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QFD: a methodological tool for integration of ergonomics at the design stage

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Abstract

As a marked increase in the number of musculoskeletal disorders was noted in many industrialized countries and more specifically in companies that require the use of hand tools, the French National Research and Safety Institute launched in 1999 a research program on the topic of integrating ergonomics into hand tool design.

After a brief review of the problems of integrating ergonomics at the design stage, the paper shows how the "Quality Function Deployment" method has been applied to the design of a boning knife and it highlights the difficulties encountered. Then, it demonstrates how this method can be a methodological tool geared to greater ergonomics consideration in product design.

Keyword: Ergonomic; Design; Method; QFD; Knife

1. Introduction

For a number of years, hand tool design has been a focus of attention on the part of users, manufacturers (Sandwick, 1995; Atlas Copco, 1998) and researchers (Eurohandtools, 1997). Concern for imposing the least possible demand on the user and thus a more "ergonomic" design (*do the job harmlessly, effortlessly, comfortably*) has now complemented the initial aim involving a concern for performance-related efficiency (*do the job better and quicker than by hand*). Since the early 1980s, we note a marked increase in the number of musculoskeletal disorders in many industrialized countries and more specifically in companies that require the use of hand tools: in the food industry (Armstrong et al., 1982), in the car industry (Vanbergeijk, 1996), in electronics (Tichauer and Gage, 1977) and in the assembly of household appliances (Aptel, 1993).

Early in 1999, the French National Research and Safety Institute (INRS) launched a research program on the topic of integrating ergonomics into hand tool design, within the scope of a multidisciplinary project entitled CEROM[1]. This project hinges around industrial problems applied to the meat boning and carving trades.

In this paper, we demonstrate how a specific design method, the quality function deployment (QFD), can be a vector for integrating ergonomics into hand tool design and, more generally, occupational risk prevention into work equipment design.

2. Problematics of integrating ergonomics into design

According to the view taken by the scientific community, we consider design as the transformation of a concept into a product with the aim of satisfying user needs whilst ensuring respect for the environment, legislation and corporate profitability (Duchamp, 1999). The initial stage of a design process therefore involves identifying and formalizing various expectations

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[1]Acronym for "Conception ERgonomique d'Outils à Main" (ergonomic design of hand tools).

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with regard to the product to be designed, amongst are which those relating to ergonomics features either explicitly or implicitly. Although much work is still required in this area, methods for fulfilling this stage are already available such as needs functional analysis (AFAV, 1989) and market identification techniques (Daetz et al., 1995; Shiba et al., 1995).

Even if user expectations and ergonomics needs have been identified and prioritized, this does not mean that the designed object will in fact satisfy all of them. Subsequent stages of the design process (overall design, detailed design and manufacturing) are, in fact, usually managed by engineering specialists. The inevitable problems that arise during these stages, combined with the difficulty or even absence of communication between the engineering specialists and those representing different disciplines such as ergonomics, can produce an adverse and/or unpredictable impact on satisfying such needs, especially those associated with occupational risk prevention. These needs are indeed often perceived as design constraints (Didelot et al., 2000) and are consequently addressed only at the end of the design process through the adoption of remedial measures embodying compromises, which can subsequently turn out to contradict operational needs. For example, the diameter of a power tool handle will often depend on technical constraints involving power supply (electric or pneumatic motor, electric batteries, etc.) to the detriment of ergonomic criteria. Another ergonomics integration difficulty relates to what we call the paradox of design ergonomics: "*to express something effectively based on a work situation, we must wait until it is fully designed, yet then it will be too late to intervene in its design*" (Theureau and Pinsky, 1984). This problem can only be overcome by an iterative design process that allows the validation of each product development phase by all design actors (Pomian et al., 1997).

QFD appears to be a methodological tool geared to supporting greater ergonomics consideration in product design because its aims are to safeguard customer needs throughout the design process, to promote communication between design actors (engineers, ergonomists, users, etc.) and to highlight possible contradictions between the various design parameters.

3. The QFD method

In the 1970s, the drive for perpetual product improvement led Japanese companies to seek optimization and rationalization in the design of their products and processes. It is in this context that the QFD method was created and developed. One of its founders, Dr Yoji Akao, defined the concept as follows: "*QFD provides specific methods for guaranteeing quality at each stage of the product development process, starting with design. In other words, it is a method for introducing quality right from design stage to satisfy the customer and to transform customer requirements into design objectives and key points that will be required to ensure quality at production stage*" (Akao, 1993).

Introduced first in North America then in Europe in the 1980s, this method has since experienced strong development in the majority of industrialized countries.

As its name suggests, the QFD approach is based on deploying user expectations (the "Whats") in terms of design and production-related parameters (the "Hows") for the new product. This process is represented by a succession of double entry "Whats/Hows" tables allowing the correlations between entries to be identified and prioritized. The first matrix, also referred to as "the house of quality" (HoQ) because of its shape (Fig. 1), is the most recognised form of QFD. In addition to "Whats/Hows" correlations, this matrix allows the integration of elements related to analyzing product competition and to identifying synergies and/or contradictions between different product characteristics. Thus, this matrix offers the twin advantage of facilitating the transition between the world of the user and that of the designer, and of combining in the same document all effective data for decision-making in relation to product development. For further details of the QFD method and its application, we recommend the reader to refer to the bibliographical references (Akao, 1993; Daetz et al., 1995; Madu, 2000).

4. Application of the house of quality

In the remainder of this paper, we present the work undertaken within the scope of the CEROM project on redesigning a boning knife (Fig. 2) to illustrate the application of the house of quality matrix and to demonstrate its advantage for improved integration of ergonomics in design.

First of all, the QFD is not an occupation-specific tool only used by specialists (which is the case with CAD/CAM[2] for example). On the contrary, this is a multidisciplinary method that has to be implemented within a working group combining different design players. In our case study, this work was carried out by a team combining engineering and ergonomics specialists, boning knife users (deboners and sharpeners) and manufacturers.

4.1. Drawing up the "whats" list

As mentioned above the initial stage of a design process involves identifying and formalizing various

[2]CAD-CAM: Computer-Aided Design–Computer-Aided Mechanical.