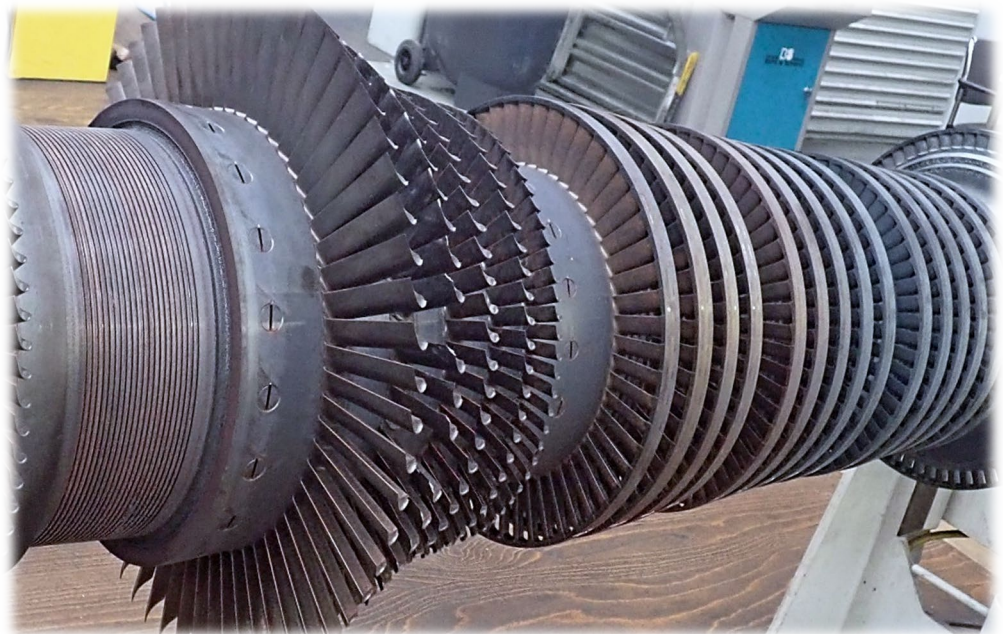


***MATERIEX CASE STUDY***  
**STEAM TURBINE FAILURE**



**BACKGROUND**

Two low pressure (LP) steam turbine rotor blade ruptures were discovered during an inspection that was carried out due to high vibrations during start-ups. The two ruptured blades had both been mounted in row 19, the 1<sup>st</sup> row in the LP stage. The fractured blade roots were cut out and sent to Materiex AB for failure investigation.



**INVESTIGATION**

The investigation included the following:

- On-site inspection and visual examination
- Fractography of the ruptured blades using SEM
- Verification of chemical composition using XRF
- Hardness measurements were conducted with a Brinell hardness tester.
- Microstructural studies using LOM

SEM - Scanning electron microscopy

XRF - X-ray fluorescence

LOM - Light optical microscopy

**FINDINGS AND CONCLUSIONS**

- Chemical composition and hardness measurements showed that the rotor blade material conformed with the specifications (Table 1-Table 2).
- The macroscopic appearance with beach marks visible on the fracture surfaces indicates that the blade fractures have been caused by fatigue, initiated at the suction side of the blade roots. Beach marks are macroscopic concentric rings that represent sudden changes in load and/or environmental conditions.
- The total number of beach marks was estimated to be 30-50 which may be interpreted to equal the number of starts/stops needed to cause the fracture. The different colours of the beach marks indicate various degrees of oxidation which may be referred to as different stages under which the fatigue crack has propagated.
- A detailed study of the fracture surface in SEM showed the presence of so-called striations (Figure 4). Striations are microscopic parallel lines associated with fatigue failures and where each line represents the crack front during one load cycle.

**Table 1. Chemical composition [wt.%]**

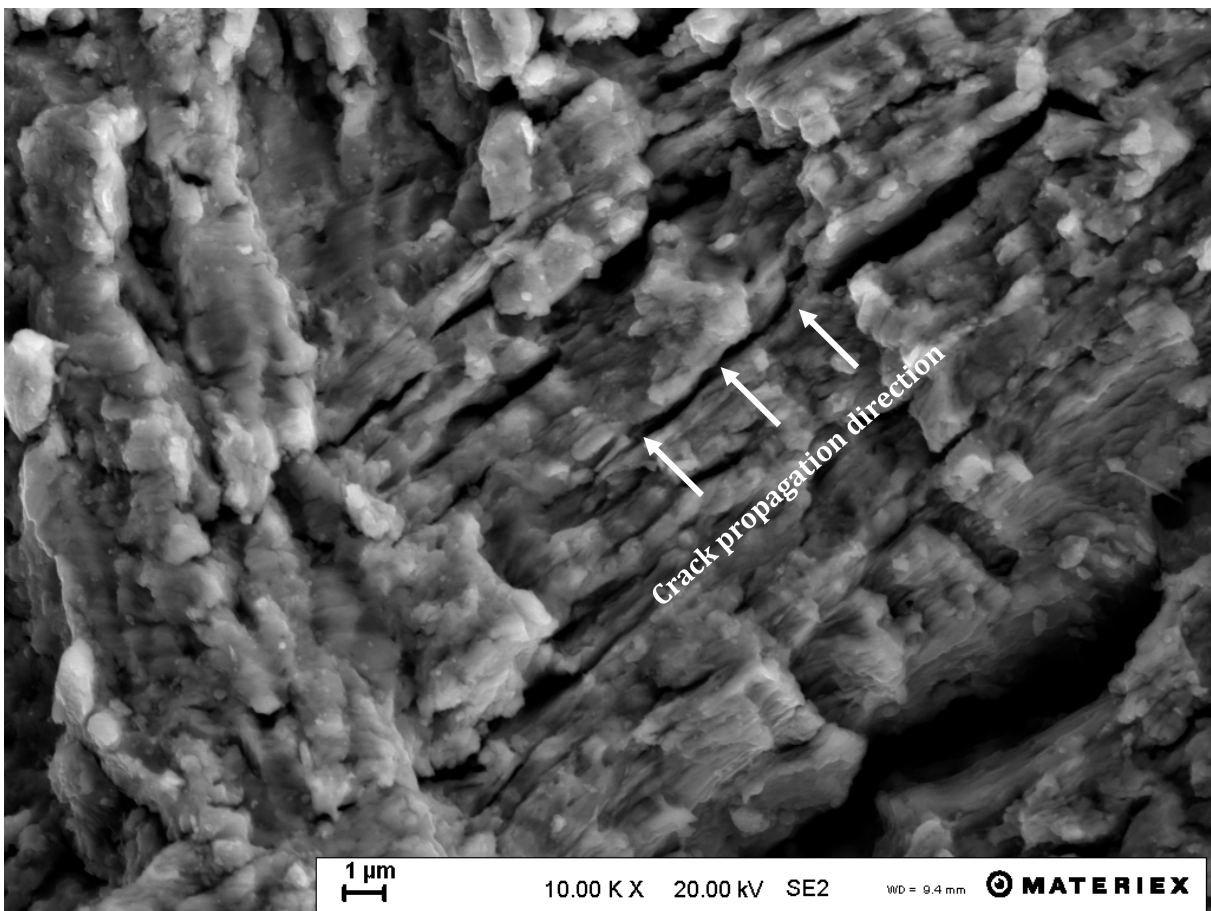
Element	Si	V	Cr	Mn	Fe	Ni	Mo
Blade foot	0.5	0.3	11.8	0.8	85	0.6	1
Specified X22CrMoV12-1	0.1–0.5	0.25-0.35	11.0–12.5	0.4–0.9	Bal	0.3–0.8	0.8–1.2

**Table 2. Average hardness and estimated tensile strength.**

Sample	Hardness [HB]	Tensile Strength [MPa]
Blade foot	260	880
Specified X22CrMoV12-1		800–950



**Figure 1.** Fracture surface of the blade root, shows a large number of beach marks.



**Figure 2.** SEM-image showing fatigue striations visible at high magnification. Arrows indicate crack propagation direction.