PRODUCT STRUCTURING: KEYSTONE FOR MANUFACTURING CONTROL

Henk Bikker
Section Industrial Organization and Management
Faculty of Mechanical Engineering and Marine Technology
Delft University of Technology
Phone (31-15)2782711, Fax. (31-15)2783057 - Mekelweg 2, 2628 CD Delft, The Netherlands

Abstract

In this paper, it is argued the product structure as a fundament and compass of manufacturing may contribute substantial to less complex control of the order flow activities.

INTRODUCTION

The demands facing the industrial companies have one focus in common: how to meet customer requests for product quality and product flexibility while improving lead time and productivity. Product generations will be replaced more frequently and most products will be delivered belonging to a product family like instruments, pumps, aircrafts and a broad variety of machines. In the consumer market this tendence is accelerated as many products are object to growing sensitivity on personal lifestyle. Within the companies for reason of productivity and lead time the stocking of raw material, parts and sub-assies and the work in progress have to be reduced. At the same time there is a trend to work in teams with more allround tasks including more control of the individuals on their own work. Teamwork has to result in as complete as possible components, sub-assies or final products.
Both external and internal developments are reflected in the control load which has to deal with an increasing number of variant-orders, -parts and -components and the corresponding routings. This increasing complexity asks on the one hand for principal approaches towards reduction of the consequences for manufacturing and on the other hand for ways and means towards effective, flexible but less expensive control systems [1]. An important question to raise is: how far may product structuring contribute to complexity reduction and complexity control.

BRIDGING THE "GAP"

The growing demands on the organization are presented in the model of the total manufacturing process in figure 1.

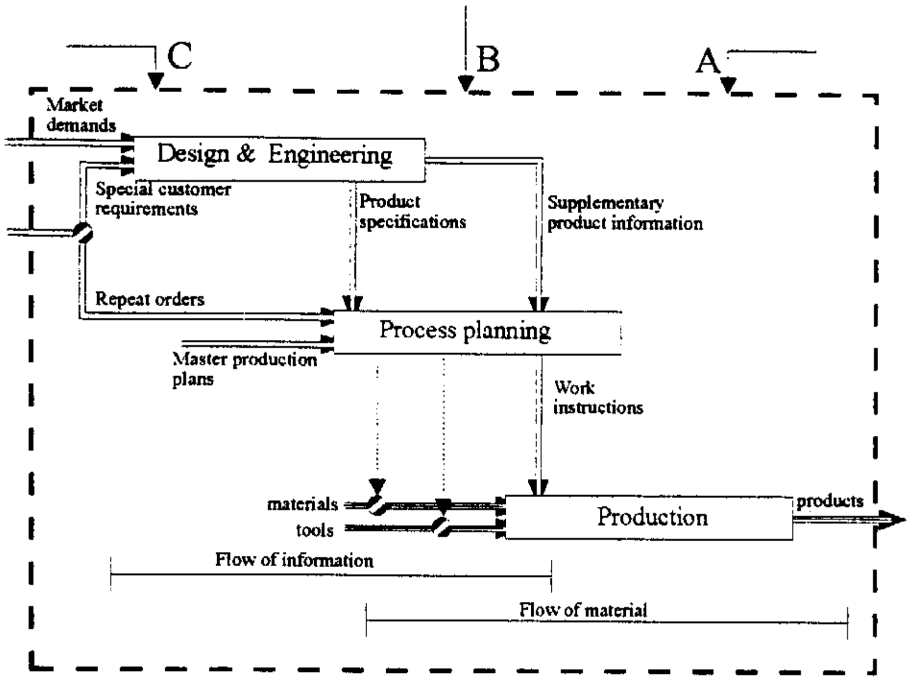

Fig. 1 Demands on manufacturing as the primary process

The demands from individual customers are reflected under A; arrow B stands for the norms presenting the general manufacturing policy, while arrow C reflects the market demands being anticipated on the longer range. Internal objectives as the quality of the organization are part of the manufacturing policy. The central question is how the changing demands posed on the company as a sytem are continuously confronted and tuned with the functioning of the organization [2]. A functional breakdown of this continuous innovation process is presented in figure 2 [3].

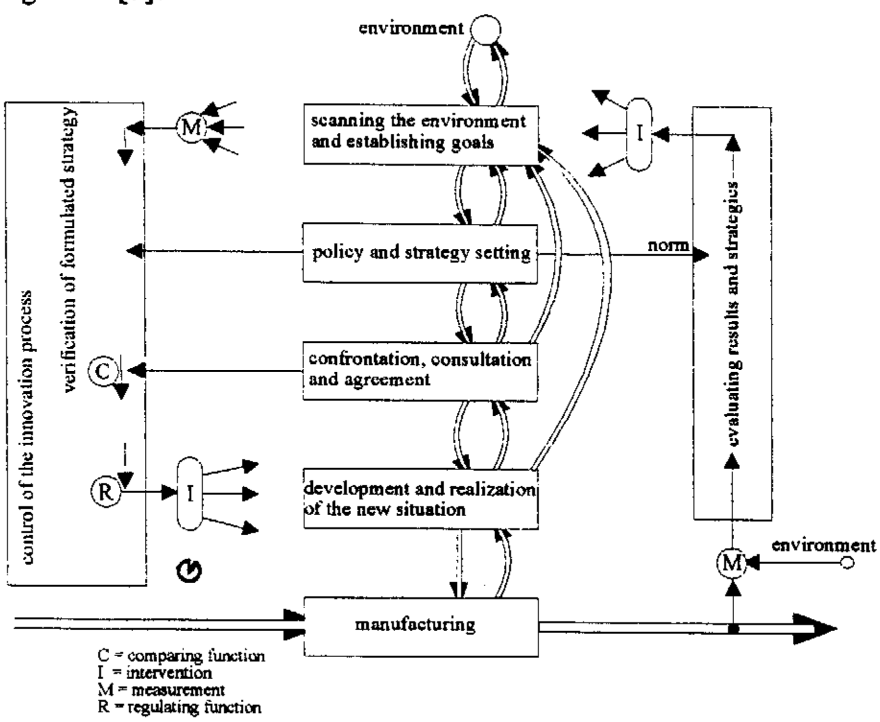

Fig. 2 Functional breakdown of the innovation process (in 't Veld)

The Manufacturing process as a system and each of the sub-systems has to be controlled. As far as the aspects quality, time and cost are concerned. The amount of control cost may in practice rize to 20%-40% or even more of the total spending of hours in the primary process. Control is used here in the meaning of regulating and evaluating processes. A general definition of all acitvities which are taken together under the umbrella "control" is not yet available.
As there is a fair chance the demands under A, B and C in figure 1 will still become more heavy in the near future it is of the utmost interest to improve the handling of such a complexity. An indispendable tool "to look inside" the interaction between the product structure, the production structure and the control structure are better models of our industrial systems. Maybe with the help of those models it is possible to approximate the impact of principle solutions to reduce the internal complexity respectively to manage the remaining complexity.

Most of our methods of modelling processes nowadays do not present clearly the control structure. The Steady State model from In 't Veld in figure 3 does. It gives in more detail the different functions which belong to the control area [3].

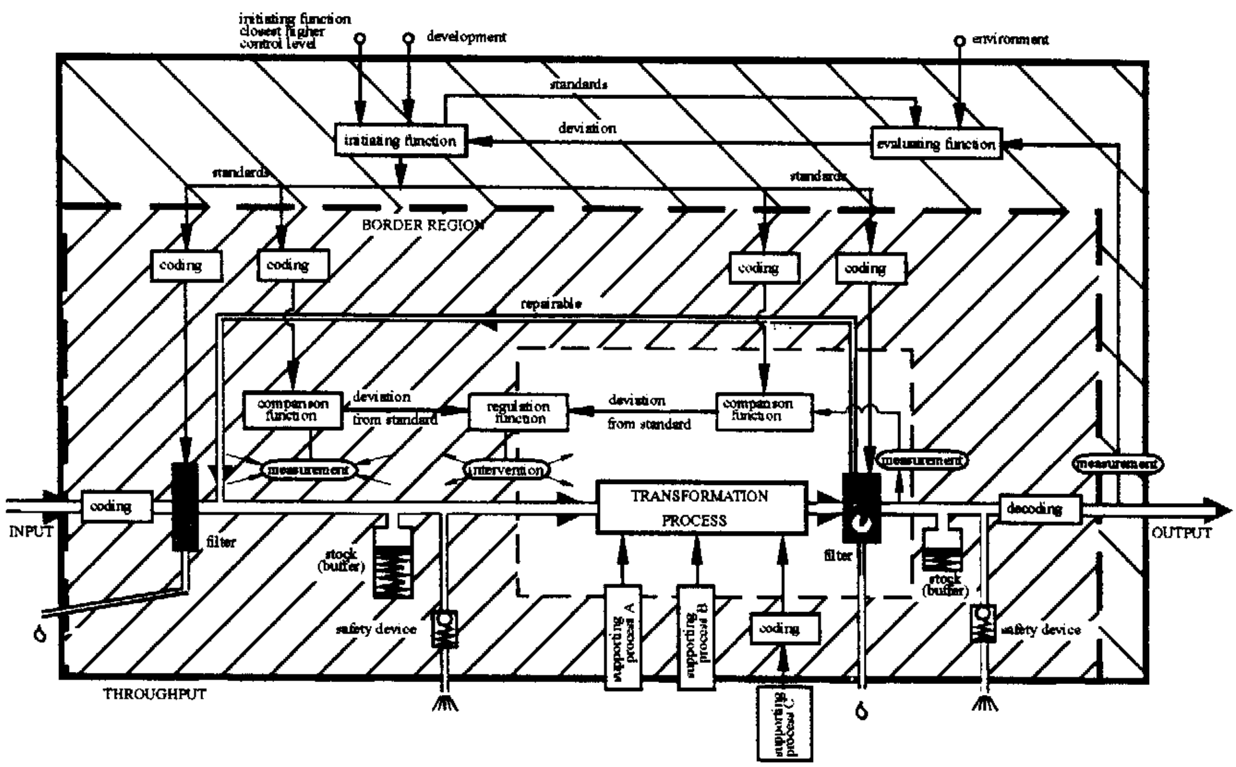

Fig. 3 The steady state model: performance of a process for one aspect (in 't Veld)

Four types of control functions are presented. The first concerns the initiating of standards which have to be frequently evaluated specific to the situation. The second and third type are the feed forward loop and the feedback loop. Both loops consist of a measurement function, a comparison and regulating function and an intervention function. Last but not least repair actions are possible to correct deficiences; presented by the symbol in the filter function.

Even the models to present quality control are in most cases still on the level of procedures relating activities to each other, but not on the stratum of control loops what it should be.

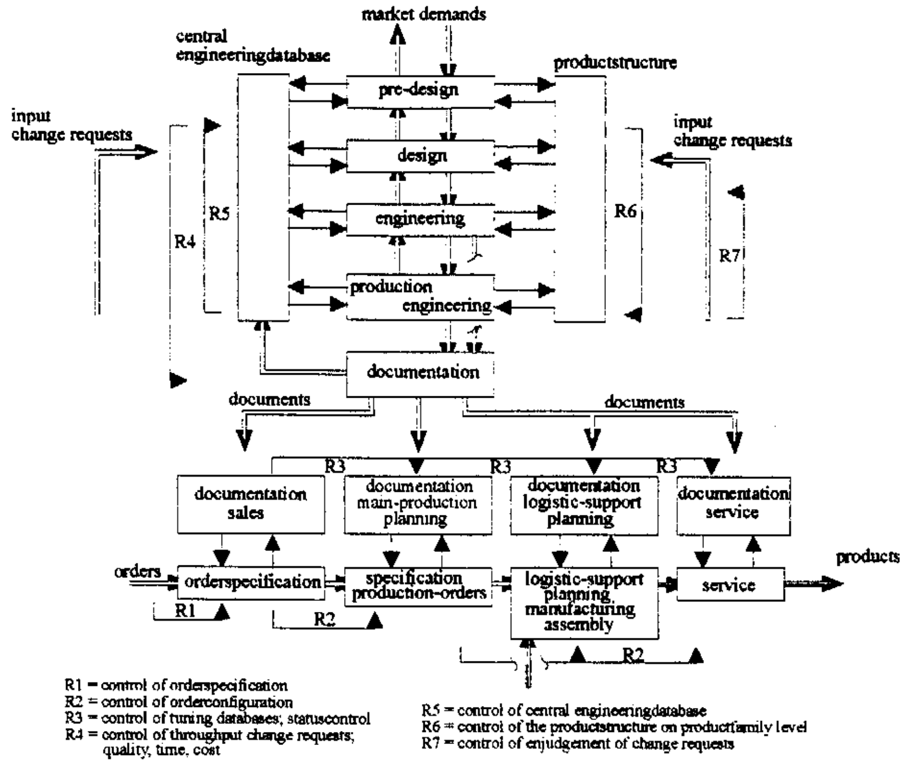

Fig. 4 Loops to control the product family, the order specification and -realization and the flow of change requests: model of the main functions

As illustrated in figure 4 a model may present the different control loops related to a product family situation [4]. The model presents two groups of functions needed to fulfil the development process of the product family respectively to manage the throughput of orders. The effectivity of the system requires to control the input and the throughput of both the product family level and the individual order level. Control of the product family concerns in particular the product structure and the corresponding product documentation. In figure 4 these functions are fulfilled by R6 resp. R3. The input respectively throughput control is fulfilled by R1 and R2. The loops R7 and R4 are to control the entry respectively the pass through of change requests. The loop R5 controls the central database. An effective control loop R6 requires anticipating the market developments and the continuous intervention into the product structure based on actual changing of customer requests.
System modelling has proven to be of great help to analyze and to design the different echelons of control.

WHAT MAKES THE CONTROL OF MANUFACTURING COMPLEX

Analyzing the tree of control-echelons most effort is needed for managing the day to day operations. The greater the number and variety of elements and their relations in between, the heavier the control load. Along the primary route the number and variety of production steps per element and per relation dictates the frequency of intervention by means of feed forward and feedback loops. The combination of both variations, of the product structure and of the production structure, makes effective control rather complicated and hardly managable. This combination is applicable to many situations in the small and medium series range

for instance with 250-1000 elements and variant-elements, a variety of 100-400 relations and 20-40 production steps to be controlled.

HOW TO REDUCE COMPLEXITY

To reduce complexity the variety of information along the primary route of the orderflow has to be reduced at all possible means; in particular R1 and R2 in figure 4. The most classical answer goes in the direction of 'freezing of the variety' on a certain level; so called 'standardization' in the product area and 'grouping of functions' in the process area. Standardization means a certain cluster of elements and corresponding relations is identified and is used more or less frequently. A simple classification code is sufficient to recognize and to communicate the selected 'cluster' along the route. At every next step the standard content (the addition sum of elements) and the standard structure (the addition sum of relations) of each 'cluster' are refered to by means of the classification code.
The organic grouping of process functions and their corresponding activities works out the same way. A simple code may be used to identify the man-machine cluster that 'will do the job'. Inside the blackbox the team controls all three aspects, quality, time and costs themselves.
However in the organic grouping there are three main directions: the nature of the operation, the specific group of (sub)products or services and the geografical location. Application of the nature of the operations is well known at internal differentiation like milling, cutting, welding, etc. For example irrespective of products all woodworking operations may be concentrated in a single central woodworking department. Grouping on (sub)product level means that all operations related to a giver (sub)product are combined within a single group. In that case all the functions of the steady statemodel together form a single group. This is known as "internal specialization" on group level. In the "ideal situation" the teammembers become more and more allround and educated to control their process as a self supporting system; no control of the throughput from outside the system is needed. The variation of the anticipated range of elements and relations can be managed by the appointed team.
Contribution of "standardization" and "grouping" opens the perspective of eliminating the lower range of control loops needed to configure the product respectively the order and to manage the order flow.

THE ROLE OF THE PRODUCT STRUCTURE

Nowadays the specification of standard clusters needed, often called the module specification, starts in the inputzone of the primary process. The corresponding parts and (sub)products are recognized again at the time the assembly and installation teams go to work. The control problems arrive mainly in the make and buy traject in between input- and outputzone. The fabrication traject is the rock on which parts split up into the different departments internal and external the company each of them specialized in a restricted number of operations. Standardization of (sub)product clusters and grouping the corresponding process activities into 'workmodules' appear no longer effective.

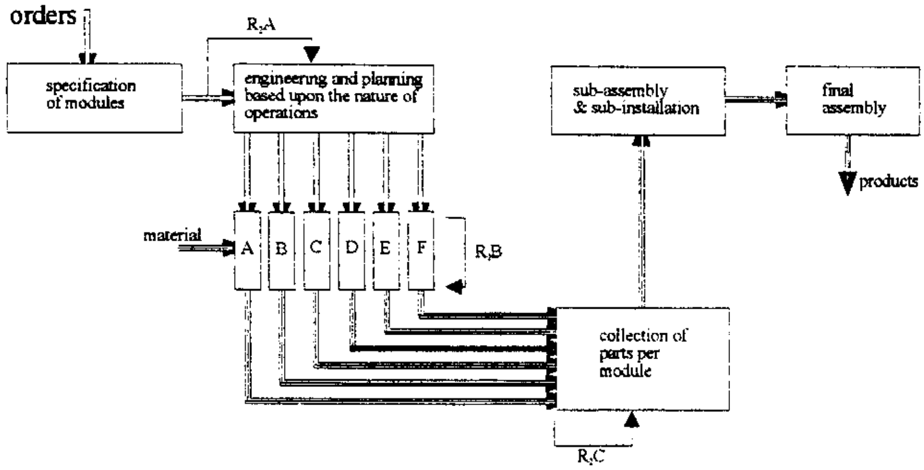

Fig. 5A Split up in the make or buy traject

In figure 5A an assortment of different operations A-F is given. The extra control loops R2A and R2/B have to be installed to select and start the operations and the monitor, the throughput. The control loop R2C has the function to rearrange the finished parts into clusters suitable for subassembly and sub-installation. Sometimes the 'split up' is avoided for instance in the case of producing hydraulic parts, pumps or instruments. The production of parts and the assembly activities of the specified product clusters are localized in the workarea of an all-round production team. The control of quality, time and cost and the matching of sub-products are part of the competences of the team. From outside the sub-systems only the priorities and volume of the inputs have to be managed; see figure 5B.

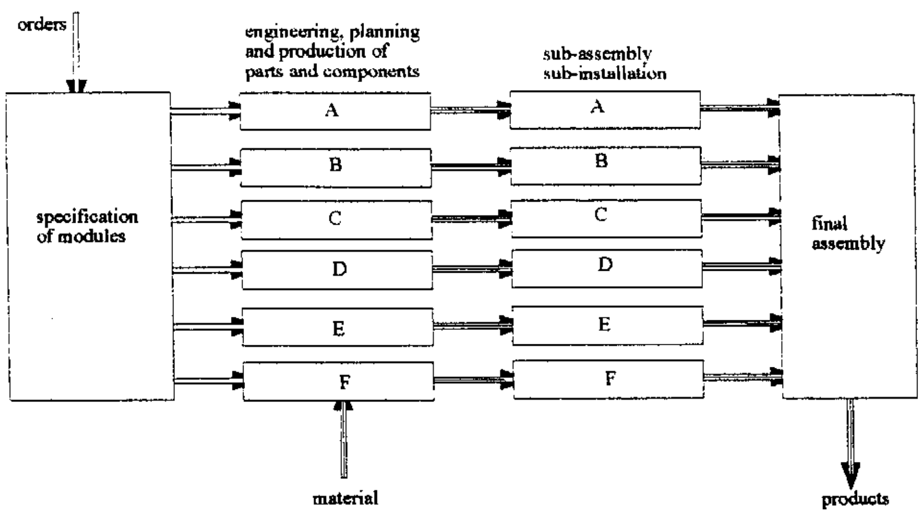

Fig. 5B Related product-subsystems and manufacturing-subsystems (production of parts, assembly and installation)

To approximate the situation modelled in figure 5B the product structure may contribute the following keypoints:

- The standardization of sub-product clusters or modules related to the product functions, which can be used in the order breakdown and be specified by means of as simple co-

des as possible. In many cases this intended standardization is already common practice.

- To serve as a fundament of an effective product documentation in such a way that the order information which connects and actuates the different main databases along the route is limited as much as possible.
- To serve as a compass far the organic structuring of in particular fabrication, assembly and installation activities. The main characteristics of specific combinations of product modules are the platform for structuring the production groups and departments. As far as it concerns fabrication the question is raised of priorities between the concentration of machinery and professional knowledge along lines of the nature of operations or the development of more flexible machines, tools and skills to support product oriented production teams.
- To stimulate a simple overview per step in assembly and installation of parts and detailassies. The cutdown of the number of different elements per step may save a lot of time puzzling things out.

CONCLUSIONS AND FUTURE WORK

The better the product structure on the module level remains recognizable concerning the fabrication, assembly and installation activities the easier the lower rank of control loops may be delegated to module respectively product oriented production teams. The organic structure of the fabrication departments is up till now the bottle-neck.
Further research has to be done to quantify the advantages and disadvantages related to control of a full module oriented process structure and to detect the key-factors which dictate the corresponding investment in machines, tools, knowledge and skills.

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