Engineering Failure Analysis 18 (2011) 1818–1830

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Reliability design and case study of refrigerator parts subjected to repetitive loads under consumer usage conditions

Seong-woo Woo [a,*], Jungwan Park [a], Michael Pecht [b]

[a] STX Institute of Technology, STX R&D Center, 448-2 Dogok 2-Dong, Gangnam-Gu, Seoul 135-855, South Korea
[b] Center for Advanced Life Cycle Engineering (CALCE), University of Maryland, College Park, MD, USA

ARTICLE INFO

Article history:
Available online 17 May 2011

Keywords:
Robustness
Parameter design
Load analysis
Accelerated life testing

ABSTRACT

When newly designed refrigerator parts failed due to repetitive loads under consumer usage conditions in the field, a general method for reliability design was proposed. A newly designed refrigerator compressor system that brings greater energy efficiency to side-by-side (SBS) refrigerators was studied. The laboratory failure mode and mechanism of the compressor was a stopping nose due to design flaws. The data on the failed products in the field, accelerated life tests (ALT) and corrective action plans were used to identify the key control parameters for the mechanical compressor system. The missing controllable design parameters of the compressor system in the design phase were the gap between the frame and the upper due to the stator frame shape. After a tailored series of accelerated life tests with corrective action plans, the B_1 life of the new compressor system is now guaranteed to be over 10 years with a yearly failure rate of 0.1%.

Published by Elsevier Ltd.

1. Introduction

Reliability is defined as the ability of an item to perform a required function under stated environmental and operational conditions for a specified period of time. Traditionally, the reliability over the product life can be illustrated by a bathtub curve that has three regions: A decreasing rate of failure, a constant rate of failure, and an increasing rate of failure, as shown in Fig. 1. As the reliability of a product (or part) improves, failure of the part becomes less frequent in the field. A company targets new product to (1) minimize initial failure, (2) reduce random failures during the expected product working period, and (3) lengthen the product life. The bathtub curve may change into a straight line with the slope angle β (Fig. 1). In a straight line there are two variables to be measured. That is, product life L_B (or mean time between failures) and failure rate λ, as shown in the following equation:

$$R(L_B) = e^{-\lambda L_B} \cong 1 - \lambda L_B \tag{1}$$

We can thus establish the reliability growth plan of parts with a constant failure rate.

Robust design techniques, including statistical design of experiment (SDE) and the Taguchi methods [1], have been developed by statisticians many years ago. The Taguchi methods describe the robustness of a system for evaluation and design improvement also known as quality engineering [2,3] or robust engineering [4]. Robust design processes include concept design, parameter design, and tolerance design [5]. Taguchi's robust design methods place the design in an optimum position where random "noise" does not cause failure and helps to determine the proper design parameters [6].

* Corresponding author. Tel.: +82 2 6944 2770; fax: +82 2 6944 2701.
E-mail address: twinwoo@onestx.com (S.-w. Woo).

1350-6307/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.engfailanal.2011.05.007