Case Studies in Engineering Failure Analysis 2 (2014) 150–156

Contents lists available at ScienceDirect

Case Studies in Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/csefa

Case study

Failure analysis of air cooled condenser gearbox

Anand Parey *, N.K. Jain, S.C. Koria

Discipline of Mechanical Engineering, Indian Institute of Technology, Indore, MP, India

ARTICLE INFO

Article history:
Received 9 July 2014
Received in revised form 21 August 2014
Accepted 25 August 2014
Available online 2 September 2014

Keywords:
Gearbox
Failure analysis
Gear quality
Spall
Pitting

ABSTRACT

Gears are very reliable components and normally work 5–6 years without failure. This article is a case study of failure analysis of a gearbox which was failed in three months after its installation. The problem was identified by maintenance engineers through vibration monitoring of gearbox. Hardness measurement of case and core revealed that the core was harder than case and the applied load was sufficiently high for failure of gear. Recommendations were given to improve the fatigue life of gearbox.

1. Introduction

The failure of gearbox caused losses in terms of cost of gear, down time during replacement and production losses. The gearbox under investigation was used for the driving the axial fan of an air cooled condenser (ACC) of a power plant in a very reputed cement industry in India. The gearbox was expected to have life of 50,000 h continuous running. However, it could not even run for 3000 h which was very intriguing. The unexpected failure of the gearbox led to investigation of the gearbox.

Diameter of the axial fan was 32 feet and had six blades. The amount of airflow can be adjusted by increasing the blade angle. The failure occurred when the blade angle was changed from 17° to 20° during summer to increase the air flow. The ambient air temperature reaches up to 45° C during summer at the location of the power plant.

This problem was identified by condition monitoring team which observed increase in vibration level drastically. This problem was observed in three other gearboxes while, changing the blade angle during summer. Failure analysis of gear is a subject of interest to many practicing engineers and researchers. Before starting the failure analysis of the gear, literature review was done to understand the various mechanisms of the gear failure. Various causes of gear failure are mentioned in literature [1–8]. Case studies on gear failure analysis are also very helpful to understand causes of gear failure and methodology of gear failure analysis. Some of the case studies on root cause analysis of gear failure are mentioned in [9–17].

In the present study, a failed gear and a pinion were examined. Apart from examining the failed gear and pinion, investigation of the geometric accuracy of new gear and pinion were also carried out to ascertain the quality of the gear.

2. Details of gearbox

The investigated gearbox had double reduction helical gears. Fig. 1 shows the cut section of the gearbox and Table 1 presents its other details including the composition of the gear material provided by the concerned industry. The input shaft

* Corresponding author. Tel.: +91 732 4240 716; fax: +91 732 4240 761.
E-mail address: anandp@iiti.ac.in (A. Parey).

http://dx.doi.org/10.1016/j.csefa.2014.08.003

Fig. 1. Arrangement of the gears of the ACC fan gear box.

having 14 teeth meshes with the bigger gear having 72 teeth mounted on the intermediate shaft. The output gear having 48 teeth meshes with the smaller gear (referred as intermediate pinion) having 15 teeth and mounted on the intermediate shaft. The intermediate pinion was observed with severe damage.

3. Investigations and analysis

3.1. Visual examination

Visual examination of the damaged intermediate pinion having 15 teeth and rotating at 290 rpm (Fig. 2a) and its meshing with the damaged output gear having 48 teeth and rotating at 92 rpm (Fig. 2b) suggested that the gears are damaged due to Hertzian fatigue. Following two types of Hertzian fatigue has been observed.

3.1.1. Destructive pitting

- In this type of pitting the surface pits are usually considerably larger in diameter than those associated with initial pitting.
- The dedendum section of the drive gear is often the first to experience serious pitting damage. However, as operation continues, pitting usually progresses to the point where a considerable portion of all the tooth surfaces has developed pitting craters of various shapes and sizes.

3.1.2. Spalling

- Spalling is similar to destructive pitting except that the pits are usually larger in diameter and quite shallow.
- Spalling often occurs in medium hard material and as well as in highly loaded fully hardened material.

Occurrence of the destructive pitting and spalling suggest that the gears do not have sufficient surface capacity and probably are not designed properly. Due to misalignment, the pinion does not mesh properly with the gear during operation and this led to a high stress concentration at the particular area. Fig. 2b shows the damaged output gear. It is clear from

Table 1
Details of ACC fan gearbox.

Parameter	Description/value
Gear type	Vertical parallel shaft, foot mounted, double reduction helical
Rating of gearbox	314 kW @ 1500 rpm
Nominal ratio	16:1
Input speed of gearbox	1480 rpm
Service factor	3.34
Gear efficiency	98%
Lubricating oil	Servomesh SP 320
Acceptable vibration	2.5 mm/s
Composition of the gear material (% by wt)	Fe: 96%; C: 0.24%; Ni: 2.33%; Cr: 0.77%; Mo: 0.20%; Mn: 0.4%; Nb: 0.03%; Pb: 0.03%