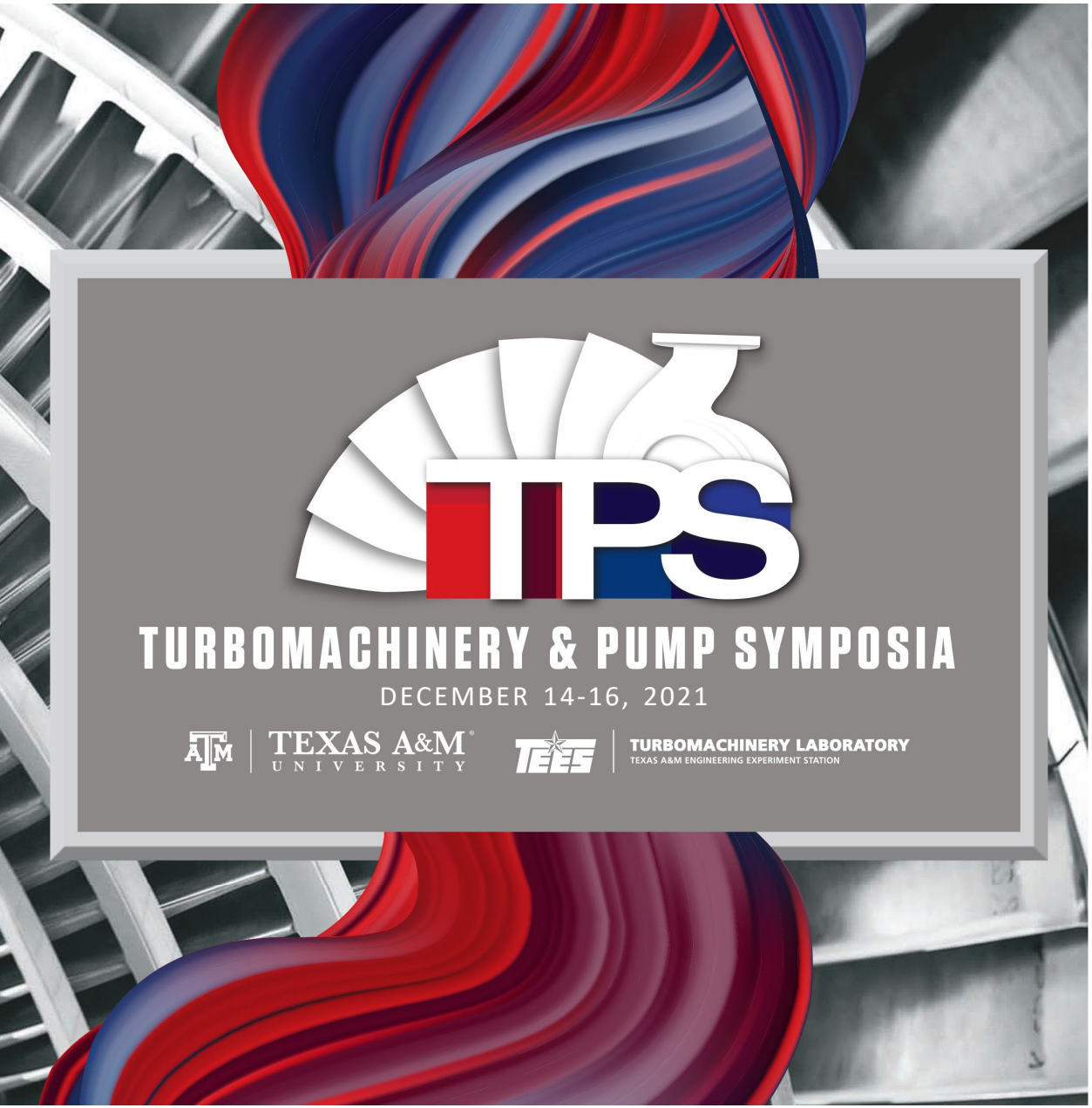

Introduction of SCC life time estimation for fir tree design on steam turbine

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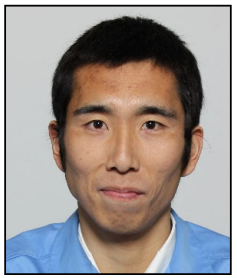

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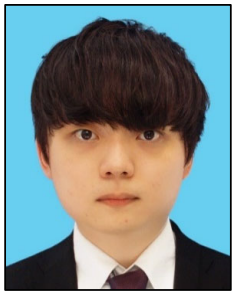

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TPS
TURBOMACHINERY & PUMP SYMPOSIA

Contents

(SCC : Stress Corrosion Cracking)

TPS
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1. Problem Statement

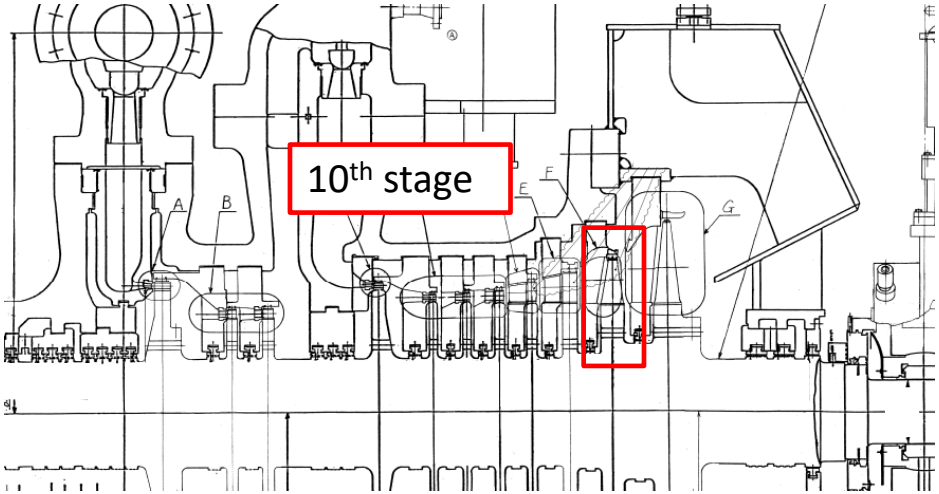
During inspection of a steam turbine rotor, cracks are found on the Fir tree blade groove. When this occurs, it is necessary to have a quick evaluation of the residual life in order to decide the maintenance plan and repair scheme.

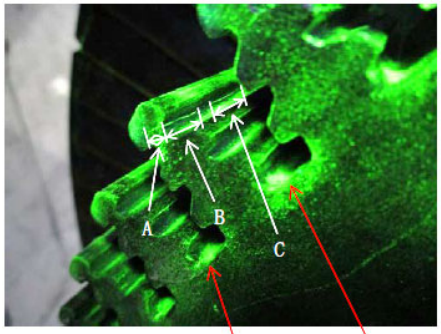
This presentation describes:

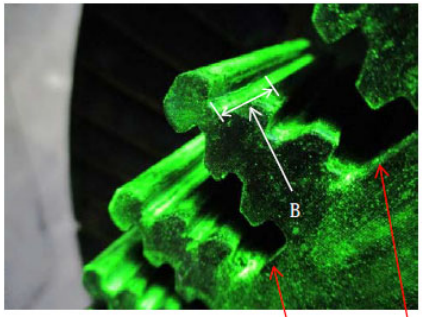
- a fast method to assess Stress corrosion cracking (SCC) residual life
- the assessment of remaining life for the turbine of the case study
- the repair done on the unit and an alternative repair to avoid SCC in the future.

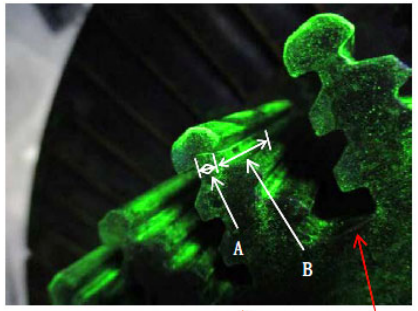
2. Background

In 2020, the compressor drive steam turbine was inspected for performing rotor maintenance. And then, MT (Magnetic particle Testing) for all stage blade grooves were performed. As a result of the test, 3 indications were found on 10th stage blade groove.







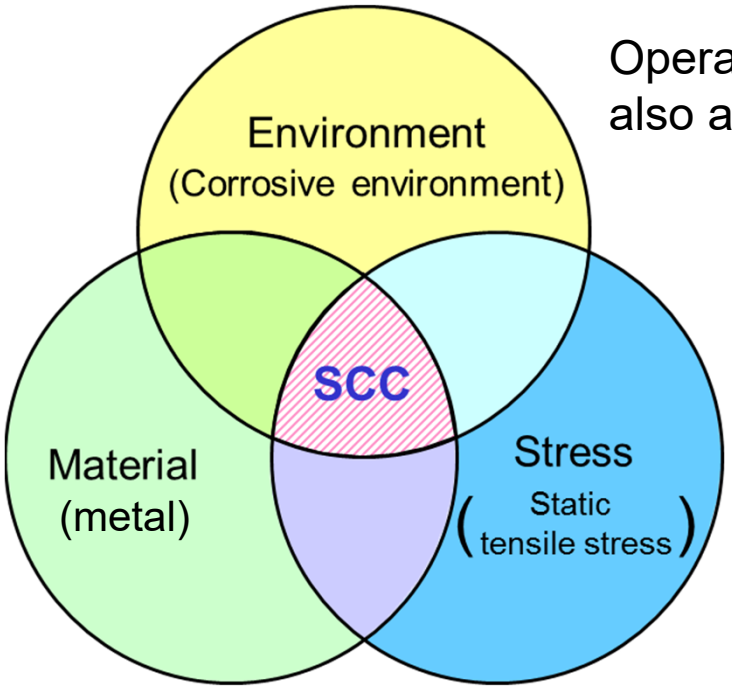


Crack Indication :
3 ~ 27 mm

3. Possible cause of the crack

SCC (Stress Corrosion Cracking) is one of the possible cause of crack

- Factors affecting SCC



Operating time
also affects SCC.

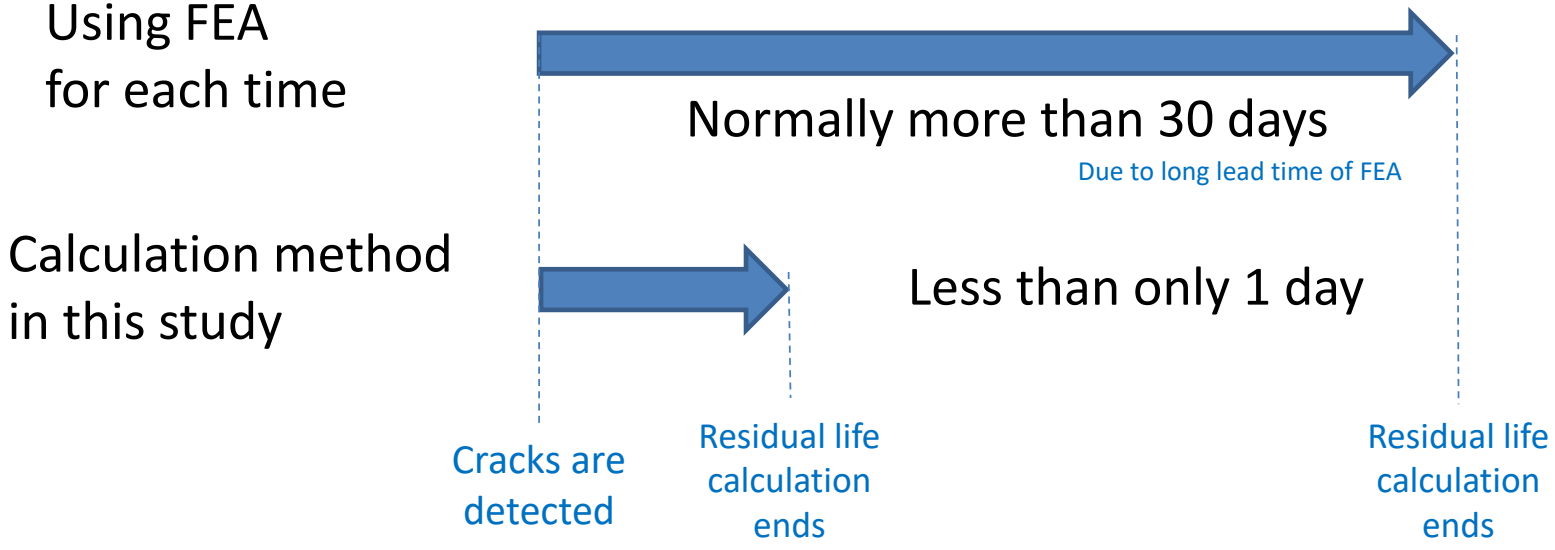
SCC will occur when these three factors occur at the same time.
(Stress, Material, Environment)

When a crack is found, residual life must be evaluated to determine if continuous operation is possible.

4. Residual life evaluation method for SCC

- **Comparison of lead time**

The residual life of Fir tree root groove calculated by…



This evaluation method determined in this study can give residual life in a short time (during maintenance operation), so that corrective actions can be taken immediately.

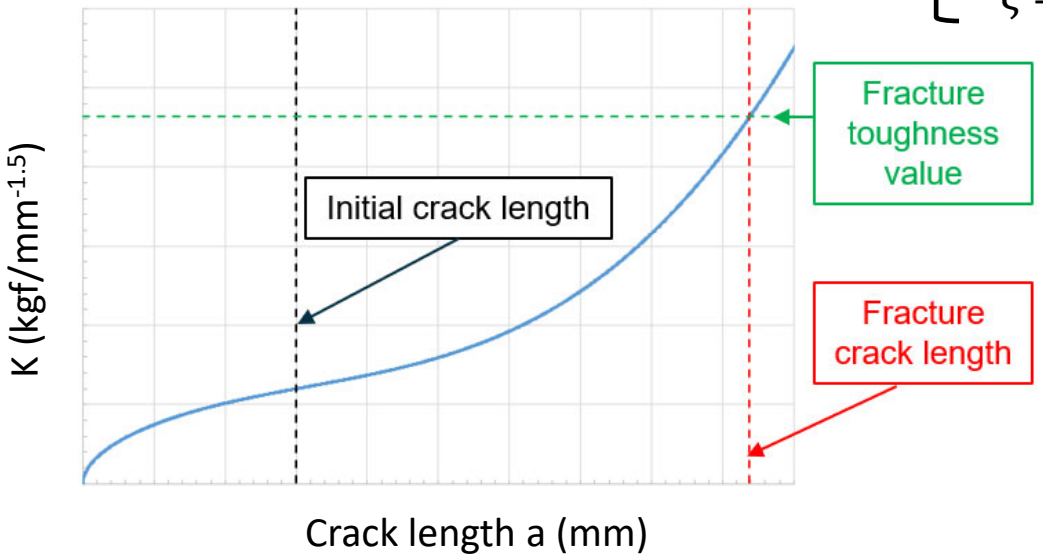
4. Residual life evaluation method for SCC

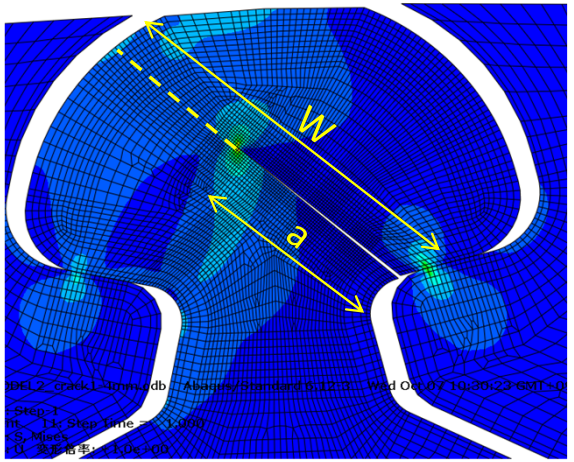
The stress intensity factor K describes the stress state at a crack tip and is used to calculate the residual life

General formula for K

$$K = \sigma_t \sqrt{\pi a} \cdot F(\xi)$$

- σ_t : tensile stress
- $F(\xi)$: coefficient of shape
- a : crack length
- W : width of groove
- $\xi = a/W$

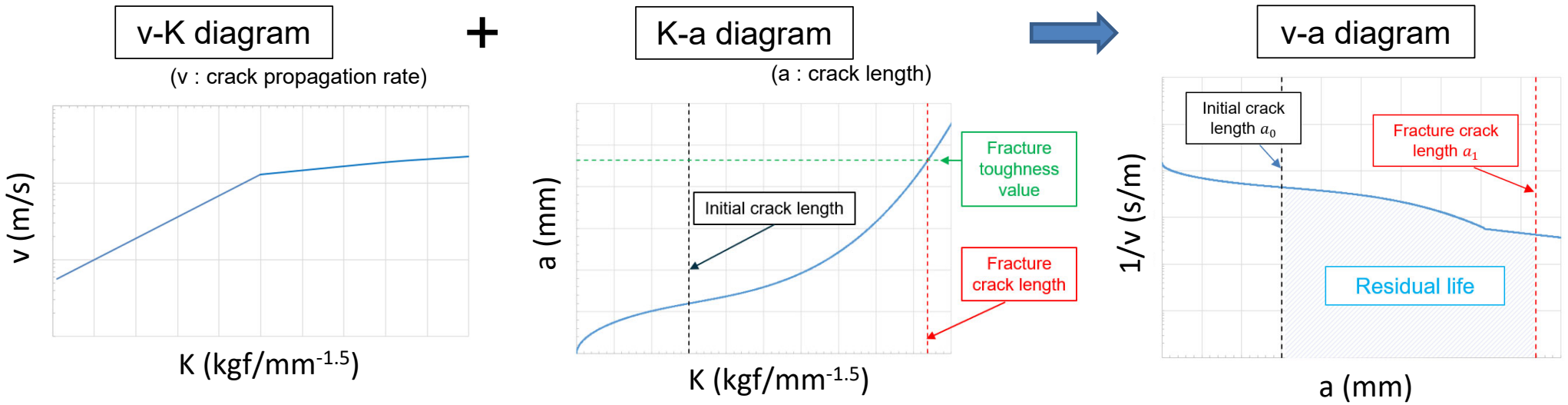




F(ξ) for Fir tree root groove is determined as empirical formula by stress analysis using blade groove 2D model with a crack

4. Residual life evaluation method for SCC

- **Calculation procedure**



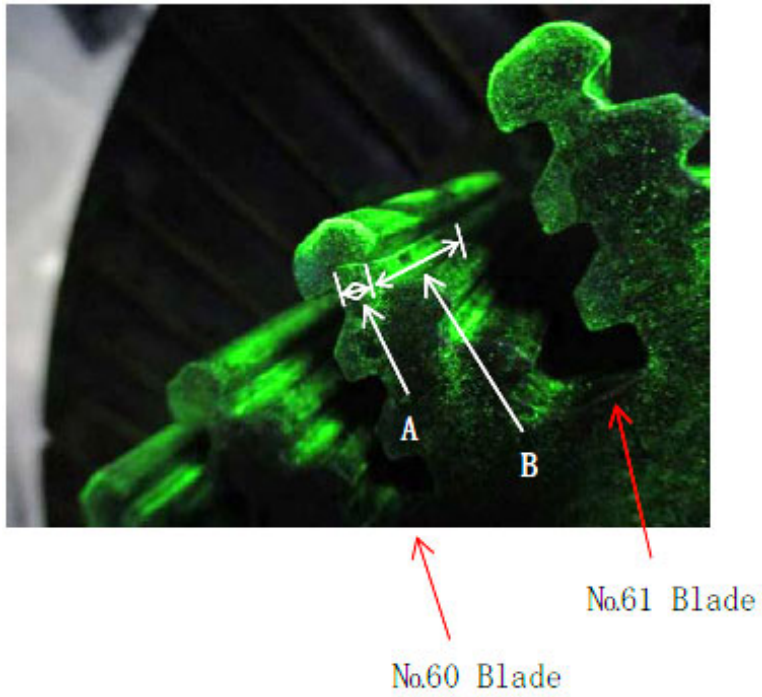
- v-K diagram is result of past SCC test for standard rotor material
- K-a diagram is obtained by the general formula between K and a
- The residual life is calculated using v-a diagram*

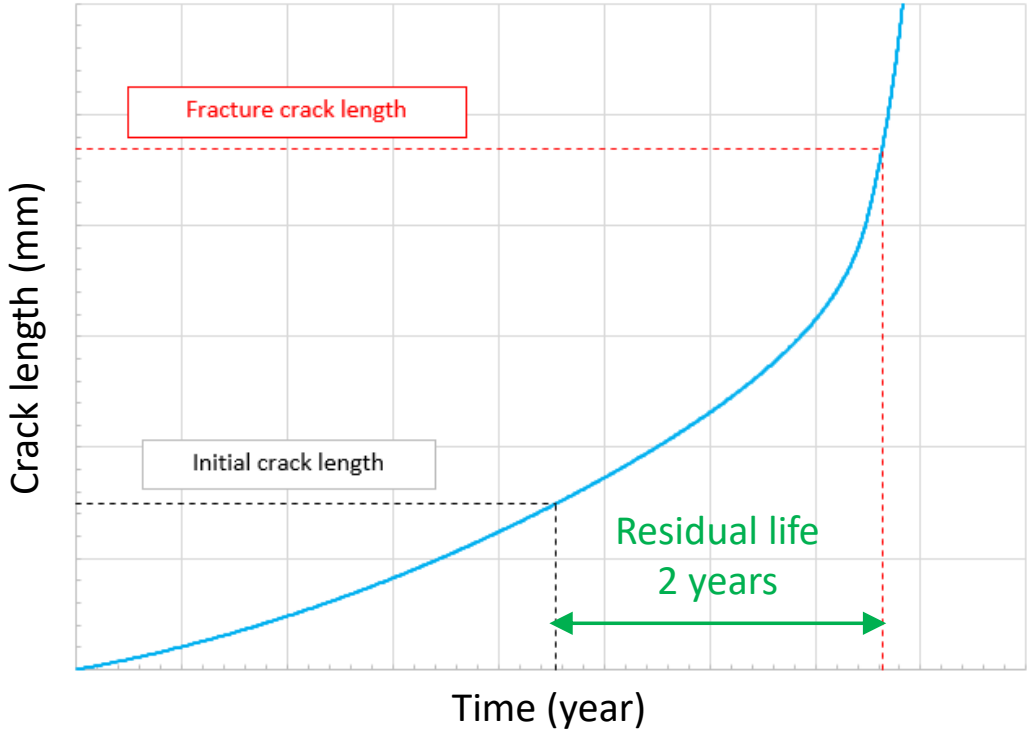
$$\text{Residual life} = \int_{a_0}^{a_1} \frac{1}{v} \mathrm{da}$$

* v-a diagram is drawn as combining v-K diagram and K-a diagram. Residual life time evaluation method is well proved one with v-a diagram.

4. Residual life evaluation method for SCC

- **Calculation result**



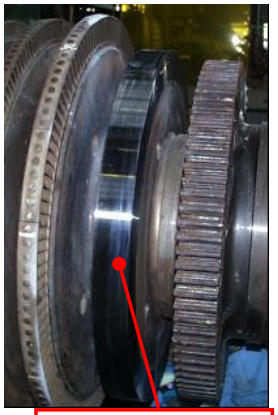


Calculated residual life is shorter than maintenance operation cycle

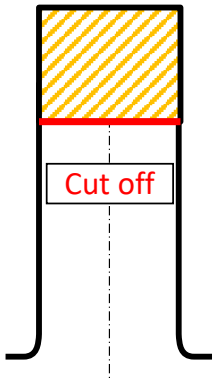
Rotor disk welding repair was performed

5. Repair plan for SCC

- **Work flow of welding repair** (Lead time is about 2 months)

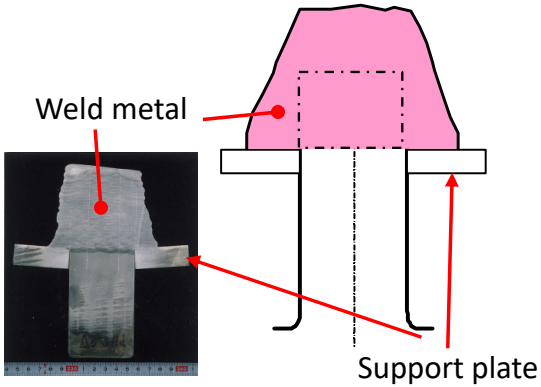


Cut off disc

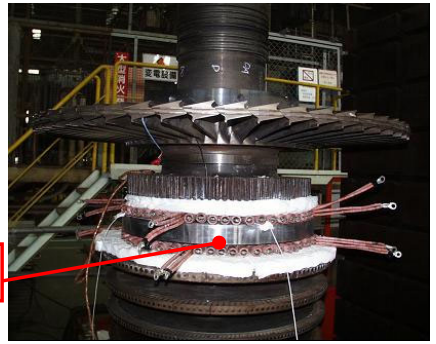


Damaged disc cut-off

Welded part



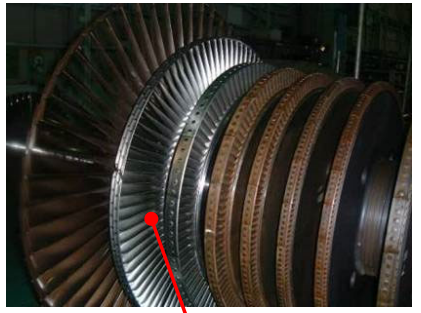
Weld build up



Heat treated disc

Heat treatment

disc/rotor machining



New blades

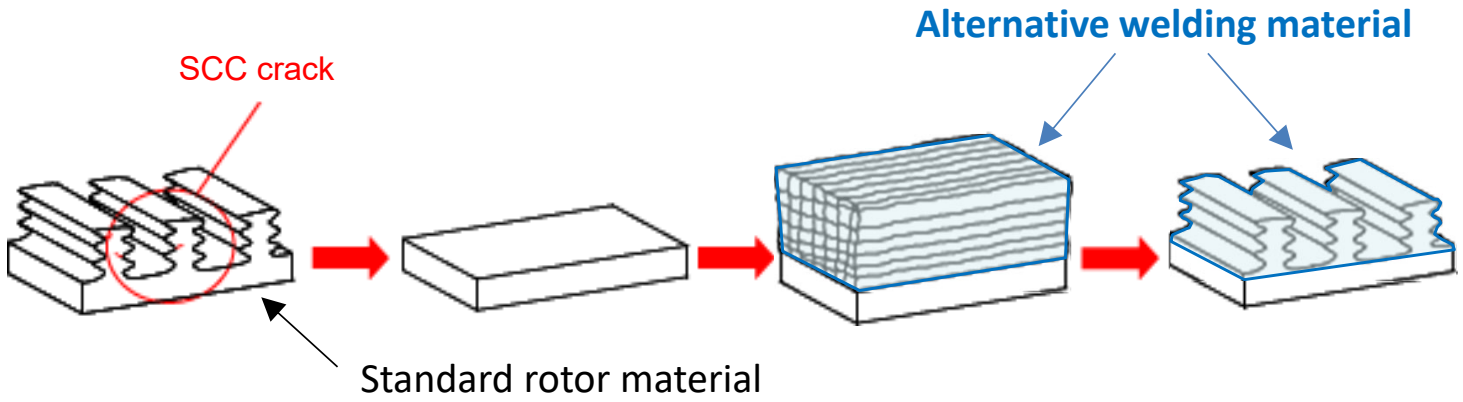
Blade assembling

6. Other recommended repair plan for SCC

Alternative welding material with High corrosion resistance

- The alternative material has more than ten times corrosion resistance of standard rotor material

- This alternative material can be welded on the standard rotor material.



The turbine rotor overlaid alternative welding material has high resistance to SCC

7. Lessons learned

- A fast method to assess residual SCC life on Fir tree blade groove of steam turbines was introduced. This method can give residual life in a short time (during maintenance operation), so that corrective actions can be taken immediately.

- Rotor disk welding repair was performed and calculated residual life was shorter than maintenance operation cycle. Evaluation of residual life was helpful in preventing unexpected SCC failures.

- New rotor welding material which has high corrosion resistance is introduced. An alternative material with higher resistance to corrosion was recommended to increase the SCC life.

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