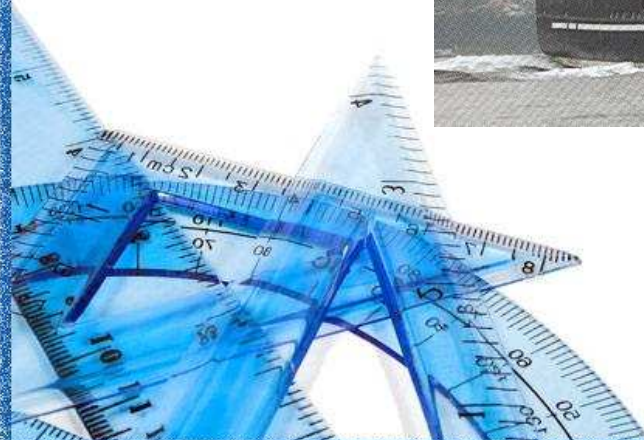


CFD validation of different propeller ducts on open water condition

Alejandro Caldas Collazo

Motivation



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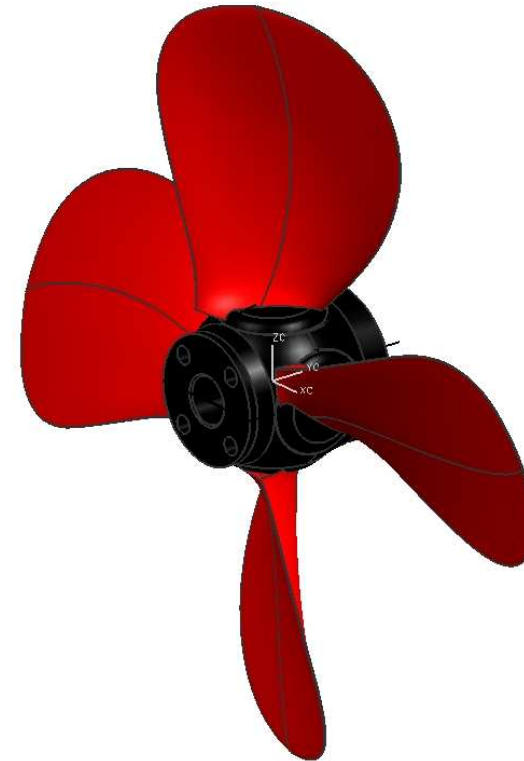
INDEX

1. Geometrical definition
2. Experimental analysis
3. Mathematical and numerical model
4. CFD results
5. Concluding remarks
6. Future work



Propeller Characteristics

- CPP
- CTO

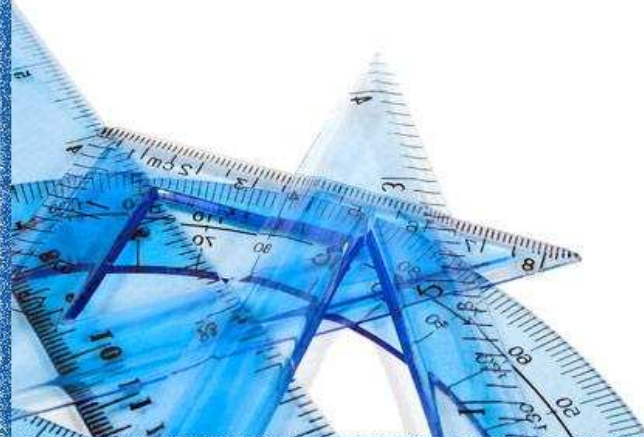


EAR	Skew	0.7 Pitch	D	P/D	Pm	Pm/D	Profile
0.55	6°	200 mm	200 mm	1	188.46 mm	0.9423	NACA 16

Nozzle Characteristics

- 19 A

	Profile	Length	Gap
N1	19 A	0,5*D	1%
N2	19 A	0,375*D	1%

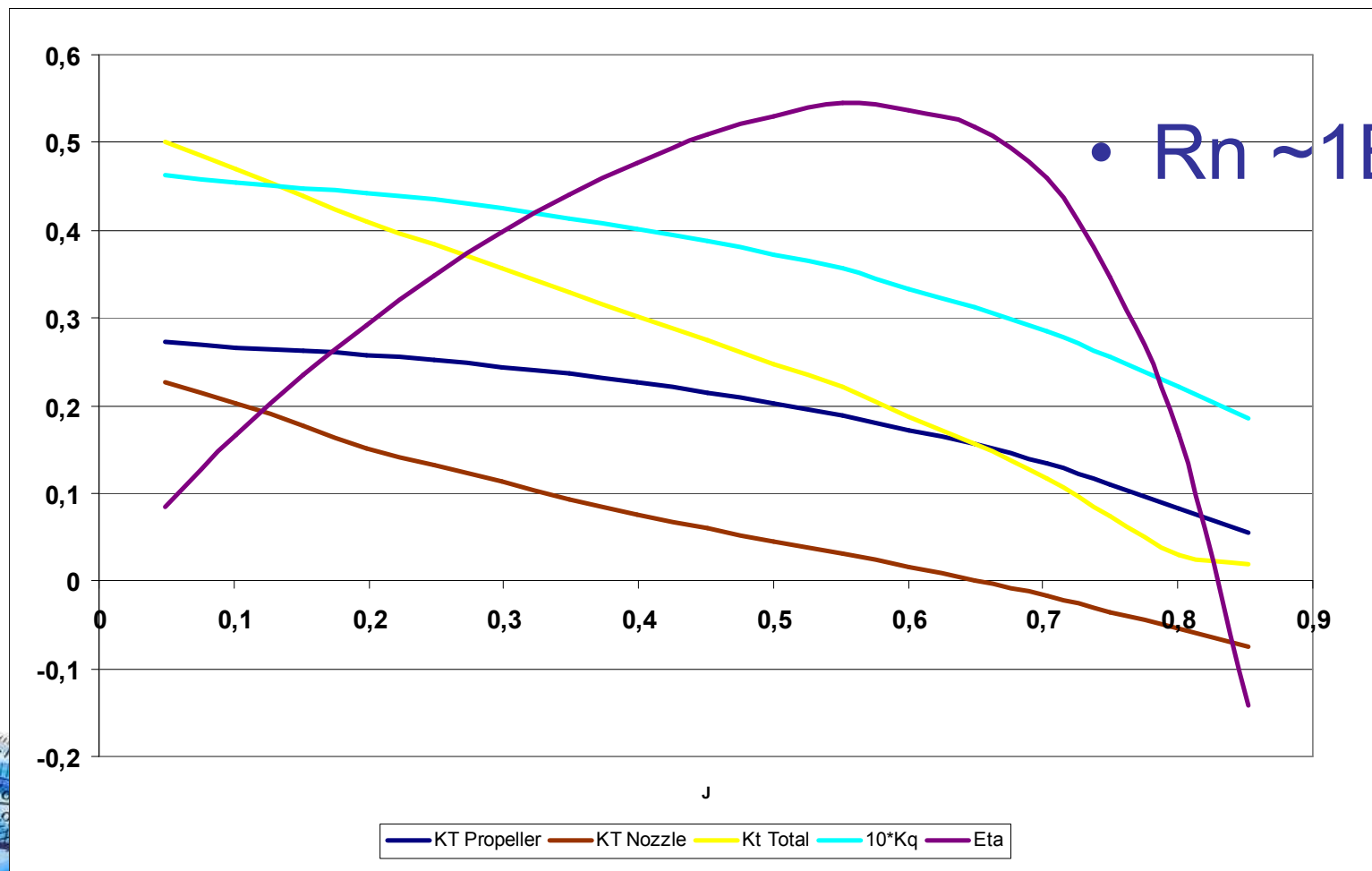


INDEX

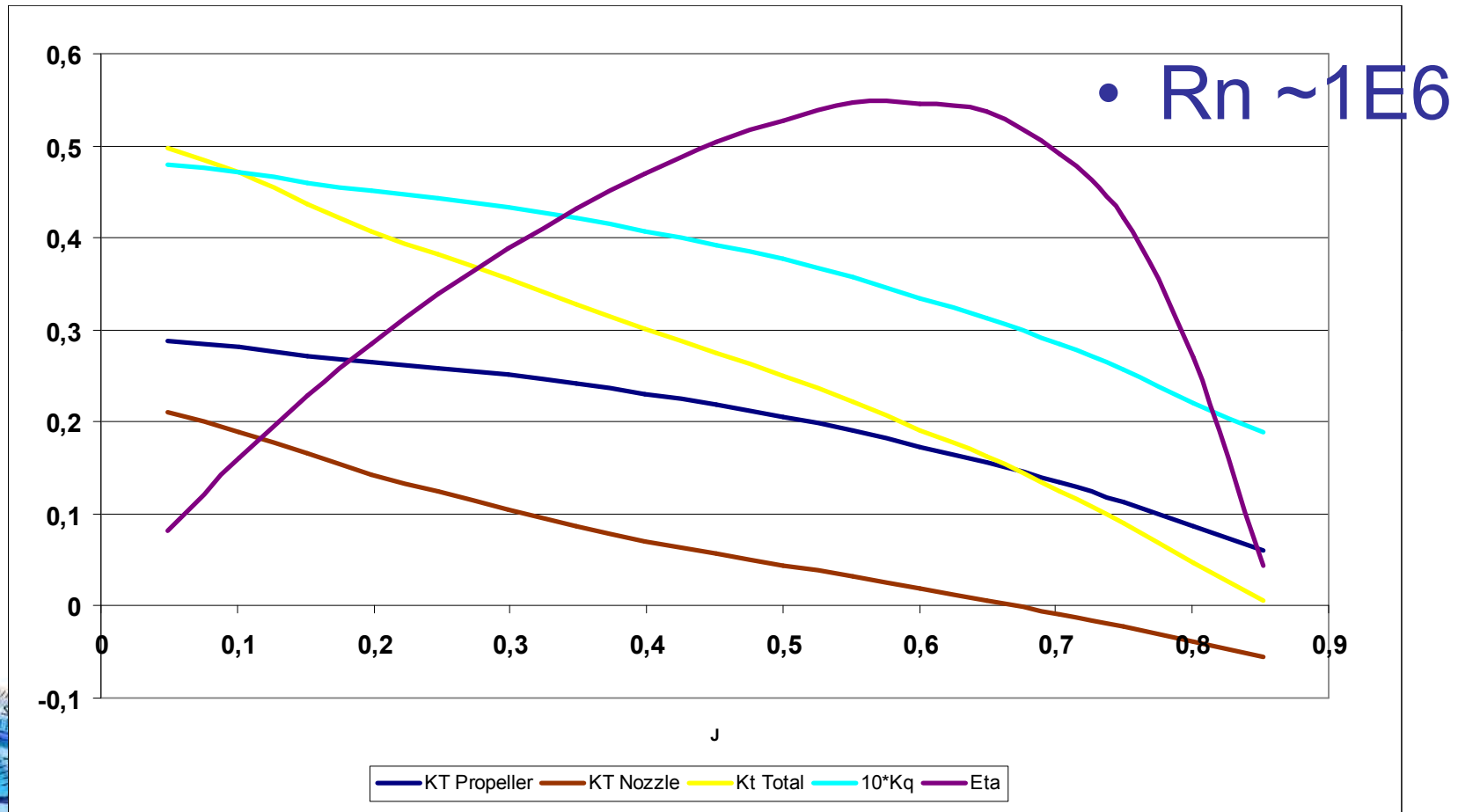
1. Geometrical definition
2. Experimental analysis
3. Mathematical and numerical model
4. CFD results
5. Concluding remarks
6. Future work



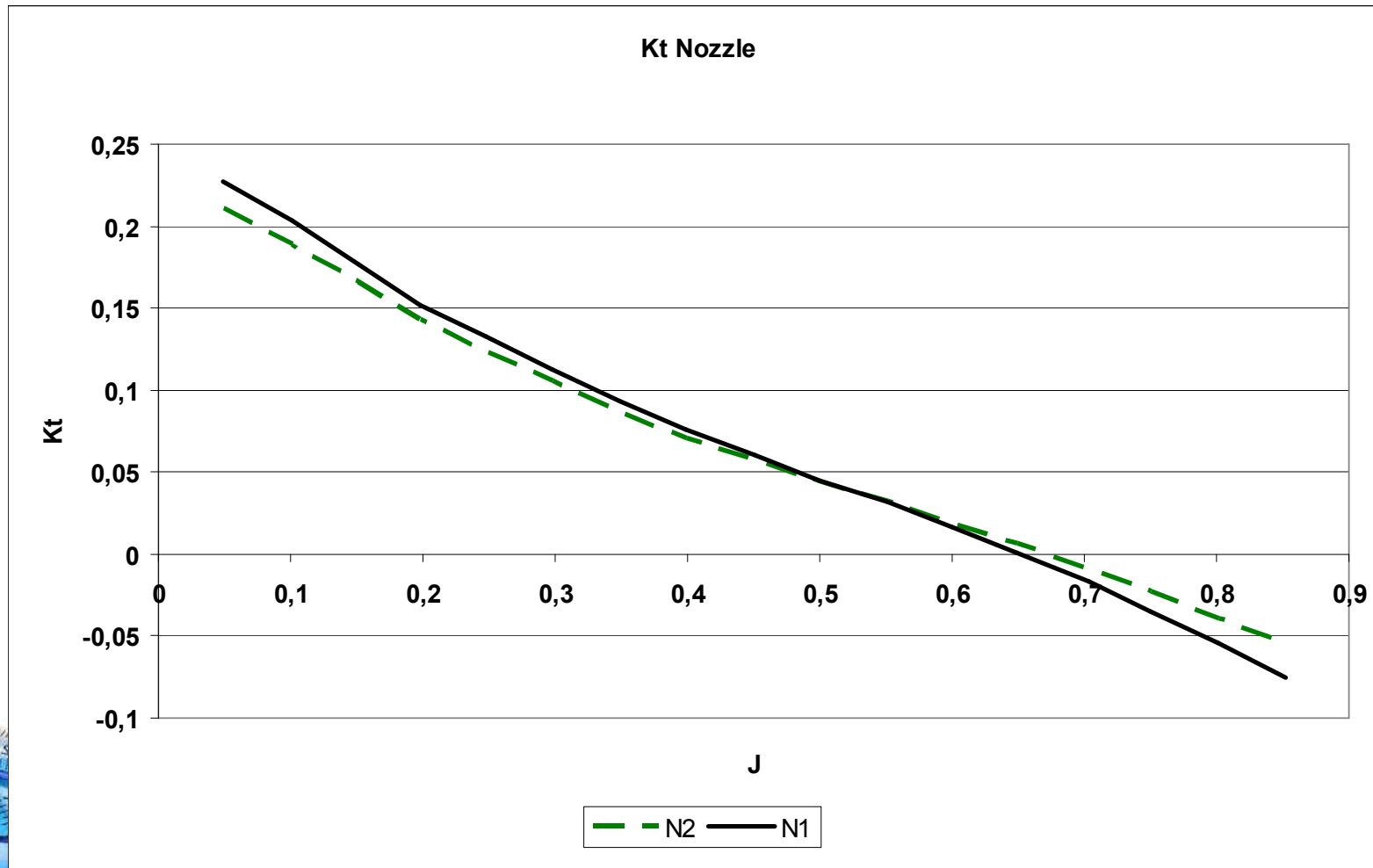
Propulsion Diagram: N1



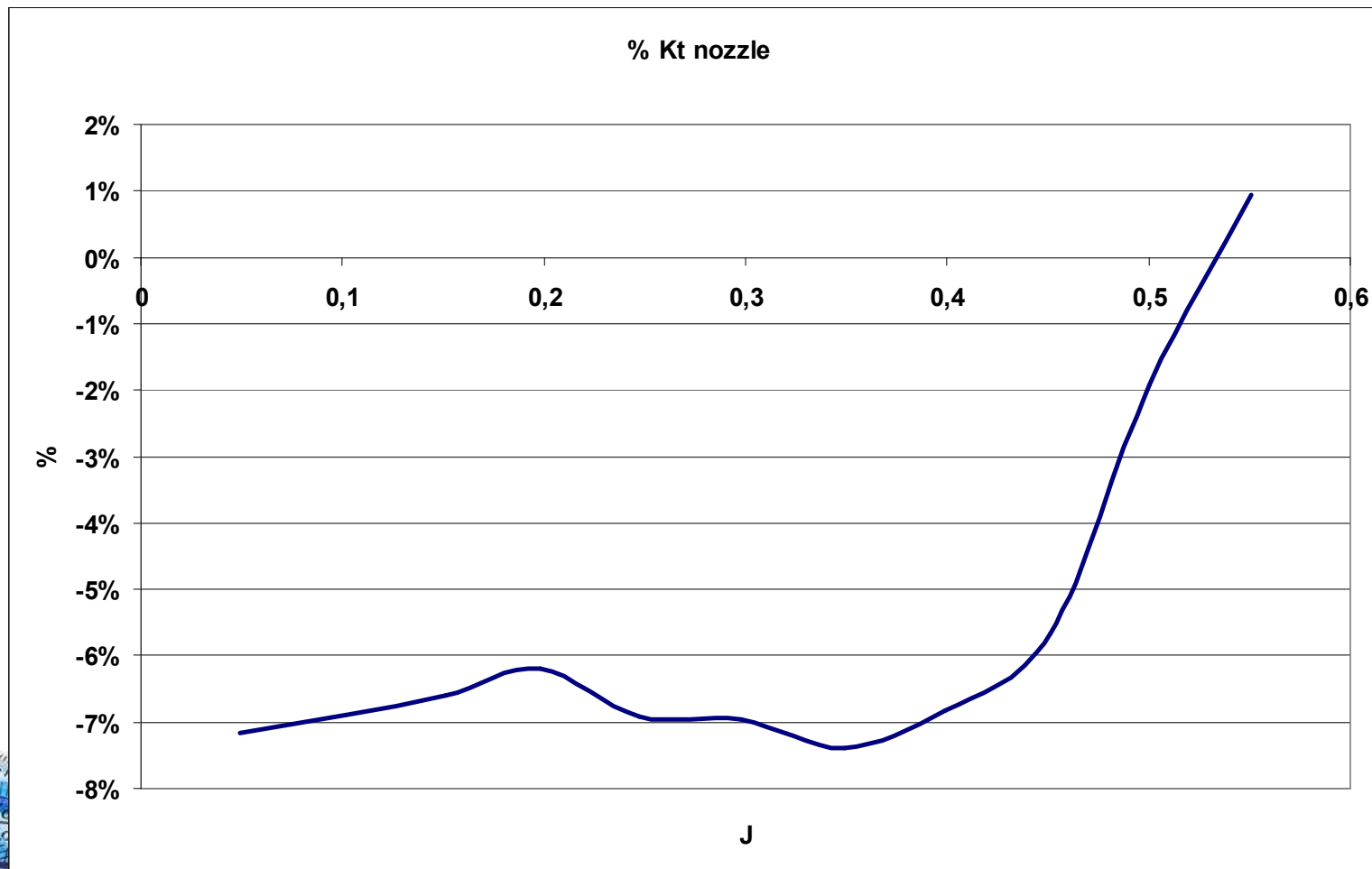
Propulsion Diagram: N2



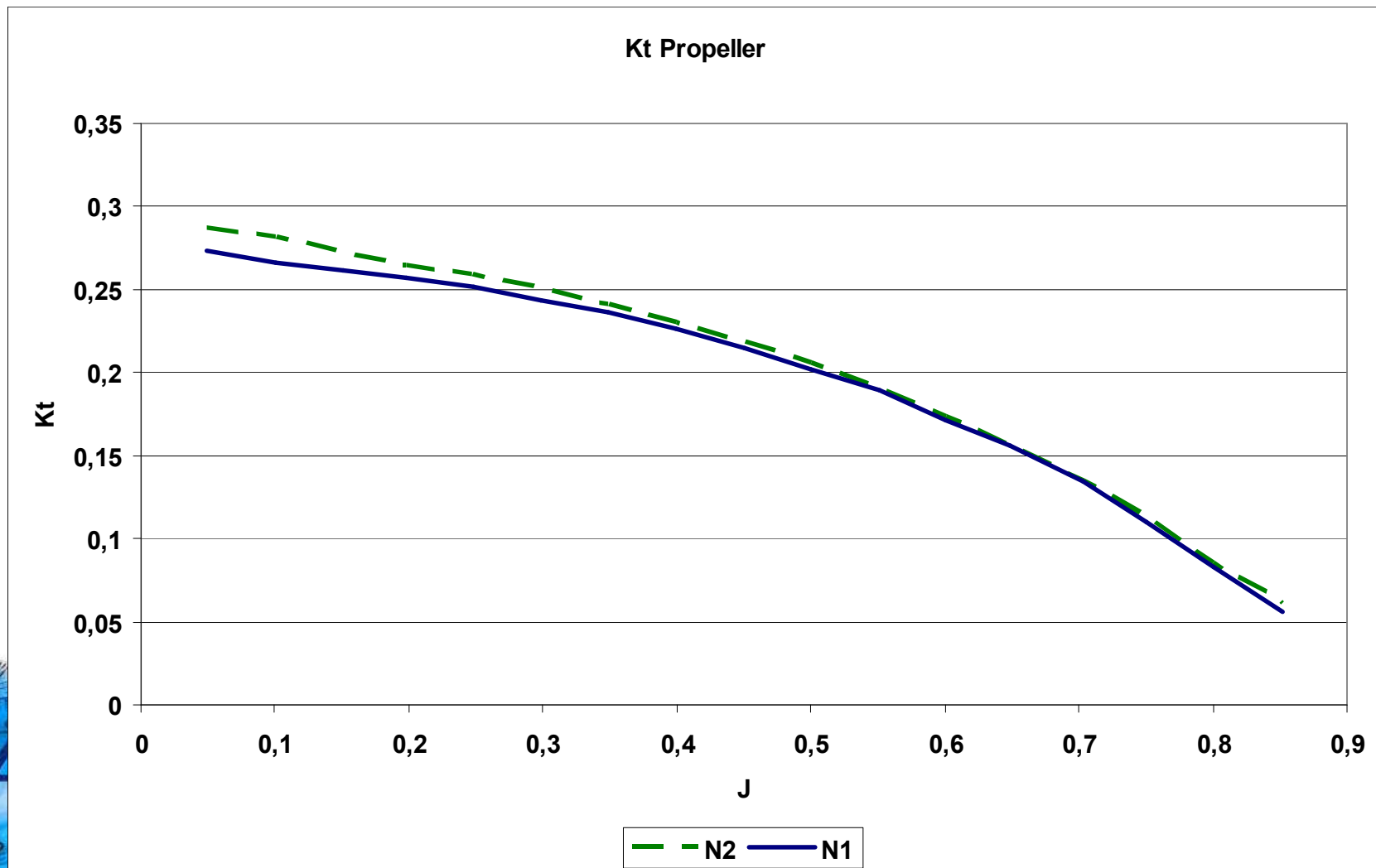
Kt –nozzle Comparison



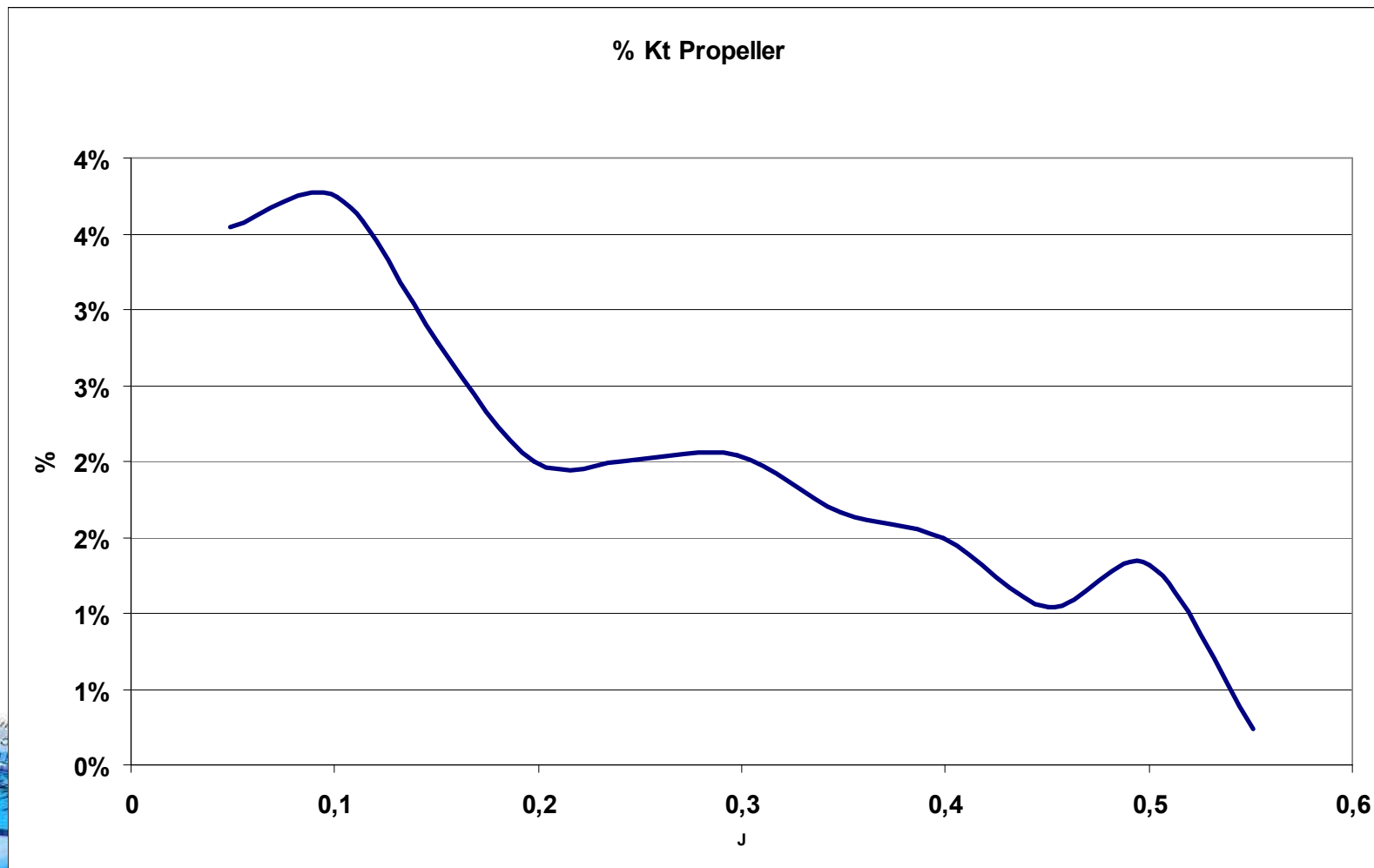
Variation percentage



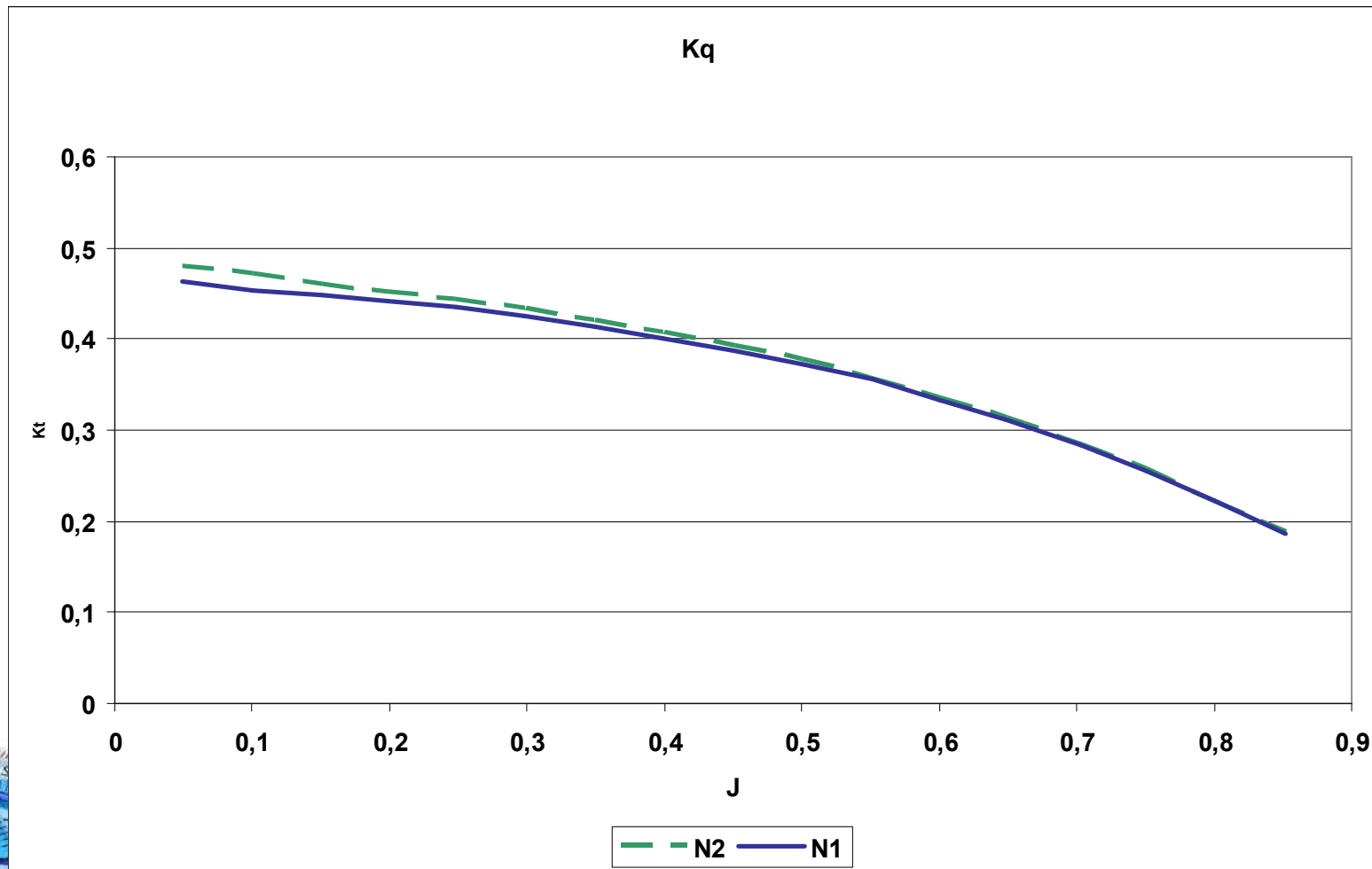
Kt –propeller Comparison



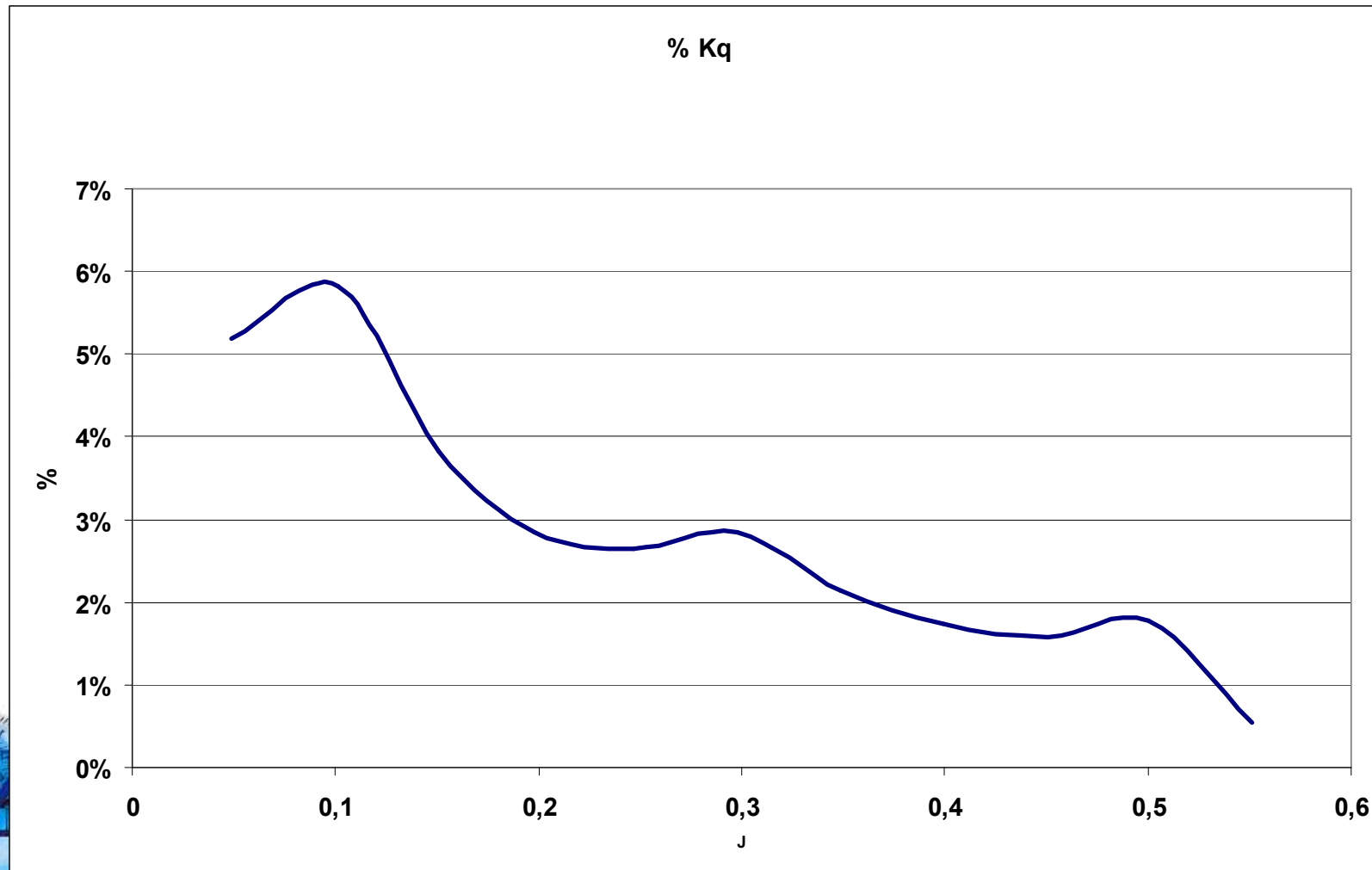
Variation percentage



Kq – Comparison



Variation percentage



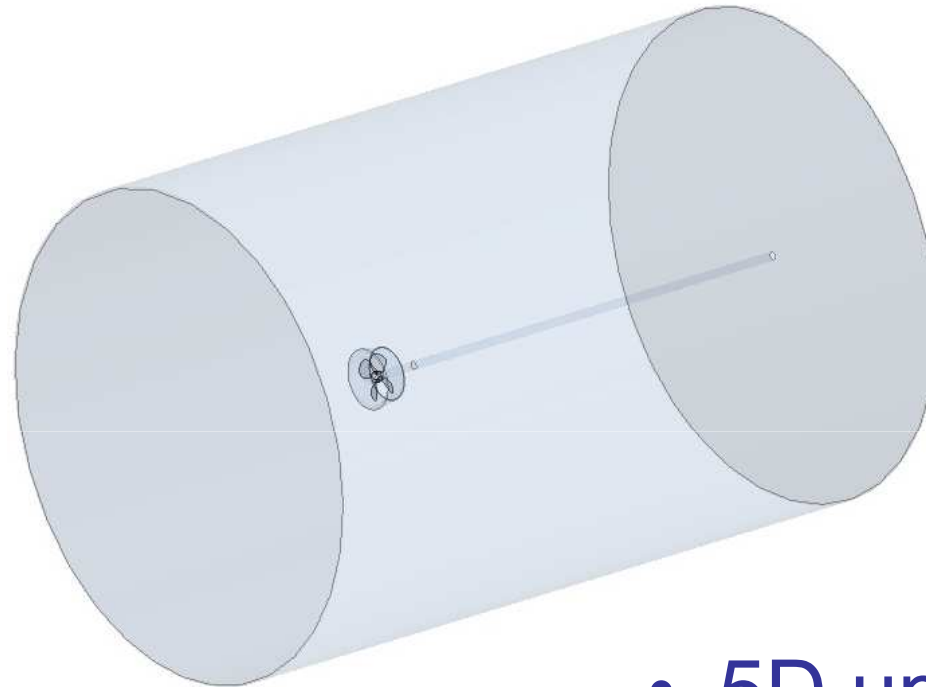
INDEX

1. Geometrical definition
2. Experimental analysis
3. Mathematical and numerical model
4. CFD results
5. Concluding remarks
6. Future work

Mathematical model

- Star CCM+
 - RANSE
 - K-e
 - Wall laws
 - Steady state
 - MRF
 - Non Periodic

Numerical Model

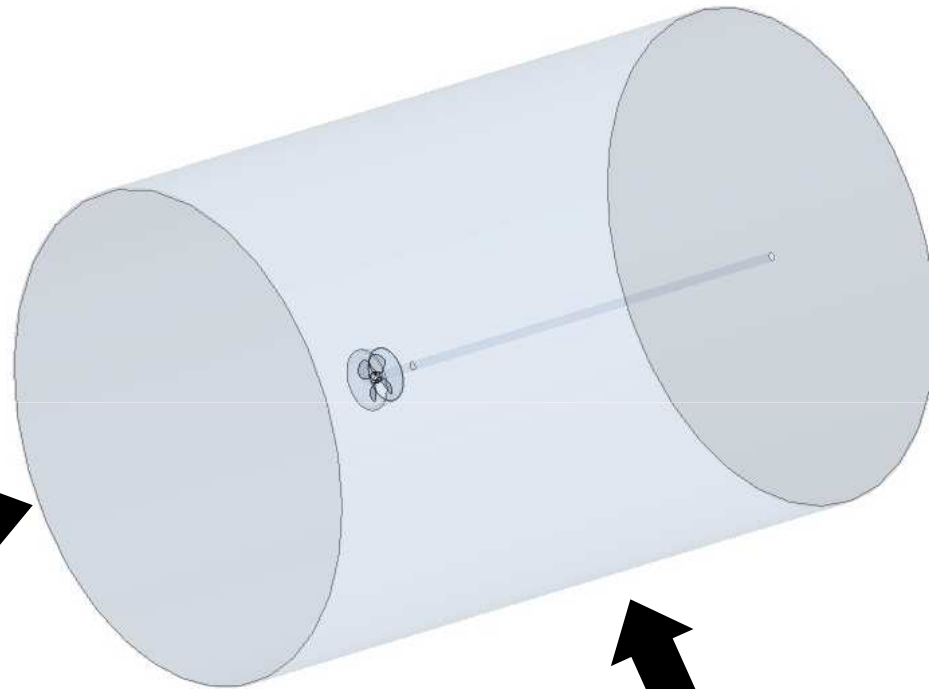


- 5D upstream
- 5D far field
- 10D downstream



Numerical Model

V
TKE
TDR

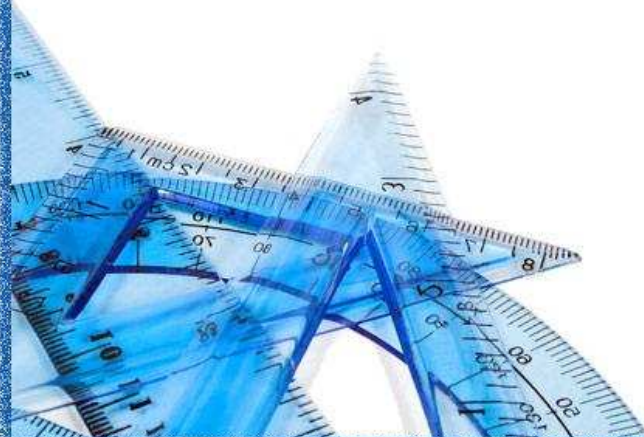
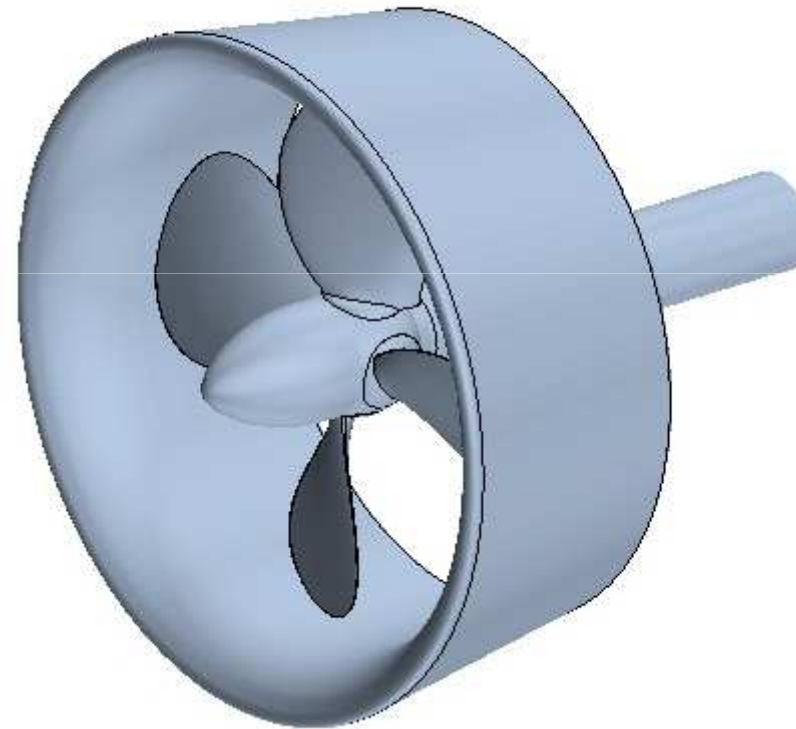


P
TKE
TDR

Symmetry

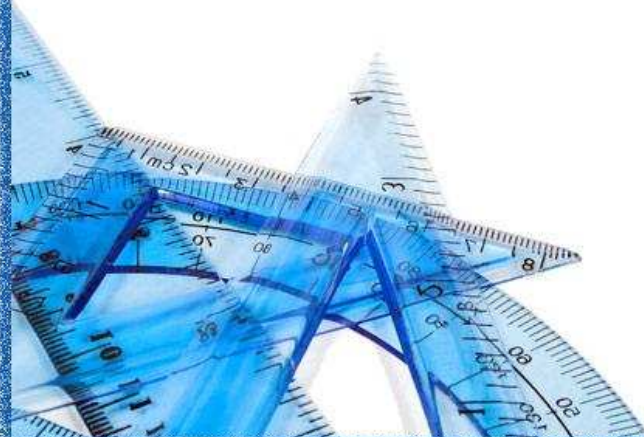
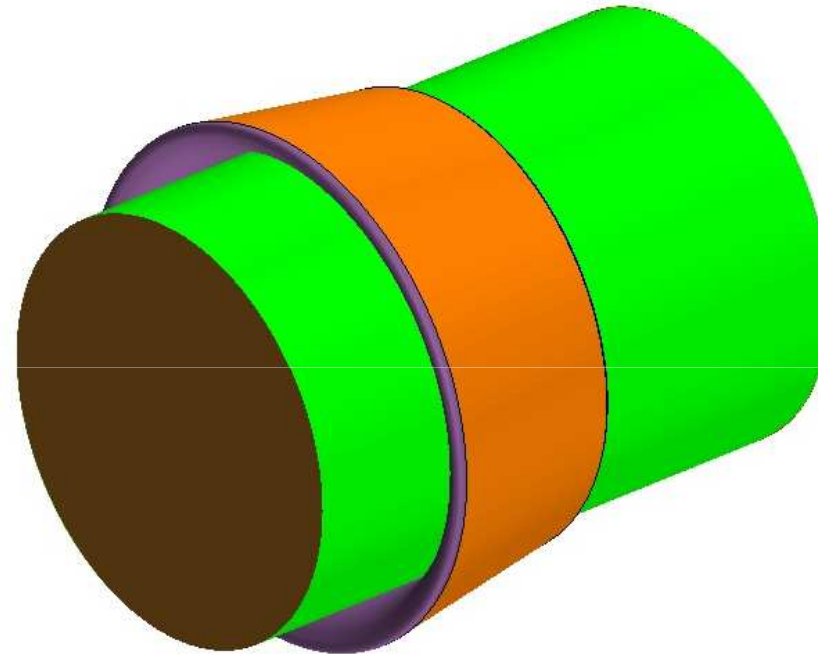
Numerical Model

- No slip
- Wall Law ($y^+ > 30$)



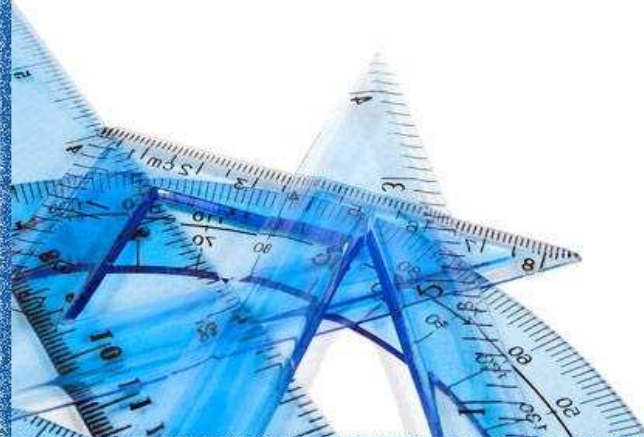
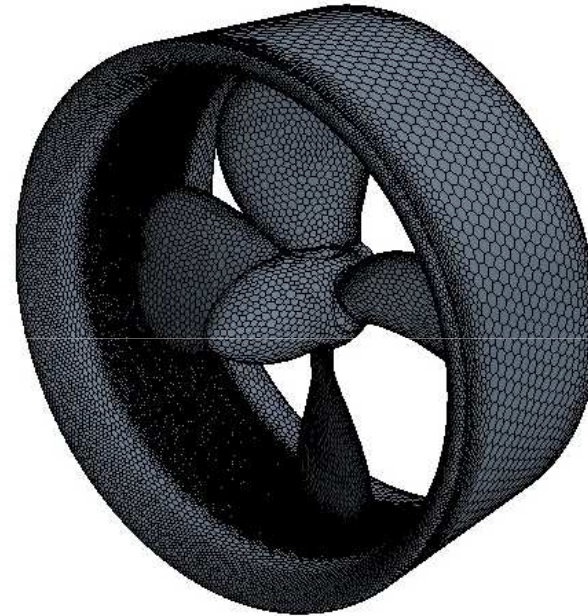
Numerical Model

Two different
physical
regions



Numerical Model

Unstructured
Polyhedral
meshes

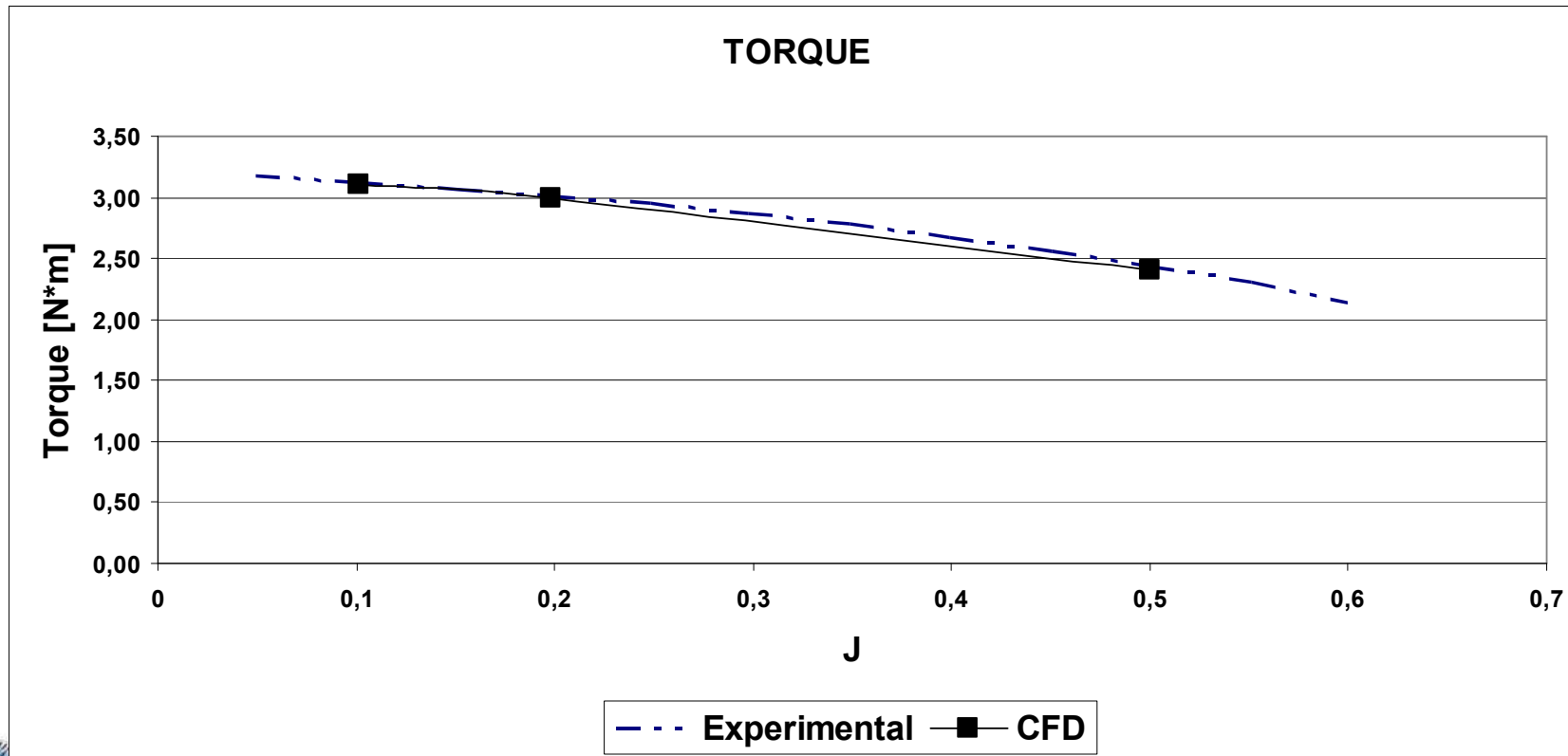


INDEX

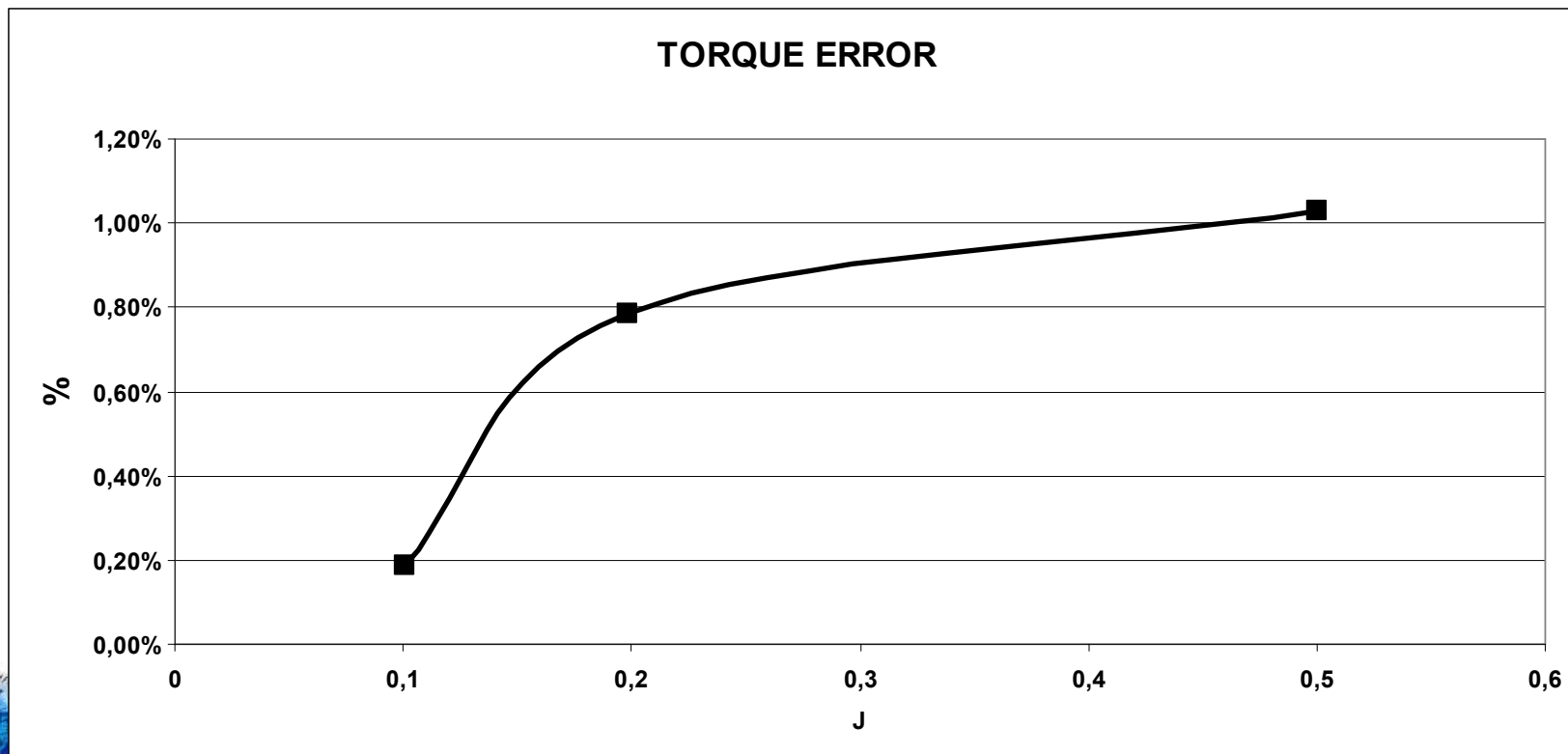
1. Geometrical definition
2. Experimental analysis
3. Mathematical and numerical model
4. **CFD results**
5. Concluding remarks
6. Future work



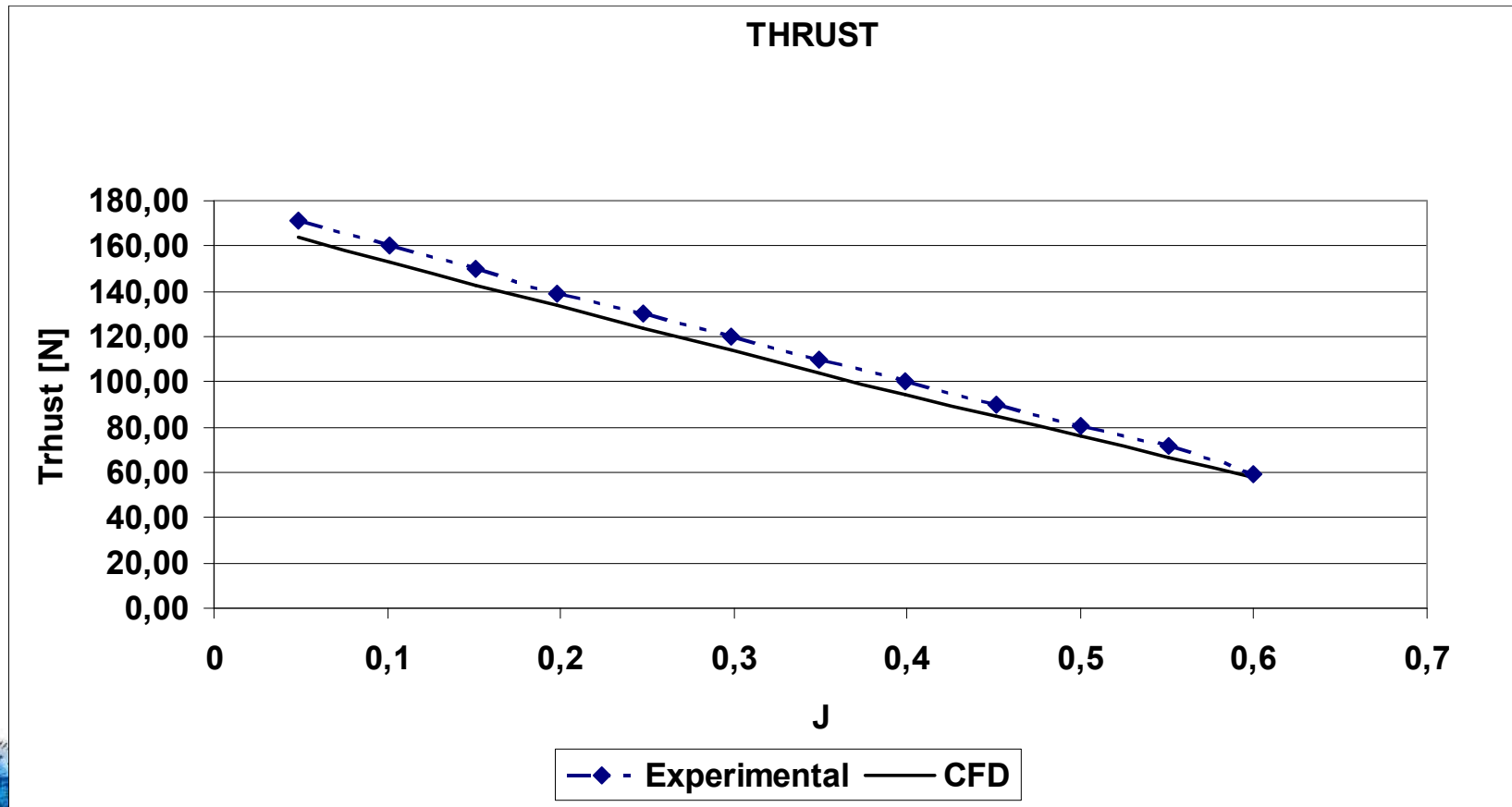
CFD Vs Experiments: N1 Torque



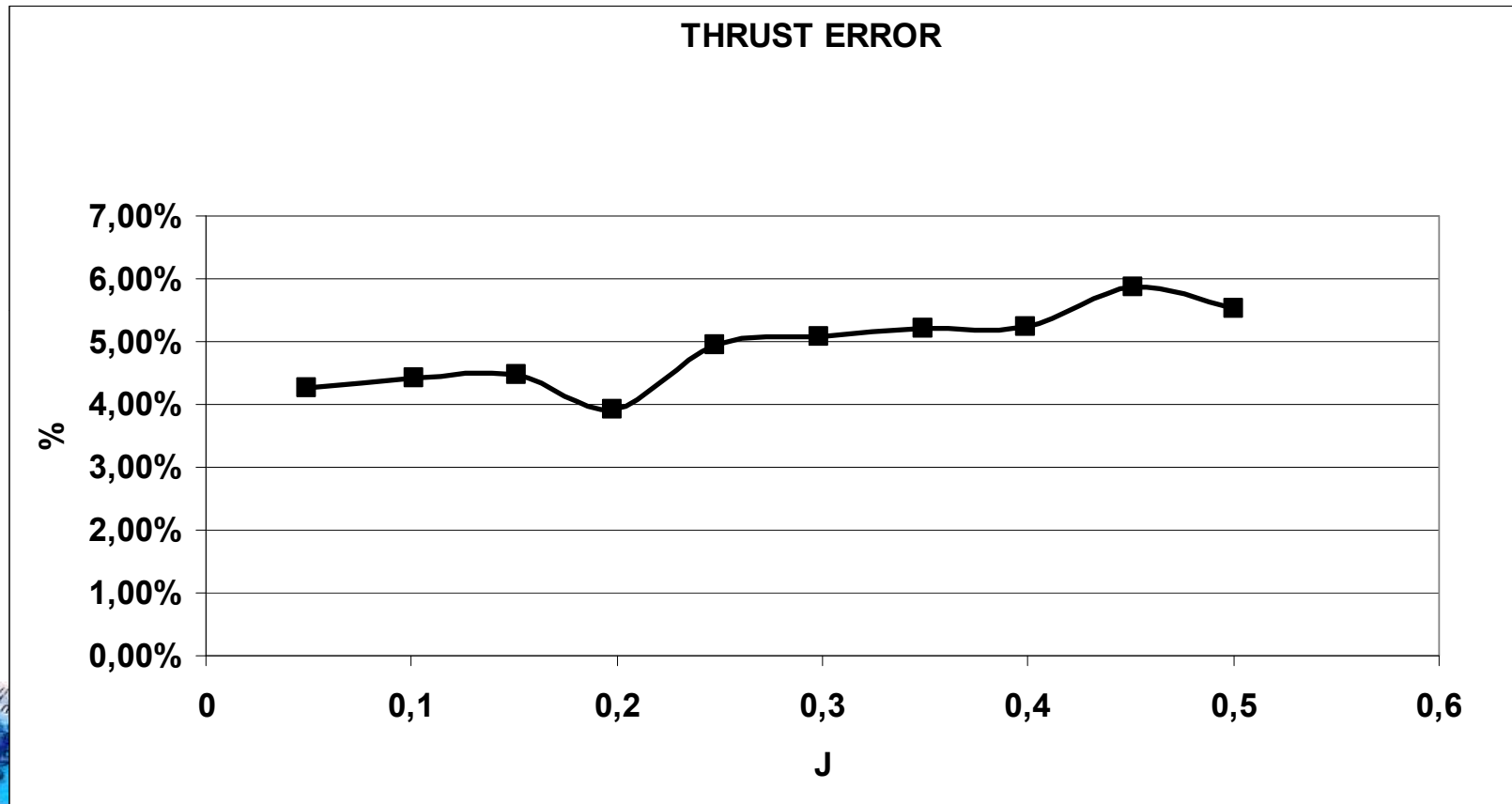
CFD Vs Experiments: N1 Torque



CFD Vs Experiments: N1 Thrust

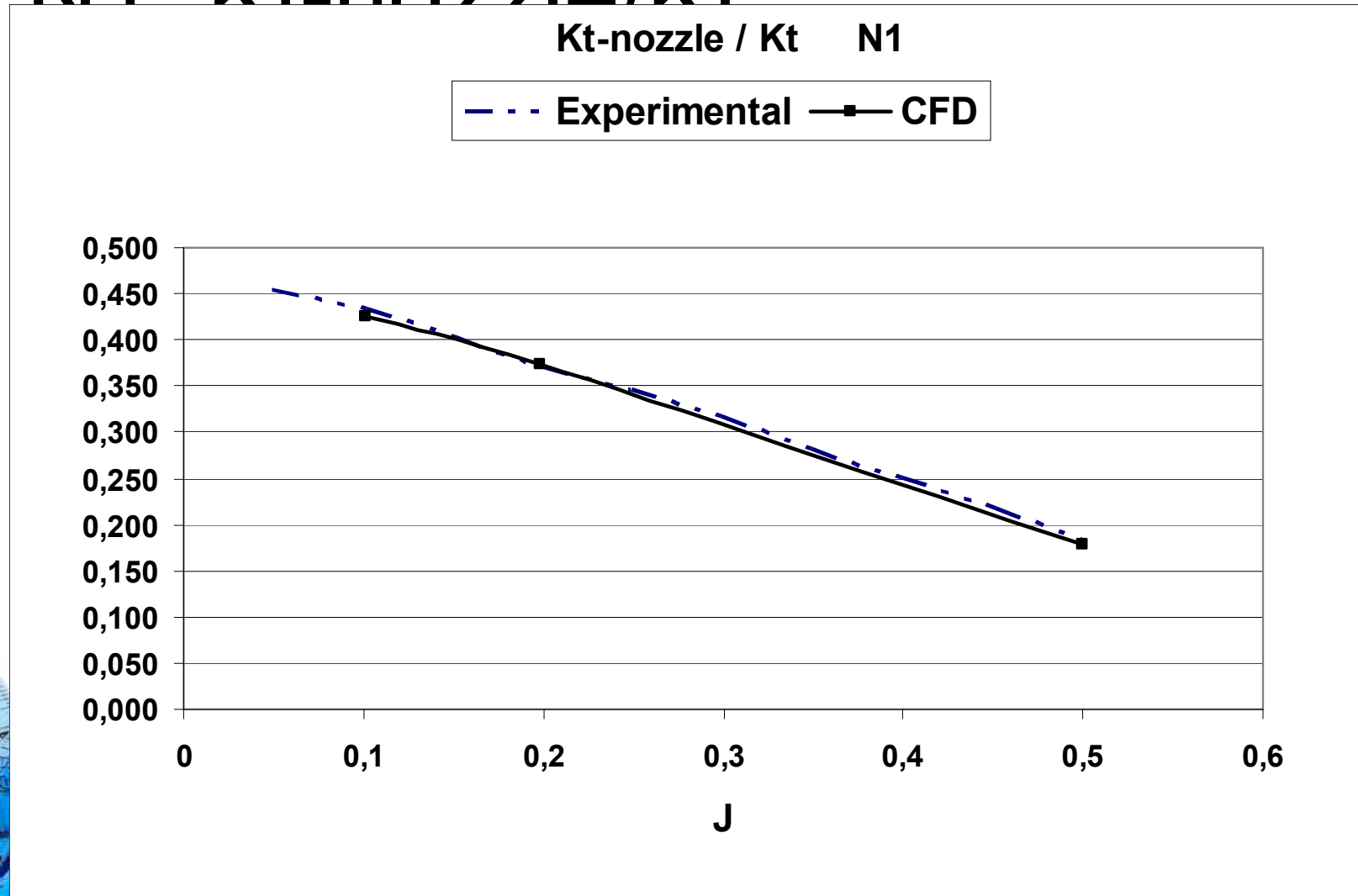


CFD Vs Experiments: N1 Thrust

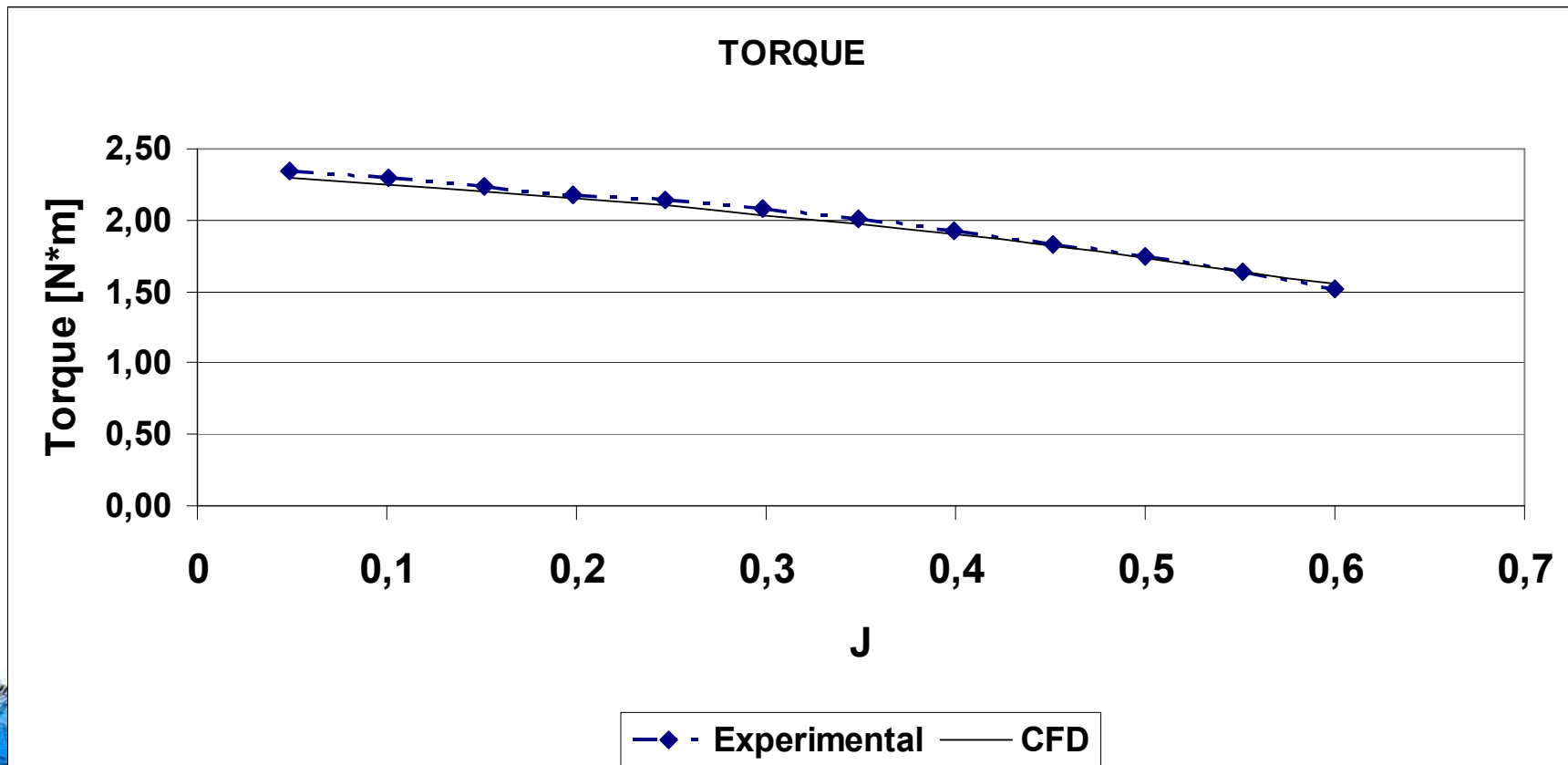


CFD Vs Experiments

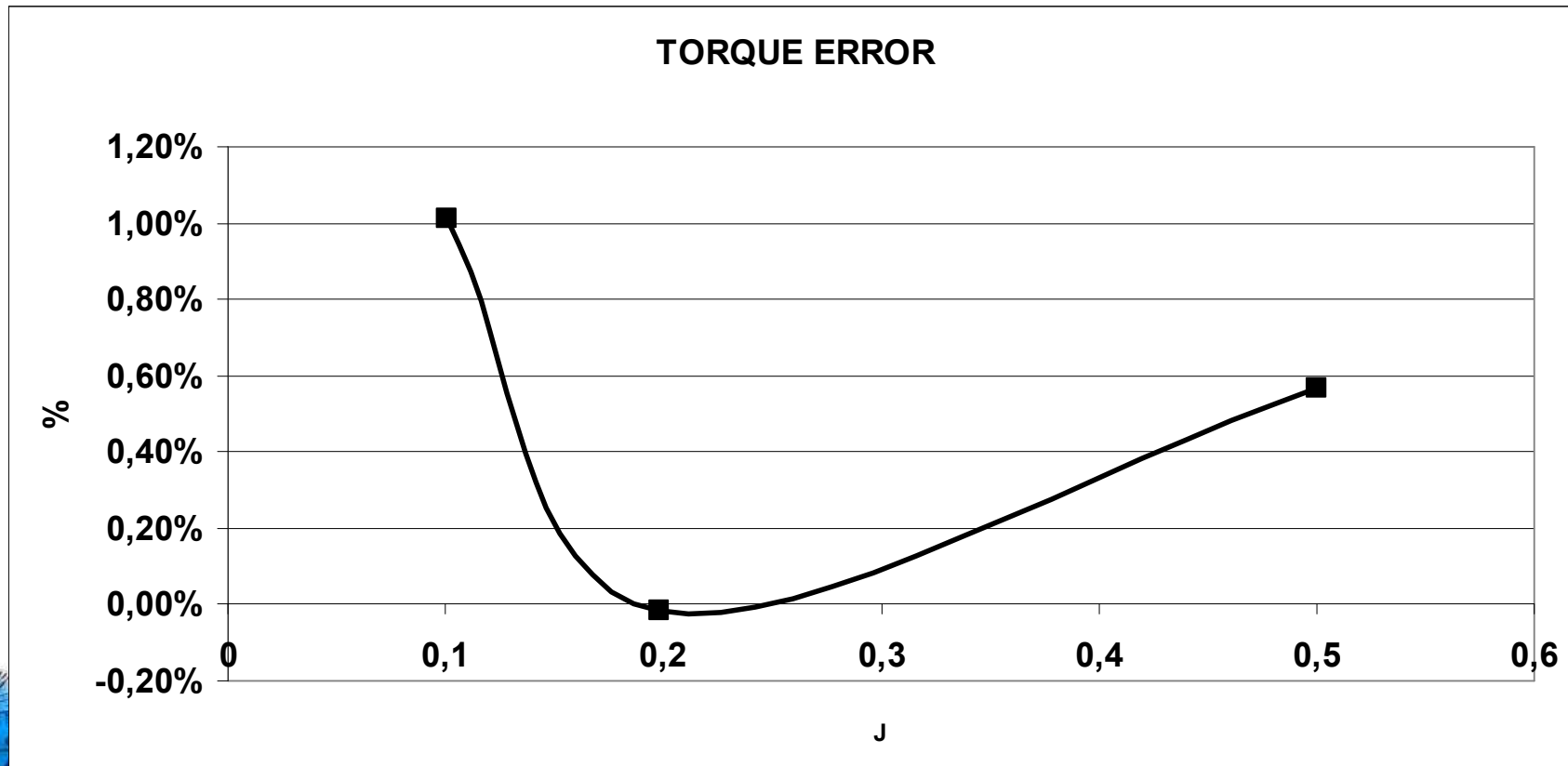
$N1 \cdot Kt_nozzle / Kt$



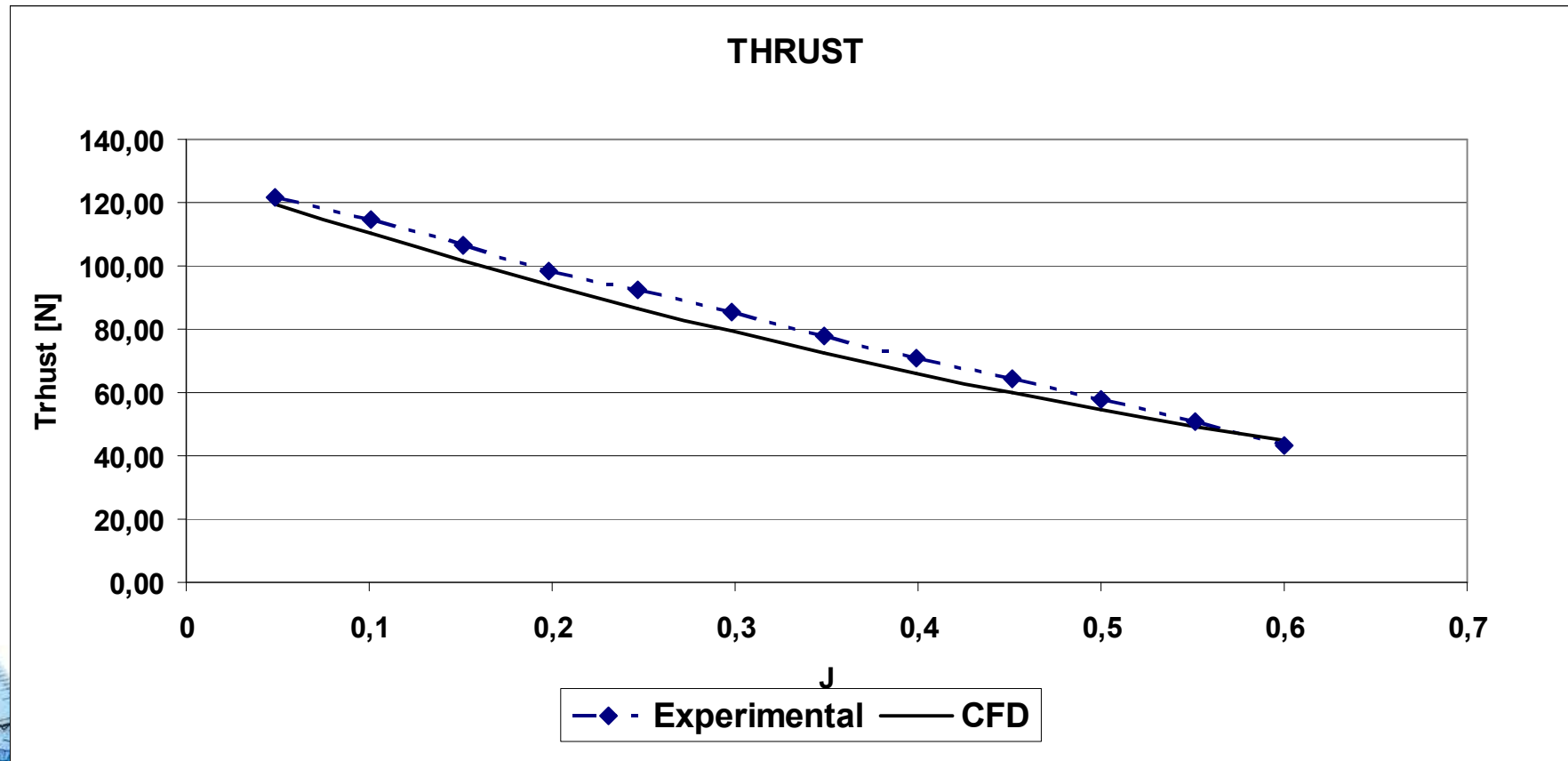
CFD Vs Experiments: N2 Torque



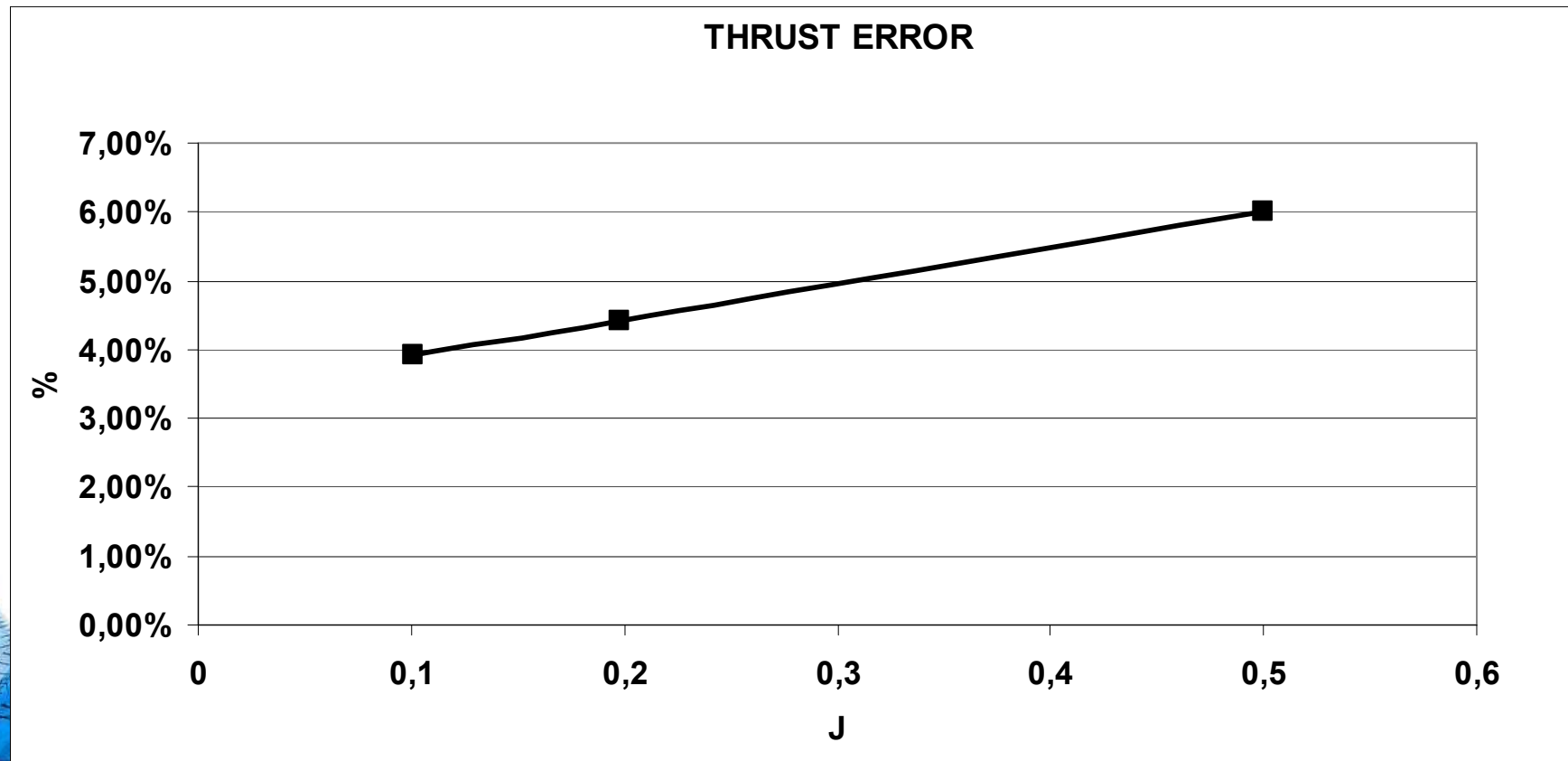
CFD Vs Experiments: N2 Torque



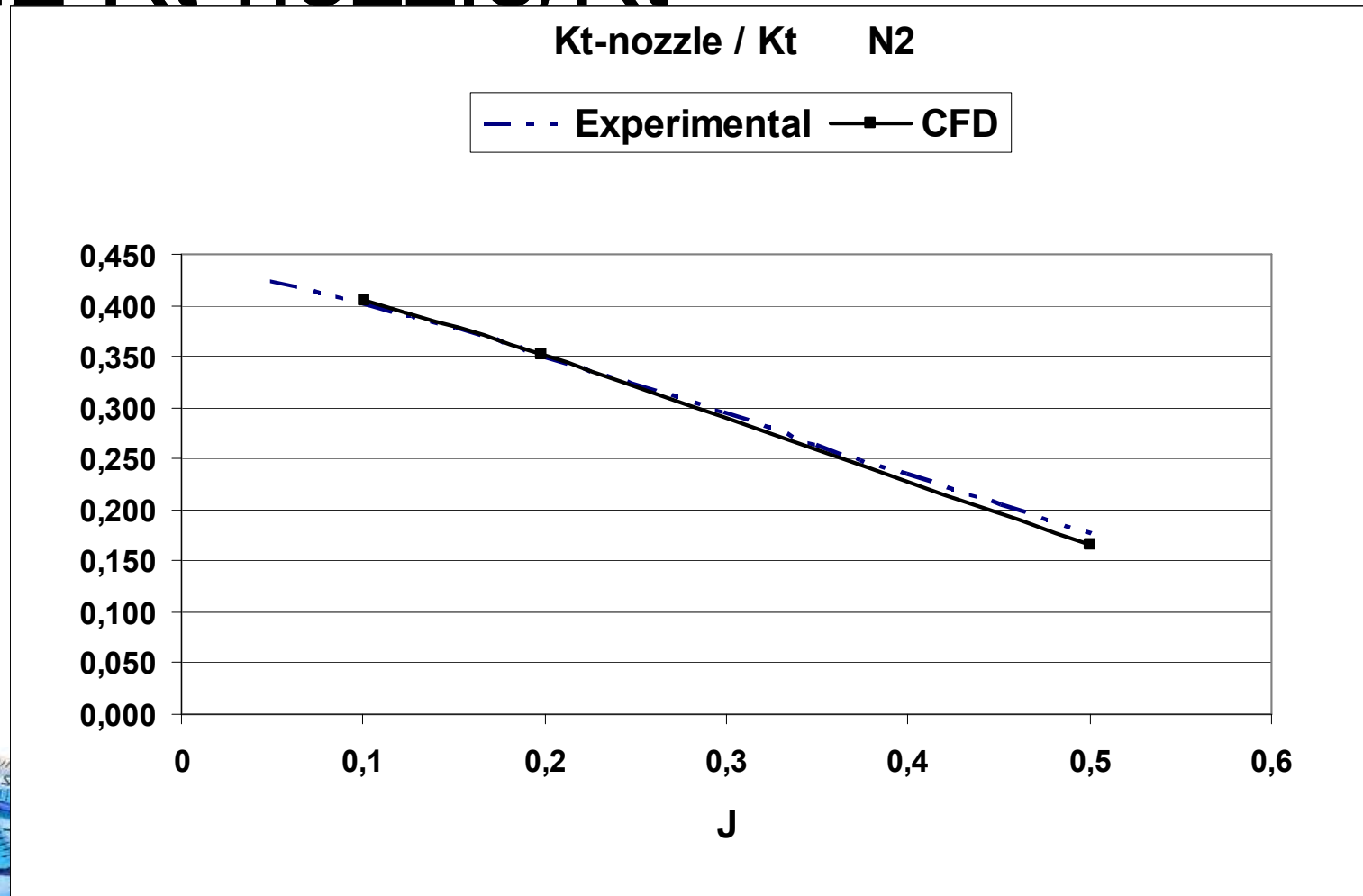
CFD Vs Experiments: N2 Thrust



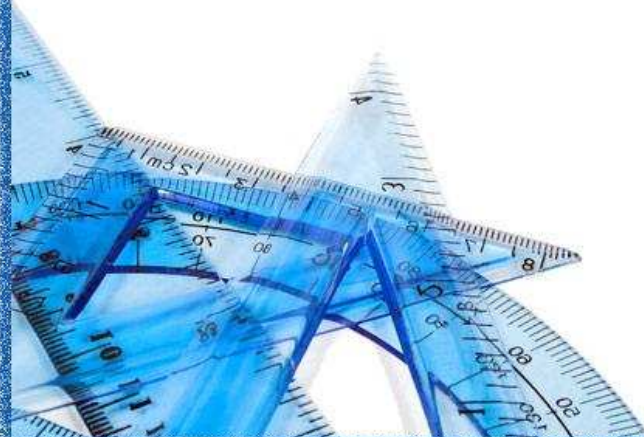
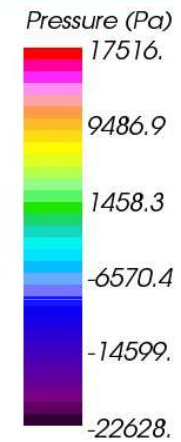
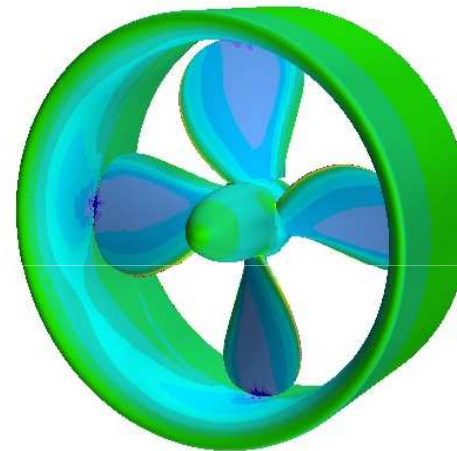
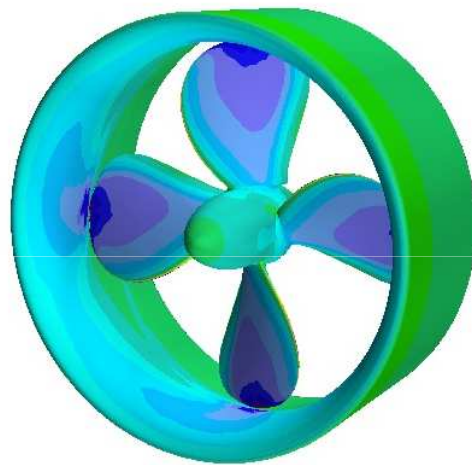
CFD Vs Experiments: N2 Thrust



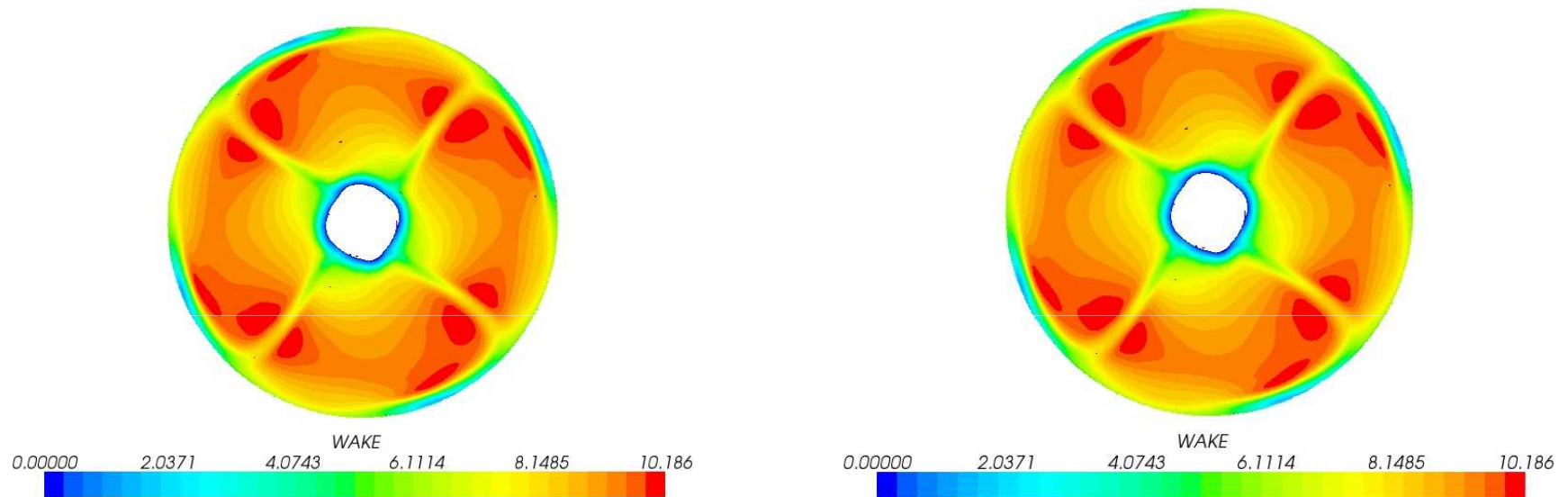
CFD Vs Experiments: N2 Kt-nozzle/Kt



N1: $J=0,2$ and $J=0,5$

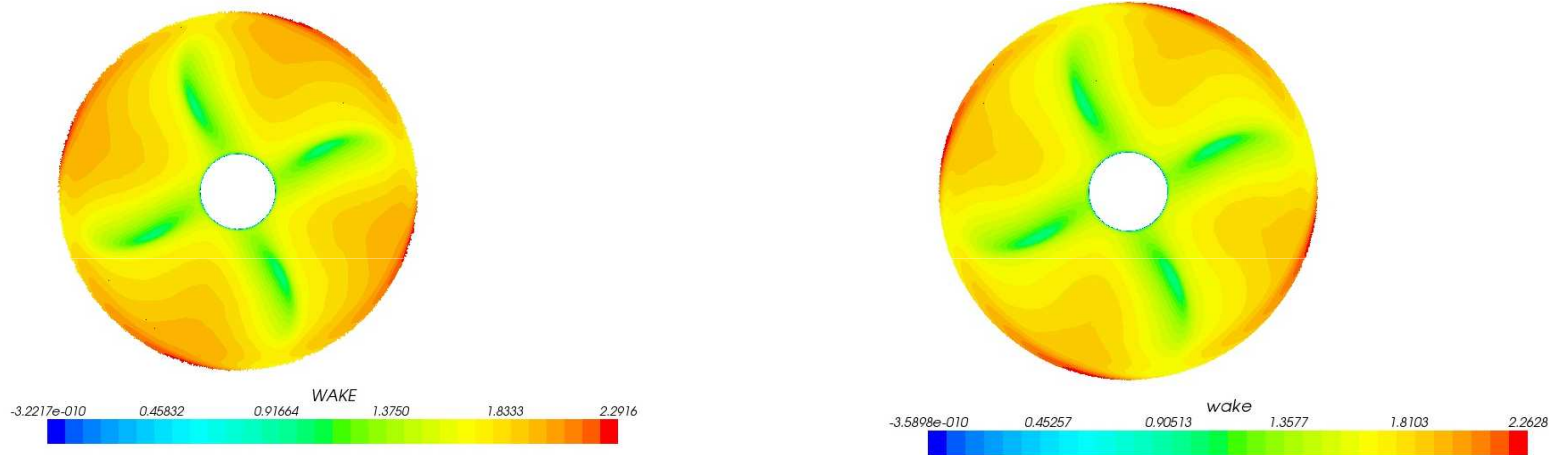


Axial velocities upstream the propeller for $J=0,1$



5% variation on averaged values

Axial velocities upstream the propeller for $J=0,5$



3% variation on averaged values

INDEX

1. Geometrical definition
2. Experimental analysis
3. Mathematical and numerical model
4. CFD results
5. Concluding remarks
6. Future work

CONCLUDING REMARKS

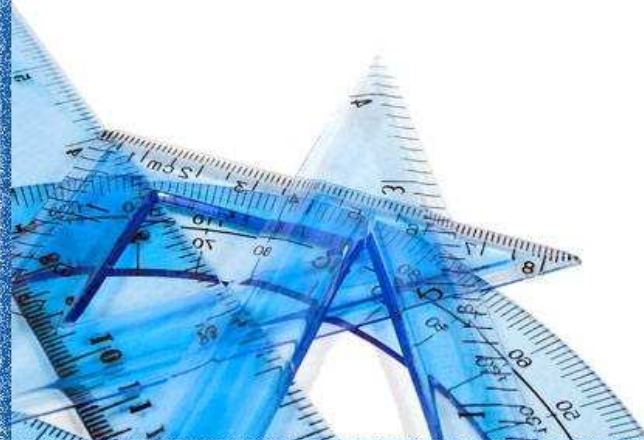


- A validation process for ducted propellers was proposed
- CPP with two different nozzle geometries.
- CFD calculations RANSE model solved with a Finite Volume Method.
- The agreement is good enough for design purposes.
- CFD numerical model can be employed as a design tool

Future work



- More Validation cases

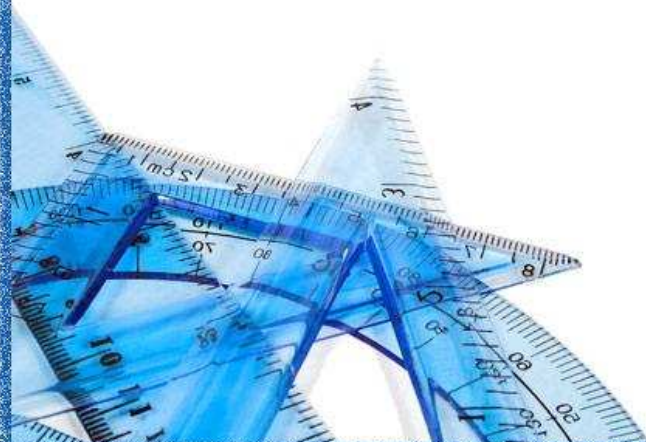


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Future work



- More Validation cases
- Rudder effects



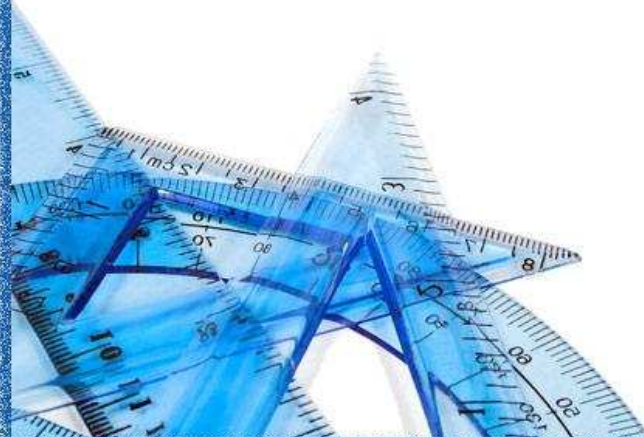
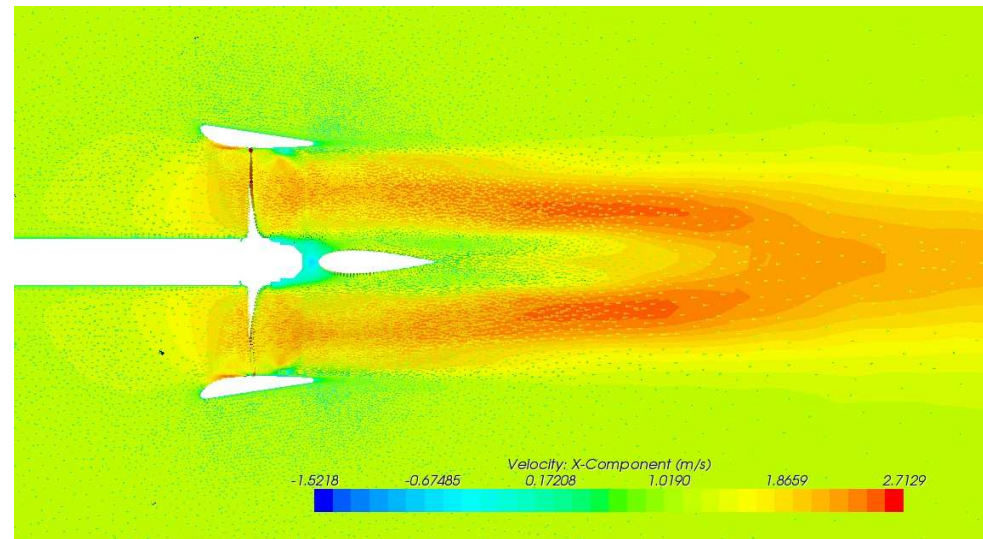
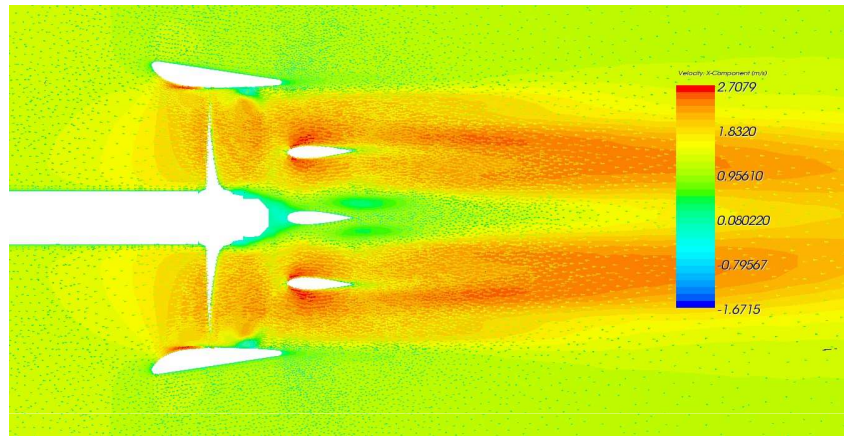
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Future work

- More Validation cases
- Rudder effects

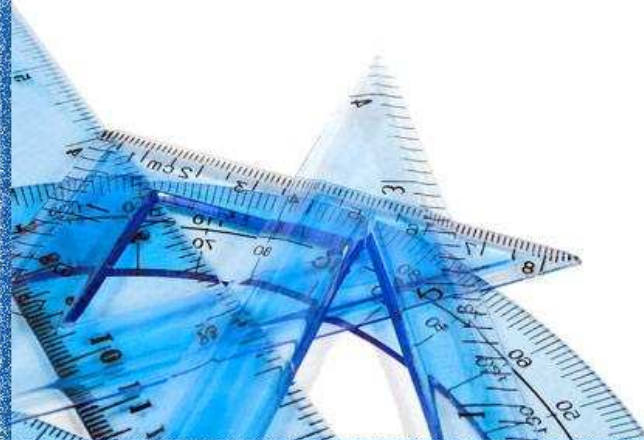


Future work



Future work

	Three Rudders	One Rudder
Height/Chord	4,14	2
Area	1	0.7

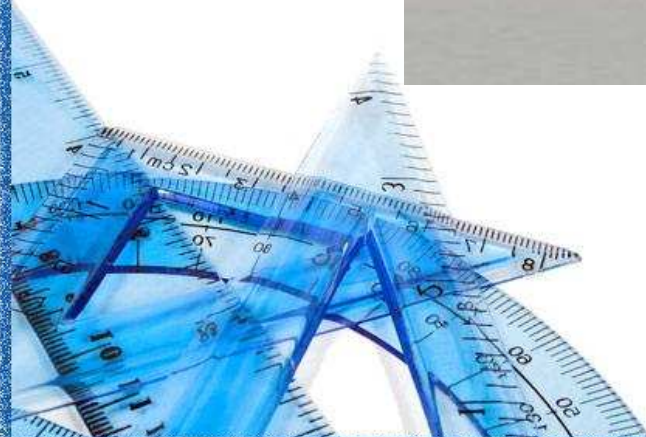


Future work

	Without Rudder	Three Rudders	One Rudder
Propeller + Nozzle [N]	58.32	62.6	63.34
Propeller + Nozzle +Rudder [N]		59.4	62.36
Torque [N*m]	1.73	1.82	1.83
η	44.35%	42.81%	44.98%

- Beyond this maneuverability aspects must be taken into account

THANK YOU!



Convergence Study

- Spatial convergence
- Iterative convergence

Torque [N*m]	Mesh 1	Mesh 2	Iterative Error	Spatial Discretisation Error
<i>3.01</i>	<i>2.99</i>	<i>2.96</i>	<i>1.17E-06</i>	<i>0.9%</i>
Thrust [N]	Mesh 1	Mesh 2	Iterative Error	Spatial Discretisation Error
<i>139.03</i>	<i>133.58</i>	<i>133.77</i>	<i>6.23E-07</i>	<i>-0.1%</i>