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Design for Quality Throughout the Total Product Life

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ABSTRACT

Product quality is far more than "fitness for use" and robustness in the manufacturing process. This paper discusses the phenomena of product quality in the entire product life. It presents a total life model which serves several purposes, such as expanding the design teams' understanding of quality and adding structure to total life scenarios in the specification phase.

KEYWORDS: Design for quality (DFQ); Life cycle analysis (LCA); Quality in design; Total Quality management (TQM); Scenario techniques.

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Product quality is far more than "fitness for use" and robustness in the manufacturing process. This paper discusses the phenomena of product quality in the entire product life. It presents a total life model which serves several purposes, such as expanding the design teams' understanding of quality and adding structure to total life scenarios in the specification phase.

1. INTRODUCTION

"Quality" is the buzz word of today in industry and the service trade and in any forum of researchers and scientists who want to sell their ideas to the industrial environment. Even though a new buzz word will probably soon show up, for instance "Environmental Awareness: The Green Company", the author insists on the fact that quality should be the most important objective in any company that wants to survive in the future marketplace. Quality is the main driver of business success. This has been demonstrated for instance by the PIMS studies (see Buzzel and Gale, 1987) and by the so called Japanese Quality Revolution which have given the Japanese a major competitive lead. While Western companies are trying eagerly to close this gap with various approaches, the Japanese now focus on product development and design because these functions have major influence on product quality as perceived by the customer and on quality (i.e. conformance) in production. Similarly, in our research we concentrate on Design for Quality (DFQ). We see methodical design as a prerequisite for quality in the design process and for successful incorporation of various quality techniques in design (e.g. QFD, FTA, FMEA) (see Cooper and Kleinschmidt, 1987; Womack, Jones and Roos, 1990).

The aim of our research is first of all to develop terminology and models to explain the phenomena of quality in design and finally to suggest tools and procedures for designing products that fulfill the quality expectations of the customers and the company. This paper focuses on modeling the phenomena of quality in all life phases of the product, and it presents useful applications of total life models.

2. CUSTOMERS EXPECT QUALITY IN ALL INTERACTIONS WITH THE COMPANY

The times are past when the relationship between a company and its customers was only a matter of advertisement and the exchange of products for money, where quality primarily meant conformance in production, secondarily adding features and stylishness to the products. Today, strong competition in open markets, powerful consumer and environmentalist groups, relentless product liability laws and media have lead to a new situation - the customers evaluate companies on a multitude of factors, apart from the product itself. The customers expect quality in all interactions with the company; the company is responsible for any action or omission at any time in its existence. A further discussion of quality in this broad sense is beyond the scope of this paper, however, we must understand that "with the ultimate aim of winning the customer, product objectives and subsequent evaluations should be closely guided by a sound understanding of customers' perceptions of quality and value" (see Kaper and Harris, 1992).

According to Porter (see Porter, 1985) companies can achieve competitive advantages by using knowledge about customers' value chains, i.e. the challenge for the company is to increase the performance of or lower the costs for the customers when they use, and in other ways interact, with the product. Porter says, that "[...] the value a firm creates for its buyer is determined by the whole array of links between the firm's value chain and its buyer's value chain. [...] Heavy trucks offer a useful example of multiple links. A heavy truck directly influences its buyer's logistical costs - a function of the truck's
carrying capacity, ease of loading and unloading, fuel costs, and maintenance costs. [...] The truck may contribute product quality through the amount of shaking it subjects the cargo to, as well as the temperature and humidity conditions in transit. The truck may also affect the buyer’s packaging costs, a function of the protection required to avoid damage. Finally, the truck may incrementally affect brand identity through its appearance and the visibility of the logo painted on the side.

Figure 1. Customer perceived quality “Q” has many dimensions.
3. QUALITY "Q" HAS MANY DIMENSIONS

DFQ requires knowledge about how the customer perceives quality in all life situations of the product and what the product's role in these quality experiences can be. We have chosen to disseminate this knowledge via a general total life model shown in Figure 1, followed by some examples:

**Design**

BMW advertise that they used Failure Mode and Effects Analysis and Finite Element Method in the designing of a new car. We must expect these design tools to be irrelevant to customers, nevertheless BMW tries to win the customers' confidence and build expectations to the car. The design process is made a quality.

**Production**

Like BMW, Fiat tries to convince customers that the highly automated production of the "Fire" motor leads to quality in the final product. Manufacturing technology is made a quality.

**Advertisement**

Very competitive or fashion-governed markets often require a constant offer of new product features even though these may not be of much practical use to the customer. However, in advertisement the "gimmicks" become powerful success factors, because there are customers to whom "the newest" is a quality in itself. For example, the design of skiing equipment is dictated primarily by how the equipment looks and what features it has. In addition to the purely functional properties the product must have certain qualities in the advertising and sales situation.

**Distribution**

When the Danish company Gerni developed a small high pressure cleaner, the design team optimized the product and its packaging to a standard pallet size. Compared to the market norm the result was drastic reduced volume, perceived as a quality by the external "customers": distribution; stores; sales; and even end-users.

**Sales**

The Danish company Ernitec put great emphasis on the industrial design of the lens casing when they developed a new line of motorized lenses for surveillance cameras, even though they are not visible when in use since the housing covers the casing. However, the lens design supported the perception of quality during the sales situation and gave a competitive advantage.

**Service**

The designer may choose standard components for parts that are exposed to heavy wear or deterioration, so that repairs are inexpensive and reliable.

**Disposal**

Opel cars are advertised as being designed and manufactured in such a way that they can be dismantled into separate categories of materials and then recycled, if future disposal systems are developed accordingly. Environmental awareness has become a quality.

Note that the quality cannot be attached solely to the product or to the user but arises from the interaction between the two in every product life phase.

4. DFQ HAS OTHER OBJECTIVES THAN SATISFYING THE CUSTOMER

The primary objective for DFQ procedures, techniques and organization is to support product development and design in building in product quality to the customer, thus contributing to external efficiency. However, this objective must be balanced with strong considerations for contribution of the product to the cost aspects of quality in order to make business. To avoid an untenable mixing of concepts belonging to each of the two areas of interest, we have found it compulsory to make a clear distinction between two types of product quality (see Mørup, 1991, 1992):

Q: "Big Q" stands for quality, and describes only those product properties which are experienced by the customer/user.

q: "Little q" stands for quality efficiency and is indicated for instance by cost of quality control, scrap, and rework.

After having examined the customers' interest in the product life phases, let us now look at the quality connections
efficiency "q" as experienced by the internal stakeholders of the company.

5. QUALITY EFFICIENCY "Q" IN ALL LIFE PHASES

Porter (1985) states that the quality contributions of company activities, especially design, cannot be determined or understood by looking at each activity in isolation. An activity is frequently affected by how other activities are performed. There are "relationships between the way one value activity is performed and the cost or performance of another. For example, purchasing high-quality, precut steel sheets can simplify manufacturing and reduce scrap" (see Porter). Olesen (1992) has introduced the term "dispositions" defined as "that part of a decision taken within one functional area [of a company] which affects the type, content, efficiency or progress of activities within other functional areas."

In product development not only the product is designed. Also those systems that are required to handle the product during its entire life are developed (or renewed) to some extent, as shown in Figure 2. While Concurrent Engineering and Simultaneous Engineering literature traditionally only describes the simultaneous development of products and production systems, the theory of dispositions also models simultaneous development in general, i.e. of the logistics, the transportation, the service, and the disposal systems. Seen from a DFQ viewpoint the theory of dispositions is indispensable because it can reveal how interdependencies between different company activities can affect quality "Q" and quality efficiency "q". Dispositional knowledge has earlier lead to the formulation DFMA principles that show how different product parameters affect manufacture and assembly. We hope to be able to formulate similar DFQ principles.

Figure 3 and the following selected examples focus on the product's and hence the design process' influence on the quality efficiency of other company activities.

Design

Xerox has found that the re-useability of designs - parts, modules, code, etc. is a very significant way of increasing the velocity and decreasing the risk of the design process and of production (see Holmes, 1993). Early re-use can increase the quality efficiency in later phases.

Quality control

By adding extra material to the edge of a drop forged component a Danfoss engineer made it easier to check if there was enough material to make a complete component. A subsequent turning process removed the extra material anyway, and the efficiency of the quality control process was improved.

Logistics, distribution and sales

The new series of welding machines of the Danish company Migatronic are highly modularized; for
Figure 3. Quality efficiency "q" has many dimensions. Internally, quality is not only a question of product/manufacturer relationships but a matter of "q" in all activities.
instance, all models are based on the same power supply module, but in different numbers depending on the choice of welding current (see Fabricius, 1993). This leads to increased quality "Q" because delivery time for customized welding machines has been reduced from several weeks to only a few days. The prime advantage is found internally because quality efficiency "q" in delivering the product has been increased dramatically.

Disposal

When BMW switched to a more ozone-friendly refrigerant in their air conditioners the designers not only redesigned the air conditioning systems but also established procedures for recovering, recycling, and recharging the new refrigerant.

Note that the distinction between what is "Q" and what is "q" can be difficult to illustrate in general models as Figures 1 and 3. For example, to a supplier of refrigerator compressors "ease of assembly" in the customers' assembly line must be considered a competitive advantage and thus a quality "Q". However, in the assembly line of the customer "ease of assembly" supports his quality efficiency "q".

6. APPLICATIONS OF TOTAL LIFE MODELS

Total life models can be expanded and detailed in many dimensions, and we see several areas of application. Below two such areas are elaborated.

6.1 IMPROVING THE PRODUCT DEVELOPER'S QUALITY MIND-SET

At the WDK workshop "Design for Quality" in Copenhagen in August 1992 (see Hubka, 1992; Mørup, 1992) participating design managers from industry expressed a major concern — in general, design engineers have very different and diffuse conceptions of quality and no real method or proficiency in building in quality. As consultants to Danish industry we have also observed that design engineers have a very fragmented picture of what quality is all about. This is true even in larger companies that claim to follow Total Quality Management and the "Voice of the Customer" as the guiding principle for all activities. The awareness of customer perceived quality seems to come in third in priority among the worries of a design engineer: 1) will the product work in a technical sense; 2) can the product be manufactured in conformance with specification and within cost limits; and 3) will the customers buy this product? Design engineers focus on the technology inside the product and the individual designer loses the conception of what lies in the word "product". He sees the product only as a technical challenge, a carrier of functions and not as integral part of a system of different users, working environments, life phases, and even society.

The total life models (Figure 1 and 3) together with more detailed models of product quality (see Hubka; Mørup, 1992) have helped us in conveying a wider quality mindset to students so that they can understand the many impacts of their products. As a supplement to traditional specifications, this mindset is extremely important for the designer who synthesizes new solutions in the design process. B.L. Whorf wrote, "language shapes the way we think and determines what we can think about."

6.2 SPECIFYING THROUGH PRODUCT LIFE SCENARIOS

Total life models are useful in the early specification phase of new products when analyzing existing products and preparing scenarios for new product/customer relationships (see Peter and Olson, 1990). A product development team can reach a common understanding of all product life aspects, discuss high-level trade-offs within and between "Q" and "q" considerations, and come to agreement on overall objectives and strategies for the later, more rigorous stages of the product specification phase. Here, the total life scenarios can be used as input to, for instance, the first matrix of the Quality Function Deployment method.

Total life models are useful in cross-functional teams for rational communication between technical and non-technical people in the early project phase. Taking the differences in design team member's backgrounds into account we have formulated opened-ended models that inspire creativity rather than the rigor of typical checklists.

7. CONCLUSIONS

Different functional areas involved in product development often have limited and conflicting concepts of quality. We see unrealistic aspirations from marketing and inexpedient focus on technology by design engineers. These problems can be avoided by using total life models that show the interplay between the product, the customers, and company
activities through the product's life. Finally, total life models can reveal the dispositional relationships within the company that are often subtle and go unrecognized and the exploration of these can lead to competitive advantage.

REFERENCES


