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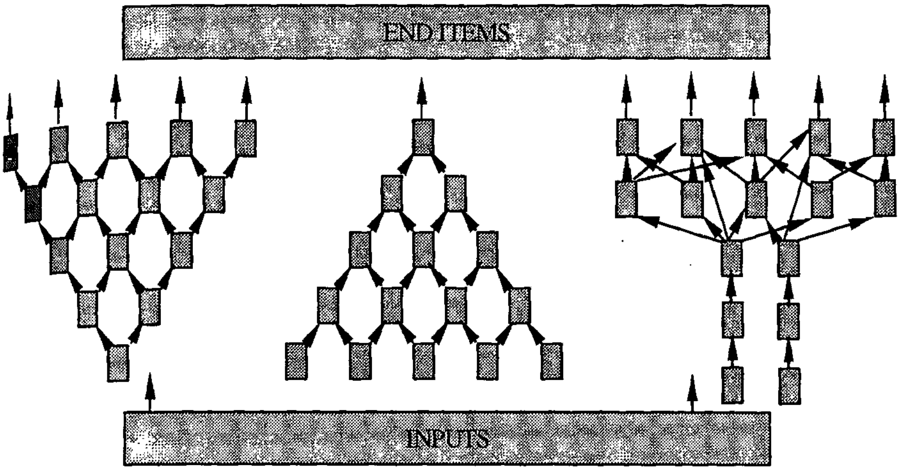
THE PLANNING AND CONTROL METHOD FOR THE MANUFACTURING ASSEMBLY SYSTEMS

The subject matter of that paper is the planning and control method of concurrent multiassortment rhythmic production realised in manufacturing assembly enterprises in conditions of necessary resource constraints. The outworked method has been transformed into original software used for decision processes aiding in the customer service facilities. Comparing with the hitherto researches the originality of the method is the described production type enabling tasks realisation in exclusive-like mode and also in the rendezvous-like mode, which is characterised for the assembly processes.

1. MARKET CONDITIONS

The contemporary world is characterised by very fast rate of the progressive changes. That stuff, which was modern, original and unknown yesterday, is the generally used standard today and will be obsolete and squeeze out by another, better, faster or more user-friendly solution tomorrow. The sudden development of technique, technology and computer science has been caused removing of the time and spatial barriers contributing to the progressive process of globalisation. The present-day customer being able to compare easily a purchase offer made to her/him with the competing firms propositions, is very demanding and her/his needs and preferences are subject to continual modifications what in the obvious way determines the activity of enterprises.

Depending on the products and processes all production enterprises can be classified into one or a combination / modification of three types designed "V", "A" and "T". In a "V" plant, there are few raw materials and they are transformed through relatively standard processes into a much larger number of the end products, what is observed in e.g. textile, oil refining, steel, chemical, paper and plastic industry. In opposite to "V" enterprise, in an "A" plant, many raw materials, components and parts are conserved into few end items (products), what is characteristic for plans, jet engines, automotive and capital goods firms [1]. In a "T" plant the final product is assembled in many different ways out of similar components and parts. The costumers place orders for different functions, colours, features, size and so on, thus production of complicate product in variant forms, differing from each other with single elements or whole sub-assemble is necessary. There are two stages of activity connected with a kind of production processes. During fabrication processes (the *leg* of the "T") occur manufacturing the basic parts and components in a relatively straightforward way and their storing. Assembly processes (the *roof* of the "T") consist of combining common elements into many possible options to create the final products. Among "T" plants there are enterprises producing various kind of appliances. All three types of plants and their short characteristic shows figure 1.



V plant
Capital- intensive
Highly mechanized
Dedicated
Inflexible
Specialization within the flow process

A plant
Less capital-intensive
Versatile
Flexible machines
Can work at different levels of product flow

T plant
Has fabrication and assembly areas
FABRICATION
Short routing
Versatile machines
ASSEMBLY
Is the predominant area
Lead time is short

Fig.1. VAT classification (according to [1])

A "V" enterprise requires a big investment for buying capital-intensive and specialized equipment. Prosperity of an "A" plant is connected with buying many different sorts of raw materials and employing highly skilled specialists. That is why, generally those two kind of plants are not among SMEs. However, a "T" and also a *"T" without leg* plant is broadly represented among SMEs disposing not so high capital in the turnover. A *"T" without leg* enterprise reduces its activity only to assembly processes and thereby gives up manufacturing connecting with fabrication processes represented by *leg* of the "T". Producers dealing only with assembly appear in promptly developing branches of industry such as car, Audio- Video and computers ones. A *"T" without leg* enterprise concentrates only on the assembly. A "T" firm manufactures and assemblies, but their main activity focuses on the *roof* of the T. That is why, that kind of firms can be called manufacturing assembly systems.
An interest of the issues of the manufacturing and assembly processes organisation in SMEs results from those premises.

2. PROBLEM FORMULATION

In relationships between customers and producers natural discrepancy of interests takes place. On the one hand a customer wants to buy cheep and fast diversified high-quality products. On the other hand for a producer assurance of higher quality of goods means higher costs and, then a higher price of products. Similarly, prompter or multiassortment production means needs of buying the modern equipment or overtime work. It, of course, also increases costs and price of products. The practical solution of that conflict boils down to find a consensus that is a point in which both customer and producer are sufficient satisfaction for making business together. The considered problems of the production planning and control are characterised by a proved very high level of complication and are connected with the so-called combinatorial explosion of the solutions [3].

Search of the optimal and quasi-optimal solutions because of the occurred difficulties have been given up in favour of the method based on the hybrid of Synchronous Manufacturing (SM), Theory of Constraints (TOC) and Drum- Buffer- Rope (DBR) putting an emphasis on effective utilisation of the system resources. Synchronous Manufacturing refers to the entire production processes working together to archive the goal of the firm, what is to make money. SM emphasis on total system performance, not on localised performance measures, such as labor or machine utilisation. According to that approach it is necessary to balance the flow of the product through the system, not system capacity. SM logic attempts to coordinate all resources so that they work together conformed to critical resource(s). That means that entire system is synchronised and subordinated to its constraints. The source of that conception is Theory of Constraints formulated by Goldratt [4]. According to that theory in each system there are critical resources (bottleneck), almost critical resources (Capacity-Constrained Resource- CCR) and noncritical resources (nonbottleneck). A bottleneck is any resource whose capacity is less than the demand placed upon it. The bottleneck of the system strikes the beat that the rest of system uses to function. Because of that vivid imagination the Drum- Buffer- Rope [5] technique relaying on TOC has been formulated. The key element of DBR is a *drum* – the constraint imposes the overall rhythm of production. A time *buffer* that is protection time assuring production process continuity is used to protect production from disruptions. A *rope* is a mechanism to force all the parts of the system to work up to the pace dictated by the drum.

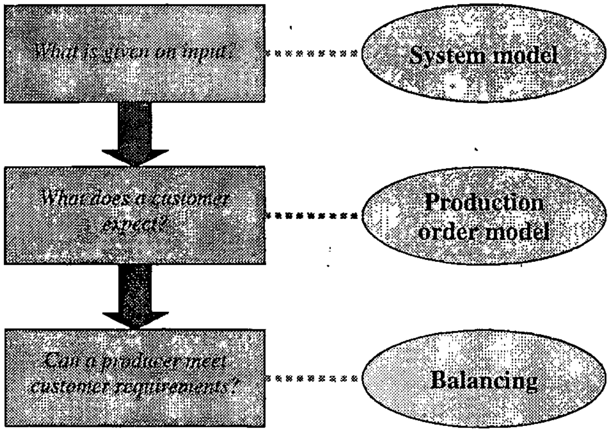


Fig.2. Stages of the research problem solving

Because of necessity of taking into consideration on one hand constraints connected with producer possibilities and on the other hand costumer needs and demands it is necessary to balance the producer's limited possibilities describing by the system model with the customer's requirements expressed by the production order model (Fig.2). Production realised in the system is repetitive, concurrent and multiassortment. The considered system is in steady state, meaning that earlier accepted production orders are realised in a certain rhythm. A starting up phase and a cease phase are omitted. In the system certain production orders are already realised and for them a system cycle has been specified according to the bottleneck.

A new production order waits for the realisation in the system. In such the system the following question appears: *Can customer needs be fulfilled in a given production system determined by its constraints?*

3. THE PLANNING AND CONTROL METHOD

In order to answer the main question the planning and control method called the method of the solution of a satisfaction task has been formulated (Fig.3). The outworked method boils down to systematic focusing by the limitation of the sufficient conditions set. Satisfaction of those conditions is advantageous for both, the customer and the producer. The first solution, which meets all checked sufficient conditions is deemed as the permissible solution and is a basis of the production plans and the procedures controlling the resources work in the system [2].

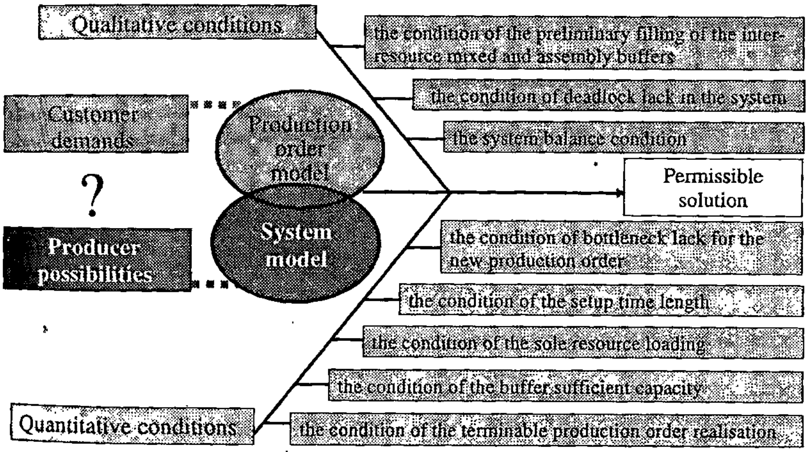


Fig.3. The method of the solution of a satisfaction task

According to the proposed approach production flow planning requires to determine whether production flow in the system realising given production tasks is possible. Depending on the system structure, the qualitative acceptable production flow and effective utilisation of the production resources take place when the different sufficient conditions are fulfilled. Those conditions are the following: the system balance condition, the condition of deadlock lack in the system, the condition of the preliminary filling of the inter-resource mixed and assembly buffers. The fulfilling of those conditions guarantees deadlock- and starvation-free work of the system in the steady state and also is the basis of the acceptation of the bunch of the production orders into the empty system and generating the procedures controlling the production flow in the system. The existing state can be disturbed when a customer wanting to commission the new single production order realisation arrives into the system. The terminable realisation of the new single production order in the modelled system takes place when the sequence of sufficient conditions is fulfilled. Those conditions guarantee to find the permissible solution, which satisfies the costumer and its realisation is possible in the system determined by its constraints. The sequence of quantitative conditions contains: the condition of bottleneck lack for the new production order, the condition of the setup time length, the condition of the sole resource loading, the condition of the buffer sufficient capacity and the condition of the terminable production order realisation. However, every ability has not been considered and the given set of the sufficient conditions can be spread out depending on needs. The next conditions can deal with the logistics system, costs as well as maintenance-repair management.

4. COMPUTER SYSTEM

On the basis of authority method original software has been outworked and its correctness has been verified. The input data needed by the computer system and the output data generated by its in the figure 4 are presented.

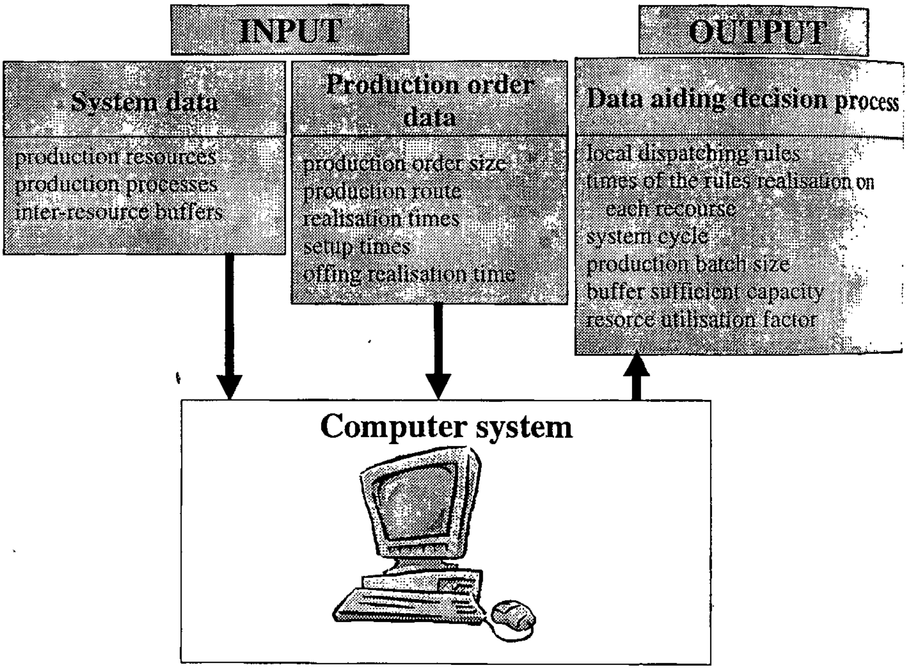


Fig.4. Input and output data in the outworked computer system

The outworked computer system is useful tool: aiding decision processes connected with production planning, generating control procedures ensuring effective production resources utilisation and ensuring fast results, that is very complicate and time-consuming by mathematics calculations way. Moreover, in the homework of in the two-parts experiment usefulness of the outworked software to practical application in the typical domestic manufacturing assembly firm belonging to the sector of the small- and medium-batch enterprises has been proved. The original computer system also makes possible to determine the adequate production system structure for the structure of given production orders. That is why it is helpful for finding the solution of the research and simulation tasks. The exemplary computer forms with the output and input data accordingly in the figure 5a and the figure 5b are presented.

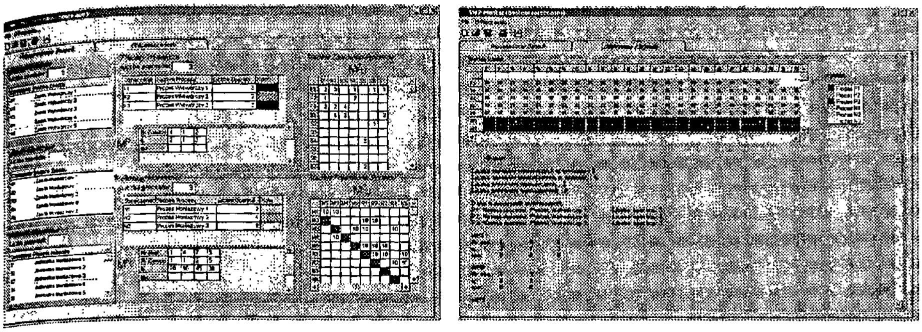


Fig.5. The computer forms; a) with the input data, b) with the output data

5. CONCLUSIONS

The outworked method is useful for multiassortment rhythmic production with short cycles realised in small batches in manufacturing assembly systems determined by their constraints and dealing in changeable environment. The elimination of the manufacturing or the assembly part of the method does not influence the correctness of its working, because of the model versatility. Therefore, that method application in the systems dealing with only assembly as well as only manufacturing is possible.

In comparison to other known methods the most important advantages of the formulated one and the software formed on its basis are as follows: simplicity of the approach using the algebraic model, short time of the results generating and low costs of the practical application.

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