VOLUME 1

ORGANIZATIONAL DESIGN AND MANAGEMENT

TAMPERE

VOLUME 1

From Experience to Innovation

PROCEEDINGS

of the 13th Triennial Congress of the International Ergonomics Association Tampere, Finland 1997

Organizational design and management

Empirical Analysis and Assessment of Automotive Assembly Work: An analysis procedure for work efficiency and ergonomic aspects

T. Engström, L. Medbo
Department of Transportation and Logistics, Chalmers University of Technology,
S-412 96 Gothenburg, Sweden

1. Background

Work in autonomous work groups is sometimes called "collective working" to emphasise the fact that operators work together on one or more products, controlling product flow and having common responsibility for production output as well as product quality. Note that efficient "collective working" requires that the product is of sufficient size, or available in sufficient quantity, so that the operators do not block each other during the work. The efficiency of assembly-lines and collective working with regard to idle time, amount of work in progress and production output (or conversely space required) has been demonstrated by simulation research (Wild 1975). Wild originally formulated and established the theoretical frames of reference for what is sometimes referred to as analysis of production losses, or loss analysis. To summarise very briefly the discourse concerning efficiency of an assembly system design, Wild's research indicates that, for a given total space allocation and a given number of operators, an assembly system with autonomous work groups, having a sufficient number of products available to work on, operates with less idle time than an equivalent assembly-line system. This line of reasoning might seem pretentious for the uninitiated. Are there any detailed shop floor data available supporting this argumentation and do such data imply a more general analysis procedure? For this reason we have made some documentation and analyses of the assembly work at two different assembly systems with quite similar production principles, using e.g. collective working based on video recordings in order to illustrate an analysis procedure based on detailed shop floor information. The plants are denoted Assembly system A and Assembly system B.

2. Method

Within the context of our research and development work in co-operation with the Swedish automotive industry we were able some years ago to video-record full-pace assembly work on automotive products in Assembly system A using one camcorder for each operator. In order to analyse this and similar materials from other assembly systems and applications we have developed a specialised equipment consisting of a computer synchronised video recorder. This equipment enabled us to define appropriate activities and to register these activities as a file with unambiguous and precise connection to the video tape through time coding, according to a general method for data collection and analysis developed by Engström and Medbo (1995). This equipment has made it possible for us to: (1) Let the recorded operators themselves perform the analysis, (2) Perform the analysis quickly. It has proved possible to perform an analysis of 20 different types of activity in real time, i.e. the analysis requires as much time as the video recording, (3) Repeat the analysis at the same or at a more detailed level, as well as add other types of information to the data file and (4) Perform parallel analyses, e.g. time-and-motion analyses, loss analyses (Wild 1975) and ergonomic analyses. Specific ergonomic evaluation methods, such as the "cube model" (Sperling et al. 1993) focused on force used, work postures and time, or the OWAS work posture classification (Karhu, Kansi and Kourinka 1997) can be used in this connection as is illustrated by Engström and Medbo (1994). The analysis and assessment of assembly work are thereby facilitated by the "true" shop floor data thus obtained. By contrast, production engineers traditionally use mean operation times based on time-and-motion studies, neglecting the effects of variation between and within operators, products and types of equipment. In practice this is important since differences in time required for assembly work depending on e.g. the choice of material feeding technique due to traditional line feeding technique or kitting of materials as is required in some alternative assembly system, are not easily allowed for in e.g. traditional time-and-motion studies.

3. Results

The data collection from the two assembly systems were made by ourselves in co-operation with the employees and was performed on three different occasions. Namely on one occasion some years ago (1992 – 1993) and on two more occasion recently (1995 – 96). The automotive products studied at full pace production were two different models. To make it possible to compare assembly systems producing different models, we have in the analysis below normalised the observed assembly work according to the direct assembly work of the products, i.e. assembly and connecting work (i.e. pipes and leadings alredy fitted). This analysis also includes handling of materials and tools at the working position, i.e. the position along the products where the respective assembly was performed, in order to make an equitable comparison using the Assembly system A observation as reference for the design of Assembly system B, as illustrated in figure 1.

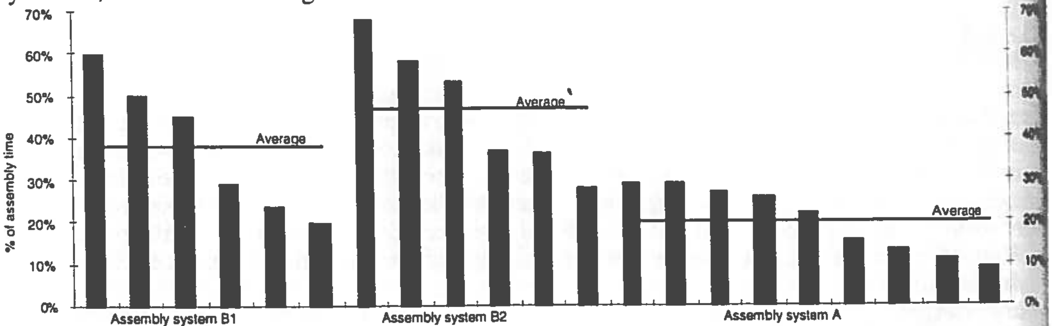


Figure 1. Compilation of video registered indirect assembly work in Assembly system B on two occasions recently and Assembly system A some years ago referenced to direct assembly work. The observed work is based on activities classified according to figure 2. The compilation contains registration of 21 work modules of approximately 100 minutes cycle time (i.e. each bar in the diagram). The diagram is normalised according to the direct assembly time.

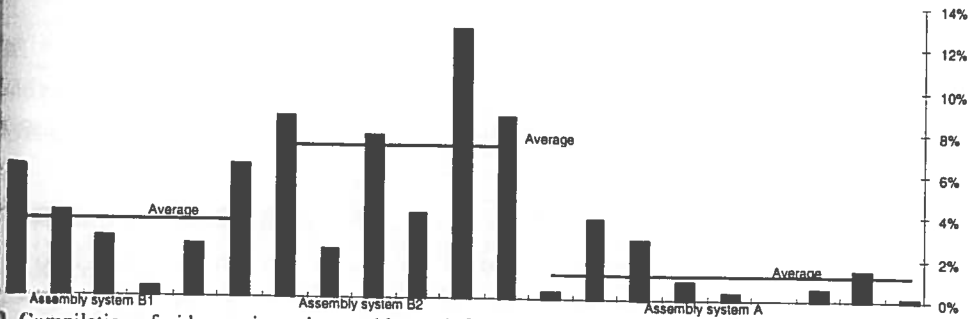
The difference in the design of the product as well as further development of the material feeding technique has contributed to differences in design of the two assembly systems. In Assembly system A the complete product was assembled within the same work group performing collective working and all materials were supplied as kits. In Assembly system B, on the other hand, the assembly work was divided into equal parts between two work groups performing collective working in pairs and having a "combined" materials feeding technique consisting of two kitting techniques and direct batching.

CLASSES OF WORK:	ACTIVITIES AND SOME COMMENTS:
1 Direct assembly work;	1.1 assembly work in the form of fitting including connecting of pipes and leading already fitted, as well as the handling of components and tools in "work position" and 1.2 "direct" adjustment. i.e. adjust the components direclty after the fitting
2 Indirect assembly work;	2.1 fetching and leaving tools, 2.2 fetching and leaving components from the kitting fixtures, 2.3 fetching and leaving components from materials containers
3 Materials handling work;	3.1 moving the product around, 3.2 moving the kitt and materials containers around and 3.2 adjustment after fitting according to 1
4 Miscellaneous work;	4.1 documenting specific fittings, 4.2 reading and making notes in the assembly instructions and 4.3 various tasks
5 Disturbances;	5.1 waiting for co-operators, 5.2 waiting for equipment and tools, 5.3 waiting for materials, materials missing, inferior or broken, 5.4 private conversation or disturbance caused by the video recorder, 5.5 asking or discussing with colleagues comering specific details of the assembly procedure, 5.6 various disturbances and 5.7 parts on the video recording which could not be analysed

Figure 2. Classification of the assembly work registered by video recordings. Classes 2 – 4 together represent indirect assembly work. This classification is identical and we have used exactly the same analysis procedure for all observations reported in this paper

The diagrams in figures 1 and 2 are a result of the data collection described above. The classification differentiates between; (1) direct assembly work, (2) indirect assembly work, (3) materials handling work, (4) miscellaneous work and (5) disturbances, as is evident from figure 2. It is a compilation of video registration of totally 21 work modules of approximately 100

...cycle time, i.e. one operator's task on one product. The classification into activities has ... designed in co-operation with the Assembly system B's employees to be a tool in the ..., evaluation and development of the assembly system as well as to explain the questions ...ed in comparing parallel and serial assembly systems,. as has been done by e.g. Wild (1975), developed further by Engström and Karlsson (1981). Figure 1 illustrates the possibility ... Assembly system A data as reference for the Assembly system B, since they both use ... production principles, e.g. collective working. The figure shows that the indirect ...bly work, indicated (2 – 4) in figure 2, still has a higher level at Assembly system B. An ...ysis of the different classes of assembly work will indicate why this is the case. In figure 3 ...ve specifically magnified a compilation of the activity "fetching and leaving tools".



...3. Compilation of video registered assembly work focused on the activity "fetching and leaving tools" as ... of indirect assembly work presented in figure 1.

...e diagrams in figures 1 and 3 show e.g: (1) The wide variation in the classified activities ...rved. Thereby further, more detailed, analyses of this type of assembly work are necessary ... the future from both a scientific and a practitioner's point of view, (2) Waiting times due to ...mbly system design in the form of e.g. waiting for tools, inferior materials feeding ...niques, the sharing of tools, etc and (3) Suitable intra-group work patterns including ...ision of labour. It is of course also possible, as has in fact been the case during full pace ...ing in Assembly system B, to use the video recordings and the proposed analysis procedure ... obtain information on e.g. whether an operator is able to work without being disturbed and if ... why and for how long are, for example, waiting times caused by product, process or ...rator variations, etc. Thus it is possible to map the true reasons for productivity ...rovement, etc, an analysis procedure which is possible to use during the design and ...ning-in phases of an assembly system.

... Comments

The results presented above imply a general analysis procedure. Thereby developing the loss ...lysis still further by taking advantage of modern computer technology in the form of a ...mbined video-personal computer equipment for data collection and analysis – a procedure ...hich quite easily will amalgamate both technical and ergonomic aspects of the shop floor work ... order to analyse e.g. alternative assembly systems. This in order to once and for all clear up ...me of the public vagueness concerning efficiency and human aspects of the early Swedish ...periences of assembly system design by detailing the early research by Wild (1975) with true ...op floor data. Thereby perhaps implying a more general analysis procedure.

...ferences

Engström T, Karlsson U. (1981). "Alternative Production System to Assembly Line – A Problem ...cerning Material Supply". Presented at VI International Conference on Production Research, Novi Sad ...1. Proceedings pp 266 – 270.

Engström T, Medbo P (1994). "Datainsamling och analys av serieproduktionsystem genom att kombinera ...eo- och persondatorteknik". Genomförande av förändring, Palmerud G (ed.). Nordiska Ergonomisällskapets Årskonferens, Stenungsund, Proceedings pp 262 – 265 (in Swedish).

Karhu, O, Kansi P, Kourinka I (1977). "Correcting Working Postures in Industry, a Practical Method for Analysis". Applied Ergonomics, Vol 8, No 4, pp 46 – 201.

Sperling L, Dahlman S, Wikström L, Kilbom Å, Kadefors R (1993). "A Cube Model for the Classification of Work with Hand Tools and the Formulation of Functional Requirements". Applied Ergonomics, Vol 24, No 3, pp 212 – 220.

Wild R. 1975. On the Selection of Mass Production Systems. International Journal Production Research, Vol. 13, No. 5, pp 443 – 461.