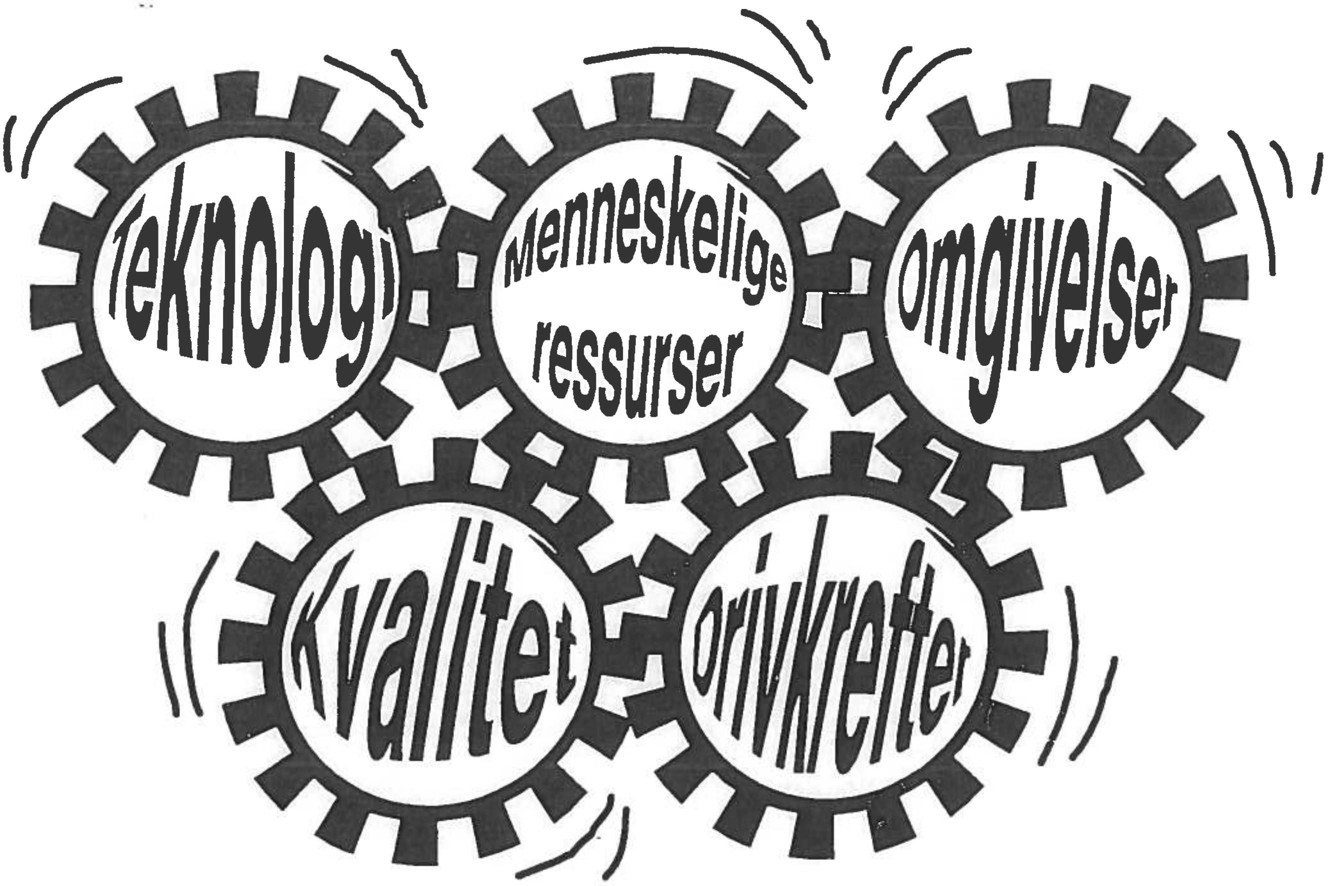

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Material Flow Patterns, Product Variants and Long Cycle Time Assembly

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ABSTRACT

This paper summarizes some experience and methods connected with the development of long cycle time assembly production systems using non-traditional flow patterns. We report general questions valid for the person or the company intending to humanize and make assembly and engineering work more efficient. Here we refer principally to the development of methods of describing products variants, so called "assembly variants". By using "assembly variants" it becomes possible to perform the planning and scheduling of production systems with parallel material flow in a more efficient way than the traditional methods allow. For example it is possible to both achieve necessary autonomy for various departments in the production flow and better utilize the buffer volumes.

1 Introduction

The existing descriptive structures generally used by the Swedish motor vehicle industry consist of market-oriented product codes and of design-oriented material control codes. Previously, there were no descriptions based on assembly similarity, and hence relevant to long cycle time assembly for either complete vehicles, or parts of them [1].

It is important to note that the existing descriptive structures used by the Swedish motor vehicle industry lead erroneous conclusions when they are applied to long cycle time assembly due to inadequate perceptions of the products and the work.
The product was thought to be far too complex and contain too many components to be possible to assemble by one work team leading to unreasonable learning times and no adequate material feeding technique were available.

One of the bases for the new assembly work is therefore a reclassification of the products' components. It is hereby possible to revise the perception of the product. This reclassification allows the description of wholes, producing holistic descriptions serving the foundation for work design and material display on the work station and also giving guide-lines to layout planing during the planning of factories for efficient, flexible and humanized manufacturing [2, 3].

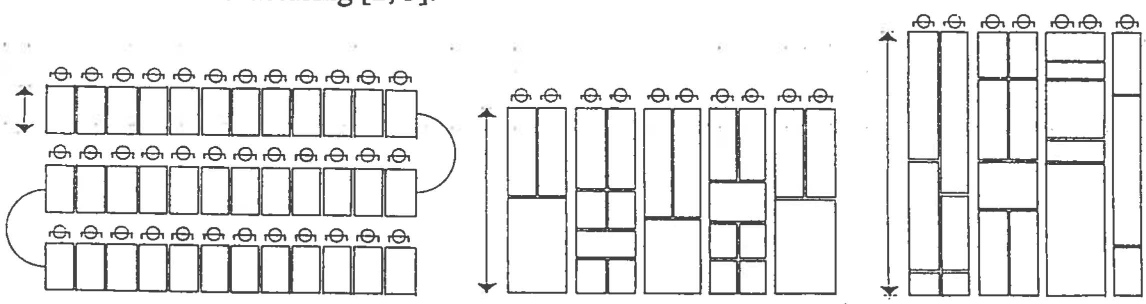

Figure 1. In production systems for final assembly there is a relationship between material flow patterns for the product and work content. A higher degree of parallelization implies a longer cycle time (in extreme cases two workers assemble a complete object at one work station). The figure above, where the arrows represent the individual workers' cycle time and the rectangles modules of work performed individually or by a pair of workers, shows this transformation of work for an automobile in a normalized form.
In long cycle time assembly work, teams containing few members have proved to function easier than ones with many, because of less complex internal work patterns. The strength of dependence between different team members is due to the task and varies with the situation. Effective work teams for long cycle time automobile assembly ought to consist of sub-teams of pairs, who assemble on more than one automobile at the same time, and are thus most dependent on each other. These pairs should be supported by one or two individuals co-ordinating several sub-teams, building subassemblies in the proximity and performing general services (checking material, cleaning, etc.).

Our method, used for planning several factories during the last five years, is based on detailing all components and functions in dismantled vehicles by means of alphabetical registers and files. These registers were compiled from existing descriptive structures, quality-related documents, dealer information, repair manuals etc. Each component was drawn and documented by means of a visualisation system [4], cross-referencing existing product structure in relation to the dismantled vehicles. The results were compiled in a database, which was used to verify the new assembly oriented product structure that we constructed.

This research work has shown how product variants can be described in a way more suited to the assembly process than earlier by employing assembly relevant differentiabilty and generativity [1]. These principles are today used in some Swedish factories for the manufacture of automobiles and trucks.

2 "Assembly variants" in highly parallelized production systems

"Assembly variants" involve access to a more nuanced language (language and knowledge being inseparably interconnected), a broader application of the "assembly-geographical atlas" [3], a language both verbal and visual that identifies the objects from the point of view of final assembly (a language suited to its purpose is a precondition for effective communication). The basic idea is that different objects belonging to the same category ("assembly variant") will be interchangeable in the assembly process, because they have certain characteristics in common.

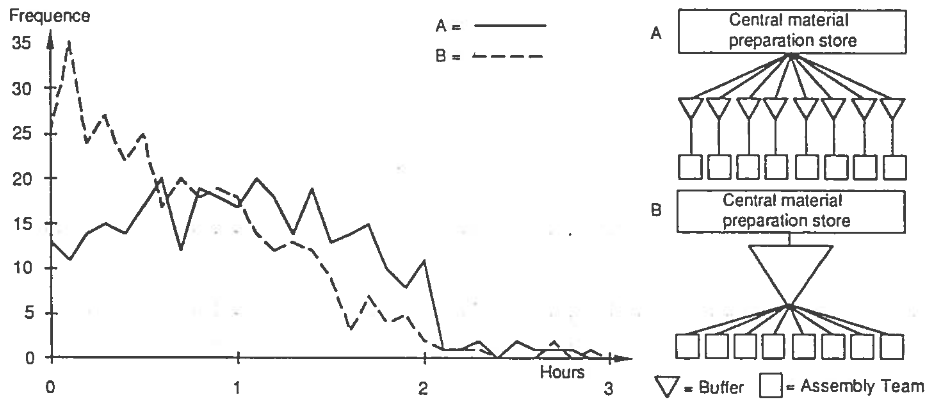

Figure 2. To the right; a schematic illustration of a highly parallelized production system for final assembly in which the material is kitted and supplied as kits to each work team. Illustration "A" shows separate buffer volumes for each work team and "B" buffer volumes exploited for reasons of commonality through the use of "assembly variants". Curve "A" to the left shows the deviation in relation to the planned production (assembly start) using traditional planning and "B" shows the deviations using non-traditional planning i.e. "assembly variants". The figure clearly illustrates both the decrease in mean deviation (from 1,5 to 0,9 hours) and the standard-deviation (from 2,1 to 1,0).

By using "assembly variants" it becomes possible to perform the planning and scheduling of production systems with highly parallel material flow in an a more efficient way than the traditional methods allow.

For example it is possible to both achieve necessary autonomy for various departments and teams in the production flow and to better utilize the buffer volumes. The material preparation stores, which prepare and supply kits containing components for each individual object to parallel work teams can thereby to a high degree control their own process due to better buffer control through multi-level planning (using both the traditional product codes and the new non-traditional "assembly variants", chosing the correct characterization at the right phase in the production flow – see figure 2).

"Assembly variants" are based on three principal categorisation criteria: - Competence requirements. - Assembly time requirements. - Tool and equipment needs - there may be further criteria, related to specific production systems (for example, low frequency variants), or if the concept is applied outside the chosen production system (for example, external logistics).

To obtain "assembly variants", the differences between products are grouped in four levels, differences that; (1) do not require different assembly work, but different components, (2) require only marginally different assembly work with relatively "obvious" differences regarding assembly, (3) it has been decided that all workers must be able to manage, both in respect of knowledge and equipment, (4) are critical dependent on competence, assembly time or equipment.

When a selection of products in a given production program is divided into "assembly variants", the individual products will be categorized into clusters of variants between at one extremes one "assembly variant" (one unique product) and at the other extreme the most common "assembly variants" (the most frequent products). The number of different "assembly variants" is considerably smaller than indicated by both the present design-oriented codes and the design-oriented material codes (see figure 3). When the actual frequencies of different "assembly variants" is known, it is possible to optimize the material flow in the production system.

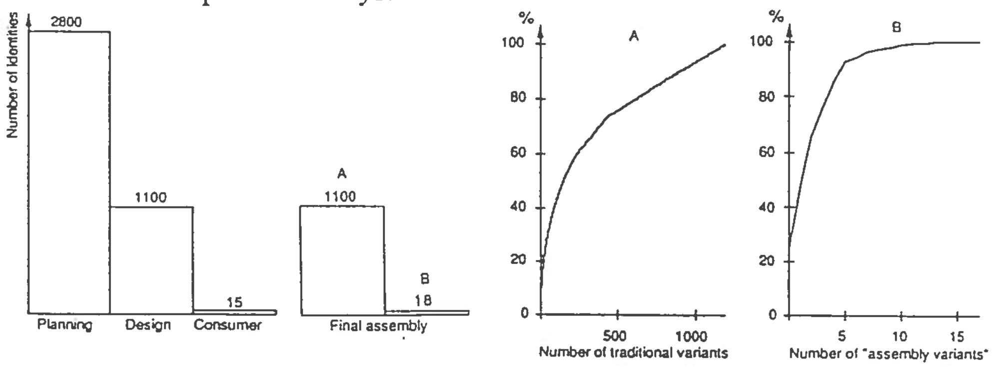

Figure 3. The figure is based on 2 800 automobiles produced during six weeks. To the left is shown the total number of different identities used by different departments. To the right is shown the cumulated amount of produced automobiles when not using (A) and using (B) "assembly variants" as an identity concept in final assembly. Note that the number of "assembly variants" is considerably smaller than indicated by both the present traditional market-oriented product codes and the design-oriented material control codes.

From the point of view of final assembly, the effect of using "assembly variant" as an identity concept can bee summarized: - A tool is provided for the workers to be able to plan production in an appropriate way. - Greater technical and administrative autonomy between different stages in the production chain is created. - Simplification of re-ordering and interchanging of individual objects between and within different phases in the production flow. - Easier handling of sequence demands.

There is therefore less need for detailed centralized production planning in highly parallelized production systems. The number of individual objects in the production plan deceased in our cases by over 95 % when "assembly variants" were used. In practice it has proved sufficient to consider only about 20 different "assembly variants" even though they represent 1 000 different traditional market and design variants.

Greater freedom results through the "assembly variants" being used for product identity in production planning without lessening the precision demands on the centralized planning. This means that: - There is less need for replanning in the material preparation and assembly workshops. - The actual materials consumption sequence is in better agreement with the planned sequence, leading to less buffering and better JIT efficiency. - A centralized materials preparation store is not affected negatively if parallel work team do not follow in detail a previously determined production plan. - Delivery times of completed automobiles is in better agreement with the production plan.

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