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Implementation of hierarchy production planning model and its theoretical comparison with manufacturing resources planning (MRP II) (Case study of Iran Khodro Company)

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ABSTRACT

Now, the companies and institutions view production management and manufacturing planning systems as one of the aspects raising important competitive advantage for them. This causes that we observe the mentions and new systems in this field. Hierarchy production planning (HPP) is raised as one of the methods. In the past decades, considerable studies have been conducted in this regard. This study attempted to adjust Meibody model of existing models in manufacturing hierarchy planning as the case study of this study based on the existing information of press shop hall 3 of Iran Khordo Company. Then, by collected data of this hall, HPP was implemented and finally by model output analysis, optimal production planning was provided for this hall. Later, HPP model is compared by considering 5 parameters of goal, performance field, content, inputs, process and outputs as theoretical with manufacturing resources planning model (MRP-II) and weaknesses and strengths of each model and performance of each of them are explained compared to other one.

KEYWORDS: Hierarchy Planning, Manufacturing resource Planning, Optimal production, Production management

1. INTRODUCTION

In the current era, due to increasing environmental changes, it is required that the companies and institutions protect their ability in effective and successful competition continually in global markets to achieve competitive advantages. Production and operation management as one of the solutions and tools fulfilling this issue is considered and to provide a brief preparation of different manufacturing systems an different production management systems (timely production system, resources planning system of company and limitations theory) and using efficient, scientific and new methods of production management and operation try to achieve competitive advantages, as low cost, high quality and speed to give the product to the customer. Then, we refer to the reasons of formation of HPP, HPP implementation advantages, different aggregate forms of HPP, MRP system and its comparison with HPP, explanation of some of applied models of HPP, different methods of problem solving of HPP. Then we explain the applied model in Iran Khodro as Aggregate Type Production (ATP), Family disaggregate *planning (FDP)*.

2. STUDY METHOD

The applied method in most of HPP methods is based on empirical-math and the required data for study is extracted and applied by field methods and existing databases. Generally, to use study models in operation, six steps are necessary: 1- Problem definition, 2- Problem classification and data collection, 3-Modelling or formulation of problem, 4- Model solution, 5- Analysis of sensitivity and model validity, 6- Model implementation

The present study attempted to express HPP, MRP-II models descriptively. Then, by existing data as analytic, the implementation and outputs of HPP model are investigated. The applied method in this study is descriptive-analytic.

The historical trend of MRP, MRP-II, ERP formation

In the early 60s, Economic order quantity (EOQ) was raised as a method for inventory management in companies. EOQ based on independent parameters as delivery time, goods price, demand, warehouse capacity, etc. attempts to determine optimal order and its time and at first, many problems were encountered in implementation. In 60s, MRP was a computers approach to material requirement planning in USA and its guidance book was published by Orlicky's (1975) [1]. Indeed, MRP technique was used before the Second World War as manually and combined in various sections of Europe. Orlicky believed that computer could use all details of MRP techniques and this made the mentioned technique in management of inventories in production process as effective. The above initial design was created to use computerized –MRP based on Bill of *Material* Processor (BOMP). Over the time, the installation of these systems in various companies was developed and some of the extensions on primary systems were Master production scheduling (MPS), Production Activity Control (PAC),ROUGH Cut capacity planning (RCCP), Capacity Requirement Planning

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(CRP) and Purchasing . The combination of planning modules (CRP,MRP,MPS) and executive model (PAC, purchase) and creating the conditions in which planning cycle can receive required feedbacks of executive cycles can lead to full type of MRP as called closed loop MRP. MRP comprehensiveness was due to the attempts of American Production and Inventory Control Society (APICS) in the early 1970s. One of the most important reasons leading to extensive use of MRP as a production management technique is using computer capabilities for storage and achieving high data volume and this is a necessary item for each company. MRP-II attraction was not only for its role as a management decision making supporter but also its integrating role in manufacturing organization was important. Today, some thoughts are raised regarding the integration of MRP systems with computerized integrated medium and adequacy of such systems compared to alternative production philosophies as exclusive techniques as optimal production technology (OPT). The frequent failures to achieve the promised benefits, raised some questions regarding MRP effectiveness. Manufacturing resource planning (MRP-II) was a varied concept based on simple MRP (materials requirement planning) and it was extended to all manufacturing system sectors. In 60s, computer capabilities in storage of BOM developed MRP. Gradually, MRP-II was raised. MRP-II is a tool for management, prediction and control of resources of a company and operational investment places of company as a concept emphasizing on integration of production operation, MRP-II includes the tools and processes converting the demand to logical production planning.

3.MRP definition

MRP (materials requirement planning) is a method starting with a prediction for independent demand of designed product and determines the demand dependency on the following requirements: 1- Different required components, 2-Exact quantitative needs, 3- Scheduling orders to provide production planning. Generally, we concluded that the main purposes of materials planning system include:1- Reduction of warehouse inventory, 2- Reduction of production time and goods delivery, 3-Estimation of real time of goods delivery, 4- Increase of production return

4.MRP performance

As we know, each planning has basic stages including data, processes and outputs. The data are divided into three groups in MRP:1- Production detailed planning (calendar planning of MPS), 2- Bill of materials (BOM), 3- Bill of raw materials and parts warehouse

5.MRP views

MRP is applied from three various views as relate. Each of three views consists of a stage of MRP development. These three views include 1) MRP-II, 2) Closed loop MRP, 3) MRP- II .Manufacturing resource planning

Gradually, for better production planning, reduction of production costs and increase of competitive capabilities, the companies attempted to integrate existing various subsystems in organization with MRP-II system. In the early 90s, to respond the need of companies, a new system was created by considering integration of various subsystems and new facilities as ERUP. ERP systems attempted to support others systems as financial systems, investment management, maintenance, quality management, project control, human resources management, sale and distribution [1] Before MRP-II, most manufacturing organizations controlled order point of parts and sub-assemblies by traditional methods. Close loop MRP is natural evolution stage of control systems development. MRP close loop includes required capacity planning and feedbacks reporting production progress. Manufacturing RESOURCE Planning (MRP-II) is extended recently. MRP-II is a manufacturing information system combining marketing and operation capital. Today, almost all MRP software systems are closed-loop systems establishing logical relation between MPS and details of inventories and purchase or required workshop orders for MPS assurance. The goals of these plans include: 1- To determine what, how much and when is ordered, 2- Determining the priority to plan inventories, capacity requirement planning (CRP) and workshop control. MRP receives required information from MPS, BOM and inventory situation records and purchase planning.

6. The advantages and disadvantages of MRP

MRP has great share in materials requirement planning. In short-term, MRP evaluates main production scheduling flexibility during reviewing plans and purchases beside the existing capacity and seller preceding time. By focusing on items as being faster as the result of delay conditions and those items being slow due to decision making for orders delay, correct priority of affairs is provided. In long-term, via transferring extensive market predictions to specific capacity needs, MRP is useful in estimation of capacity needs. Major MRP limitations are regarding exact information requirement and extensive computerized facilities. As minimum inventory is one of MRP sale indices, this system depends on the fact that inventory documents are exact. If the materials list is not exact, MRP generalizes high level demands to false lower requirements and this leads to maintaining lags and those engineering changes affecting the materials form and they can be controlled exactly.

7. MRP effective planning factors

In MRP, three factors are used as the main factors in inventory report planning and it leads to high efficiency of MRP plan as:1- Delivery time, 2- Confidence stock, 3- Ordering times and ordering policy

8. The relationship between MRP and MRP-II

MRP-II is a developed level of MRP system as performing not only production operation planning by computer but also it can coordinate various parts of factory and information support for performance of plans or production. These systems are used for planning and control in the factories producing as workshop, lump and group.

9.Definition of MRP-II

MRP-II is a system consisting of all manufacturing resources (e.g. raw materials, equipment and machineries, human resources and monetary resources) and by their management, it plays the crucial role in directing the organization to its basic goal (achieving profit)[2]

According to the definition of Wellman in his book of MPC system is as it presents information for efficient management of materials, optimal use of human resources and equipment, creating coordination between internal activities with contractors and relationship with customers regarding market requirements. Now, there is not basic difference between MRP- II and ERP in academic communities and industry except the term MRP- II is applied for manufacturing companies and factories, the term ERP is used for each organization. It seems that gradually factories and manufacturing companies apply ERP instead of MRP-II. Required resources of ERP are human, money, machine, raw materials and data.

10. The features of MRP-II and ERP systems

1-Flexibility, 2-Modular and open, 3- Comprehensive, 4-Beyond the company, 5-Best corporate practice6- Reality simulation

11. The goals of MRP-II system

1-Providing support services for decision making for all management levels, 2- Automatic calculation of work flow and materials flow, 3- Acting based on the concept of close information loops among the factory units, 4-Centralization of MRP system planning with support activities of workshop levels as tools control and materials transportation systems, 5- Control of flow times based on planned delivery time by input-output control methods

12.Closed MRP in MRP-II systems

MRP systems are called infinite capacity systems as in these systems, it is assumed that resources and capacities are available for plan and based on this assumption, planning is performed. The applied MRP system in MRP-II system is closed. It means that after providing production scheduling plan by MRP system, this plan is available in another part of MRP-II system with capacity requirement planning (CRP) from the view of resources and capacities and its implementation is analyzed. If the available resources and capacities are more than required resources and capacities to implement the above plan and the plan can be executed, otherwise some corrections are made in the above scheduling plan and then, it is entered into following sections as purchase unit, then MRP-II databases. Thus, MRP-II system computes the command of receiving the above materials by considering delivery time and plans receiving these materials by its databases. After notification of plan to follow up and control of MRP-II workshop levels, to make parts and products at determined time, additional plans are provided for allocation of tasks in work center.

13.MRP-II mechanism

MRP acronyms are used in three different but dependent concepts. Each of concepts shows a degree of progress and change of MRP:1- MRP I: Materials requirement planning, 2-MRP with closed loop, 3- MRP-II manufacturing resources planning

MRP I. It was the first evolutionary stage in MRP as called MRP. It provides correct amount, the data of need and planning of order times for one by one of subsets, required parts and materials of production in MPS list. Before MRP-II, control of applied parts in products is done by ordering point system.

14.Limitations of MRP-II system compared to MRP system

1- Only planning with it is performed that acceptable MRP is available. If CRP procedure determines the condition in which there is no capacity, MRP cannot present the best solution to overcome the above problem and the manager should analyze for decision making. 2-MRP only searches for acceptable plans and not effort is made to optimize the plan. Some of MRP systems apply classic optimization methods as EOQ to find the optimal order quantity for different manufacturing requirements at various levels (based on preparation and inventory carry costs), 3- MRP-II system doesn't work well under the conditions in which preparation times are dependent upon operation sequence, 4- MRP-II system doesn't have optimal control capability of system when the manufacturing products and parts have different operation sequence, one example of these systems is flexible manufacturing systems (FMS) [3].

15.Hierarchy production planning (HPP)

HPP is a method dividing big optimization problems as called integrated problems to a series of minor issues [4]. Planning in these systems starts with classification of products in various families and types [4] In HPP, higher hierarchy levels show planning problem at a general and comprehensive stage, and the lower hierarchy levels provide detailed explanation of system.

The main benefits of HPP are as follows [5]:1- complexity is reduced, 2-It acts better to random outcomes, 3-Parallel planning hierarchy is with management hierarchy and this relation leads to better organizing and management of affairs, 4- It reduces the requirement to detailed information in long-term planning, 5- It allows to use various criteria in each management level.

16. The reasons of formation of HPP

Various models have been presented for comprehensive long-term planning and short-term scheduling. For example, some of comprehensive long-term planning methods are as follows: a. Analytical methods, b: Searching modules, c: Optimal math methods, d: Heuristic methods, e. Simulation methods. Also, some of the presented methods regarding short-term scheduling as optimal size determination modules of manufacturing and operation order techniques are as follows: a) Economic production quantity, b) Material period balance, c) Wagner algorithm, d) Limited loading systems. We can say there are some methods around the world linking these two important tasks as clearly and exactly. Initial efforts to link short-term and long-term planning can lead to integrated method. The aim of this method is to apply some inputs as demands, production requirements, capacities, bill of materials (BOM), products, etc. and optimize the entire problem in a time horizon by planning at big scale. Except input and calculation information requirements, this method cannot keep execution as an applied method for the realistic organizations and big size of such models prevents their computerized solution.

17.Important advantages of HPP implementation

In manual or empirical systems, due to some mistakes or negligence, it is observed that in materials shortage is created in production line and this leads to loss. 2- Various personnel are used for planning production, production control, ordering and operation of planning and operation control. 3-In manual systems, production planning is not possible for lower than one week and most planning is done weekly or monthly. 4- In case of random events as failure of machineries, absence of employees or etc., we can solve the problem again and new plan is presented in accordance to the needs and goals of company [5]

5- By performing HPP system, the applied or non-applied capacity of all machineries and devices is determined at different periods. 6-HPP system can allocate different capacities for production planning at different periods, 7-In the companies in which planning is done manually or empirically, the major time of managers is dedicated to daily or short-term operation.8- By implementation of HPP system, each time we can achieve goods inventory list during design in each manufacturing stage and stored final inventory in warehouse. In manual systems, to compute materials inventory in hall or warehouse, much time and hours should be dedicated. 9- In case of daily and exact planning and scheduling, personnel of manufacturing unit can organize their tasks better and reduce tensions of managers and personnel of manufacturing sector. 10-One of the important advantages of this system is as exact production planning technique is defined, by this plan, purchase and control of raw materials is done easily and less costly and accumulation of great amount of materials leading to warehouse costs is prevented.

18.Different types of HPP problem solving methods

One of the most important parts of HPP is data collection and finalizing its solution model. Later, different types of HPP problem solution methods are shown in two levels ATP, DPP.

19.Explanation of famous model in HPP

Proth Mehra Minis Herrmann model

These four theorists presented a two-level HPP in 1994 in complex manufacturing systems [6]. The assumptions of designing this model are as follows:1- The materials belonging to a family in their production period pass from a series of common cells but it is not necessary that the materials pass from a series of equal machines, 2-The materials belonging to a family of materials should have similar process times inside each cell, 3-At most one operation on a material can be done in each initial period, 4- A maximum material of a manufacturing cell passes in each minor period, 5-A material inside a manufacturing cell passes at most from a machine.

Formulizing integrated problem

Here, integrated problem is formulized and its optimal solution is the best answer achieved by hierarchy model and it can be used to evaluate effectiveness of hierarchy method.

This leads to optimization of production plan $u_{J,w}^{\kappa}$ optimal delay maintenance costs P_{j,n_j}^{κ}

$$\min min mize \quad \sum_{k \in H} \sum_{j \in P} \left\{ \left(\sum_{w=1}^{n_j - 1} I_{j,w} \left(s_{J,w}^0 + \sum_{a=1}^k (u_{j,w}^a - u_{j,w+1}^a) \right) \right) + P_{j,n_j}^k \right\}$$

subject to :

$$P_{j,n_J}^k \ge I_{j,n_j} \left(s_{J,n_J}^0 + \sum_{a=1}^k (u_{j,n_j}^a - d_J^a) \right)$$
(1)

$$P_{j,n_J}^k \ge -B_J \left(s_{J,n_J}^0 + \sum_{a=1}^k (u_{J,n_J}^a - d_J^a) \right)$$
(2)

$$P_{j,w}^k \ge 0 \tag{3}$$

$$\sum_{j \in P} \sum_{w \in R_J} \delta_{J,w}(i) . u_{j,w}^k . t_{j,w} \le T; \forall i \in M, k \in H$$
⁽⁴⁾

$$u_{J,w}^{k} \leq s_{j,w-1}^{0} + \sum_{a=1}^{k-1} (u_{j,w-1}^{a} - u_{j,w}^{a}); \forall w \in R_{J}$$
⁽⁵⁾

$$\sum_{k \in h(k)} \sum_{j \in f} u_{j, \upsilon_{j}^{q-1} + 1}^{k} \leq \sum_{j \in f} \left(s_{j, \upsilon_{j}^{q-1}}^{0} + \right)^{(6)}$$

$$\sum_{q=1}^{(k-1).z} \left(u^a_{j,\upsilon_J^{q-1}} - u^a_{j,\upsilon_J^{q-1}} \right); \forall f \in F, q \in \widehat{R}_f, k \in HA$$

$$\tag{7}$$

$$u_{J,w}^k \ge 0; \forall w \in R_J \tag{8}$$

1 limitation $\cdot 3 \cdot 5 \in \mathcal{B}$ e $\mathcal{B} \in P, k \in H$ s

20.Aggregate Type Planning (ATP)

ATP is the highest production planning level in HPP model and provides decisions in this level of general strategies for production planning. At this level, for formulizing problem after making some changes in ATP model, for consistency of model for Iran Khodro Company, some changes are made in the model and its formulized model is shown as:

(P₁) Minimize
$$Z = \sum_{i=1}^{n} \sum_{t=1}^{T} (c_{it}I_{it} + s_{it}S_{it}) + \sum_{t=1}^{T} (o_tO_t)$$
 (1)

Subject to :

$$X_{it} + S_{it} - I_{it} - S_{it} + I_{it-1} = d_{it}$$
 t=1,...,T i=1,...,n (2)

$$R_{t-1} + H_t - F_t = R_t$$
 t=1,...,T (3)
r t=1 T (4)

$$\sum_{i=1}^{n} a_i X_{it} \le R_t + O_t$$
(4)

$$R_t \le W_t \tag{5}$$

$$O_t \le \alpha_1 R_t \tag{6}$$

$$M_{i}X_{it} \le M_{it} + U_{it} \qquad i=1,...,n \quad t=1,...,T \qquad (7)$$

$$M_{it} \le M_{it} * \qquad (1)$$

$$U < \alpha M \qquad t=1,...,n \qquad (9)$$

$$X_{i_{1}} = \sum_{i_{2} \to i_{1}} X_{i_{2}} = 0 \qquad \qquad t=1,...,T \quad i=1,...,n \qquad (10)$$

$$R_t, H_t, F_t, O_t \ge 0$$
 $t=1,...,T$ (11)

$$M_{it}, U_{it} \ge 0$$
 $i=1,...,n \ t=1,...,T$ (12)

Where, target function and its limitations are as follows:

(1) It shows objective function minimizing inventory maintenance costs, deficiency cost and extra work costs. For simplicity, it is assumed that other parts of cost as common production costs, labor force, employment cost and dismissal and common costs and extra work are fixed machineries and are excluded from target function (2) inventory balance equations (3) labor force balance equations (4) limitation of using labor force at common hours and extra work hours, 5) The limitation of total existing labor force (6) limitation of using labor force at extra work hours, 7) Limitation of using machineries at common and extra work hours, 8) Limitation of total machine work days, 9) The limitation of using machineries at extra work hours, 10) to, 12) non-negative limitations of variables. In limitations 7, 8, 9, it is assumed that

production of items of a type of product is done in a specific sector (on a machine) and manufacturing of plan in limitations 4, 5, 6 can be considered.

21. Family disaggregate planning (FDP)

At FDP, the aggregate decisions at ATP level are disaggregated to achieve the decisions defining the product family production. At this level, the balance between product family production and aggregate type production are the most important requirements that should be fulfilled. Production levels of various product families are obtained by following formula:

$$Y_{j} = \left[\frac{D_{j}}{\displaystyle\sum_{j \in j(i)} D_{j}}\right] \left(X_{i} + \displaystyle\sum_{j \in j(i)} I_{j}\right) - I_{j}$$

Where,

 X_{I} = Production level of type i in current period (1/4 time horizon) as obtained by ATP level plan.

D_i: The demand for family j in current period

 $J_{(i)}$: The set of families in type $i_{(i)}$

Ii: Inventory of family j at the beginning of current period

 Y_i : Production level of family j in current period

22. Theoretical investigation of HPP, MRP-II models

To evaluate the two studied models, based on various existing parameters in these two models and their performance field, it is better to determine some indices to evaluate and compare two models and then study the indices. The increase of these data causes that managers use the models and systems as HPP, MRP-II. Indeed, one of the common goals of both of these models is analysis of existing data and logical relation between them and suitable use of them.

MRP-II model has wide performance field compared to HPP and by integration of the data at company attempts to create a coordinated system among all parts of organization. Company planning, production, master production scheduling (MPS), materials requirement planning and capacity, etc. are capabilities of MRP-II. HPP focuses on production part and only thinks about an optimal production plan. MRP-II didn't make any effort in this regard and only focused on a production plan. Indeed, HPP by focusing on its activity on production planning attempts to put various parameters beside each other and finally achieves an optimal production plan.

Content

MRP-II consists of all financial modules and can support trading planning in terms of financial aspects. MRP-II is a great information system holing all the existing information in company and it consists of their interaction and control information flow. HPP only by receiving production-based information regulates an optimal production plan and delivers to management to be used for following decisions. Thus, we can consider HPP a part of integrated system to manage production sector and it includes the entire relevant information.

Inputs: As it was said, HPP model is used as a part of MRP-II model. The inputs in HPP are dedicated to manufacturing problems but MRP-II has various inputs due to extensive performance field and it consists of all manufacturing and non-manufacturing parameters of company. One of the important inputs of MRP-II as its main input is MPS. BOM of product as one of the important production parameters is one of the common inputs in both models.

Output: MRP-II has various outputs as materials requirement planning (MRP), confidence stock and order size in each ordering time, production delivery time and general and long-term planning of production based on products family, production and goods inventory reports, etc. HPP only focuses on production and planning and its output is detailed production plan.

23. The results of theoretical comparison of two models and HPP model

The theoretical comparison of HPP with MRP-II model shows that two models have close goals but MRP-II model with its extensive performance field can focus on all current processes of a company. HPP focuses on production and reaches observed superiorities compared to MRP-II. Also, based on investigations, we can say HPP model has high ability in optimization of production plan and by hidden work process in the models, production and maintenance costs and work capacity of workshop can be improved considerably. Generally, some of the results and advantages regarding the evaluation of HPP are including 1- Minimizing shortage and delays in demand(as shown in outputs of production scheduling stage for press shop 3 workshops of Iran KHordro, the delays are minimized and there is no shortage)2-Providing production planning for long-term time horizons by considering the limitations and requirements of production, 3-Reduction of inventories in design flow and can lead to reduction of maintenance costs reduction of product items, 4-Creating manufacturing scheduling by considering requirements as economic ordering quantity (EOQ) besides fulfilling demand has the lowest frequencies and regulation costs. 5- Using a mechanized planning system instead of manual

system as considering initial inventory requirements, cautious stock and daily demand, 6- Exact definition of inconsistency in demand and production scheduling plan and finding solutions to eliminate it before its occurrence by outputs of evaluation stage of production scheduling plan, 7-The possibility of absorbing changes and unexpected events as creating problems in Maser production scheduling (MPS). In other words, if some problems are occurred as failure of machineries, the increase or reduction in demand, etc. and within one hour, new production scheduling is provided.

24. Conclusion and solutions for Iran Khodro Company

As the most important issue in press shop 3 Hall of Iran Khodro Company is achieve MPS by production comprehensive planning management), it is considered to fulfill the needs of various assembly lines of Iran Khodro company and demand of Issaco company. Using manufacturing scheduling planning system covering time, demand and capacity requirements and limitations is very vital. Now, production planning part of press shop 3 can use a non-mechanized method to provide production plan and achieving approved plan of this hall as providing production scheduling plan for some next days as partially. The production planning experts by this hall by a distinction criterion as called resistance (dividing the inventory of product items by daily demand) can defined the inventory of product items continuously. By a control form in Excel software, new scheduling plan of machines is determined and controlled. By considering the above items and outputs of HPP showing full and early providing of master production time and its ability in production scheduling plan in long-term periods, if this proposed plan is used, production planning management of this hall can provide production scheduling plan of next months.

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