Influence of selected methods of production flow control on environment

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Abstract. The chapter presents issue of influence of everyday activity of manufacturing enterprises on the environment. Authors draw attention to how great impact on the state of the environment have decision taken by production managers. Special attention is drawn to, inter alia, redundant transport during production processes and also generation of waste during production. In the chapter methods of production flow control are presented and compared them in terms of impact of the result of using it on the environment. In group of methods which are discussed are methods of family MRP - material requirements planning (MRP I), manufacturing resource planning (MRP II) and enterprise resource planning (MRP III / ERP). It is also analyzed optimized production timetable (OPT) and the Japanese methods of production flow control (JIT, KANBAN). At the end of article indicate of those methods of production flow control which are least harmful to the environment.

Keywords: production flow control, material requirements planning, just in time

1 Introduction

Production processes are inextricably linked to the necessity of transporting raw materials, semi-finished materials, tools, waste generation, both in the form of unused and no longer possible to reuse the raw materials, as well as shortcomings, which can not be recycled from exhaust emissions and other pollutants. Any production will not remain so without any impact on the environment. In the face of environmental problems facing the world today, the challenge for manufacturing companies has become such a production control to reduce the negative impact of operations on the environment. Awareness of people managing companies with environmental risks which are inherent to the manufacturing process is growing. Companies trying to harm the environment as little as possible not only in that they see a financial gain, which does not require payment of any penalty environment, but more often they feel responsible for future generations.

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The methods of production control is generally speaking we can divide the methods of classical and modern. The division is of course conventional methods. Classical methods for controlling the flow of production are contained in two areas:

- intercellular control of every cell in respect to all degrees of sophistication in the structure of manufactured products;
- intracellular control includes setting and monitoring of the conduct of the tasks of production only in the production of basic cells.

In turn, the modern methods of production control are:

- MRP I - Material Resource Planning, method which connects inventory control with planning of production;
- MRP II - Manufacturing Resource Planning, method for the hierarchical production planning, scheduling concerns at all levels - strategic, tactical, operational, until the scheduling of treatment;
- ERP - Enterprise Resource Planning, method relating to all significant corporate resources in terms of marketing, financial and logistics;
- OPT - Optimized Production Technology, method of optimizing the flows of materials, semi-finished products, finished goods by bottleneck;
- JIT - Just In Time (connect with technique of KANBAN), method that eliminates inventory and accelerating the flow of materials, intermediate products in the circuit logistics company.

It is worth noting that modern methods of production are based flow control is whether the principles drawn from elements of the classical methods. For this reason, the remainder of this article will discuss ways to control the production of only using the methods form modern group.

2 Methods – MRP system

2.1 Material Requirement Planning (MRP)

Material requirements planning is a systematic planning and control methodology for production and inventory. It is a procedure for planning and controlling the raw materials, purchased parts, and work-in-process inventories required in manufacturing a product. MRP is especially suitable for situations in which an end product is being assembled or manufactured from a variety of parts and components.

MRP is expressly designed for dealing with dependent, discontinuous, non-uniform demand, which is characteristic of manufacturing environments. Because of this, the benefits of MRP, when used properly, can be significant. They include the following [6]:

- inventory reduction – MRP determines how many of a component are needed and when in order to meet the master schedule. MRP enables a manager to procure that component as it is needed, thereby avoiding the costs of excessive inventory;

- reduction in production and delivery times – MRP identifies materials and component quantities, timings, availabilities, and procurement-and-production actions required to meet delivery deadlines. By coordinating inventories, procurement, and production decisions, MRP helps prevent delays in production;
- realistic commitments – realistic delivery promises can please customers. By using MRP, production can give the marketing department timely information about likely delivery times to prospective customers.

MRP, as a form of supply and production control based on an analysis of orders for finished goods, coordinate the material characteristics of the product in case to production scheduling.

2.2 Manufacturing resource planning (MRP II)

Manufacturing resource planning is a method for the effective planning of all resources of a manufacturing company. It is made up of a variety of processes, each linked together: business planning, production planning (sales and operations planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems is integrated with financial reports such as the business plan, purchase commitment report, shipping budget, and inventory projections in dollars. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

In MRP II the specific actions of the company has been allocated to appropriate levels of management. Strategic level includes the general objectives of the company, production planning, financial groups and other groups participating in it. These groups must ensure that adequate financial as well as material resources to produce at a specific time agreed quantity of product or service, and other groups in the area of marketing, distribution and sales. However, the tactical level of model which supervising the main production schedule, using the computer system, compares what is needed for the production with what he has. Given the time of receipt of materials and the acquisition of the remaining missing factors of production, the schedule is adjusted to the realities of realization. MRP II besides to control inventory levels also makes operational priorities of the constituent elements and controls the use of the capacity of individual episodes. The operative level notes the connection production activities and auxiliary operations with the business plan and financial results obtained at the strategic level of the company.

2.3 Enterprise resource planning (ERP)

The ERP systems allow making the assessment of material flows in production systems [2]. The Association for Operations Management APICS defines Enterprise Resources Planning (known also as MRP III) as framework for organiz-

ing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage.

Structure of ERP system shows figure 1. Lead time, ideal supply and the intended performance are those parameters which serving the dynamic adjustment based on a broad-based governance rules parameters in the method of ERP. A key part of the whole model of ERP is the method of demand planning. This model is designed to quickly create more accurate analysis of their use during the implementation of long-term business plan, and of daily or weekly demand analysis, to determine the current data for the forecast.

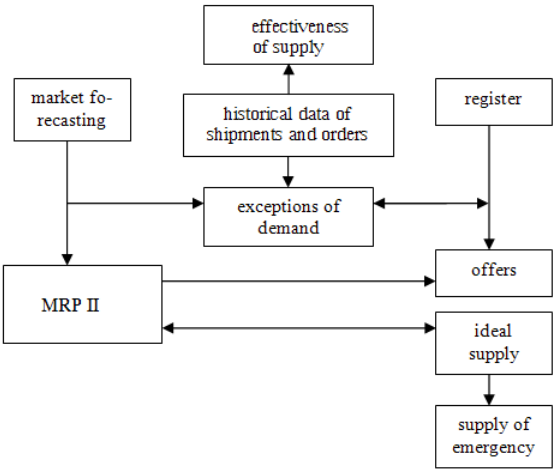

Fig 1. Structure of ERP system *Source: [1]*

Table 1. Advantages and disadvantages of using ERP system

ERP systems	
Advantages	**Disadvantages**
Provides integration of the supply chain, production and administrative process.	Very expensive to purchase and even more costly to customize.
Creates commonality of databases.	Implementation may require major changes in the company and its processes.
Increases communication and collaboration among business units and sites.	Is so complex that many companies cannot adjust to it.
Has a software database that is off-the-shelf coding.	Involves an ongoing process for implementation, which may never be completed.
May provide a strategic advantage over competitors.	Expertise in ERP is limited, with staffing an ongoing problem.

Source: [4]

3 Optimized production technology (OPT)

Optimized production technology is a proprietary scheduling system developed by dr E.Goldratt. The aim of OPT is to schedule bottleneck capacity in an efficient way. This schedule is the master for the demand placed on other capacities. OPT method needs special computer software. OPT method based on two fundamental manufacturing phenomena:

- dependent events, what means that all processes rely upon the completion of preceding operations;
- statistical fluctuations, process times fluctuate around an average.

The effect of these phenomena is that the capacity of a plant must be unbalanced and therefore bottlenecks are inevitable. The OPT method of scheduling dictates that material should only be launched on to the shopfloor at the rate at which it is consumed by the bottleneck.

The main features of OPT are described as follows [8]:

- balance flow not capacity;
- the level of utilization of any part of the system, which is not a bottleneck, is dependent on other constraints in the system, not the potential of the worker;
- tache utilization and activation of a resource are not synonymous;
- an hour lost at the bottleneck is an hour lost for the total system;
- an hour saved at a non-bottleneck is just a mirage;
- bottlenecks govern both throughput and inventories;
- the transfer batch may not, and many times should not be equal to the process batch;
- the process batch should be variable, not fixed;
- schedules should be established by looking at all the constraints simultaneously. Lead times are the results of the schedule and cannot be predetermined.

The steps used to develop OPT shown in figure 2.

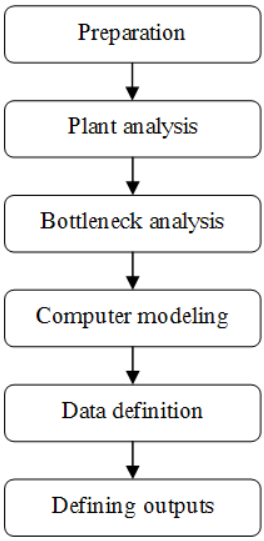

Fig. 2. The steps used to develop OPT

The benefits claimed for OPT are that it will schedule finite resources in order to achieve maximum factory effectiveness. Main benefits of using method:

- addresses the key problem of bottlenecks;
- improves profitability by simultaneously increasing throughput;
- reduces inventory and operating expenses.

4 Japanese methods

4.1 Just-in-Time (JIT)

The Association for Operations Management APICS defines just-in-time as a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery, and includes all stages of conversion from raw material onward. The primary elements of Just-in-Time are to have only the required inventory when needed; to improve quality to zero defects; to reduce lead times by reducing setup times, queue lengths, and lot sizes; to incrementally revise the operations themselves; and to accomplish these activities at minimum cost. In the broad sense, it applies to all forms of manufacturing job shop, process, and repetitive and to many service industries as well.

JIT typically require less floor space for equal levels of production. Reductions in square footage can reduce energy use for heating, air conditioning, and lighting.

Reduced square footage can also reduce the resource consumption and waste associated with maintaining the unneeded space (e.g., flourescent bulbs, cleaning supplies). Even more significantly, reducing the spatial footprint of production can reduce the need to construct additional production facilities, as well as the associated environmental impacts resulting from construction material use, land use, and construction wastes.

Just-In-Time can result in more frequent "milk runs" for parts and material inputs from sister facilities or suppliers, leading to an increased number of transport trips. This can contribute to traffic congestion, as well as environmental impacts associated with additional fuel use and vehicle emissions. Through efficient load planning, however, the environmental implications of increased milk runs can be significantly reduced or eliminated. What is also important, JIT when not implemented throughout the supply chain, can just push inventory carrying activities up the supply chain, along with the associated environmental impacts from overproduction, damaged goods, inventory storage space heating and lighting [7].

4.3 Kanban technique

Inseparable element of JIT systems is the method of kanban production management, which is based on the flow of documents in the form of cards attached to the trucks, which are delivered small amounts of components and other materials needed for production. It was introduced by Toyota Motor Company in Japan in the years 1950-1960 and defined as "a system of organization of parts supply, semi-finished materials for manufacturing at the time of the actual demand for these items" [5].

This system provides strict inventory control. In the traditional approach to overriding goal of industrial capacity utilization was not counted then the expenditure on the maintenance of magazines. Whiles the task of Kanban system is to start production ingredients only when it is really need it [1].

Benefits of kanban scheduling [3]:

- reduces inventory;
- improves flow;
- prevents overproduction;
- places control at the operations level;
- creates visual scheduling and management of the process;
- improves responsiveness to changes in demand;
- minimizes risk of inventory obsolescence;
- increases ability to manage the supply chain.

From a financial side, the inventory reduction not only saves the carrying cost of the inventory but also the physical space occupied by the existing inventory. The freed-up space can then be used for new business opportunities or may eliminate the need for planned expansions or leasing of offsite warehouses.

Steps to implementing kanban shows figures 3.

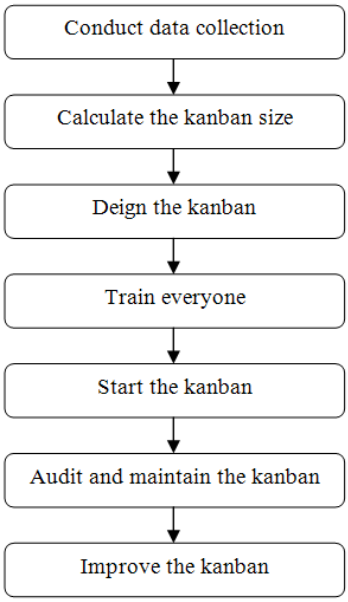

Fig. 3. Steps to implementing kanban

JIT connect with kanban systems reduce the amount of necessary in-process and post-process inventory, thereby reducing the potential for products to be damaged during handling and storage, or through deterioration or spoilage over time. Such damaged inventory typically ends up being disposed of as solid or hazardous waste. Frequent inventory turns can also eliminate the need for degreasing processes for metal parts, since the parts may not need to be coated with oils to prevent oxidization or rust while waiting for the next process step.

JIT connect with kanban systems help eliminate overproduction so potential benefits of using it for environmental performance is:

- decrease the number of products that must be scrapped or discarded as waste;
- decrease the amount of raw materials used in production;
- decrease the amount of energy, emissions, and wastes that are generated by the processing of the unneeded output.

It is important to note that JIT or kanban may not succeed at reducing or eliminating overproduction and associated waste if the products produced have large and/or unpredictable market fluctuations.

5 Summary

There are two systems in control of production - a pull and push. In the push system, production begins by anticipating future needs, i.e. make to stock. How-

ever, in a pull system initiates production as a reaction to the current needs of customers, in the case of typical make to order. These approaches can be combined and used simultaneously in a single production system. This is where we produce parts according to demand forecasts, and then assemble to order. So in the first part we deal with the production push, then pull production system.

Discussed methods of production control can also be attributed to these systems. MRP, MRP II and ERP systems can be likened to push, while JIT and KANBAN technique to pull system. While these methods are mainly the smooth implementation of material flow in so OPT method may serve to strengthen the results achieved by the chosen method. The efficiency of material flow is in fact subject to various constraints and bottlenecks in production. The efficient use of the possibility of bottlenecks, and so the more we use the opportunities arising from the application of the method of OPT, including the effectiveness of the method becomes greater, and consequently increases the efficiency of the whole enterprise. Making the most of opportunities bottleneck is having a positive impact on the environmental performance of the method, even in because of preventing the movement of defects. Setting the post of quality control before the bottleneck also affects the efficient use of machinery and reducing defects.

Comparison of MRP systems and Japanese methods of production control in terms of the impact of the method on the environment shown in table 2. Due to the fact that the goal of this article is to show the impact of flow control method of production on environment, the methods were compared in terms of only those aspects that were considered by the authors as the most important from the standpoint of environmental impact. They are:

- informatization - means amount and the way in which documents are archived;
- employees - shows how to approach and requirements put for workers influence on their ecological thinking;
- logistics – the way of reflect in production flow control of lenght of transport routes and the size of work in progress or inventory;
- defects - an approach to quality control of semi-finished products, and thus the impact on the prevention of deficiencies, and therefore unnecessary consumption of resources.

Table 2. Comparison modern method of production flow control in terms of the impact on environment

	MRP systems	Japanese systems
Informatization	MRP systems most commonly used for continuous production in accordance with specific schedules require extensive computerization.	Japanese systems using flexible production structure characterized by the simplified rules and minimum documentation archives.

Employees	In MRP systems, the emphasis is on targeting the specialized employees perform certain tasks. The current assessment of the labor productivity and a sense of the minimum impact on how the allocation of tasks is not conducive to ecological thinking.	Japanese systems pay attention on the training and ability to self-assessment. This approach makes employees have a greater impact on what is happening at the company exhibit a creative approach to the task and willing to report improvement proposals, also in terms of reducing the negative impact of production on the environment.
Logistics	Large inventory, long distances between the warehouse and production line, complex storage.	Minimum stocks of materials, supply of materials as close to the production stations.
Defects	The quality of semi-finished goods is controlled by a special cell, which often means the need to transport semi-finished products in the specified location.	The role of quality built into every thinking worker. Individual controlling and improving the quality makes it virtually deficiencies do not occur.

Analyzing data from table can be concluded that the Japanese methods of production control are more environmentally friendly, because of the better handling organization of transport or even a much smaller amount of waste. It is significant here that the approach to an employee in a subjective way, conducting training, also green, and use of knowledge, experience and ideas of employees in implementing improvements.

It is worth noting that a combination of methods is most appropriate. Evidence of this even when the fact that in the literature from time to time there are new methods of production control, which were created by combining various elements or objectives of the existing methods. Selection of appropriate control methods should be supported by thorough analysis of the situation, type of production, specific industry and market in which to exist. Not without significance is the introduction of cost-effectiveness analysis of a system of production control, because you should realize that if even the method of MRP and OPT, it is necessary to apply the appropriate software. Also, the introduction of any of the Japanese methods will require a reorganization of production, and thus incurred expenses.

References

1. Brzeziński M (2002) Organizacja i sterowanie produkcją (Organization and manufacturing control). Placet, Warszawa.
2. Golińska P (2010) Sustainable supply chain management – challenges for integration of distributed data sources. In: Grzybowska K. (ed.) New insights into Supply Chain. Publishing House of Poznan University of Technology, Poznan: 153.
3. Gross JM, McInnis K. R (2003) Kanban made simple. Demystifying and Applying Toyota's Legendary Manufacturing Process, Amacom, New York: 5.
4. Heizer J, Render B (2008) Operations Management. Pearson Prentice Hall, New Jersey.
5. Martyniak Z (1996) Nowoczesne metody zarządzania produkcją (Modern methods of production management). Wydział Zarządzania Akademii Górniczo-Hutniczej im. St. Staszica w Krakowie, Kraków.
6. Panneerselvam R (2005) Production and Operations Management. Prentice-Hall of India Private Limited, New Delhi.
7. Productivity Press Development Team (1998) Just-in-Time for Operator Learning Package. Productivity Development Team, Oregon.
8. Turner S (2010) The Little Black Book of Management: Essential Tools for Get-ting Results NOW. McGraw-Hill Companies.