

Design for Reliability-Shibshankar Dey

Requisiteness of Reliability of Product

There are a number of reasons why reliability is an essential attribute of a product.

Reputation

A company's reputation is very closely attached to the reliability of its products it produces. The more reliable a product is, the more likely the company is to have a good reputation.

Customer satisfaction

A reliable product may not drastically affect customer satisfaction in a positive manner. However, an unreliable product will definitely attract customer dissatisfaction. Thus high reliability is a quite essential requirement for customer satisfaction.

Warranty Costs

If a product fails to perform its desired function within the warranty period, the replacement and repair costs will not only reduce the profits, but also gain unwanted negative attention.

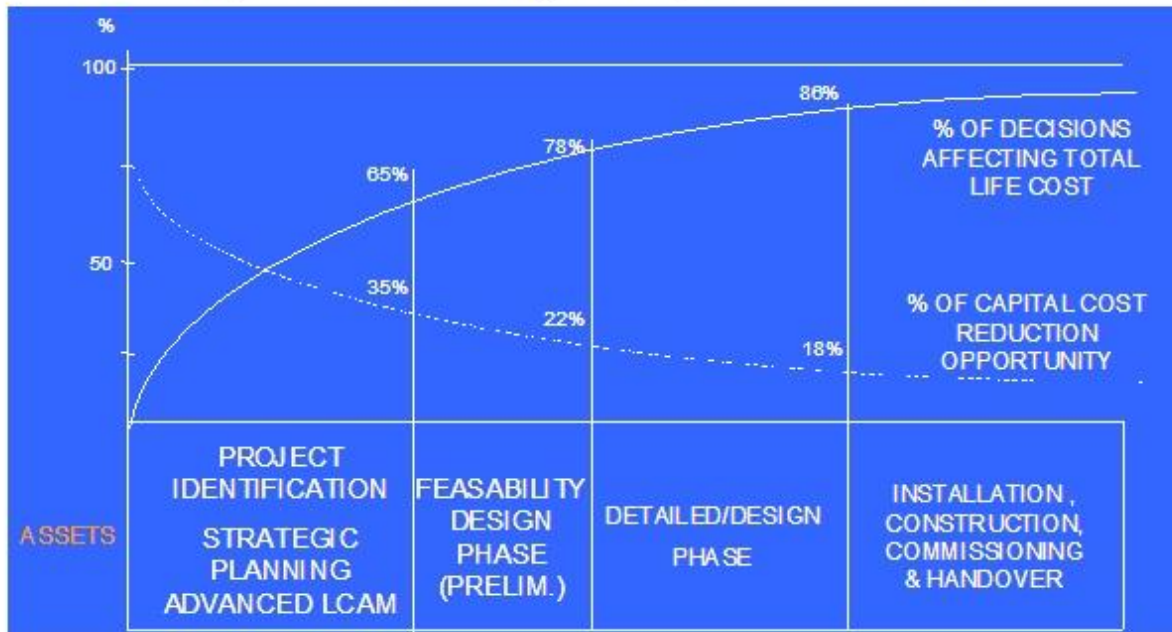
Repeat business

A focused effort towards improved reliability shows existing customers that a manufacturer is serious about its product, and committed to customer satisfaction. This type of attitude not only has a positive impact on future business but also gives a competitive edge.

Cost Analysis

Companies 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 a product might be higher than those of its competitor's product, the overall lifetime cost is lower than that of a competitor's because their product requires fewer repairs or less maintenance.

Figure 3 → Times of Opportunity for Cost Reduction



Customer requirements

Demand from customers for an effective reliability program is ever increasing based on the benefits of such programs.

Competitive advantage

Companies often publish the product reliability numbers to enhance competitiveness.

Design for Reliability

Design for reliability is a process which is performed during the design of the product so as to ensure that the product is able to perform to a required level of reliability. Traditionally, the reliability achieved is the outcome of

- the reliability that naturally accompanies with the design required for the product, and
- the reliability that come due to standard and historic practices followed by the design and manufacturing units. (like using standard well established components in critical areas)

The demand to achieve desired performance level in an efficient and optimized manner has led to a growing movement towards increasing applications of *design for reliability* and its spread to industries where it had not been used in the past. Previously design practices tend to focus on mainly on *functionality* and *robustness* or product integrity. In developing the design for the

products, the following characteristics are usually missed: - (a) key failure modes and failure rate of the product, (b) key failure mechanisms that may be present in the service environment, (c) usable life of the product, (d) cost of maintenance required to maintain the inherent reliability, (e) availability, and (f) rigorous testing.

As to address all of the above issues, the process of *design for reliability* has been developed to ensure a predictable and reliable life of usual components. Some of the key elements for *design for reliability* is as follows.

Concurrent Engineering

Concurrent engineering is a feature that ensures the design is not completed before reliability requirements are identified and dealt with.

Configuration Design

The physical configuration is the key important characteristic that determines the reliability of an asset. Depending on the severity of the product service and the maximum economic reliability of available components present in the product, it may be necessary to build redundancy into some locations.

Component Selection

The second important characteristic that determines reliability is the choice of components that make the product. Components with better load bearing ability rather than cheap components should be considered as better option.

Design and Build

It is possible to create a strong configuration and select robust components, and still produce a product that is unreliable. There are design and assembly practices like use of protective grommets at points of wear, use of strain relief at bends, or changes in direction that ensure the configuration and components deliver the desired reliability.

Verification and Performance Testing

The final assembled product may not always perform as expected. Interactions between dynamic components can produce unexpected effects. As a result, it is necessary to verify that the assembled product functions as expected. It is also essential to simulate the wear and tear that represents an entire life using accelerated testing.

Customer Needs

The product must be designed not only based on functionality but also considering the customer needs.

Steps to ensure Design for Reliability

The activities towards *design for reliability* for a component should be spread over from the *conceptual design, embodiment design, detail design, actual production* and *service*. For example, the *design for reliability* activities in the *conceptual, embodiment and detail design* stages involves

- (a) the integration of the estimation of reliability requirement and the determination of likely service environment in the problem definition,
- (b) investigation of redundancy and ensuring provision for accessibility for maintenance during configuration design,
- (c) selection of reliable parts and components, establishment of failure modes and effects, estimations of likely failure rate and mean time between failures,
- (d) building and testing of prototypes, and so on.

Similar activities in the *production* and *service* stages involve environment tests and checking for quality assurance, collecting feedbacks on service failures and customers' comments, ensuring proper replacement of parts, etc.

The overall process starts with the conceptual design to identify the problem or objective, to estimate the required level of reliability, and to carefully understand and consider all the factors that make up the service environment. In the configuration design step of embodiment design the physical arrangements of the various components present in the product are to be determined as it critically affects the reliability. Also, various redundancies are tested and it should be ensured that the physical arrangement is good enough to allow access for maintenance. In the parametric step of embodiment design, the selected components are to be tested for their reliability. Both physical and computer models should be tested and subjected to the widest range of service environmental conditions and various failure modes must be established. During detail design the final specifications are finalized for manufacturing and testing the preproduction prototype and the final production designs are prepared. The work of the design department is not finished even after the designs are released to the production department. The production models are given further environmental tests and these help to determine the quality assurance program and the maintenance

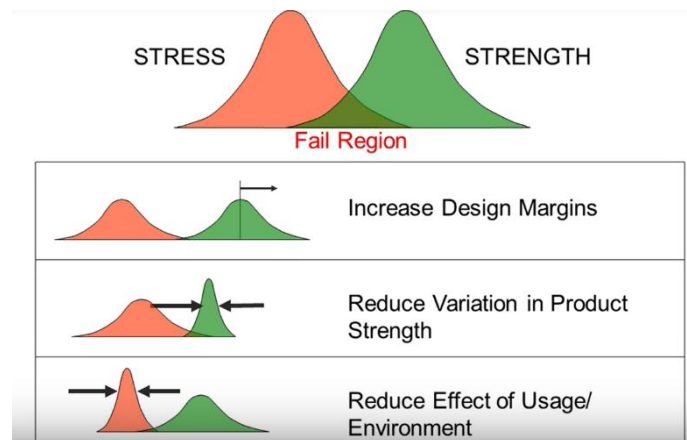
schedule. Once the product is put to service there is a constant feedback related to field failures and *mean time between failures* that help the design department to redesign efforts and follow-on products.

Ways to improve Reliability by design

Various techniques are used by the design team to improve reliability. The work of the design department is not finished even after the designs are released to

Reducing variability

Mechanical properties of engineering material exhibit variability. Fracture and fatigue properties show greater variability than the yield strength and the tensile strength. Conservative design values of material properties are essential so as to obtain design of a reliable product. Variability in the material property had a huge impact on the probability of the failure of product hence affecting the reliability of the product too. The probability of failure can be reduced if without changing the mean value of the material properties if we could reduce the variability in the properties.



Derating

The reliability of the product can be increased if their maximum operating conditions (temperature, pressure, etc) are at values lower than their nameplate values. This reduces the probability of failure and increases the reliability of the product.

Redundancy

One of the most efficient ways to increase reliability is with redundancy. Components that are critical are duplicated such that two or more of them may exist in parallel to perform the same function within the product thus increasing the reliability of the product. The existence of parallel paths results in load sharing and each duplicate component is derated and has its life increased by a longer than the average time. Another way to increase the redundancy is by having a standby unit that cuts in and takes over when the current operating unit fails. The unit should be provided by sensors and switching mechanisms to sense the failure and to place the unit in service. The sensors and the switching mechanisms are the weak links in a standby redundant system

Durability

The material selection and the design details should be finalized with the objective of producing a product that is resistant to degradation from factors like corrosion, erosion, fatigue, wear, etc. This usually requires selection of high performance material which can be expensive so as to increase service life and reduce the maintenance cost. Such decisions can be justified by using techniques like **life cycle costing** and so on.

Ease of inspection

It is very essential that cracks or any other flaws are identified when they occur in the product. Ideally it should be possible to perform various visual methods for detections of such cracks or other flaws, but special design features may have to be provided in order to ensure this. The product should be designed in such a way that it is capable for ready inspection.

Simplicity

Simplification of the component and the product reduces the chances for failure and errors and increases the reliability.

Specificity

The greater the level of specificity, the higher will be the inherent reliability of the design. Specifying standard components for the product increases the reliability. It means the component being used has a history and their reliability is known.

Replacement

Whenever it is required to use components with high failure rates the design should specifically take care for the ease of replacement of such component.