INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

THE ASSESSMENT OF QUALITY IN DESIGN STAGES

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Keywords: design for quality, design for x, life cycle analysis, quality measure, design for six sigma

1. Introduction

In recent decades the importance of Quality has become more and more important in the industrial world as well as in social life. This has come about thanks to the awareness that Quality, understood as "Total Quality", which permeates every aspect of the company, is a complex property of a product and is by now seen as an imperative not only in order to be more competitive and to guarantee an orderly development of production, but also to ensure a total compliance of the expectations and of the needs of users and customers.

This new approach to Quality, as can be clearly seen in the most recent studies in the field, assigns the designer a fundamental role: in fact, it has been shown that acting in the first stages of the design and development process it is possible to guarantee not only their optimization from a performance point of view, but also to become more market competitive, drastically reducing the cost of successive modifications and corrections. Indeed, evaluating the ability of a product to satisfy in an efficient and appropriate way certain requisites before putting it on the market has become a fundamental point in design and development activities of successful products. The need to evaluate product Quality before deciding its production has become more and more important both because of expenditure of the resources which its introduction on the market requires, and for the influence that it can have on the "image" of the company.

The aim of the research is an attempt to find the right trend to follow to integrate Design Methodologies and the developed Quality Indicators within a proper "Assessment Procedure": such an approach allow us to define exactly the way to meet both customer needs and technical requisites in order to improve products' Quality, and also assure an optimal compliance with the recent evolutions of Quality standards in Industry (in particular: ISO 9000, QS 9000, Six Sigma).

2. Scientific Background

Nowadays, the term "Quality" ascribed to a certain product is used with very different meanings: in fact, sometimes a product is considered to have a better quality if it is ascertained as more durable, while on the other hand Quality is often misunderstood with the high or low level of performance obtainable from a product; in many other cases the fulfilment of aesthetical properties affects in a rather considerable manner the usual evaluation of a product, leaving the objectives out of consideration.

Moreover, depending on who is assessing the quality level of a product (designers, producers, customers, sellers, etc.) the aspects underlined are sometimes in conflict with one another, so that defining the exact meaning of "product Quality" as well as finding a certain set of assessment criteria

is surely a difficult task for the designers: in fact, traditional design concepts have to be balanced (performances, price, safety) and simultaneously adapted to the producers bottom line.
In such a context, the primary importance of design activities in improving quality level of products has been detected by many Authors, who have studied this problem in depth in order to point out the fundamental relationship between Quality, Cost and Time.

3. Methodology

Results of an intensive research started in 2002, which has been carried out with the support of the research department of “Safety Technologies” of ISPESL, concerning the Design for Quality and Reliability of Products and their evaluation in design stages, show that there are certainly good examples of design approaches and methodologies which take into account the above mentioned aspects.
Although they all represent important advances towards the field of “Design for Quality”, they are disconnected from each other, or focused only on solving a particular problem, or concerning a particular characteristic/aspect of the product.
Moreover, it is necessary to underline that the great variety and peculiarity which distinguish one product from another make the problem particularly complex.
It is clear, then, that the main difficulties to be solved do not concern the absence of design tools at the designer’s disposal, but mainly regard both the lack of instructions or guidelines which can lead the design team towards the right choice of such tools, and the ineffective and often incorrect use of the selected methods or techniques by most designers.
The wide development of new tools and methodologies of the last few years is an index of the great attention given to Design and of the acknowledgement of the important role performed within the burdens of product Quality.
On the other hand it is clear the need to organize the use of such tools in order to improve their choice and implementation. In particular, since Quality ought to be considered as a product property, not as an elementary property, but as a “complex” one, it is clear that every necessary action to evaluate Quality level of any product strictly depends on the assessment of its “external properties” which in a more or less direct way influence product Quality.
The assessment of such properties both allows the designers to develop a measure of the product’s Quality level, and at the same time shows which characteristics have to be modified in order to obtain an improvement of the whole product’s quality; i.e. :

- Aesthetics
- Assembly
- Disassembly
- Environmental Impact
- Ergonomics
- Functionality
- Maintainability
- Performances
- Packaging
- Recycling
- Reliability
- Safety

Usually all these properties are not of the same relevance to Quality: some of them ought to be considered as more important than others and the designer has to pay specific attention to them.

3.1 The measure of Quality

In order to state criteria which can allow us to the measure and assess the products’ Quality, it was possible, through a detailed study of the above mentioned properties, to define both a series of parameters aimed at the evaluation of each one of them (“sensors” or “evaluation indicators”, in order to find out in a quantitative way the value of each characteristic), such indicators also regard the cost evaluation, as well as the assessment of customer needs/demands. In particular, each one of these indicators is characterized by the following aspects:

Table 1. "Indicators" Characteristics

Simple	*comprehensible, easy to apply, not expensive (time and resources)*
Reliable	*results have to be easy to reproduce*
Meaningful	*entirely represent the measured aspects*
Easy to review	*easy to improve and implement*

In this way, a "Sensorial Pyramid" for the assessment and control of the products' Quality, which also considers links among all the properties, was defined. In Figure 1 a scheme of the above mentioned Pyramid is shown.

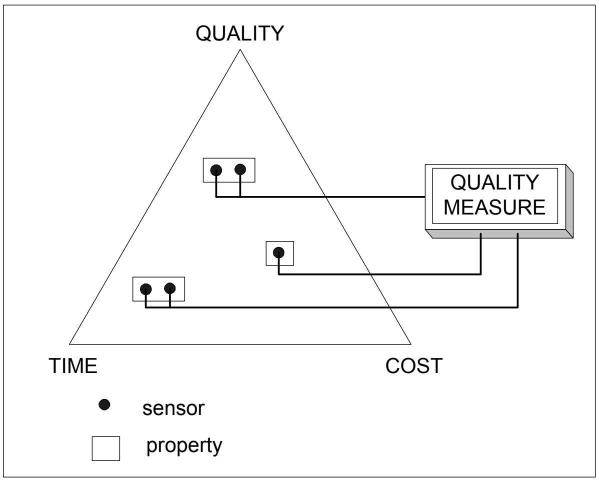


Figure 1. The "sensorial Pyramid"

The Pyramid represents the whole parameter which we want to measure: the rectangles represent properties which influence such a parameter; sensors (or "indicators") collect the effective property levels of the product's design and make up a "control net" through which designers can estimate positive or negative aspects of the design, as well as choose the optimal solution among different alternatives.

3.2 The measure tool

On the basis of the criteria exposed, for each one of the above mentioned properties, a proper "report-card" has been developed, in order to reach an easy and fast qualitative evaluation.
Each card is based on a detailed study of the property and provides a value of its level (V_o); such a value has to be compared with a defined value of the property (V_d) which usually consists of the desired level or optimal level. The comparison between them is made by the indicators' value, and the final result is called P_p (partial property) (1); considering all the values of the partial properties, it is possible to obtain the value of the recorded property (P_R). It has to be underlined that it is not possible to sum values of heterogeneous properties; for this reason, the final results of the assessment procedure can be represented in a graphical way, as shown in figure 2, using the general formulas applied for the evaluation procedure, which are the following:

$$Po_{ji} = \frac{Vo_{ji}}{Vd_{ji}}; \qquad Pp_j = \frac{\sum_1^n Vo_{ij}}{\sum_1^n Vd_{ij}}; \tag{1}$$

where, considering n sensors S_n (i =1, ..n) and k partial properties P_{pij} (j =1, .m), for each one of them: V_{oij} represents the observed value of the partial property and V_{dij} represents the desired value.

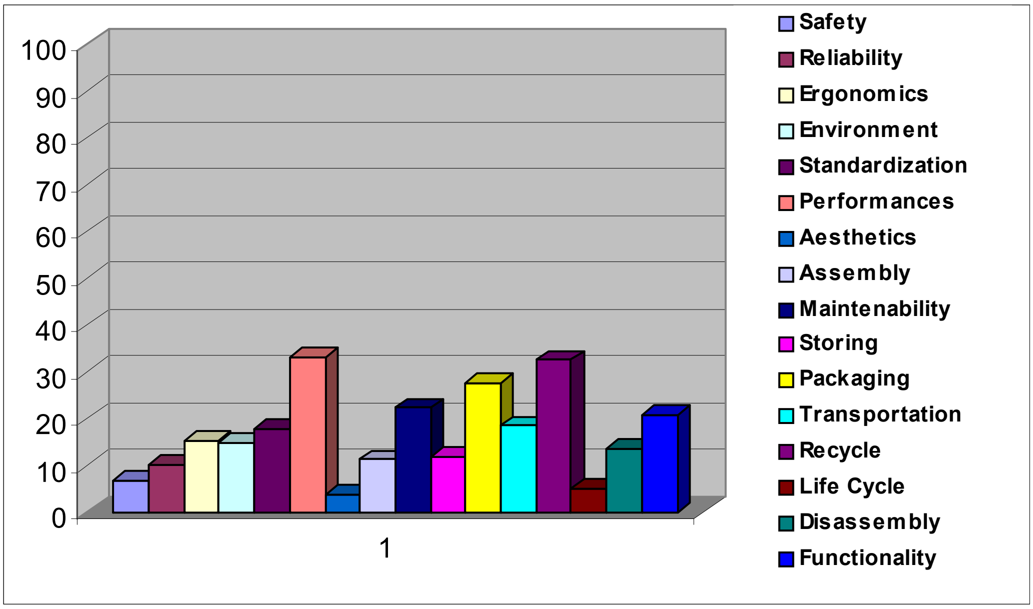


Figure 2. Graphical representation of the measurement procedure

3.3 The assessment Design Methods

Together with the use of specific techniques to assess the product's quality level, methods developed on purpose to solve this task have also been taken into account, such as Quality Function Deployment and Benchmarking, whose results are well known as optimal indicators of Quality level.
Moreover, considering the great number of parameters which influence Quality, the use of specific design tools, such as SWOT (Strengths, Opportunities, Weaknesses, Threats) Analysis, FMEA, FTA, Axiomatic Design, TRIZ, LCA is foreseen as well.
All such Design Tools were implemented in the Design Strategy: for each of these the proper moment of use and the proper sequence were defined in order to reach results with the maximum effectiveness during each phase of the Design Process. In figure 3 an example concerning the first and the second phase of the design process is shown.

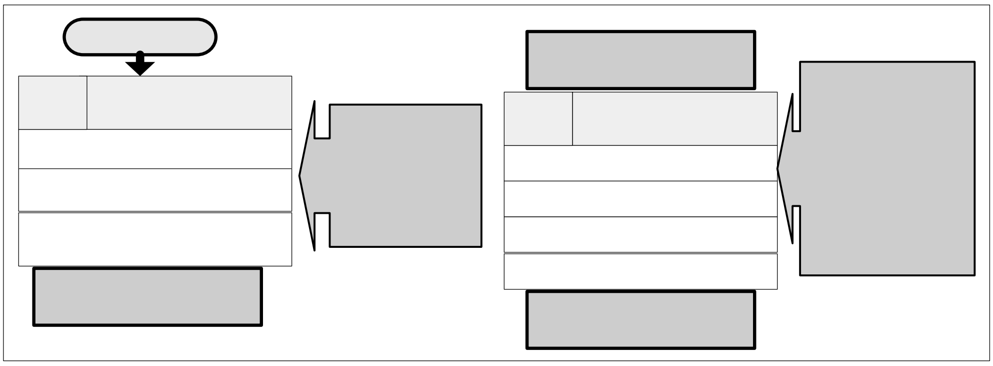


Figure 3. The Measure Procedure's design tools concerning the first two phases of the design process

In particular, a Design Process, in which such tools have to be used, was developed in order to simplify its use even by unskilled designers and to raise this approach both to new ISO 9000 standards and to be in compliance with safety requirements and certification.

4. Case Study

The effectiveness of our study was tested on a project in cooperation with an Italian company, regarding the assessment of the Quality level of the design of a new rubbish bin which will be used in the streets of the centre of Rome, with the aim of assessing and increasing quality level since its early design stages.

In particular, on the one hand the task was to improve technical performances of the Mechanical System, like mechanical strength, environmental sensitivity (e.g. corrosion), reliability, maintainability, easy to clean, etc. in order to satisfy operators expectations, who daily have to manage the system; on the other hand it was necessary to satisfy citizens (users) needs concerning the aesthetic degree, the conformity with urban decorum, as well as usability (Functional Requirements are listed in Table 2).

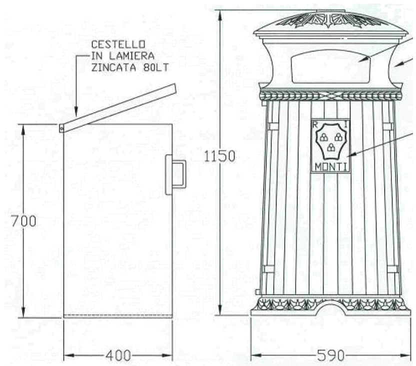
Table 2. Axiomatic Design: Functional Requirements

Rubbish Bin	
1	Urban decorum conformity
2	Avoid the introduction of big objects
3	Unease opening in case of no authorized operations
4	Ease disassembling for operators
5	Safe transportation and maintenance
6	Ashtray separated from the main structure
7	Robustness against………
8	Robustness against environmental ….
9	Easy to be recognised
10	Possibility to put a district "logo"

The work carried out allowed us to significantly improve Reliability and Ergonomics of the mechanical system as well as to increase its aesthetical degree (in figure 4, an example of the most common failure of the rubbish bin concerning the hinge fracture (a) and the layout of the redesigned system (b) are shown; in figure 5 the most important results and improvements are shown).

Moreover, following the suggested approach, all design stages have successfully satisfied both Safety and Quality certification.

(a)



(b)

Figure 4. (a) Example of the hinge break of the trash bin, which has been come out as the most comon failure; (b) General layout of the re-designed system

5. Results and Conclusions

The developed Design Procedure and its verification in an industrial case indicate that this approach is a promising design tool for assessing Quality level of any kind of product during design activities, helping the designers to avoid the occurrence of partial or incomplete results, as well as an excessive time consumption. Moreover the Procedure has shown to be very useful when design work has to be in compliance with standards or regulations (e.g. ISO 9000, Machine Directive, etc.).

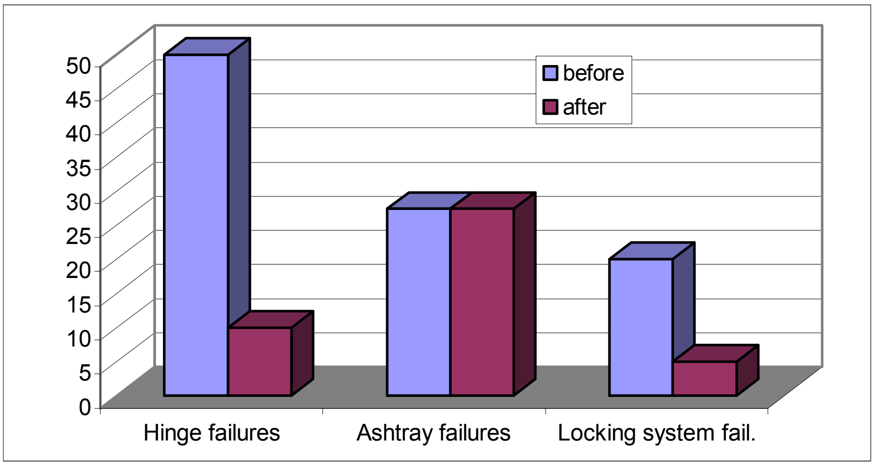


Figure 5. Failure occurrence before and after the re-design

Acknowledgement

The study was carried out with the support of the research department of the Italian Institute for Prevention and Safety in Rome (ISPESL) and in cooperation with the Agency for Environment of the City of Rome (AMA spa), and in particular with Dr. Aldo Vendittozzi.

Authors also wish to thank Ing. Valeria Mazzola and Dipl. Eng. Pontus Osterberg for the important contribution given during the preparation of the present paper.

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