Alloy Corrosion in Steam Turbines

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Abstract. In the presented paper the system for determination of pits due to alloy corrosion in steam turbines is described. For two-dimensional task the number of pits in different areas is determined by microscopy technique with image analysis.

Introduction

The accumulation of damage due to localized corrosion [pitting, stress corrosion cracking (SCC) and corrosion fatigue (CF)] in steam turbines components, such as blades, discs, and rotors, has been consistently identified as being among the main causes of turbine unavailability [1]. Accordingly, the development of effective localized corrosion damage prediction technologies is essential for the successful avoidance of unscheduled downtime in steam turbines (and other complex industrial and infrastructural systems) and for the successful implementation of life extension strategies.

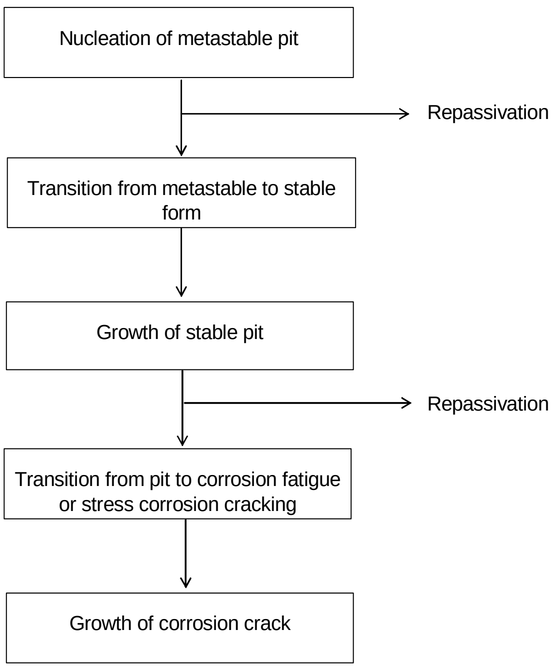

Fig. 1. Schema for the nucleation and propagation of corrosion damage.

Description of Damage Progression

It was suggested recently [2) that damage function analysis (DFA) is a more effective method for predicting the progression of damage, particularly when combined with periodic inspection. DFA is based upon deterministic prediction of the rates of nucleation and growth of damage, with particular emphasis on compliance of the embedded models with laws. It is often reported that damage in low pressure steam turbines initiates in highly localized areas, most commonly at corrosion pits that act as stress raisers. After nucleation, the corrosion events develop and pass through distinct stages.

It is evident, if we wish to describe the accumulation of damage quantitatively, that we must be able to describe each of the stages in deterministic form; namely, initiation of metastable pits, the survival of a (few) metastable pits to form stable pits, the growth of stable pits, the transition of pit into cracks, the growth of subcritical cracks, and finally unstable fracture. The quantitative description of pit growth is one of the key problems in predicting corrosion damage in steam turbine and a nucleation of pits as well.

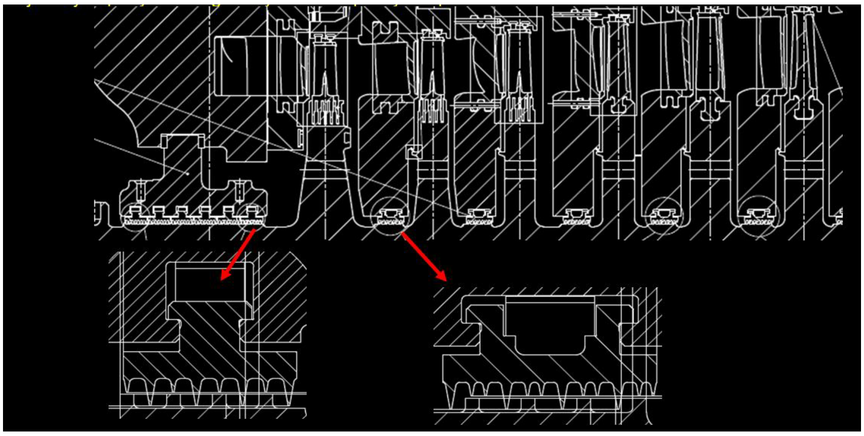

Fig. 2. Steam turbine packing of distributing rotors ETU23.

In the presented paper the system for determination of pits is described. For two-dimensional task the number of pits in different areas is determined by microscopy technique with image analysis. At the same time the max. and min. depth is found, what is key parameter of DFA as shown at Figs.1 and 2. Table 1 comprises the found parameters of corrosion for distributing rotors ETU23 (alloy X22CrMoV12-1).

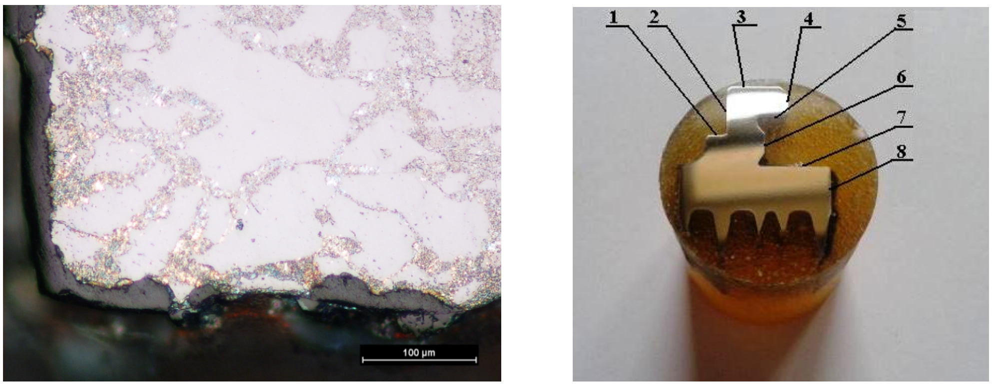

Fig. 3. Pitting corrosion after 6700 hrs in 650 °C steam, part No.1.

Table 1. Parameters of pitting observed by the Nikon Eclipse ME600 microscope and image analysis by Nikon Elements, part No.1 (by V. Mušutová, Klokner Institute).

					Depth [µm]			
Area	**No of Pits**	**Σ L i [mm]**	**Density**	**Oxide [%]**	**Max**	**Min**	**Mean**	**St. Deviation**
1	6	1.5567	3.85	79.00	35.39	13.06	25.95	6.997
2	31	3.9507	7.85	66.74	36.39	5.65	21.58	7.825
3	17	0.7627	22.29	12.09	29.05	5.80	19.73	5.802
4	15	0.8248	18.19	33.35	30.00	14.52	20.78	5.079
5	18	0.8534	21.09	28.19	28.08	7.40	19.05	5.113
6	3	2.8381	1.06	99.22	32.88	29.19	30.81	1.540
7	42	5.3321	7.88	64.00	39.71	4.35	21.91	8.932
8	29	2.4345	11.91	41.68	36.76	9.67	22.65	7.453

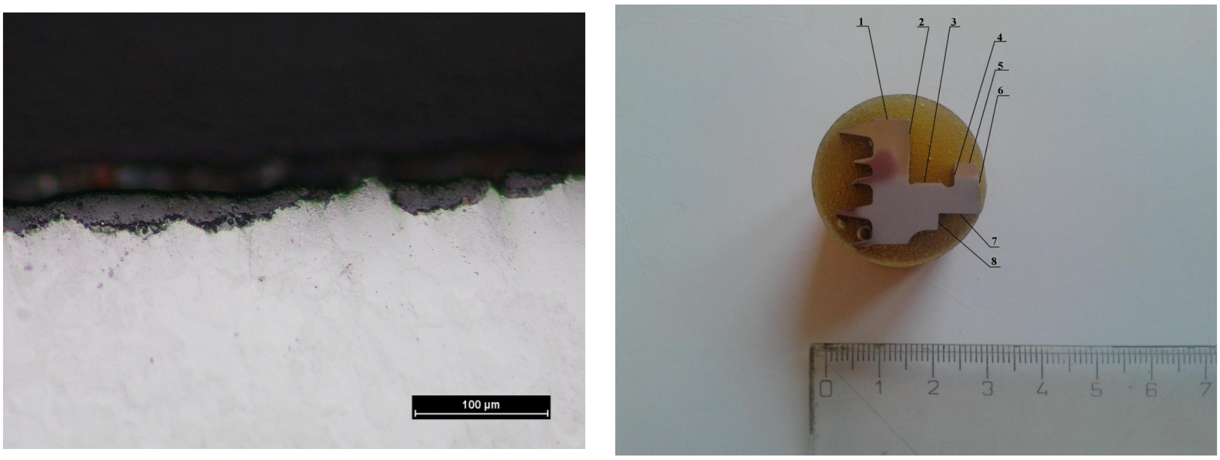

Fig. 4. Pitting corrosion after 6700 hr in 650 °C steam, part No 2.

Table 2. Parameters of pitting observed by microscopy Nikon Eclipse ME600 and image analysis by Nikon Elements, part No2 (by V. Mušutová, Klokner Institute).

					Depth [µm]			
Area	**No of Pits**	**Σ L i [mm]**	**Density**	**Oxide [%]**	**Max**	**Min**	**Mean**	**St.Deviation**
1	40	4.1944	9.54	80.48	27.04	8.45	18.57	4.944
2	58	6.6833	8.68	68.26	29.54	7.87	20.71	5.381
3	17	3.3763	5.04	83.93	30.05	13.02	21.36	4.900
4	28	2.0299	13.79	63.79	31.33	11.13	20.66	5.028
5	18	2.4452	7.36	78.46	29.57	9.68	21.36	4.815
6		N/A						
7	39	2.8553	13.66	49.98	35.68	8.72	19.52	5.855
8	14	1.5375	9.11	80.08	31.88	18.06	24.11	3.682

Conclusions

In the presented paper the system for determination of pits due to alloy corrosion in steam turbines is described. For two-dimensional task the number of pits in different areas is determined by microscopy technique with image analysis as the basis for predicting a complete cycle of damage development: the nucleation, growth, and death of individual events (pits/cracks) and the evolution of damage in an ensemble of events occurring in a progressive manner.
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References

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