ICPR'81
VI INTERNATIONAL CONFERENCE ON PRODUCTION RESEARCH
Novi Sad, Yugoslavia, August 24-29, 1981

EFFECTIVENESS, QUALITY AND HUMANITY OF PRODUCTION SYSTEMS

— PROCEEDINGS —

Vol. 1: EFFECTIVENESS OF PRODUCTION SYSTEMS

Edited
by
D. M. Zelenović
University of Novi Sad
Yugoslavia

Novi Sad, 1981

ALTERNATIVE PRODUCTION SYSTEM TO ASSEMBLY LINE A PROBLEM CONCERNING MATERIAL SUPPLY

by

Tomas Engström

Head of Material Handling Research Group, Department of Transportation and Logistics,
Chalmers University of Technology, 412 96 GOTEBORG, Sweden

Ulf Karlsson,

Associate Prof.
Department of Industrial Management, Chalmers University of Technology,
412 96 GOTEBORG, Sweden

1 INTRODUCTION

Main goals for a good assembly system are:

- Lower production costs
- Flexibility in production volume
- Custom build products
- Good economics
- Meaningful work content
- Group work with profit-center for every group

Earlier research in Sweden (Karlsson 1979) has showed that the combination of high production flow, a lot of material supply and medium to large products has been impossible to solve without line assembly. With high flow and large products it has been possible to solve (i e Saab-Scania car body shop and Daimler-Benz - Truck cabin body shop). The problem with parallel material supply is space for the material container at the work station, which gives extra cost for transport, building and capital bound in material. This research started in January 1978. The project is sponsored by the National Swedish Board for Technical Development. The main objects that have been studied are cars, buses and trucks from Saab-Scania and Volvo. But other products have been analysed, forklift trucks, vacuum cleaners, stoves, refrigerators, dishwashers, sailing-boats, motorsaws and lawnmowers. The analysis has been focused on four topics:

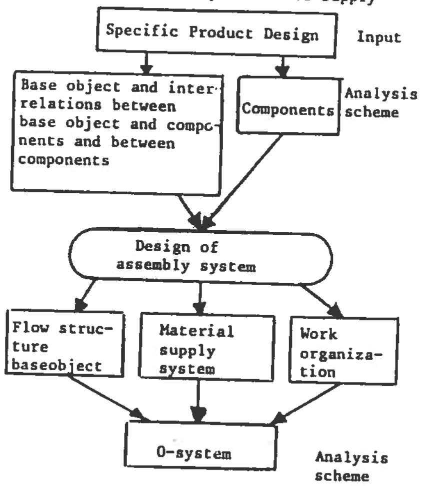
1 Product design
2 Layout
3 Materials supply
4 Work organization

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.

In our research we found that the design of the product was a very important dimension that in some cases dominated the material supply and work operations totally. We then started to analyse which relations there were between the product and the material supply system. We can say that a classification of this type will lead to trying to change the product design in specific ways to get a "better" material supply and baseobject flow system. Will this "better" system also give a "better" work organization and a "better" system of work ergonomics? To answer these questions we found that we needed a model for social and economic evaluations. The social evaluation model was already developed by Karlsson (1979) and the first step to an economic evaluation model was taken by the same author. But what we needed was an economic model that would compare different assembly systems as well as compare the systems to a theoretical zerosystem. Karlsson had developed a zero-system for working time at assembly lines based on research from Wild (1975) and the evaluation of a parallel system for car bodys at Saab-Scania in Trollhättan. To establish a model for system design of a specific product we made up the following chart below.
The classification scheme for the product design is the following list for each component. We call it component analysis (Engström 1981).

- Form-volume (cylinder box or specific)
- Stiffness
- Need of specific care (glass or painted surface
- Preassembled or not
- Number/baseobject

- Variant (replace or extra)
- Type of fittings/number of fittings
- Need for specific tools
- Palett, box or synchronized supply



For the analysis of the baseobject and its relation to components and between components we made a specific scheme. We call this analysis design analysis (Engström 1981). It consists of:

1 Assembly time and adjustment time
2 Degree of possible preassembly
3 Degree of sequence bound assembly
4 Assembly direction in relation to sequence bound
5 Variant places in the assembly system

FLOW PATTERN FOR BASEOBJECT

Practical alternative mass production systems which has been developed are manual lines with buffer stocks, parallel systems, collective systems and combinations of these (Wild 1975).

MATERIAL SUPPLY

There are three different types of material supply (besides the conventional supply systems) (Engström 1981).

1 Components loaded together with base object
2 Material market or islands. This means that the worker has a decentralized store where he can fetch the material in a supermarket wagon, but sometimes it is possible to go directly to the store.
3 Marriage point.

1 and 2 are suitable for parallel stations. 3 for short lines (one station).

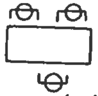
There is a great freedom to design the material supply system. We have found that in a lot of cases a longer cycle time makes it possible to use manual wagons (can get material to more than one object and to more than one worker as well as specific wagons for specific material) in combination with other equipment (autocarriers or forklifts).

THE ECONOMICAL ZERO-SYSTEM CALCULATION

We have started with two restrictions:

1 Possible cycletime with 115 MTM within max 8 weeks training. (We will get back to this later.)
2 Number of workers working on one product at the same time.

Example: In trucks learning time is 4-8 weeks for a work cycle of 120 minutes at 115 MTM. Possible number of workers is 3. The maximum stations than is:



Cycle time C = 120 minutes

This restriction is from the type of product and the cost for training of workers. By empiric data the following is known:

Number of workers/ baseobject	Cycle-time	Work speed	Learning time
8 m sailing yacht 2 persons	12,5 h	95 MTM	1-3 weeks
Truck or bus chassi 3 persons	2 h	115 MTM	4-8 weeks
Passenger car 2,5 persons	20 min	112 MTM	3-6 weeks
Stove, engine, gearbox 1 person	10 min	112 MTM	1-3 weeks

The pedagogical research is insignificant in this area but there are some factors that influence the learning time. (Karlsson 1981).

For a specific baseobject there is "maximum station" restricted by cycle time and number of workers. This station is the base for the calculation of the zerosystem. We have an assembly unbalanced time for the base-object. This time is the chosen MTM-time (for example 115 MTM). The time in minutes are the zero-unit for work cost. This maximum work time is 100% (or salary money). From this level we can compare assembly systems. Upon this 100% we get (A) losses in manpower.

1 Balance loss +?%
2 Variant loss +?%
3 System loss +?%
 - inspection people
 - adjustment people
 - instructors
4 Handling loss +?% (higher by shorter cycle time)
5 Replacement pool losses +?% (when replacement is not in work)
6 Material supply loss +?%
7 Maintenance loss +?%

Losses in manpower (need for extra people) is high in line production. For example; only balance loss, system loss and handling loss = 67% (Karlsson 1979) at welding and grinding cars body lines. Inefficient material supply and sophisticated mechanical equipment gives extra need for manpower in material supply and maintenance.

The zero-unit for capital loss is the cost for the base-object and the cost for the supply material x 0,67 (no material in the beginning of the assembly and all in the end of the assembly) during the unbalanced assembly time/number of workers/objects. This cost is of course depending of the internal percent interest and is 100% (or money). Upon this 100% we get (B) capital losses.

I Capital loss in equipment
 1 Building space
 2 Assembly equipment
  - tools, jigs
  - supply material equipment (lifters)
  - baseobject handling equipment
  - maintenance equipment (spare parts, tools)
 3 Transportation and store equipment
  - transport (cars, forklifts)
  - store (paletts, boxes, lifters)
  - maintenance equipment

II Capital loss in material
 1 At the work stations
 2 In buffer stocks of baseobject in different stages
 3 In the store

III Other capital losses
 1 Production stability and flexibility
  - lost production
  - cost for change in production volume;
   · learning time
   · balance work
   · overtime work
   · absenteeism
   · quality level
   · variant capacity
 2 Work organization - conflict frequency
  - quality between departments
  - waiting time of material, transport, maintenance, rigging
 3 Learning cost
  - primary work
  - secundary work (job integration - quality inspection, maintenance etc)
 4 Cost for labour turn over

Now we have the calculation model.

Unbalanced assembly time in minutes (work speed in MTM)
Number of workers per object
Possible cycle time in minutes
} Constant data in

Production rate objects/hour variable data in.

Losses manpower and capital data out.

By changing the production rate we also get an instrument to measure the scale economy and where mechanization is profitable. We also get indicators for changes in the product design, the work organization, the material supply system and the flow structure.

As we can see the product design is the base for possible system design and the production costs.

SOCIAL ASPECTS

We now get to the social evaluations. There are a few examples from the litterature how to operationalize a meaningful work task. Turner & Lawrence (1966) Emery & Thorsrud (1969) Huse (1975) tried to establish evaluation models. Karlsson (1979) has developed these models into the following four dimensions:

1 Variety
2 Autonomy
3 Responsibility
4 Feedback

Variety are of two different kinds. Object variety which means the total varieties; different jobs, different functions and different places. This is the satisfaction variety. Motor varieties, which means different movements during a work cycle or job rotation on similar jobs but with different movements (for example load a machine with the right hand in the morning and another machine with the left hand in the afternoon).

Autonomy are also of two different kinds. Technical autonomy which means that the worker can work unpaced and leave the work station whenever he wants. Technical autonomy is necessary for administrative autonomy. At a machinepaced job there is nothing to administrate because the machine administrates the worker.

Administrative autonomy means the possibility to administrate the work by the worker himself or by the work group. This autonomy contains one "vertical" and one horisontal aspect. The vertical concerns the relationship between workers and their superiors, especially for foreman. The horisontal aspect concerns the relationship of the worker's tasks to other functions in the company such as transport, maintenance, inspection and adjustment. If the worker or the work group takes over a lot of horisontal and vertical work (administrative autonomy) they must take responsibility for both quantity and quality. Responsibility gives work load, a work stimulation and freedom. Responsibility is the cost for freedom. To have responsibility you need feed-back. In work shops this should be within a day. This means that the worker should know his quantity and this quality in specific terms not bad or good.

When meaningful jobs are discussed people often think that cycletime is of great importance. This is wrong because it is the total variation that is important and that autonomy is more important than variation, see Karlsson (1979).

ERGONOMIC ASPECTS

We have found out that ergonomic problems in assembly work are of three different sorts, shoulder load, elbow load and back load by bad working position. All these workloads are connected to short cycle time. Longer cycle time solves the problem of bad working positions. The worker gets exercise by changing positions during the cycle. Women who have on the average 50% of men power in the upper body have today large problems in assembly work. A change to longer work cycles will mean a solution to this problem.

CONCLUSION

By using a method for analyzing the product design (Engström 1981) we have a method for design of the material supply system and the base object flow pattern for different products. By using the zero-calculation system we have a possibility to compare different systems with the zero-system. By using the evaluation model for meaningful work we can create better work conditions. It is hoped that the models developed here will aid the production systems designer. In the future we hope to go deeper into concepts about products for lower production costs.

REFERENCES

T Engström. Assembly system 1981 (doctoral thesis), Chalmers University of Technology/ in press.

E Huse. Organizational development and change, St Paul 1975, West corp.

J R de Jong. Fertigkeit, Stuck und benötige Zeit, Darmstadt 1960, REFA.

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

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

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

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

R Wild. Mass production in engineering, Int J Prod Res, 5, 533, 1974. On selection of Mass production systems, Int. J Prod Res, 5, 443, 1975.

R Wild and N D Slack. The operating characteristics of single and double nonmechanical flow line systems, Int J Prod Res 2, 139, 1971. Production flow line and "collective" working a comparison,. Int J Prod Res 4, 411, 1975.

A N Turner and P R Lawrence. The Industrial Jobs and the Worker, Boston 1965, Harvard University Press.