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Planning Support for Decentralized Order Processing in Production Islands

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Abstract

Traditional production concepts have difficulty in meeting increased market requirements. Demands for short throughput times, meeting deadlines, complying with individual customers' wishes, and the problem of overheads generally, call for new production concepts. Lean production is the buzzword. But what sort of form might a suitable production planning and control (PPC) System ? This paper presents a planning support System for decentralized order processing in production islands, which helps overcome the weaknesses of centralized PPC Systems, thus serving to break down Company hierarchies, to refocus on individual responsibility and the expertise of skilled labour, and so reduce costs, too.

Developing Production Concepts

In single-part or small-series production, the market calls for short delivery times and a high degree of flexibility with respect to customer' wishes, coupled with a simultaneous decrease in lot sizes. Companies still endeavour to attain these goals, while retaining established organizational structures, by making increasing use of new technologies. Whether traditional organizational structures can respond adequately to changed market demands is questionable; approaches of his sort would appear to offer only limited prospects of success [1].

Another answer to the changed market requirements is a concept that originated in the automobile industry: lean production [2,3]. It involves a social reorganization of production, breaking with tayloristic principles of rationalization, abandoning the division of labour, breaking down Company hierarchies, while at the same time increasing profitability by optimizing material flow. Here, the technical and managerial activities, which were originally performed separately, are amalgamated by integrating data and functions. The aim is to cut costs and increase flexibility of production by reverting to the principles of individual responsibility and the expertise of skilled labour. The basic ideas behind this concept also constitute the guidelines for the planning support System presented below.

New production concepts, such äs that of the production island [2,4], support such a process of Company restructuring in terms of work organization. They provide a more suitable response to market demands, allowing äs they o the implementation of many of the approaches outlined here.

2 Production on the Basis of Production Islands

The concept of production islands aims at the integral processing of products. A production Island is structured along the lines of parts r product families; configuration of resources is in accordance with the object principle. Production islands are designed to meet the following criteria: maximum depth of producti flexibility of production, and minimum number of stations. A further characteristic of production islands is the decentralization of planning, decision-making, control and monitoring tasks. The integration of planning, executive and supervisory activit within an Island results in a closed flow of Information and coherent production processes. Activities are enriched by a high degree of autonomy in scheduling work, drawing up parts lists, and in per-sonnel and machine resource allocation. Internal quality control within each production island ensures that only perfect products leave production. The skilled workers' sense of responsibility in self-reliantly solving synchronization problems encountered when drawing on resources is enhanced, thus enabling them to respond better to break-downs. Setup times and Stocks at the respective production stations are optimized. Non-material incentives such äs a high degree of autonomy and teamwork help to pro-mote Job satisfaction and increase personal motivation. Since all the staff are equally well qualified, productivity potential can be better utilized. The workers' expertise is used to reduce reject levels and increase the flexibility of production [5].

To implement these ideas, companies must make changes organizational and operational structures, combining functions and shortening information and communica-tion paths by flattening hierarchies. Engineering firrns with a limited ränge of products bu a wide variety of variants have specialized in meeting individual customer require-ments. In such companies, all the production islands are similarly equipped so äs to enable them, in principle, to process any order. A stochastic production structure is designed to give workers maximum scope of action and decision-making. Production planning and control calls for tools to support skilled workers in the selection, planning, control and monitoring of Orders and the calculation of offers.

In the concept presented here, decisions have to be taken on the selection of Orders, the scheduling of material requisition and the resources to be used, äs well äs the question of cooperation with other production islands. Suppliers can be treated äs external production islands. To promote cooperation and ensure t breakdowns are properly dealt with, communication must be suitably supported. Furthermore, task-related data must be constantly updated and visualized in a user-friendly fashion. The use of information Systems is intended to help make the production process more transparent for the individual workers, thus enabling them to better master the complexity of the process and better coordinate the work procedures involved.

Production Islands and Production Planning and Control System Concepts

Traditional production concepts such äs the Material Resource Planning System (MRP II), Optimized Production Technology (OPT) or the Load-Oriented Order Release System are, it is true, recommended for single-part or small-series production [6], but exhibit weaknesses where new production principles are involved.

The basic idea behind MRP II, a deterministically oriented method, is to get away from consumption-governed resource planning. The functional elements of the PPC are subject to centralized coordination and control [7]. Exact schedules are drawn up

on the basis of apparently complete Information. Since, however, in single-part or small-series production, data often have to be roughly estimated, and äs breakdowns frequently occur in the production process, constant replanning is needed. Skilied workers are not involved in the planning process, although their experience would enable them to respond flexibly to breakdowns. A "MRP cannot tolerate 'informal Systems[1] for getting the Job. Therefore a MRP System appears to work best for companies with mass production assembly lines" [8].

OFT is a production planning and control method that m a Company äs a network of production units, customer Orders, products and raw materials [9]. Production processes are optimized by means of a bottleneck control system. OPT is based on implemented algorithms and therefore does not allow th assignment of planning tasks to island workers Since, in production Islands, every machine constitutes a potential bottleneck, it is difficult to locate the actual bottlenecks [10].

The Load-Oriented Order Release System (BOA, cf. [11]) is a stochastic method for production control. The funnel model on which BOA is based allows for fluc ations in production Output by introducing load barriers and a schedule barrier. Released or-ders are counted in the load Situation of the subsequent work Systems. Workers' per-formance is taken into account äs a potential bottleneck, but no attention is paid to the fact that in production islands the number of machines often exceeds the number of skilled workers [12]. Also, the fact that the parameters are determined ex p t facto makes it difficult to comply with new order requirements. For this reason implementa-tion of BOA in a production island context is problematical.

More recent organizational concepts for production isl have recognized the need to assign the task of medium-term scheduling, lot-size and capacity planning to the production islands themselves. Thus, one concept [13] interposes between a central PPC System and the individual islands an island coordinato whose Job it is to coordi-nate the production islands' resources, to allocate them to the respective Orders, and to monitor them by means of factory data capture. In our view, this step towards decen-tralization is not sufficient because production based on the production island principle requires a planning and control system that takes into account bo the stochastic nature of the process and the experience of those working in the islands.

A Planning Support System

In our scenario of an engineering firm engaged in single-part and small-series production, a central PPC System is used merely for rough planning and the preparation of production Orders. It provides for a so-called pool level, interposed between the central PPC system and the production islands. This pool level constitutes both a buffer for the Orders released for production (order pool) and a collecting point for planning assignments relating to the calculation of offers (planning pool). The planning pool serves to Support the drawing-up of offers and production planning.

From both of these pools the production islands can autonomously select and schedule their Orders, subject to final deadline schedules. This System is designed, on the one hand, to break down Company hierarchies, shorten communication paths and shift tasks to those areas where practical experience is available. And on the other, it means that skilled workers are given the sort of scope of ac on and decision-making that enables them, for example, to select Orders in such a way äs to minimize setup times. For selecting and feeding in Orders, a decision-support tool is provided to the production island. This is operated by a so-called production island manager, a Job performed on a rotation principle by one of the skilled workers.

To avoid exceeding product delivery deadlincs and fail re to meet material delivery dates, and to support coordination among the different production Islands, provision is made for a so-called pool coordinator, who is also appointed on a rotation principle from amongst the production island managers, and is the person to address on ques-tions concerning production or deadlines. He is also responsible for giving priority to urgent Orders, for coordinating trouble-shooting, and for preventing failure to process Orders on the grounds that they are unattractive. The pool coordinator and the production island managers meet regularly to discuss these matters.

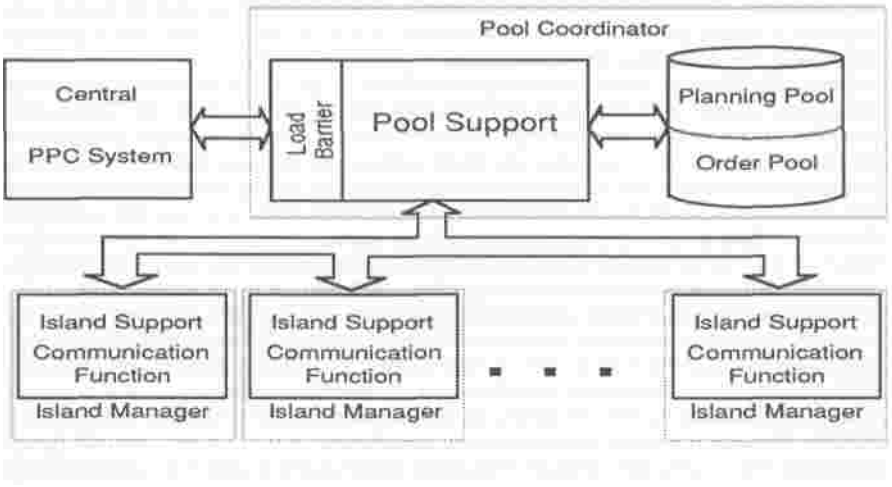

Figure 1: System structure

4.1 Planning Pool

The planning pool provides the Company with support in calculating the terms of new products, in drawing up offers, and in production planning. It keeps a record of order specifications, together with all the relevant data available, which are taken from the individual production Islands, supplemented in accordance with requirements (e.g. the estimation of throughput times and the drawing-up of work schedules), and subsequently returned to them. The skills and expertise of the workers on the Job are taken into consideration, because they are able to provide de led Information about production problems and work schedules. This means that problems of optimization and risk assessment in production can be taken into accoun in planning.

4.2 Order Pool and Load Barrier

The order pool manages all the production orders issued by the PPC System. A completely specified order includes work schedules, parts lists and, in some cases, workshop drawings and NC programs. In a production island, machine capacities normally exceed personnel capacities; thus, the order pool's capacity is limited by the total personnel capacity of all the Islands. To prevent overloads from occurring, Orders must pass through a load barrier before being fed into the order pool.

The purpose of the load barrier is not to achieve optimal utilization of machinery, but to ensure efficient employment of personnel resources. For this reason, personnel capacities are used äs a basis for calculation, and holiday leave and other periods o absence are taken into consideration. The following technical parameters are also taken into account: throughput times, order deadlines, material procurement times, and integral production within an island. The load barrier is a parameter which can be set by the pool coordinator and which takes account of the personnel capacities available in a selectable period of time. If this parameter is set at a low level (< 100%), it c unters deterministic planning. This allows flexible planning of the sequence in which Orders are to be processed and permits a suitable response to urgent Orders and b owns.

To keep material Stocks to a minimum, orders for mater are not issued until the corresponding order is ready to be processed. That is why the longest delivery times for the required production materials must be taken into account when calculating the earliest possible production Start. The scheduling of Orders in the production Islands has to be geared to this.

4.3 Pool and Island Support

One of the functions of pool support is to manage the order and planning pools and to inform the relevant production Islands of any changes in them. Orders currently in the order pool are compared with the machine configuration of the various production islands with a view to the machines required according to the ork schedule. The aim here is to ascertain whether complete production can be taken care of by one production island or whether it must be distributed between an initial and a follow-up island. In addition, pool support draws the pool coordinator's attention to an i ent failure to meet the latest possible production statt or to the possibility of exceeding the longest delivery time for the required materials.

Island support makes available to the island manager data conceming his particular production island and provides island workers with a user interface offering decision-support functions for order processing. The individual islands are only notified of orders which they can process directly; these are displayed in the form of modified Gantt diagrams. Functions for filtering orders (e.g. according to integral production, schedules, etc.), order data and access to a communication window help to make the planning and control process more transparent. Support is given to the autonomous planning of personnel resources and the management of data concerning orders currently in production and the load Situation with respect to the island in question.

4.4 Communication Function and User Interface

The communication function is used to coordinate suborders and trouble-shooting. Order data must be made available to the follow-up island, and transfer dates, throughput times and specific order problems discussed and set down in binding form. In the case of production breakdowns, the communication function can be used to provide the relevant production island with an alternative Job. Since data exchange is performed via a ISDN network, both language and order data can be transmitted simultaneously; internally existing telephone lines can be used. And, by using a newly developed trans-mission language, a soft- and hardware-independent Computer link-up with external companies is possible.

To optimize design of the user interface with respect to the tasks and the workers in the production islands, and to cut down the training effort involved, a graphical user interface (GUI) based on OSF/Motif was developed for the planning support System. Only if accepted Standards and norms are applied throughout can the users be expected to deal with different Systems at a single workplace. OSF/Motif may be considered äs a

Standard on UNIX Workstations. By implementing suitable Symbols, we believe we have established a comprehensible and easily learnable connection between the user Interface and the functionality.

Outlook

The planning support System presented above provides the skilled workers in a production island with order-related data, thus allowing transparency of planning. The System makes available functions supporting a decentralization of responsibilities; these permit a flexible production sequence in accordance wi e requirements of the respective Situation. In line with the principle of lean production, the System enables activities to be amalgamated, hierarchies to be broken down, and costs to be cut by qualified decision-making. Machine setup time and the time during which machines ie idle can be reduced, and storage costs for material that is not required immediately can be cut. The System gives the skilled workers in the production islands a large degree of personal responsibility; whether it is accepted in this form has yet to be eval ted.

Data protection problems arising through the use of an ISDN network can be surmounted by employing a different sort of configuration. The essential point would appear to be that, by consistently supporting the concept of semi-autonomous work groups, a decisive step is taken towards harnessing innovation and productivity poten-tial that has previously remained untapped.

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