The implementation of MRP II in two Brazilian industries*

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Abstract

This paper presents the implementation process of the MRP II – Manufacturing Resource Planning – in two Brazilian factories, and reports on difficulties in programming and controlling the shop floor in make-to-order and assembly-to-order environments. It proposes a formal architecture for a production planning and control system by using hybrid systems, including Linear Programming, Queue Theory and Kanban System. Suggestions are presented on how to improve the in-plant logistic performance considering the client service and the minimum production cost.

Key words: MRP II; Linear programming; Queue theory; Production and planning control; Hybrid model.

The increasing complexity of the manufacturing systems gives rise to some philosophies of production management aiming at improving efficiency of the production process. Two main philosophical lines are the just-in-case and the just-in-time ones. The just-in-case philosophy gives priority to the use of structures and production work centres, which are optimised by the batch production of parts, generally depending on sale forecasts, which guarantee the dimensioning of the capacity and the scheduling of routine procedures. The factory is said to be managed by the *push* system.

Radically different in its basic principles, the objectives of the just-in-time philosophy are to provide top priority to flexibility and to prevent systematically any

* Este texto foi escrito especialmente para apresentação no ICIL' 99 – International Conference on Industrial Logistics, realizado em St. Petersburg, Rússia, jun./1999.

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kind of waste. Some of the just-in-time principles of action are production of items in smaller batches, reduction of inventory levels during the production process stages, and being driven by client needs. Therefore, the factory is said to be managed by the *pull* system.

Systems such as the Manufacturing Resource Planning, MRP II, take care of the manufacturing resource planning, besides providing for the planning and control of industrial activities. MRP II also aims at integrating the production process as a whole, with the other areas of the enterprise more directly associated with the factory.

Global competitiveness requires from the enterprises an organisation based on fundamental processes, oriented towards supplier's satisfaction and client's needs. This requires performance patterns that seek to transform the manufacturing function into a competitive weapon for the organisation. New performance indices should reflect production process flexibility, faster task realisations, reliability for both internal and external information systems, and high quality. Together with these requirements, the principle of "making it cheaper" should always be present.

The analysis of two implementations of MRP II, in two factories of different characteristics – one from the precision mechanic sector, with a batch production process; and the other from the electro-electronics sector, with a continuous production process – has shown failure in the implementation process. This paper identifies key points in these implementation processes and proposes a novel production planning process, based on the use of hybrid systems, to add further features to the existing MRP II methodologies, little known in Brazil. The second part of the paper presents a brief bibliographical review on the theme. The third part identifies the MRP II implementation process. Finally, the fourth part discusses the proposed production planning hybrid model.

The MRP II system

According to Little and Yusuf (1995) and Orlicky (1975), MRP II has been the most important advancement in material flow planning and control since 1960. It is important to recognise this assertive as long as several other systems and methodologies for material and production control have been developed for the past 25 years.

Hall and Vollmann (1978) define that the MRP II system is, to a certain extent, simply a computer programme for production. It enables the system management, at the right time and in a more efficient way, to put forward purchase orders, part manufacturing and subsets, which assemble the complete products. In a broader sense, however, it represents a complete set of related tasks, which starts with the sale forecast and input sale orders and finishes with the feed-back from the shop floor.

It is important that enterprises seek to create integration and structure strategies that allow a more agile management of their processes, through getting reliable information in real time. According to Yusuf and Little (1998), it is necessary that complements be added to MRP II systems through other software packages, such as, for example, improving the existing functions. Besides, MRP II should be used together with other industrial control systems, such as Just-in-Time (JIT), or Optimised Production Technology (OPT), in order to get combined gains from those systems.

Love and Barekat (1989) propose a decentralisation of MRP II to operate in cellular manufacturing environment. Every manufacturing cell should have its own computer with MRP II, tied to the central MRP II. Those authors argue that this decentralisation scheme reduces lead-time and improves management capability and data maintenance, besides providing an agile what-if analysis tool. Some enterprises in the great Belo Horizonte area have initiated decentralisation processes of their systems, regarding local bill of material calls for item control, which are managed through JIT/Kanban philosophy.

The use of hybrid systems to control and plan the flow of materials within the plant has become usual since the beginning of 1990. Ming-Wei and Shi-Lian (1992) identify some types of hybrid systems. In some of those systems, some materials are defined as MRP II items and others as JIT system items. The choice of such items should be carefully planned in order to obtain combined gains. The correct definition of the type of production process, or of the industrial environment in which the enterprise operates, is of paramount importance to this definition.

This paper proposes the use of the MRP II system both to control higher level items of the product structure and to analyse preliminarily the capability. JIT controls shop floor items, through the Kanban system, and optimisation decisions are made via Queue Simulation and Linear Programming.

Hybrid systems with MRP II and OPT are reported by Reimer (1991) and Spencer (1991). According to those authors, the OPT system uses the MRP II data base for engineering, processing and distribution of purchase orders, in order to get a detailed resource schedule.

Limitations for capacity planning are found in MRP II technology. Nonetheless, capacity planning is a critical function in manufacturing management, mainly in environments with high degree of complexity of detailed production planning. The MRP II system considers, for example, that manufacturing lead times are fixed, that is, it does not take into account whether or not the factory is congested. Besides, it does not allow overlapping of operations, that is, the division of production batches into smaller fractions not taken for posterior operations of the productive process, aiming at making a gain in throughput time.

Variations in production plans, an ordinary thing in Brazilian enterprises, end up generating waste of time, as well as indirect costs, in the reprogramming tasks. Therefore, an expert production programmer is required to overcome this difficulty, but it is not a guarantee for an effective performance of the process.

Many constraints and characteristics of the industrial environment contribute to rendering production programming a more complex problem, obviously in different degrees, according to more or less present factors. Some of these constraints and characteristics are outlined below (CORREA *et al.*, 1997):

- production orders have different delivery dates and they are generally in a different state of realisation;
- they may present set-up with variable time and tasks;
- they may present alternative production routes, which may have different productivity and performance due to technological characteristics of the machines and equipments;
- they may belong to clients of different relative importance;
- regarding manufacturing resources, machines may crash, materials may be unavailable, workers may not come to work;
- regarding operations, there are rework problems, problems of definitions and size of the production batches, and problems resulting from orders requiring simultaneous availability of machines.

The difficulties mentioned above can be minimised with the use of the so-called Finite Capability Production Planning Systems (FCPPS), which, according to Correa *et al.* (1997), have the main characteristic of taking into account the technological features of the system in the productive capacity, as an *a priori* constraint for programming decision making, seeking to guarantee feasibility to the resulting production programme, that is, to fit it into the available capacity.

A more complex and sophisticated modelling of programming problems can be achieved with Finite Capability Production Planning Systems. The system user should model the manufacturing system by informing the manufacturing routing, unit manufacturing times, set-up times, technological resources, production calendar, constraints, the finished product and component demands and real conditions of the production system at a given time, as well as availability of raw-material, labour and idle machines, and whether there are queues or not.

Compared to recent manufacturing planning and control systems, which incorporate additional functions that are out of its traditional focus, MRP II presents some deficiencies. Some of these functions are: human resources planning, decision making support applications (RICCIUTTI, 1992), management of the supplier chains, maintenance, quality, security and health of personnel (WOLFENDEN, 1994). Systems providing these functions are called Enterprise Resource Planning (ERP). Recently, a strong move towards the concepts of enterprise management as a whole can be noted, with a great deal of publications about those systems coming out. Suppliers and consultants have also been offering these systems as the final solution for entrepreneurial problems.

MRP II IMPLEMENTATION

This section describes the implementation of MRP II in two industries in Brazil. Lets call them industry A and industry B, for reference purposes. The project implementations started approximately at the same time in both industries, in 1993. Up to July 1996, industry A project had not been concluded, being recognised officially as a complete failure. In 1995, industry B gave up its project. Industry A drew a new implementation plan, involving a hybrid system of MRP and Kanban, which started to produce reasonable results in 1998. Industry B is carrying out an appraisal for software change and configuration of a new implementation process. Both industries still have serious problems with their production program tasks.

The main causes of failure in the MRP II implementation in industry A can be classified in three types: technology selection and acquisition, technical data structuring, and management and project follow-up. A detailed discussion of these causes can be found in Vitorino and Terra (1997) and Vitorino (1998).

A deeper analysis has shown the problem in both industries to be of a strategic nature. The problem occurs during the technology selection and acquisition phases and in the implementation and follow-up phases. In the first semester of 1997, industry A carried out a global MRP II project review, deciding to go on for a second implementation attempt. The objectives of the new implementation project involved using MRP II for raw materials planning and control based on the sale plans and adopting the Kanban technique for shop floor control programming.

Again, several problems with product structures and routing emerged, which have been solved during the current year, through data base simplifications and reorganisation of the factory into a few work centres, to facilitate the updating of production orders generated by the system.

The implementation of the Kanban system in the shop floor was done by a specific software package to plan system detailing, such as the numbers of containers for transportation, container dimensions, and control system. The results obtained within the shop floor level are considered efficient at the moment, regarding production follow-up and organisation of the factory area, but it is recognised that the results need to be improved and that there is room for improvement.

THE PRODUCTION PROGRAMMING SYSTEM

Based on the arguments presented in the previous sections, enterprises need to seek hybrid configurations for their production planning and control system (PPC). Therefore, this paper offers contribution to allow PPC to collaborate with the improvement of competitiveness in industry. Figure 1 depicts the configuration of PCP, which will be discussed below.

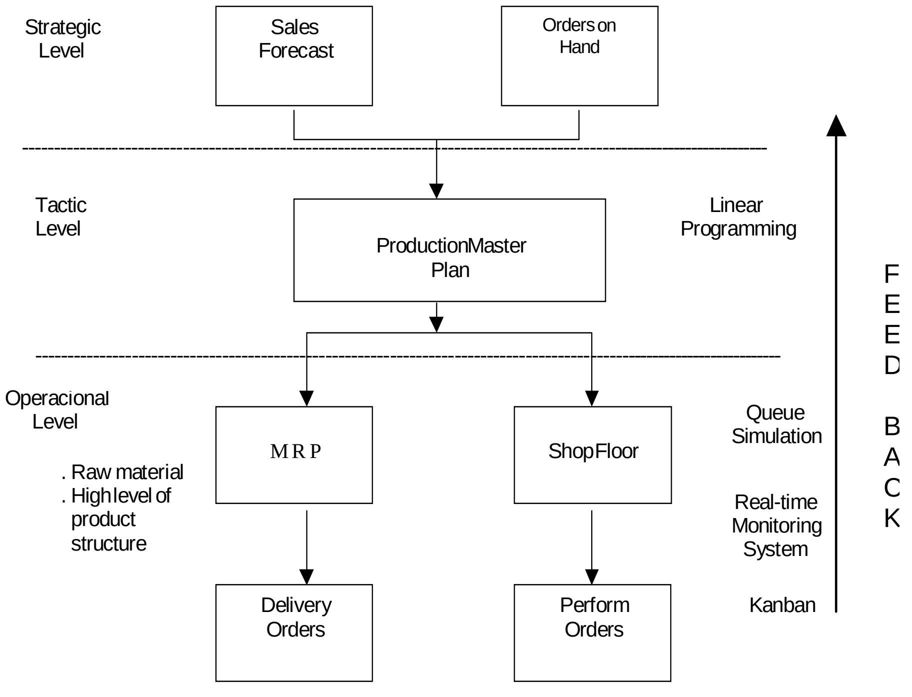

Figure 1: Configuration of a hybrid PPC model.

Strategic level

This level is responsible for realistic plan definitions as a target to be aimed at by the several areas involved. It sets up the sale plan aggregated by finished product families, in general, for a twelve-month scenario, based on the Business Plan.

Tactical level

This level sets up the functions responsible for transforming sale needs into a master production plan, defined as an optimal plan, generated by a model of Linear Programming. The optimal plan takes into account cost commitments, maintenance of employment levels, optimal inventory levels, and meeting client needs. The linear programming model should aim at minimising the total production cost (CT). Constraints are associated with the capacities in regular regime (R), in extra-time regime (E), in regime of subcontracting of finished and semi-finished units (S), increments of production (AP), and decrements of production (RP). Contracted capacities (T) and inventories (I) should also be part of the model. Cost constraints are associated with the capabilities, such as unit cost at normal regime (Cr), unit cost at extra-time hours (Re), cost of subcontracting of units (Cs), cost of rising the production rate of a unit (Ca), cost of reducing the production rate per unit, per time period (A), and other costs, such as rework, obsolescence, etc.

As there is more than one planning period, relations between theses variables should be taken into account in the model and written as explicit constraints of the problem. A summarised modelling for this problem is:

Minimise $CT = \Sigma\, Ri(Cr) + Ei(Re) + Si(Cs) + APi(Ca) + RPi(Cd) + Ii(A)$

Subject to $Rt \leq R$ (regular capacity limit)

$Et \leq E$ (extra-time capability limit)

$St \leq S$ (limit on the capacity of product sub-contracting)

$APt \leq AP$ (production generated by personnel hiring)

$RPt \leq RP$ (production lost by personnel firing)

$It = It\text{-}1 + Rt + Et + St + Apt + RPt - Demand$

Rt, Et, St, APt, RPt and $It \geq 0$

For making-to-order processes, cost minimisation should be contemplated, and fresh models built and linked to each other. The proposal is that the models should be set specifically for each problem, in the light of the general problem, so as to avoid optimal conflict solutions. Commercial grade codes available in the market may be used for the solutions of the models.

It should be remembered that Linear Programming, as an Operational Research approach, has the decision-making process as primary objective. However, because the mathematical model may only represent a relative reality, in defining the final master production plan the manager must incorporate to it qualitative aspects of reality, normally translated as common sense, expertise or intuition.

Operational level

The function executed at this level is divided into two parts. MRP II manages the first part. The algorithm realises by pushing raw materials and other (few) parts of the product structure, at the right time, to be pulled by the Kanban system. The other parts of the structure are previously defined by the production management, in function of more specific control needs, for instance. The use of ghost items in the structures provides adequate ties between the *push* and *pull* systems, taken advantage of the combined use of these systems. The second part is responsible for shop-floor execution and control. The technologies for that are the Kanban system and the Queue Simulation, supported by real-time monitoring. The Kanban system takes care of the programming and control of items manufacture and planned final products. The use of Queue Simulation is critical for production optimisation. Before starting the production process, via Kanab, a shop-floor simulation is carried out for a certain period, which can be, for example, a shift of work. This simulation can yield the buffer size and identify bottlenecks, process inventory levels, and solve problems of loss of capacity in function of the production process losses, mix of production, and also aspects of machine and production line set up.

Simulation techniques today must be extensively used by the Production Planning and Control Departments of the enterprises. Programming languages and simulators are now accessible from both functional and cost level viewpoints. A broad range of simulation packages, which can simulate anything that moves or is transported in a network, can now be found in the market at reasonable prices.

The configuration of a production monitoring system in real time is a desirable, but not a fundamental factor for the architecture of the hybrid model for production programming and controf. A detailed cost benefit analysis must be carried out, considering the characteristics and technologies of the physical process and the manufacturing policy of the organisation.

Conclusion

Motivated by the failure in the implementation of MRP II in two Brazilian enterprises, a new hybrid model was conceived. The proposed model incorporates the operational research field, through Simulation Techniques, Queue Theory and Linear Programming. The Kanban system, as a sole executor of the sop floor, completes the hybrid model of planning, programming and control.

The antecedents and organisational culture of the enterprise should be considered, verifying the whole set of required skills for the use of a hybrid programming system. As well as suggesting a programming configuration integrating several technologies, this paper tried to offer guidance to those organisations facing problems with production planning and control.

Resumo

Este trabalho analisa a implantação do sistema MRP II em duas indústrias localizadas em Contagem – MG – e reporta as dificuldades que o sistema apresenta na programação e no controle do chão de fábrica em ambientes de produção sob encomenda e montagem sob encomenda. Além da análise, propõe uma configuração híbrida para o planejamento e o controle da produção, suportada pela Programação Linear, pela Teoria das Filas e por Kanban. Também sugere alternativas para incrementar a performance da logística interna.

Palavras-chave: MRP II; Programação linear; Teoria das filas; Kanban; Modelo híbrido.

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