Stress Corrosion Cracking on Steam Turbine Rotor Grooves: Experiences and Countermeasures from EGAT Power Plants

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Presentation Topics

- EGAT Steam Turbine Portfolio
- SCC on Steam Turbine Rotor
- Life Assessment and Evaluation
- Experiences and Countermeasures
- Summary
- Questions and Answers

*SCC refers to Stress Corrosion Cracking

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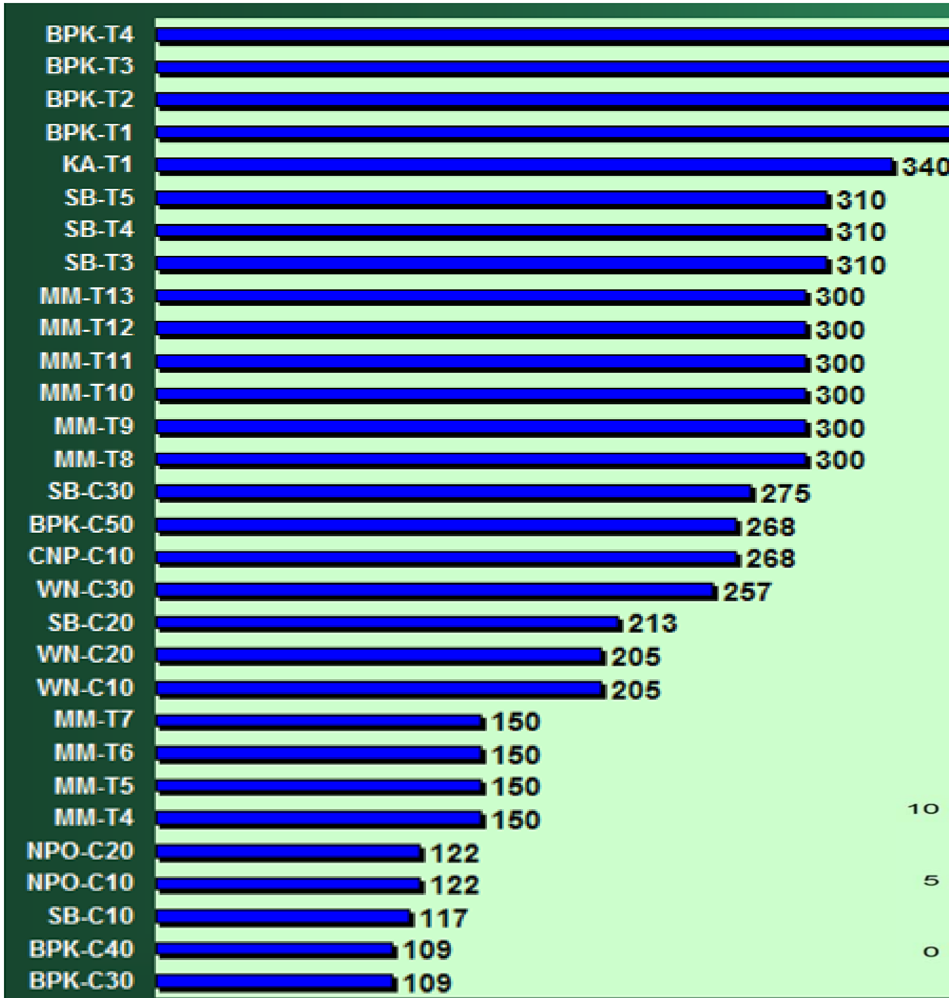
EGAT Steam Turbine Portfolio



EGAT Power Plants

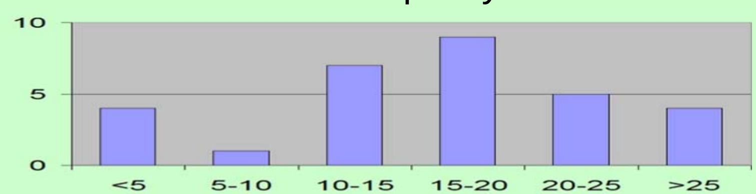
Statistical Data

30 Steam Turbines

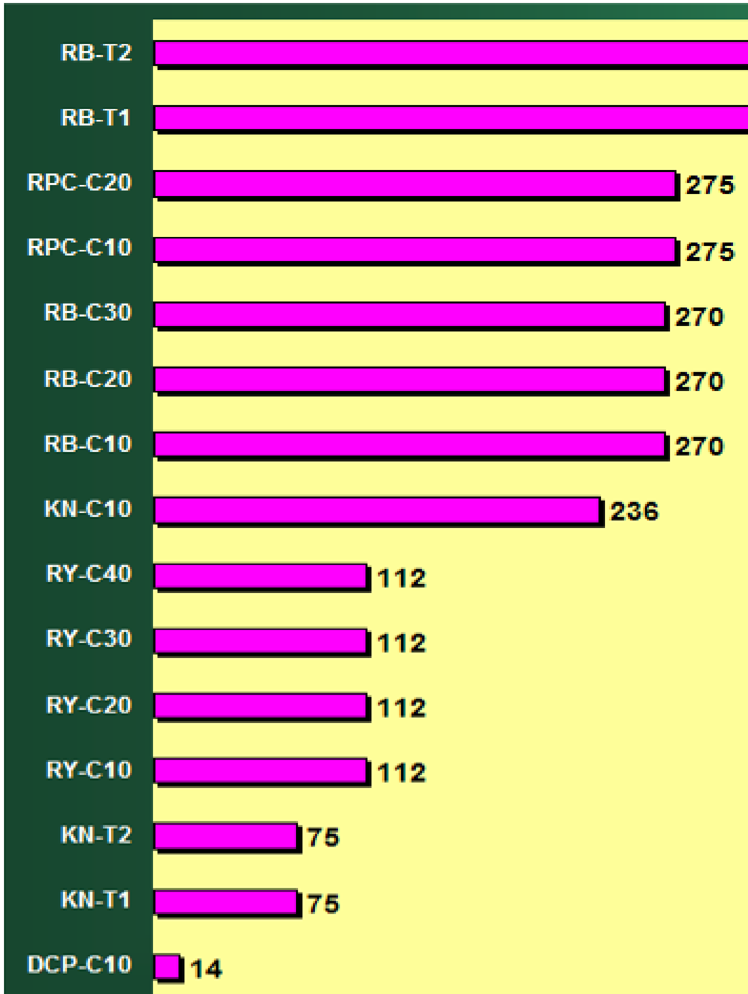
- 12 combined cycle plants
- 28 thermal plants

Largest	600 MW	Oldest	35 years
Smallest	109 MW	Newest	<1 years
Average	274 MW	Average	17 years

Total Generation Capacity 8.2 GW



EGAT Steam Turbine Portfolio



EGAT subsidiaries

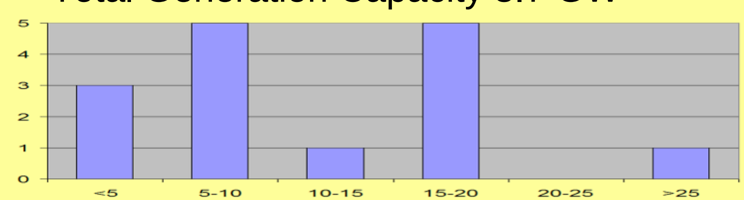
Statistical Data

15 Steam Turbines

- 10 combined cycle plants
- 4 thermal plants
- 1 co-generation plant

Largest	735 MW	Oldest	29 years
Smallest	14 MW	Newest	1 year
Average	240 MW	Average	11 years

Total Generation Capacity 3.7 GW



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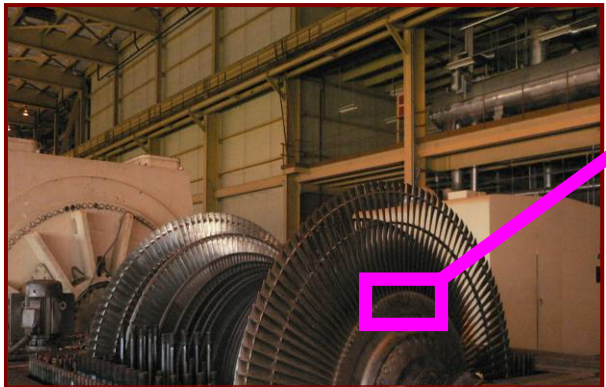
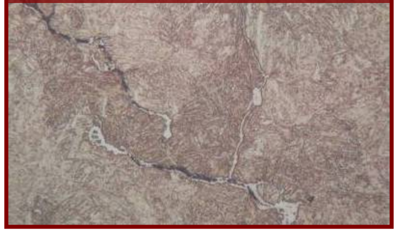
SCC on Steam Turbine Rotor


550 MW Steam Turbine

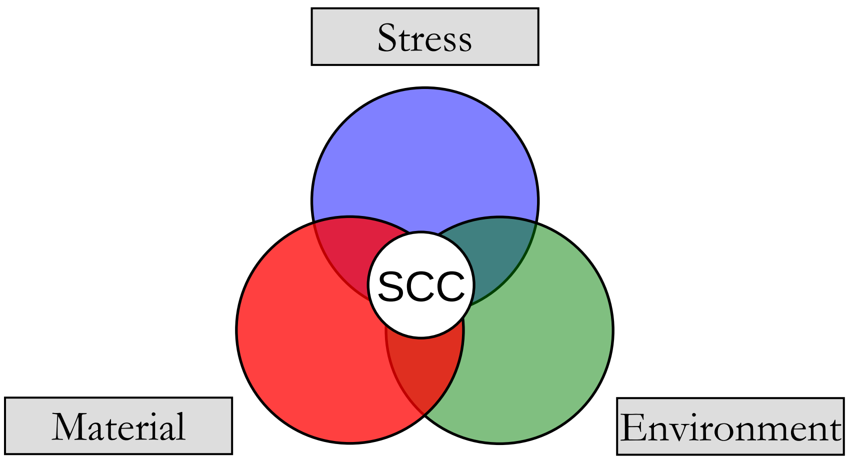

Blade Attachment


Double Flow LP Rotor


Crack

SCC


SCC on Steam Turbine Rotor

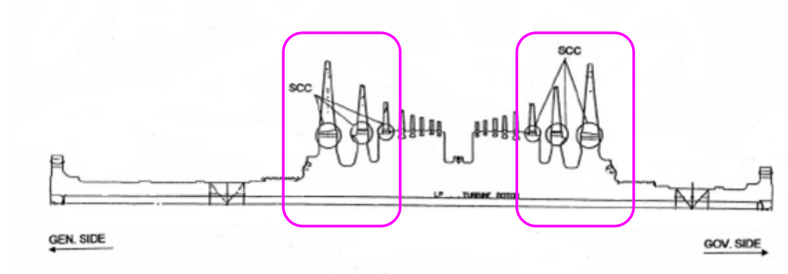


SCC failure is the function of

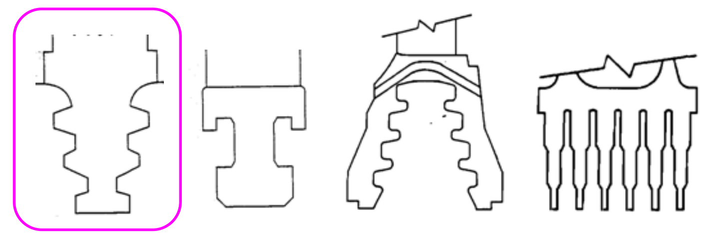
- Stress Intensity

- Rotor Material

- Steam Environment



The probability of occurrence is high especially in attachments of the 3 last stages.



SCC could be found in all blade attachment designs but the most prevalent is fir tree type!

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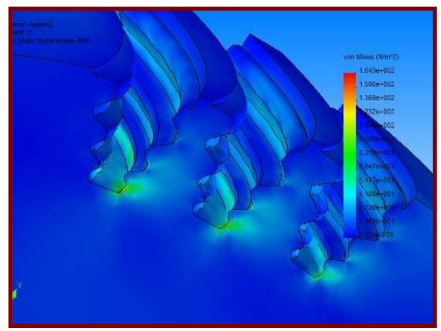
Life Assessment and Evaluation

(1)*
Blade Removal

(2)
Groove Cleaning

(3)
Magnetic Particle Test

(4)
Replication Test



Evaluation

Critical Crack Depth

and

Crack Growth Rate

(5)
Crack Grinding

(6)
Indication Measurement

(7)*
Remaining Life Assessment

Note: (1) 10% sampling of all L-0 blades for life assessment is normally applied

(7) In case of determination of critical crack depth and crack growth rate, EGAT shall consult with OEM

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Experiences and Countermeasures

- Experiences
- Countermeasures
  - Crack Grinding
  - Running (until next outage)
  - Blade Cutting or Removal
  - Steeple Machining
  - Welding Repair
  - Rotor Replacement

Experiences

- The first steam turbine life assessment program had been carried out since 1997.
- SCC were found in 11 out of 21 steam turbines that life assessments were done.
- SCC were found in L-0, L-1, and L-2 around 53%, 47%, and 20% respectively.
- The periods for steam turbine life assessments in EGAT range from 15 to 42 years with an average of 21 years.
- Several corrective actions had been implemented for example crack grinding, running until next outage, blade cutting or removal, steeple machining, welding repair, and rotor replacement respectively.

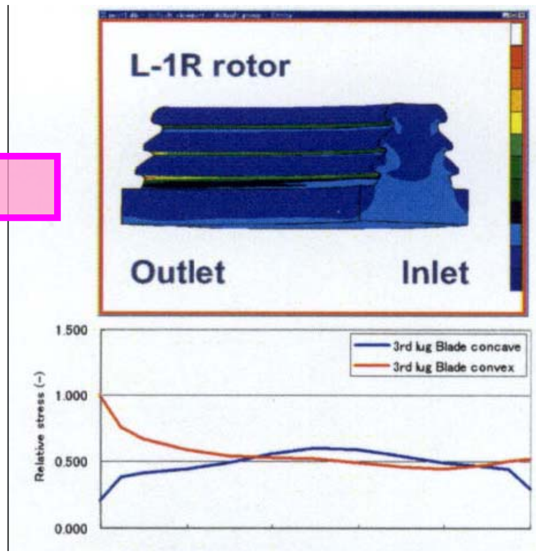
Countermeasure: Crack Grinding

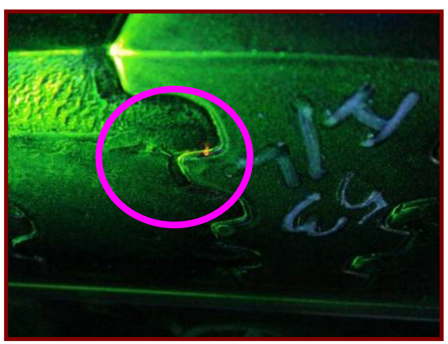
Short to Medium Term

- Advantages
  - one of low cost options
  - first common corrective action to every crack found
  - may stop further crack propagation
- Disadvantages
  - suitable for only shallow cracks
  - crack may propagate at other areas instead
- Plants
  - SB-T (2 units)
  - MM-T (5 units)

Countermeasure: Running (until next outage)

Short Term





- Advantages
  - economical choice
- Disadvantages
  - requires complete remaining life evaluation
  - unacceptable outage duration unless remaining life assessment has been prepared in advance
- Plants
  - BPK-T (2 units) can extend for 5 years operation but need LP groove end face inspection every 2 years

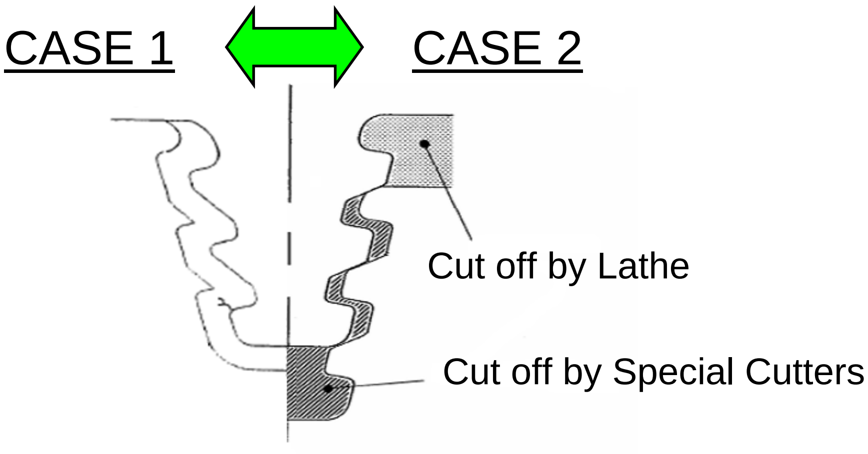
Countermeasure: Blade Cutting or Removal

Short Term

- Advantages
  - comparatively low investment cost
  - suitable for unit which has very deep cracks
- Disadvantages
  - lost of performance or efficiency
  - may require baffle plates in order to prevent consequence failure in other blade rows (~2 weeks)
- Plants
  - SB-T (2 units) with baffle plates install and 90% load limitation
  - MM-T (1 unit) without baffle plates install and 75% load limitation

Countermeasure: Steeple Machining

Medium to Long Term



- Advantages
  - will reset the SCC cycle
  - possible to reduce stress by enlarge groove radii
- Disadvantages
  - geometry limitation
  - high cost for maintenance
  - unfavorable extended outage (~6 months)
  - requires some modifications for blading
- Plants
  - SB-T (3 units) by dropped steeple machining in case 2

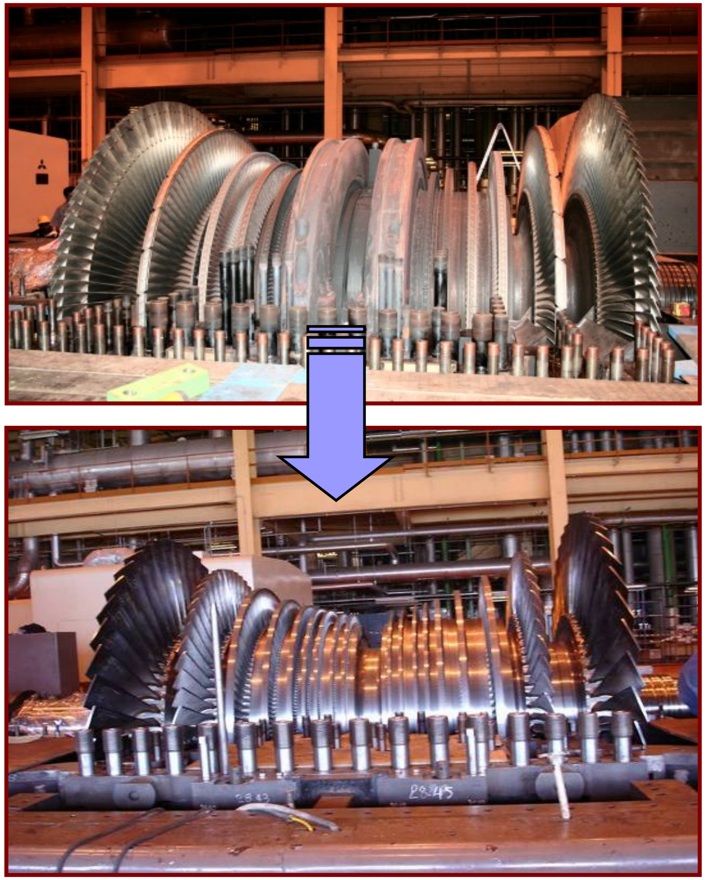
Countermeasure: Welding Repair

Medium to Long Term

- Advantages
  - will reset the SCC cycle
  - can apply weld material with high resistance to SCC
- Disadvantages
  - high cost for maintenance
  - unfavorable extended outage (~6 months)
  - may have effect on rotor material particularly in HAZ
- Plants
  - SB-T (1 unit) by partial welding because steeple machining can't eliminate some deep cracks

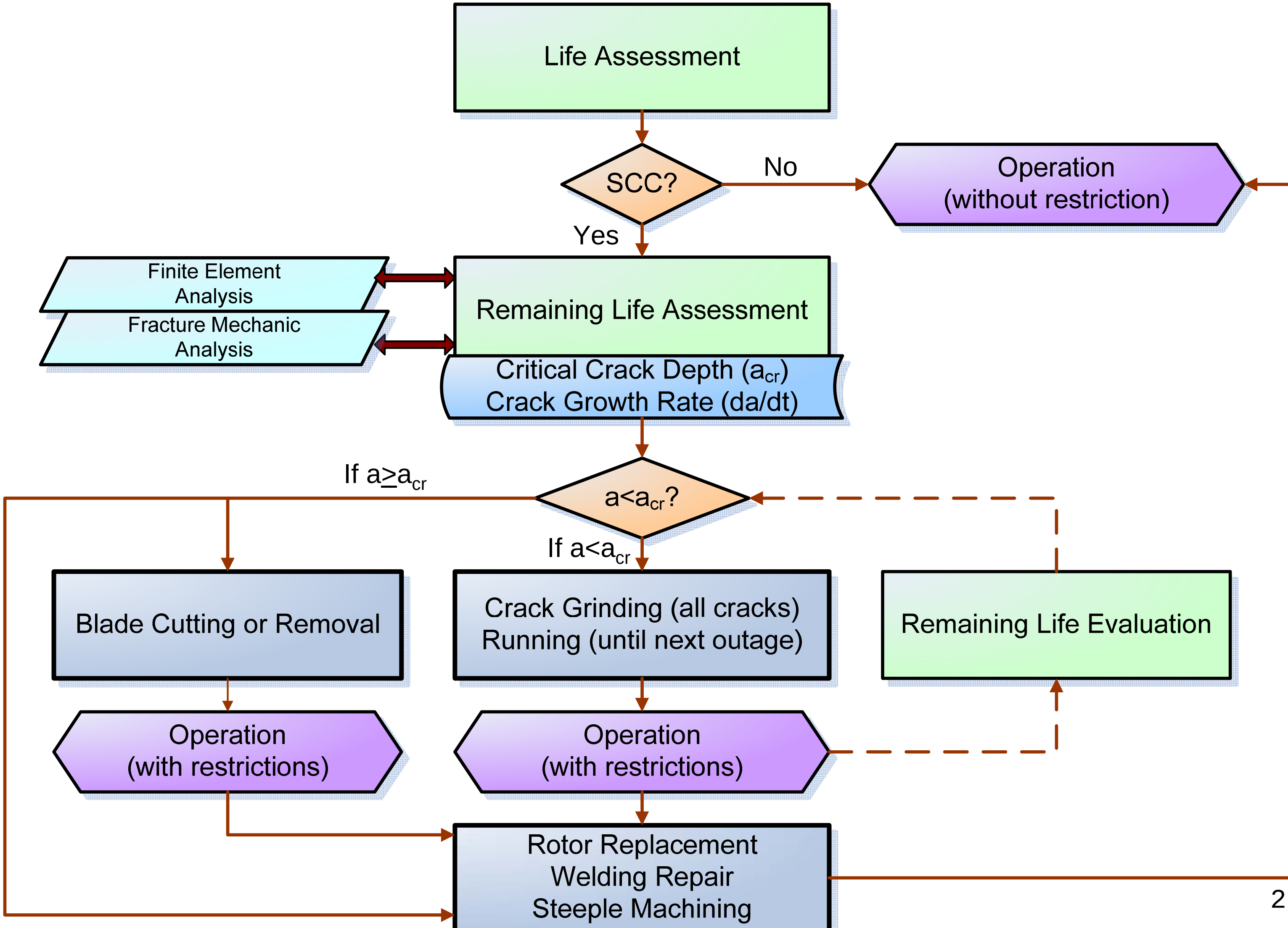
Countermeasure: Rotor Replacement

Long Term



- Advantages
  - archives thermal efficiency or heat rate improvement
  - higher SCC resistant by upgrade rotor material or improve design
- Disadvantages
  - high investment cost
  - requires time to implement (~2½ years)
  - should consider for compatibility with nearby components
- Plants
  - BPK-T (2 units) with 13.9 MW up from 550 MW each
  - MM-T (3 units) with 5.0 MW up from 300 MW each

Countermeasures



Experiences & Countermeasures

No.	Plant	COD (year)	Inspection (year)	SCC Indication			Sampling (/stage)	Countermeasures
				L-0	L-1	L-2		
1	NB-T1*	1961	2003	No	No	No	1 groups	No Actions
2	SB-T1*	1970	1998	No	No	No	2 groups	No Actions
3	SB-T2*	1971	1997 2000	Yes Yes	Yes Yes	No No	2 groups 100%	Grinding Grinding
4	SB-T3	1974	1997 2000 2001 2006	Yes Yes Yes -	- No - -	- No - Yes	1 group 100% 100% at end face	Grinding Grinding Re-machining (drop steeple) Blade Cutting (with Baffle Plate installed)
5	SB-T4	1975	2001 2005	Yes -	No -	No Yes	100% at end face	Re-machining (drop steeple) Blade Cutting (with Baffle Plate installed)
6	SB-T5	1977	1999 2002 2007	No Yes -	No - -	No - No	2 groups 100% at end face	No Actions Re-machining (drop steeple) Welding Repair (partial) No Actions

Note: NB-T is North Bangkok Thermal Power Plant and SB-T is South Bangkok Thermal Power Plant

Experiences & Countermeasures

No.	Plant	COD (year)	Inspection (year)	SCC Indication			Sampling (/stage)	Countermeasures
				L-0	L-1	L-2		
7	MM-T1*	1977	1998	-	Yes	-	5 grooves	Grinding
8	MM-T3*	1978	1999	Yes	-	-	100%	Grinding
9	MM-T4	1984	2002	No	No	No	2 groups	No Actions
10	MM-T5	1985	2008	No	No	No	2 groups	No Actions
11	MM-T6	1985	2005	No	No	No	2 groups	No Actions
12	MM-T7	1985	2007	No	No	No	2 groups	No Actions
13	MM-T8	1989	2004 2006 2008	Yes Yes No	- - Yes	- - -	100% 12 grooves 17 grooves	Grinding Grinding LP Turbine Retrofit
14	MM-T9	1990	2006 2007	Yes -	Yes -	Yes -	100% N/A	Blade Removal (without Baffle Plate installed) LP Turbine Retrofit
15	MM-10	1991	2006 2009	Yes Yes	Yes Yes	No -	100% 10 grooves	Grinding LP Turbine Retrofit

Note: MM-T is Maemoh Thermal Power Plant

Experiences & Countermeasures

No.	Plants	COD (year)	Inspection (year)	SCC Indication			Sampling (/stage)	Countermeasures
				L-0	L-1	L-2		
16	BPK-T1	1983	2003	No	Yes	No	1 group at end face	Grinding Running (until next outage)
			2005	-	-	-	N/A	LP Turbine Retrofit
17	BPK-T2	1983	2001	No	Yes	No	1 group at end face	Grinding Running (until next outage)
			2003	No	Yes	No	at end face	Running (until next outage)
			2005	No	Yes	No	at end face	Running (until next outage)
			2006	-	-	-	N/A	LP Turbine Retrofit

Running (until next outage) requires Remaining Life Assessment and Evaluation.

Note: BPK-T is Bangpakong Thermal Power Plant

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Summary

- Root causes of SCC are the combination of applied stress, steam environment, and susceptible material.
- Determination for major root cause is crucial for long term operation.
- Steam turbines operating more than 15 years are prone to this failure mechanism .
- There is no unique countermeasure for solving SCC problem on LP rotor groove because of inspection, operation, and economical constraints.
- Critical crack depth, outage duration, spare parts, and cost benefit analysis are the key factors for deciding on which suitable action should be taken.

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End of Presentation

Thank you for your attention!

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