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IMIT

INFLUENCE OF AUTOMOTIVE DESIGN ON THE PRODUCTION SYSTEM

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SUMMARY

This paper analyses the background to and difficulties in developing alternative production systems and points out and exemplifies 6 restrictions of such systems.

Finally, a method is outlined for developing and analysing alternative production systems to those used today.

1 INTRODUCTION

During the last five years some alternative forms of assembly in the Swedish mechanical industry have been introduced. The conventional assembly line has been substituted by new kinds of production lay-outs, often combined with assembly in partially autonomous groups.

Reported advantages of the new systems range from decreased balance delays and system losses, lower conversion times and higher quality to increased work content and autonomy.

In some cases there has been a more thorough development of work organization and skill requirements in conjunction with the implementation of new production systems (Karlsson 1979).

The main goals for a good assembly system can be summarized in the following words:
- lower production costs
- flexibility in production volumes
- customer built products
- good ergonomic conditions
- meaningful work
- group work with profit centers for every group.

A production system is described by the following four dimensions:
1 Product design
2 Layout
3 Materials supply
4 Work organization

Because of the complexity of the system there is no possibility to optimize the assembly system. We must instead by knowledge of the four dimensions and its implications in every case, design the system and then check it against an evaluation model.

6.1.2

Technical factors influence the possibility of designing alternative production systems, i.e. the possibility of changing is dictated by the technical restrictions.

2 DIFFICULTIES CONCERNING DEVELOPMENT OF NEW PRODUCTION SYSTEMS

In the following text we will mention some difficulties/problems concerning the process of developing a new production system.

Usually, the union(s) and the management of the company have agreed upon the need for a new system, for economic and social reasons. Sometimes the task of developing a new production system is given to the workers. This means, however, that the workers are given a task which they have not the education to carry out in a satisfactory way. The workers can be given the task of specifying what necessary demands the new system should meet and also be asked to evaluate to what extent these demands are met. The management and the union(s) should together specify the demands on the production system.

The demands are handed over to the production engineers, who will design the new production system. The production engineers should make several suggestions for new production systems. The suggestions shall meet with the demands (economic and social) on the system. Evaluation of the suggestions is made by management, unions and the foremen and the workers concerned by the change.

The problem is to be able to visualize both hardware and organization. A model built to 1:50 scale containing both machines and people (workers) together with a description of symbols on overheads is one solution we have found useful. Slides of the model are easy to discuss for non-specialists in production engineering (supervisors, workers, personnel staff, economists and the top management).

After the evaluation the suggestions are modified or new alternatives developed. These new suggestions are evaluated, modified and so on,until one suggestion can be agreed on.

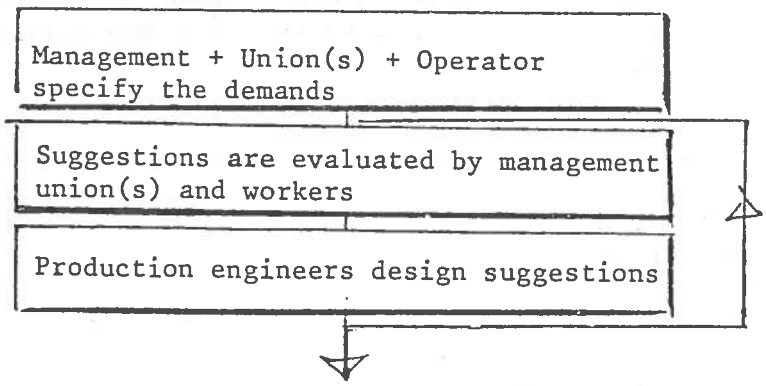

Figure 1 The working process when designing new production systems.

The production system must be designed from the product´s design. It is vital that the management informs the workers about the company´s situation and the different alternatives.

Our experiences show that the management tends to forget the above mentioned information. This leads to the fact that the workers often misunderstand the problem and do not understand that there are several alternative production system solutions on different levels.

In order to make comparisons possible at different scale levels there is a need to define a zero scale mark regarding design (with respect to its effect on assembly time) and production volume. Developing this zero scale mark is an important part of a fully economical analysis (Engström and Karlsson 1981).

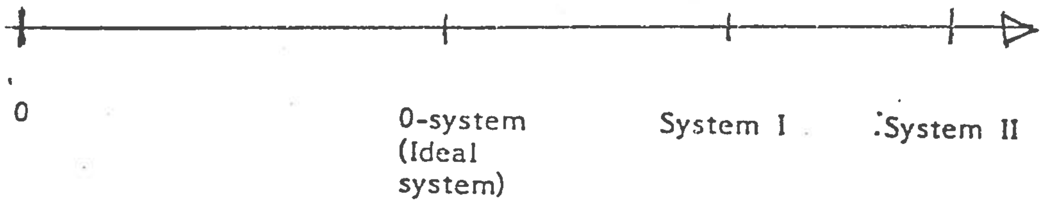

Figure 2 O-system evaluation for a specific product design.

3 EXAMPLES OF RESTRICTIONS INFLUENCING THE POSSIBILITY OF CHOOSING AN ALTERNATIVTE PRODUCTION SYSTEM

3.1 The content of autonomy

The autonomy of the groups is based on them being given a certain meas re of technical independence in relation to the remainder of production.

It is found (Karlsson 1979) that the most important factor as regards the attitude towards the work situation is the opportunity to vary the pace of work, i.e. the opportunities available for increasing the pace of work. This presupposes a low degree of mechanical control during the cycle. The pace of the work can be raised during part of a cycle, during the entire cycle or during several cycles, depending on the degree of mechanical control employed.

An accumulating increase in pace presupposes the availability of buffers in the system to accept variations in the output. Scope for increasing the pace is important to the individual, since it provides him with the freedom of varying the pace of work and thus determining his own periods of rest, and by offering him the sense of security that he can manage the job. The work is therefore experienced as less pressing.

For example, a production system with high operator density and low system capacity, in combination with a design requiring sequence bound assembly, gives small possibilities of technical autonomy.

3.2 Quality control, design and process degree

Research into the design degree (time to manufacture + time to check and adjust) has shown that in most designs, 80 % of the quality is dependent of design and 20 % operator dependent. A high degree of design can compensate for a mediocre process solution and a good process solution can compensate for a low degree of design. It is quite clear with this type of reasoning that the personnel (the workers) are more important with a low design degree than with high degree.

A low design degree, a difficult product to assemble correctly, demands a great work-organizational investment in the workers. They have to know what is wrong and which defects are more serious than others.

The problems which today´s researchers have no solution for are the following: What is design dependent adjustment (supplier dependent and worker dependent are separated)? How can these be measured?

3.3 Ergonomic restrictions

It is found through research (Engström and Karlsson 1982) that ergonomic problems in assembly work are of three different kinds; shoulder joints, elbow joints and back. These problems are connected to short cycle time. Longer cycle time "solves" the problems of bad working positions with high amount of injuries. The worker gets exercise by changing positions during the cycle. Women have on the average 50 % of the men´s power in the upper body and consequently significantly more women have problems in assembly work.

If the cycle time is 5 times longer the worker gets 3 times stronger.

Easily made changes in design, like replacing a slotted screw by a rivet can eliminate unsuitable working loads.

A short cycle-time (Engström and Karlsson 1982) is the most frequent reason why women and persons with minor disabilities cannot work at a certain work-place.

An extension of cycle-time usually means that neither auxiliary lifts nor mechanization of certain processes are necessary. We shall present two examples of this. In diesel engine assembly on an undriven line, next diesel-pump, weighing 20 kg, at table level in a fixture is selected every 10 minutes by the worker. The low frequency and the use of a male worker, with a "strong" grip, means that there is no ergonomic problem and no need for auxiliary lifter or other mechanization.

Alongside gear-box assembly, some renovated gear-boxes are assembled by single workers in a parallel system. Conventionally the cogs are forced onto the axles by a hydraulic press. In the parallel system, the workers use a pipe and a hammer to push on the cogs. The long cycle time obviates the need for a press. The low frequency during the cycle means a low risk of injury and time won by mechanization is negligible. A short cycle time gives a high frequency which in turn means a need for mechanization, partly for ergonomic reasons and partly for economic reasons.

Note that a short cycle time is a consequence of straight base-object flow. In Sweden the workers´ safety board´s publications and education programes for technicians, foremen, and safety stewards, in combination with an expanded company health service has stimulated the development of increasingly better work-places.

To design auxiliary equipment which at the same time fulfils demands for technical autonomy and ergonomics is a prerequisite for improved production systems.

3.4 Variants and mechanization

For reasons of competition it can be expected that the number of variants will grow even more. Such a development demands the creation of an alternative to the line.

When the lot increases and the number of variants decreases, a high degree of automation is advantageous in the manufacture of components or automation of assembly of for example, ball-point pens. When the number of variants is large and the lot size is small, automation is not motivated such as in assembly of yachts. Line based production has been in a middle field which makes if unbigious from an automatization perspective.

The increased resource demand that the variants make in final assembly can be offset by strategic design changes and adapted production systems.

3.5 Disturbance graphs and mechanization

When looking at the characteristics of a highly mechanized production system this can be done by using disturbance graphs (Svensson 1981) analysing the equipment with regard to the art and the number of stops and the time used for repairing. These disturbance graphs form a base for decisions on what type of maintenance the work group could carry out and the use of parallelized equipment instead of a material buffer before and after the equipment (Svensson 1980).

Generally speaking if equipment shows a disturbance graph with a high frequency of short stops it is probably profitable to decentralize the maintenance to the working group. It equipment shows a disturbance graph type with few but long stops, it is doubtful (maybe unwise) to decentralize the maintenance.

Bennet and Jenney (1979) have made studies on different types of equipment and divided the equipment into four different categories:
- mechanical equipment
- electrical equipment
- electronical equipment
- hydraulic equipment

Their studies show that there are differencies between the four categories with regard to time of repair, frequency of stops (time between the repairs) and search time for finding the cause of the stop.

It is clear that mechanization restricts organizational forms.

3.6 Design organization - a case study of the development of a car instrument panel

The work took 3 years. This was a short time, according to the project leader. 15 designers were involved, and, at times, 2-3 production engineers. With low-frequency contacts with companies for purchasing, material, and service (principally quality). The work was carried out in parallel by two groups. The project leader followed the panel all the way to the production stage. Clear demands (9 in all) were made by the project leader. Examples of demands are improved ergonomics during final assembly and a short assembly time.

The chosen system with a project leader able to balance the climate system group against the panel group was very efficient but tended to increase responsibility of the project leader. Everyone sat in the same room and there were daily meetings. The only creativity method employed was brainstorming where participants were few and chosen for their experience of respective problems.

The personnel had great freedom to exercise their creativity freely within the targets, which according to the project leader, is an efficient method.

From experience, it can be said that combining several functions for each component leads to advantages regarding quality, dimensions, price, short assembly time, simpler purchasing and administration. The economic improvements from integration of several functions were clenest visible for small components in this case. For this reason the ultimately chosen panel consisted of several highly integrated "islands" kept together by putty (function joining material consisting of plastic and metal 50/50). Solutions with clips were tried but fell off after little use. Experience also shows that it is more efficient go give individual designers responsibility for larger pieces. At Jonsereds chain-saws one designer carried out the design of a complete chain-saw. In this case low weight and low price was given such a high priority that the amount of work needed to meet the specifications made it impossible for one designer to do the job and thus only a parallel organization became feasible. Prototype tools are now made and tested by the suppliers for better precision (as opposed to previous direct production).

This case shows that product designs with ease of production in mind can be made by suitable organization in the category of company which can support a design department > 40 persons, but still is too small for pilot plants.

4 METHOD FOR DEVELOPING AND ANALYZING ALTERNATIVE PRODUCTION SYSTEMS

To make it possible to describe the range of feasible alternative solutions in automobile production, we have formulated the following model.

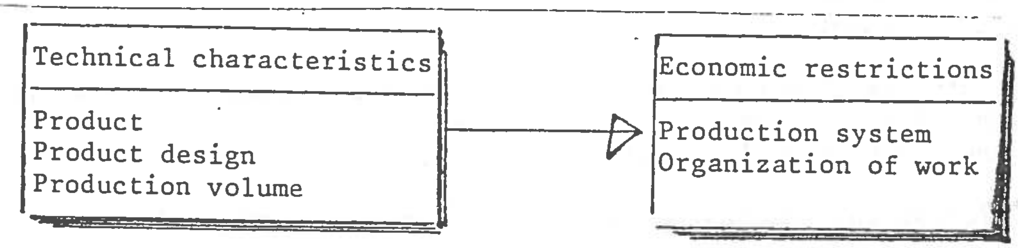

Figure 3 Development and analysis model.

On the basis of fixed technical characteristics, work organization is liable to vary due to layout, level of mechanization, quality of personnel, kind of labour relations, etc. The scope of variations are limited by economic considerations.

The model can also be presented as:

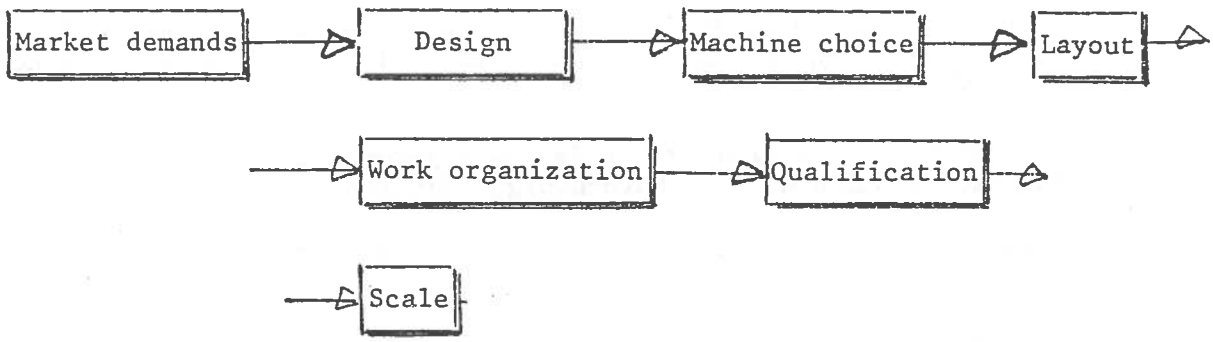

Figure 5 Development and analysis model.

To apply the model, freedom and restriction in regard to other production systems must be clearly defined.

Each article present in a chosen product must first be classified according to manufacturing technique, design and machine choice. In the next stage work organization and qualification are analysed.

When the restrictions of possible solutions have been clarified the economy of scale can be analysed. If the resource consumption for the chosen systems is put in relation to a hypothetical, resource-minimized system (0-system calculation) the economy of scale can be described.

If the study is to be made with the allocated resources, the product used as a starting point must not be too complicated. As a suggestion one can start by a study of a 3-wheeled automobile such as Ford Ghia Cockpit and the analysis could then stepwise be extrapolated towards more complex automobiles such as a Mercedes or similar car.

LITERATURE

Bennet, D J & Jenney, B W, (1979) Reliability: Its Implications in Production System. Design. Omega Vol 8, No 4, 443-440.

Engström, T, Assembly system 1982, Chalmers University of Technology, (unpublished).

Engström, T, Karlsson, U, Alternative production system to assembly line, a problem concerning material supply, VI Int conference of prod research, 267, 1981.

Karlsson, U, Alternativa produktionssystem till lineproduktion, Dept of Sociology, University of Gothenburg, 1979 (doctoral thesis).

Karlsson, U, Production system evaluation, 1981, Chalmers University of Technology, Gothenburg.

Luke, H D, (1972), Automation for Productivity, Beker and Hayes, New York.

Murrell, K F H, Operator variability and its industrial consequences, Int J of Prod Research: 1, 39, 1962.

Svensson, L, Utvidgat arbetsområde - rapport 1 (not published), IMIT, Gothenburg.

Thorsrud, E & Emery, F E, Medinflytande och engagemang i arbetet, Stockholm 1969, SAF.

Turner, A N & Lawrence, P R, The industrial jobs and the worker, Boston 1965, Harvard University Press.