National High School of Technology
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production planning by MRP at finite capacity

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industrial Engineering

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Abstract: Manufacturers are always required to innovate and take special care on optimizing their company organization and make time critical decisions to keep costs low thus increasing profit margin. Researchers are equivaly playing their part keeping their solutions effective and up to date. In this context the most common production planning method in the industry is MRP, but it is not flawless. We noticed that the MRP algorithm does have a major flaw that it does not take into account the production capacity we will be suggestion other methods that could be used alongside MRP to fill in its gaps and establish the best production plan

Key-words: MRP, CRP, planning, production capacity planning, production management

Contents

1. Introduction

"Production planning aims, for a planning horizon in general of a few months, to optimize the use of the productive factors available for the production of one or more several products meeting specific characteristics. It is a treatment process of information leading to a provisional programming based on an approach optimization" Vincent Giard [1]
In other words, production planning makes it possible on the one hand to anticipate for its meeting demand, forecasting supplies, and planning the use of resources Production. On the other hand, it can also be used as a way to optimize the production by seeking, for example, to minimize costs while respecting deadlines.
There are different production planning systems:
Hierarchical planning (Hax et Meal, 1975), MRP (J. Orlicky,1975)[5], OPT (E. Goldratt,1969) Kanban (T. Ohno, 1959) [2]
In this article, production planning, we will focus Only for MRP methods., The MRP method (Material Requirement Planning) or component requirements planning is the best known of the existing techniques in production management. The MRP method appeared in the United States in the sixties, initially very simple, MRP-0 (1960) could be called "production replenishment method" , has highlighted the type of product, the product with the independent need and the product with need depend , A system that from the request forms estimates the finished products and the current stock levels, calculates the component requirements (how much and when) to meet the demand, the production capacities are not taken into account, but in (1970) MRP0 to which we added the calculation of the loads generated on the production by the result of the MRP. Planning always proceeds at infinite capacity, and is called MRP-1, and Evolution of MRP-1 which integrates the calculation of production costs and a load capacity adjustment algorithm. This allows the desired load to be adjusted to the available load for each production center, the process is called MRP-2

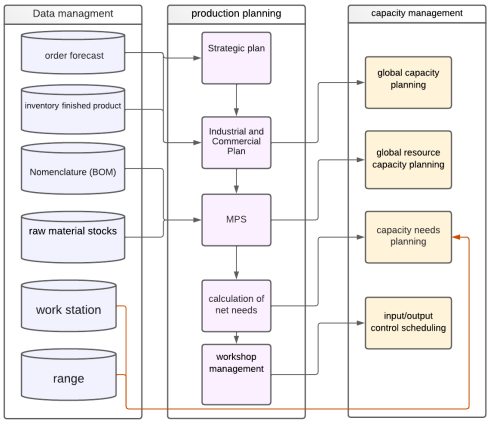

Figure 1: Modeling planning decisions in MRP II,[7]

what is the Prerequisite for setting up an MRP?

2. Material Requirement Planning MRP

The MRP method appeared in the United States in the sixties, initially very simple, MRP-0 (1960) could be called "production replenishment method" , has highlighted the type of product, the product with the independent need and the product with need depend [, A system that from the request forms estimates the finished products and the current stock levels, calculates the component requirements (how much and when) to meet the demand, the production capacities are not taken into account, but in (1970) MRP0 to which we added the calculation of the loads generated on the production by the result of the MRP. Planning always proceeds at infinite capacity, and is called MRP-1, and Evolution of MRP-1 which integrates the calculation of production costs and a load capacity adjustment algorithm. This allows the desired load to be adjusted to the available load for each production center, the process is called MRP-2 what is the Prerequisite for setting up an MRP?

2.1. Prerequisites for the implementation of an MRP

One of the main characteristics of an MRP compared to other mode of planning cation of production, is the mass of data necessary to establish component requirements.
Prerequisite for implementing an MRP-0: Necessary conditions for the company to set up the MRP-0 system are: Existence of a production master plan Existence of a complete nomenclature of the components used Existence of a weak stock status information system: requires MRP Good knowledge of the stock status of components, at the beginning or at the end of each period of the planning horizon Existence of a lead time file: it is essential to be able Calculate the release dates of OF (production order) or order submission.
Requirements for the implementation of an MRP-1: Necessary conditions for the company to implement the MRP-1 system are: Existence of a file of ranges: the ranges determine used by the operations thus making it possible to calculate the load Existence of a resource file: this file establishes the production capacity
Requirements for the implementation of an MRP-2: Necessary conditions for the company to implement the MRP-2 system are: Existence of a production and storage cost file Existence of files necessary for determining priorities

2.2. The logic of MRP:

the planning goal is described (a production plan for a time scale defined by a planning horizon and a refresh period.
A production plan answers the following questions, among others:

- what to produce?
- when to produce?
- haw much to produce?

The MRP method makes the answers to these questions coherent, and ensures their logical sequence by measuring the consequences in the short term.
There are four steps involved in the MRP2 logic:

1. The Industrial and Commercial Plan (PIC).
2. The Production Master Plan (PDP) .
3. The Calculation of Needs.
4. Supply staking and management of production resources.

2.3. The general diagram of the MRP2

Management of Production Resources (MRP2) is a concept of production the management to anticipate the exact needs with their time lag. Based on demand forecasts and customer orders, the MRP2 method manages production, from the long term to the very short term, using five planning levels:

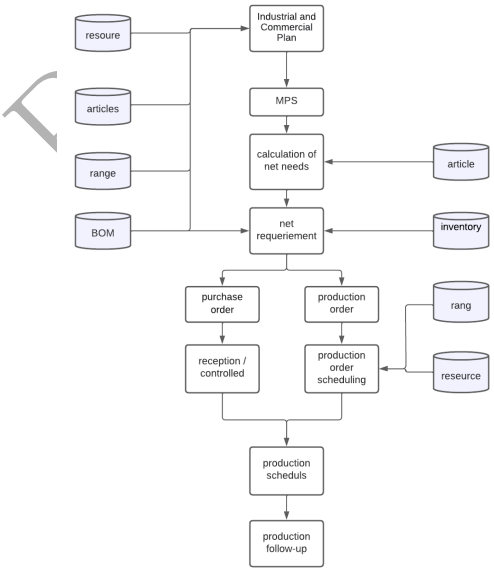

Figure 2: MRP Flowchart.

2.4. Industrial and Commercial Plan:

The PIC is drawn up jointly by the general management, the management of the production and commercial management based on the order book and business forecasts. It defines sales volumes, inventory levels, equipment and resource requirements, plan production capacities or long term from 2 to 12 months.
the input data to establish the commercial industrial plan are:

- the resources
- Nomenclature
- the articles
- the ranges

the articles: An article is a product of the company or an element entering the composition of a product, which we want to manage. It is a general term corresponding to a finished product, a sub-assembly, a component or a raw material
Nomenclature (BOM): a hierarchical list that represents all the components of a product (sub-assembly, intermediate product, part), called article-parent, the relationship that we establish between a compound and a component is called a nomenclature link, each link is characterized by coefficient indicating the quantity of component necessary for the production of a compound
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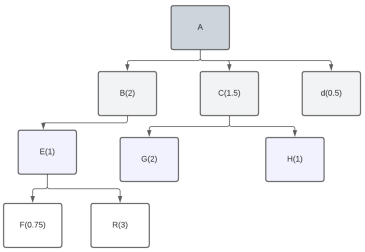

Figure 3: Nomenclature.[3]

the ranges: prepared by the method office, is a description of the manufacturing method of a given product, this description includes the operations, the work stations involved and the standard preparation and processing times

2.5. Production Master Plan (PDP):

established by the production department to define the types and the volume produced manufactures medium term the quantities to be produced per period (real units) taking into account the forecasts of the orders and the state of the stocks is the economic data, The production master plan thus established is then validated to be transformed into a product production plan and constitutes a starting point for the calculation of component requirements

2.6. Needs planning:

the needs for items to be manufactured, from the production master plan is the nomenclature to determine the quantities of components (raw material and semi-finished product) necessary for the manufacture of products for a given period. There are two types of needs: the calculation of net needs and the calculation of gross needs

Gross needs : the calculation of net needs is removed from the product nomenclature

Net requirements : Net requirements correspond to gross requirements and material availability, starting from the projected stock

2.7. Production schedule:

The result of the net requirements calculation is a set of production orders. Each order is characterized by a quantity and a date. These 0F (forecasts) were developed without taking into account the actual capacity of the production system. R le but to adjust the load capacity

2.8. A production order

is a document that orders manufacturing to produce a certain amount of the ingredient. This document initiates production and identifies the item to be manufactured, quantity and deadline for manufacture In addition, the adjustment aims to ensure that: the load is lower than the capacity. This is an obvious material constraint. the load tends towards the capacity. This is an important economic constraint, because it make the use of the means of production profitable.

2.9. Production follow-up:

It concerns the launch and follow-up of purchase and manufacturing orders, scheduling.

This approach nevertheless presents certain limits relating to the methods of calculating needs, the absence of sufficient capacity control (we reasoned as if the production capacity was infinite) can cause problems of the type of delay in delivery or stock of 'In progress.

3. Production capacity planning

Capacity management must absolutely be taken into account to avoid obtaining unachievable production plans. It is therefore the role of production capacity planning that will intervene at different times during the production master plan development phase in order to avoid these problems.

Therefore, production capacity planning presents the various techniques that have been developed to ensure that production plans are achievable.

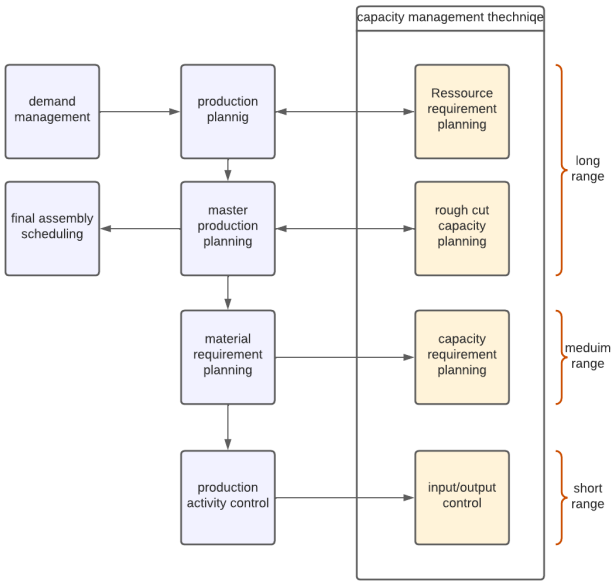

Figure 4: the different capacity management techniques[4]

3.1. Planning of means of production Need

Resource requirements plans (RRPs) – involve looking forward in the long term to predict the requirements for large structural parts of the operation, such as the numbers, locations and sizes of new plants.[6]

The first phase of production capacity management consists of planning the needs for long-term means of production (Resource Requirement planning) this process is similar to that of MRP Except, that instead of planning the needs in components, we planned the needs in human, material, and financial resources necessary for the realization of the production plan (PDP)And on the other hand, the difference of the MRP this planning relates to the whole periods of the PDP and use item families without any notion of BOM levels (Hierarchical planning).

Implementation:

Establish its resource profile which defines the resource requirements necessary to produce one unit of the product of the family, for each family of articles

The manufacturing time of an item includes the manufacturing times of all these Components. Resources are also grouped by work center the method used in this one is much more precise and detailed. It is based on a production plan and resource profiles established for each product. These profiles take into account the execution times on each resource. A profile is presented in the form of a 2-dimensional table: (resource, deadline) the columns represent the production times from the date of availability of the article, the lines the resources needed for a product P The intersection of a straight line and a indicates the resource time required to manufacture a unit of products if it must be available on date t.

	machining	assembly	packaging
A	314	197	90
B	100	86	56
C	57	38	25

Table 1: Example of resource profiles for 3 item families.

In this example, machining a unit of A takes 190 hours

after establishing the resource profile for each family by multiplying, for each period of the PDP, the times obtained thanks to the profile by the quantities of forecast production, we thus obtain the production capacities required by the long-term PDP.

These results are compared to the capacities available to detect the adjustments to be made. These adjustments may require heavy investment in new production units that must be taken into account as soon as possible.

3.2. Validation of the production master plan

after which establish the needs of the resources necessary for the realization of a production plan by the previous method this will make it possible to validate the adequacy between available capacity and loaded from the PDP, before launching the execution of the MRP Currently, there are three PDP validation techniques which are grouped under the term RCCP (Rough Cut Capacity Planning). These techniques differ according to the data required and their complexity.
Rough-cut capacity plans(RCCPs):are used in the medium and short term, to check the master production schedules against known capacity bottlenecks, in case capacity constraints are breached. The feedback loop at this level only checks the MPS and key resources
These techniques differ according to the data required and their complexity.

3.2.1 Global factors approach

This technique, also called CPOF (Capacity Planning Using Overall Factors), is the older. It relies on the following information to establish a provisional schedule of charges: – a production master plan – the total time needed to produce each part of a product – the proportion of time used by each workstation in the workshop

- a production master plan
- the total time needed to produce each part of a product
- the proportion of time used by each workstation in the workshop

The App:
The first step is to calculate the number of workshop hours required per month by multiplying the PDP quantities by the average time to produce a product.
Then simply divide that time by the historical proportion of time used by each work center to get its forecast load.
The validation of the PDP then consists in checking for each period and each workstation that the available capacities are sufficient.
This method is particularly well suited to workshops manufacturing products of a same family because in this case it is easy to obtain the temporal proportions of each work center in relation to the workshop.

3.2.2 Capability sheet approach:

This approach corresponds to the approach by resource profile presented in the section previous. The only difference is that at this level, we no longer process products by family and by type but by reference. Moreover, its role is centered on the validation of the PDP and not on the investments to be made

3.2.3 Approach by resource profile:

the method used in this one is much more precise and detailed. It is based on a production plan and resource profiles established for each product. These profiles take into account the execution times on each resource. A profile is presented in the form of a 2-dimensional table: (resource, deadline)
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	t1	t2	t3
R1	a_{112}	a_{111}	a110
R2	a_{112}	a_{111}	a_{110}

Table 2: resource profile of product P1.

	t1	t2	t3
R1	a_{212}	a_{211}	a210
R2	a_{112}	a_{111}	a_{220}

Table 3: resource profile of product P2.

	period 1	period 2	period 3
product1	b_{11}	b_{12}	b_{13}
product2	b_{21}	b_{22}	b_{23}

Table 4: production plon for product 1 and 2 over 3 months.

In this example, products P1 and P2 have average lead times that span over three periods. A From the production plan and the two previous resource profiles, it is then possible establish the forecast load for each resource.

	period 1	period 2	period 3
resource1	c_{11}	c_{12}	c_{13}
resource2	c_{21}	c_{22}	c_{23}

Table 5: estimated load of resource 1 and 2 over 3 months.

$$c_{11} = a_{110}b_{11}+a_{111}b_{12}+a_{112}b_{13}+a_{210}b21+a_{211}b_{22}+a_{212}b_{23}$$

$$c_{21} = a_{120}b_{11}+a_{121}b_{12}+a_{122}b_{13}+a_{220}b21+a_{221}b_{22}+a_{222}b_{23}$$

$$c_{12} = a_{110}b_{12} + a_{111}b_{13} + a_{210}b22 + a_{211}b_{23}$$

$$c_{22} = a_{120}b_{12} + a_{121}b_{13} + a_{220}b22 + a_{221}b_{23}$$

$$c_{13} = a_{110}b_{13} + a_{210}b_{23}$$

$$c_{23} = a_{120}b_{13} + a_{220}b_{23}$$

The main interest of this method is the consideration of production times. The method is thus more precise, at the cost of more computation time.

3.3. Planning of production capacity needs:

CRP (Capability Requirements Plans (CRP))

the CRP is able to calculate the load caused by these orders on the resources of a workshop by simulating their execution. On the snapshot as well for each period of the planning horizon, the load and capacity of each resource.

Generally, the CRP is used in conjunction with the MRP because it helps to verify that all scheduled production orders can actually be processed by production without causes an overflow. Thus, it is often the last test before validating a production plan. belfig:quadtree

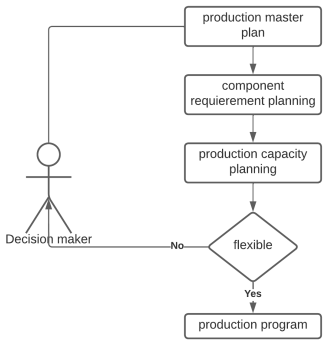

Figure 5: PDP-MRP-CRP control loop

Load calculation:

The CRP uses the production orders generated by the MRP and breaks them down according to the work centers they must cross. For each of the sub-orders obtained, it calculates the load generated on the workstation and adds it to the load removed since the beginning of the period. The same is true with the firm and/or manual planned OFs in order to obtain load information that is as precise as possible.
The distribution of a production order to the workstations is obtained from the range of the product to be produced. This is why the existence of a range file has become Mandatory from MRP1 systems.
CRP Results: The CRP produces workload diagrams per workstation. These diagrams present for each period the capacity available in number of hours and the load emitted by the Schedule. These diagrams identify overcharges when the load created exceeds the available capacity and underutilization otherwise

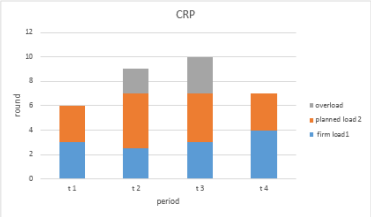

Figure 6: Example of load diagram generated by the CRP

Until now, the production capacity planning techniques studied have only served to verify the adequacy between the requested loads and the available resource capacities. In case of overload, you had to go back to the production master plan and adapt it until the problems disappeared. However, an overload is not always synonymous with redesigning the PDP, there are methods to make it disappear on temporary loads. Typically, these methods are only found in MRP-II systems under the name of Load Capacity Tuning.

4. Load smoothing techniques

Load smoothing techniques fall into two categories depending on the object they are concerned with:

- Parallel smoothing applies to resources
- Serial smoothing deals with operations that use the overloaded resources.

4.1. Parallel smoothing

Parallel smoothing: Parallel smoothing is the quickest solution to implement when faced with an overflow. Temporary capacity because it consists of increasing the capacity of overloaded resources at the price of a higher cost of production.
Smoothing by capacity adjustment: Smoothing by increasing capacity consists of directly increasing the capacity of overloaded resources by increasing their availability as much as possible. In this case, the production manager can either increase the working time by placing it in the place of overtime or increase the pace with the risk that this entails.
Smoothing by capacity transfer: Also called parallel smoothing, it consists of calling on subcontractors to reduce production costs or transfer the operation or operations that overload a position to equivalent positions.

4.2. Serial smoothing:

If all the sets of the same family of interchangeable sets are overloaded on a given period, this means that only "serial" smoothing (time lag of the operation) may cancel the surcharge. There are then two possibilities: the shift to the right and the shift left. The shift to the right can only be considered in an exceptional way, by playing on safety stock

5. Conclusions

this article made it possible to understand the operation of an MRP and to raise it main shortcoming, namely the failure to take production capacities into account when drawing up planning. However, there are a number of methods for planning production capacity needs at different times in the production management system production.
these methods cannot guarantee that there will be no overruns of ability. There are therefore load smoothing techniques that can be applied to results of the MRP to try to eliminate the problems of overflows temporary. This type of process only appeared with type MRP-2

References

[1] Gérard Baglin, Olivier Bruel, Alain Garreau, Michel Greif, and Christian van Delft. Management industriel et logistique. 3eédition. *Gestion Economica*, 2001.

[2] Pierre Béranger. *Les Nouvelles Règles de la production: vers l'excellence industrielle*. Dunod, 1995.

[3] Alain Courtois, Chantal Martin-Bonnefous, Maurice Pillet, and Maurice Pillet. *Gestion de production*. Les Ed. d'Organisation, 2003.

[4] Irawan Irawan, Titin Nasiatin, Suhroji Adha, Octoberry Julyanto, Citra Puspita Rani, and Rahardian Dimas PK. Analysis of production capacity planning and control in pt. krakatau wajatama with rought cut capacity planning (rccp). *Journal of Industrial Engineering & Management Research*, 1(2):207–218, 2020.

[5] Georges Javel and Joel Le Bert. *L'Organisation et la Gestion de Production*, volume 138. Masson, 1993.

[6] Nigel Slack, Stuart Chambers, and Robert Johnston. *Operations management*. Pearson education, 2010.

[7] A Thomas. Impact du concept de chaîne logistique sur les systèmes de gestion de production-le nouveau rôle de la planification tactique et les nouveaux outils. *Ecole d'été d'automatique–Gestion de la Chaîne Logistique. Session*, 24, 2003.