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Backward design and cross-functional design management

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Abstract

This study establishes a framework for backward design analyses and cross-functional performance management system to achieve product design for excellence. The authors define backward design as opposed to regular forward design. A cross-functional viewpoint emphasizing downstream knowledge and lessons learned is introduced for proactive product design management. The study proposes several approaches for backward design endeavors, including Extended Failure Mode and Effect Analysis (EFMEA), Attributes Function Deployment (AFD), Feedback Tracking and Analysis System (FeTAS), Fuzzy Decision Tree, etc. Based on the backward design concerns, a cross-functional design management system is then established to serve as an incentive system for designer to incorporate cross-functional concerns.

The contributions include: (1) Proposing backward design mechanisms; (2) Establishing a cross-functional design management system which is conducive to design for excellence.

Keywords: Design for excellence; Backward design; Cross-functional design management; Design for manufacturing; Design management

1. Introduction

A typical product life cycle, among others, includes the marketing function to collect user requirements; the design function to design the product; the manufacturing function to make the product; and the logistics function to move the product through the distribution channels onto the end users. Of the many functions involved in the realization and usage of the products, product design is at the center. Since all functions are impacted by the appropriateness of the product design. It is known that many manufacturing problems and inefficiencies came from designers' ignorance of manufacturing constraints. As such, the term Design for Manufacturing (DFM) was established to stress the importance of early consideration of manufacturing issues in the design stage. The same idea applies to other functions that are impacted by the design stage. The term DFX (Design for X) has been coined, where X stands for any aspect that is impacted by the design function. Another interpretation for DFX is Design for eXcellence. When all aspects are considered in the design, the design would be excellent.

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This study proposes a backward design framework as a part of an integrated DFX framework. The backward design framework will allow cross-functional performance management toward significant cross-region, cross-departments (such as manufacturing, procurement, sales/market, etc.), cross-companies, and cross-viewpoints (such as cost, quality, etc.) to enable speedy product development, flexibility, and cost optimization.

2. Background and previous work

As early as in the 1960s, several companies in America developed manufacturing guidelines, such as the *Manufacturing Producibility Handbook*, for the product design stage. The book was published in 1960 for internal use by General Electric Corp. In late 1970s, Boothroyd and Dewhurst (1983, 1986, 1994) conducted a series of studies on design for assembly (DFA), which considered the assembly constraints during the design stages. Expanding from DFA, Stoll (1988) developed the concept of design for manufacturing (DFM) to simultaneously consider all the design goals and constraints for the products that will be manufactured. O'Driscoll (2002) provided a DFM flowchart framework to help designers implement DFM practices. The implementation of DFA and DFM had enormous impacts including simplification of manufacturing process; reduction of design, purchasing and manufacturing costs; improvement of quality; and speeding of time-to-market (Corbett, 1987). It can also support speedy and stable introduction of new products with flexibility.

More recently, for environmental, quality, maintainability, reliability, and supply chain management issues, researchers have focused their attentions on design for environment (Fiksel & Wapman, 1994; Leonard, 1991), recyclability (Henstock, 1988), life-cycle (Alting, 1991; Ishii, Adler, & Barkan, 1988; Ishii, Lee, & Eubanks, 1995), assembly and dis-assembly (Boothroyd & Alting, 1992; Jovane et al., 1993), etc. These studies can be referred to as Design for X (DFX).

Based on multiple years of performance benchmarking of notebook computer companies in Taiwan (Sheu & Chen, 2003, 2004a, 2004b), the authors compiled a list, as shown in Table 1, of common other-than-design operational problems or inefficiencies which were due to designers' failure to consider other-than-design issues during the design stage.

Among other reasons, the authors attributed common causes for these design-related problems and inefficiencies as described below:

(1) Multiple DFXs and their conflicts. Although DFX literature is widely available in the past, most studies had concentrated on one specific "X" topic such as DFM, DFC, DFE, etc., they did not consider simultaneously for multiple "X" considerations. In reality, requests from different Xs commonly have conflicts. For example, cost considerations often conflict with quality constraints; environmental requests may create manufacturing difficulties, etc. It is important to have a mechanism allowing simultaneous consideration of multiple "X", providing easy identifications of conflicts, and facilitating some sort of conflict resolution for an overall best design.
(2) Designers' ignorance of other-than-design processes/problems. Designers usually are not familiar with detail operations of the downstream functions. As such, the designers' ability to identify and address the constraints presented by the downstream functions is limited.
(3) R&D initiation of DFX endeavors. Traditional DFXs are usually initiated by R&D department. The down stream functions may have less influence on the priorities of the problems. The main concerns of the downstream functions may not be given high priority by the designers.
(4) No incentives for designer to concern over problems encountered by other-than-design functions. Design-introduced problems and pains usually occur at downstream stages of the product realization cycle, so, there are no intimate pains felt by the designers. There is no incentive for designers to apply priority on others' pains.
(5) Cross-functional mentality issues. Often, R&D staff members are more senior or with higher educational background compared to those of other-than-design functions. As such, R&D engineers often take special pride in their work considering their function superior to other functions such as manufacturing, procurement, etc. In addition, designers may consider DFX as favors to other-than-design functions.