SAND2012-3249C

Cavitation Testing of a Specifically Designed Marine Hydrokinetic Turbine Hydrofoil

PENNSTATE ARL

Ryan Phillips
Arnold Fontaine
William Straka
Michael Jonson

C. P. van Dam
Henry Shiu

Sandia National Laboratories

Matthew Barone
Erick Johnson

Objective and Motivation

Marine Hydrokinetic Turbine hydrofoils present unique challenges when compared to wind turbine airfoils. Some challenges include:

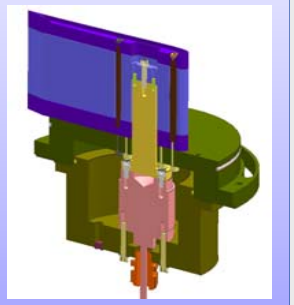
- Marine bio-fouling
- Cavitation
- Trailing edge singing

Objective: Cavitation performance from water tunnel tests on a hydrofoil designed by UC-Davis specifically for use in MHK turbines at full scale Reynolds number.

Experimental Setup

The 2-D evaluation was conducted in the Penn State Applied Research Lab 12" water tunnel facility.

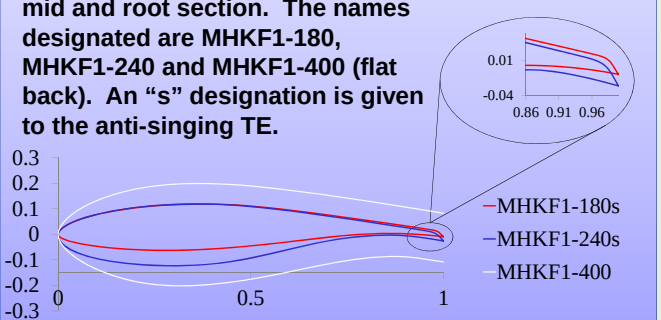
The model design was a unique 3-piece design. The middle section was the only section attached to the load cell thus eliminating end wall and gap effects.



CAD drawing of the 3-part model

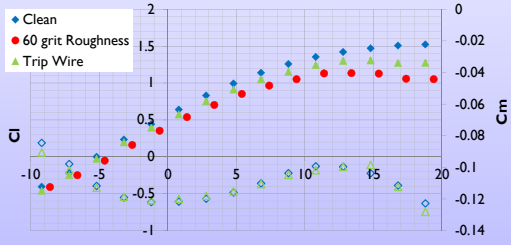
Hydrofoil Design

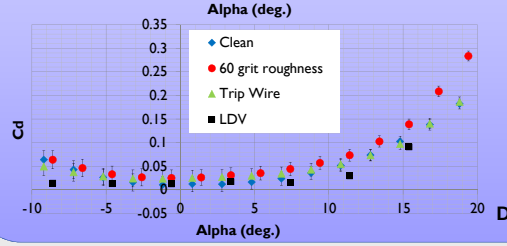
The blade is broken down into three sections which include a tip, mid and root section. The names designated are MHKF1-180, MHKF1-240 and MHKF1-400 (flat back). An "s" designation is given to the anti-singing TE.



MHKF1 Foil shapes showing anti-singing trailing edge modification

Force Results



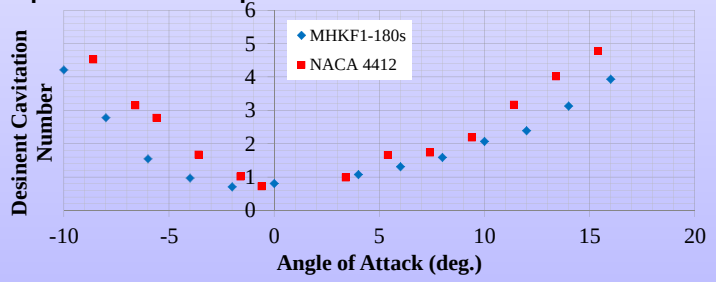


- Clean: hydrodynamicly smooth
- Distributed Roughness: 60 grit carborundum distributed to cover appx. 50% are up to 7% chord
- Trip Wire: diameter of .016" glued to the 7% chord location

Distributed Roughness

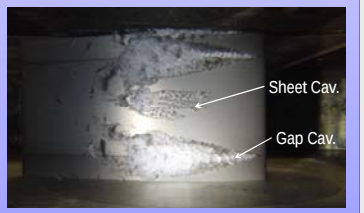
Cavitation Results (Clean)

Baseline tests were conducted on a NACA 4412 foil to compare with historical data. The MHKF1 foils showed improved cavitation performance over the NACA 4412 foil.



Desinent cavitation number comparison

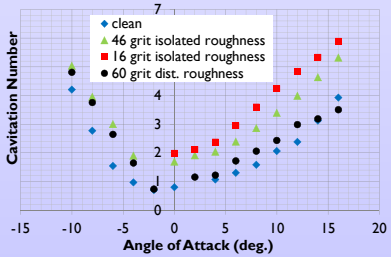
NACA 4412 sigma= 1.1
alpha = 8 deg.



MHKF1-180s sigma = 1.1
alpha = 8 deg.

Cavitation Results (Soiled)

The effect roughness has on cavitation is very important in a marine environment due to the likelihood of bio-fouling. Both distributed and isolated roughness were tested.

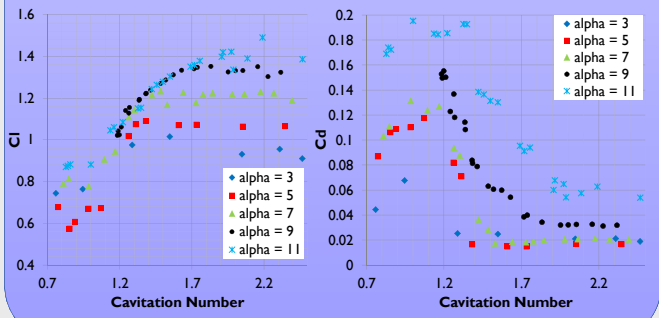


Isolated Roughness

MHKF1-180s distributed and isolated roughness cavitation comparison

MHKF1-180s Sigma = 1.0
dist. roughness (60 grit)

MHKF1-180s sigma = 1.2
iso. roughness (46 grit)



MHKF1-180s cavitation force breakdown

Acknowledgments

This research is supported by the Department of Energy and Sandia National Lab through contract # 775396

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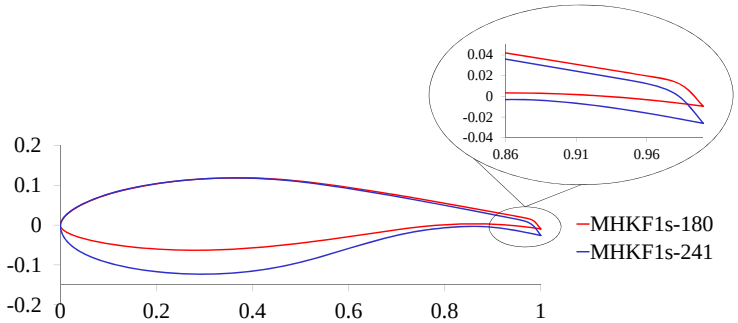
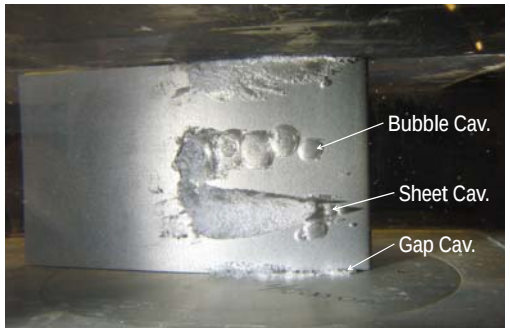
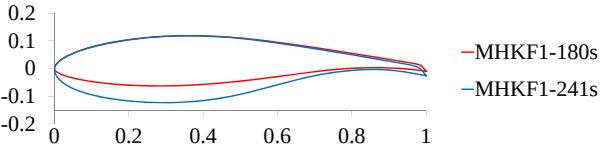

0.04
0.02
0
-0.02
-0.04
0.86
0.91
0.96
0.2
0.1
0
-0.1
-0.2
0
0.2
0.4
0.6
0.8
1
MHKF1s-180
MHKF1s-241


Bubble Cav.
Sheet Cav.
Gap Cav.


0.2
0.1
0
-0.1
-0.2
0
0.2
0.4
0.6
0.8
1
MHKF1-180s
MHKF1-241s