Simultaneous Layout
Planning, Organisation
Design and Technology
Development

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Preparing for World Class Standards in Production

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1 INTRODUCTION

Today West-European industries have to come to grips with a multitude of environmental demands, i.e. increased global competition, more persistent customers and a highly-responsive, well-educated and multi-cultural workforce. Technological design, work organization and business development are no longer seen as the prerequisite of specialised departments, but are more and more integrated as part of an explicit business strategy to better cope with these developments. Self-Managed Teams and Business Process Re-engineering are the new solutions to improve both the quality of work and the effectiveness of the organisation at the same time.

Although modern enterprises are in a constant flux of transformation, the planning of a new facility indeed offers a unique opportunity to practice integral organisational renewal, to further push the concurrent design of innovative production technology, modern team-based work organisation and actual facility planning/work space design.

This paper presents a case study at a product line of Philips Electronics Industries. The purpose of this paper is to show that layout planning, organisation design and technology development can be done simultaneously.

2 COMPANY BACKGROUND

Philips Electronics Industries, Roermond, the Netherlands, has planned a product line for Ceramic Multi-layer Actuators (CMA). This product, a micron-level actuator, basically consists of very thin
piezo-ceramic layers separated by metal electrodes. A small voltage applied to its electrodes causes the piezo-ceramic layers to deform and produce a displacement. A CMA offers good functionality for controlled motion, down to the micron level.

The production process, basically consisting of a sequence of coupled steps, is as follows. First, ceramic powder is mixed with chemicals to a slurry. This slurry is processed to a foil on which the metal electrodes are printed. Next, the foil is stacked and sintered. Finally, the mature ceramic is cut and outer electrodes are attached.

The industrial application of CMA’s is expected to increase. Contemporary CMA’s are used in printer heads, pneumatic valves and micromechanical applications. The CMA is expected to enter multiple markets.

Product and process development are also located at the Roermond site. The Ceramic Innovation Centre has been placed near the production plant.

To plan the new facility, CMA management has formed a multi-disciplinary design team, to incorporate as many good ideas and detailed data as early as possible in the design, and to make its initial layout and organisation design. In the remaining paper simultaneous layout and organisation design (including the incorporation of technology development) shall be referred to as workplace/workspace design.

As CMA production at Philips has started only recently, ample opportunities for efficiency improvements exist. Of course, the design of the new facility will also incorporate the anticipated efficiency improvements.

3 THE DESIGN PROCESS

The macro design decisions were made at plant level, while at the same time the actual planning effort was undertaken at the factory level. Because further changes in production mix and technology were expected in the near future, the organisation design could go no further than a rough indication of the necessary machinery and operators for each process step, the principal grouping of operators and machinery into units, a streamlining of these units according to the order flow and a rough estimation of the required number of indirect personnel. For the same reason, the organisation-based workspace design was only specified as a block-layout design.

For efficiency reasons a special approach was applied: A small multi-disciplinary design team did the actual design work after consulting/interviewing all key personnel. Table 1 shows the actors and their roles in the design process.

Table 1 The participants in the design process

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Figure 1 The design process
3.1 THREE PHASES IN THE WORKSPACE/WORKPLACE DESIGN

In the first phase a small team made preparations for information gathering and processing. For this goal a Lotus123 template was written. For each typical production mix, this template was able to translate specified product dimensions and forecasted production volumes into detailed production process quantities. Next, these quantities were entered into an algorithm to compute the required number of machines per process step, and the required number of operators and the amount of physical workspace. Additionally, the template was fed with data representing actual production characteristics such as yields, machine capacities, man/machine ratios and the required amount of volume and nonvolume-based physical workspace. An example of a volume-based production characteristic is the workplace area that is needed for a foiler caster to execute the job. This includes physical workspace for maintenance, repair and access for loading and unloading the machine. An example of nonvolume-based physical workspace is the area covered by a desk.

In the second phase, several members of staff and line personnel were consulted by the design team about their assumptions concerning future production characteristics. The CMA personnel produced many highly-valued suggestions. The assessed assumptions about changes in product, process, and equipment design were also used as inputs for the Lotus template. During the planning process, the design team asserted that the resulting data were not too conservative, nor too optimistic. For instance, the anticipated efficiency improvements proved to be comparable with a moderate learning curve.

In the third phase, several alternative designs were developed. Next, these alternatives were systematically evaluated and ranked by top management. Subsequently, both the highest-ranked design alternative and its accompanying optimal design characteristics were fed back to the development department as a directive to work with. Thus, for the very first time, process development staff was instructed to change their machine and process specifications to support the desired organisation design!

3.2 DESIGNING THE ORGANISATION

Current modern sociotechnical organisation design theory prescribes that the following steps should be taken into account in designing an organisation:

A. Workspace design
   1. Parallelization: There should be several parallel order flows to be able to form order families with similar production characteristics.
   2. Segmentation: These streams should be further partitioned into segments in cases where the process is too voluminous and/or too complicated to be handled by one production team.

B. Workplace design
   3. The micro production structure (workplaces and the work skills of team members).
   4. Local control tasks are allocated to the production teams.
   5. Remaining interlocal control tasks are allocated to operational staff teams.
   6. Remaining global control tasks are allocated to the business unit team and the support teams.
The applied design process clearly deals with minimising the division of labour. Normally, self-managed production and staff teams are formed, using the above-mentioned sociotechnical design rules and shopfloor management principles. Due to the fact that the order flow already was homogeneous, only part of this procedure was followed at Philips CMA, at the business unit level. At the factory level there was a need for segmentation, because calculations indicated that more than three hundred operators (including allowances for indirect tasks) were required. There were also other reasons for segmentation such as the high skill level per production step and the required room conditions. Segments were formed on the basis of the Schumacher analysis, while several cohesion factors were examined (for example: clean-room conditions), as described by Van Amelsvoort (1992). The resulting segments were still too large to form production teams of an acceptable group size. At this level some segments could be further divided in subflows, using parallelization techniques. Figure 2a depicts this process. Production structure alternatives for the new plant where formed by examining the consequences of forming several fully-parallel production flows (N=1, 2, 3). Figures 2 b,c and d depict this process.

\[\text{Figure 2 about here}\]

At this level, the upper limit of the number of parallel streams was determined by the segment that had the greatest number of semi-parallel streams. So, a slightly different sequence of design steps was followed.

This was also the case for the role of control tasks in the design process. The allocation of control tasks should play a prominent role at the front end of the design process, because judgements about the size of a production team cannot be made without considering allowances for indirect tasks.

Figure 2e shows a combination of figures 2a and 2d. For these alternatives an integral evaluation was made. Section 4 gives a summary of the different aspects.

3.3 DESIGNING THE WORKSPACE

Conventional layout design practices usually do not take the production structure into account, thereby hampering the formation of self-managed production teams (also known as mini-companies). The management of CMA deliberately chose for the alternative in figure 2e. This decision was crucial to workspace requirements as decisions on the number of workplaces determine the required space for the layout planning.

From a sociotechnical point of view, layout planning and organisation planning should coincide. This was exactly what happened at CMA: Organisation design and layout planning overlapped considerably.
RESULTS OF THE DESIGN PROCESS

CMA management chose for a design alternative consisting of several parallel streams in the back end of the process. In the front end of the production process special machines restricted full parallelisation. Though this situation is not ideal, the front units can supply the three end lines fairly adequately.

Experienced managers judged that the resulting system was superior in terms of safety, stocks, robustness and throughput times. As a result, it is expected that the regulation of production quality will occur more rapidly, while scrap rates will be reduced. It is also plausible that the system can cope more easily with quantitative and qualitative fluctuations in demands and can switch over to new technologies without significantly reducing the capacity of the system. And last, but not least, from a sociotechnical point of view the system is balanced: It shows optimal group size.

The matching layout design was made up of workspace that was carefully planned around a central meeting space. Each production area can be easily reached by aisles that apply to internal safety standards. Figure 3 shows a global picture of the layout.

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Figure 3 The block layout

This layout has several advantages:

1. Machinery can easily be reached from the outside of the building. Therefore machines can easily be replaced without disturbing and polluting the adjacent production areas.
2. Because similar processes are kept together in the same area, production teams can temporarily switch over to machines belonging to other streams in emergencies. Also, there is no need for extra space and internal walls, and there is no loss of space because of overlapping circulation.
3. The production areas are shaped in such a way, that it is possible to switch over to new technology.
4. The central meeting space encourages and facilitates multi-functional communication, the so-called staff/staff integration and staff/line integration by adjacency planning. Emphasis was placed on visual contact between the meeting space and the production areas. The walls will consist of windows to facilitate the visual contact. This is clearly an example of glass wall management.
5. Additional machines can be located in the existing building whenever necessary, because workspace is calculated for maximum capacity (a so-called decentralised expansion strategy).
6. Expanding the facility to meet unforeseen demands is possible as production areas are placed near the exterior walls.
7. Areas, in which people spend most of their working day, are located near the outside of the building so that they can experience daylight and can look outside.
8. Potentially dangerous areas are insulated and placed as much as possible to the outside of the building.

9. The building costs are minimal in the long term, as space considerations were both general and detailed enough to minimise future adjustments to the building. Also, odd shapes were avoided so that the cost of in- and external walls were minimal.

10. Loading and unloading of raw materials and finished products can be done at a single central loading dock, close to the begin and end of the production process.

11. The mini-companies that have customer/supplier relationships are located near each other. In this way the 'customer first' philosophy has a clear physical element.

12. The inspection of extraordinary quality problems can be done without polluting the production areas, as products can be put in special cupboards that give access to the main aisle circulating around the meeting space. Specialists located in this area can now come together quickly to diagnose and eliminate the problem.

The workplace/workspace design exercise produced both a very detailed list of requirements, and a sound prototype of an integral design method. Future facility planning projects will certainly benefit from this work.

5 DISCUSSION

CMA is just one example of the growing group of companies that have put the lessons they learned in the past to good use.

- First, a major emphasis has been placed on product design, as it proved to be a major determinant of production costs.
- Secondly, CMA has invested in early planning. As the total cost of a product is largely determined in the first phases of a design project, CMA has prepared a lot of design work 'up front'. CMA can now concentrate on improving the initial design and realise an even better facility.

The CMA case also has managerial implications. A company that is planning organisational renewal should ensure the design of self-managed production teams concurrently takes a functional requirement in the layout planning phase. A company that neglects interactions between aspects may discover that the possibilities for laying out an adequate system of self-managed teams is seriously hampered by the physical and functional constraints of the facility. This certainly will result in the suboptimal functioning of the new production system.

The CMA case may also have some theoretical implications with regard to layout design and organisation design. The description of this case gives information about the methodology used and the application area of the methodology.

First, contemporary layout literature seldom shows how to deal with organisation design. The interaction between the design of production teams and layout planning apparently is missing. A better description of the interface between layout planning, organisation design and technology development would be most welcome.

Second, the role of control tasks in the organisation design process is something that has received inadequate attention in the literature. Better guidelines for the determination of the amount of allowance for indirect labour and how and when to deal with this matter in the design process would be a welcome addition too.
Third, the sociotechnical design sequence with regard to steps 1 and 2 may be less critical in industries like CMA. The technique of letting the segment with the maximal number of semi-parallel streams be determined by the upper bound of parallelisation may be a useful technique in cases where the division of labour is restricted due to special machine conditions.

REFERENCES


Figure 1 The design process

Van de Kuil et al., 1996
Figure 2: Design alternatives

Van de Kuil et al., 1996
Figure 3  The block layout at Philips CMA  Van de Kuil et al., 1996
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* = key decision maker

Van de Kuil et al., 1996