Chapter 8

Reliability Analysis of Engineering Systems: An Accelerated Life Testing for Boiler Tubes

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ABSTRACT

Nowadays, reliability and reliability-based design in any system has become very important. There are some parts in many systems that designing their test process take too much time and money in order to be analyzed for their reliability. Boilers, as the hearts of plants, contain various components. One of the most important components is Super-heater tubes. Creep failure is the most common failure mode in these tubes which grows faster by increasing the temperature. Accelerated Life Testing (ALT) is used to study the performance of a component under high stress in a short period of time and use of the test result in order to assess the performance of the component under design stress in a desired lifetime. In this chapter, the reliability of Super-heater boiler tubes in plants was examined by applying ALTs. The obtained results indicated that considering the life of components at the beginning of the test, reusing them under the same stress did not exhibit desirable reliability. Furthermore, some recommendations have been suggested to improve the reliability.

INTRODUCTION

The reliability of a plant is the most basic concern in the power industry. The reliability of the boilers is usually calculated by using functional data analysis in the long term or by utilizing short-term testing and extrapolating them for long term functions (Suik & Pihu, 2009).
Capital cost, power consumption, and availability are all necessary considerations in the economic optimization of power-generation equipment design. The capital and running costs of the boiler are relatively small compared to the plant for which it is an auxiliary. However, such plant depends implicitly for its revenue-earning capacity on the reliability of the boiler. Awareness of these overall economic considerations has led to the maximum availability design concept for large boiler (Weldon, 1964-1970).

Boilers are essentially shell-and-tube heat exchangers, with water being boiled to steam or transformed to high pressure hot water. Heat is generated by burning a fossil fuel; the combustion gas can be ducted around tubes containing the water (water-tube boiler), or the hot gas can pass inside the tubes with the water being in the shell (fire tube boiler) (Hall, 2012).

Boilers are designed to produce the steam for plants. They act as a heart of the plants and are composed of many components and parts. Therefore, in case of its failure for whatever reason, the plant would completely shut down. Steam is produced in some components and in the other components, the temperature are increased for further use.

The components studied in this chapter were the tubes, that the produced steam was directed through them. Their temperature was increased under extreme heat. The section containing Super-heater and tubes are called Super-heater tubes.

These tubes were made of seamless Molybdenum Chrome by the method of forging. The purpose of this project was to design various ALTs and analyze and assess the reliability of boiler tubes. The chapter was organized in a way that the principles and generalities of ALT will be discussed in the next section. In Section 3, the particular issue will be discussed along with the scope of the research, the system performance and the work condition. Method for designing the ALTs as well as the environment requirements for the tests were included in Section 4. Finally, analysis of the exam data, assessment, and reliability analysis will be presented in the last section.

A plant in Australia is discussed in this study to illustrate the economic value of boiler tubes. The program to reduce the failures in boiler tubes in NSW was arranged in 1988 and continued to work ceaselessly. It was a huge success and reduced the unavailability from %15 to less than %.1.

When you discuss availability requirements with a user or project leader, he will invariably tell you that 100 percent availability is required: “Our project is so important that we can’t have any downtime at all.” But the tune usually changes when the project leader finds out how much 100 percent availability would cost. Then the discussion becomes a matter of money, and more of a negotiation process (Marcus & Stern, 2003).

At its simplest level, availability, whether high, low, or in between, is a measure of the time that a server is functioning normally. In other word, Availability is the probability of finding system on a required condition for future use (Roy & Ronald, 1983).

\[
A = \left( T_a - T_{po - T_{uo}} \right) / \left( T_a - T_{po} \right) 
\]

where

- \( T_a \) is the total time period of availability.
- \( T_{po} \) is the total break time when the plant is out of service due to expected maintenance.
- \( T_{uo} \) is the total break time when the plant is out of service due to unexpected maintenance.
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