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AN EVALUATION OF PRODUCTION SYSTEMS FROM THE ERGONOMIC VIEWPOINT;
A PLEA FOR AN INTEGRAL APPROACH TO DESIGN.

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SUMMARY

A study has been carried out in twelve different plants in which production systems were considered from the viewpoint of ergonomics. Discussions about this were held with officials both from different departments and from as many different levels of the organization as possible; on-the-spot observations completed the interviews.

Technological and organizational changes are being introduced at many locations and a good starting basis has been provided for improving production systems. Nevertheless, a number of subjects are not yet receiving the attention which they should be given; a view that is shared by the interviewees. They include the integral approach to design; man-system communication on the future shop floor and the selection, education and training of the future employee.

INTRODUCTION

Production systems are subject to change. The requirements to be met by the product, including quality and producibility (Design for Manufacturing), and the production system, including efficiency, quality and flexibility, are leading increasingly to the use of extensive mechanization and automation. The advanced technology is ultimately intended to lead to flexible production systems (ref. 1). The position of the production department in the organization will become more and more important, because it has the implicit and explicit knowledge concerning the production process. There are fewer production workers on the shop floor and they can call up information about the automated production process via display screens among other media. Jobs are changing from direct performance to monitoring; when breakdowns occur, appropriate intervention is necessary.

Automation calls for timely Organizational Renewal (see e.g. ref. 2). Departments initiating the new technology should realise that the organization must be prepared for this. Departments which have to work with this technology should realise that they can no longer operate without it. The greatest challenge for management lies in the efficient integration of technological and socio-organizational innovation (socio-technical innovation). Management will have to pursue an appropriate policy to achieve this.

The successful design and construction of new production systems require good teamwork between management, users and experts. One of the disciplines whose help can be enlisted in 1988 is Ergonomics. Ergonomics can no longer be disregarded in the design and construction of automated production systems. It is sufficiently well known from practical experience that with "common sense" alone, the designer fails in his task (refs. 3-4). The present study was started in order to gain an insight into the state of the art.

APPROACH

The chosen approach involved visits of one or several days to twelve different plants. The local Organization manager was consulted with regard to the persons to be interviewed and the workplaces to be visited. Prior to each visit the participants received the points on which ideas would have to be exchanged. In order to obtain the best possible picture of the situation, discussions were held with people both from the various departments and from as many different levels of the organization as possible. Altogether eighty people have been interviewed, of whom about forty belonged to Development and Plant Engineering. On-the-spot observations completed the interviews.

For reasons of time, it was decided not to make a separate report for each plant. In almost every case, an evaluation discussion took place at the end of the visit. The overall report is now in discussion in the plants.

RESULTS

This section contains three parts:

- The future workplace on the shop floor.
- Selection, education and training of the future employee.
- The design process for production systems.

The future workplace on the shop floor

One of the most important aspects is the user interface or the man-system communication. To an increasing extent the production worker will have to make use of the display screen in order to obtain information about the production process. A great deal of information about "man-computer interaction" is available in ergonomics literature (e.g. refs. 5-7). The question which will first have to be answered in practice, however, is as follows:

What information should be presented at what time to what person?

According to Brödner (ref. 8), an appropriate user-interface should among other things be adjustable to different degrees of user's experience (flexible dialogue procedures). This requires a process analysis, a task analysis and an error analysis. Failure to make these analyses may result in the system providing information in accordance with the views of the designer and not in accordance with those of the user (conceptual misfit). The possible consequence of this may be:

- irritation on the part of the user;
- mistakes in job performance with all the resulting consequences;
- a reduction in efficiency, because the system is not used as intended.

Once it is known what information is needed for which user category, by using ergonomic guidelines, it is possible to examine how the information can best be presented on the display screen. An example of this statement is given in ref. 9; field and simulation studies have resulted in design rules setting out how alarm information should be presented to the operator in a control room of a chemical plant.

In the plants visited the wish was expressed for support in designing and/or improving the man-system communication. Prototyping and participative design studies have already been started.

Selection, education and training of the future employee

In applying advanced technology, two approaches are essential for ensuring good coordination between man and system:

1. Fitting the job and the job situation to the limitations and possibilities of the person performing the task (ergonomics).
2. Fitting the person performing the task to the job (situation) via selection, education and training (Human Resources Management).

Both approaches are currently being used in the process industry (refs. 10-11). Discussions about this are taking place in some of the plants visited. It was agreed that the aim must be to achieve high technology in combination with people and not high technology instead of people. In the literature (e.g. ref. 12), too, the technical ideal of the unmanned factory is also regarded as misleading. Here it should be added that extensive automation leads to the paradoxical situation that, because they seldom occur, breakdowns are becoming less easy to handle.

To the production worker, production automation means a reduction of his "grip" on the production process. But occupational skills (deciding how these are to be obtained and maintained in the case of extensive automation is a fundamental task!) remain essential for achieving a good level of utilisation of capacity and profitability. Skilled machine operators reduce machine down times. In ref. 13 the myth of the de-skilling trend is dealt with; the upgrading hypothesis is postulated. Apart from occupational skills, other important job requirements we shall mention here include: stress resistance; flexibility; the ability to maintain an overview of the linked/integrated production processes; willingness and ability to communicate; problem-solving in small groups and motivation.

The selection, education and training of future production personnel is more than ever a challenge for a Personnel Department which, in my view, will have to operate in close cooperation with Production and Organization in order to answer questions relating to the required level of education, the general nature of the education and the way in which the training has to be subdivided, for instance, into basic training, specific training and refreshment training.

The production system design process

A production system passes through a number of stages in which a great many departments have to cooperate (e.g. Development, Plant Engineering, Drawing Office, Electrical Plant Engineering, Production Planning, Engineering Works, Production and Organization). In ref. 14 a design methodology is presented from a Human Factors (Ergonomics) point of view. Theoretically speaking, a project comprises three stages: 1. Start-up (generation of ideas, making, carrying out and implementing a concept); 2. Optimisation and 3. Evaluation.

In the plants visited, there are two striking features we would like to mention here. Firstly, the product life cycle is becoming increasingly shorter. On the one hand, this results in the products not being developed to a sufficiently high level and, on the other hand, it is impossible to acquire sufficient experience with their production itself. Secondly, because of the pressure for renewal, projects often end after the start-up phase; optimisation either does not take place or is inadequate and is almost never done by the project team itself; an evaluation is seldom made. As a result of all this, it is more than ever necessary to avoid errors at the design stage. The probability of errors can be reduced by: 1. Consultation with experts; 2. Allowing users to participate, and 3. The evaluation of completed systems. This will be dealt with in the following sections.

1. Consultation with experts. The persons interviewed agreed that in view of the multitude of requirements to be met by a production system nowadays and the fact that ergonomics is more than common sense, consultation with experts is desirable at the design stage. It is questionable whether consultation with e.g. ergonomic experts is necessary in every case. With regard to complicated problems in the field of Information Ergonomics and Ergonomics of Automation, the answer is Yes! In the case of relatively simple Production Ergonomics problems, the designer himself must involve ergonomics in this. He can no more neglect e.g. the measurements of the human being who has to operate his machine than he can disregard the strength calculations of the machine. This is primarily a question of education, starting at the university and the polytechnic. In addition, an internal course can certainly prove useful here (as an eye-opener). But, as some designers/constructors confided to me: "... We are still technocrats, we prefer to solve the problem technically and that is why we believe that consultation with you people is important at the design stage."

2. Allowing users to participate. From the discussions it may be concluded that ergonomics is frequently introduced unconsciously in the design projects. In addition, the decision as to whether it is introduced or not is a highly individual one. Involving the (future) production workers, however, is already a step in the right direction. In some of the plants good experience has been acquired with this. Experience in the process industry has shown that user participation is important and should take place at the earliest possible stage of a project.

Wherever possible, it is advisable to allocate specific tasks to production workers themselves. In a current study (in the process industry) we are presently experiencing success with releasing workers for other jobs: a former production foreman is now entrusted with carrying out the automation project; two operators have been released to write the new manuals during dayshift. It is the production worker himself who has the most knowledge of his own job situation (expert). It is extremely unwise of the designer to neglect this knowledge.

3. The evaluation of completed systems. In the interviews, it regularly emerged that, in general, project teams hardly if ever got round to evaluate a system once it was completed. The reasons then mentioned were: "unnecessary", "forgotten" and often "lack of time". The last reason, in particular, was due to what was termed: "... everyday pressure" or "... the multitude of projects with which we are confronted". A multitude of projects can, however, frustrate innovation. The question arises as to how the priorities for the projects are established and, in particular, by whom? In my view, one of the interviewees summed up the problem very well with the words: "We do too much at the same time and always with different people".

It is advisable, to keep a project team - possibly supplemented by some external experts - in existence during the evaluation phase and to have it report its findings to the Plant Management Team after a certain period of time.

CONCLUDING REMARKS

Production or manufacturing automation requires an integral approach. The aim of each design team must be to achieve high technology in combination with people and not high technology instead of people. To avoid errors in the design phase as much as possible one should: consult experts, allow users to participate and evaluate completed systems. Ergonomics (Human Factors) can no longer be disregarded in the design and construction of automated production systems. For a convincing strategy, ergonomists should have the courage to get involved in key projects (case studies).

Deciding what the new occupational skills are and how they must be maintained in the case of extensive automation is a fundamental task.

The ultimate challenge for plant management lies in the socio-technical innovation.

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