STRESS ANALYSIS AND CORROSION FATIGUE TEST OF THE PROPELLER BLADE IN CYCLOIDAL DRIVE

Capt.Swieng Thuanboon, Royal Thai Navy

Topic

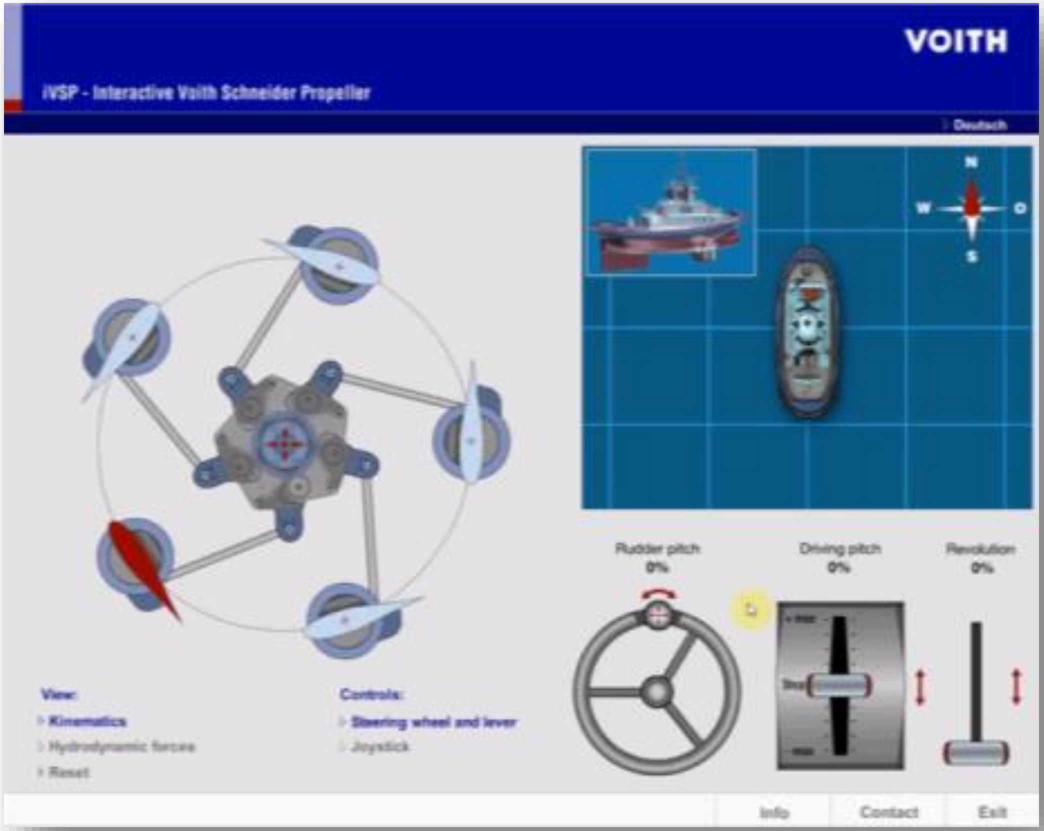
- Background Information
- Stress analysis of propeller
- Corrosion Fatigue Test

Background Information

- Vertical drive propellers, or Voith Schneider: VSPs in the Navy, are used in Mine Squadron.

Background Information

- How Voith Schneider work



Background Information

- Why ?? Must use a Voith Schneider blade
- Allowing the ship to be highly mobility
- Suitable for use as a minesweeper
- Manganese aluminum bronze materials has non-magnetic properties.

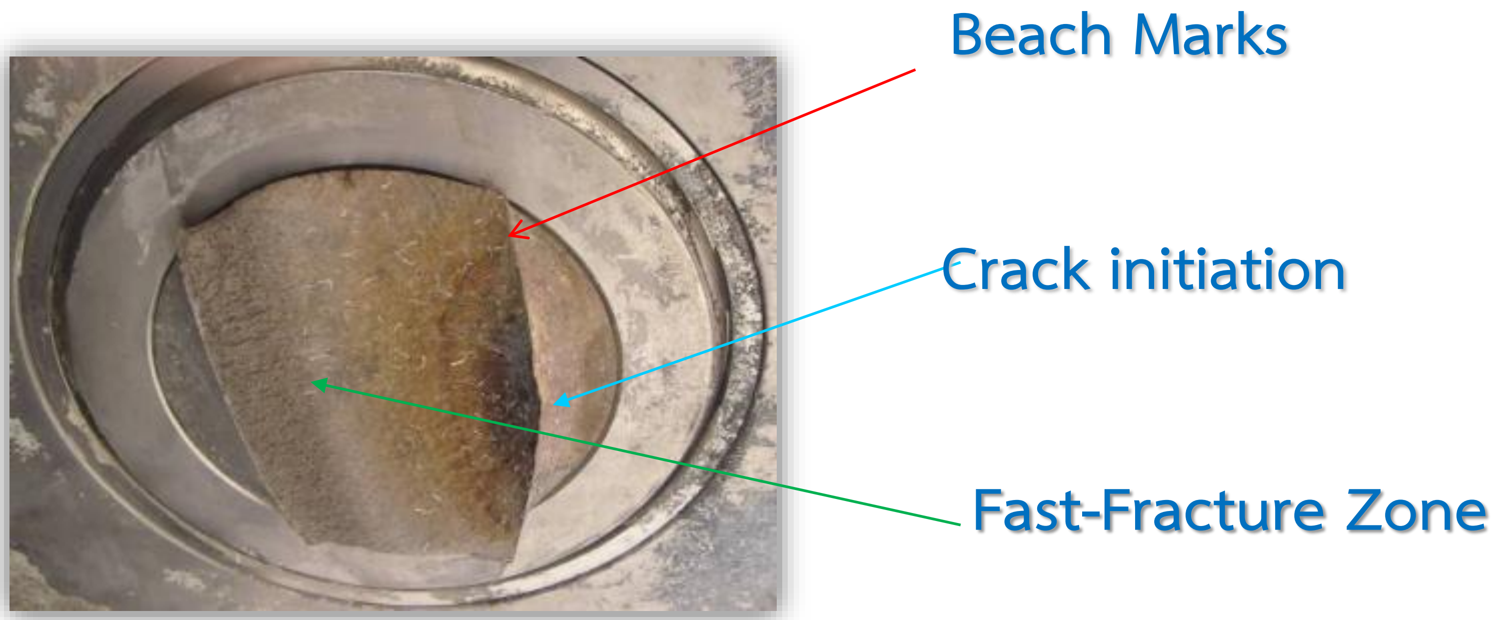

Background Information

- The propeller blades were broken regularly causing the navy to lose a lot of budget. Because it must be imported from foreign countries

Background Information

- Failure analysis found that the reason for the broken propeller due to many reasons
- The main cause is Corrosion Fatigue which is caused by loss of aluminum

Background Information

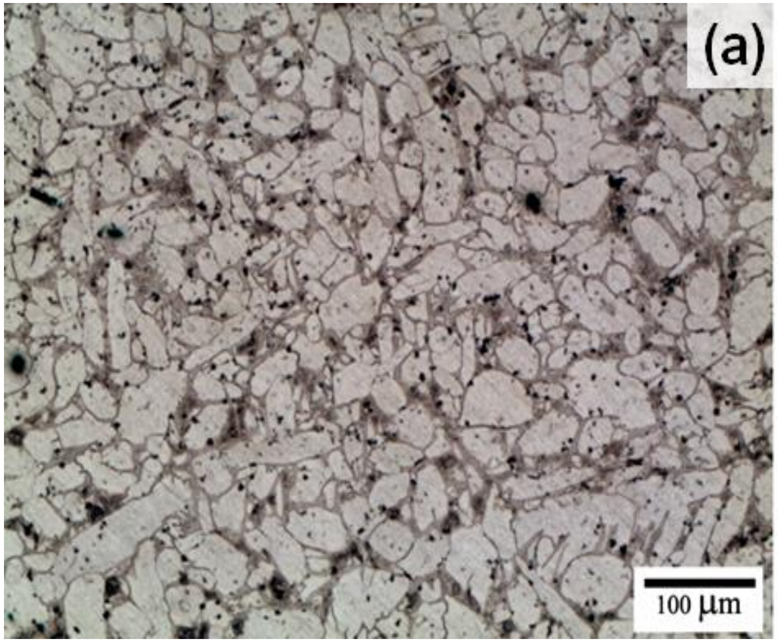


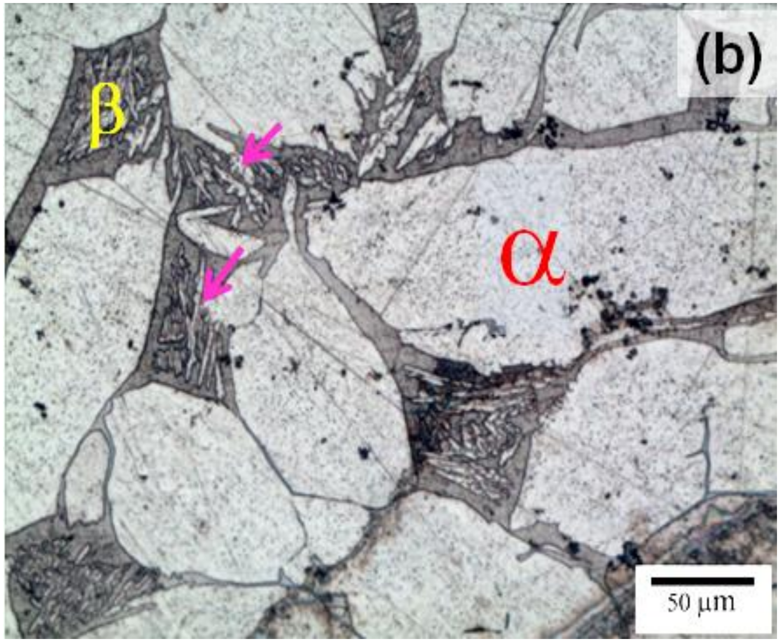
Background Information

- Propeller material is Cu-8Al-8Mn-1.5Ni-2Fe
- Corrosion due to loss of aluminum (De-alloying) causing the strength of the propeller to be reduced

Microstructure of Propeller

Microstructure of Cu-8Al-8Mn-1.5Ni-2Fe consist of alpha and beta



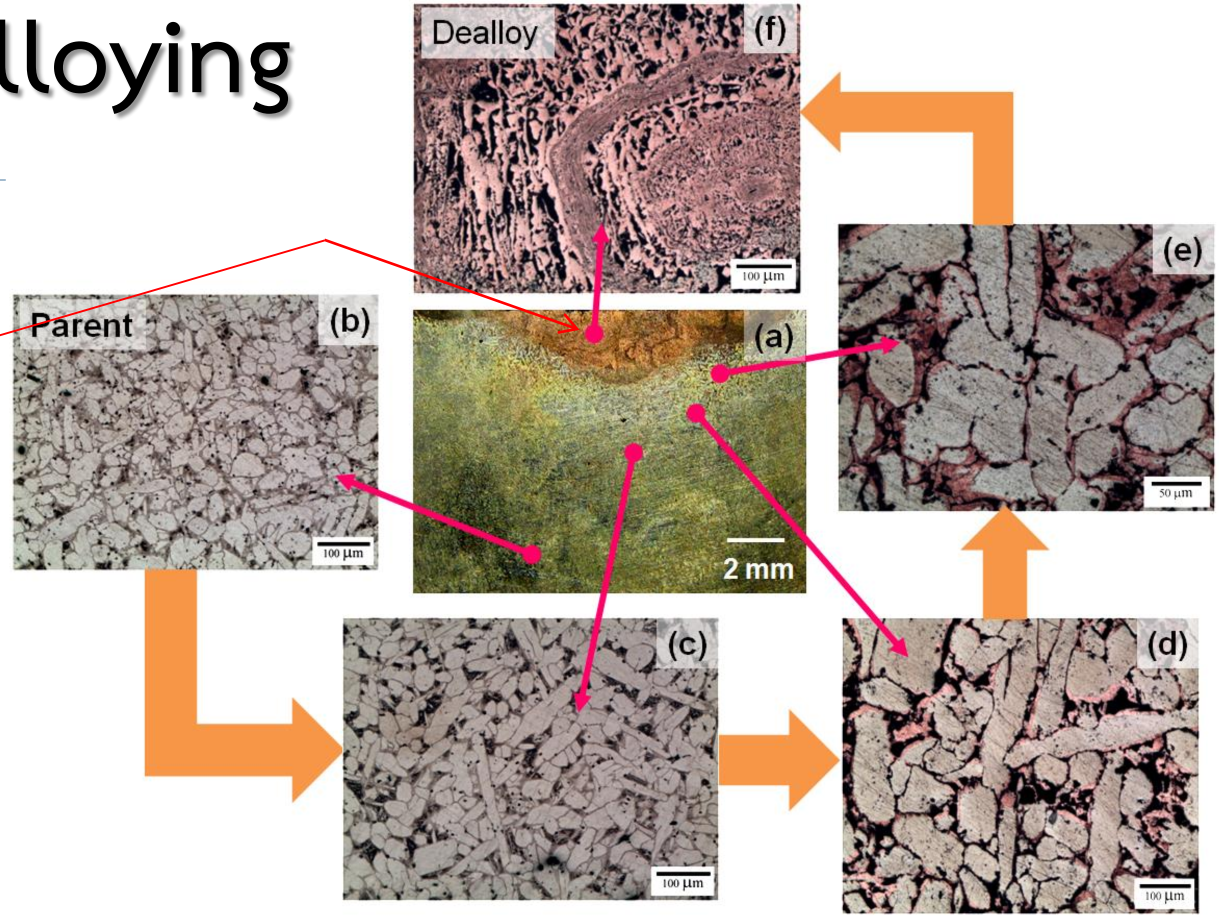


(a) Magnification 50 x

(b) Magnification 200 x

Step of dealloying

Broken propeller



เฟส	บริเวณที่เกิดการกัดกร่อนแบบสูญเสียธาตุ			บริเวณโลหะเดิม			
	Al	Mn	Cu	Al	Mn	Ni	Cu
α	5.91-8.10	8.02-9.35	Bal.	8.34-8.73	8.07-8.63	–	Bal.
β	0.74-1.15	1.30-1.63	Bal.	12.67-14.09	9.77-10.67	3.31-6.07	Bal.

Aluminum at dealloying location reduce

Dealloying of Aluminum Bronze

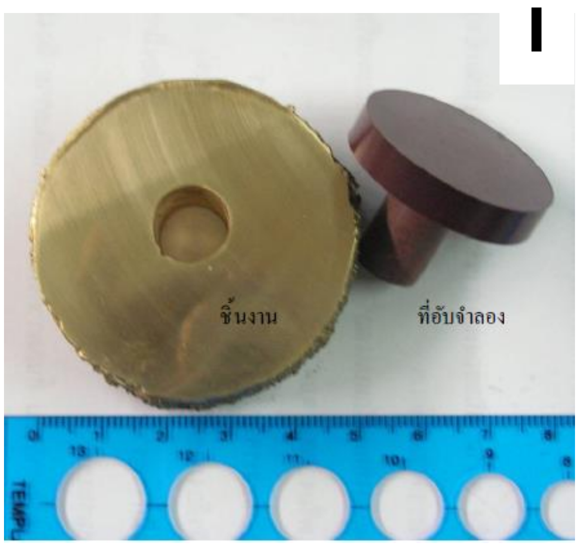
An Investigation Into Dealloying of Cast Ni-Al Bronze

by C. A. Zanis and R. J. Ferrara

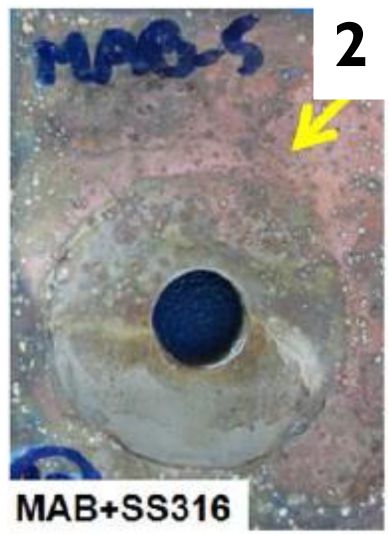
1) a restricted oxygen supply favors dealloying, particularly stagnant water, crevices and porous surface films
2) chlorides, especially in salt water, cause dealloying
3) dealloying appears favored by acidity, although it can also occur in alkaline situations
4) environments which favor the presence of Cu ions may induce dealloying. These include surface deposits, stagnant flow conditions and crevices or pits
5) surface residual stresses, differential aeration or contact with more noble metals may cause anodic behavior and accelerate dealloying corrosion
6) dealloying may be prevented in certain alloy systems, including Al bronze, by cathodic protection with Zn anodes or contact with less noble metals such as steel
7) dealloying reactions increase with temperature.

Dealloying test of propeller material

Max Dealloying Min



Crevice Cell



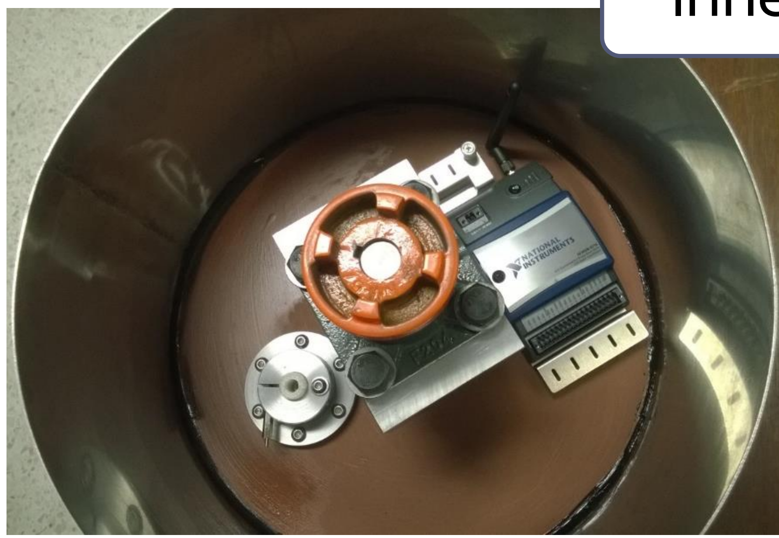
Fouling deposit on propeller

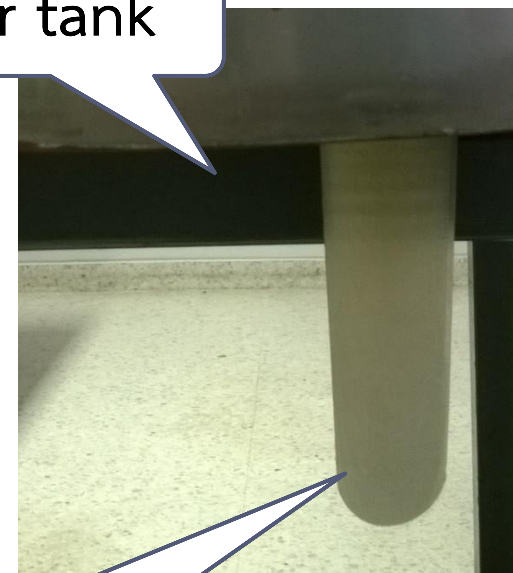
Stress analysis of propeller

- Model propeller size 1:10
- Material Thermoplastic Polylactic Acid (PLA)
- Rapid Prototype forming
- To simulate the work of the VSP propeller

Stress analysis of propeller

Experimental equipment

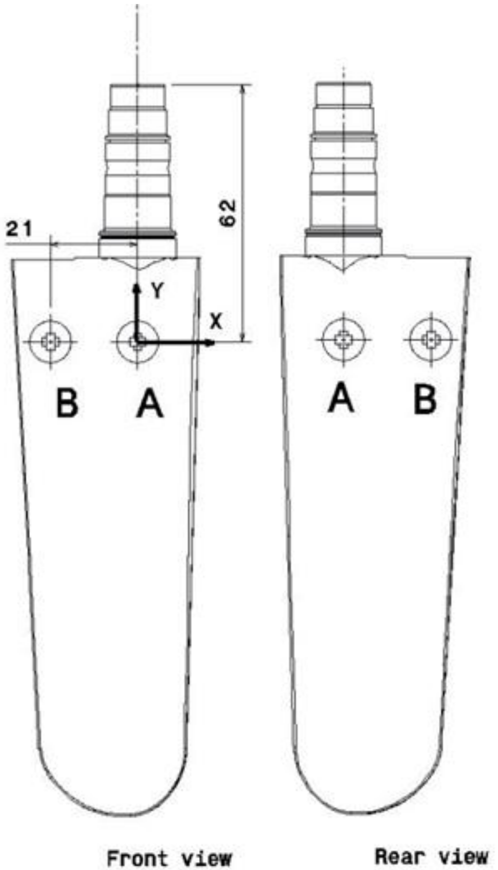


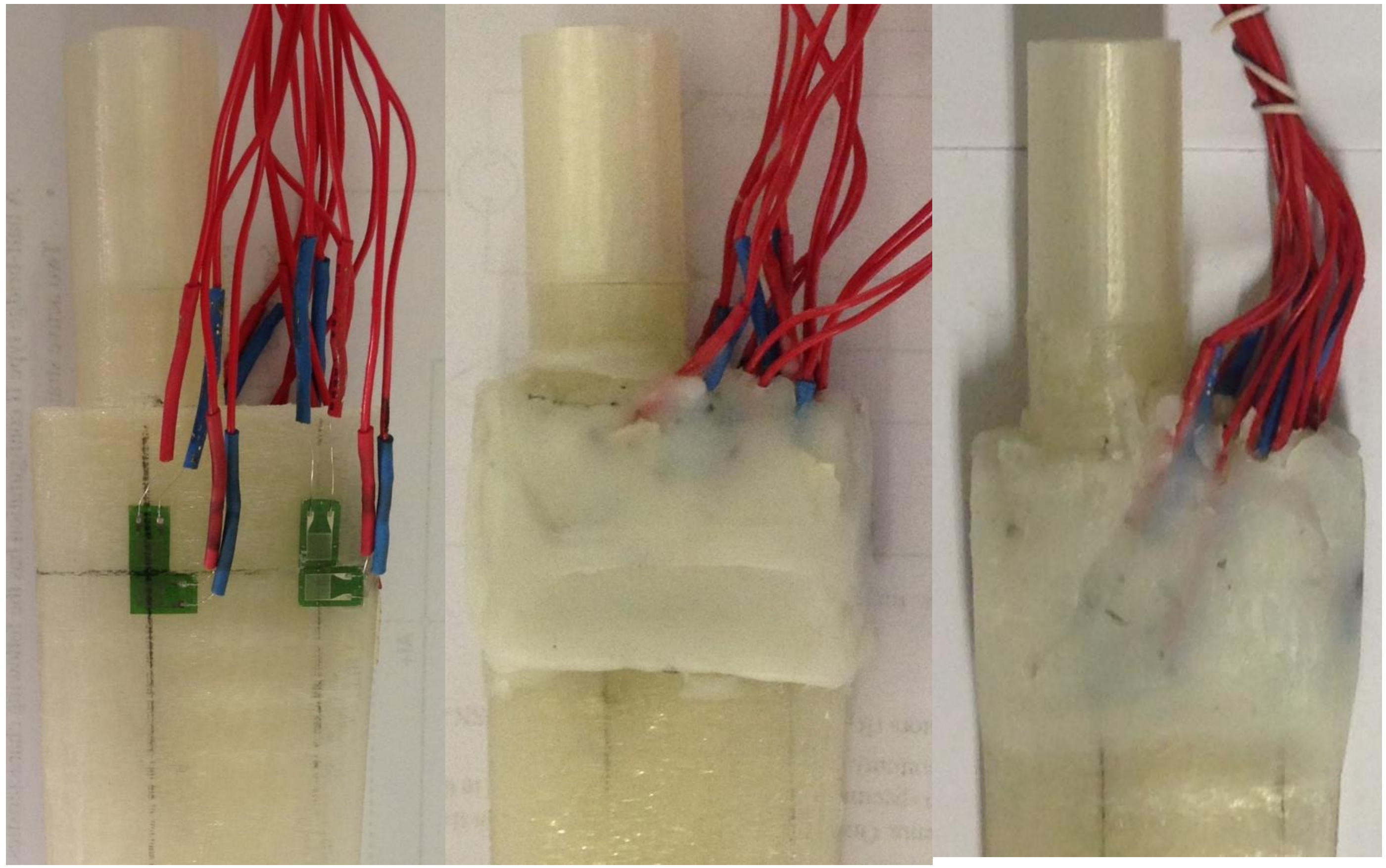


Install sensors to measure various values

Stress analysis of propeller

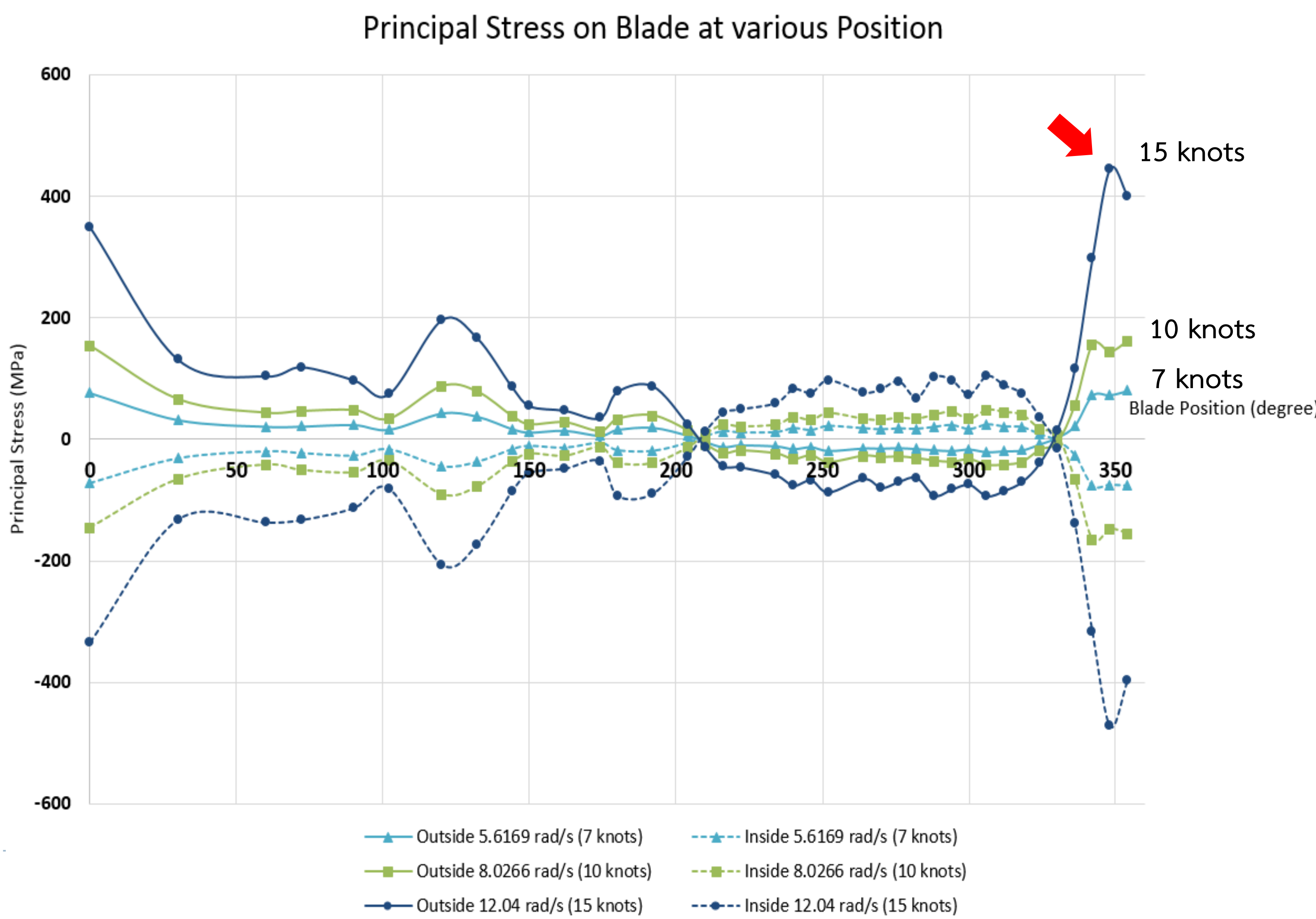
Strain Gages Installation





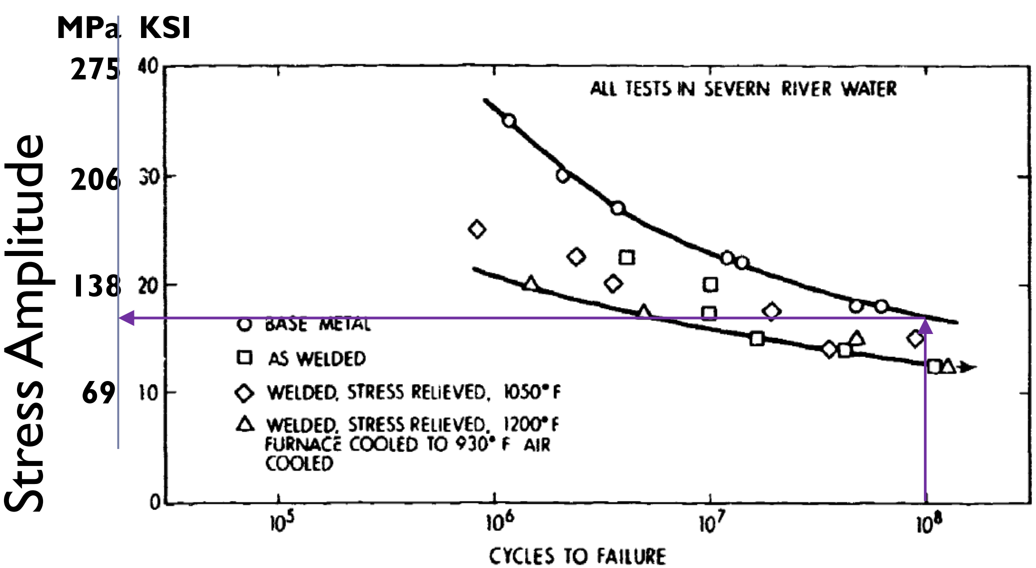
Installed a sensor to measure the load that occurred during the propeller rotation simulation.

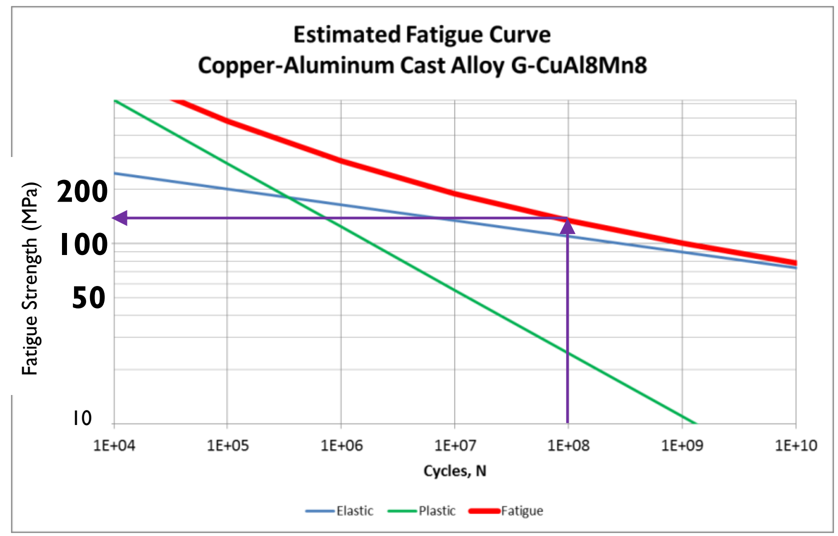
Stress analysis of propeller



Stress analysis of propeller

Material properties



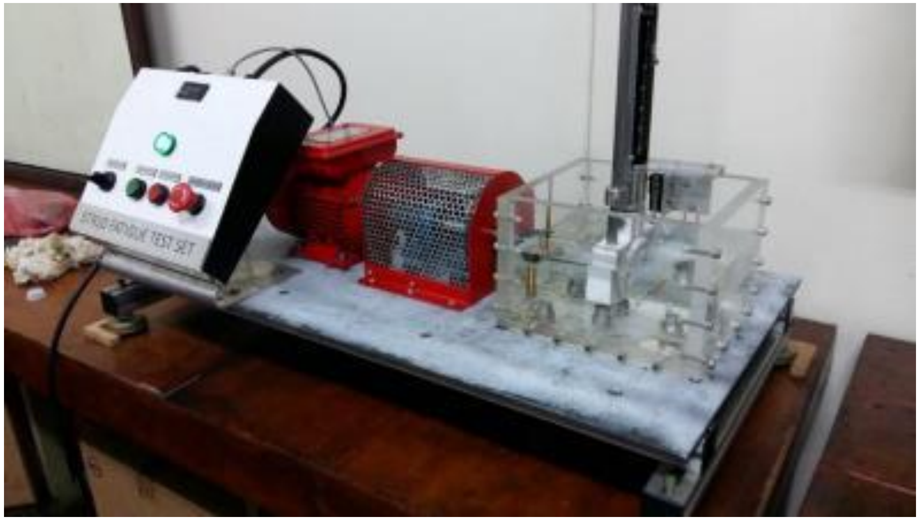


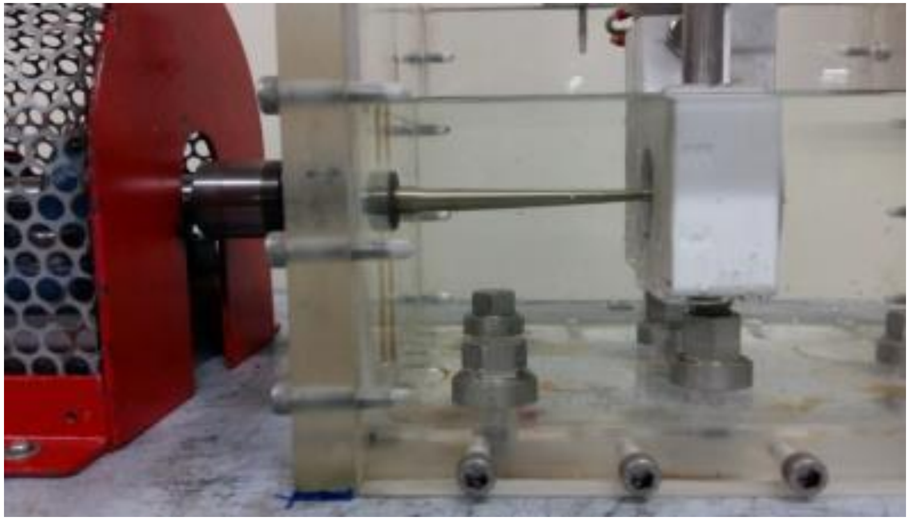
0.2% Yeild	Rp0.2	N/mm^2	≥270	≥260
Tensile Strength	R_m	N/mm^2	≥640	≥620
Fatigue (Endurance)	σ_{bw}	N/mm^2	≥150 ในอากาศ, ≥110 ในน้ำทะเล	

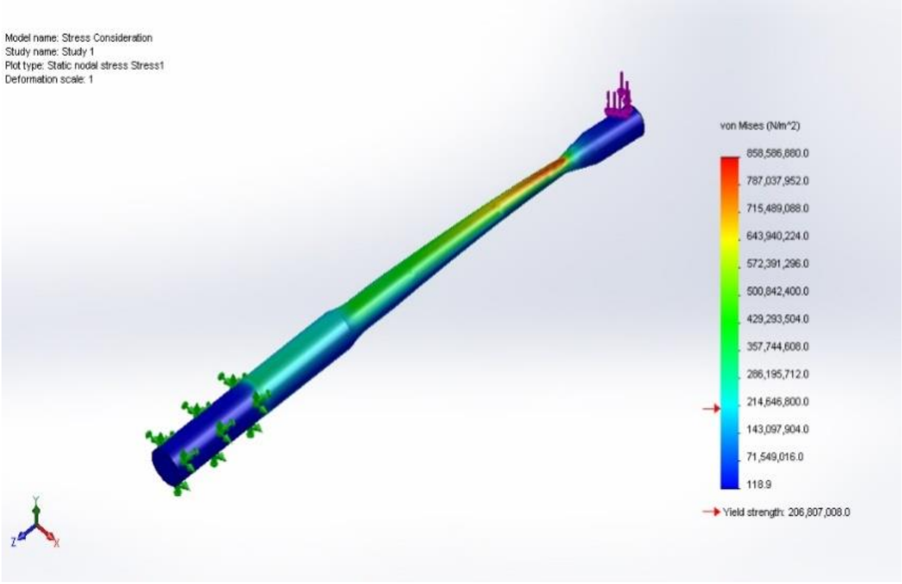
@10^8 cycle

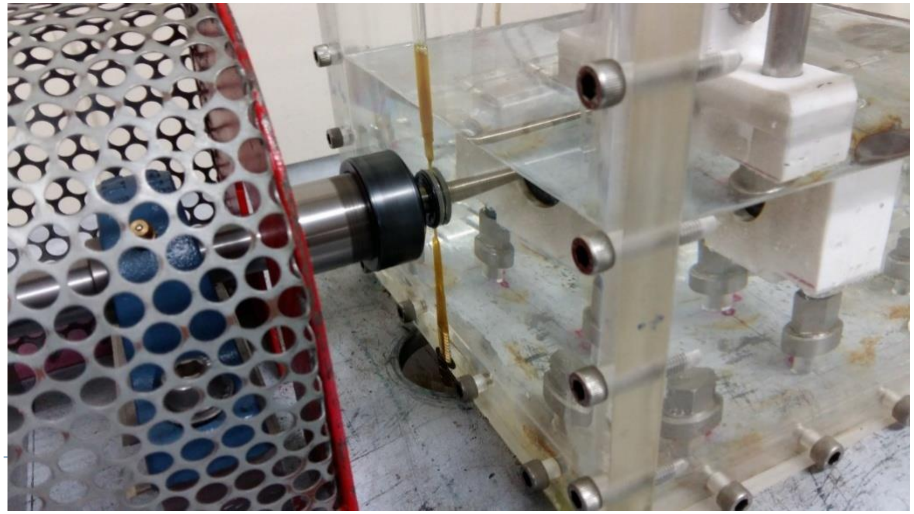
Corrosion Fatigue Test

Rotational Fatigue

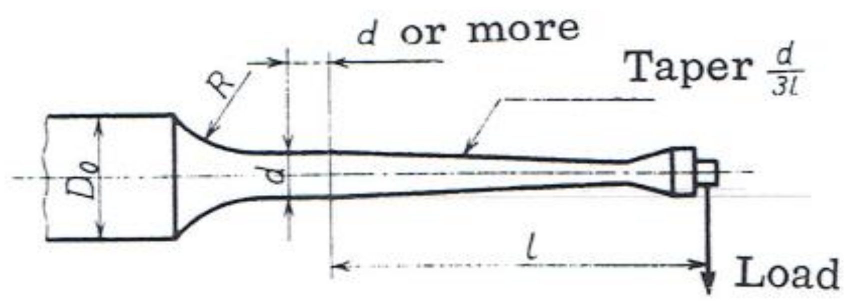








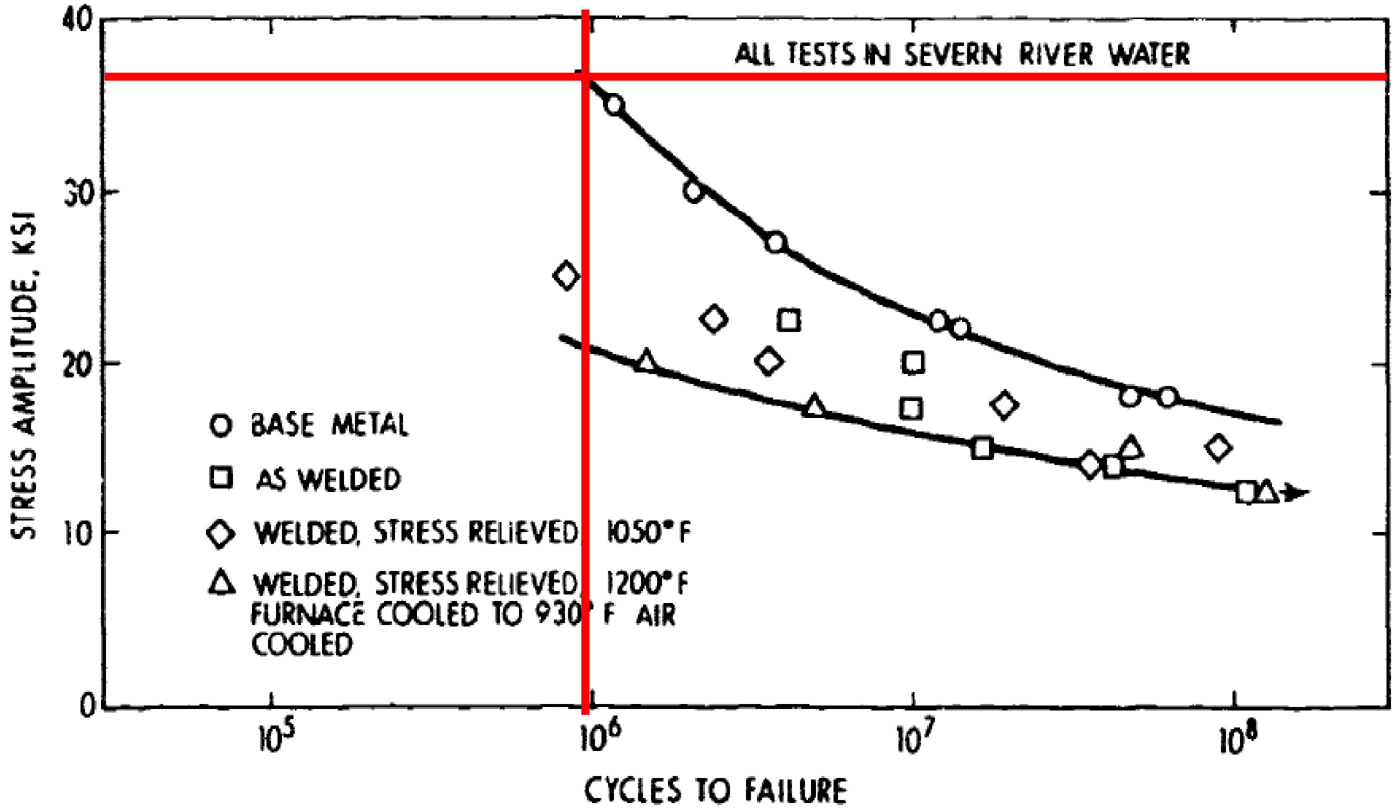
Corrosion Fatigue Test



Symbol	d mm	R	l
3- 6	6	3 d or more	5 d or more
3- 8	8		
3-10	10		
3-12	12		

Rotational Fatigue sample: JIS Z 2274-1978

Corrosion Fatigue Test



Rotational Fatigue load setup: 36.5 KSI =251.631 Mpa

: about 10 knot

Corrosion Fatigue Test

Properties	Tensile (N/mm2)	Yield Strength (N/mm2)	Elongation (%)	Hardness (HB)	Impact Test (J)	Fatigue (Cycles)
Ref.	≥620	≥260	≥24	≥140	≥20	1,000,000
As cast	734	456	14.8	212	15.11	-
Heat treatment	706	433	27.6	198	35.20	2,728,794

Thank you