

Thesis Report
On
Material and Labor Cost with Dynamic Lead Time

Submitted in partial fulfilment of the requirement
For the award of degree of
Master of Engineering

In
PRODUCTION AND INDUSTRIAL ENGINEERING

Submitted By
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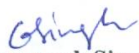
July 2012

CERTIFICATE

This is to certify that the work in this thesis report entitled "**MATERIAL AND LABOUR COST WITH DYNAMIC LEAD TIME**" submitted in partial fulfilment of requirement for the award of **Master of Engineering Degree in Production and Industrial engineering** in Mechanical Engineering Department of Thapar University, Patiala, is an authentic record of work carried out by me under the guidance of **Mr A.S. Jawanda, Associate Professor, Mechanical Engineering Department, Thapar University, Patiala.**

The matter embodied in this report has not been submitted in part or full to any university or institute for the award of any degree. The matter in this report is an original compilation by me with referred material from published literature duly acknowledged.

Dated: 14 Aug 2012
Place: Patiala



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This is to certify that above declaration made by the student concerned is correct to the best of my knowledge and belief.



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ABSTRACT

The area of material required planning based on MPS system has had a lot of improvement done over time by various research considerably aspects of both inputs and outputs to the production system and even consider varieties with the production system which effect the overall efficiency of the system.

Traditional Production control systems are based on the manufacturing planning concept and they do not sufficiently support the planner in solving production capacity problem, ignore capacity constraints and assume that lead times of many material are fixed, this leads to problems of shortfall in manufacturing, that cannot be resolved in the short term. The main focuses on solving these capacity problems by improving capacity planning at the material requirement planning level through integration of MRP and finite capacity planning. This results in a planning methods for simultaneous capacity and material planning. The planning method is based on a new and more accurate primary process model, giving the planning algorithm more flexibility in solving capacity problems. The algorithm is based on advanced scheduling techniques and uses aggregated information, thus combining speed and accuracy.

This thesis has addressed the problem of capacity planning required form MRP by considering flexible lead times and also considering the strategy of making up for shortfall in production by POR of product from other manufacturer or have overtime if possible in production to make up for the losses. The cost incurred in making up for the material shortfall is also considered and makes management decision more informed about the cost implication.

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1. INTRODUCTION

Material and requirement planning [7] is a technique of working backward from the scheduled quantities and needs dates for end items specified in a master production schedule to determine the requirements for components needed to meet the master production schedule. The technique determines what components are needed, how many are needed, when they are needed and when they should be ordered so that they are likely to be available as needed. The MRP logic serves as the key component in an information system for planning and controlling production operations and purchasing. The information provided by MRP is highly useful in scheduling because it indicates the relative priorities of shop orders and purchase orders.

Materials Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements.

MRP is one of the powerful tools that, when applied properly, helps the managers in achieving effective manufacturing control.

MRP Objectives

1. Inventory reduction – MRP determines how many components are required, when they are required in order to meet the master schedule. It helps to procure the materials / components as and when needed and thus avoid excessive build up of inventory.
2. Reduction in the manufacturing and delivery lead times – MRP identifies materials and components quantities, timings when they are needed, availabilities and procurements and actions required to meet delivery deadlines. MRP helps to avoid delays in production and priorities production activities by putting due dates on customer job orders.
3. Realistic delivery commitments – By using MRP, production can give marketing timely information about likely delivery times to prospective customers.
4. Increased efficiency – MRP provides a close co-ordination among various work centres and hence helps to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

Functions Served By MRP

1. Order planning and control. When to release orders and for what quantities of materials / components.
2. Priority planning and control. How to expected date of availability compares to the need date for each component.
3. Provision of a basis for planning capacity requirements and developing a broad business plans.

1.	What do we want to produce and when Production. Schedule and when.	Provided by Master Production Schedule
2.	What components are required to make it and how many.	Bill of Materials (BOM)
3.	How many are already scheduled to be available in each future period.	Inventory status file
4.	How many more we need to obtain for each future period.	Difference in required and available.
5.	When to order these amounts so they will be available when needed.	Planned order release.

Questions: Addressed in MRP Processing

1.1 MRP Terminology

1. Dependent Demand - The demand for an item depends on another item. The demand dependency is the degree to which the demand for one item is associated with demand for another item.
2. MRP - A technique for determining the quantity and timing of dependent demand items.
3. Lot size - The quantity of items required for an order.
4. Time phasing - Scheduling to produce or receive an appropriate amount (Lot) of material so that it will be available in the time periods when required.
5. Time bucket - The time period used for planning purposes in MRP.
6. Gross Requirements - The overall quantity of an item needed at the end of the period to meet the planned output levels.

7. Net Requirements - The net quantity of an item that must be acquired to meet the schedules output for the period. It is calculated as, Gross requirements minus schedules receipts for the period minus amounts available from the previous period.
8. Requirements explosion - The breaking down of(exploding) of parent items in to component parts that can be individually planned and scheduled.
9. Scheduled Receipts - The quantity of an item that will be received from suppliers as a result of orders that have been placed.
10. Planned order receipts - The quantity of an item that is planned to be ordered so that it will be received at the beginning of the period to meet net requirements for the period. The order has not yet been placed.
11. Planned Order Release - The quantity of an item that is planned to be ordered or it is a plan (quantity and date) to initiate the purchase or manufacture of materials so that they will be received on schedule after the lead time offset.
12. Lead time offset - The supply time or number of time buckets between releasing an order and receiving the materials

1.2 MRP System

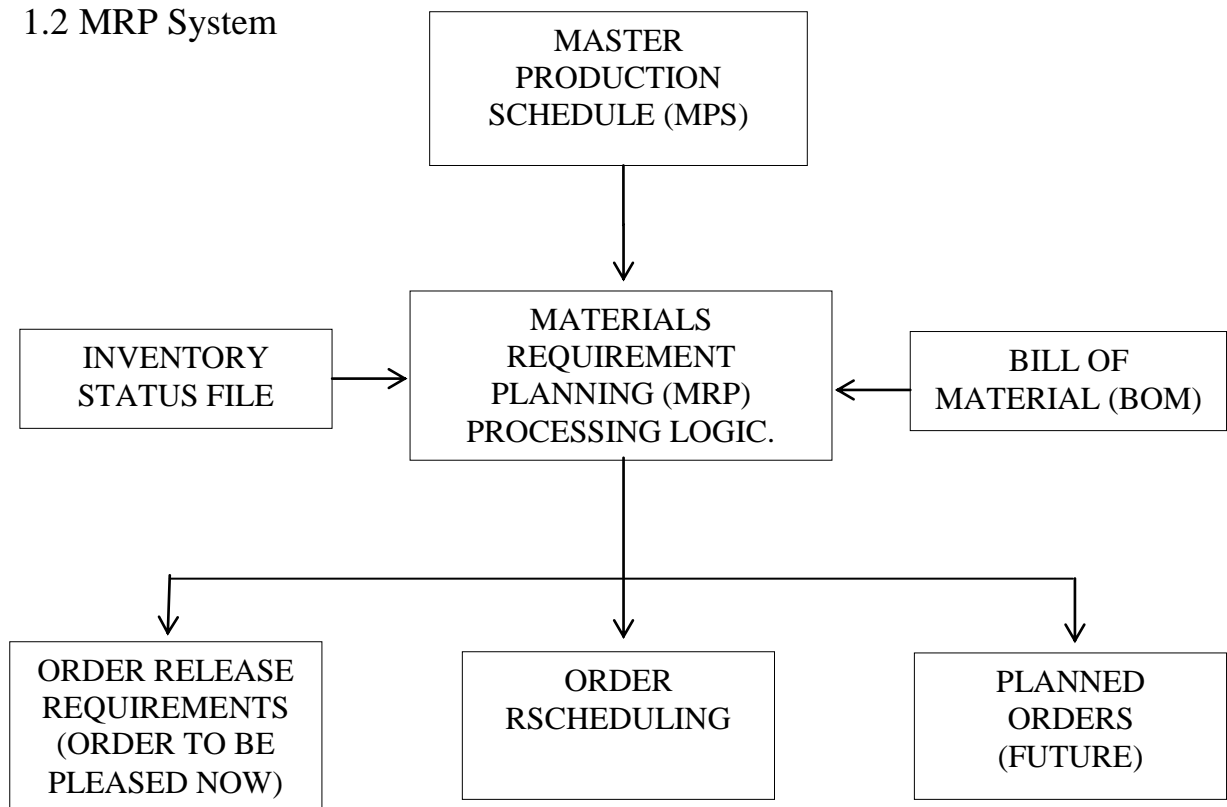


Fig no.1-Component of MRP system [11]

The inputs to the MRP Systems are:

1. A master production Schedule(MPS)
2. An inventory Status file.
3. Bill of material (BOM)

1.2.1 Master Production Schedule (MPS)

MPS is a series of time phased quantities for each item that a company produces, indicating how many are to be produce and when. MPS is initially developed from firm customer order or from forecasts, of demand before MRP system begins to operate. The MRP system accepts whatever the master schedule demands and translates MPS end items in to specific component requirements. Most systems then make a simulated trial run to determine whether the proposed master schedule can be satisfied.

1.2.2 Inventory Status File

Every inventory item being planned must have an inventory status file which gives complete and upto date information on the on hand quantities, gross requirements, schedules receipts and planned order releases for the item. It also includes planning information such as lot sizes, lead times, safety stock levels and scrap allowances.

Basically, the job of the inventory status file is to keep about the projected use and receipts of each item and to determine the am unit of inventory that will be avaiable in each time bucket. If the projected available inventory is not adequate to meet the requirement in a period, the MRP a programme will recommend that its item be ordered.

1.2.3 Bill of Materials (BOM)

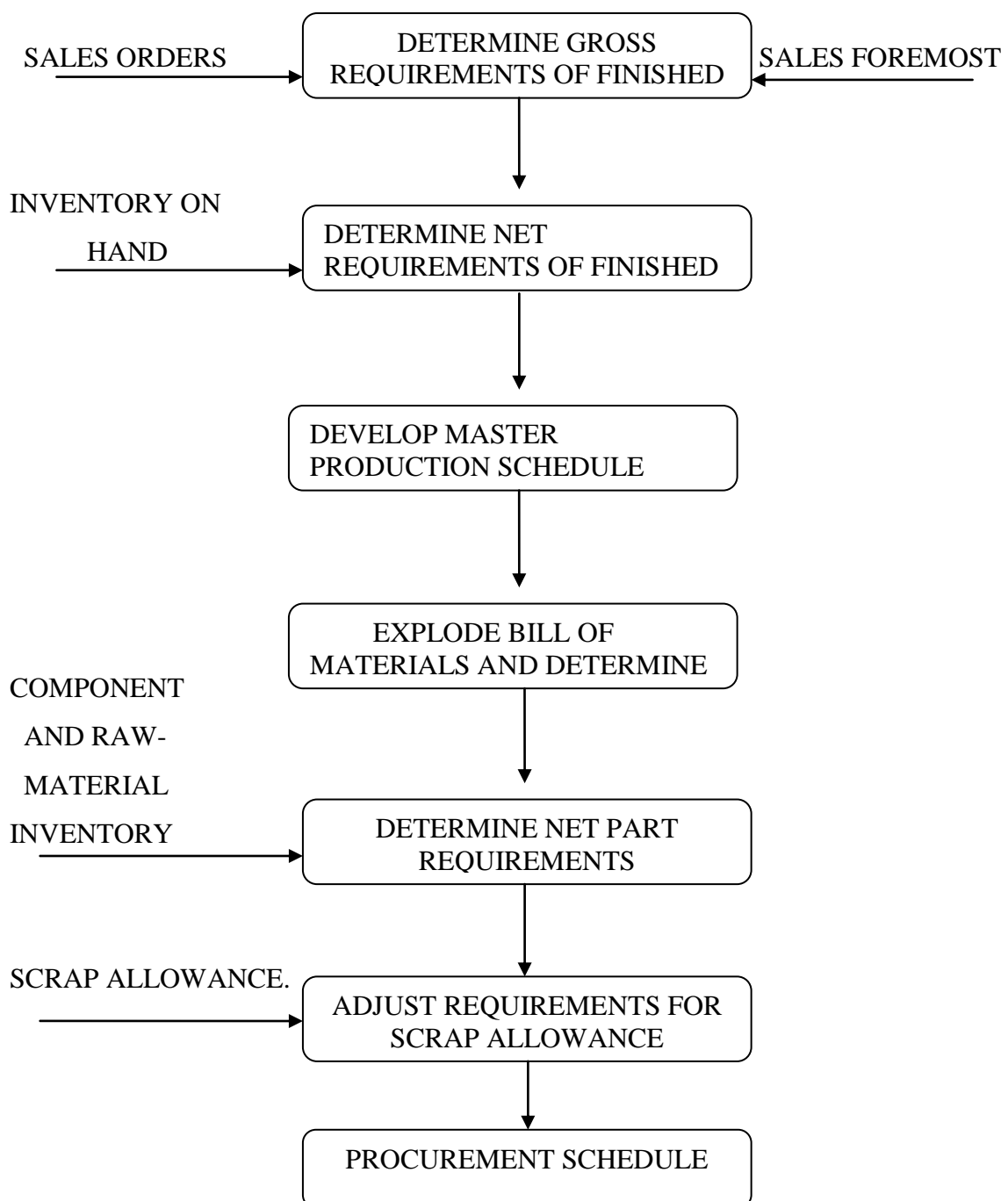
To schedule the production of an end product, an MRP system must plan for all the materials, parts and subassemblies that go in to the end product. The Bill of Material file in the computer provide this information, BOM file identifies each component by unique part, number and helps processing by a process which 'explodes' end item requirements in to end item requirements into component requirements.

The BOM identifies how each end product is manufactured, specifying all subcomponents items; their sequence of build up, their quantity in each finished unit and the work centers performing the buildup sequence. This information is obtained from product design documents, work flow analysis and oilier standard manufacturing information.

The BOM processor is a software package that maintains and updates the BOM listing of a component that go in to the product. It also links the BOM file with the inventory status file so that the requirements explosion correctly accounts for the current inventory levels of all components.

Product Structure - the primary information to MRP from Bill of material is the product structure.

Fig no.2-Flow Chart of the step in MRP [11]



1.3 MRP Outputs

The most visible outputs are the actual and planned order releases that go to purchasing and in house production shops. A variety of reports can be generated from the information made available by an MRP Program.

To MPS Planners

- ❖ Simulation of proposed MPS
- ❖ Research information for open order (due to cancellation, delays, shortages)

To Purchasing and Production

- ❖ Changes to keep priorities valid
- ❖ Order releases (Purchase and shop orders)
- ❖ Planned order releases

To capacity Requirements Planning

- ❖ Order release information for load profiles, delays, shortages

To Management

- ❖ Performance measurement of (vendors, cost, forecast accuracy)
- ❖ Exception reports (on due dates BOM file etc)

1.4 MRP Logic

MRP processing logic accepts the master schedule and determine the components schedules for successfully low-level items of the product structures. It calculates for each item in each product structure and for each time period (typically one week) in the planning horizon how many of that items are required (Gross requirements) how many units from inventory are already available, the net quantity that must be planned (planned order receipts) and when orders for new shipments must be planned (planned order releases) so that all material arrive when needed.

Net Requirements are calculated by adjusting for existing inventory, items already an order as recorded in inventory status file.

$$\begin{array}{ccccccc} \text{Net} & = & \text{Projected Gross} & - & \text{Inventory} & + & \text{Scheduled} \\ \text{Requirements} & & \text{Requirements} & & \text{on hand} & & \text{receipts} \end{array}$$

Order releases are planned for components in a time phased manner (using lead time data from the inventory file) so that materials will arrive precisely when needed. This is referred to as planned order receipt. When the orders are actually issued to vendors or shops the planned receipt becomes the scheduled receipt.

1.5 Capacity Requirements Planning (CRP)

Capacity is a measure of the productive capability of a facility per unit of time. Capacity decisions begin with the initial facility layout and extend to aggregate planning, master scheduling, capacity requirements planning.

CRP is a technique for determining what personnel and equipment capacities are needed to meet the production objectives embodied in the master schedule and the material requirements plan.

CRP is an effort to develop a match between the MRP schedule and the production capacity of the company. Determination of the capacity of the work centre and the capacity requirements imposed on those work centres by particular product mix enables a company to know what level of sales, its production system can support. Thus company will be able to make realistic sales commitments. Capacity planning helps to avoid under utilization of capacity and also CRP enables the company to anticipate production bottle-necks in some work centres in time to take corrective actions.

To be effective, capacity requirements planning must be coordinated with MRP. Working together MRP and CRP programme translate the master schedule to requirements for components and capacity. Simulating the impact of the master schedule that provided the input for MRP program. CRP can be used to refine the master production schedule (MPS) further after MRP is run.

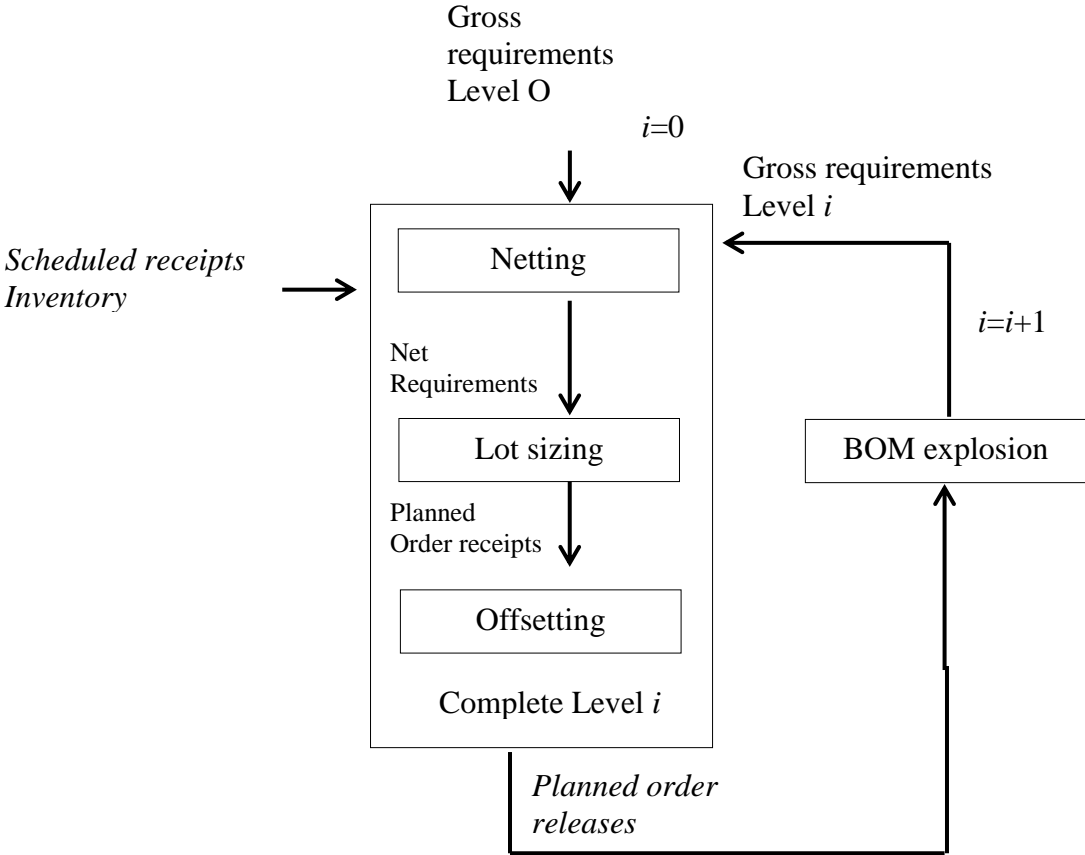
Inputs for CRP Process

1. Planned orders and released orders from the MRP system.
2. Loading information from work centre status file.
3. Routing information from the shop routing file.
4. Changes which modify capacity give alternative routings or alter planned orders.

Outputs of CRP

Apart from information for modification of capacity or revision of MPS, the major outputs of the CRP system are the verification of planned orders for the MRP system and load reports. The firm can plan for the average amount of labor and equipment that is expected without actually designating the capacity for specific orders.

Fig no.3-Traditional Approach for MRP system [7]



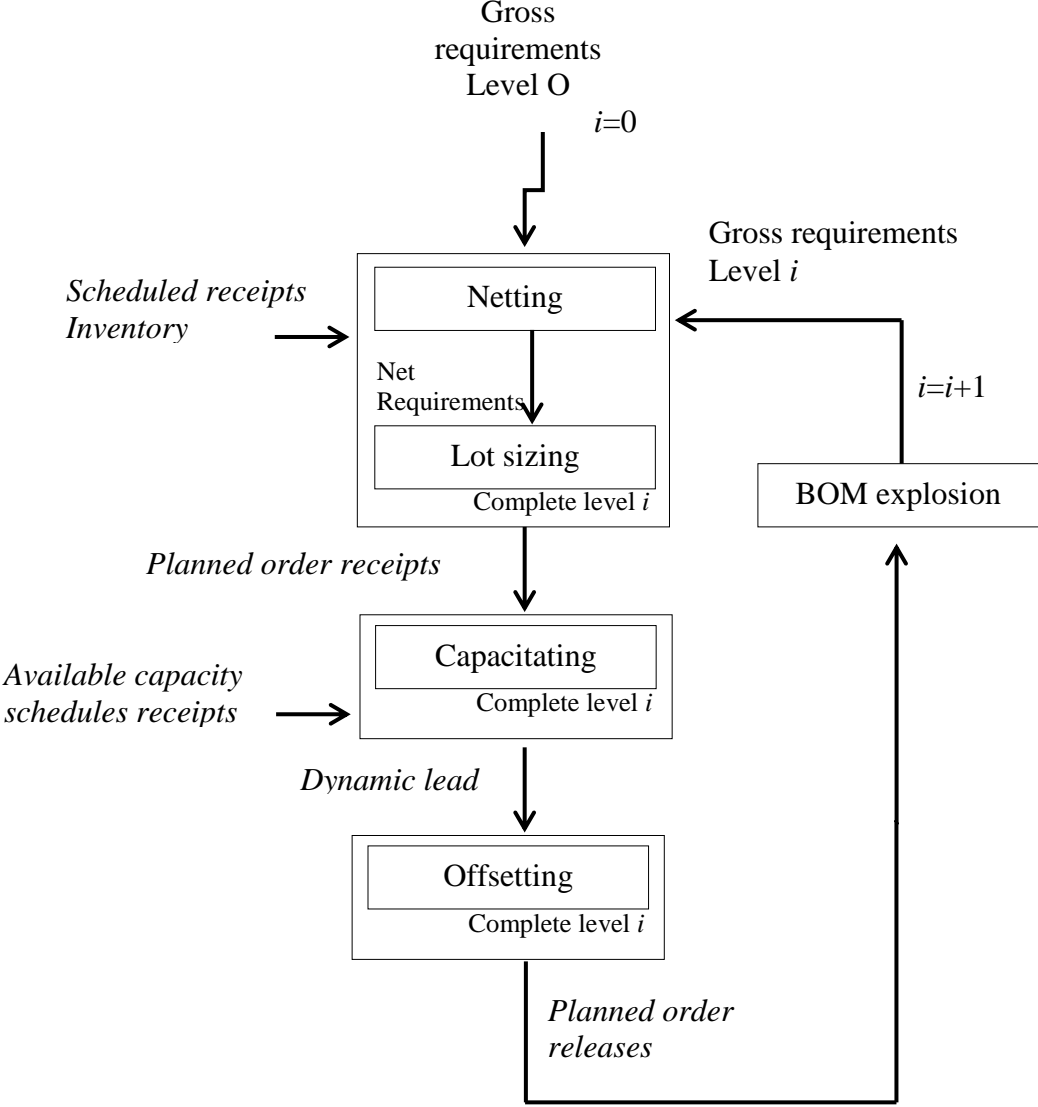


Fig no.4 – Modified Approach for MRP system included with Capacitating [7]

1.6 Netting

In the netting step, the net requirements are determined by taking into account the gross requirements, scheduled receipts and inventory. The gross requirements for the end items are predefined by the MPS. The gross requirements for sub items are set by the BOM explosion during MCRP. Scheduled receipts are converted to planned order receipts and may be released or not released to production. Sub items needed for scheduled receipts are allocated in stock or taken from stock. Netting is performed as in traditional MRP. Net requirements are calculated under consideration of projected inventory, safety stock etc.

2. LITERATURE SURVEY

The finite capacity of machines, fixed lead times and traditional production systems are not considered, assumed or supported in MRP traditional or in solving capacity problems. Due to above mentioned reasons, capacity constraints are being ignored and fixed lead times are being assumed. Various MRP techniques for capacity adjustment such as lot splitting, safety stock, alternative routings etc are discussed to obtain capacity feasible solutions in this paper by the Herbert Jodlbauer and Sonja Reinters [7].

Many solutions have been suggested or focus on solving these capacity problems by improving capacity planning at integration of MRP and finite capacity planning. This results in a planning method for simultaneous capacity and material planning. The planning method is based on a new and more accurate primary process model, giving the planning algorithm more flexibility in solving capacity problems. The algorithm is based on advanced scheduling techniques and use aggregated information, thus combining speed and accuracy. This whole theory has been suggested by Martin Taal and Johna C. Wortmann [17].

Another Research by the Harl [5] & Nagendra [12] shows that ignoring finite machine capacity leads to capacity infeasible schedules, which have to be revised by the user. Because of complex algorithms, capacity requirement planning function in some MRP-II packages is very time consuming. Though, these packages provides little assistance. Another alternative is the implementation of a shop floor control system (SFC). The main drawback of using SFC scheduling system is that they tackle only the symptoms; the real cause, failing capacity planning at the other MRP-II planning levels, is ignored. This sort of alternative approached by the Bakke and Hellberg [1] and also by the Taal and Wortmann [17].

The Research paper of Bala Ram and Xuefeng [15] addresses situations where a flexible BOM could be used to deal with unexpected shortages when using MRP to plan for requirements of dependent demand items. James C. Chen [4] provides a capacity requirements planning for twin fabs of wafer fabrication. They adjust capacity to the actual equipment loading, but there is not capacity threshold.

Harl and Ritzman [6] show that a minor extension to the MRP logic can improve customer service significantly. The approach taken here is to incorporate finite capacity planning techniques in the MRP logic. The main contribution of this paper is that it

presents an intuitive planning method that integrates MRP logic with several different finite capacity planning techniques. In addition this paper : (1) presents a primary process model that represents the constraints and flexibility of 'Real-life' production system more accurately than the current MRP-II model; (2) addresses key issues such as robustness and aggregation that are often overlooked when designing capacity planning methods; (3) explicitly considers the role of the human planner in the (automatic) planning process.

Choi and Seo [4] use capacity filtering algorithms for flexible flow lines to convert an infinite capacity loading profile to a finite capacity loading profile. Thus rather theoretical approach needs some adjustments (additional constraints, integration of dispatching rules, etc.) to deal with real life problems.

Capacity sensitive lot sizing has been the focus of extensive research by the Bahal and Ritzman [6] with capacity sensitive lot sizing the capacity load is take into account in the lot size computation. The main shortcoming of the capacity sensitive lot sizing methods is that they often use complex algorithms. The drawbacks of these type of algorithms are that they:

- Are not capable of handling the large like planning problems.
- Are not understood by planners i.e. are considered as 'black boxes'.
- Tend to show nervous behavior in dynamic production environments.

The focus on lot sizes is also very limited as there are many more methods to solve and prevent capacity problems, e.g. moving orders in time, changing routings etc. 'An early proposal : Schedule based MRP uses a form of forward loading to schedule the jobs on the available capacity. This guarantees feasible start and finish dates for the production orders. A weak point of this scheduling method is that it ignores a main goal of MRP: minimizing inventory cost by starting production orders as late as possible.

Sum and Hill [16] describe a method that not only adjusts lot sizes to minimize setups but also determines the start and finish times of production orders while taking into account capacity constraints their algorithms iteratively splits or combines production orders to minimize set up and inventory cost.

Moreover, Pandey [14] pointed out that complex algorithms are often not easily understood by the planner, and so they have developed a less mathematically complicated system for finite-capacity MRP (FCMRP), which is executed in two stages. First, capacity-based production schedules are generated and then, in a second step, the algorithm produces an appropriate material requirements plan to satisfy the schedules

obtained from the first stage. The model is restricted to lot for lot as the only possible lot-sizing rule and there is a single resource for each part type.

Wuttipornpun and Yenradee [20] studied an FCMRP system where they use a variable lead time for MRP depending on the lot size, processing and setup time. After scheduling jobs, they reduced capacity problems by using alternative machines if possible and adjusting the timing of jobs (starting the jobs earlier or delaying them). Limitations of this model are: bottleneck machines produce only one part, lot-for-lot is the only lot-sizing rule that is allowed and there is no overlap of production batches. A further development of this approach is TOC-MRP (Wuttipornpun and Yenradee [20]). With similar limitations, the Theory of Constraints (TOC) philosophy is adopted in FCMRP, which results in a better performance compared to FCMRP.

Commercially available FCMRP software uses two different approaches for including finite capacity: pre/post-MRP analysis and finite-capacity scheduling (Nagendra and Das [12]). Neither of them resolves the capacity problem during the MRP run itself. Additionally, computational effort increases substantially and so Lee [9] proposed parallelizing the MRP process and using a computational grid, to achieve a breakthrough in its performance under conditions of finite capacity.

Kanet and Stoblein [8] described 'Capacitated ERP' (CERP) – a variation of MRP that takes resource capacity into account before exploding requirements to lower level components. The model is limited to one-stage production, single-level BOM, single resource and no backorders.

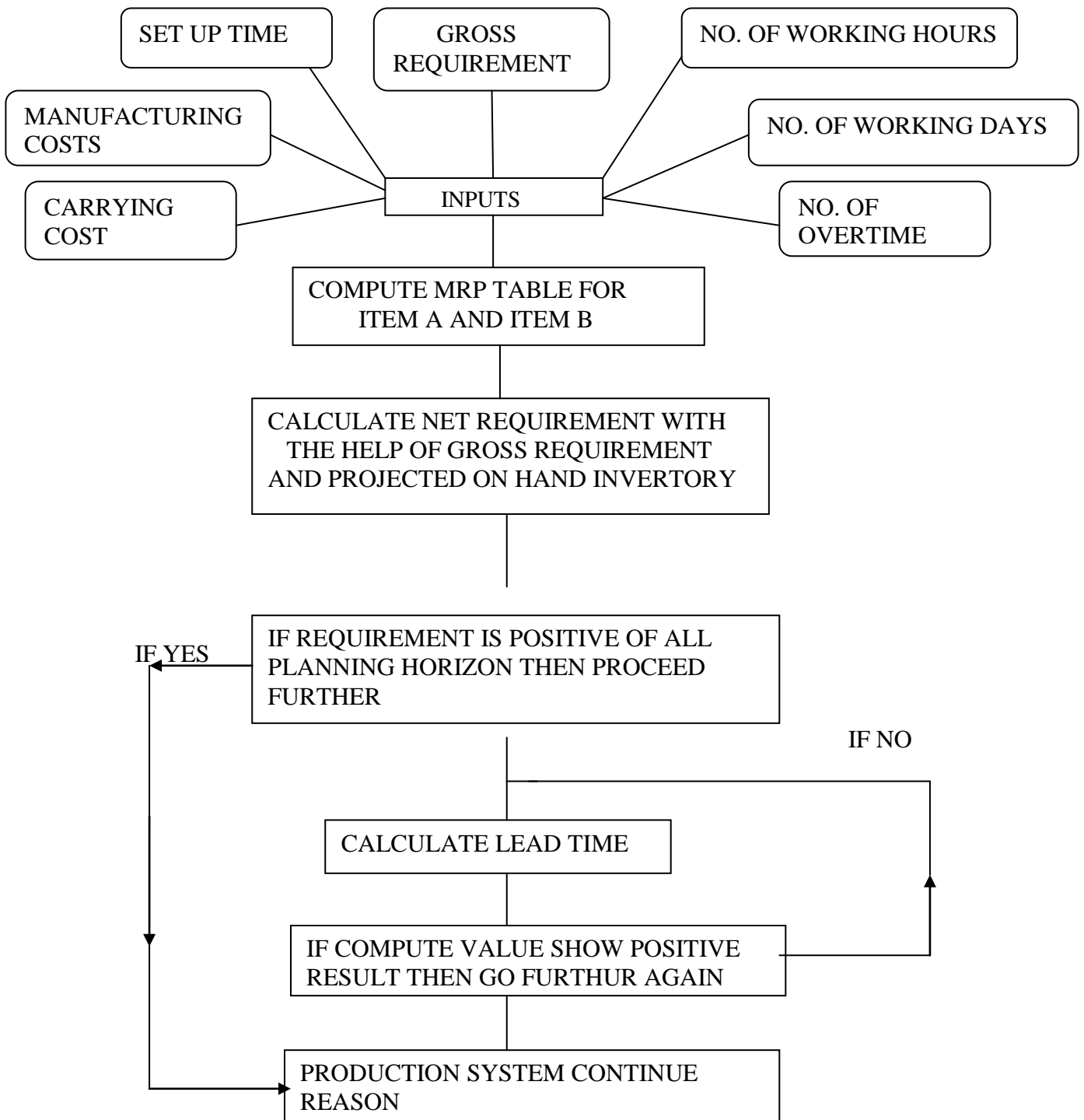
Table 2-1- Main approaches of MRP and finite capacity planning [7]

Approach	References	Limitations
Traditional MRP	Orlicky [13]	Fixed lead times, infinite capacity
MRP – CRP	Harl [5]	Identification of capacity problem after an MRP run, considerable participation of planner is necessary.
MRP-SFC	Taal and Wortmann [17]	Capacity problems are not solved on MRP level.
FCMRP	Pandey [14]	Capacity problem are not solved on MRP level, lot sizing: only lot-for-lot, single resource for each part type.
	Wuttiornpun and Yenradee [20]	Capacity problems are not solved on MRP level, lot sizing : only lot-for-lot, bottleneck machine : one part type
Finite capacity scheduling algorithms	Choi and Seo [4]	Flexible flow line, theoretical approach, constraints for real-life problems are missing
	Vanhoucke & Debels [19]	Company specific constraints
MRP and integrated capacity planning	Billington and Thomas [2]	Mathematical programming formulation of the problem, high computational effort for real-life problems.
	Tardif [18]	Same routing for all products
	Sum and Hill [16]	Capacity sensitive lot sizing with complex algorithms (not easy for planners to understand, high computational effort for real-life problems)
	Taal and Wortmann	Fixed lead times
	Kanet and Stoblein [8]	One-stage production, single-level BOM, single resources, no backorders

3. PROBLEM FORMULATION

MRP constitutes a set of techniques that use bill of material, inventory data, the master production schedule to calculate requirements for materials.

Fig no.5- Flow chart of the modified MRP system



MRP-II: Manufacturing Resource Planning is a system built around materials requirements, planning and also including the additional functions of production planning, master production scheduling and capacity requirements planning.

ERP-Enterprise resource planning is a software architecture that facilitates the flow of information among different functions of an enterprise. It encompasses a broad set of activities. It is supported by multi-module application software, which helps the firm to manage business activities.

As can be seen, considering finite capacity in MRP is an old issue in production research, but one that has not yet been solved satisfactorily. Theoretical scheduling algorithms cause high calculating times for real-world problems and are not easy for planners to understand. MRP-CRP, MRP-SFC and FCMRP approaches are also very time consuming and attempt to solve the capacity problem after an MRP run. Research contributions that try to integrate capacity constraints into MRP are often limited to simple production environments.

The main aims to modify traditional MRP in two directions:

1. by calculating overtime of workers and its effect on overall unit cost and
2. by using dynamic lead times.

For capacity adjustment, different measures like alternative routings, safety stocks, adjusting lot sizes and adding capacity are applied in a predefined sequence. Lead times are not predefined fixed parameters. They are calculated dynamically, and are dependent on lot sizes, inventory and required machine capacity. The presented approach can handle multiple products, multiple resources, multi-stage production and multi-level BOM. There is no restriction concerning the lot-sizing rule. As in traditional MRP, all lot-sizing rules can be used. An advantage of this approach in practice is that it is based on the well-known MRP methodology. Dynamic lead times and finite capacity are integrated at every stage of the MRP run to reduce the shortcomings of MRP.

3.1 PROBLEM DEFINITION

Traditional material requirements planning does not consider the finite capacity of machines and assumed fixed lead times. To obtain a capacity feasible production plan, different measures for capacity adjustment such as alternative routings, safety stock, lot splitting and lot summarization are only discussed, the same problem we can also solved by another method, overtime calculation of workers and with the help of these calculations, organization can also increases the production of that period where the period they have faced the negative production or shortage of products in planning horizon. In that case there will be no need to increases the machine capacity. Moreover in case of overtime calculations of workers, no doubt, some parameters are also affected (such as unit cost, set -up cost, manufacture cost, inventory cost, carrying cost etc).So, as a result, it will affect the total cost of the product as well as lead time. In crux, we will be check further what is the effect of these costs on the product and lead time, if we implemented on practical.

3.2 PROBLEM IMPLEMENTATION

In the traditional material requirement planning method only capacity of machine is considered, when the organization had faced the shortage of final product and with the assist of increasing capacity of machine, no doubt, company easily achieved the target whatever required. Furthermore this sort of diversity also solved by the other method, for instance, consideration of overtime calculation for workers and in this case there is no need of increasing the capacity of machine. Moreover for calculation of overtime for workers some parameters are necessary required such as basic time, delay allowances etc. to eradicate that problem. Therefore all the necessary input data are must be given by the organization before starting the process.

ITEM	X	Y	P	Q	R
SAFETY STOCK	12	12	12	12	12
PROCESSING TIME	13	8	6	4	7
LOT SIZING	FOP	FOP	FOP	FOP	FOP
	4	4	5	5	5
SET UP TIME	44	39	29	34	19
ALLOCATED MACHINE	M1	M1	M2	M2	M2
ON HAND INVENTORY	21	67	52	52	61
BASIC TIME	0.88	0.82	1	2	1
DELAY ALLOWANCES	2	3	4	5	6
NO. OF OVERTIME HRS.	3	4	5	6	4
NO. OF WORKING DAYS	26	25	27	28	27
NO. OF WORKING HRS	8	7.5	8.5	8	8
REQUIRE RAW MATERIAL UNIT	50	40	30	40	25
UNIT COST	4	3	2	1	2
PROCUREMENT COST	5	4	3	2	2
INTEREST RATE PER UNIT	0.1	0.2	0.3	0.4	0.5
SET UP COST	3	2	3	2	4
MANUFACTURE COST	5	4	4	3	3

Table no.2-A: Input data for all items

PROBLEM IMPLEMENTATION

In this problem item X consist of item P and Q whereas item Y consist of Q and R. It will depend upon the assembly, No. of component required for each assembly etc .The available capacity of these two machines are M1 and M2 is 422 units. In the planning horizon of 10 periods, the gross requirements of the MPS and the scheduled receipts are listed under the (Table no.3-B) given below. With this information projected inventory and net requirements can be computed as in traditional MRP under consideration of the safety stock. For determination of planned order receipts the lot sizing rule fixed order period (FOP 4) is applied.

Table no.3-B: MCRP table for X and Y item

PERIOD		1	2	3	4	5	6	7	8	9	10
ITEM X											
GROSS REQUIREMENT		12	12		12	22			32	12	12
SCHEDULED RECEIPTS		22									
PROJECTED INVENTORY	21	31	19		7						
NET REQUIREMENT					5	22			32	10	10
PLANNED ORDER RECEIPTS					27				52		
ITEM Y											
GROSS REQUIREMENT		22	22		22	42			22	22	22
SCHEDULED RECEIPTS											
PROJECTED INVENTORY	67	45	23		1						
NET REQUIREMENTS					21	42			22	22	22
PLANNED ORDER RECEIPTS					63				66		

PROBLEM IMPLEMENTATION

By using the MCRP table (Table no.4-C) for machines, cumulated available capacity and cumulated required capacity are determined. The difference cumulated available capacity minus cumulated required capacity is equal to the free cumulated capacity. A negative sign indicates a capacity problem in periods 4 and 8.

PERIOD	1	2	3	4	5	6	7	8	9	10
AVAILABLE CAPACITY	422	422		422	422	422		422	422	422
SCHEDULED CAPACITY RECEIPTS	327									
PLANNED CAPACITY RECEIPTS				966				1327		
CUMULATE-D AVAILABL CAPACITY	422	844		1266	1688	2110		2532	2954	3376
CUMULATED REQUIRED CAPACITY	327	327		1293	1293	1293		2620	2620	2620
FREE CUMULATED CAPACITY	95	517		-27	395	817		-88		756
CAPACITY ENVELOPE										

Table no.4- C: MCRP TABLE for Machine, M1

This problem is also solved by relaxed safety stock, suppose the maximum shortage of final product is -27 products in any planning horizon, then, organization consider the +27 as a maximum relaxed safety stock so according to the requirement of the organization, they have never faced the problem of negative production any planning horizon.

PROBLEM IMPLEMENTATION

PERIOD		1	2	3	4	5	6	7	8	9
ITEM X										
GROSS REQUIREMENT		12	12		12	22			32	12
SCHEDULED RECEIPTS		22								
PROJECTED INVENTORY	21	31	19		7	-15				
NET REQUIREMENTS						15			32	12
PLANNED ORDER RECEIPTS						47				
CALCULATED LEAD TIME						2.4				
PLANNED ORDER RELEASES					47					
ITEM Y										
GROSS REQUIREMENT		22	22		22	42			22	22
SCHEDULED RECEIPTS										
PROJECTED INVENTORY	67	45	23		1	-41				
NET REQUIREMENTS						41				
PLANNED ORDER RECEIPTS						63			22	22
CALCULATED LEAD TIME						2.3				
PLANNED ORDER RELEASES					63					

Table no.5- D: MCRP table for X and Y with relaxation of safety stock.

By using the (Table no.5-D), Company can be decided in which planning horizon they will actually give the order for finished product, so according to the data, planning horizon 5

PROBLEM IMPLEMENTATION

indicates the negative production , it mean consideration of quantity of product is required from this period with the help of calculation lead time.

PERIOD	1	2	3	4	5	6	7	8	9	10
MACHINE M0	422	422		422	422	422		422	422	422
AVAILABLE CAPACITY	327									
SCHEDULED CAPACITY RECEIPTS					966				1327	
PLANNED CAPACITY RECEIPTS										
CUMULATED AVAILABLE CAPACITY	422	844		1266	1688	2110		2532	2954	3376
CUMULATED REQUIRED CAPACITY	327	327		327	1293	1293		1293	2620	2620
FREE CUMULATED CAPACITY	95	517		939	395	817		1242	334	756
CAPACITY ENVELOPE	327	749		1171	1593	2015		2437	2859	3281

Table no.6- E: is the modified form of Table no.4- C, with relaxation of safety stock for M0.

Before the calculation of lead time, firstly, calculate the cumulated required capacity , with the help of that observer can easily get the value whether it is positive or negative ,where negative value occur it means where production is negative and here is needed for improvement, otherwise it will lead to shortage of products, For instance, (planning horizon 4).

PROBLEM IMPLEMENTATION

Calculated Cumulated required capacity(CCRC) = cumulated required capacity(r4)-(processing time × no. of order release + set up time) +{(overtime calculation for workers/ no. of cost included) ×[total cost of managing inventory + economic order quantity + set up cost + manufacture cost + procurement cost + carrying cost]}

Therefore,

Overtime calculation for workers =[basic time + delay allowance/ no. of working days × no. of working hrs.] × 2

Economic order quantity = $\sqrt{(2 \times \text{required material unit} \times \text{procurement cost} / \text{unit cost} \times \text{interest rate})}$

Total cost of managing inventory = [(required raw material unit × procurement cost) / economic order quantity] + [(economic order quantity × unit cost × interest rate) / 2]

Then we have,

Lead time = capacity envelope of period 4 - Calculated cumulated required capacity (CCRC) / Cumulated available capacity of period 4 – Cumulated available of period 3

For calculation of all above analysis we can get the value of different tables those are mentioned above.

Then calculated lead time for item A = 2.4, B =2.3.

4. RESULT AND CONCLUSIONS

After taking the overview of the reference paper and some other papers, the thing which was observed that nobody worked on the overtime calculation of workers and how they affect on the overall cost of product to eradicate the same problem. From the previous calculated lead time (on behalf of consideration of increasing the machine capacity) it has been found that the value of lead time is 1.51. Now the same problem has been solved with some new inputs and calculations. In this research work they had observed only five inputs such as processing time, lot sizing, etc. but in the new method eleven inputs are considered such as no. of working hours, no. of working days, etc. Moreover for the overtime calculation of workers, it will require important parameters such as no. of working days, working hours, basic time, delay allowances etc. In the nutshell, when the above said overtime calculation method has been implemented on the same concept ,one thing, which came into picture that, this method we can also successfully applied on the material and capacity requirement planning system because there is no major difference between calculated values. In this research work observer had been calculated 1.51 and 1.7 values but now it has been observed that 2.4, 2.3. So this mean, these results are also valid.

FUTURE SCOPE

- **Alternative routings:** The arrangement of workstations is determined by the route. Routing prescribe the flow of work in the plant and is related to considerations of layout of temporary storage locations of raw materials and components.
- **Applying lot splitting with consecutive processing:** In this method, if our lot size is more than machine capacity, then it can be shifted to the next workstation, so that our orders complete within the mentioned time.
- **Through the ordering of components from sub contractors,** this problem we can also solved because there are number of advantages of procuring are such as, to provide an uninterrupted flow of materials, tools, supplies etc. to ensure continuous production, collect information about the new materials, tools, equipments etc., which may reduce the manufacturing costs, to select suitable sources of supply and also develop reliable alternative sources of supply, to maintain inventories at the optimum levels and thus minimize investment in stock.

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