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Studies on the Uncertainty for Material Requirement Planning in Industries and its Solution

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Abstract:
In the present article, deals with Rescheduling of the products by considering the limited available capacity or lack of safety stock and rescheduling the products, when capacity is reduced or not available is carried out. For this the problem has been modeled on the line of network scheduling problem (NSP) under limited resources. For solving this problem, selected simple decision rules have been suggested and presented. With each of these rules some cost is associated. In order to estimate these costs, cost functions have been formulated, which are functions of sonic parameters related with system. A simulator has been designed and implemented. The cost functions are enumerated using the data provided by the simulator. Different types and various problems were randomly generated by varying product structure, variation in MPS and breakdowns patterns.

Keywords: Material Requirement Planning (MRP), Uncertainty, Rescheduling

I. FUNCTIONS AND TERMINOLOGY OF MATERIAL REQUIREMENTS PLANNING

MRP is software based production, order planning and control systems used to manage the manufacturing process. MRP requires information concerning independent demand, which comes from the master production schedule (MPS). The MPS contains gross requirements and scheduled receipts (status of outstanding orders).MRP systems use four pieces of information to determine what material should be ordered and when:

a) The Master production and order schedule: The master production schedule, which describes when, each product, is scheduled to be manufactured.

b) **Bill of Materials:** Bill of materials, which lists exactly the parts or materials required to make each product. Bill of Materials gives information about the product structure, i.e., parts and raw material units necessary to manufacture one unit of the product of interest.

c) Priority planning and control: Production cycle times and material needs at each stage of the production cycle time.
d) Supplier led times.

II.THEORY AND BENEFITS OF MRP

The materials should be facilitate when their lack would delay the overall Production schedule and delayed when the schedule falls behind and postpones their need.

MRP systems having the following advantages:

1. Ability to price more competitively.
2. Reduce sales price.
3. Reduce inventory.
4. Better customer service.
5. Better response to market demands.
6. Ability to change the master schedule.
7. Reduce setup and tear-down costs.
8. Reduced idle time.

In addition to these benefits, MRP systems also give advance notice so managers can see the planned schedule before actual release orders.
Tell when to de-expedite as well as expedite.
Delays or cancels orders.
Changes order quantities.
Advances or delays order-due dates.

Figure.1.1, represents, the basic components of the typical MRP system.

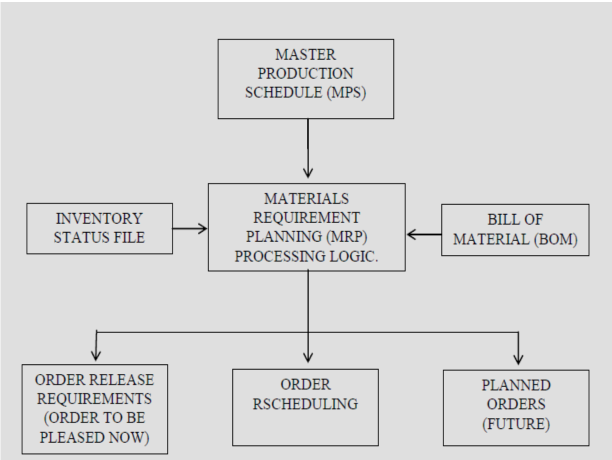

Figure.1.1. Components of the MRP system.

III. UNCERTAINTY THEORY

Uncertainty is can be defined or it is used to measure the difference between the model and the real system or between the estimation of variables and their true values. Uncertainty is unavoidable in manufacturing process or it other word we can say there is always possibilities of Uncertainty in manufacturing industries.
The different uncertainties like quality and lead time significantly affect the competitive outcomes of the system. To put this quote into an MRP context, it suggests that a well

plan that was generated yesterday might not be executable today due to events that are both unpredictable and unexpected. An example of this uncertainty is late delivery of a purchased part from a supplier. The effect of this would be a delay in the manufacture of the parent assembly that is difficult to quantify because the loading on the shop floor when the part ultimately arrives may be very different to that planned when it was due to arrive.

Table 1.1 gives some major classification of Uncertainty with its examples.

S.No	Uncertainty	Definition and examples
1	Input	Uncertainties created from external supply and demand e. g. late delivery from supplier and customer changing delivery lead-time.
2	Process	Uncertainties created from internal supply and demand e. g. machine breakdown and labour absenteeism.
3	Output	Uncertainties resulting from a combination of input and process. e.g. material shortages and scrap/rework.

COX AND BLACKSTONE [1] defined uncertainty as unknown and also non predictable future events that cannot be predicted quantitatively within useful limits. Thus in simple words it can be state that the happening of uncertainty is unpredictable; its effect is difficult to quantify. Since MRP is designed to operate instable and predictable batch manufacturing environments, investigated by Koh and sad, [2] the presence of uncertainty may prevent optimum performance. So it can be said that uncertainty is one of the challenges in manufacturing industries is the propagation and accumulation of uncertainty, which affects the reliability of the outputs.

MRP THEORY

Material Requirements Planning (MRP) was developed by the USA in the 1960s. American Production and Inventory Control Society (APICS) launched a high profile MRP education and promotional program called the "MRP crusade" in 1972. At this time MRP was viewed merely as an order launching system. Two subsequent stages were recorded in the development of MRP. MRP sometimes assume infinite capacity as no concern is given to used and available resources capacity in generating the Planned Order Release schedule after that the first came with the realization that for the Master Production Schedule (MPS) it should be realistic and maintained, the MRP system should receive feedback from the other operational systems such as capacity planning, shop floor control and purchasing, and this concept was known as Closed Loop MRP it was first practiced about 1969.

LIMITATIONS OF USING MRP

As with all control systems, MRP based systems must operate within control limits that are known and understood. There follows a brief explanation of some of the main limitations. MRP based systems use fixed lead-times to plan purchases and manufactures. In reality, such lead-times are known to vary. Without controlling actions, component and/or product shortages/overages occur, directly affecting total costs of the system and due date performance. In infinite capacity systems, net requirement plans are created with no regard to the availability of resources, loadings for which are aggregated and reported separately, necessitating a re-planning loop. Advanced MRP based systems provide the facility to allow such re-planning and many also include finite scheduling. In reality, variable or unknown effects of efficiency losses and changes in utilization are largely ignored. MRP based systems use predefined routing(s) to sequence the flow of materials and subassemblies from work centre to work centre. In the case of unplanned events, necessary routing changes may occur that are not recorded in the system. Variability in production quality may be incorporated by the use of a planned scrap rate. Any variation from this rate will affect either due date performance or yield or both. All the above limitations of MRP based systems were widely recognized and researched by, investigators

UNCERTAINTY FACTORS IN MRP

In this section includes the different definitions, the source factors of various uncertainties, its effect on manufacturing, and measurement of the uncertainty. There are some common types of Uncertainty may be or present in the planned MRP

1. System Uncertainty
2. Uncertainty in demand forecast
3. Operational Uncertainty
4. Uncertainty in demand forecasting
5. Lead time Uncertainty
6. Uncertainty in External supply process
7. Uncertainty in operation process
8. Uncertainty in Internal supply process etc.

VARIOUS TYPES OF UNCCERTAINTIES

- **Input uncertainty:**

Thus, in this paper, input uncertainty is defined as the uncertainty that occurs in the external supply or demand from the MRP-planned manufacture. Examples of input uncertainty include late delivery from external suppliers at supply or order due date changes from external customers at demand.

- **Process uncertainty:**

It is defined as the uncertainty that occurs at internal supply or demand from the MRP-planned manufacture. Examples of process uncertainty are machine breakdowns at supply or process yield losses at demand. At the output level of an MRP-planned manufacture, finished products have already been completed, thus uncertainty occurring at this level could not, and will not, affect manufacturing capability and the performance of the products. Therefore, output uncertainty is not defined and applied for this categorization. A variety of approaches can be used to handle with the unwanted effects of uncertainty, e.g. safety stock, safety lead-time, overtime and subcontracting. The approach used depends on the type of uncertainty, the severity of its effect and enterprise preferences. To examine the proposed approaches to cope with uncertainty, the categorization is extended to include two categories of approaches used, known as Buffering and Dampening (BAD). Cox and Blackstone [1] defined Buffering as a quantity of resource waiting for processing, e.g. raw material, semi-finished inventories or a work backlog that is purposely maintained behind a work centre. It can include other resources such as machines, labor and money. Planning methodologies such as rescheduling and safety lead-time could not be categorized under buffering. To categorize this type of approach, the term dampening has been coined. Using the categorization structure developed, the uncertainty and the BAD approaches proposed, identified from the literature review on research on uncertainty under MRP-planned manufacture, are categorized. Both discrete and combination studies on uncertainty are considered to address whether uncertainty has been studied holistically. The experimental methods used by researchers are also explored to highlight the most frequently used and applicable methods, and to question the validity of the conclusions drawn. Input and process uncertainties at the supply and demand chain of MRP-planned manufacture will be discussed and criticized in turn.

EXPLANATION OF THE PRESENT PROBLEM

It is assume that a manufacturing firm that produces many end products. The structure of the product varies from product-to-product and it may be single level or multi-level. Generally, the products may be multi-level in structure with both concurrence and commonalty of components. Each of the product have a master production schedule (MPS) is prepared, that gives the required quantity and due date as specified. Employing the MPS and MRP technique detailed production schedules are prepared so that the demands are fulfilled on time. The original production plans and capacity requirements are calculated using CRP technique; but such a plan may not be practicable due to limited resources, in general, the components, sub-assemblies, and assemblies that are to be produced, with the available resources, in any period can be of the following types :

(a) Components of the same product needed at different levels of the product structure.

(b) Components of different end products needed at different levels of the respective product structures. But for whose due dates of end products are in the same period.

(c) Components of different end products needed at different levels of their respective product structures, the due dates of end products being different. This is the most general case.

(A). MATHEMATICAL MODELING

Present problem can be modeled as the project network scheduling problem under resource constraints.
As discussed above, the limited amounts of resources are not sufficient to satisfy the demands of concurrent activities. So the sequencing decisions are required. The objective is to make the sequencing decision in such a fashion that the deviation from the original production schedule is minimized. A mathematical programming model is formulated by Wiest [3] and described in appendix.

B. NETWORK SCHEDULING SOLUTION APPROACH

The problem of scheduling the activities of a project so that none of the resource availability's are exceeded and none of the precedence relations are violated is an exceedingly difficult task for projects of even modest size. Such problems form a class of problems mathematically referred to as a large combinatorial optimization problem. That is, there are finite but extremely large numbers of combinations of operation start times - each combination representing a different schedule. So some simple decision rules are generally applied to solve such a problem. It is observed that the capacity problem arises mostly because of the sequential nature of the planning process that assumes infinite loading capacity of the facilities while running MRP systems. To reduce the occurrence of this problem it is suggested that an integrated system of MRP technique and network analysis should be used. Such a system takes care of the available capacity while planning. Capacity requirements of the planning system can be calculated using CRP technique. When the planner is still confronted with capacity problem, his task is to find out the new sequence in which the jobs are to be processed on the constrained facility, as well as the time periods and the alternate facility on which the shifted jobs are to processed. The primary considerations in scheduling the components are due dates, flow time, and work center utilization. Scheduling is partially addressed by MRP as the due dates for components are coordinated by it. It is in this context that MRP is best seen as a scheduling technique. The detailed execution/scheduling of MRP plans is sometimes a separate issue, as in the task of in scheduling jobs to maintain the due dates, the scheduling task becomes very complex. Further in the finite loading approach the due dates are typically adjusted to reflect finite capacity constraints.

C. SCHEDULING APPROACH AND VARIABLES OF THE SYSTEM

In the present study we have assumed that MPS is represented in units of lots, which are of equal size and each such lot will be exploded and scheduled as such. After completion of NIPS, the scheduling of lots on different work center is done on first come and first scheduled basis. In case the requisite capacity is not available, attempt is made to schedule it in earlier periods. However if such a scheduling is not feasible, then it is shifted to earliest available slot and schedule thereafter. An alternative strategy will be to schedule it only in the first available period.
The state of the production-inventory system can be expressed in term of the values of some of the measure, which are affected by the scheduling decisions. The impact of scheduling decision can be analyzed by taking the difference of these variables value, before and after the scheduling decision. If there is some change in the original production schedule its impact may transmit to the next planning cycle. Accordingly, the relevant parameters for the system can be grouped into three categories, as explained by [ ]

1. Constraints inside the planning period are

(a) WIP inventory level,
(b) Finished goods inventory level,
(c) Resource level.

2. Parameters at the borderline of the planning period are

(a) Finished goods inventory level,

3. Customer service linked parameters are

(a) penalty due to delayed supply,
(b) Penalty due to partially fulfilled demand,
(c) Penalty due to rejection of the orders because of missed due date or because of inadequate quantity.

4. Parameter outside the planning period is –

(a) Nerviness introduced in the system-As a result of the curative actions, some disturbance will be created in the production schedule. That can be measured in terms of the level of nervousness in the system. Apart from these there are some intangible losses viz. losses of goodwill, loss of potential customers, impact on the worker's morale etc. It is difficult to quantify these losses.

D. QUALITATIVE AND QUANTITATIVE RELATIONSHIP BETWEEN THE PARAMETER VALUES

(a) **WIP inventory:**

WIP inventory in the system is likely to increase whenever some of the components produced as per the original plan, have to be rescheduling in the earlier period. However, is they are scheduled in the later period,

$$W = \sum_l \sum_i V_{il} * h_{il} (T_{1,il} - T_{2,il}) \quad 1$$

Change in WIP inventory cost due to shifting

$$C_1 = (Wf - Wo) \quad 2$$

(b) **Finished goods inventory:**

In case if the scheduling is only in an earlier period, the finished goods inventory will not be affected. For any product the finished goods inventory be defined by

$$I = V_k * h_k * (t_{1k} - t_{2k}) \quad 3$$

Therefore change in the finished goods holding cost

$$C_2 = (I_f - I_o) \quad 4$$

(c) **Resource utilization level:**

Because of shifting of some of the jobs resource in various periods will change. Since the objective is to make the minimum changes in the original production schedule a penalty factor has been associated with any such change. Thus Non desirability of the production planning change can be controlled by controlling this factor.

$$C_3 = \sum_n [Un' - Un] * P \quad 5$$

(d) **Parameters beyond the planning period**

Total penalty C4

$$C_4 = [Qi * (T_{fi} - T_{oi})] \quad 6$$

The customers may impose penalty for less supply or even the entire lot may be rejected. Thus the customer related costs may increase.

Pi Price per unit due to partially fulfilled demand

S = Shortage = (Demand – Actual Production)

$$C_5 = P_i * Shortage \quad 7$$

IV. CONCLUSIONS

Impact of method of scheduling

It can be concluded from Table.1 (Sum of study methods), it can be observed that Method -1 performs better than Method - 2 in most of the cases.

Table.1: Sum of study methods

	Method-1				Method-2			
Heuristics →	R1	R2	R3	R4	R1	R2	R3	R4
	40	33	42	35	22	22	52	20
Total →	**150**				**116**			

However Method -2 has provided better results in at least 30% of cases. The scheduling strategies involve both the methods and the better solution may be selected. In Method - 2, heuristic R3 (Operations remaining) seems to perform better than all the heuristics, while method I the heuristics seems to perform similarly.

Impact of Product structure

It can be concluded from Table.2 (Impact of Product Structure) RI R2R4 seems to perform better than R3 (Operations remaining) for small product structure. However in all multi products and in Method - 2 rule R3 seems to be performing better. In may be due to larger complexity of the problem.

Table.2: Impact of Product Structure

		Method-1				Method-2			
→ Heuristics		R1	R2	R3	R4	R1	R2	R3	R4
Single end product ↓	PS1	4	3	5	10	4	1	10	6
	PS2	13	6	5	6	9	1	3	5
→	PS3	5	9	1	5	1	11	2	2
Total		**22**	**18**	**11**	**21**	**14**	**13**	**15**	**13**
		Method-1				**Method-2**			
→ Heuristics		R1	R2	R3	R4	R1	R2	R3	R4
Multipleend product ↓	PS1	1	1	16	3	1	1	16	1
	PS2	6	4	13	3	1	1	18	1
	PS3	11	10	2	15	6	7	3	5
Total →		**18**	**15**	**31**	**21**	**8**	**9**	**37**	**7**

Impact of variation in MPS

It can be observed and concluded from Table 3 (Impact of Variation in MPS) heuristics seems to be least effect by MPS.

Product structure – 1

Table. 3. Impact of Variation in MPS

Method-1

Heuristics →	R1	R2	R3	R4
MPS11 ↓	5	1	1	3
MPS12	2	1	3	5
MPS13	6	1	1	2
Total →	**13**	**3**	**5**	**10**

Method – 2

Heuristics →	R1	R2	R3	R4
MPS 11 ↓	2	0	8	2
MPS 12	2	1	1	3
MPS 13	0	0	1	1
Total →	**4**	**1**	**10**	**6**

Product structure – II

Method – 1

Heuristics →	R1	R2	R3	R4
MPS 41 ↓	1	1	4	0
MPS 42	0	0	6	1
MPS 43	0	0	6	1
Total →	**1**	**1**	**16**	**2**

For the various level in the MPS, as obvious from Table .3 heuristics seems not be affected by the level of MPS.

Impact of number of breakdowns

It can be seen from Table 4 (Impact of Machine Break-down into the Single Periods for all different level of Break-down) it seems that R3 is better other heuristics. If number of breakdowns less and they are only one heuristics has to be used one will use Method - I and with heuristics - 3. However better approach will be to build the choice of the heuristics and the methods.

Table .4. Impact of Impact of Machine Break-down

		Method-1				**Method-2**			
Heuristics →		R1	R2	R3	R4	R1	R2	R3	R4
Brak-down ↓	M 11	5	2	8	6	4	4	9	2
	M 12	7	4	6	6	2	3	11	3
	M 13	7	8	11	8	6	2	9	3
Total →		**19**	**14**	**25**	**20**	**12**	**9**	**29**	**8**

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