Aspects Regarding the Monte-Carlo Simulation of Products Reliability

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Abstract: - Reliability is a traditional measure of quality. A reliable product rarely fails. This aspect, which is sometimes reformulated as "being free of deficiencies", it is a very important dimension of quality. This paper presents an approach to evaluate the reliability and unreliability of the industrial products taking into consideration the parameters deviation. This involves using a first order variance analysis as a procedure to determine the overall standard deviation.

Key-Words: - reliability estimation, parameters deviation, improvement.

1 Introduction

The everyday usage term quality of a product is loosely taken to mean its inherent degree of excellence. In industry, this is made more precise by defining quality to be "conformance to requirements at the start of use" [1]. Assuming the product specifications adequately capture customer requirements, the quality level can now be precisely measured by the fraction of units shipped that meet specifications.

The objective of reliability prediction is to support decisions related to the operation and maintenance of the product including to [2]:

- Reduce output penalties including labor costs and outage repair;
- Help in the design of future products, by improved safety margins and reduced failures;
- Increase profitability;
- Optimize maintenance cycles and spares holdings;
- Maintain the effectiveness of equipment through optimized repair actions.

"Quality" is the fundamental enterprises stay in business, training of all staff, the quality of the ceremony and build a reliable system of quality control is consistent two aspects. In the supplier's selection process and finished goods, all aspects of processing, checking, "substandard materials warehousing", "orderly transfer does not fail", the letter, the real operation to ensure the validity of the ISO 9001 quality assurance system [3], [5], [6]. The first step to product quality control is to reflect in the development of products the users' requirements for product quality. After setting the target, we aim at producing the products that are consistently high in quality and can meet the standards that we set. The basic concept is that each process of production is equally important as it plays an important role in product quality control.

One phase from the next is generally a decision milestone, sometimes referred to as a gate. For many products, the phases may be abbreviated or combined. For example, the Concept/Planning and Design/Development phases may be combined under a compressed schedule for a new product that is simply an update or slightly modified version of an older, proven product. Reliability measurement tasks would concentrate only on the differences between the old and the modified product. As a result, the number of engineering tasks would be reduced. It is important to understand that tasks performed in one phase are often the result of the analysis, trade-offs and planning performed in an earlier phase. For example, analytical measurement techniques addressing alternative approaches to the reliability of products would be performed during Design/Development, with reliability testing to measure the results of the process decision following during the Production/Manufacturing phase.

2 Reliability Concepts

Reliability is considered to be a performance attribute that is concerned with the probability of success and frequency of failures, and is defined as: "The probability that an item will perform its

intended function understated conditions, for either a specified interval or over its useful life"[3].
Reliability is a measure of a product's performance that affects both product function and operating and repair costs. Too often performance is thought of only in terms of speed, capacity, range, and other "normal" measures. If, however, a product has such poor reliability that it is seldom available for use, these other performance measures become meaningless. Reliability is also critical to safety and liability issues.
Superficially, measuring reliability is a simple matter. One merely counts failures and divides by operating time to come up with a mean time between failures (MTBF), the most common reliability measure.

2.1 Statistic Process Control

While the need to set targets has been widely discussed in the TQM, benchmarking and re-engineering literature, guidance aimed at helping management report and interpret performance against targets has been fragmented [7]. The three forms are first, the target is a single lower limit; second, the target is a single upper limit; and third, the target is a zone between an upper and a lower limit. The four methods to calculate the level of improvement needed to reach target are the counting, distance, histogram and capability index methods.

For every measured parameter, upper control limit has to be determined. It is used to recognize and react to significant deviations from statistically acceptable limits in product or process reliability.
Upper control level or alert value is statistical value which shows the limit below which deviations are considered statistically acceptable.
In case of exceeded alert limit value, system reliability is considered to be unstable.
Repeated exceeding of the alert value represents a negative trend which has to be stopped by application of appropriate corrective action.
Upper control limit is based on statistical calculation of standard deviation covering recent twelve month period. It should not be placed too high because in that case negative trends would not be shown and opposite, if it is placed too low, because even small deviations from mean values will trigger exceeding.
Upper control limit is established by multiplying standard deviation above mean value with deviation factor (normally between 2 and 3). Deviation factor is defined by operator and it is depending on dispersion of data – smaller factor is more appropriate for large fleets and greater factor is appropriate for small fleets.

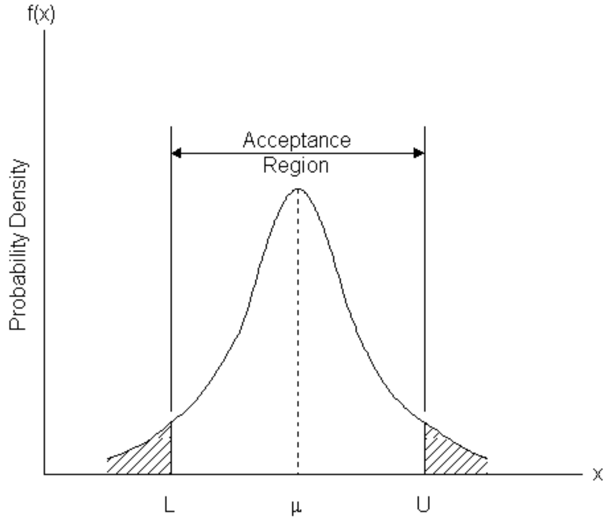

Figure 1. Probability distributions and acceptance regions

Procedure of UCL establishing is [8], [9]:
a) Calculation of standard deviation:

$$\sigma = \sqrt{\frac{\Sigma\left(x^2\right) - \frac{(\Sigma x)^2}{N}}{N-1}} \qquad (1)$$

where: x – monthly value of parameter in observed months; σ – standard deviation; N – number of observed months for which standard deviation is calculated.
b) Calculation of upper control limit – UCL:

$$UCL = \bar{x} + k\sigma \qquad (2)$$

where: $\bar{x} = \Sigma x / N$, k – deviation factor (normally between 2 and 3).
This calculation of upper control limit (UCL) should be repeated every 12 months. Upper control limit can be increased or decreased by maximum 10 % compared to the previous UCL.
This methodology enables analysts to determine whether there is any margin left in the product after calculating its worst-case maximum and minimum performance. It also allows these values to be compared to the product's specified upper and lower tolerance limits, which cannot be exceeded per its design specifications

2.2 Monte-Carlo Simulation

A random variable X is said to be normally distributed if it density function is specified by [5]:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}. \qquad (3)$$

Suppose that:

$$\mu_i = \mu_0 + a \cdot t \ , \tag{4}$$

$$\sigma_i = \sigma_0 + b \cdot t \ , \tag{5}$$

where σ and μ are two parameters that denote the mean and the standard deviation.

Let

$$z = \frac{\Delta - \mu_i}{\sigma_i} \ . \tag{6}$$

Substituting equation 6 in linear variation function we obtain:

$$z(\sigma_0 + b \cdot t) = \Delta - \mu_0 - a \cdot t \ . \tag{7}$$

3 Six Sigma Methodology

Six Sigma has evolved over the last two decades and so has its definition. The term "Sigma" is often used as a scale for levels of "goodness" or quality. Using this scale, "Six Sigma" equates to 3.4 defects per one million opportunities. Therefore, Six Sigma started as a defect reduction effort in manufacturing and was then applied to other business processes for the same purpose.

Six Sigma is a business improvement methodology that focuses an organization on:

- Understanding and managing customer requirements;
- Aligning key business processes to achieve those requirements;
- Utilizing rigorous data analysis to minimize variation in those processes;
- Driving rapid and sustainable improvement to business processes.

When practiced as a management system, Six Sigma is a high performance system for executing business strategy. Six Sigma is a top-down solution to help organizations:

- Align their business strategy to critical improvement efforts;
- Mobilize teams to attack high impact projects;
- Accelerate improved business results;
- Govern efforts to ensure improvements are sustained.

The Six Sigma Management System drives clarity around the business strategy and the metrics that most reflect success with that strategy. It provides the framework to prioritize resources for projects that will improve the metrics, and it leverages leaders who will manage the efforts for rapid, sustainable, and improved business results.

4 Case Studies

The methods used for estimation of products reliability should be those that meet the customer's needs in accordance with the strategy of the organization making the measurements. For this reason, a variety of measurement methods, including test methods and specialized analytical techniques, have been developed.

The case study consists of measuring process of an industrial product dimension. The specified lower limit is 21.9 and the specified upper limit is 12.50.

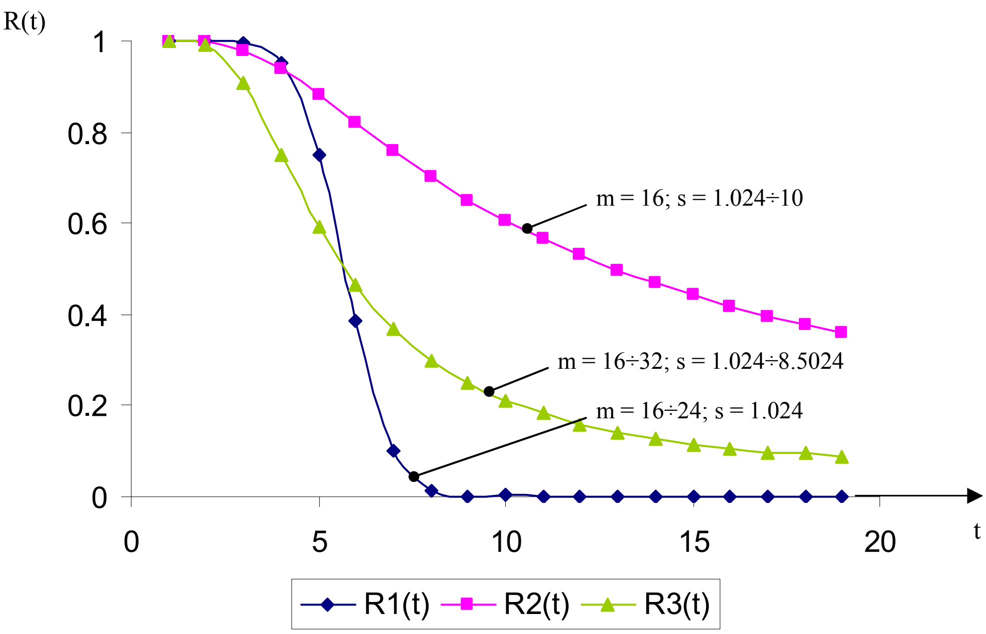

Figure 2. Products reliability function

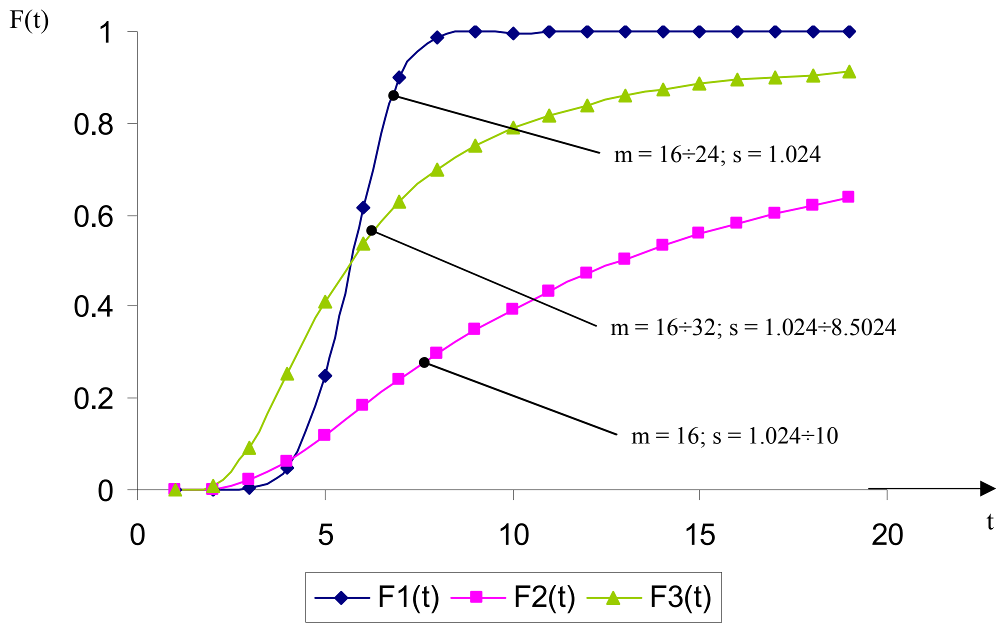

Figure 3. Products unreliability function

The link between parameters deviation and reliability or unreliability of the products analyzed with two specified limits for m ≠ constant and s ≠ constant.
The reliability function for analyzed products it is shown in figure 2.
Figure 3 shows the estimation of the products unreliability function based on the experimental data.
In a worst-case scenario, survival of all parts simultaneously at their maximum drift values ensures survival to any degree of part variation in any combination. Calculating product performance under the worst-case scenario it is not exceeding the specified upper and lower performance tolerance limits, ensures a solid process against part variation.

5 Conclusions

Functions and performance of equipment, the social impact and damages produced by failures are increasing, and high reliability has come to be demanded of products, processes or systems.
The importance of reliability is revealed from the following:
An unreliable product will negatively affect customer satisfaction severely;

- High reliability is a mandatory requirement for customer satisfaction;
- If a product fails to perform its function within the warranty period, the replacement and repair costs will negatively affect profits, as well as gain unwanted negative attention;
- A concentrated effort towards improved reliability shows existing customers that a manufacturer is serious about their product, and committed to customer satisfaction. This type of attitude has a positive impact on future business;
- Resellers may take reliability data and combine it with other cost information to illustrate the cost effectiveness of their products. This life cycle cost analysis can prove that although the initial cost of their product might be higher, the overall lifetime cost is lower than a competitor's because their product requires fewer repairs or less maintenance.

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