Information systems in manufacturing planning

Martina Žákovská, Marie Jurová
Faculty of Business and Management,
Brno University of Technology,
Kolejní 4, 612 00 Brno, Czech Republic

Abstract:

**Purpose of the article** The goal of each company should be creating a value to the customer. The company proceeds many processes with the labour to fulfill their goal. One of them is process of manufacturing planning and control. The way, in which is the production process scheduled, determines a position of company in the market and also their performance. The purpose of this paper is to explore the relationship between the process of manufacturing planning and control and the suitable planning system.

**Methodology/methods** It has been used the method of the secondary data collection from reputable ScienceDirect database and EBSCO approach within the Brno University of Technology, Faculty of Business and Management (2014) and literature review. The article has been prepared using the method of expert estimate, analysis, synthesis and induction.

**Scientific aim** The understanding the interconnection between information system and process of customer order execution is important for companies considering the implementation of new planning system.

**Findings** In the base of expert evaluating it was found, that operations planning and control for manufacturing companies has expanded successively over the last 60 years. In this paper is given a historical perspective identifying the main benefits and disadvantages of production planning systems from the first systems focused on material planning to the highly specialized advanced planning and scheduling systems. Process of planning and executing the customer order is divided to many activities and affect the final product. The process should be set properly and be supported with the proper information system.

**Conclusions** There is a potential for optimization the process of production planning and control in interconnection to the proper information system. Still, an understanding of how to set the process of production planning and control properly with the information system is unexplored.

**Keywords:** ERP, manufacturing planning, industry, advanced planning and scheduling, MRP, MRP II

1. Introduction

Production planning and management involves managing all aspects of production, including materials management, planning and scheduling of machines and human resources and coordination of suppliers and key customers. (Vollmann et al., 2005). Effective planning and management of material flow and production resources, i.e. production planning and control is generally regarded as crucial for the success of manufacturing companies (Jacobs et al., 2011).
Several tools of management of development of production plan and evaluation of its subsequent observance originated in the past. Start of production planning took place in the spirit of the ROP and MRP concept, followed up by a more advanced concept of MRP II. Despite production planning using ERP systems the market was penetrated by instruments of advanced production planning and scheduling APS. The individual approaches are described in detail in the following chapter.

2. Production Planning History

In the 60s of the 20th century cost reduction was the main competitive strategy. The production strategy of the company consisted in extensive series production, minimizing of production costs, and assumed stable economic conditions. Material ordering system using the reorder-point system (ROP) fully met their needs at that time (Jacobs, 2007). The system was described in detail for the first time by Wilson, who also introduced the hitherto used term “safety stock” (Wilson, 1934).

The first production plans with this configuration have resulted in ordering material in stock, thereby increasing the inventory. Number of shortcomings gradually increased, the principle of planning caused production outages, lost productivity and low delivery performance ability in respect to customers (Jonsson & Mattsson, 2009).

In a typical manufacturing environment the main production schedule is determined by the quantity of finished product required in each scheduling period. The company, however, also needs a set of information about raw materials, lower subassemblies and components, from which the final product is assembled. MRP generates production and purchase orders for components also at lower levels. For that it uses the information on the inventory stocks and bills of materials (Chen, 2001). MRP appropriately dealt with information about the need for material and inventory, but did not address another important source of production - production capacities (Jonsson & Mattsson, 2009).

MRP was gradually extended with additional functions for the company management for the planning, administration and control of productive resources. This change was so fundamental in the original concept that Wight (1984) introduced the concept of MRP II, which indicated the Manufacturing Resource Planning (Chen, 2001). In the process of creating the production plan the system took into account material requirements, production lead time and need for capacity resources to execute the contract with regard to the outlined start and end dates of production. The system planned the contracted production into manufacturing resources according to forward or backward scheduling logic (Rondeau & Litteral, 2001).

Companies maintained high inventory of material, semi-finished products and production capacities, in order to avoid capacity problems. The pressure to reduce costs, however, also forced them to reduce inventories and investments in capacity resources. This led to capacitive overload, originating variable production bottlenecks, uncontrollable production lead times. The traditional system based on the principle of MRP II was not able to solve these problems (Taal & Wortmann, 1997).

In the 90s of the 20th century, the concept of MRP II was expanded with additional functions such as production, marketing, finance, purchasing until the emergence of ERP, when the term was coined by Gartner Group of Stamford, Connecticut, USA. This ushered in a new era of enterprise information systems (Chen, 2001). Blackstone...
and Cox (2005) defined ERP systems as a system framework for organizing, defining and standardizing business processes necessary for effective planning and management of organizations, so that organizations can use their inside knowledge to pursue an external benefit (Chen, 2001). The area of planning and control of productive resources constitutes one of the activities of the ERP system (Fig. 1).

![ERP system structure](image)

**Figure 1 ERP system structure. Source: Chen 2001, custom processing**

MRP II concept is based on fixed dates of production delivery to shipment. In fact, this term influences many factors, e.g. material availability or workload. MRP II also ignores capacity constraints and leaves capacity problems to planners (Taal & Wortmann, 1997). At the end of the 90s it became clear that the ERP system is not an adequate instrument to cover all requirements, whether it was the diversity of the materials and manufacturing capabilities, the ability to meet customer requirements and shortening of lead times (Stadtler & Kilger, 2005). This is dealt with by APS systems of advanced planning and scheduling representing state-of-the-art methods that use information technology to simulate, optimize, streamline production and logistics. APS is able to combine the diversity of production process, plan different scenarios and take into account a number of limitations (David et al., 2006). They apply “what-if” simulations of alternative plans, under which it is possible to evaluate the impact of the changes performed, such as specification of the time for planning of the job-order, changes in the quantity or cancellation of orders, transfer of technological operations using alternative procedures, increase or decrease of the capacity of critical sites (Grimson, Pyke, 2007; Michel, 2007).

The advantage of APS compared to MRP II technologies consists in taking into account all requirements for the production and also the consideration of material and capacity constraints, which means that it considers available capacities over time in the planning and scheduling process. Thereby, the plan becomes more realistic and
feasible, production is not loaded with excess inventory and the company is able to realistically propose and then meet deadlines given to the customer (Stadtler, 2005).

All calculations are performed by APS closely linked to the enterprise information system, i.e. APS does not retain any information and data of the company, but performs calculations over the data base in the IS and reimports the resulting plan into the information system (Fig. 3) (Stadtler & Kilger, 2005).

This method of plan calculation of and transfer of data constitutes further benefit of the APS system, which is the speed of Planning incorporation (Stadtler, 2005).

3. System approach to organization management

System approach to organization management is based on system sciences, whose beginning can be traced back in the 30s of the 20th century (Jančarová, 1998), when in 1928 the biologist Ludvig von Bertalanffy conjectured that biological structures cannot be examined as individuals, but as a comprehensive system. In the 1960s Robert L. Kahn and Daniel Katz identified the general characteristics of the system and organization. According to them, each system has inputs and outputs and there is an agent operating between the two that converts the inputs into the outputs (for example production activity) (Pernica, 2005).

There is a number of definitions that deal with the concept of the system. According to Bertalanffy the system is a set of elements, among which there is an interaction (Pernica, 2005). In addition to the Bertalanffy’s definition there is a frequently quoted definition by Skyttner (2005): “A system is a set of interacting units or elements that form an integrated whole intended to perform some function”. Other authors refer to a system as a purposefully defined set of components and connections that, as a whole, show certain properties or behaviour. The system acts as a whole towards the surroundings, but its individual parts are in mutual interaction, and also interact with the system as a whole. Parts of the system are indicated as elements and the element is considered as an integral part of the whole. Among the elements or sets there are links as direct (unmediated) connection (Habr & Vepřek, 1972; Vodáček & Rosický, 1997; Pernica, 2005).

Each system is placed within a set of other groups of elements that are not considered part of the system, but have important links to it. This environment is called a system surroundings (Pernica, 2005). The system is separated from its surroundings by a boundary (Vodáček & Rosický, 1997). According to Rosický (2009) the interaction of an autonomous system of with the surrounding environment constitutes the basis of system hierarchy, the fact that each element of the system can be considered as a system ... and each system constitutes an environment in which it exists and interacts with its elements. Rosický further states system on the topic of interaction with the environment that “This fact is very serious and is related to the fact that the system, which in a given environment successfully fulfils the required functions may fail in another environment.” Awareness of this characteristic is essential for the transfer of system theory in connection with the operation of systems in the environment of manufacturing (and non-manufacturing) companies.

The method of arranging elements and links of the system is collectively called the system structure (Němec, 1997). The structure of the system is composed of subsystems. The system may have multiple subsystems, to which Vodáček and
Rosický (1997) further state the following: “The subsystem is considered such a set of elements and links that can be purposefully earmarked (mutually show stronger or more numerous links than to other parts of the system)”. Thanks to these links the elements inside the system form relatively independent wholes.

According to Němec (1997), the purpose of the organization is to allow the system to implement the desired behaviour. According to him the organization is characterized by its content, structure, communication and decision-making process. Like Němec (1997) Jančarová (1998) considers the purpose of organization to be ensuring of the outlined objectives. Development of system towards the specified destination is addressed also by Duchoň (2008), who states that the system achieves its objective thanks to changes in time.

System theory applied to the management and control of the company is based on the assumption that all organizations are systems and all systems are a part of larger systems. The degree to which the subsystems are functionally linked to higher systems, will ultimately determine whether the subsystem prospers (Bedrnová & Nový, 2007).

In system theory, the system is defined in two ways (Tóth, 2008):

- Externally, according to its purpose. Each system has its role in the superordinate system.
- Internally, according to its own subsystems and internal functions. Each system is composed of partial systems and subsystems that are interconnected and thus fulfil the objective and purpose of the master system.

The literature speaks about a systematic approach to problem solving. Jančarová (1998) considered the systemic approach to be the “way of thinking, way of solving problems, or way of acting, while the phenomena being understood comprehensively in their internal and external relations”. The essence of the system approach is a comprehensive insight into the problem, considering of the possible variables and elements that can affect the entire system. This allows a view from above and finding new ways of solution. Jančarová (1998) further states that the main benefit of system approaches is the conscience of interaction between the system components and the system as a whole, as well as between the system and its surroundings. Systems approaches can, according to Jančarová, be applied to solve any problems, especially those that have a rich structure and are intricately branched.

4. Production department as a subsystem

If we start from the ideas of the above-cited authors, consider undertaking an organization whose system makes part of a higher system (market). By the same logic, the system then is divided into subsystems, which should support its mission. These subsystems are individual business units - manufacturing, economic, business, personnel, and other departments.

Each subsystem has its own mission and objective within the integrity of a higher system (company), and attempts to achieve it through various processes.

From the viewpoint of the production department the most important process is the process of production. The manufacturing process has close ties to the processes of selling and purchasing processes (Jurová, 2013). The purchasing process provides
inputs that are converted into outputs through the production process. These outputs are also used by the sales process to cover the relevant commitments. Individual subsystems can be perceived as small cogs, which can achieve the outlined corporate goals only based on good cooperation.

In setting the objective of production management, it is important to consider the target of the superordinate system - the enterprise. Jurová (2013) in her book emphasizes the importance of satisfying customer needs. It is also dealt with by Goldratt in his book Goal (Goldratt, 1981). The main purpose of the production department is not only the production of job orders with the lowest possible costs, but to satisfy customer requirements for delivery of the product in the required time, quantity and quality. Thereby the production target becomes interlinked with the objective of the entire company.

Means of ensuring and creating the conditions for achieving goals, according to Jurová, (2013) is the planning process. Řepa (2007) and Grasseová et al. (2008) define the process as a set of activities that transform inputs into summary outputs for other workers or processes by giving added value inputs. The added value originate by using resources such as personnel, material, equipment, tools and so on. Another definition of the process is provided by Basl (2002), Nenadál et al. (2005).

As with the system, even in a business process the authors speak about the goal of the process. Basl and Blažiček (2012) define a goal as one of the objects of the business process. The goal is to be the final state, which is to be used to achieve this process, as shown in Figure 2.

![Figure 2 Elements of business process](image)

Figure 2 Elements of business process
*Source: Andersson et al. 2006, custom processing*

Planning is one of the managerial functions recognized and defined by Henry Fayol. Wöhe (2007) considers crucial the so-called comprehensive planning, which is unlimited in time and is superordinate to the strategic, tactical and operational plans. It is conducted by the top management and involves the specification of responsibility to the industry, information policy, profit division policy, financing principles, creating of the management concept and setting of corporate goal and mission. Jonsson and Mattsson (2009) recognizes the strategic, tactical, operational execution level of planning. Each planning level falls into a different time horizon. Strategic planning
ranges from one year on, the tactical level takes place in period from 6 months to 1 year. The level of operational management is a matter of one day to several weeks. Planning and management of the process falls within the operational level and the execution level (Jonsson & Mattsson, 2009).

The implementation process of the production order has defined inputs and outputs. Inputs to the process are shown in Figure 3 (Jonsson & Mattson, 2009).

Figure 3 Inputs in the implementation process of production order
Source: Jonnsson&Mattson, 2009

5. Discussion of the production order planning process

When applying the system approach to management of the organization it is first necessary to define a higher level of the system and identify the role of the organization in this system. System approach emphasizes the awareness of the existence of interaction between system components and system as a whole. The fact, in which superordinate system the organization fulfills its role, is important to determine the mission and goals of the organization (Jančarová, 1998). According to the systemic theory an organization must have a role in a higher superordinate system. If it cannot find a role in the higher system, it cannot survive on the given market. In case that the higher does not perceive the value of the subsystems, it will ignore this subsystem. That means an end to the participation of these subsystems in higher-level system (Tyson&Jackson, 1997).

After the higher level of the system is defined and the role of the organization identified, attention should be focused on internal subsystems. These subsystems should ideally be designed to mutually and jointly support the organization's purpose. Assuming that the organization knows its true purpose, it is the way in which the organization’s subsystems are arranged that will determine the success or failure of an organization. As a result of this statement there should not be subsystems in the organization that do not have a role in the organization’s purpose. Each subsystem must contribute to the success of the purpose of the subsystem. Similarly, the managers and individual employees are subsystems and must know their role and the purpose for which they make part of the system.
In applying the systems theory, the companies should ask themselves the following questions:

1. What value the monitored organization offers to a higher system? Does the company offer products that serve a higher system?
2. Do all subsystems monitor its mission in the hierarchy of the organization? Is the goal and mission of the subsystem related to the goal and mission of the higher system?

In the course of planning of the production order it is important to take into account all the inputs that the production order implementation process requires. The task of planning is to balance these inputs appropriately so as to effect the manufacturing job order in the required quantity, time and quality.

The planning process involves planning of the following inputs: material, capacity and information regarding the production order. In addition to these direct inputs the production schedule is affected by changes that may be initiated by the customer or by the company itself (e.g. material unavailable for the start of production order, lack of capacity). The course of the execution of the job order may be associated with bottlenecks (Goldratt, 1981), which may be the material and capacity constraints. The company should cope with that in order to meet its goal of satisfying customer requirements (Jurová, 2013).

Given that the process of planning of the production order and its subsequent implementation is associated with many variables, this process can be seen as unstable and the manufacturing company must reck with its frequent changes and be prepared for it in a qualified manner.

The logic of the system - subsystem - process relationship and their interactions, where the mission and the objective of the process should be in relation to the mission and the goal and of the subsystem and mission and goal of subsystem should be linked to the mission and goal of the system implies the importance of the process as such throughout the hierarchy of these relationships because they stand at the very beginning of the fulfillment of the corporate goal. From the opposite sequence of responsibility, however, the process itself should be adequately supported by the superior subsystem in order to adequately fulfil its mission.

This support should consist of an appropriate information system that controls the production planning and management. Due to the amount of data that needs to be maintained and calculated in the process of production planning and management, this system must currently in the data-demanding period be really precise and above all it must correspond to the mission of this process.

Information system, which also falls under the category of the above-defined systems is defined by inputs and outputs. In the case of realization of production order these inputs are constituted by information about resources, changes and ideally also bottlenecks. The information system is stable in the short time perspective (within 5 years). In the longer term it is necessary to develop the system to maintain the development trend with the company to which it is supposed to serve.

Due to the stable system (in the short term) the process of planning and production control is unstable and variable over time. Changes that may threaten the production plan are many. It is clear that the process of production planning and control of orders is an important part of the fulfillment of corporate goal and deserves significant
attention. Because of its variability also the system is essential that covers the process and provides facilities for data structure entering the process.

6. Conclusion

The process of planning of manufacturing orders passed has greatly evolved in its history. The first systems that were focused on planning of material requirements for the main production have evolved through systems for the material and capacity planning of production resources up to modern methods of production planning and scheduling.

The actual quality of the plans is not based solely on highly advanced and comprehensive management tools, but on accurate and correct information. Data entered in the information system must reflect the fact, whether it is a feedback from the manufacturing workshop or unavailability of manufacturing resource in the resource calendar. In the current market environment the competitive advantage is the ability to respond flexibly to customer requirements. Speed of APS system planning allows to respond more flexibility to changes in customer requirements and reflect the changes more effectively and quickly into the operational plan. Possibility to reflect immediate changes in orders to the production plan constitutes genuine added value of production planning. Neither the APS approach is a panacea and their implementation in a manufacturing company will not solve all the problems of trade, procurement, planning and production. APS is a tool that helps the company to find the causes of problems and effectively remove them, but shows a high sensitivity to input information. This feature is a possible object of further research that can define the ideal data structure for the best possible outcome of the process of planning and management of production, whether through MRP, MRP II or APS system.

References


Tóth, E. (2008): *Úvod do systémového managementu.* (244 s.) Praha: Vysoká škola hotelová v Praze


**JEL Classification:** M15, M21