Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER 511898
UNCLASSIFIED	

TITLE

Investigation of Cracked Propeller Blades on an Icebreaker

System Number:

Patron Number:

Requester:

Notes: Paper #24 contained in Parent sysnum #511874

DSIS Use only:

Deliver to: CL

#511898 - (24)

Investigation of Cracked Propeller Blades on an Icebreaker

by L.N. Pussegoda and L. Malik

Fleet Technology Ltd., 311 Legget Drive, Kanata, Ontario K2K IZ8

ABSTRACT

Examination of two blades of a four bladed CP propeller, from the port shaft of an icebreaker that had through thickness fractures is discussed. The fractures propagated radially from the blade tip part way down the blade before arresting. The direction of the chevrons on the fracture surface indicated that the fracture initiation sites were located in the tip region of the blade. The other two port propeller blades with major portions lost in operation also had fracture initiation sites at the tip region.

Metallography revealed that extensive multi-pass weld build up and weld repairs had been carried out in the blade tip regions. These regions also displayed lack of fusion and porosity type flaws.

In the initiation region, the cracks propagated in stages displaying run-arrest events. The main through thickness crack did not occur until the crack propagation reached the un-refined as-cast microstructure. This is because of the superior toughness of the refined microstructure in the repair region.

The fracture features of the initiation region in blade 1 demonstrated loading from both sides of the CP blade. This opened up the possibility of fatigue crack propagation in that region. Finally, recommendations and suggestions were presented aimed at avoiding such failures in the future.

Investigation of Cracked Propeller Blade on an Icebreaker

L. N. Pussegoda, L. Malik *and* B. Paterson
Fleet Technology Limited

Presented at
8th CF/CRAD Meeting on Naval Applications of Materials Technology

Dartmouth, Nova Scotia, May 11-13th, 1999

FTL FLEET TECHNOLOGY LTD.

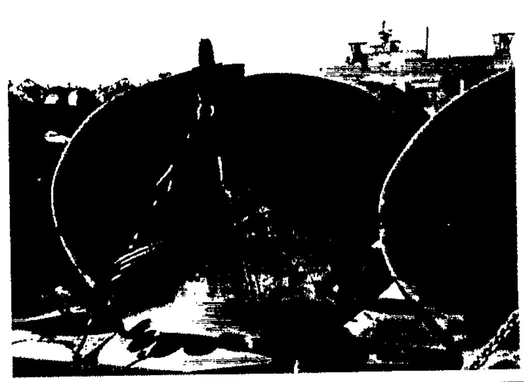
Site Investigation Findings 1

- **A Broken Blade (two out of four)**

  CP Port Propeller - damaged,

  Starboard - no damage,

  Material – Cunial (Ni-Ai-Bronze)



FTL FLEET TECHNOLOGY LTD.

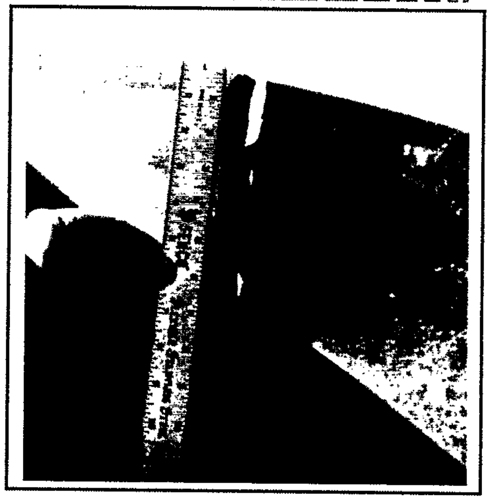
Site Investigation Findings 2

No significant surface scratches or gouges

Significant loading from the HP side from relative movement.

All four blade cracks commencing from tips. Two stages of fracture.

Damage incident report 60 to 70% multi-year ice.



FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 1

Investigations Performed on the Two Cracked Blades

- Visual Examination
- Fractography
- Metallography
- Chemical Analysis

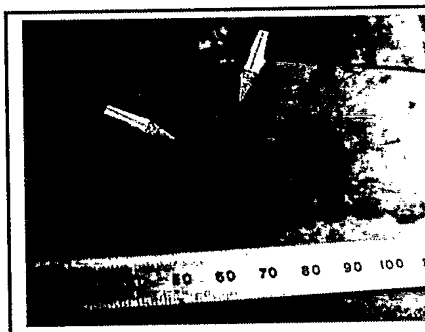
FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 2

- **Visual Examination (surface)**

  Weld buildup or repair at the blade tip (30 mm)

  Couple of grooved repairs in the radial direction maximum length 200 mm



A close up of region showing surface cracks indicated by arrows

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 3

- **Visual Examination (fracture)**

  Chevrons point to the origin of final fracture

Fracture surface of blade 1

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 4

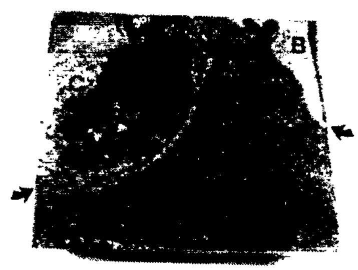
- **Stereoscopic examination of the origin of final fracture** (Blade 1)

  (A) – coarse morphology;

  (B) – smooth fracture, and

  (C) – ratchet marks

Planar flaw between (A) and (C) and thumb nail (or semi-elliptical) profile on either side. Indicates fatigue growth before final fracture.



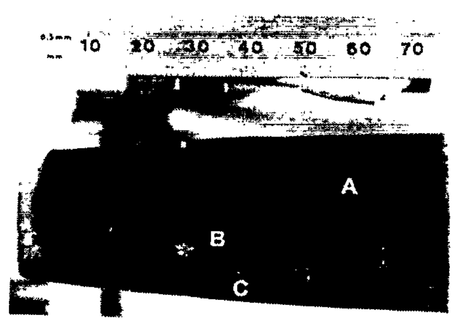
The portion used for stereoscopic examination. Arrows mark the start of the buildup repair.

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 5

- **Stereoscopic examination of the origin of final fracture** (Blade 2)

Local fracture propagated in stages.



Arrows point to internal flaws. The three different surface morphologies are identified as (A), (B) and (C).

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 6

- **SEM examination**

  Objective: examine fracture facets in regions (A), (B) and (C) at high magnification.

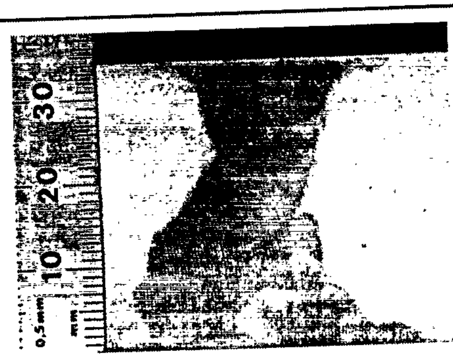
  Cleaning in 50/50 (vol.) HCl and distilled water to remove surface oxides. Propagation region displays underlying features found in brittle fracture of bronze castings (flat facets bounded by ductile tear regions).

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 7

- **Metallography**

  Through thickness repair



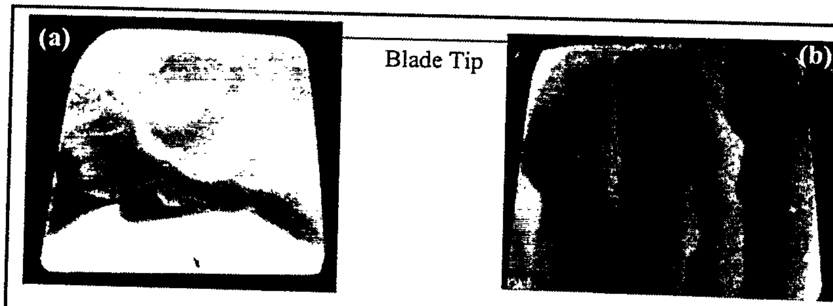
Full thickness cross-section showing a weld repair in blade 2. Alcoholic ferric chloride etch.

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 8

■ **Metallography**

Buildup performed by multiple weld passes through the entire thickness.



Macrographs from blade 1(a), blade2 (b) behind the fracture faces.

FTL FLEET TECHNOLOGY LTD.

Laboratory Investigation 9

■ **Chemical Analysis (wt%)**

Element	C95800 (Ni-Al-Bronze)	Built Up Region	As-cast Region
Cu	remainder	81.17	79.92
Fe	3.5 to 4.5	3.66	4.67
Mn	0.8 - 1.5	1.48	1.15
Ni	4 - 5	4.38	4.33
Al	8.5 - 9.5	9.27	9.5

FTL FLEET TECHNOLOGY LTD.

Discussion

- Origin for the final fracture point to the blade tip. In this region flaws are associated with repairs/buildup with weld passes.
- Were there previous growth events locally before final failure?

Blade 2

- Fracture surface morphology indicates crack propagation in buildup areas caused by discrete loading events
- Arrest of cracks in this region; a) unloading, b) encountering higher toughness region (refined microstructure in the buildup region), c) at a boundary of a weld pass, and d) encountering an internal flaw with different orientation

FTL FLEET TECHNOLOGY LTD.

Discussion (cont.)

- **Blade 1**
  - Fracture in the origination region in one plane, in contrast to several planes in blade 2.
  - Arrest of crack in this region; a) unloading, b) encountering higher toughness region.
  - Metallography performed X-section normal to planar flaw showed refined structure in region (C) compared to as-cast structure in (A).
  - As propagation events occurred on both sides of planer flaw the explanation for arrest is the unloading option from both sides. Fatigue loading cycles are the most probable.

FTL FLEET TECHNOLOGY LTD.

Recommendations

- Proper methods of buildup by welding need to be developed, documented, and implemented to avoid unexpected costly failures.
- Any buildup or repairs need to be qualified by radiography or ultrasonic inspection to verify soundness.
- Blade tips need to be examined for planar defects during maintenance.
- Before repairs are carried out on cracked blades, investigations will be useful to obtaining a historical background with a view to creating a database on damage to CP propeller blades.

FTL FLEET TECHNOLOGY LTD.