Comparison of Management Practices between Sweden and Japan
Programme

Seminar in Osaka, Japan, 22 – 25 November 2000
Osaka University of Economics, Faculty of Information Management

22nd (Wednesday)
9:30～12:00 Visit to Daihatu Ikeda Plant
– Light Passenger Car Assembly Line and Midjet Atelier

Opening of the Seminar

14:00 Introduction: Local Organizer

14:30～16:00 Issue I
Tetsuro Nakaoka (Osaka University of Economics)
"Skill Formation in Japanese Automobile Manufacturing Lines"

Lennart Nilsson (Göteborg University)
"Learning Strategies in order to support Production Concept and create Competence in relation to Different Kind of Work Organization on the Production Line"

- - Coffee Break (30 min.) - -

16:30～18:00 Issue II
Tomas Engström and Lars Medbo (Chalmers University of Technology)
"Summarizing Merits and Malfunctions of Parallel Flow Assembly Systems – Some experiences from substitution of assembly line"

Hikaru Nohara (Hiroshima University)
"Convergence and Divergence between Japanese Model and Swedish Model"

18:30～ Welcome Party

23rd (Thursday)
9:30～11 : 00 Issue III
Tomas Engström (Chalmers University of Technology) and **Lennart Nilsson** (Göteborg University)
"Explaining and Reporting on Learning and Assembly Performance in Parallel Flow Assembly Systems –Practical and theoretical frames of references"

Mikael Wickelgren (Göteborg University)
"The Role of Emotionality in Product-development in the Car-industry"

- - Coffee Break (30 min.) - -

11:30～13:00 Issue IV
Lars Medbo (Chalmers University of Technology)
"Material Supply, Product and Product Descriptions for Assembly System Design – Experiences from design and operation of some Swedish assembly systems"

Koichi Shimizu (Okayama University)
"New Simultaneous Engineering and Skill Formation at Assembly Shops"

- - Lunch (1 hour and half) - -

SUMMARISING SOME MERITS AND MALFUNCTIONS OF PARALLEL PRODUCT FLOW ASSEMBLY SYSTEMS – SOME EXPERIENCES FROM SUBSTITUTION OF THE ASSEMBLY LINE"

Main topic: Work organisation on the production line

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Abstract:

This paper report on practical end theoretical frames of references as well experiences from design and running in of unorthodox assembly systems, i.e. parallel product flow assembly systems utilising long cycle time assembly work. This summarisation comprise an introduction, explaining the time losses in line assembly, explaining production principles and effects of their practical applications and explaining some intriguing effects and facts. The two last sections deals with merits and malfunctions of the unorthodox assembly systems discussed. The paper also include selected examples which illuminates facts and arguments developed in this paper

1 INTRODUCTION

The authors with more than two decades experiences from research and development work within the Swedish automotive industry has emphasised the need to clarify, and summarise merits and malfunctions of parallel product flow assembly systems utilising long cycle time assembly work. This since, which might turn out as puzzling statement for the uninitiated reader, the design process and actual end result of many Swedish initiative to improve the assembly work and respectively assembly systems designs within the automotive are by no means a rational process. This might be an insight gained by experienced engineers, while there is a tendency among e.g. social scientists to over-interpret the rationally of assembly system design processes. Albeit various speculations and hypothesis are an integrate part of all scientists professional life.

It may be argued, though, that in reality large-scale industrial design processes do not commonly proceed as "rational" concept-driven processes. This was for example the case for the Volvo Uddevalla plant which assembled automobiles during 1993 – 1993 (later recreated as the AutoNova plant in 1995), and the design of the early Japanese "lean production" plants was similarly not a concept-driven process, as documented by Ohno (1988). In both cases, design elements that fitted in with previous commitments and external contingencies were successively added, generating a reasonably integrated production system. And in both cases, somewhat pretentious labels – "lean production" (Womack, Jones and Roos 1990) and "reflective production" (Ellegård et al. 1992) – have been coined in retrospect, elevating clusters of production practices to general production concepts.

Thus, while neither of the two design processes referred to was concept-driven as is have been argued by Ellegård (1989) and Granath (1991), there is some justification for characterising both as concept-generating design processes, i.e. design processes generating new production concepts rather than implementing pre-existing ones. This discourse is further explained by Engström, Jonsson and Medbo (1998) who in detail explains why that the final design of this specific plant was in many respects a inevitable design process. That is, arguing that the design of the Volvo Uddevalla plant may be described as a process with an "internal logic" in which design options were successively eliminated through irreversible design decisions until only one alternative remained. An unorthodox alternative comprising, among other things, long cycle time assembly work never used before for full-scale production of automobiles.

The sometimes controversial question of efficiency versus humanisation of the assembly work have of course been severely debated among the practitioners during the authors two decades of experiences. In this respect, to be fair it ought to be noted that, even thought, practically proved and theoretically explained, the performance aspects of parallel product flow assembly systems have not been accepted among most practitioners within the automotive industry. The positive effect of increased efficiency in relation to traditional assembly systems has in one case been noted as puzzling, explicitly underlining the lack of a explanation from the traditional theoretical frames of references (Eckerström and Södahl 1981). On the other hand, in some cases has in depth theoretical analysis been carried trough underlining the potentials available in parallel product flow assembly systems (Rosengren 1974; Wild 1975).

> Example 1: Assembly operators thus proved to be able to perform long cycle times (80 – 100 minutes) assembly work at a high work pace, and the work pace did not drop significantly even for extremely long cycle times. Even the results of the analysis of automobiles assembled entirely by two female operators (with a mean cycle times in excess of 300 minutes) observed a high work pace in relation to the one stipulated by the motion-and time-studies. A work pace higher than stipulated was also noted for all nine observed automobiles. As shown in Figure 1, their work pace did not differ significantly from that of operators with mean cycle time of 80 – 100 minutes.

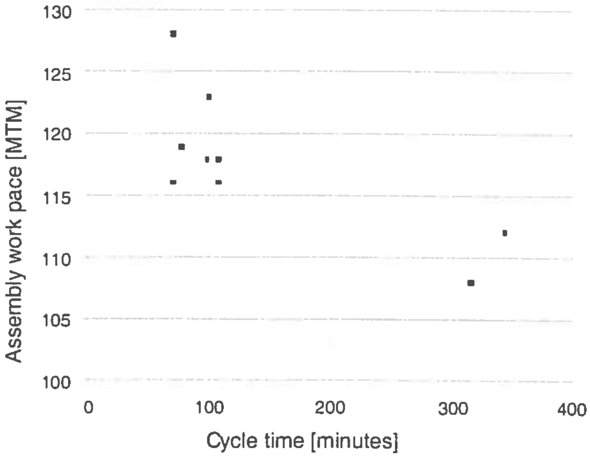

Figure 1. Assembly work pace for complete automobiles as a function of normalised cycle time in the Volvo Uddevalla plant. The diagram illustrates that even for long cycle times of

approximately 320 minutes (i.e. the two females completing their own automobiles) operators had a high work pace. 100% equals normal work pace. Source of data: the author's video recordings and the Volvo Uddevalla archive according to Engström, Jonsson and Medbo (1996 and 1999).

2 TIME LOSSES IN LINE ASSEMBLY VERSUS PARALLEL PRODUCT FLOW ASSEMBLY SYSTEMS – SOME BASIC FRAMES OF REFERENCES

Traditionally, production engineers use mean operation times based on time-and-motion studies when determining cycle times, thereby neglecting the fact that operators have an inherent variation in pace and efficiency in the performance of repetitive work. Such variation in time required for assembly work occurs both as inter-operator variation and as intra-operator variation, i.e. variation between operators on the same assembly line as well as variation between successive work cycles for a particular operator. Furthermore, the amount of assembly work to be performed at each workstation will vary between work cycles and workstations due to different product variants. There will also be process variation due to tools and mechanised equipment etc.

In line assembly, inter-operator or intra-operator variation are normally not accounted. As a result, if the time the product is available at a workstation is equal to the mean time needed to complete the work tasks assigned to that workstation, meaning that inter-operator and intra-operator variation is neglected, idle operator time will occur in some cases while unfinished work will result in other cases. If the production pace is increased, idle time will decrease but unfinished work will increase; if the production pace is decreased, unfinished work will decrease but idle time will increase. (The allocation of work tasks to workstations is often based on the product variant requiring most work, i.e. the most time consuming product variant will pace the product flow.)

The important conclusion is that line assembly systems – in fact any assembly systems that fail to accommodate inter-operator and intra-operator variation – generate idle operator time and/or need for re-work. In both cases, time is lost, that is productivity suffers (Wild 1975; Rosengren 1982).

3 PRODUCTION PRINCIPLES AND EFFECTS OF PARALLEL PRODUCT FLOW ASSEMBLY SYSTEMS – SOME MERITS

The production principles implemented at the defunct Volvo Uddevalla and at the Autonova plants are summarised in (A) – (E) below.

(A) Organic product flow pattern and true autonomous group work

This means that a parallel product flow is organised as a successively decreasing flow frequency (analogues to the branches on a tree) and that operators in a work group carries out assembly work on several products simultaneously including integrated workstations for subassemblies. Thus it is possible to vary work methods and work pace, depending on how the assembly work proceeds, independent of other work groups' work status and variation. The number of "assembly active" automobile bodies (i.e. automobiles that are possible to work on) and the "worker density" around these automobile bodies (i.e. the number of operators simultaneously performing assembly work on each automobile) obviously affect the actual production capacity or, conversely, the target assembly time given the target production capacity.[1]

(B) Pre-structured materials supply to individual products

This means that for example larger components with their obvious positions in the product are fed directly to the workstation while the small and medium sized components are delivered as materials kits. [2] For example by means of materials kitting fixtures which, apart from the large components, also may comprise a number of plastic boxes containing medium-sized components as well as plastic bags containing small components. These plastic bags ought to contain the small components (screws, nuts, clips, etc.) needed for specific product taking consideration of to the product design change orders and the spectra of product variants. The potential of pre-structuring of the small components is vital since, among other things, these components represent an extensive share of the total assembly time. Through grouping and structuring them into e.g. plastic bags instead of supplying them en masse, a considerable reduction in materials-handling time is achieved. Moreover, this way of exposing the materials function in itself as a work instruction for the assembly operators.

(C) So-called naturally grouped assembly work

Naturally grouped assembly work means that the traditional disintegration is broken and professional skills created (the characteristics of a skill are: natural rhythm, holistic view, functional grouping and result orientation). The skills involve a number of tasks being combined in work functions (Ellegård, Engström and Nilsson 1991). In practice are the natural relationships between materials display, administrative work description and the method of working preserved. This in turn has led to the development on the shop floor of a professional language and concepts, which draw on the designer's work to a greater extent than usual as is explained further in (D) which underlines the call for an appropriate administrative support and reorganisation.

(D) A reformed product description system

The so-called naturally grouped assembly work calls for reorganised information systems, where information on product and work can be derived from an assembly-oriented product structure and where they are describing the product and work using a number of predefined interrelated "charts" see Engström and Medbo (1992a). The naturally grouped assembly work is thereby

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[1] When individual operators' tasks are machine-paced by an assembly line or due to handling of tools, fixtures, heavy components, etc., the "working-up" potential is restricted. Collective "working-up" may be promoted if a work group as responsibility for quality requirements and can take advantage of the fact that the total assembly and adjustment time is shorter if the components fitted are adjusted directly than if a special operator performs this adjustment or the defective products are left to a rework area (Engström and Karlsson 1981, Karlsson 1979).

[2] For products like automobiles and trucks, the components for approximately one hour´s assembly work could be supplied as materials kit on a standard EUR-pallet. The components are then packed into different standardised packages according to size and appropriate grouping with the possibility to place packages into each other like 'Russian dolls'. This makes it possible to position the materials kit, compact in size, at the work station. Alternatively, the kits could be composed and fetched by co-workers at a convenient moment (Engström and Karlsson, 1981).

supported and formalised by the information system, which is capable of breaking down the product into its smallest physical components. This in order to, in an appropriate way, relate the necessary information to support the long cycle time assembly work (see e.g. Medbo 1994 and 1999).

(E) Materials and production scheduling system based on the principle that products that are similar for assembly purposes are also principally similar when it comes to materials handling aspects and product description including work instructions, so-called assembly variants.

The overall production scheduling system must suite the specific characteristics of the parallel product flow assembly system, where planning as well as the physical flow of materials, most be "organised parallel" in order to avoid e.g. queues as well as "unnecessary" re-sequencing, etc. It is a matter of organising the production scheduling system so that the materials consumption sequence is consistent with the planned sequence. If this is not the case the efficiency potential of the parallel product flow will not be exploited. This can be achieved by utilising a production scheduling system using "assembly variants" (see section 4). A measure that leads to e.g. to reduced buffer volumes, better just-in-time efficiency and a reduced number of product variants (see Engström and Medbo 1992b).

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The application of these production principles (A – E) has in practice lead to the following not obvious, nor initially generally accepted, effects (I) – (II) below.

(I) Reduced space requirements including buffer volumes

Parallel product flow assembly systems will, compared to traditional serial product flow assembly system, have less space requirement. This phenomenon is due to e.g. fewer products are needed to be positioned in intermediate buffers between different production phases or respectively positioned in the adjustment/rectification area. The need for transport aisles for materials and products are reduced since most automobiles are "assembly active" and since the shop floor space required for, e.g. starting and stopping of various transport equipment, are delimited.[3]

(II) Reduced need for expensive tools

Parallel product flow assembly systems will, compared to traditional serial product flow assembly system, have a substantial reduction in need of tools, fixtures and other manufacturing equipment. This phenomenon is due to several reasons. Firstly, due to the fact that: (1) the degree of mechanisation is lowered on account of a greater work content and by the possibility to use less complicated/expensive tools due to the lower frequency of use. Secondly, due to that (2) fewer tools with a fixture function are required, as the assembly operators in the work group commanded the whole tolerance chain and were capable of fixing the component, adjusting its position and finally fitting it to the required torque. Another reason is that (3) expensive production equipment could be utilised jointly by several work groups. Finally, due to that (4) glued components could be fitted using small fixtures with low pressure but were allowed to be

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[3] That is, most products are subjected to assembly work and not moved around inside the plant several times during their assembly (see Engström 1993 for exact figures on space requirement).

applied for a longer period – as opposed to short cycle work and products that move from workstation to workstation, implying that gluing requires high pressure and a short application period.

(III) Increased flexibility leding to e.g. a reduced need for technical production support (i.e. production engineering and supervisory functions)

A parallel product flow assembly system will, correctly designed, have an substantially increased flexibility by various measures such as flexible work scheduling, which in turn leads to shorter lead-times than the traditional serial flow assembly system. Thus e.g. the potential to manufacture customer ordered products with extra short lead times, which have already been sold to the customer, are increased. Flexibility of an assembly systems is even more important today than it was some years ago, due to factors such as greater product variation, shorter lead times, more customer-ordered products, more frequent model changes, etc.[4]

The Volvo Uddevalla plant had thus a flexibility advantage in comparison with a serial product flow assembly system. However, this flexibility was never – neither publicly or within Volvo – recognised, described or utilised as an advantage of the plant, which might come as an surprise for some readers. This flexibility included the ability to manufacture a broad range of products or product variants as well as the ability to easily change the range of products or product variants manufactured in form of e.g. possibility to manufacture short series of special products (like ambulances or police automobiles). The efficient information handling led to speeding up of the time and resources needed to implement a change of model and to effect change orders. In this respect the Volvo Uddevalla plant also proved superior to Volvo's other automobile plants (see figure 3).

> Example 2: The flexibility of the Volvo Uddevalla plant manifested itself in many ways, for example in lower costs in connection with annual model changes as shown in Figure 3. Note that the model change costs per automobile were much lower (approximately 50%) in Volvo Uddevalla plant despite the smaller scale. The comparison concerns the Volvo Uddevalla plant and the serial product flow assembly system in Volvo's main Torslanda plant.

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[4] This flexibility advantage derived from several sources, including those listed: (1) Since assembly was being performed in a number of parallel work groups rather than in a serial product flow, different product models or product variants could be assembled simultaneously in the Uddevalla plant much more easily than in a conventional plant. (2) Similarly, new models or new product variants, as well as pre-series products, could be introduced in one or more work groups without involving or disturbing the others. In a serial product flow system, on the other hand, the introduction of new products involves a reformation of the total assembly system. This requires a substantial amount of work, as well as equipment, to get a smooth product flow through all workstations along a serial product flow. (3) Extended cycle time assembly requires a more knowledgeable work force; this, knowledgeable work force is able to handle diverse and changing products. (4) Parallel product flow assembly requires multi-purpose, non-specialised tools and production equipment; such tools and equipment will not have to be extensively modified when new products are introduced. (5) Parallel product flow, long cycle time assembly work requires an administrative support for materials handling and assembly work in the form of product variant specifications, work instructions, picking lists, etc. designed from the production point of view, which provides an overview of products and product variants. Such an administrative support enhances flexibility.

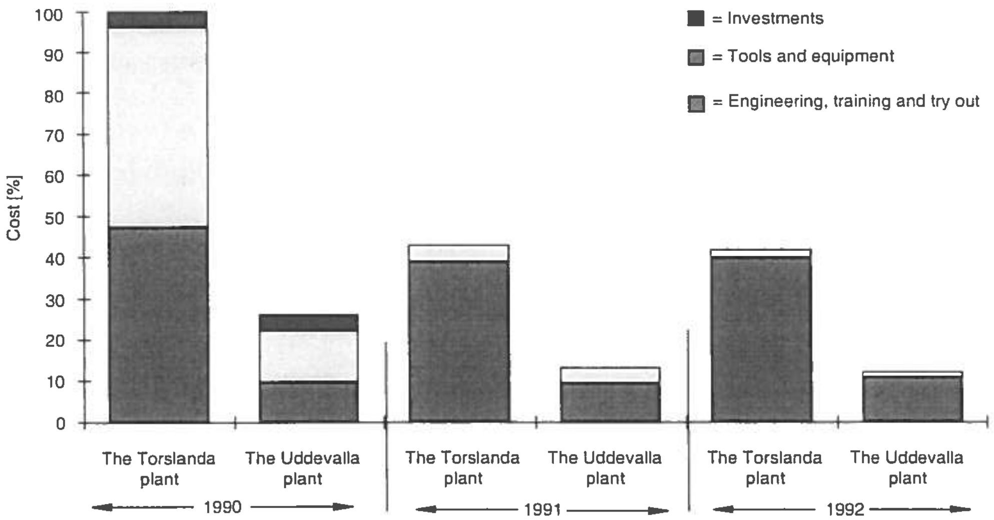

Figure 3. Annual model change cost normalised to 100% total cost of the Volvo Torslanda plant per automobile for the same automobile types (740/940 models) in the Volvo Uddevalla and main Volvo Torslanda final assembly plants during 1990, 1991 and 1992 based on data from Volvo. The Volvo Torslanda plant used a serial product flow assembly system with a approximately 2 minutes' cycle time. [5] In 1990 there was a major model change which explains the high costs for this year. Note that it is foremost the "soft costs" (e.g. engineering, training, etc,) where the parallel product assembly system has its advantages probably due to a less problematic procedures to co-ordinate. Source of data: Volvo data and the Volvo Uddevalla archive in accordance to Engström, Medbo and Jonsson (1996 and1999).

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[5] The maximum production capacity in Torslanda was 170 000 automobiles per year, while the maximum capacity for the Volvo Uddevalla plant was 40 000 automobiles per year (the actual production volume for the 740/940 model at Torslanda were approximtely the double of the volume in Uddevalla). However, this capacity was not utilised during the period 1990 – 1992.

4 INTRIGUING EFFECTS AND FACTS BASED ON EXPERIENCES OF IMPLEMENTING PARALLEL PRODUCT FLOW ASSEMBLY SYSTEMS – SOME OBSERVED MALFUNCTIONS

Apart from various managerial effects and perplexities, only hinted in this paper, the criticism of parallel product flow assembly systems runs along two lines. One line concerns the need of a revised production scheduling system while the other lines deals with product quality aspects of the long cycle time assembly work.

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Take the defunct Volvo Uddevalla plant as an example once again. The production scheduling system in Volvo Uddevalla plant allocated each individual order to a specific work group, defining a production sequence for each work group. These sequences were synchronised to one planned overall sequence for the total plant. Thereby both the flexibility and performance were negatively affected. Meaning that the technical autonomy was not exploited, i.e. possibilities to accumulate the "working up". From a product scheduling point of view the Volvo Uddevalla plant where thus operating as a traditional serial product flow assembly system.

However, a revision of the production scheduling system according to parallel product flow assembly system characteristics was planned in the Volvo Uddevalla plant before the plant was closed down. The basic principle was that different instances of the same so-called "assembly variant" are interchangeable for production scheduling purposes (Engström and Medbo 1992; Medbo 1994).[6]

A production scheduling system using "assembly variants" would have improved the assembly performance in the Volvo Uddevalla plant substantially, since technical autonomy would have served as an incentive and the waiting time due to materials fixtures, automobile bodies, etc. This measure would have resulted in doubling the delivery precision (Engström and Medbo 1992; Medbo 1994. Also, the space utilisation of the plant could be improved due to buffer function. For example simulations that we have performed showed that the use of assembly work group scheduling according to "assembly variants" could decrease the demand of buffer capacity with 35%, at the same time the delivery precision would increase with 40%.

In conclusion, while the Volvo Uddevalla plant was a parallel product flow assembly system, it operated somewhat similarly to a system composed of a number of short machine-paced assembly lines, due to the design of the AGV-system and the production scheduling system. For example, it was not possible for a work group to start assembly of the "next automobile" ahead of schedule. Thus is was impossible for a work group to create a sufficient safety margin which enabled them to fulfil its production quota even if the assembly work was adversely affected by unexpected contingencies. That is the important collective "working-up" was a impossibility though less members of work group member increases the technical autonomy which might have been the most important incentive for having increased operator competence and competence

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[6] A considerable reduction (approximate 98%) of product identities, compared with using traditional design and market oriented product numbers, could be achieved, i.e. some thousand product numbers (separate vehicles identities) could be complemented with about 20 "assembly variants". In fact e.g. 1 100 products could be transformed into 18 "assembly variants" (e.g. Engström and Medbo 1992a).

overlap as well as reduction of work group size. Though this mechanism where nor fully understood by management and engineers.[7]

Given certain preconditions, the more parallel work groups there are, the fewer breaks there will be in the assembly sequence for the single work group determined by the production plan. Each sequence break then represents a greater amount of assembly work. The individual parallel work group, which for a given production volume consists of fewer individuals if the parallellisation is increasing, will be able to master their own preconditions to a greater extent and due to their smaller size, will also be able to distribute the assembly work and vary the work pace more easily.

Through the reformed product description system, it is possible to allow high frequency product variants, identical from the assembly point of view, to replace each other so that the plant as a whole can follow the planned sequence, so-called assembly variants. This implies a combination of separate and common queues of products and kitted materials, as well as separate and common buffer volumes.[8]

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By tradition, productivity tends to be a dominating concern in manufacturing. In many industries, other concerns are now becoming at least as important, however. For example, labour costs in final assembly of automobiles amount to less than 5 percent of total costs of the product, so even if labour productivity in final assembly is improved dramatically, the resulting cost reduction is marginal. By contrast, performance aspects that are critical in diversified quality production are increasing in importance (Streeck 1992), notably a production system's capacity to produce high-quality product i a flexible way are extremely vital today. However, the product quality aspects in parallel product flow, assembly systems are not fully understood and needs further research.

> Example 3: As expected, the mean quality according to the audit-based quality index differed between the work groups in the Volvo Uddevalla plant. The average product quality in the Uddevalla plant was high – in fact better than in Volvo's line assembly plants (Volvo Personvagnar AB 1992) – but the product quality varied considerably. According to our interviews with quality audit specialists within Volvo, this variation in quality might be one of the important negative aspects of

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[7] This fact might also help to explain the somewhat unsatisfactory psychosocial workload observed in our survey of assembly operators in the Uddevalla plant (Engström et al. 1995).

[8] Production sceduling in a parallel product flow assembly system must also take into account the necessity of product variant-resistant work patterns within the work groups performing final assembly, i.e. the distribution of work within the work group in a predetermined way with regard to the effect of different product variants spread over time, when certain individuals are undergoing training, when members are absent etc. These work patterns are recommended as a starting point, not a prescribed working method. The work patterns must, however, describe the work both as a whole and in detail at the same time. One must know when the product has to be assembled, how much time is required, and be able to control materials and quality in these new production systems it is not, therefore, a question of eliminating the production engineering work, as this takes a different form, and parts thereof can be performed by most knowledgeable persons as regards details in the work process, i.e. by the operators. In this context, for example, both the traditional methods of quality measure techniques/instruments and the principles of standardised work (Adler 1993) are inconsistent with the tangible achievement of the production principles for parallel product flow assembly systems.

the production principles applied. It is better to have a low variation in quality and a slightly lower average quality. There was no really good explanation for this quality variation. Sometimes the defect where pointed out was important and obvious for the operator: "How on earth could we forget this?". Note, though, that the 940 model (earlier before redesigned denoted 740 model) was the most difficult Volvo automobile to assemble due to the numerous components included and the fact that the body did not always meet the quality in tolerances needed. (In fact, the 960 model, though more luxurious and loaded with various auxiliary equipment, was easier to assemble since it was of a later, more mature, product design. The mean assembly defect score was 46.5 units per automobile, but the defect score varied considerably (see figure 3).Note that the authors analysis based on questionnaires have shown that work group with high competence overlap had the best performance, the highest product quality as well as lees stress than other work groups (Engström, Jonsson and Medbo 1996).

Parameter	*Value*
Mean:	46.5
Median:	44
Minimum / maximum:	2 / 206
Coefficient of variation:	0.598

Figure 3: Statistical parameters for distribution of assembly defect score, based on internal audits of 1071 automobiles during August 1991 – October 1992. Source of data: the Volvo Uddevalla archive in accordance to Engström, Jonsson and Medbo (1996 and 1999).

5 FINAL COMMENTS

Above the authors has briefly explained the time losses in line assembly and the production principles and effects of, as well as the underlining of some intriguing effects and facts of parallel, product flow assembly systems which implicitly crystallises a question concerning the availability and acceptance of these insights. That is, whether or not the experiences and principles brought forward are general accepted knowledge within the Swedish automotive industry. A fact supported by the direction of the ongoing revision of most Swedish assembly systems. However, these revisions are, according to the author's experiences, in fact based on vague practical and theoretical frames of references.

It might come as a surprise for some foreign readers, that the presented context of knowledge is not publicly accepted within the Swedish automotive industry. In fact it seams to be degradation of once established thought and concepts back to the 1950s and 1960s, a phenomena which is mixed up with influences from earlier Japanese initiatives. This state of the art may depend on influences from American management literature as well as the fact that the few experienced practitioners (a hand full of manufacturing engineers) within Volvo/Ford and Saab Automobile/General Motor corporations are now retired.

Anyway, the critical topic for the future is to e.g. illuminate the topics discussed above, by means of e.g. schematised layouts including intra-group work patterns and buffer functions complemented by the appropriate product and process data. This in order to understand the technical and administrative autonomy in relation to assembly system design. A suggested approach, which also calls analysing various (abstract) product descriptions (such as product structures and product variant codification) versus, disassembled (physical) product (in order to grasp the product design). This would be appropriate for comparisons between for example Swedish versus Japanese practices. Independent of, if the focus is on detailed manufacturing engineering aspects, learning and competence strategies on operator level or for understanding various management aspects.

It is the authors opinion that this could be achieved by taking advantage of the data and experiences already at hand as well as utilising the various methods for assembly system design only hinted in this paper but published elsewhere.

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