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Homework #13 - Design For Six Sigma – Part 2

TECH 50000 - Quality Standards

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Chapter 12

Review Questions

8. Define reliability. Explain the definition thoroughly.

Reliability is formally defined as the probability that a product, piece of equipment, or system performs its intended function for a stated period of time under specified operating conditions. This definition has four important elements: probability, time, performance, and operating conditions. First, reliability is defined as a probability, that is, a value between 0 and 1. Thus, it is a numerical measure with a precise meaning. Expressing reliability in this way provides a valid basis for comparison on different designs for products and systems. The second element of the definition is time. Clearly a device having a reliability of 0.97 for 1,000 hours of operation is inferior to one having the same reliability for 5,000 hours of operation, assuming that the mission of the device is long life. Performance is the third element and refers to the objective for which the product or system was made. The term failure is used when expectations of performance of the intended function are not met. Two types of failures can occur; functional failure at the start of product life due to manufacturing or material defects such as a missing connection or a faulty component, and reliability failure after some period of use. The final component of the reliability definition is operating conditions, which involves the type and amount of usage and the environment in which the product is used.

13. Explain the product life characteristics curve and how it can be used.

The product life characteristics curve is actually the failure rate curve, which is a plot of the cumulative failure over time. The slope of the curve at any point (i.e., the slope of the straight line tangent to the curve) gives the instantaneous failure rate (failures per unit time) at any point in time. These curves can be used to understand patterns of failure rates over time. Knowing the product life characteristics curve for a particular product helps engineers predict behavior and make decisions accordingly.

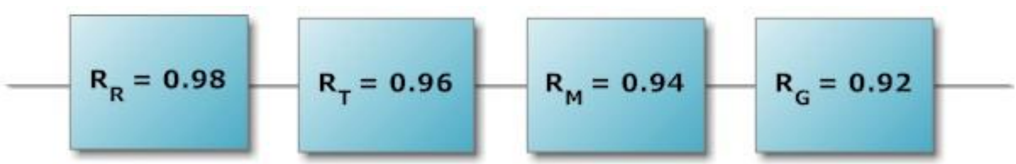
22. What is the difference between accuracy, precision, and reproducibility?

Accuracy is the closeness of agreement between an observed value and an accepted reference value or standard. The lack of accuracy reflects a systematic bias in the measurement such as a gauge out of calibration, worn, or used improperly by the operator. Accuracy is measured as the amount of error in a measurement in proportion to the total size of the measurement. One measurement is more accurate than another if it has a smaller relative error. ***Precision*** is the closeness of agreement between randomly selected individual measurements or results. Precision, therefore, relates to the variance of repeated measurements. A measuring instrument having a low variance is said to be more precise than another having a higher variance. Low precision is the result of random variation that is built into the instrument, such as friction among its parts. This random variation may be the result of a poor design or lack of maintenance. ***Reproducibility*** (also called operator variation) is the variation in the same measuring instrument when it is used by different individuals to measure the same parts and indicates how robust the measuring process is to the operator and environmental conditions. Reproducibility is influenced by the training of the operators in the use of the instrument, clarity of the directions or procedures of the measurement process, calibration of gauges between workers, gauge maintenance, and worker health.

Problems

17. An automated production system consists of three operations: turning, milling, and grinding. Individual parts are transferred from one operation to the next by a robot. Hence, if one machine or the robot fails, the process stops.

a) If the reliabilities of the robot, turning center, milling machine, and grinder are 0.98, 0.96, 0.94, and 0.92, respectively, what is the reliability of the system?

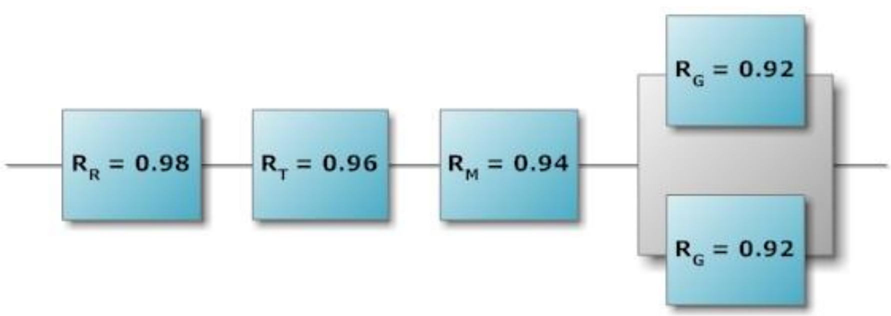


Based on the parallel system series diagram above for the reliabilities of the Robot, Turning Center, Milling Machine, and Grinder; we can compute the reliability of the entire system as follows:

R_S = (0.98) (0.96) (0.94) (0.92) = 0.8136

b) Suppose that two grinders are available and the system does not stop if one fails. What is the reliability of the system?

Because this second scenario involves two grinders, the diagram for the system series of reliability would look as that which follows:



We must first compute the reliability of the parallel subsystem G:

$R_G = 1 - (1 - 0.92)^2 = 0.9936$

The equivalent parallel system is shown below:

Therefore, we can compute the reliability of the entire system as follows:

R_S = (0.98) (0.96) (0.94) (0.9936) = 0.8787

22. A blueprint specification for the thickness of a dishwasher part at Partspalace, Inc., is 0.325 ± 0.025 centimeter (cm). It costs $10 to scrap a part that is outside the specifications. Determine the Taguchi loss function for this situation.

The Taguchi loss function for this situation is as follows:

$L(x) = k(x - T)^2$

$\$10 = k(0.025)^2$

k = 10/ 0.000625 = 16,000

k = 16,000

Therefore,

$L(x) = 16{,}000(x – T)^2$

24. A team was formed to study the dishwasher part described in Prob. 12-22. While continuing to work to find the root cause of scrap, they found a way to reduce the scrap cost to $5 per part.

a) Determine the Taguchi loss function for this situation.

The Taguchi loss function for this situation is as follows:

$L(x) = k(x - T)^2$

$\$5 = k(0.025)^2$

k = 5/ 0.000625 = 8,000

k = 8,000

Therefore,

$L(x) = 8{,}000\ (x – T)^2$

b) If the process deviation from target can be held at 0.015 cm, what is the Taguchi loss?

The Taguchi loss is as follows:

$L(x) = 8{,}000\ (x - T)^2$

$L(0.015) = 8{,}000\ (0.015)^2 = \$1.80$

40. A process has upper and lower tolerance limits of 5.80 and 5.00, respectively. If the customer requires a demonstrated C_p of 2.0, what must the process capability be? If both C_{pu} and C_{pl} must also be 2.0, determine the mean and standard deviation of the process, assuming a normal distribution of output.

σ= 0.0667, $\overline{x} = 5.4$

$$C_p = \frac{\text{UTL} - \text{LTL}}{6\sigma} = \frac{5.80 - 5.00}{6(0.0667)} = \frac{0.8}{0.4002} = 2.0$$

$$C_{pu} = \frac{\text{UTL} - \overline{x}}{3\sigma} = \frac{5.80 - \overline{x}}{3(0.0667)} = \frac{5.80 - 5.4}{3(0.0667)} = \frac{0.4}{0.2001} = 2.0$$

$$C_{pl} = \frac{\overline{x} - \text{LTL}}{3\sigma} = \frac{\overline{x} - 5.00}{3(0.0667)} = \frac{5.4 - 5.00}{3(0.0667)} = \frac{0.4}{0.2001} = 2.0$$