Numerical Investigation of Propeller-Ice Interaction Effects

Master Thesis Defense

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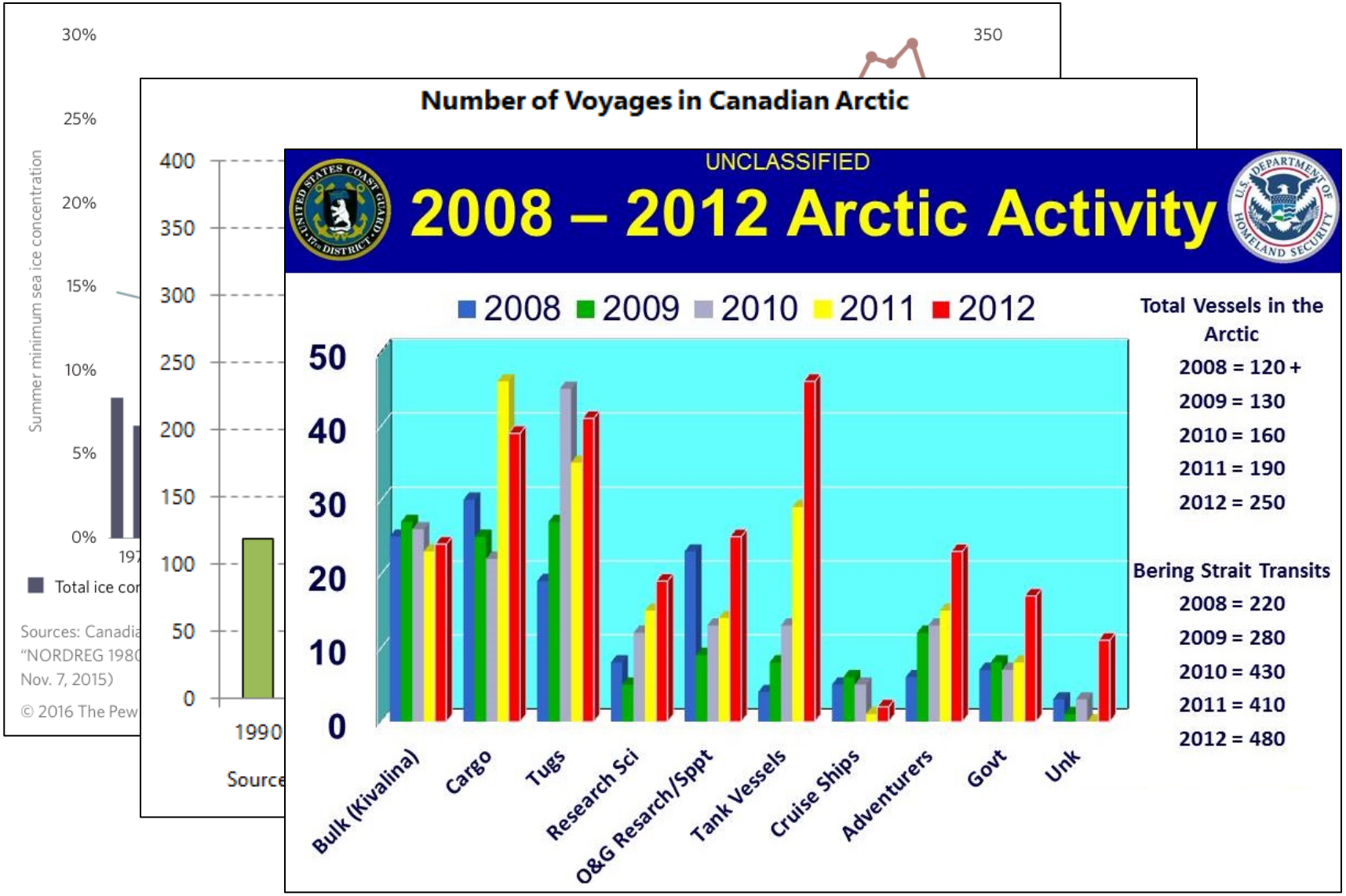
La Spezia 2018

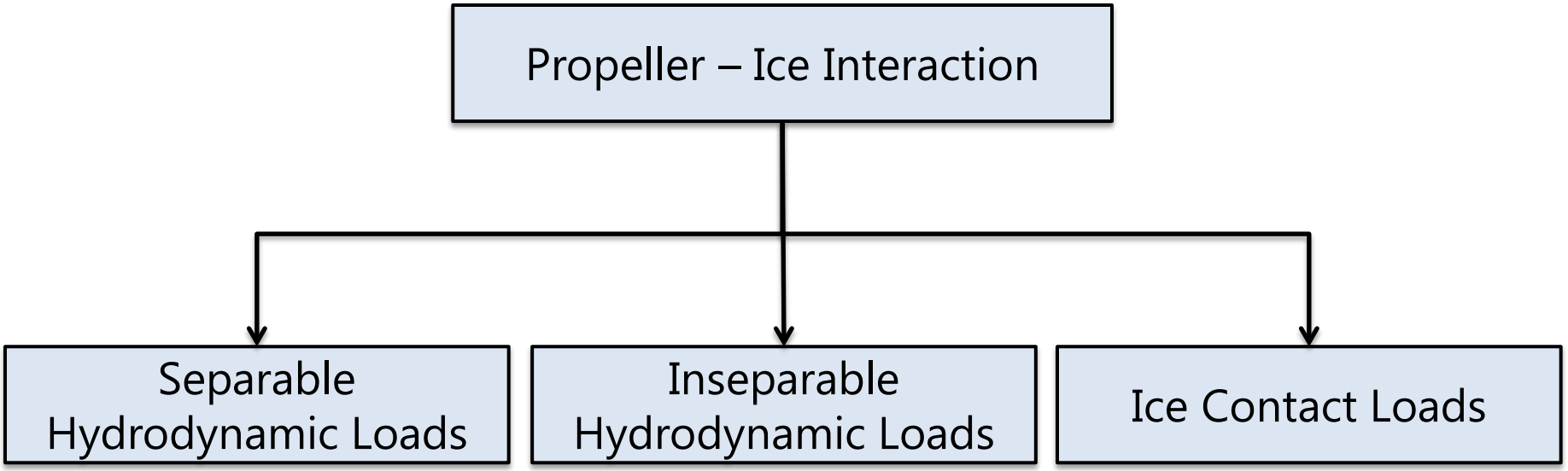
Contents

Motivation

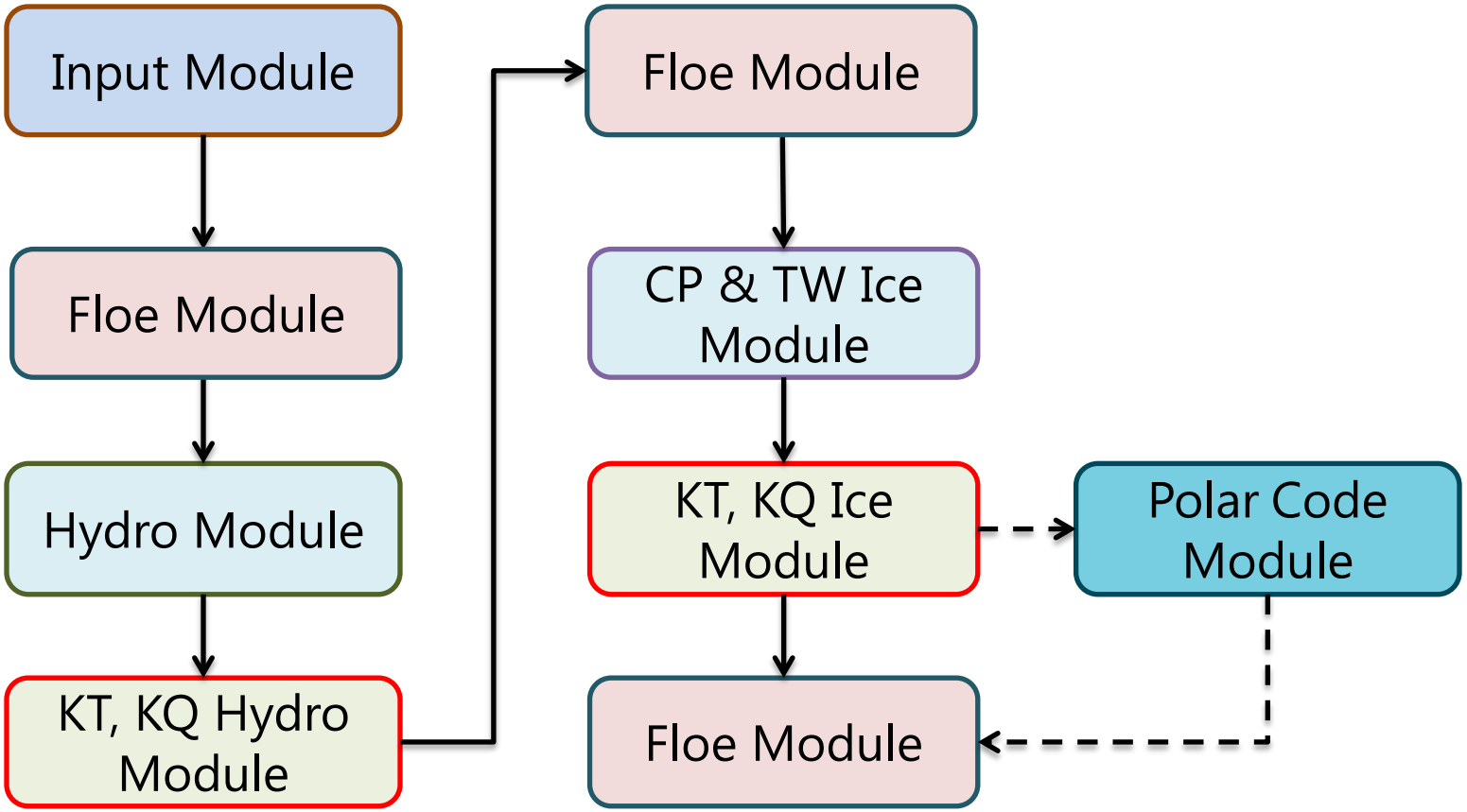

30%
25%
20%
15%
10%
5%
0%
Summer minimum sea ice concentration
350
Total ice cor
Sources: Canadia
"NORDREG 198
Nov. 7, 2015)
© 2016 The Pew
Number of Voyages in Canadian Arctic
400
350
300
250
200
150
100
50
0
1990
Source
UNCLASSIFIED
2008 – 2012 Arctic Activity
2008 2009 2010 2011 2012
50
40
30
20
10
0
Bulk (Kivalina)
Cargo
Tugs
Research Sci
O&G Resarch/Sppt
Tank Vessels
Cruise Ships
Adventurers
Govt
Unk
Total Vessels in the Arctic
2008 = 120 +
2009 = 130
2010 = 160
2011 = 190
2012 = 250
Bering Strait Transits
2008 = 220
2009 = 280
2010 = 430
2011 = 410
2012 = 480

Theoretical Background

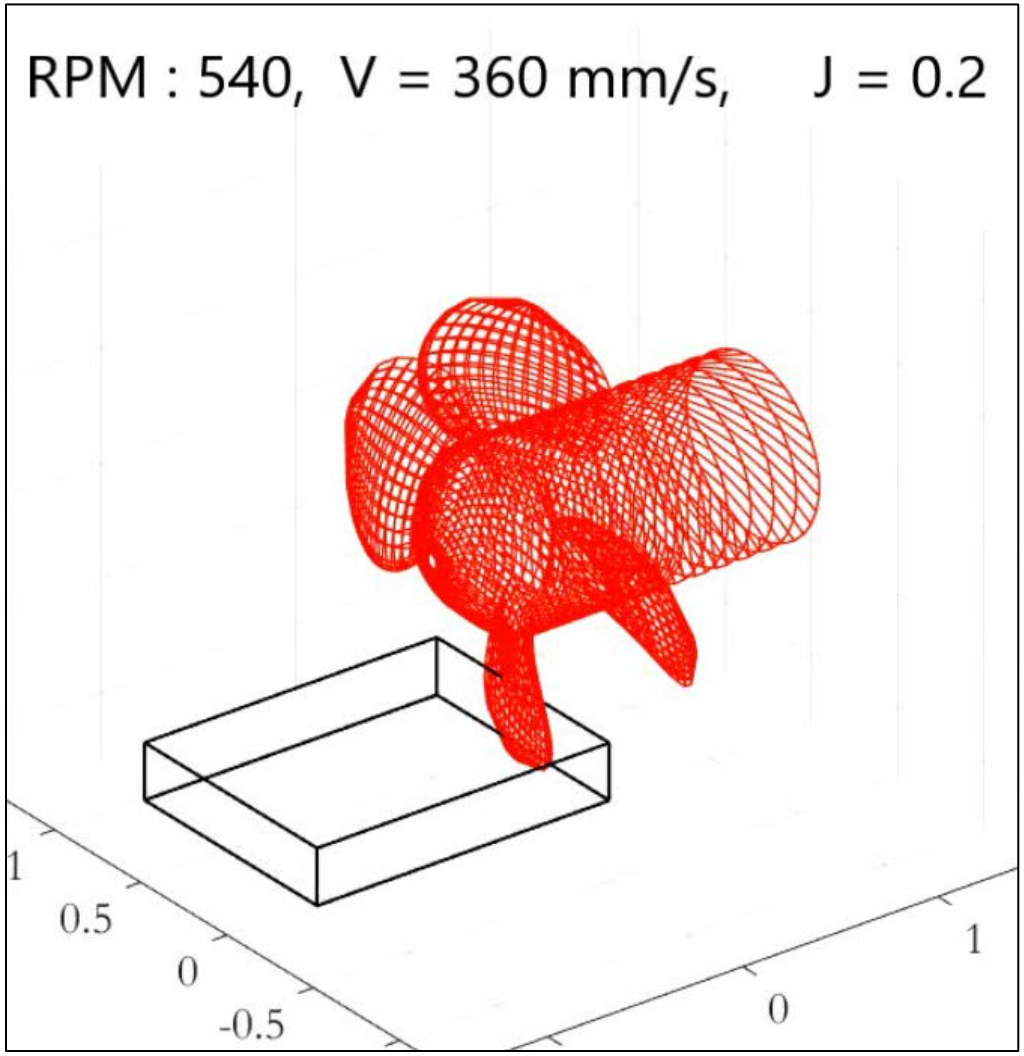
Three types of loads, Wang J., (2007)



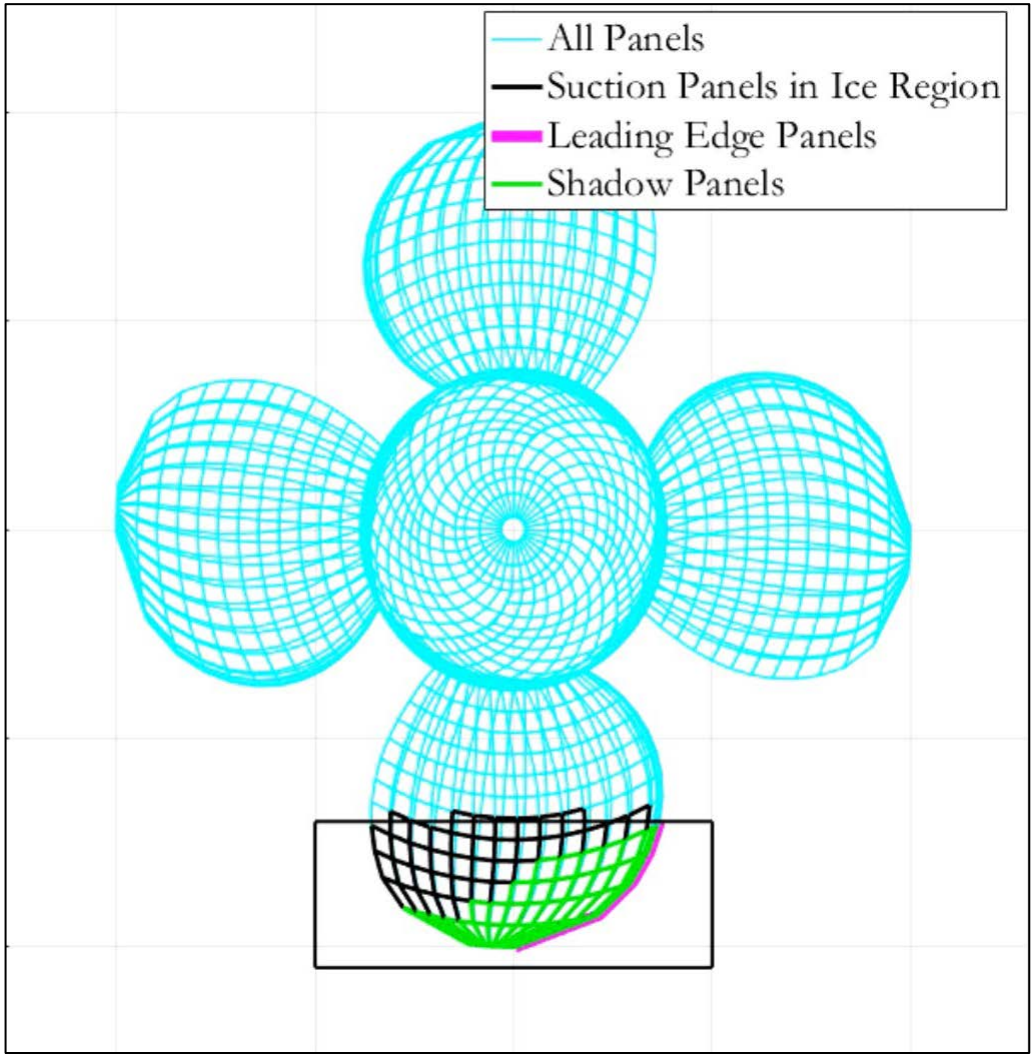
Numerical Code – Algorithm



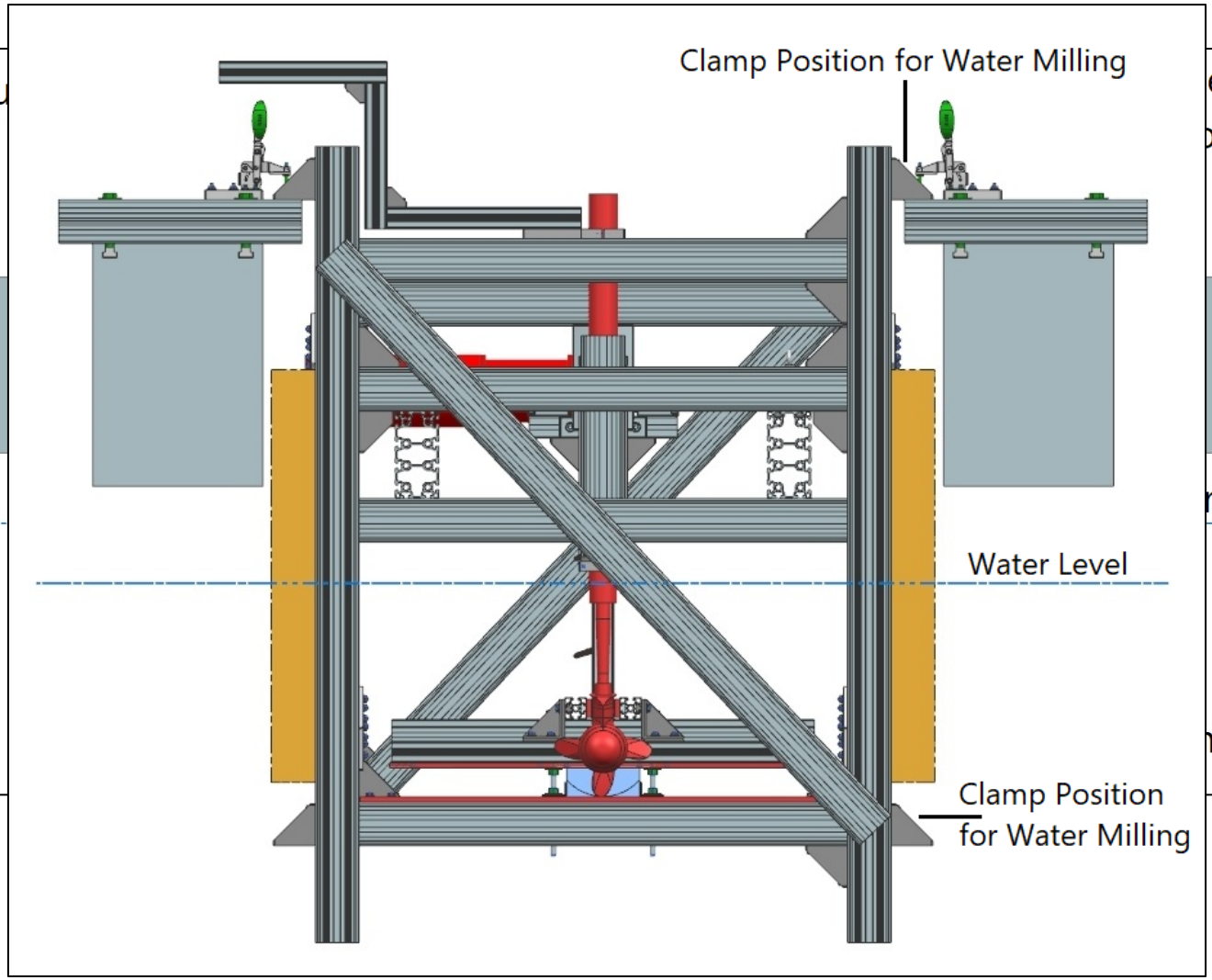
Numerical Code – Simulation of Ice Milling



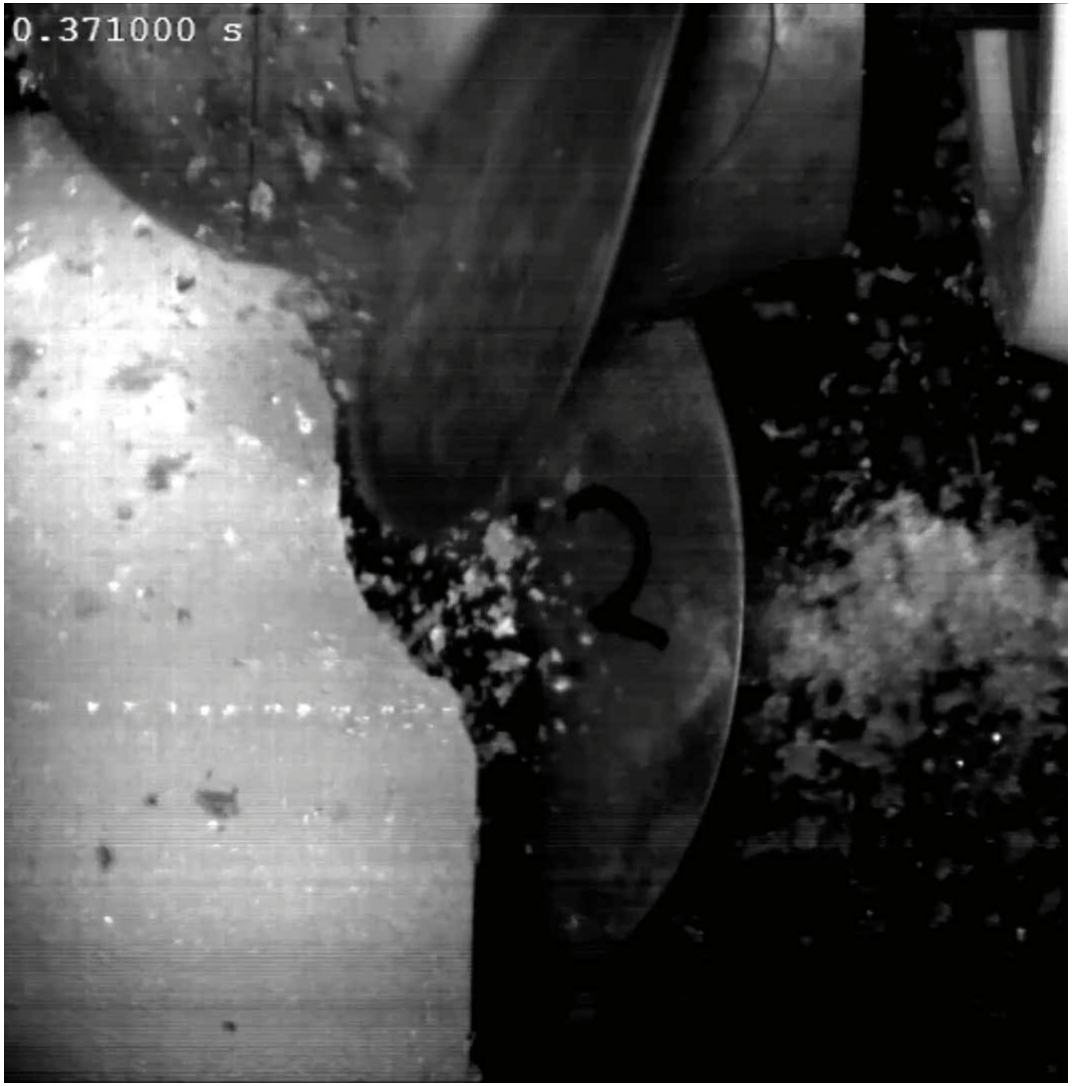
Numerical Code – Selection of Panels



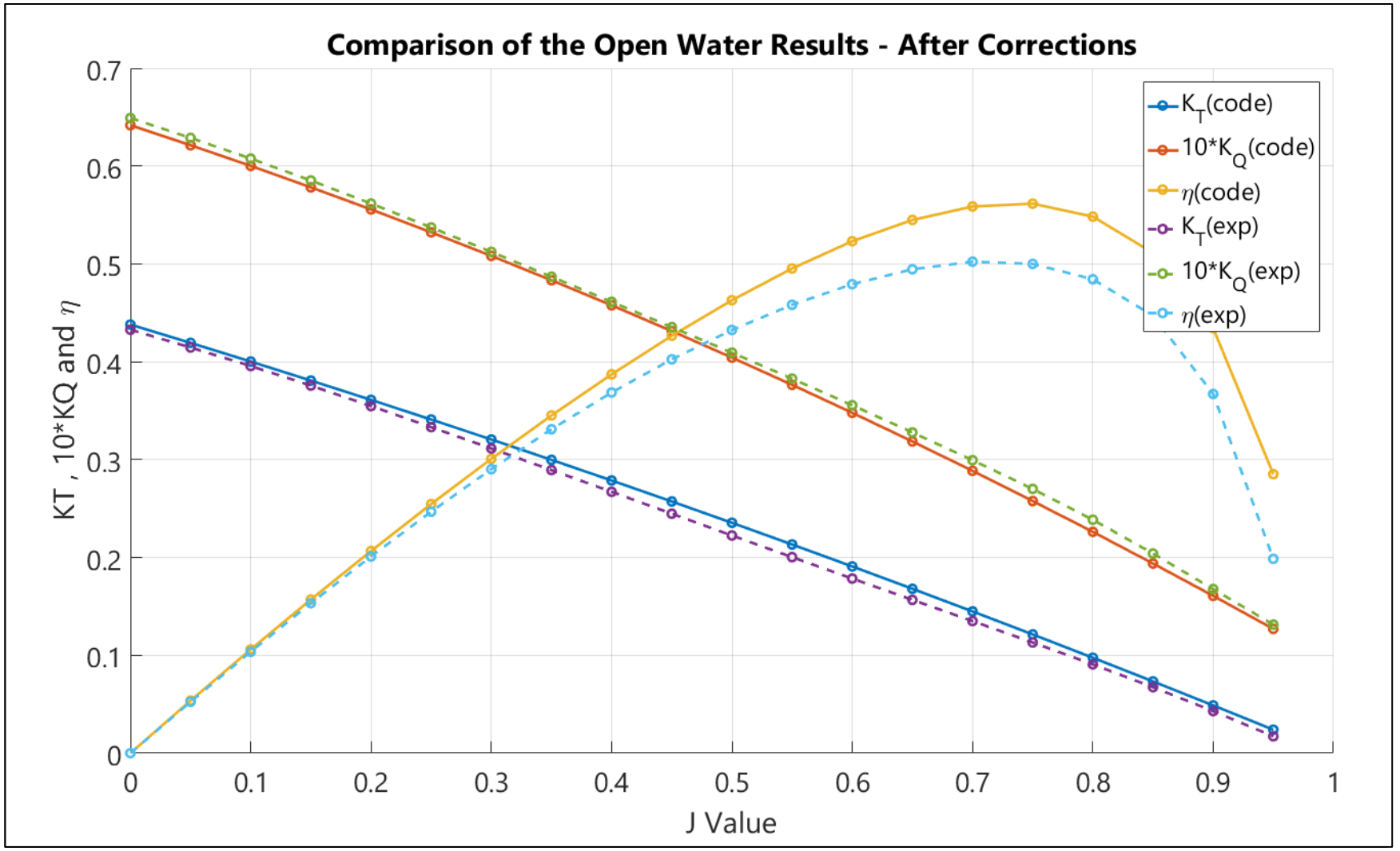
Experiment – Setup



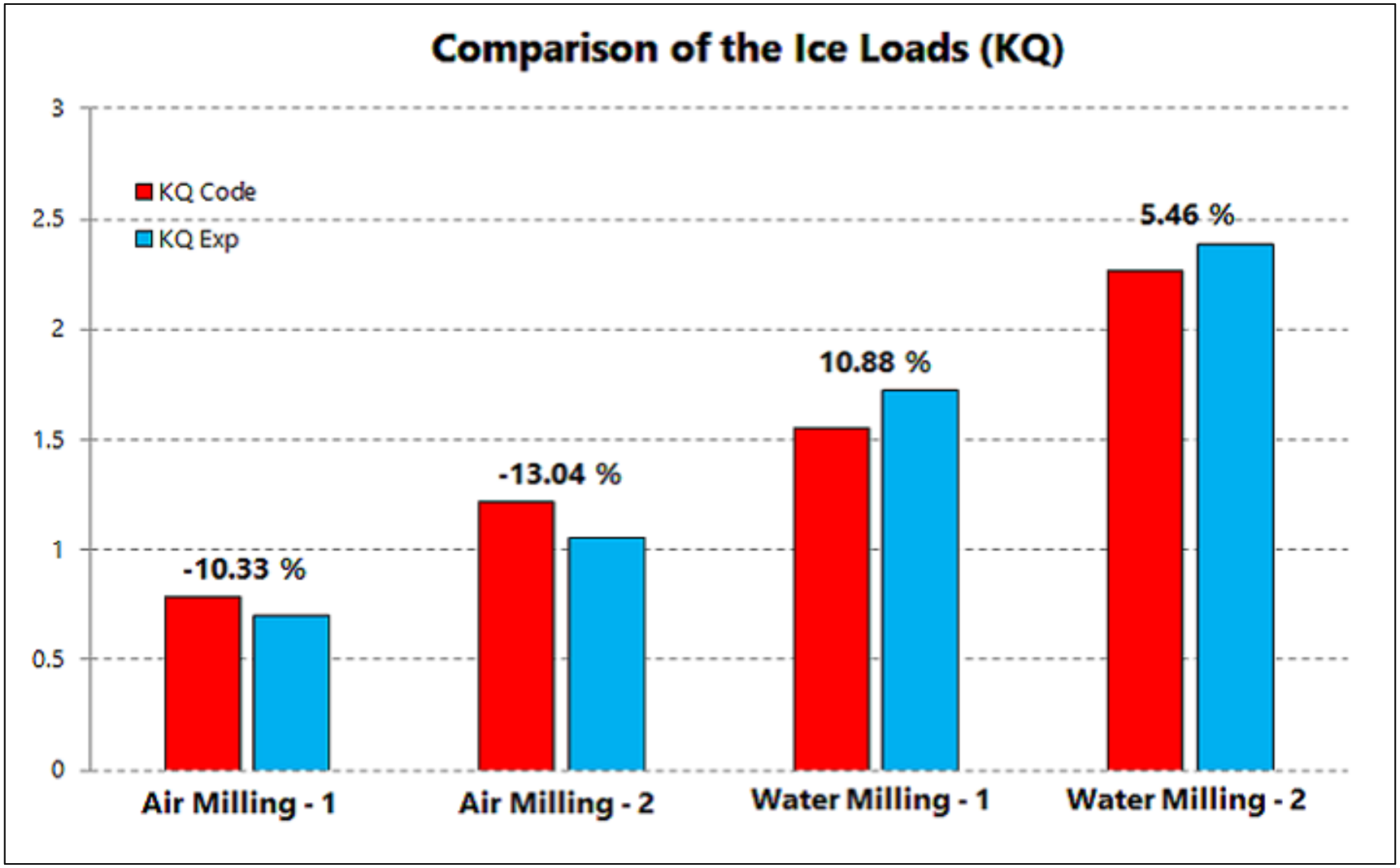
Experiment – High Speed Footage



Calibration – Open Water Loads



Calibration – Ice Loads



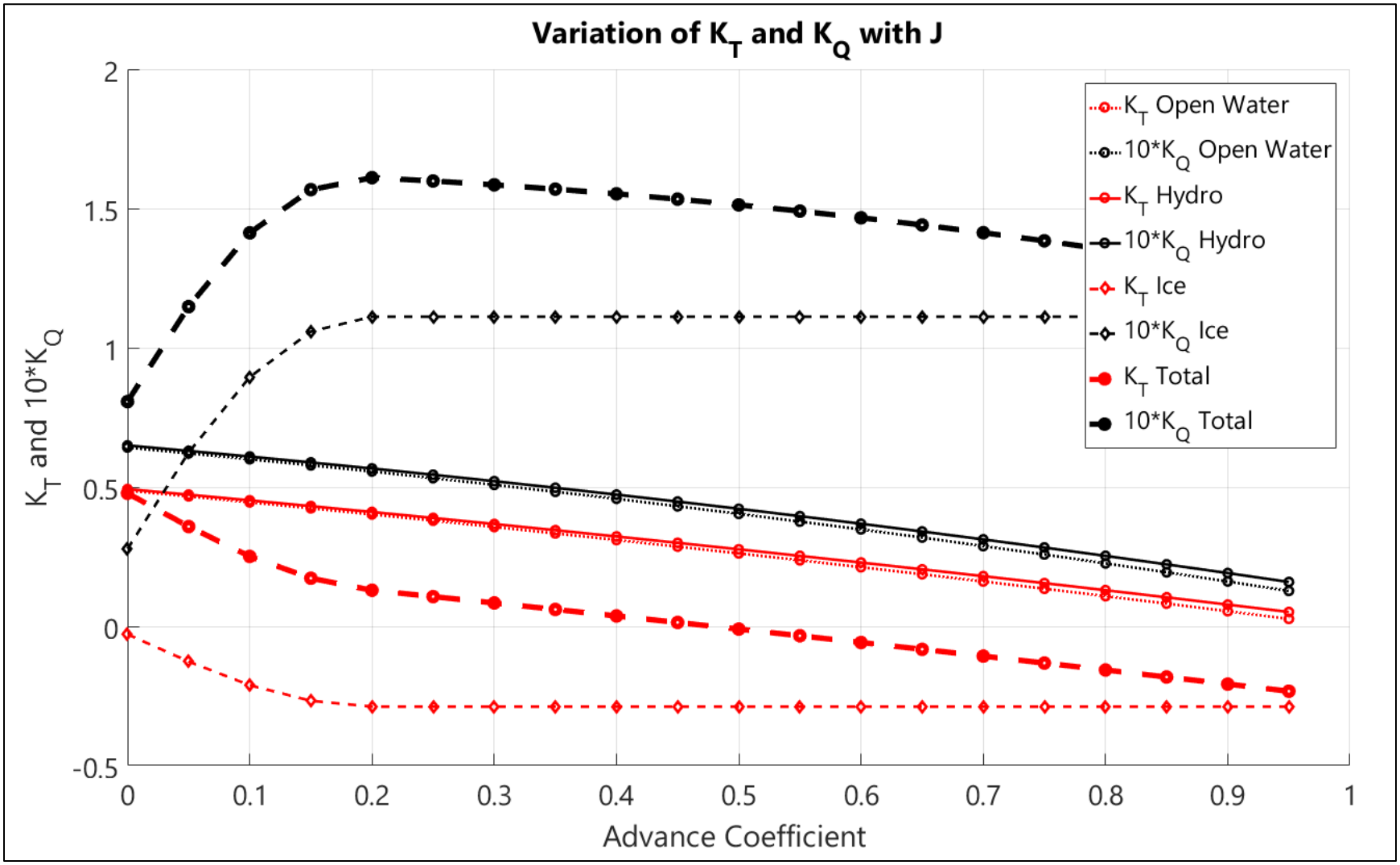
Calibration – Inseparable Hydrodynamic Loads

- No direct calibration
- Calibration done mathematically,

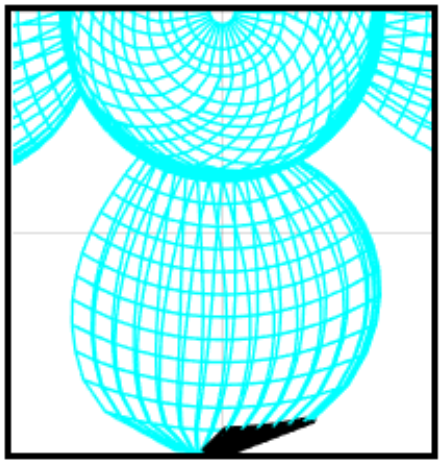
Inseparable HL = Total Loads – (Separable HL + Ice Contact Loads)

- Total Loads from Water Milling Experiment
- Separable HL from Open Water Experiment
- Ice Contact Loads from Air Milling Experiment

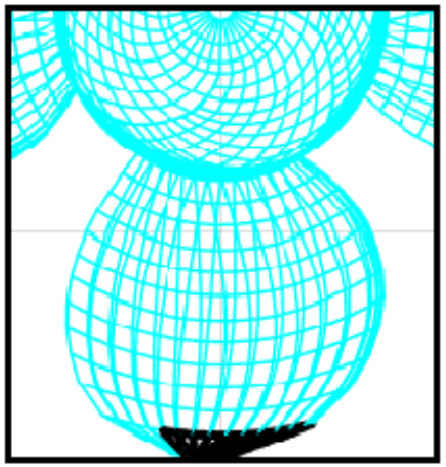
Results – Influence of Advance Coefficient



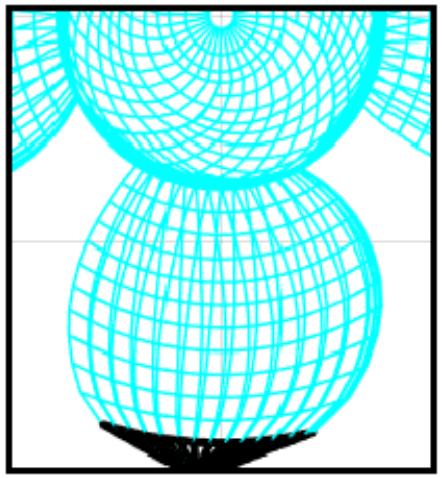
Results – Critical Advance Coefficient



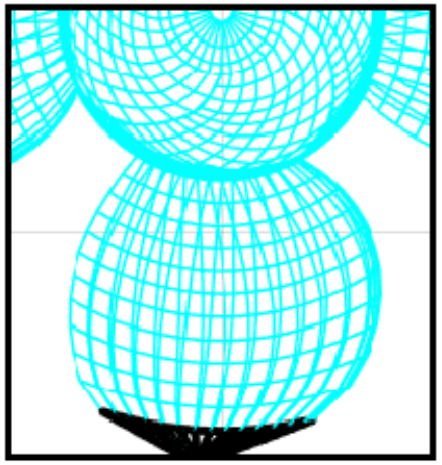
J = 0.05



J = 0.1

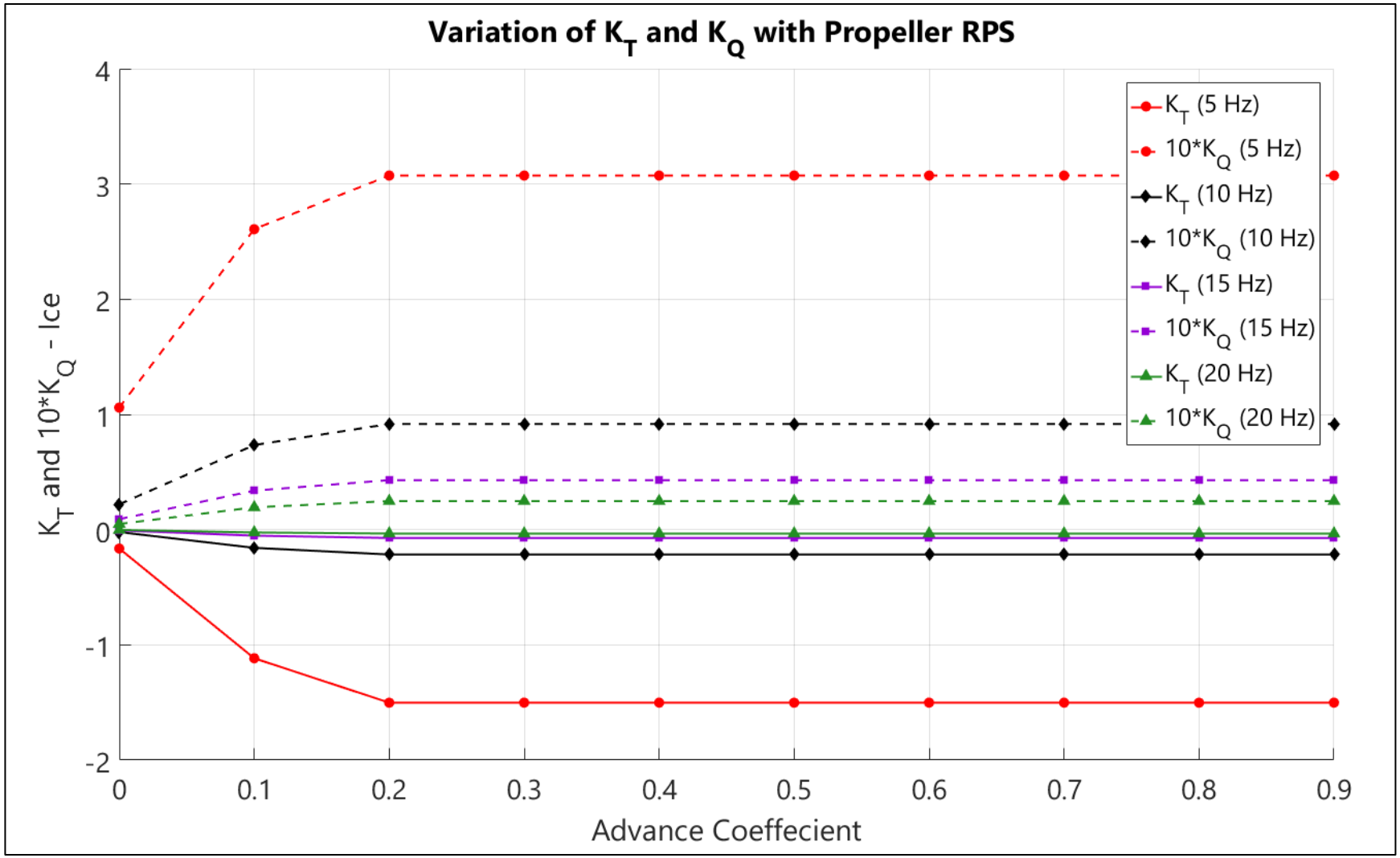


J = 0.2

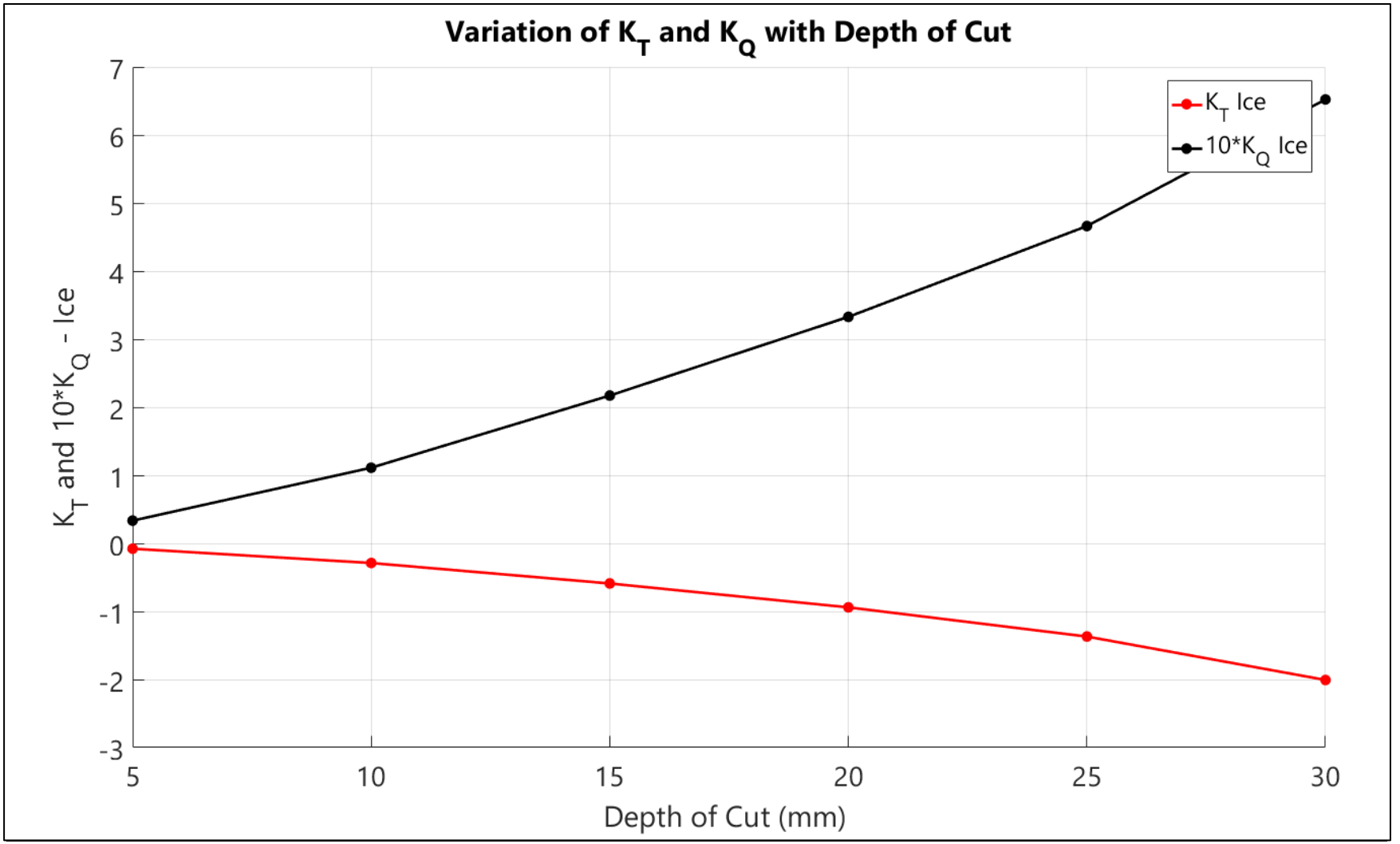


J = 0.25

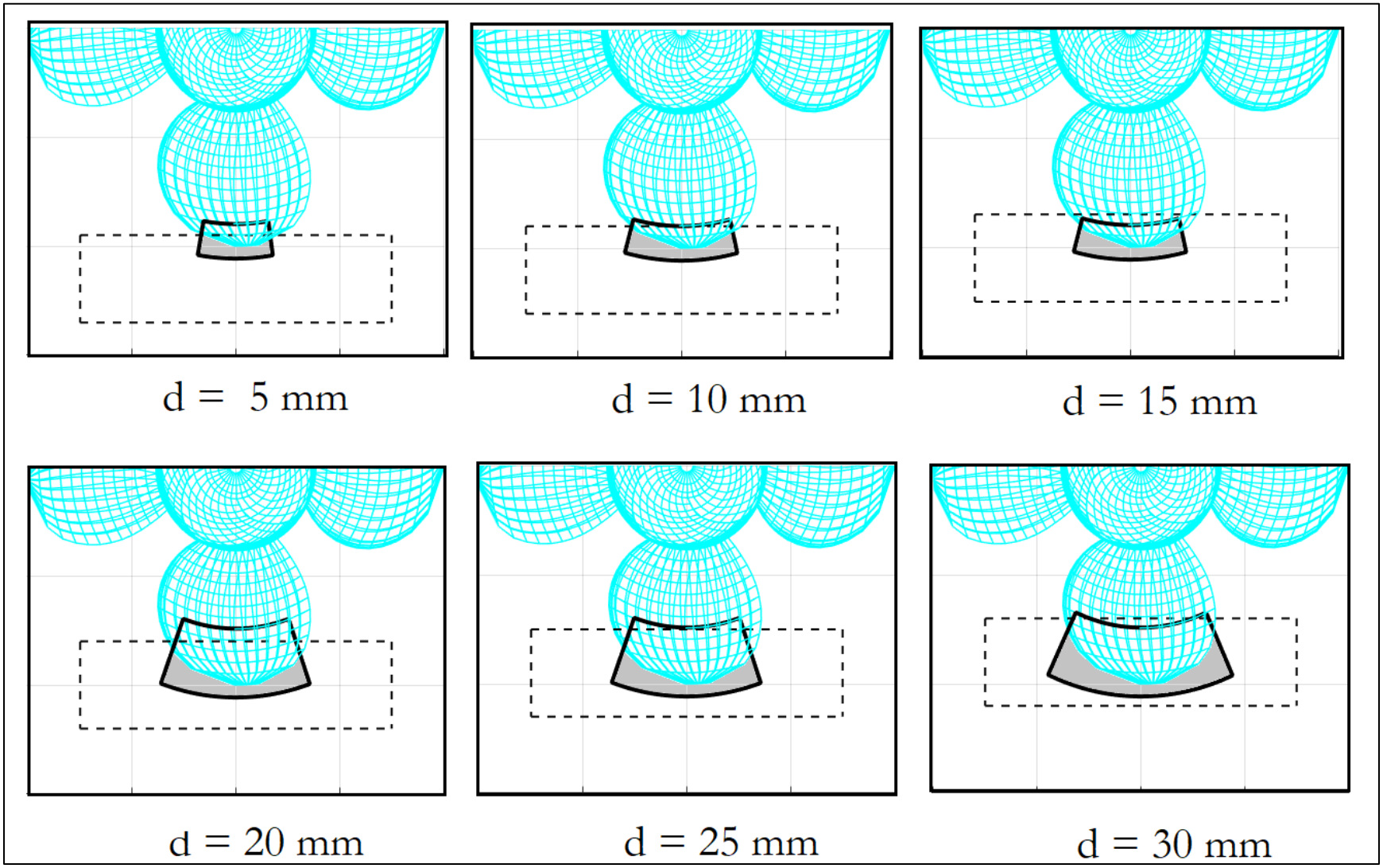
Results – Influence of RPM



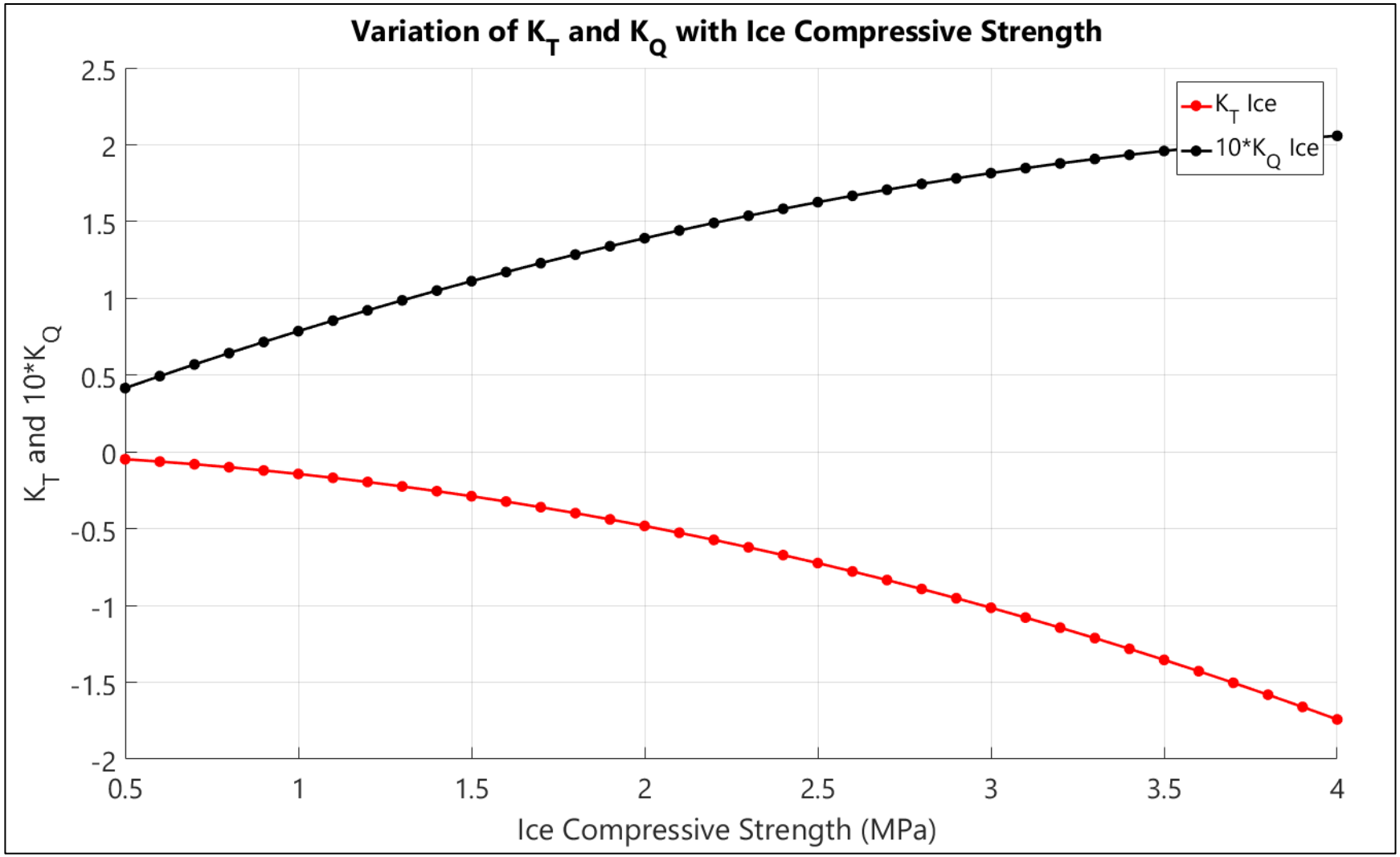
Results – Influence of Depth of Cut



Results – Influence of Depth of Cut



Results – Influence of Compressive Strength



Conclusion

- Hydrodynamic Loads
  - *Panel Method*
  - *Viscous Correction*
- Ice Contact Loads
  - *Empirical Formulae*
- Calibration from Experiments
- Results in agreement with physical observations

Future Work

- Hydrodynamic Loads
  - *RANSE code*
  - *Kinematics of Ice particles*
- Ice Contact Loads
  - *Analytical Methods*
  - *Ice Fracture Characteristics*

Thank You…