行政院國家科學委員會補助專題研究計畫成果報告

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※　**電子產品最佳預燒時間和成本之決定－以交換式整流器為例**　※
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計畫類別：個別型計畫
計畫編號：NSC 89-2213-E009-171
執行期間：89 **年** 8 **月** 1 **日至** 90 **年** 7 **月** 31 **日**

計畫主持人：蘇朝墩

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執行單位：國立交通大學工業工程與管理學系

中　華　民　國 九 十 年　九　月　二 十　日

行政院國家科學委員會專題研究計畫成果報告
電子產品最佳預燒時間和成本之決定－以交換式整流器為例
Intelligent Approach to Determining Optimal Burn-In Time and Cost for Electronic Products

計畫編號：NSC 89-2213-E009-171
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國立交通大學工業工程與管理學系

一、中文摘要

「預燒」已廣泛的應用在檢測產品出廠前的不良缺失。過去也有一些研究嚐試利用數學模式或成本模式來決定一機制（或系統）的最佳預燒時間和成本。然而，這些過去的研究中，有許多假設在實務上並不恰當，而且所需的成本數額亦很難獲得。如何有效的決定最佳預燒時間和成本已經困擾實務工作人員許久。另一方面，在實際的製造過程中，一新的電子產品常常是由一舊的產品所延伸出來，而這一舊的產品稱之為基礎產品。利用新產品和基礎產品之間的關係，本計劃發展一類神經網路的方法來決定最佳的預燒時間和成本。本計劃並以一實際的案例（交換式整流器）來說明所提方法的有效性。

關鍵詞：預燒時間、預燒成本、類神經網路、倒傳遞網路、交換式整流器

Abstract

Burn-in is an engineering method extensively used to screen out infant mortality failure defects. Previous studies have attempted to determine the optimum burn-in time and cost for a device or a system. However, for the mathematical model, many assumptions are inappropriate due to practical concerns, and for the cost model, the required costs are difficult to find. How to effectively determine the optimal burn-in time and cost has perplexed manufacturers for quite some time. In the actual manufacturing process, a new electronic product is always extended from an old product, called the base product. By adopting the relationship between new product and base product, this project will present a neural network-based approach to determine the optimal burn-in time and cost without any assumptions. In addition, a case study of the production of a switch mode rectifier will demonstrate the effectiveness of the proposed approach.

Keywords: burn-in cost, burn-in time, neural network, back-propagation network, switch mode rectifier

二、緣由與目的

Defects associated with electronic devices can be categorized mainly as patent defects and latent defects. Patent defects do not meet specifications and are readily detectable by inspection or functional testing that includes environmental stress screening. Latent defects can not be detected by inspection or functional testing until they are gradually transformed into patent defects by environmental stress screening. Burn-in is designed to detect patent infant failure in the electronics industry. The failure rate of an electronic device starts high, decreases rapidly during the infant mortality period, and then stabilizes in the steady-state period. Since infant mortality failure critically affects the overall reliability of devices or systems, determining the burn-in time and cost to effectively screen latent defects in infant mortality is important. This issue has received considerable interest (Kuo, et al. (1998)).

Stewart and Johnson (1972) developed a cost model using Bayesian decision theory to decide optimal burn-in time and replacement policy. Plesser and Field (1977) used a cost model to obtain an optimal burn-in time for repairable electronic systems. Meanwhile, Nguyen and Nurthy (1982) derived the optimal burn-in time for products sold under warranty. Furthermore, Chou and Tang (1992), and Mi (1996) determined the optimum burn-in time by using a cost model, with the costs including setup costs, direct burn-in cost, repair cost, and warranty cost. Koh, et al. (1995) utilized temperature stress as the accelerated condition to obtain effective burn-in time. Meanwhile, Chien and Kuo (1996) presented a nonparametric approach that can estimate the optimal system burn-in time without complex parameter estimation and curve fittings. Chien and Kuo (1997) proposed a Bayesian nonparametric approach to determine system burn-in time. Finally, Yan and English (1997) applied environmental stress screening to construct an integrated cost model and determine the optimal burn-in time.

Previous approaches, including curve fitting for a failure model, cost for optimal burn-in time model and environmental stress model, are ineffective in determining optimal burn-in time and cost for practical operations. In the curve fitting for a failure model or an environmental stress model, many assumptions are too broad and, thus, are inappropriate for many cases. Also, although many researchers have adopted the Weibull distribution to model the failure rate of electronic components, this is only an approximation. If other distributions, such as lognormal or Gamma distributions, are used for parametric analysis, the overall level of the system failure becomes untractable. In the cost model, these costs are difficult to estimate and in practice more attention may be paid to data collection, with the results usually being sensitive to the assumed costs. Additionally, in the electronics industry, the product line of a firm always extends from the base products, called the product family. In a product family, each product shares very similar characteristics. Obtaining the optimal burn-in time and cost for each product via traditional methods is tedious and monotonous.

When an electronic product enters mass production, its optimal burn-in time and cost must be known. This project presents a neural network-based approach to enhance the analysis of burn-in time and cost. Neural networks are highly parallel computation systems which can learn from examples. Neural networks can be used to construct the desired mapping function without requiring any assumptions concerning the functional form of the relationship between predictors and response (Stern,1996). This capability enables them to be applied in manufacturing. Neural networks are more easily comprehended and implemented than other statistical approaches. This project also performs a case study of the production of a switch mode rectifier and compares it with the statistical approach, to examine the effectiveness of the proposed approach.

三、結果與討論

The following describes a detailed procedure for determining optimal burn-in time for an electronic product:

Computation of the correlation ratio

Step 1: Identify the base product and new product to be studied.

Step 2: Let the correlation ratio (CR) of the base product be 1. Compute the CR of the new product as follows:

$$CR = \frac{CC_{new}}{CC_{base}},$$

where CC_{new} = the total number of critical components in the new product.

CC_{base} = the total number of critical components in the base product.

Optimization based on the base product data

Step 3: Develop a BP network model (Model 1) to obtain the relationship between (burn-in time, correlation ratio) and (burn-in cost, failure rate).

Step 4: Present all possible burn-in

times (1~24 hours) and correlation ratios to the Model 1 and compute the estimated burn-in cost and failure rate.

Step 5: Obtain the optimal burn-in time by comparing the estimated data obtained in *step 4*, that is, find the time with the smallest estimated burn-in cost and failure rate.

Modifications based on practical considerations

Step 6: Develop a BP network model (Model 2) to obtain the relationship between (burn-in cost, failure rate, correlation ratio) and burn-in time.

Step 7: Obtain the estimated burn-in time by inputting the desired burn-in cost, failure rate and correlation ratio into Model 2.

This project initially identified the base product and the new product to be studied. The base product is the technological core for a product family, and the new product is a modification of the base product. Some kind of relationship exists between the base product and the new product. Since the number of critical components will influence the reliability of a product or module, this project uses the ratio of critical components between the new product and the base product (called correlation ratio) to represent this relationship. Letting the correlation ratio of the base product equal 1, then the correlation ratio for the new product can then be computed.

Previously, burn-in was completed when failure reached an predetermined value or time, and this value or time was always set according to customer or engineer experience. By collecting the required data, however, we can use Model 1 to obtain the estimated burn-in cost and failure rate. Subsequently, comparing these estimated data will reveal the optimal burn-in time. Additionally, to control the burn-in cost and failure rate below a criterion, Model 2 can be used.

四、計劃成果自評

Burn-in is an effective means of screening latent defects in the electronics industry. How to determine an effective burn-in time and burn-cost has concerned manufacturers for quite some time. Although many burn-in models have been developed, none have been practical. Previously, the optimal burn-in time and cost for an electronic product were determined by customer or engineer experience, which was time consuming and expensive. This project presents an effective neural network-based approach to determine optimal burn-in time and cost. The proposed approach can effectively screen out latent defects before a product is shipped to the customer. A case study of the production of rectifier was performed and compared with the statistical approach. According to those results, the proposed procedure yields a very low failure rate after burn-in.

The above research result has been accepted for publication in *International Journal of Quality & Reliability Management* (**ABI**, **EI**).

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