Sociotechnical design processes and working environment: The case of a continuous process wok

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A five-year design process of a continuous process wok has been studied with the aim of elucidating the conditions for integrating working environment aspects. The design process is seen as a network building activity and as a social shaping process of the artefact. A working environment log is suggested as a tool designers can use to integrate considerations of future operators' working environment.

1.Introduction

In 1994, the first steps were taken to initiate a project which almost resulted five years later in an innovation. Almost, because the innovation process is still going on and has not yet resulted in a new commercial product. The artefact is a continuous process wok for the food industry with a potential for substituting the present batch processes in the food industry. The scene of the innovation process is the Danish food sector, including research and development institutions. The actors are primarily *Fast Food*, *Bio Institute*, and *Food Engineering*.

Based on a longitudinal study of the five-year design process, this paper is a preliminary investigation of the conditions for integrating working environment aspects into such a process. The theoretical starting point has been inspired by actor-network theory (Latour 1987 and 1992; Callon 1987 and 1995; Law and Callon 1992) and the social construction of technology approach (Pinch and Bijker 1987; Bijker 1995).

2. The actors

Fast Food produces ready-prepared dishes for the retail and catering markets. Today, around 330 employees work at three manufacturing sites, two in Denmark and one in the UK.

Bio Institute is a department at a technical university, is responsible for education and research within two main areas: food engineering and biochemical engineering. The department is organized in a number of research groups. The wok project is being carried out by the Food Science and Technology Group, headed by a professor appointed twelve years ago. He came from a research position at a major Danish pharmaceutical firm.

Food Engineering has specialized in stainless steel machines and equipment for the food, chemical, and pharmaceutical industries. Besides the two owners, two design engineers, two supervisors, and ten skilled craftsmen are employed.

3. Building the wok network

The processes of building the wok network and shaping the content of the technology are summarized, primarily in chronological order, in the following.

3.1 The Problem: Boiled - Not Stir-fried

In the autumn of 1994, the quality manager at Fast Food contacted Bio Institute. The quality manager had difficulties processing vegetables for ready-prepared dishes. They were boiled instead of stir-fried as in a wok. The quality manager had a vison of new products, where the customers could easily see and identify the crispy vegetables. As a result of the inquiry, the professor from Bio Institute visited Fast Food for more information about the problems.

On his return to the department, the professor "started inventing" or rather started to solve the technological problem experienced by Fast Food. He addressed the problem as caused by insufficient heat transfer per unit raw material and time units. In considering alternative ways of frying the vegetables in order to obtain real stir-frying, he considered quite another process known to him, namely the diffusion process used to manufacture sugar from sugar beets. This process is continuous, contained in a sort of tube equipped with a transportation mechanism. He then asked himself: "Why don't we fry in such a tube?". This metaphor or analogy was the origin of the professor's vision: Frying in a tube with a spiral to transport the ingredients.

3.2 The Artefact

Stir-frying - in contrast to boiling - requires a combination of high surface temperature, short processing time, and adequate evaporation from the ingredients (vegetables and meat). Continuous frying was achieved by using an iron frying tube with an open upper front. The underside of the tube is heated by natural gas. A stainless steel spiral conveyor inside the tube transports the ingredients until they leave the tube as finished food. The spiral is suspended in a floating manner and capable of moving transversely to the axis by means of double-acting hydraulic cylinders, thereby continuously scraping the heat surface.

3.3 Mobilizing Internal and External Networks

To transform the vision of the continuous process wok into an artefact, Bio Institute and Fast Food made a formal agreement and then applied the governmental R&D programme, FOETEK, for financial support, which they succeeded in receiving. The goal was to build a pilot plant prototype to demonstrate that the new principle was capable of functioning. Thus, in the early phase, the idea of a working prototype was born as an 'obligatory passage point' in stabilizing the network.

At Bio Institute, the professor mobilized an *internal network* of resources, including the head of the pilot plant facility, a mechanical design engineer, PhD students, laboratory technicians, and the in-house workshop consultant (J-Consult) headed by a mechanical design engineer. In an iterative process based on the professor's ideas, descriptions, and sketches, this group succeeded in designing and constructing a pilot plant prototype of the continuous process wok. The design process included experiments with plastic models of the tube and the spiral.

During the development process, Fast Food contributed by delivering processing know-how, recipes, raw materials, and quality assessments of processed products.

The unfinished prototype was presented at a yearly open-house event at Bio Institute. Food Engineering participated in this arrangement, maybe after being advised to do so by Fast Food. The managing director of Food Engineering contacted the professor, and on the same day, they signed a confidentiality agreement enrolling Food Engineering in the *external network*.

In the autumn of 1998, the real 'obligatory passage point' was coming up. Bio Institute was prepared to demonstrate the functionality of the prototype to representatives from Fast Food and Food Engineering. The demonstration went well and thereby established the basis for proceeding with the project.

3.4 Changes in Network and Artefact

It was obvious that the further development of the continuous process wok was strongly influenced by the interests and visions of Food Engineering. At this time, Fast Food was partially excluded from the network. The new quality manager was afraid that a continuous system would constrain the flexibility of Fast Food, which he conceived as crucial. But other factors also played a role. Fast Food was losing money for the first time in many years, and they did not feel sure that an investment in the continuous system would be profitable. They considered implementation of a continuous system to be too heavy a project. On the other hand, Fast Food did not withdraw totally.

In the spring of 1999, Food Engineering had to decide in which direction to proceed.

Different possibilities were open, including the construction of a larger prototype or full-scale machine to be tested by Fast Food. One of the key problems was the increased volume of raw materials in an up-scaled machine. The effect on product quality was not known. Food Engineering decided to build an up-scaled prototype to be tested in their own facilities. With Food Engineering as the applicant, they received support from the FOETEK programme to build and test an up-scaled prototype. However, the sponsoring agency of the FOETEK programme enrolled Fast Food in the project again by making their participation a condition for financial support.

At this stage, the artefact changed again. Because they had seen vegetables (onions!) stick to the frying tube, Food Engineering regarded the spiral concept as risky. This demonstrates that technological testing - as pointed out by Pinch et al. (1992) - is an interpretive process in which test results gain their meaning and validity only within a wider context of technical, social, and political factors. The managing director decided to choose one of the other concepts described in the patent application, namely a rotating tube. He found this concept less risky and easier to manufacture. An up-scaled prototype was constructed and a series of tests are going on, with Bio Institute now participating in the project as a consultant.

4. SOCIAL SHAPING OF THE WORKING ENVIRONMENT

In the design process described, only few working environment considerations were included. The design group at Bio Institute put most emphasis on the safety aspects of the machine and an air exhauster to remove flue gas and cooking smell. These measures seemed to be minimum requirements in order to operate the wok machine in the pilot plant facilities.

What does the character of the design process mean to strategies for integration of working environment aspects? The design process was demonstrated to be a social process involving network building, coordination, and negotiation between different professional knowledge domains and between actors with different perspectives and interests in relation to the continuous process wok. During the design process, the artefact was changed dynamically according to the balance in the actor network. Hence, the potential working environment for the future operators was being designed and re-designed. Therefore, it does not seem appropriate to rely on strategies in which working environment criteria are stated in the requirements specification. First, such specifications only existed as very rough sketches and descriptions. Second, it turned out that specifications were not just translated into design objects. They were transformed, subject to interpretation, as the design object changed from sketches, technical drawings, plastic models, and prototype. These conditions point to the necessity of making a working environment perspective an integral part of the network instead as an add-on measure.

4.1 Designers' Inscription of the Users

Looking at the network building process, one can point out one group of actors who were excluded from the wok network: the future operators of the continuous process wok. They might have been represented by the operators at Fast Food. Instead they were 'inscribed' in the technology, meaning that the designers envisaged certain roles for the operators and their working environment (Akrich 1995). Often these notions about the users first become explicit when the designers are asked who the operators are and how their work will be. The professor expressed the vision that the operators should have jobs in which they could make use of their abilities. At the same time, he realized that it looked like the job would only comprise surveillance tasks. The designers were very focused on *the machine*. They did not form an overall picture of the working environment in the continuous process wok *system*. They were not able to explicate the man-machine interactions and which tasks would be necessary to feed the system with raw materials. Nor did they think about cleaning and maintenance operations, job requirements, and training of the operators.

5. FACILITATING WORKING ENVIRONMENT CONSIDERATIONS

Working environment considerations could have been facilitated in different ways in the wok project. Such considerations might have been the task of a working environment professional in the network. It is well known, however, that access to the early stages of a design process of innovative equipment may be very difficult for such professionals to obtain. Another approach would have been to develop a tool for the designers. Again, it is known that ergonomic tools and data may be accessible to designers but not used. In the wok design process, the attention of the designers was directed toward different design objects: written descriptions, sketches, technical drawings, models of key components, and finally a prototype. These design objects were important as mediators in the process. The final, absent wok was constantly made present by these 'mediating objects' (Vinck et al. 1996). These objects resemble a sort of 'social glue', facilitating the distribution of knowledge among design participants. The malleability of the artefact is also reflected, since the objects are mediating the comunication, negotiation, and compromises between the different participants in the design process. A mechanism for integrating working environment aspects, then, may be to see them as a design object. When the designers are designing the artefact, they are simultaneously designing many aspects of the operators' working environment. This may be visualized for the designers by using a *working environment log*. Such a log has to follow the artefact as the actor network changes. For example, the log for the wok would be passed from Bio Institute to Food Engineering, when this enterprise became dominant. A working environment log should include a base line as reference point. In the case of the wok, the base line would include a systematic description of the working environment in the present production process at Fast Food (pictures, diagrams, written text). It would include the present operators' evaluation of their work, and the goals of the future working environment compared to present conditions. The elaboration of the log could be guided by working environment professionals, f.ex. the occupational health service staff affiliated with Fast Food. For the designers, the log should serve as a new design object mediating how the potential working environment of future operators changes when they change the design. Such changes have to be reported to the log and compared to the base line and the goals. The designers' work with the log should be another coordination mechanism in the design process (Cohen et al. 1998): Changes should be reported and a shared understanding of the impacts have to be reflected in the design network.

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