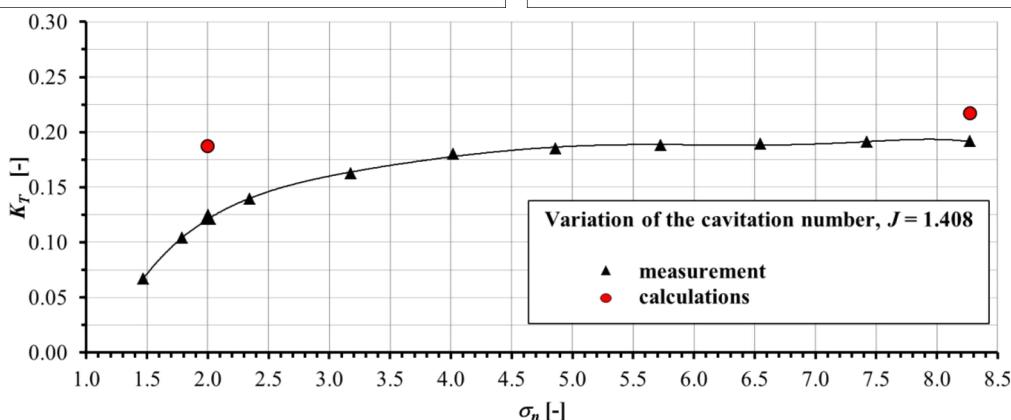
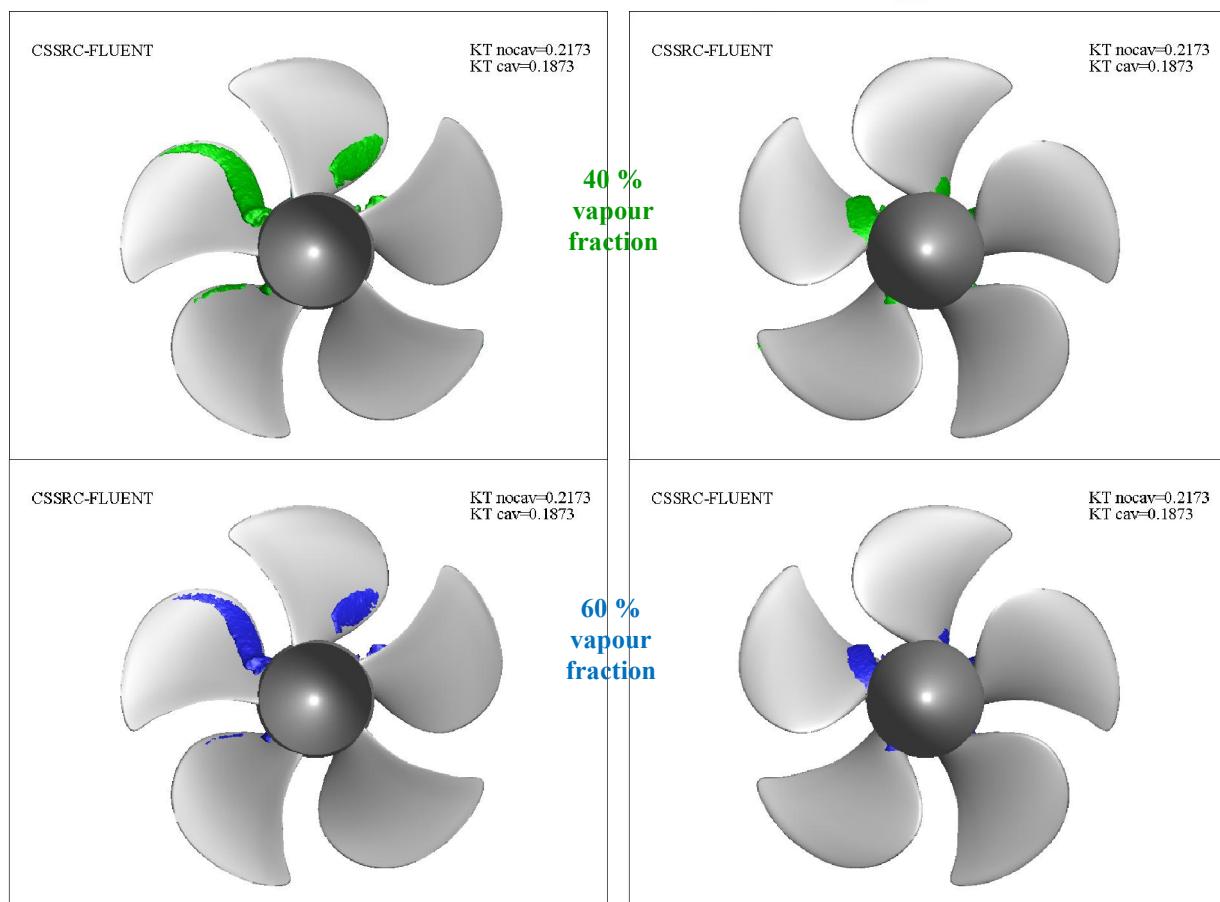
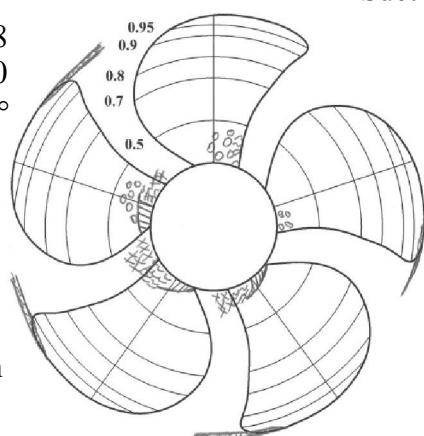
Pressure side



**Case 2.3**

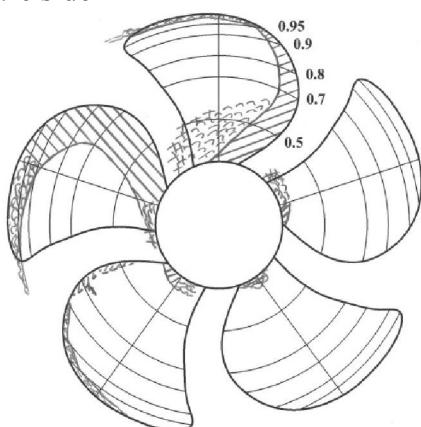
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



#### 4.9 Case 2.3, ROTAM-Fluent

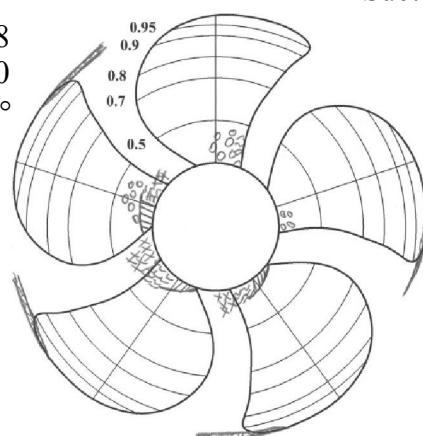
Pressure side



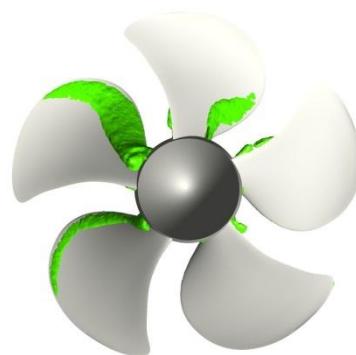
ROTAM-ANSYS

**Case 2.3**

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$



Suction side

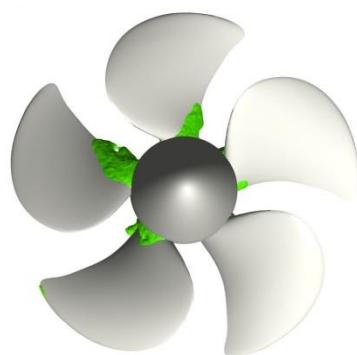


KT non-cav= 0.214  
 KT cav= 0.167

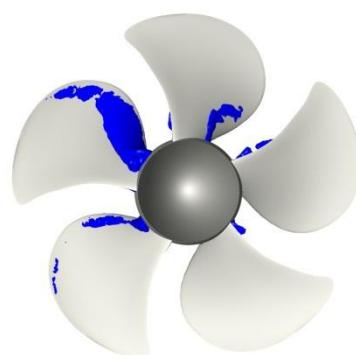
40 %  
 vapour  
 fraction

ROTAM-ANSYS

KT non-cav= 0.214  
 KT cav= 0.167



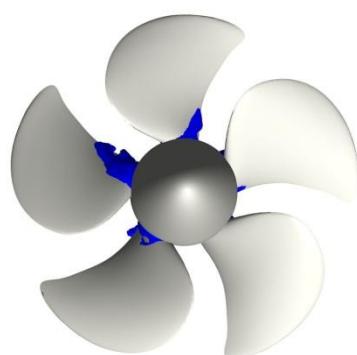
KT non-cav= 0.214  
 KT cav= 0.167



60 %  
 vapour  
 fraction

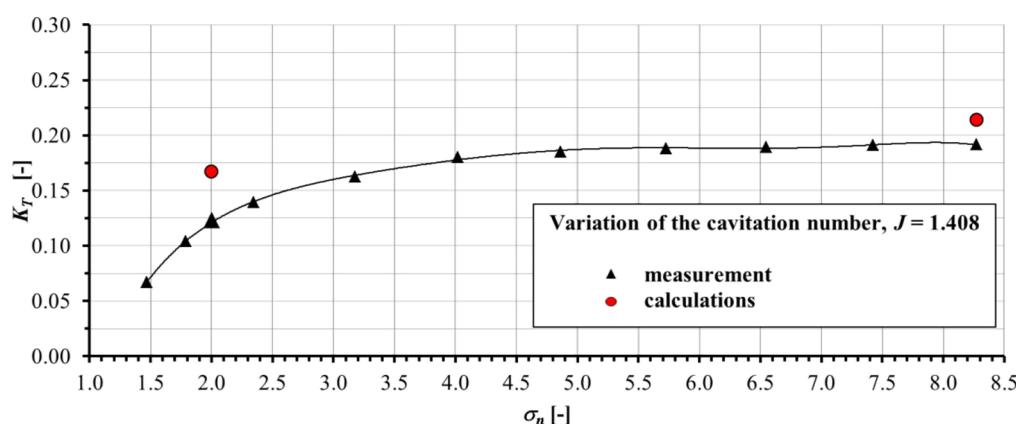
ROTAM-ANSYS

KT non-cav= 0.214  
 KT cav= 0.167



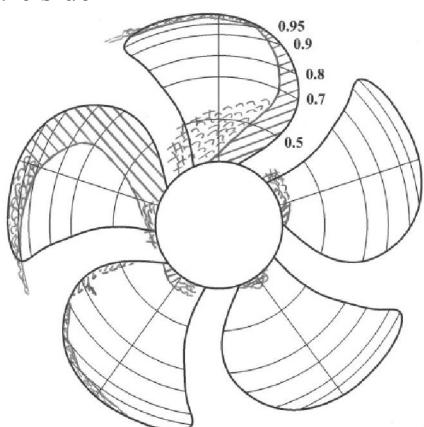
Z  
 Y  
 X

Z  
 Y  
 X



#### 4.10 Case 2.3, SSPA-Fluent-Sauer

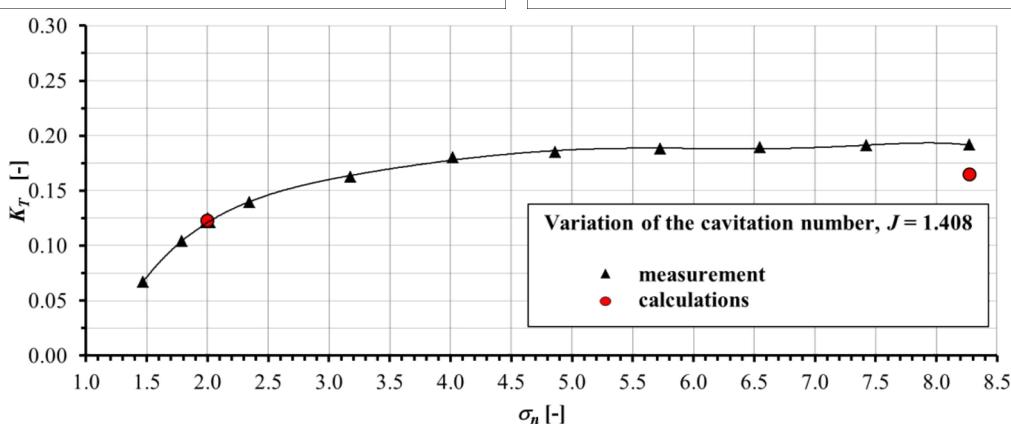
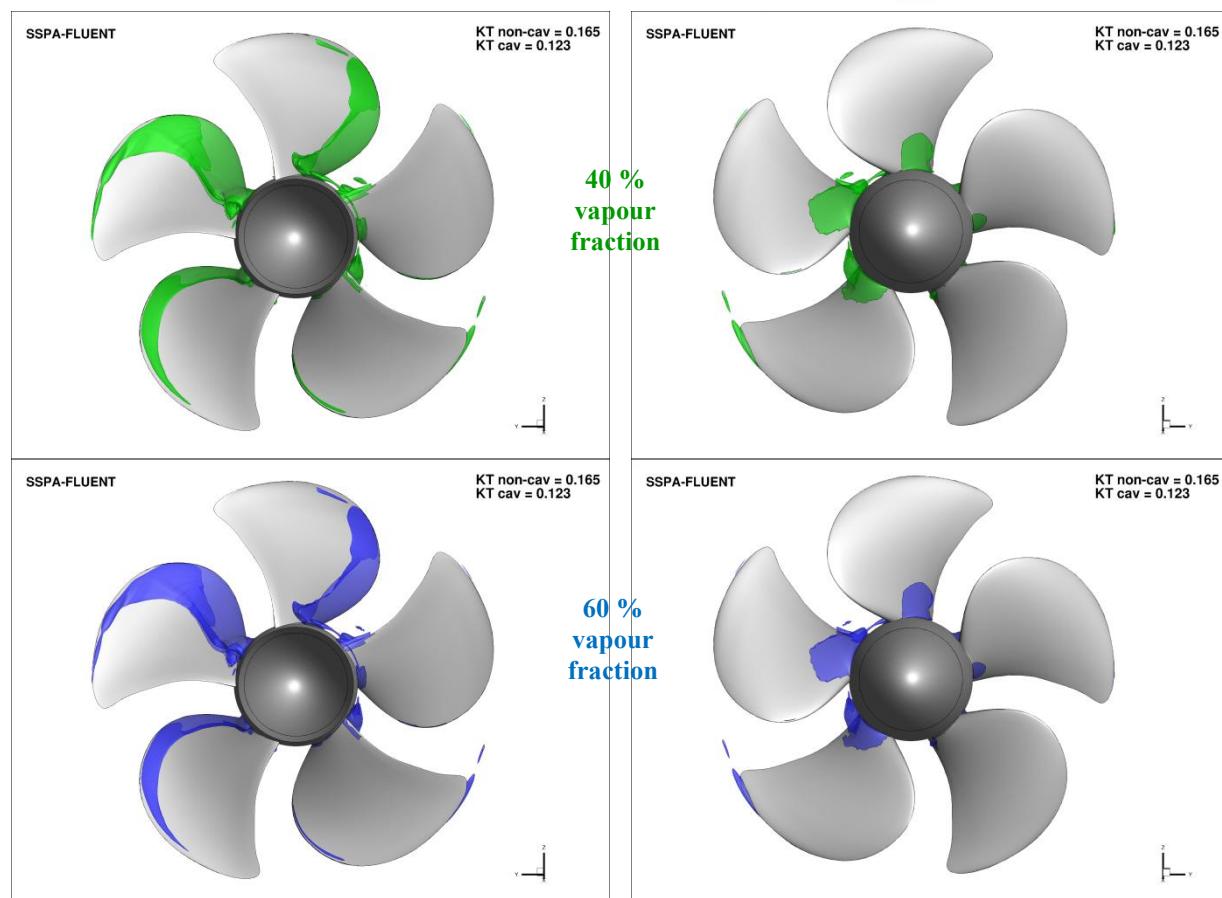
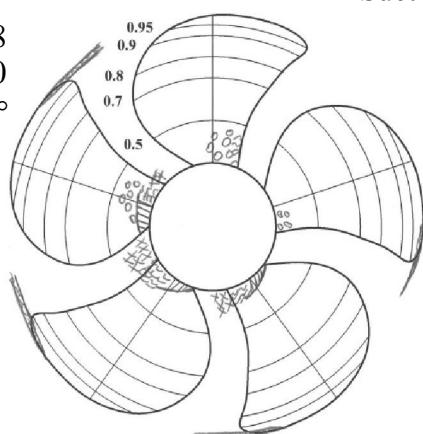
Pressure side



**Case 2.3**

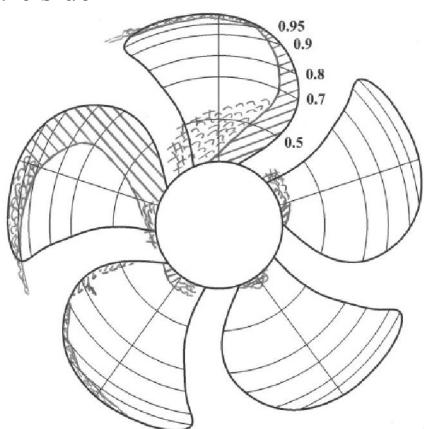
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



#### 4.11 Case 2.3, SSPA-Fluent-Zwart1

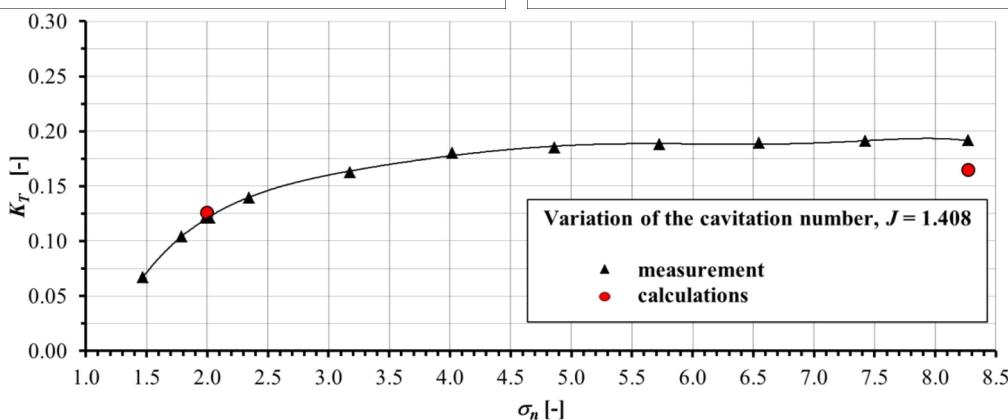
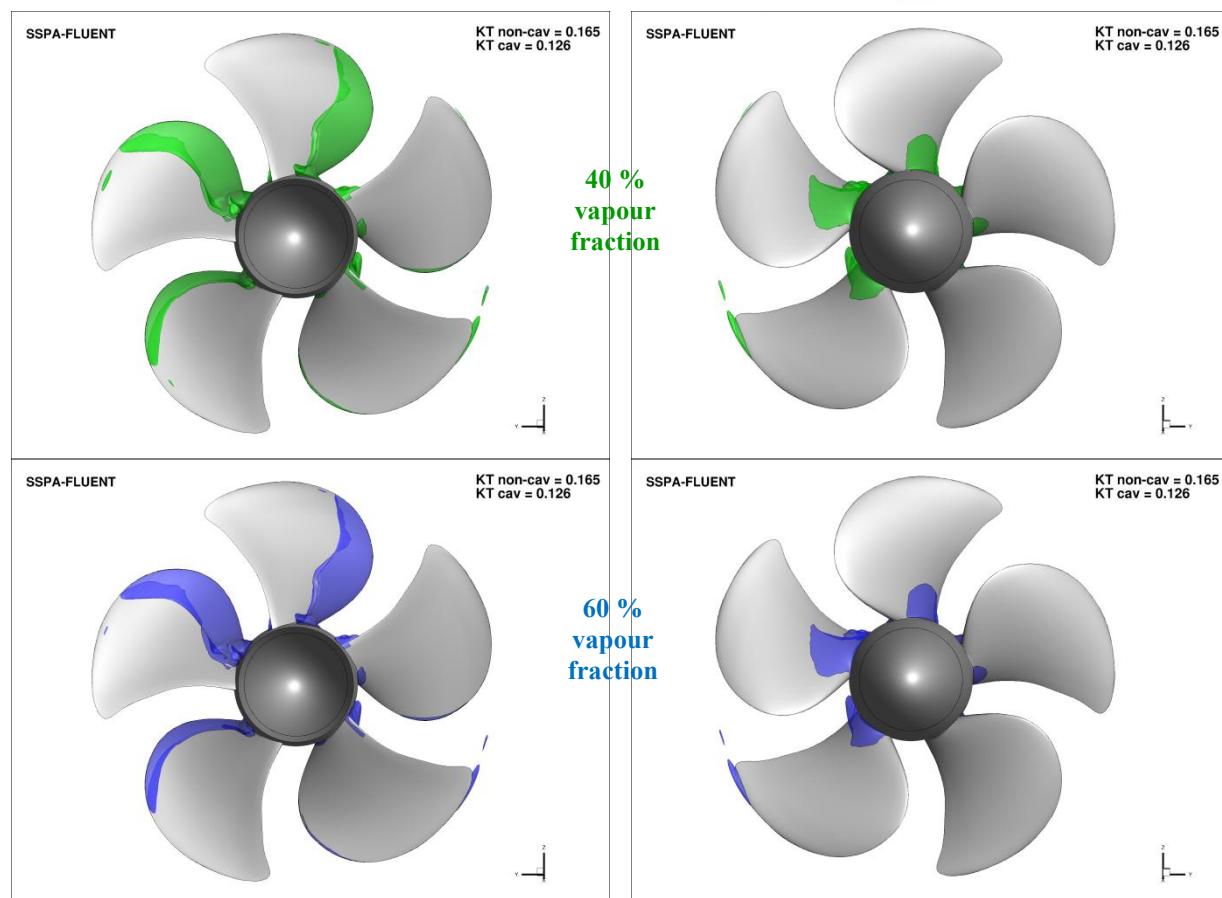
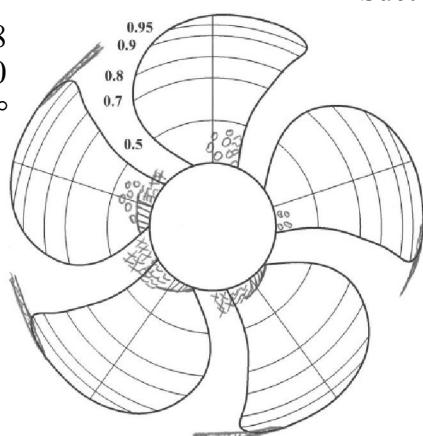
Pressure side



**Case 2.3**

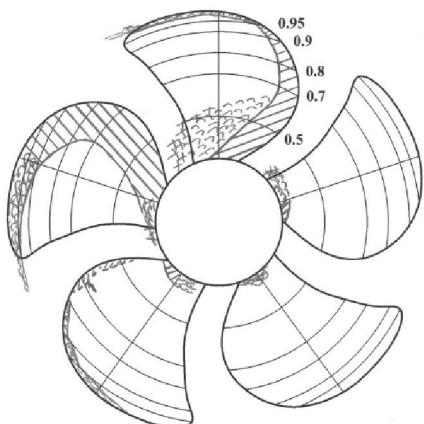
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

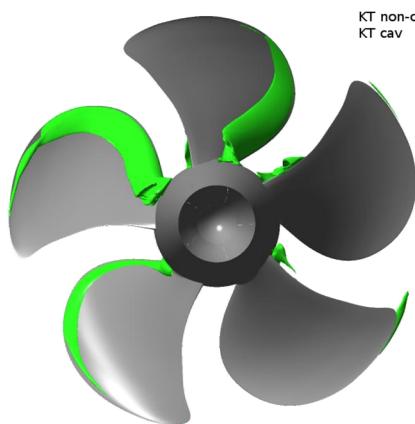


#### 4.12 Case 2.3, TUHH-CFX

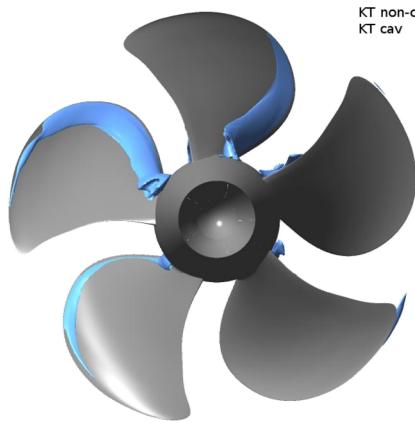
Pressure side



TUHH-CFX

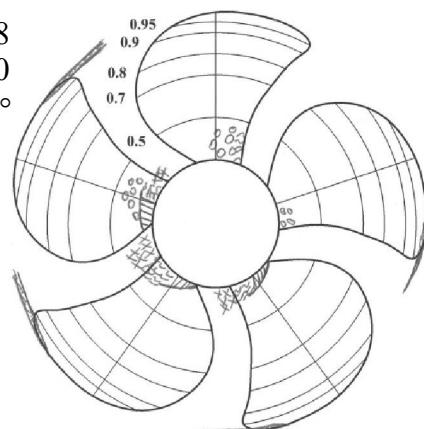


TUHH-CFX



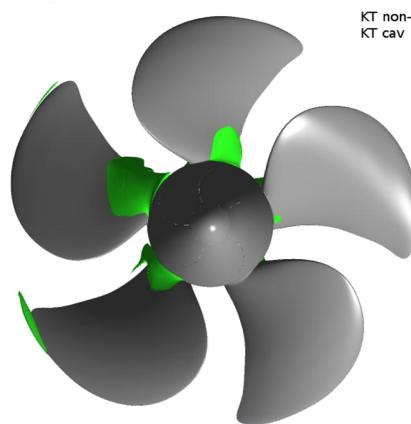
Case 2.3

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

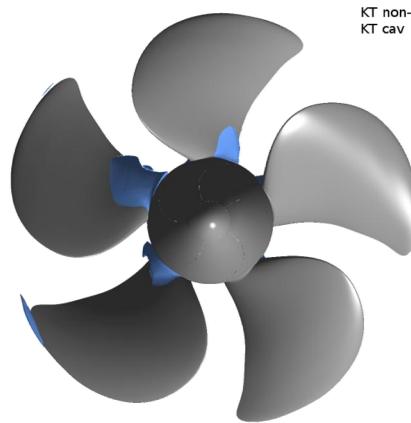


Suction side

TUHH-CFX



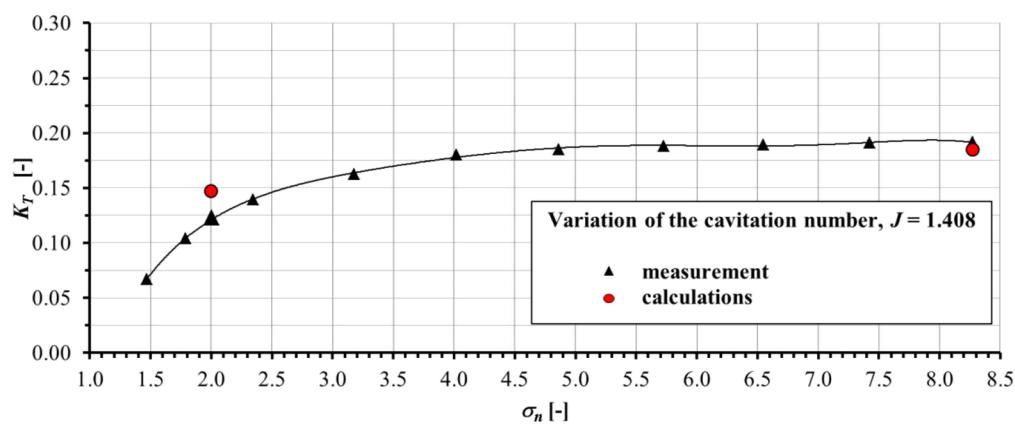
KT non-cav = 0.1847  
 KT cav = 0.1470



KT non-cav = 0.1847  
 KT cav = 0.1470

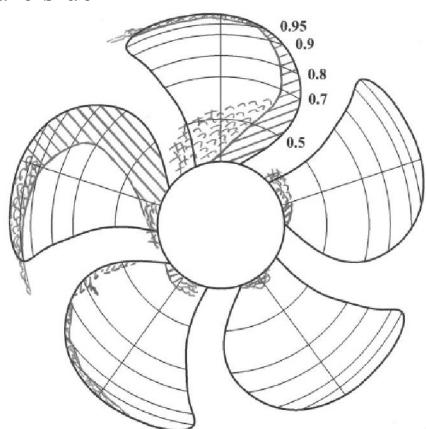
40 %  
 vapour  
 fraction

60 %  
 vapour  
 fraction



#### 4.13 Case 2.3, TUHH-panMARE

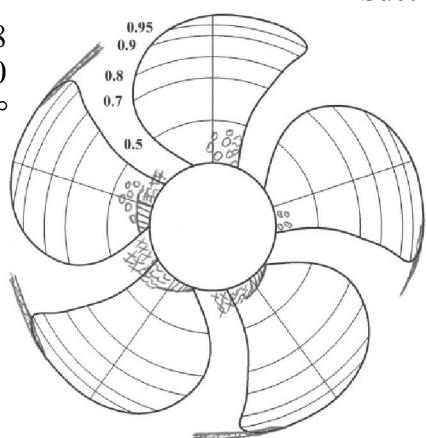
Pressure side



**Case 2.3**

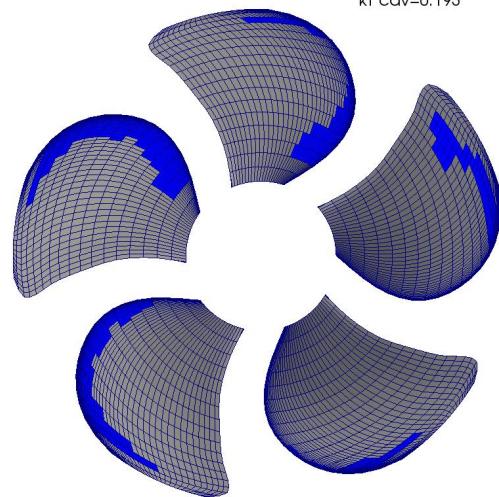
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



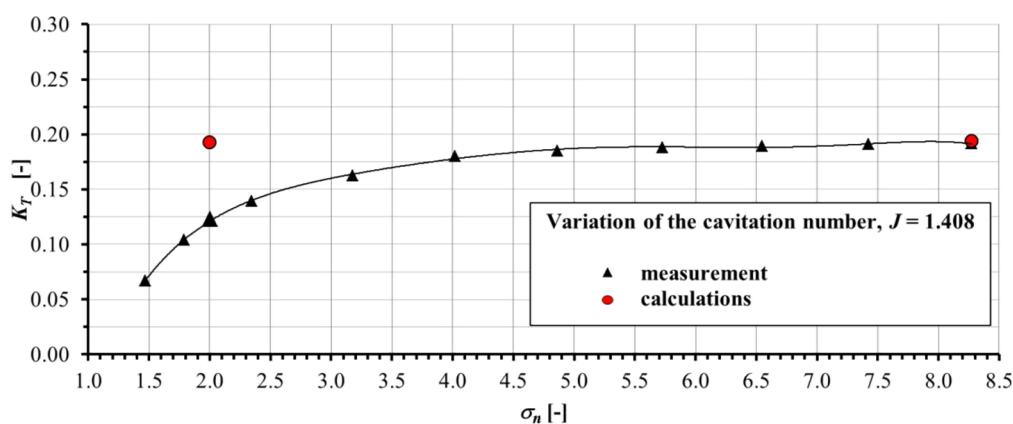
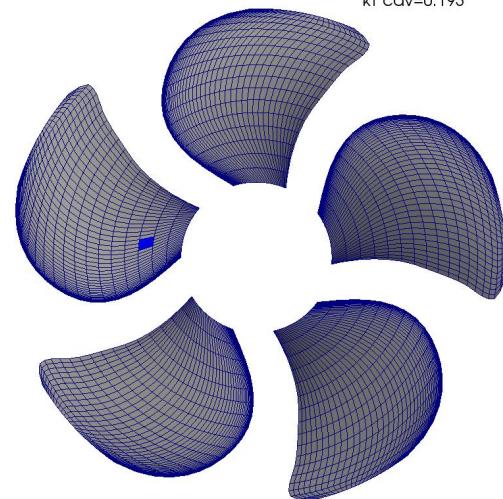
TUHH - panMARE

$kT$  noncav=0.194  
 $kT$  cav=0.193



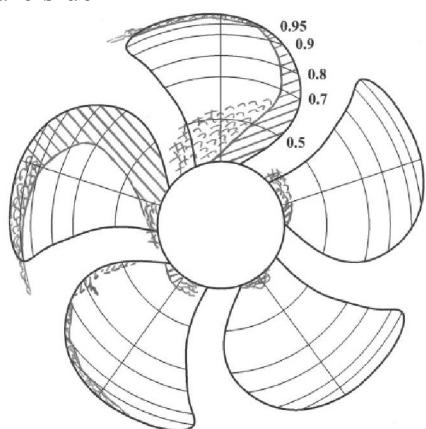
TUHH - panMARE

$kT$  noncav=0.194  
 $kT$  cav=0.193



#### 4.14 Case 2.3, UniGenoa-BEM

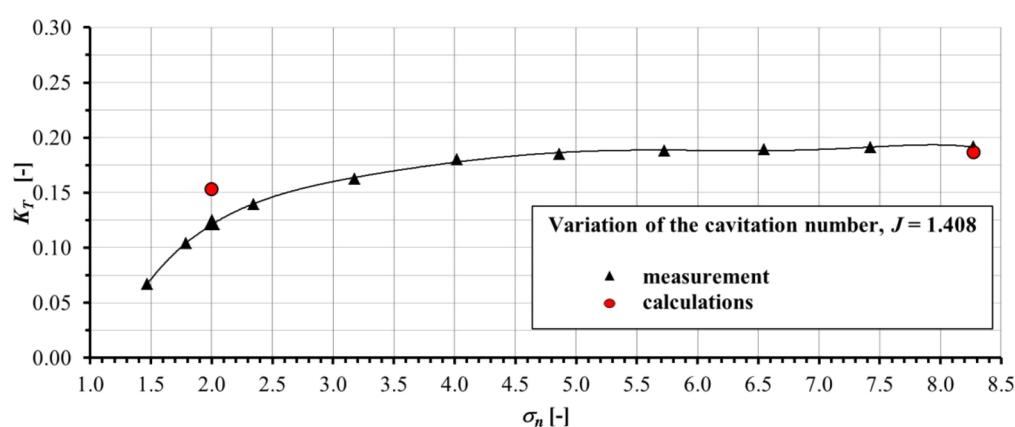
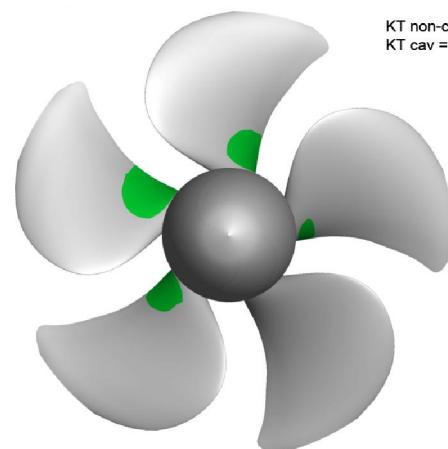
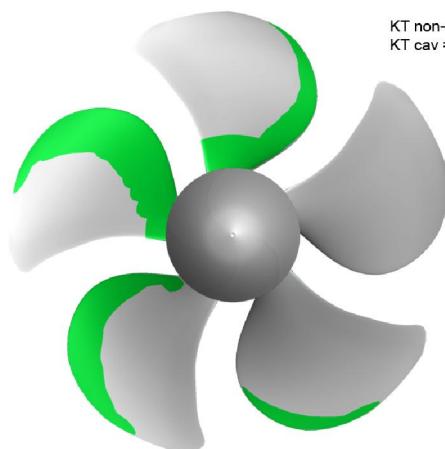
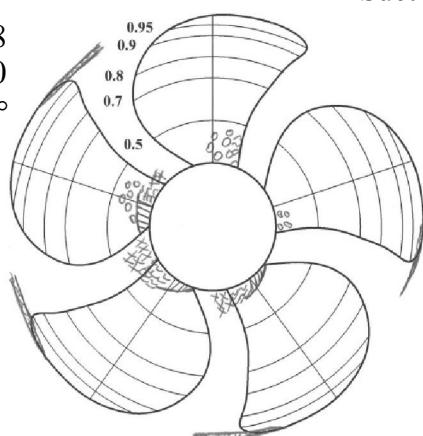
Pressure side



**Case 2.3**

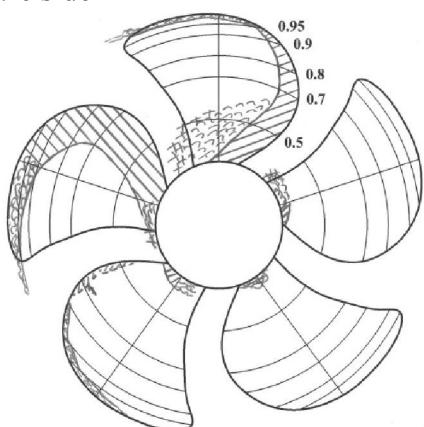
$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side



#### 4.15 Case 2.3, UniGenoa-StarCCM+

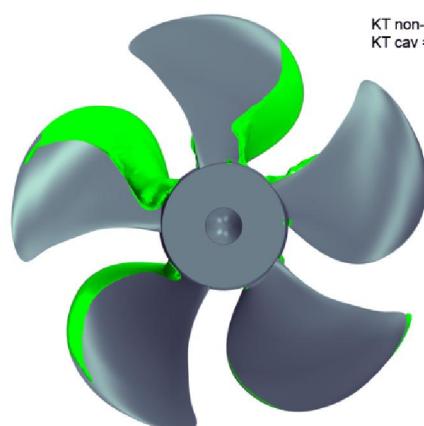
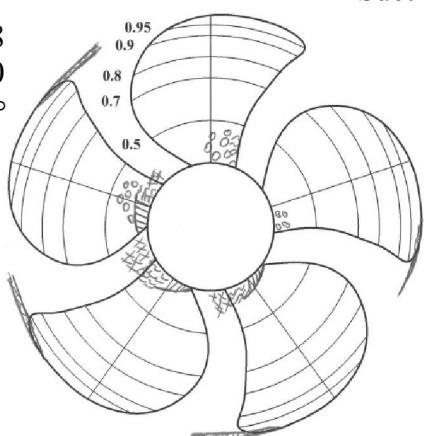
Pressure side



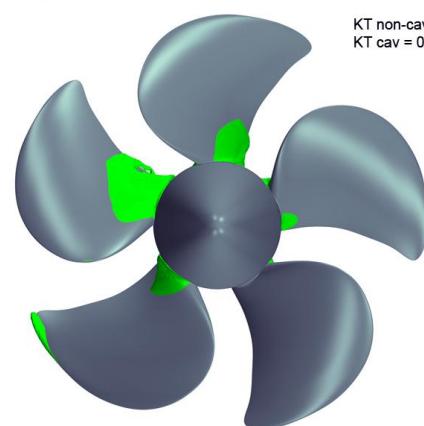
**Case 2.3**

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

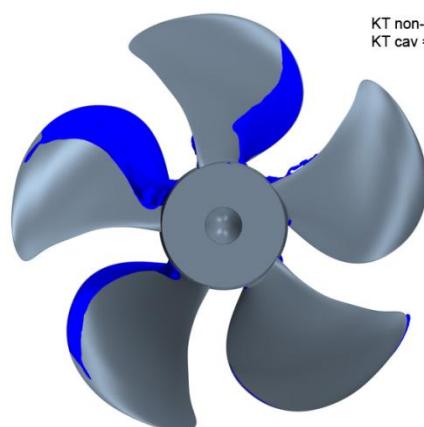
Suction side



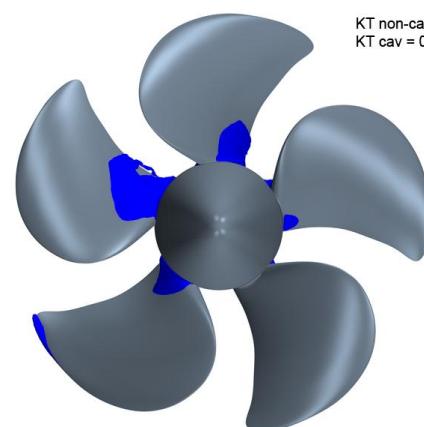
40 %  
vapour  
fraction



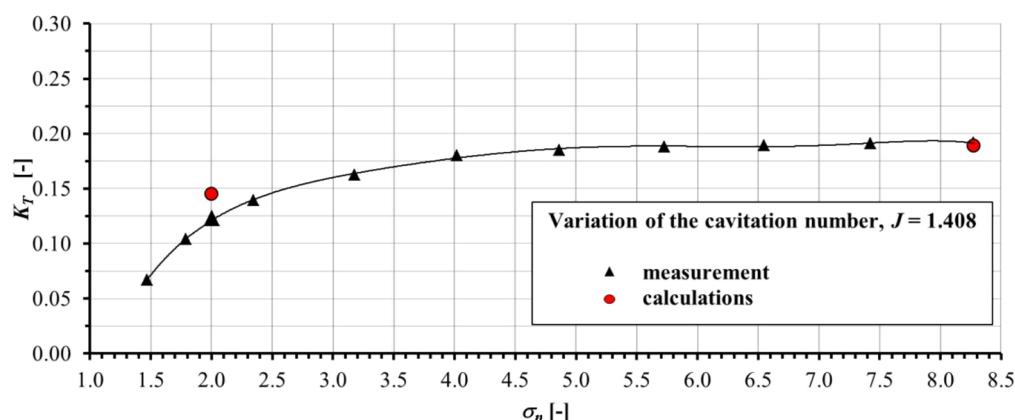
KT non-cav = 0.1890  
 KT cav = 0.1452



60 %  
vapour  
fraction

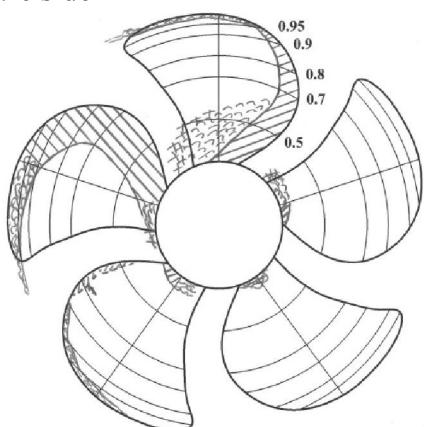


KT non-cav = 0.1890  
 KT cav = 0.1452



#### 4.16 Case 2.3, VTT-FinFlo

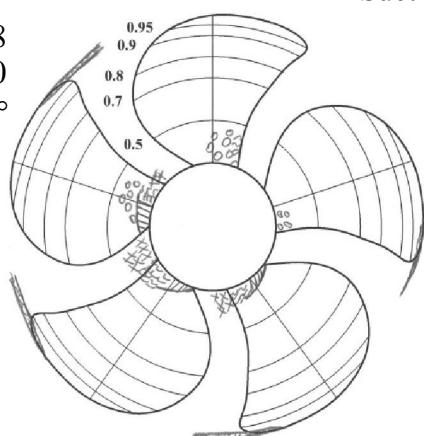
Pressure side



**Case 2.3**

$$\begin{aligned} J &= 1.408 \\ \sigma_n &= 2.000 \\ \psi^{bp} &= 12.0^\circ \end{aligned}$$

Suction side

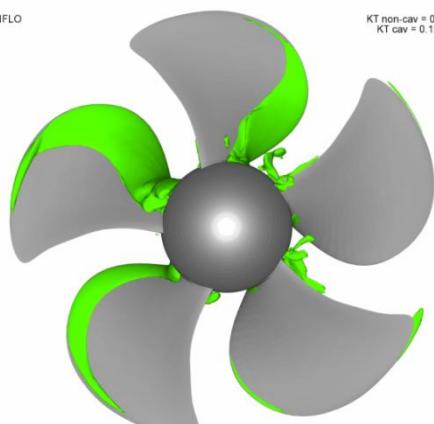


VTT-FINFLOW

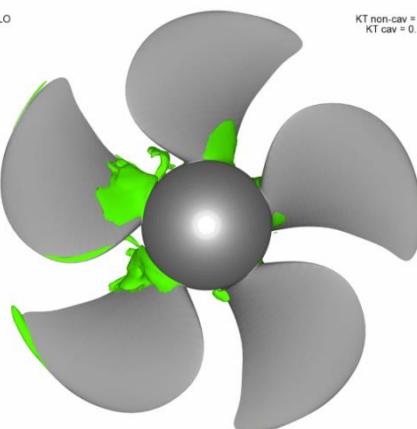
KT non-cav = 0.189  
 KT cav = 0.129

VTT-FINFLOW

KT non-cav = 0.189  
 KT cav = 0.129



40 %  
 vapour  
 fraction

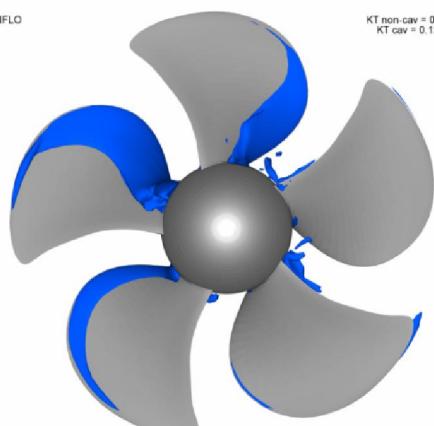


VTT-FINFLOW

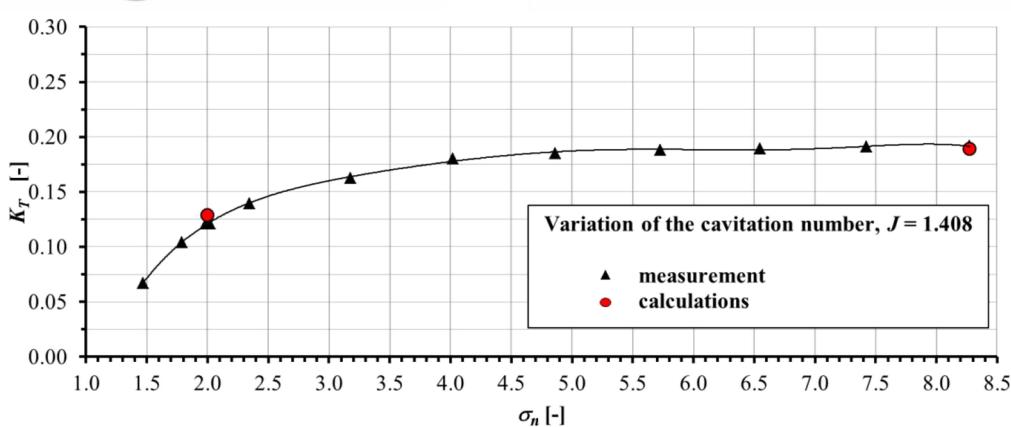
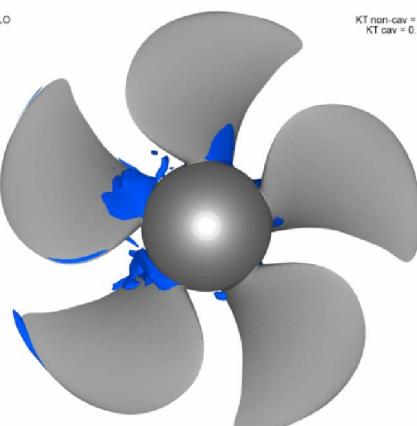
KT non-cav = 0.189  
 KT cav = 0.129

VTT-FINFLOW

KT non-cav = 0.189  
 KT cav = 0.129



60 %  
 vapour  
 fraction



## 5 Comparison

### 5.1 Thrust coefficient, non-cavitating

	case 2.1 $K_T$ [-]	case 2.2 $K_T$ [-]	case 2.3 $K_T$ [-]
<b>Exp. (non-cavitating)</b>	<b>0.392</b>	<b>0.265</b>	<b>0.189</b>
ACCUSIM-CFX-FCM	0.392	0.255	0.181
ACCUSIM-CFX-Kunz	0.392	0.255	0.181
ACCUSIM-CFX-Zwart	0.392	0.255	0.181
CAT-OF	0.385	0.287	0.208
Chalmers-OF	0.405	0.262	0.181
CNRS-ISIS	0.402	0.266	0.182
CRADLE-SCTetra	0.417	0.279	0.200
CSSRC-Fluent	0.401	0.290	0.217
MARIN-ReFresco	0.403		
ROTAM-Fluent	0.420	0.293	0.214
SSPA-Fluent-Sauer	0.391	0.249	0.165
SSPA-Fluent-Zwart1	0.391	0.249	0.165
SSPA-Fluent-Zwart2	0.391		
TUHH-CFX	0.395	0.258	0.185
TUHH-panMARE	0.334	0.250	0.194
UniGenoa-BEM	0.380	0.257	0.187
UniGenoa-StarCCM+	0.406	0.267	0.189
VTT-FinFlo	0.401	0.266	0.189

## 5.2 Difference in thrust coefficient, non cavitating

	case 2.1 $\Delta K_T$ [%]	case 2.2 $\Delta K_T$ [%]	case 2.3 $\Delta K_T$ [%]
ACCUSIM-CFX-FCM	0.00	-3.77	-4.23
ACCUSIM-CFX-Kunz	0.00	-3.77	-4.23
ACCUSIM-CFX-Zwart	0.00	-3.77	-4.23
CAT-OF	-1.79	8.30	10.05
Chalmers-OF	3.32	-1.13	-4.23
CNRS-ISIS	2.55	0.38	-3.70
CRADLE-SCTetra	6.38	5.28	5.82
CSSRC-Fluent	2.30	9.55	14.97
MARIN-ReFresco	2.81		
ROTAM-Fluent	7.14	10.57	13.23
SSPA-Fluent-Sauer	-0.26	-6.04	-12.70
SSPA-Fluent-Zwart1	-0.26	-6.04	-12.70
SSPA-Fluent-Zwart2	-0.26		
TUHH-CFX	0.77	-2.49	-2.28
TUHH-panMARE	-14.80	-5.66	2.65
UniGenoa-BEM	-3.06	-3.02	-1.06
UniGenoa-StarCCM+	3.57	0.87	0.00
VTT-FinFlo	2.30	0.38	0.00

### 5.3 Thrust coefficient, cavitating

	case 2.1 $K_T$ [-]	case 2.2 $K_T$ [-]	case 2.3 $K_T$ [-]
<b>Exp. (cavitating)</b>	<b>0.363</b>	<b>0.167</b>	<b>0.123</b>
ACCUSIM-CFX-FCM	0.365	0.173	0.131
ACCUSIM-CFX-Kunz	0.368	0.166	0.128
ACCUSIM-CFX-Zwart	0.365	0.166	0.130
CAT-OF	0.349	0.157	0.084
Chalmers-OF	0.373	0.196	0.157
CNRS-ISIS	0.353	0.122	0.084
CRADLE-SCTetra	0.372	0.212	0.146
CSSRC-Fluent	0.385	0.257	0.187
MARIN-ReFresco	0.387		
ROTAM-Fluent	0.385	0.218	0.167
SSPA-Fluent-Sauer	0.380	0.190	0.123
SSPA-Fluent-Zwart1	0.377	0.192	0.126
SSPA-Fluent-Zwart2	0.367		
TUHH-CFX	0.386	0.205	0.147
TUHH-panMARE	0.382	0.144	0.193
UniGenoa-BEM	0.390	0.246	0.153
UniGenoa-StarCCM+	0.389	0.208	0.145
VTT-FinFlo	0.375	0.192	0.129

### 5.4 Difference in thrust coefficient, cavitating

	case 2.1 $\Delta K_T$ [%]	case 2.2 $\Delta K_T$ [%]	case 2.3 $\Delta K_T$ [%]
ACCUSIM-CFX-FCM	0.55	3.59	6.50
ACCUSIM-CFX-Kunz	1.38	-0.60	4.07
ACCUSIM-CFX-Zwart	0.55	-0.60	5.69
CAT-OF	-3.86	-5.99	-31.71
Chalmers-OF	2.75	17.37	27.64
CNRS-ISIS	-2.75	-26.95	-31.71
CRADLE-SCTetra	2.48	26.95	18.70
CSSRC-Fluent	6.06	54.07	52.28
MARIN-ReFresco	6.61		
ROTAM-Fluent	6.06	30.54	35.77
SSPA-Fluent-Sauer	4.68	13.77	0.00
SSPA-Fluent-Zwart1	3.86	14.97	2.44
SSPA-Fluent-Zwart2	1.10		
TUHH-CFX	6.34	22.46	19.51
TUHH-panMARE	5.23	-13.77	56.91
UniGenoa-BEM	7.44	47.31	24.39
UniGenoa-StarCCM+	7.16	24.43	18.05
VTT-FinFlo	3.31	14.97	4.88

## 5.5 Thrust breakdown, absolute difference

	<b>case 2.1</b> $\Delta K_T$ [-]	<b>case 2.2</b> $\Delta K_T$ [-]	<b>case 2.3</b> $\Delta K_T$ [-]
<b>Experiment</b>	<b>0.029</b>	<b>0.098</b>	<b>0.066</b>
ACCUSIM-CFX-FCM	0.027	0.082	0.050
ACCUSIM-CFX-Kunz	0.024	0.089	0.053
ACCUSIM-CFX-Zwart	0.027	0.089	0.051
CAT-OF	0.036	0.130	0.124
Chalmers-OF	0.032	0.066	0.024
CRADLE-SCTetra	0.049	0.144	0.098
CNRS-ISIS	0.045	0.067	0.054
CSSRC-Fluent	0.016	0.033	0.030
MARIN-ReFresco	0.016		
ROTAM-Fluent	0.035	0.075	0.047
SSPA-Fluent-Sauer	0.011	0.059	0.042
SSPA-Fluent-Zwart1	0.014	0.057	0.039
SSPA-Fluent-Zwart2	0.024		
TUHH-CFX	0.009	0.054	0.038
TUHH-panMARE	-0.048	0.106	0.001
UniGenoa-BEM	-0.010	0.011	0.034
UniGenoa-StarCCM+	0.017	0.060	0.044
VTT-FinFlo	0.026	0.074	0.060