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Effect of Heat on Computer's Processor Failures

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Abstract*— This paper presents the effect of heat on computer's processor speed. There were two types of temperature variation that affect system performance: global temperature variations and local temperature variations. The disparity in power dissipation between active units and inactive units could result in severe hot spots on a chip, creating large temperature variations which could reduce functionality or caused timing failure. The goal of the analysis to understand the failure rate behavior of a particular item, Weibull++standard folio had been used to perform life data analysis. Degradation analysis was useful for tests performed on highly reliable products. This analysis consists of two steps: first, the failure times of the units on test were extrapolated using measurements of their degradation overtime and second, once these failure times were obtained, life data analysis is used to estimate the reliability of the product. Degradation was used to analyze the measurements of a computer processor decreasing performance. Then the failure time plot to compare the failure times that are expected from a design with a specified reliability to the actual failure times that are observed during a test. Data obtained from field failures could provide valuable information about how a product actually performs in the real world. The results indicated that the system will fail if any of the modes occurred and failure rate behavior for each failure mode was known and could been described with a life distribution and parameters. In life data analysis, it was assumed that the components being analyzed were non-repairable; that was. They were either discarded or replaced upon failure. However, for complex systems such as computers will be repaired (not discarded) upon failure. Failures were recurring events in the life of a repairable system, and data from such a system are known as recurrent event data. Weibull++ includes a choice of two methods for analyzing recurrent event data: parametric and non-parametric analysis. Event logs, or maintenance logs, capture information about a piece of equipment's failures and repairs, such as the date/time the equipment failed and the date/time the equipment was restored. This information was useful for helping companies achieve productivity goals by giving insight about the failure modes, frequency of outages, repair duration, uptime/downtime and availability of the equipment.

Index Terms*— Reliability, maintenance, failures, Weibull++, thermal and lifetime.

I. INTRODUCTION

The electronic devices are usually designed using commercial-off-the-shelf components with known cost and reliability. However, some component characteristics, such as the failure rate, exhibit significant, unit-to-unit variability, The LHS method was used by E.P. Zafiropoulos, E.N [1]. Dialyses to simulate the component failure rate distributions and the stochastic nature of the components failure rates was propagated to the system failure rate.

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A. Sittithumwat et al [2] established assuming constant failure rates for the components and was extended to optimization given limited information about equipment condition reasoning using fuzzy sets. G. Cassanelli et al[3] determined methodology is to minimize the deficiencies of the traditional reliability prediction methods calculating a corrective factor using the available field return data Anduin E. Joseph B. Bernstein et al.[4]reviewed and a new failure rate-based SPICE reliability simulation methodology is proposed to address some limitations inherent in the former methods. Both types of simulation are based on the same wear out failure physics but addressing reliability from different perspectives. Soon-Bok Lee and Ilho Kim[5] investigation about the fatigue life of cyclic bending test which showed linear relationship with damage parameters such as inelastic strain and dissipation energy, but the fatigue life acquired from thermal cycling test has non-linear relationship due to the thermal degradation. Touw[6] reduced the number of numeric integrations required for using Bayesian estimation on mixed Weibull situations from five to two, thus making it a more feasible approach to the typical user and also examined the robustness of the Bayesian estimates under a variety of different prior distributions. M. Diatta et al.[7]demonstrated that repetitive ESD stresses on a protection device such as a bidirectional diode induce progressive defects into the silicon bulk. With ''Sirtl etch" failure analysis technique, the defects could be localized quite precisely at the peripheral in/out junctions. The degradation mechanisms during repetitive IEC 61000-4-2 pulses have been investigated on a protection diode with the objective of improving the design for sustaining 1000 pulses at 10 kV level. Govind S. Mudholkar [8] estimated a new model based on the use of data transformation, which was presented for modeling bathtub-shaped hazard rates and parameter estimation methods were studied for this new (transformation) approach Various parametric skewed distributions are widely used to model the time-to-failure (TTF) in the reliability analysis of mechatronic systems, where many items were unobservable due to the high cost of testing [9]. The study of J. Virkki et al. [10] was done with real time measurements; a great number of test channels are required. To circumvent this, they developed a matrix measurement system in which a matrix board which could help test numbers of components and enable statistical analysis of the results. The board could be used for components such as ceramic capacitors. The method suits various reliability tests and facilitates effective comparison of components from different vendors. The large amount of test data made statistical analysis possible [10]. Mansour Aghababaei Jazi et al. [11] proposed a discrete inverse Weibull distribution, which was a discrete version of the continuous inverse Weibull variable and it, was shown that the hazard rate function can attain a unimodal or monotone decreasing shape for certain values of parameters. Software failure data with time was observed by Shaik.Mohammad Rafi et al. [12] and their experimental results indicate that our proposed model fits fairly well compared to other models. Kahadawala Cooray et al [13] modeled reliability data by presented two-parameter family of distribution as an alternative to several known distributions. Thermal effects on processor performance, has been studied, T. Abbas et al [14] compared four methods for Computer cooling to remove the waste heat produced. They observed that Heat sink method have been the optimum. Zheming Zhang and Jingshen Wu [15] used finite element method to calculate the temperature distribution on computer's chip. Their study indicated that the metal migration phenomenon in different solder materials and the cycling thermal loading would be the two key facts to make the crack occur easily. 3-D self-consistent electro thermal technology computer aided design (TCAD) simulations have been studied by Takahashi, N et al and M. Shrivastava et al [16]- [17]. The analytical modeling framework for FinFET self-heating have been developed by Chuan Xu, et al.[18], they also established a platform for building more compact models for circuit-level simulation and analysis. M.-N. Sabry and M. Dessouky [19] presented a model to predict effect of heat and reliability of the downscaling semiconductor chips.Wangkun Jia et al. [20]. Gave an approach for thermal behavior in a semiconductor integrated-circuit structure to capture the peak temperatures in multi-fin Fin FETs.

II. MODELS AND METHODS

To understand the failure rate behavior of a computer 'processor under heat stress. Time to failure data as shown in table 1.

Table 1 failure rate behavior of a computer 'systems

System No.	Time of Failure(hours)
1	26280
2	4320
3	4320
4	61320
5	5760
6	15840
7	26280
8	8760
9	25920
10	2880
11	1344
12	2160
13	720

The study had been dependent on the times-to-failure data by recording the exact times when the processor failed under temperature' stress. At the first the study focused on estimation of MTTF (mean time to failure), MTBF (mean time between failures), and reliability after certain hours and warranty time. Data set was entered; next step was to set up the analysis used to fit a distribution to the data set as follow: Rank Regression on X (RFX), Standard Ranking Method (SRM), Median Ranks (MED) and Fisher Matrix Confidence Bounds (FM). Censored data means data with missing information. When a processor had been failed between observations and the exact time to failure is unknown. Degradation analysis was useful for tests performed on highly reliable processor that. This analysis consists of two steps: first, failure times of the units on test were extrapolated using measurements of their degradation over time. Second, once these failure times were obtained, life data analysis is used to estimate the reliability of the product. This analysis assumed that the measurements would monotonically decrease (or increase) with time. Then, degradation measurements were entered into the folio's data sheet and enter number for the processor's critical degradation. First, need to specify how failure times would be extrapolated from the luminosity measurements. Next, need to specify how the extrapolated failure times will be analyzed. Based on engineering knowledge, select 2P-Weibull from the life data model area. Combining the Test Data for processors: The analysis showed that the failure behavior of processors a follows a 2-parameter Weibull distribution. Reliability Demonstration test design. The reliability demonstration test tool was used to plan a test product's reliability exceeds a specified target. Sometimes, however, tests would be performed just for comparative purposes. The difference Detection Matrix calculates how much test time was required before detects a statistically significant difference in a reliability. The reliability of a product was calculated based on its ability to perform without failure for a specified period of time. The study focused on determination whether it was possible to demonstrate the required reliability with the information provided. Next If not, designs a test for number specimens that will demonstrate that the component meets the required reliability if all specimens pass the test. On the control panel, the analysis settings as follow:2P-Weibull , rank regression on X (RRX), standard ranking method (SRM) and Median Ranks (MED) to analyze the data set . Analysis of the conditions of the failure was determined in the following: what are the modes of failure and in case of any failure to broker certain fails the whole system and the behavior of each failure occurs on the distribution of life parameters. Weibull++ event log folio to convert maintenance logs into times-to-failure data. Analyzes illustrate the impact of repairs on the life of the system equipment. Determine the number of times failure and times repair of each subsystem.

III. RESULTS AND DISCUSSION

MTTF, estimation the average life of the computer' processors, the reliability of the processors after hours of operation and the warranty time for the processors. The results created a new Weibull++ standard folio. Rho (correlation coefficient) and LK (log-likelihood function) were equal (0.976556) and (-137.143075) respectively.

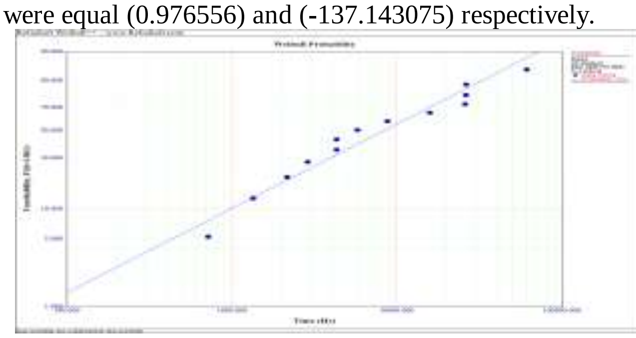

Fig. 1 Weibull probability with the approximate B10%.

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A B10 of approximately 1000 hours means that 10% of the population will be failed by 1000 hours of operation as shown in fig. 1 The reliability and probability had been calculated at 400 hours (95.3891% and4.6109 %.). To estimate the warranty time during which no more than 2% of the processors would fail the result was 153.48 hours. Therefore, with a 90% probability, the true value of the MTTF was estimated to be between 8037and 233223.2155 hours. Then selecting to display the two-sided bounds. The following plot shows the 90% two-sided confidence bounds on the Weibull probability plot showed in fig. 2.

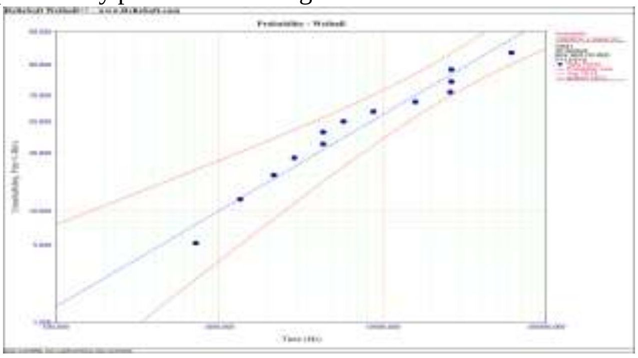

Fig. 2 Two-sided confidence bounds on the Weibull probability.

Fig. 3 showed that first failure had been occurred sometime between 73 and 339, second between 173 and 468, and so on as shown. Based on the expected failure distribution at any time could been observed failure' time early.

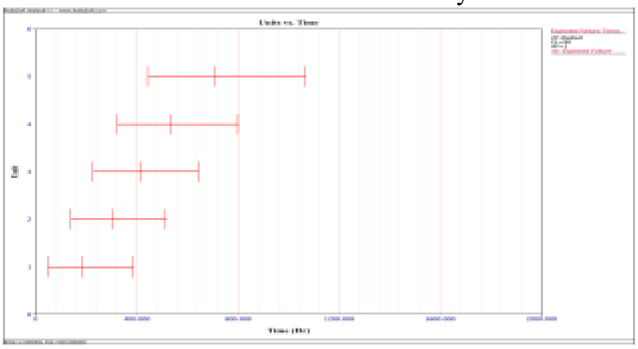

Fig. 3 Expected Failure time.

In figure (4) it has been observed that the first failure actually at 720 hours and so on different than expected failures.

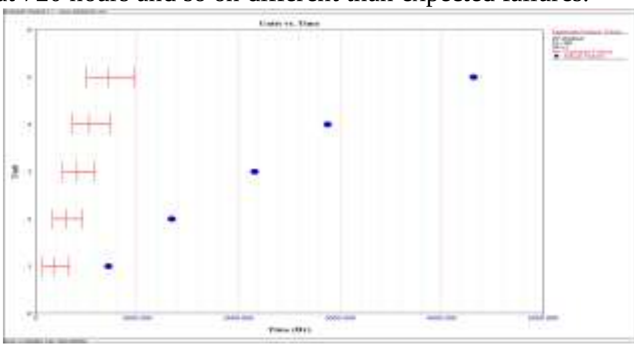

Fig. 4 Comparison between expected and actual failure time.

Test time for given sample size was solved to specify that required test times for sample sizes that range from 500 to 10000, using an increment of 500. This result for the test has been used to calculate metric and life distribution information which has been provided earlier to calculate the test times needed under many different scenarios. It could be reduce the sample size as shown in fig. 5.

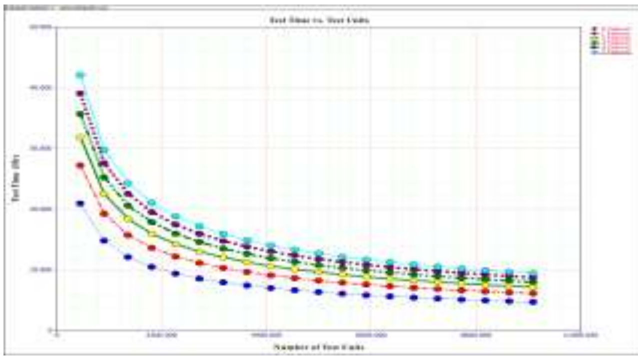

Fig. 5 Number of test units Vs. Test time.

First to specify how failure times will be extrapolated from the luminosity measurements. The failure mode under consideration was metal fatigue under heat stress. Next, need to specify how the extrapolated failure times would have been analyzed. Based on engineering knowledge, 2P-Weibull had been estimated. Degradation fit results shown in fig. 6 to see the parameters of the degradation model that was fitted. MTTF, B10% equal (38.2, 4.026) respectively.

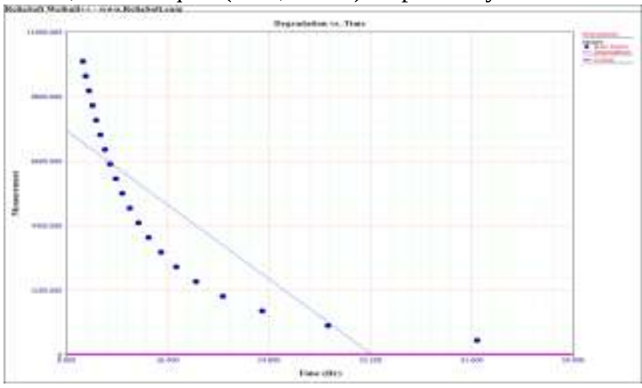

Fig. 6 Degradations' V.s Time

BX% Life to calculate the time by which 10% of the processors would be failed and Reliability to obtain the reliability at 500hours of operation were calculated respectively (500 hours and 91.3%). To determine whether it was possible to demonstrate the required reliability with the information provided. The analysis including 2P-Weibull, Rank Regression on X (RRX), Standard Ranking Method (SRM) and Median Ranks (MED) had been calculated. The results showed the stress distribution was a 2PWeibull distribution with beta = 0.87998 and eta = 12849 as shown in fig. 7.

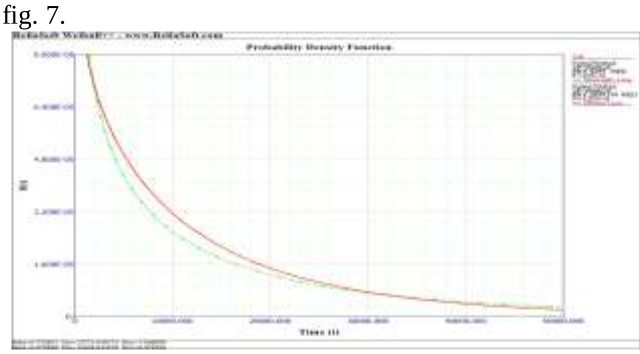

Fig.7 Stress-Strength Distribution

Analysis again using a reliability block diagram (RBD). Fig. 8 showed a diagram the modes connected in a series configuration. This indicates that the product would fail if any of the modes occurred. To

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analyze the diagram and calculate the product's overall reliability. Which was identical to the result you obtained Weibull++ standard folio. Fig. 9, 10 showed reliability and unreliability plots. After performing the CFM analysis again for only modes, mode1 and mode 3, to calculate theB10 life. The result showed 140 hours, which indicated that the product would be likely to meet the requirement if the designers were able to address the mode2 failure mode (best case scenario).

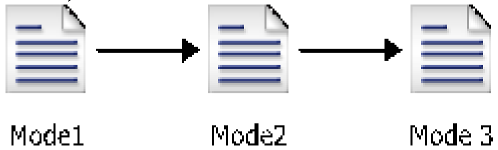

Fig. 8 connected 3 systems in a series configuration

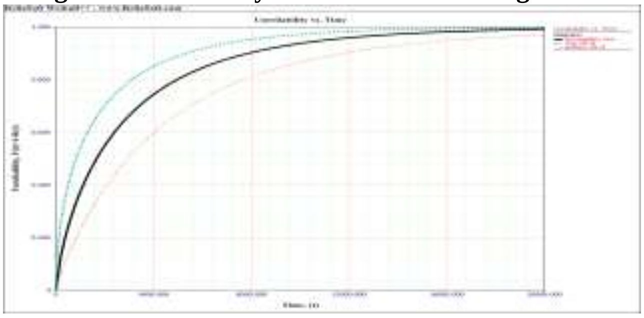

Fig. 9 Reliability for connected 3 systems in a series configuration

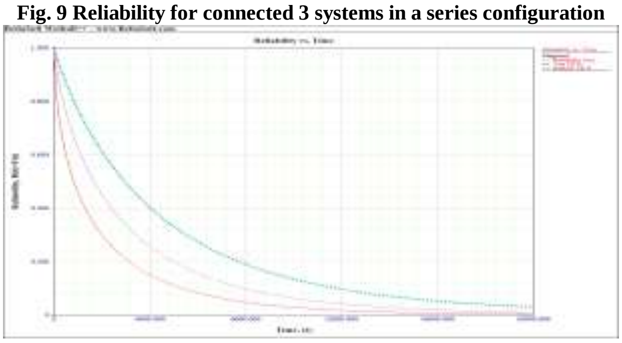

Fig. 10 Unreliability for connected 3 systems in a series configuration

IV. CONCLUSION

The work illustrated failure modes for computer systems. Weibull++standard folio had been used to estimate the warranty time which was near 153.48.By two-sided confidence bounds on the Weibull probability MTTF was estimated. The results of expected failure analysis indicated that first failure had been occurred sometime between 73 and 339 also the predicted failure time different than the actual failure and has been indicated it could be reduce the sample size. Degradation fit results the failure times of the units on test were extrapolated using measurements of their degradation over time. Second, once these failure times are obtained, life data analysis is used to estimate the reliability of the system. Analysis, the required test "time" with stress was estimated to predict the failure time. It concluded that if the CPU is not cooling and the failure modes would be occurred and system temperatures must be viewed within the system BIOS or using a utility to monitor the CPU settings.

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