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IMPROVEMENT OF PRODUCTION PLANNING IN COMPANY PARS KOMPONENTY

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Abstract: The article analyzes the current status of production planning in company Pars Komponenty s.r.o., proposes a new method of planning based on application of the principle of MRP. It is a discrete type of production with high complexity of BOM and MTO (Make-to-Order) and ETO (Engineering-to-Order) from the point of decoupling point. The original planning system plans according to production capacity backward without collisions, but for a given type of production does not work in practice. Planning system was analyzed and the main problems were identified, which were high work in progress and material stocks. This article target is to propose a new planining system based on the inclusion of time reserves of purchased material items. New planning system was tested in practise with benefit in reducing both the material inventory and work in progress.

1 Introduction

This article describes the design and implementation of a more efficient method of production planning in the company Pars Komponenty s.r.o. based on the application of principles of MRP systems.

Pars Komponenty s.r.o. develops and manufactures components for mass passenger transportation vehicles, in particular, railcars, underground vehicles, trams, trolleybuses and buses.

The bearing manufacturing program of the company is manufacture of interior and exterior doors, pneumatic and electric door systems, windows, baggage racks, lifting platforms for disabled passengers and interior partitions for mass passenger transportation vehicles.

It is a discrete type of production and MTO (Make-to-Order) and ETO (Engineering-to-Order) from the point of decoupling point. This type of production is very specific and the designers who design unique products to meet specific customer requirements play an important role here. The customer and business world are more interconnected here. When the product is designed as well as manufactured the customer makes changes and clarifications.

This type of production is specific for:

- High complexity of BOM (even 20 levels)
- High number of operations that enter into the planning process
- Extensive modifications of existing products in accordance with customer requests
- A large number of customer changes during production (especially for prototypes)
- Material utilization mainly in accordance with customer specifications and requirements and therefore longer delivery times
- Limited outsourcing at other suppliers, as the customer certifications are needed
- The occurrence of floating bottlenecks, due to irregularity of production series composition

2 MRP Systems

MRP is a concept developed in the early 1960s in the USA. It can be said that it was focused more on inventory control than on the planning and management of the production process. Its basis is to replace the until then widely used inventory management system, which is according to the standards more effective and is based on the directed order of material according to the actual needs of production where the information is processed by the means of computer technology. The starting point for the calculation of the material requirement plan (MRP analysis) is the gross production schedule. It is built on the basis of purchase orders, or prediction of demand for products [1], [3].

The rapid development of MRP began with the transformation of the production plan which was designated by the number of final products manufactured according to the specific requirements of individual workplaces. This MRP itemizes constantly, transforms basic information, for example the need for the necessary capacity, materials, people, raw materials for the manufacture of parts and assemblies. With the ongoing time of production it determines which department, when and how much of what passes [3], [4].

MRP therefore answers these three basic questions:

- What is needed?
- How much is it needed?
- When do we need it?

The primary inputs to the MRP are:

- Bill of Materials (BOM) – a list of all usable materials and raw materials, parts and sub-groups, forming the final product. It is one of the three primary inputs to MRP.
- Master production schedule – a schedule which says how many finished parts is required and when.
- Stocks – a range of stocks. It provides information about each item in a production mix over time [4].

Input information is processed by different computer programs and they determine binding requirements for each period of the planning horizon. The master production schedule is one of three basic inputs to the MRP. It specifies which items are produced and when they should be completed and in which quantities. Requirements of the master production schedule are generated from the following sources: customer requirements, demand prediction and storage requirements to reduce or increase reserves. They affect seasonal variations or external needs [6], [8].

The master production schedule is usually prepared in weekly periods for several months (a quarter). The length of time horizon is determined by the length of the continuous time of product production. The length of planning time horizons also stems from the needs of customers.

At the end of the twentieth century with the development of competition and computer technology there rapidly increased demands on the quality of company´s management, and special demands on the quality control of its production system. Widespread development of computer technology has created major innovation of MRP system.

This innovation of the original MRP system is called MRP II (Manufacturing Resources Planning). The main benefit of MRP II has been connection of running production systems with the main areas of management of the entire enterprise. Only a quick connection of marketing, financial management and production allows the application of a real business perspective to the production activities of the company. Only the integration of efforts across the company enables the actual implementation of such total quality management. MRP II is directed at the integration of all management in search of prosperity in an increasingly challenging competitive environment [2], [3], [4].

Material Requirements Planning remained the focus of MRP II. The system always starts with the aggregating of all contracts, the sum of total demand. Managers of production, marketing and financial management then jointly draft the main plan of the production. Responsibility for developing the draft plan of the main production is not left to production managers, since detailed knowledge of this document is a prerequisite for the successful work of the company as a whole.

In the next stages of work with MRP II everything is gradually specified and is flexibly adapted to important needs and circumstances, such as technical, to preserve the original concept. System MRP II has improved simulation capabilities and the finding of answers to questions like “What happens if ...?” Working with MRP II should be a continuous process of searching and deciding about preferred alternative solutions. Reminding one that management is a decision-making process which is aimed at the achievement of business goals [2], [3], [4].

2.1 *Important Aspects of the Use of MRP II*

Top-down planning

There are two basic approaches to processing production plans using the MRP:

- Regenerative approach. This approach is based on the master production schedule, which breaks down by BOM (Bill of Materials) of the product. There are generated priorities. There are completely recounted net requirements from planned orders. The entire planning process is carried out in batches with high demands on time and computing capacity. To make everything clear and on time, everything is processed in a regenerative manner (usually weekly or monthly).

- The net change. In this approach, each network changes orders or material requirements, which is immediately reflected into the computer system. Whenever an unplanned event occurs (unscheduled contract, a change of BOM, increased consuption of resources etc.), there is initiated partial conversion of needs (articles) affected by the change [3], [4].

Regenerative systems work with master production schedules as a fixed document, which is issued regularly (monthly) in the new version. While the access of network change considers the master production schedule as the subject of the changes which have occurred since the last processing. In most of our businesses the slow approach of regenerative-approval approach (access of straitjacket) is still used. The philosophy of network change brings the necessary advantage of quick reactions. There is a certain disadvantage of “instability” of the system which is manifested especially in low labour discipline. A badly designed and used system of network changes leads to unplanned events. Production planners are then burdened with a stream of meaningless exceptional messages which cause chaos [3], [4], [7].

Time Display

In the terms of the flow of time, it is possible to distinguish two types of MRP systems:

- The system working with the time period (Busketed) which performs in each period (a day, a week) and accumulation of quantitative information is included in this period. Each period represents a data cell, which generates a predetermined number of the planning horizon. The planning horizon means the time interval from today to the specified date in the future. In this framework there are generated material plans. The planning horizon in the world is at least equal to the longest lead time + production time for obtaining material and raw material. If less, there can be problems associated with time for arrangement of material. In the case of materials with an extremely long order period with unnecessary extension of the planning horizon, the orders must be based on the techniques of statistical inventory process (safety stock, the use of safe consumption per capacita etc.). A too long planning horizon in the master production schedule again brings a risk of unrealistic prediction of requirements.
- System which works with no time period (Bucketless): Each data element (request, order) contains timing information. There is no need to accumulate information over time periods. Approach allows daily monitoring of planned and actual requirements. It is flexible but places greater demands on computer technology. They are redeemed by better use of advance time and overhangs, thus more accurate information for decision making [3], [4].

Rescheduling bottom-up

MRP like any current planning system must be able to react quickly to changes of plans. This is the way of management “top” system plans. However, in cases of various deviations and unexpected events (failure in production, delivery delay etc.) there is a need to respond. So firstly to find out which articles are affected by this event. This process of control production plan is called bottom-up replanning [3], [4].

3 Case study of planning system at Pars Komponenty

The following chapter describes the analysis of the current status of production planning system in company Pars Komponenty s.r.o., proposed a new method of planning based on application of the principle of MRP II and verification of the proposed solution by comparing the plan and reality.

3.1 Description of the Original Production Planning System

The input to the production plan is a business plan compiled by the sales department based on the customers´orders. After deduction of the time required for the final inspection and shipping, from the originated selling terms, the production plan can be crude with the utmost production deadlines. The standard planning process in the information system works on the principle of MRP II. The system plans according to production capacity forward or backward, either with or without collisions. For a given type of production with the need to adhere to established sales terms only backward planning can be used, but neither option (with collisions / without collisions) works in practice.

When planning without a collision an unrealistic plan occurs, because the system does not allow capacity constraints. It only works with net technological times and technological delays. Therefore production is planned under ideal conditions for unlimited capacity, which cannot be achieved in real conditions. The use of such a production plan for the management and purchase of inventory would lead to the late delivery of material and to the collapse of production.

While planning with collisions very different problems occurred. The system could not find the space capacity of the generating plant. In this case, the system created a production schedule too far in advance, by as many as several weeks or even into the past. The standard planning system did not address the possibility of an operative solution of the narrow point through coceptional innings. The use of such a plan has not been possible for bot the control of production and the basis for the purchase of materials. There would be a disproportionately high amount of inventories as well as work in progress.

Another problem was the removal of offline batch of manufacturing operations. This means that the operation has been physically done, but not accounted in the information system, so the system continues to block the capacity for this operation. In addition to this method of removal operations mistakes occurred due to the human factor thereby blocking further production capacity. During replanning, due to customer or internal changes an absurd production plan resulted.

The entire process of planning and management in production was thus based on the experiences of workers (especially dispatchers of production) which determined operationally what and when would be released to manufacturing. Based on the experience there the following table was prepared for the purchasing department and production that defined deadlines for delivery of materials to production (see Table 1). Extra dates have been divided according to the production lines and fields of materials.

Table 1 Deadlines for delivery of materials to production

	Group of materials	Doors	Windows	Platforms
1.	Al profiles	3 months	2months	
2.	Metallurgical	3 months		3 months
3.	Locks, Swing-Plug doors	2 weeks		
4.	Step Boards	2 weeks		
5.	Fasteners	3 weeks	3 weeks	3 weeks
6.	Blocks of electronics	2 weeks		2 weeks
7.	Buttons, switches	3 weeks		2 weeks
8.	Wire	2 weeks		2 weeks
9.	Tractions	2 weeks		3 weeks
10.	Brakes			3 weeks
11.	Motors			3 weeks
12.	Forging, casting	3 months		
13.	Bearings	4 weeks		5 weeks
14.	Lines	4 weeks		
15.	Pneumatic components	3 weeks		3 weeks
16.	Rubber	3 weeks	3 weeks	
17.	Glass	3 weeks	3 weeks	
18.	SOD 97, 98, SPD10, JKP01	2 weeks	2 weeks	2 weeks
19.	Horns	2 weeks	2 weeks	2 weeks
20.	Pneumatic components – EVV panel	2 weeks	2 weeks	2 weeks
21.	Plastic	2 weeks	2 weeks	2 weeks
22.	Sensors	2 weeks	2 weeks	2 weeks

Delivery dates include net production time and time reserves for cases of technical downtime or lack of human capacity, protection against material shortages caused by late delivery by the contractor, contingency reserve (faults) etc.

The Purchasing Department created orders according to these terms by complex calculation from the terms of production, which featured a large amount of work involved and significantly increased staff requirements. In manufacturing, the production was initiated according to the delivery of metallurgical materials and then it was managed by the dispatcher of production. The whole procedure of production is therefore limited to "emergency" problems.

3.2 Summary of Problems of the Original Method of Production Planning

The main problems were:

a) High material stocks because of the term protection, both of the purchase and manufacture
b) Line of materials did not always enter into the production process at the same stages, so in the terms of production the delivery of the material was inaccurate, eg. Metallurgical material usually enters 2-3 months before the date of manufacture. In the production of spare parts there are material requirements of production to production of the complete product entirely different
c) The management of production and purchase entirely outside the information system
d) High work in progress
e) High labor intensity of inventory management
f) Inability to replan the production plan for the reason of outdated accounting data in is
g) The total lack of support of the information system

3.3 Proposal for a New Method of Production Planning

The newly proposed method of planning is based on the principle of MRP of reverse planning with collisions. Plans are according to the technological times and sequences of processing at each stage of production, but with the inclusion of time reserves of purchased material items.

These time reserves should extend the production process for real continuous production time to produce a production plan corresponding with the real requirements for purchased material and featured purchase plan without the necessity to recalculate delivery times. This established plan permits the use of automatic ordering of materials, thus greatly reducing the labor intensity of inventory management in the purchasing department.

The principle of the creation of the plan is shown in a simplified manufacturing product tree consisting of three preparations (see Figure 1), where TV is a production deadline. For the manufacture of products, respectively semi-finished products, there serve bills of materials for the production schedule. These dispatches are reciprocally connected in the relation of superior-subordinate document.

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Final product

Oper.	Time	Material	Reserve time	Plan from-to
10	150min	mat.A	1500min	TV-2150min to TV
		mat.B	2000min	
20	200min	product A	-	TV-2350min to TV-2150min
30	100min	mat.C	2000min	TV-5450min to TV-2350min
		mat.D	1000min	
		product B	-	

Product A

Oper.	Time	Material	Reserve time	Plan from-to
10	100min	mat.A	1500min	TV-4450min to TV-2350min
		mat.B	2000min	
20	200min	-	-	TV-4650min to TV-4450min

Product B

Oper.	Time	Material	Reserve time	Plan from-to
10	200min	product C	-	TV-5650min to TV-5450min
20	200min	mat.D	1000min	TV-6850min to TV-5650min

Product C

Oper.	Time	Material	Reserve time	Plan from-to
10	200min	mat.F	500min	TV-6350min to TV-5650min

Figure 1 Simplified scheme of technological continuity and creation production plan

Time reserve in one operation is not added, but the reserve operation is given only by the highest value of material assigned to the operation.

For the meaningfulness of the new production planning and in particular its replanning for the reason of permanent changes especially from the customers´side, we have established the following points:

a) Online conducting of operation, so we removed the differences between the physical and financial status of completion of production
b) Gradual conducting of production, ie. That the operation cannot be conducted if it is not a priority
c) Accurate material assignment to operations
d) Possibility to conduct operations by units
e) Possibility of conducting operation proportionally, because of the assembly operations, where the process times required for the installation of one piece are in the order of days.

3.4 Setting up a New Way of Planning

To set the time for planning of time reserves we have chosen eight representatives of key product lines, where we checked in detail a new plan based on the experience of production dispatchers. We gradually put final touches to time reserves for individual fields of materials according to the Table of Extra Materials (see Table 1), which had to be extended to more subsets. This allowed a more accurate assignment of time reserves for individual materials and the resulting production schedule matched real possibilities of production capacity. The result was the gradual debugging of time reserves for individual fields of materials. The final distribution of fields of materials for time reserves is shown in Table 2.

Table 2 Fields of materials

Type	Field	Type of material
Fasteners	**11**	Screws
	12	Matrix
	13	Washers
	14	Screws
	15	Cotter
	16	Rivets
	17	Pins
	18	Special
	10	Other
Metallurgical	**21**	Steel – fe
	22	Steel - Stainless
	23	Aluminum
	24	Non-ferrous metals
	20	Other
Electrical	**31**	Installation
	32	Machinery and equipment
	33	Electronic components
	30	Other
Chemical	**41**	Adhesives
	42	Paints, thinners
	43	Cleaners
	44	Oils
	40	Other
Rubber, PVC	**51**	Rubber profiles
	52	Rubber panel
	53	Hose
	54	O-rings, oil seals
	55	Polyamide, PVC, fabrics
	56	Plugs, caps, fillings
	50	Other

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Table 2 Fields of materials - continuation

Type	Field	Type of material
Components	61	Bearings
	62	Pneumatic
	63	Belts, chains
	64	Lin. Leadership
	65	Mechanisms, transmissions
	66	Springs
	67	Cases
	60	Other
Subcontracting	71	Castings and forgings
	72	Products
	73	Locks
	74	Step boards
	70	Other
Non-metallic	81	Glass
	82	Fabrics
	83	Hides, skins, felt
	84	Brushes, strip
	85	Honeycombs
	80	Other

Table 3 The main outputs compared to planned dates for delivery of materials and the terms of their actual consumption

Field	The most frequent deviation (days)	Frequency (%)	Mean (days)	Standard deviation (days)
12	22-28	34.41	22.31	7.1
18	22-28	28.82	21.28	4.17
21	8.14	16.22	7.75	23.53
22	1.7	18.18	-5.44	18.26
23	22-28	18.7	17.8	17.24
24	8.14	28.57	1.69	17.41
31	8.14	55.56	16	5.84
32	29-35	62.5	26.74	8.01
33	29-35	70.37	29.74	3.34
51	15-21	36.76	22.78	7.33
55	22-28	23.08	6.5	18
56	22-28	44.9	26.65	5.13
61	1.7	47.37	9.03	4.76
62	22-28	51.51	18.36	9.37
63	1.7	50	9.9	6.23
64	8.14	26.32	9.32	12.94
66	22-28	52.86	22.63	6.38
71	29-35	20.56	16.46	17.09
73	8.14	32.14	5.68	23.94
81	22-28	37.84	19.19	4.79

3.5 Verification of a New Way of Planning

Verification of the new production planning was performed after four months of operation, where we investigated the differences between the planned delivery dates of materials to production and their actual consumption. For each field of material there was statistically processed the deviation from plan to reality in the form of average and standard deviation.

After evaluation of all the data, it was discovered that only one third of the material was removed as planned and the remaining two thirds was taken earlier or later than scheduled. The material was taken up mainly after the schedule time, which indicates a large permanent protection of the production dispatchers and purchasing departments. In Table 3 there is given for each field the size of the most common material deviations by which the reality differed from the plan, as well as the frequency deviation, the average deviation is reckoned from all data material consuption according to the reality and the standard deviation of the data [5].

3.6 Benefits of Newly Proposed Process for Planning

The main benefit of the new proposed method of planning should be to reduce both the material inventory and work in progress. This is due to two factors. The first is the reduction of time reserves of the original materials to delivery deadlines (see Table 1). The second factor is that the purchasing department will be based on the actual bill of material of the product, not estimated times (see Table 1) and it is going to order material as it should gradually enter into production, even though it will be the same material.

Another benefit is the simplification of the workforce of the purchasing department, because no longer do they have to calculate the amount and timing of delivery of the material in a complicated way, as was the case with the original system. The staff of the purchase department also have the possibility of using IS standard function for automatic order of materials according to the requirements of the plan schedules.

The third benefit is the ability to track the course of the production (compared to reality and plan), which enables quick and flexible response to emerging issues.

4 Conclusion

A new production planning system has been introduced to the company, which is based on the principles of MRP systems. This system is based on backward planning with collisions. It is planned according to technological continuity and processing times at each stage of production and the inclusion of time reserves of purchased material items.

The material was divided into 49 fields and into these fields have been calculated and allocated reserves. There reserves have been agreed by dispatchers of production to avoid jeopardizing the fulfillment of contractual terms.

The system has been operating for four months and after that was verified by comparison of the planned dates for delivery of the material in terms of production and their actual consumption. For each group there was statistically processed material deviation from the plan in the form of mean and standard deviation. Time reserves are analyzed periodically to verify and refine the values.

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