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Case study

# An investigation into failure analysis of interfering part of a steam turbine journal bearing

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ABSTRACT

Journal bearings as so sensitive parts of steam turbines are very susceptible to failure through different mechanisms of wear, fatigue and crush during service conditions. Failure occurring through these mechanisms lead to turbine completely shut down as a result of interfering in working conditions of bearing different parts. In this research, failed interfered part of a journal bearing related to a 320,000 kW steam turbine was examined. Failure analysis investigations were performed by utilizing of stereographic, optical microscopy, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS) analysis and hardness test. Surface crush, large amounts of surface cracks, no noticeable changes of failed surface chemical composition and microstructure with significant hardness improvement were the main obtained results. The studies were revealed that the bearing part loosing and inappropriate clearance can produce relative displacements under cyclic gradient loading. This condition was detrimental for the service life of turbine journal bearing via failure through fretting fatigue mechanism.


## 1. Introduction and background

Damaging through bearings as the main backing for the rotating parts may lead to interfering of the fixed and rotating tools with some changes in their positions. This can be a source for bearing axis bending and subsequently may lead to its fracture. In the other cases, the temperature of other parts increased as a result of mentioned damaging. When a bearing is damaged, it is often removed from service and replaced before reaches to its full, useful and economical life. Advancements in bearing design, materials, bearing maintenance and repair methods have greatly improved the potential for and popularity of the bearing repair as an effective way to extend the life of the bearing [1].

Two different types of bearing are utilized in the construction of steam turbines including; journal and thrust. The first type preventing from vertical movement of bearing axis and the second thrust one fixed the axis through longitudinal direction [2,3]. Turbine bearing failures in electric utilities have been responsible for outages amounting to ~1.1–1.8% of the theoretical power output. Significant imposed additional costs due to bearings damaging and consequent unexpected unit shut down leads to performing of widespread failures analysis studies in order to drawing of a beneficial procedure for overcoming from this problem. It has been reported sixteen damaging mechanisms for failure of steam turbine journal

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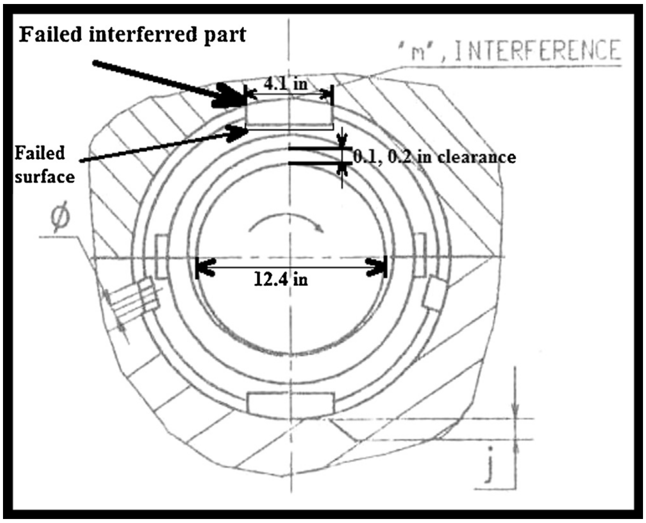


**Fig. 1.** Schematics represent the journal bearing assembly.

bearings as well as; abrasion, bond failure, cavitations erosion, corrosion, electrical pitting, erosion, fatigue, fretting, high chromium damage, non-homogeneity, overheating, seizure, structural damage, surface wear, tin oxide damage and wiping [2]. Some of these damaging mechanisms more frequently contributed through bearing failure which short expressions about them summarized as follow.

Abrasion is a mode of bearing failure due to the erosive action of a large number of solid particles that are harder than the bearing surface. Under certain conditions both the bearing and shaft may be damaged by the abrasive action of the particles [2]. Fatigue and bond failure are two other main damage mechanisms for bearings failure. Bond failure is a separation of the bearing alloy from the supporting structure at the interface between the two metals, and is caused by poor adhesion of bearing alloy to the backing metal [2]. Fatigue failure is the cracking and fracture of metals due to an excessive number of cycling stresses when the stress level is above a threshold limit characteristic for a specific material at a specific temperature [2]. Despite no applied cyclic loading through bearing service condition, fatigue failure performed due to un-equilibrium loading condition and Babbitt low strength. Fretting is another form of corrosion or fatigue surface damages occurs on contacting components subjected to small amplitude oscillatory motions which can leads to bearing failure [2]. If fretting assisted by oxidation of worn steel with leaving of corroded appearance, it's often referred to as fretting corrosion [3]. Shrunk-on parts, bearing pivots, loose bearing shells and similar parts prone to repeated relative movements are most susceptible to this sort of damage. When fretting phenomenon arises from cyclic stressing of one or both components, it's often known as fretting fatigue [3]. In this case, according to the contact geometry and the in-service loading conditions, fretting fatigue can result either in material system locking or material wear and mechanical systems looseness or early fatigue crack nucleation and propagation until failure, reducing drastically the service life of the components [4,5]. Several factors affected the fretting fatigue behavior of materials, in which contact pressure, coefficient of friction, slip amplitude, and cyclic axial stress are relatively important [6–8].

In the steam turbines, usually journal bearings which constructed from several parts have been utilized. The backing parts are made generally from hard steels provides rigidity and allows higher levels of press fit or crush for better retention [9]. Inter contacting with lining parts and in-service complex loading conditions leads to more susceptibility of journal bearings to some of the mentioned failure mechanisms such as; abrasion, fatigue, fretting and may bond failure. In the present research, failure analysis of a failed interfering journal bearing part of a steam power plant turbine was assessed and failure mechanism determined by monitoring of the metallurgical characteristics and failure features through different microstructural and mechanical experiments.

## 2. Materials and methods

During repairing of a 320,000 kW steam turbine, after disassembling of bearing journal-pad type, some surface damages on its interfering part have been observed. Fig. 1 illustrates the general location view of this damaged part in journal bearing

**Table 1**
Nominal chemical composition of investigated Q235B steel (in wt.%).

| Fe | C | Si | Mn | Cr | Ni | Cu |
|---|---|---|---|---|---|---|
| Base | 0.12–0.2 | 0.3 | 0.3–0.7 | 0.3 | 0.3 | 0.3 |