

# 5

## PRODUCTION PLANNING AND CONTROL

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### 5.1 INTRODUCTION AND MEANING

Production planning and control is a tool available to the management to achieve the stated objectives. Thus, a production system is encompassed by the four factors. *i.e.*, quantity, quality, cost and time. Production planning starts with the analysis of the given data, *i.e.*, demand for products, delivery schedule etc., and on the basis of the information available, a scheme of utilisation of firms resources like machines, materials and men are worked out to obtain the target in the most economical way.

Once the plan is prepared, then execution of plan is performed in line with the details given in the plan. Production control comes into action if there is any deviation between the actual and planned. The corrective action is taken so as to achieve the targets set as per plan by using control techniques.

Thus production planning and control can be defined as the “*direction and coordination of firms’ resources towards attaining the prefixed goals.*” Production planning and control helps to achieve uninterrupted flow of materials through production line by making available the materials at right time and required quantity.

## 5.2 NEED FOR PRODUCTION PLANNING AND CONTROL

The present techno-economic scenario of India emphasize on competitiveness in manufacturing. Indian industries have to streamline the production activities and attain the maximum utilisation of firms' resources to enhance the productivity. Production planning and control serves as a useful tool to coordinate the activities of the production system by proper planning and control system. Production system can be compared to the nervous system with PPC as a brain. Production planning and control is needed to achieve:

1. Effective utilisation of firms' resources.
2. To achieve the production objectives with respect to quality, quantity, cost and timeliness of delivery.
3. To obtain the uninterrupted production flow in order to meet customers varied demand with respect to quality and committed delivery schedule.
4. To help the company to supply good quality products to the customer on the continuous basis at competitive rates.

Production planning is a pre-production activity. It is the pre-determination of manufacturing requirements such as manpower, materials, machines and manufacturing process.

Ray wild defines "*Production planning is the determination, acquisition and arrangement of all facilities necessary for future production of products.*" It represents the design of production system. Apart from planning the resources, it is going to organize the production.

Based on the estimated demand for company's products, it is going to establish the production programme to meet the targets set using the various resources.

### Production Control

Inspite of planning to the minute details, most of the time it is not possible to achieve production 100 per cent as per the plan. There may be innumerable factors which affect the production system and because of which there is a deviation from the actual plan. Some of the factors that affect are:

1. Non-availability of materials (due to shortage, etc.);
2. Plant, equipment and machine breakdown;
3. Changes in demand and rush orders;
4. Absenteeism of workers; and
5. Lack of coordination and communication between various functional areas of business.

Thus, if there is a deviation between actual production and planned production, the control function comes into action. Production control through control mechanism tries to take corrective action to match the planned and actual production. Thus, production control reviews the progress of the work, and takes corrective steps in order to ensure that programmed production takes place. The essential steps in control activity are:

1. Initiating the production,
2. Progressing, and
3. Corrective action based upon the feedback and reporting back to the production planning.

**5.3 OBJECTIVES OF PRODUCTION PLANNING AND CONTROL**

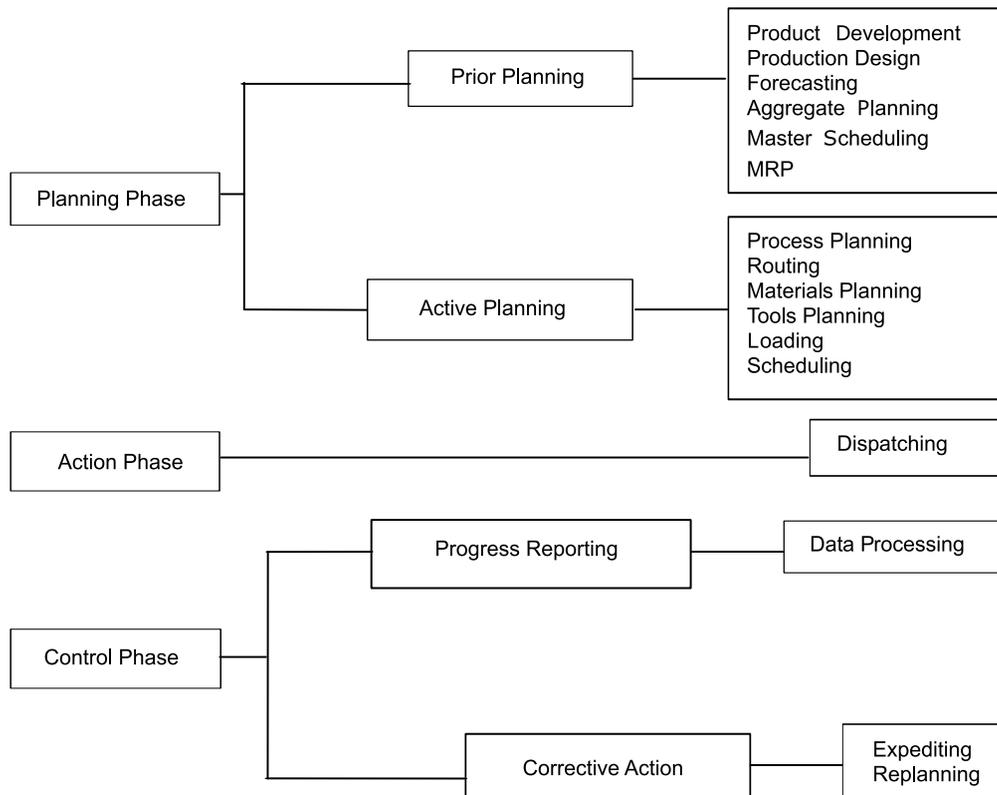
Following are the objectives of production planning and control:

1. Systematic planning of production activities to achieve the highest efficiency in production of goods/services.
2. To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
3. Optimum scheduling of resources.
4. Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
5. To conform to delivery commitments.
6. Materials planning and control.
7. To be able to make adjustments due to changes in demand and rush orders.

**5.4 PHASES OF PRODUCTION PLANNING AND CONTROL**

Production planning and control has three phases namely:

- A. Planning Phase
- B. Action Phase
- C. Control Phase



**Fig. 5.1** Phases of production planning and control

### 5.4.1 Planning Phase

**Planning** is an exercise of intelligent anticipation in order to establish how an objective can be achieved or a need fulfilled in circumstances, which are invariably restrictive. Production planning determines the optimal schedule and sequence of operations economic batch quantity, machine assignment and dispatching priorities for sequencing.

It has two categories of planning namely

1. Prior planning
2. Active planning.

#### **PRIOR PLANNING**

Prior planning means pre-production planning. This includes all the planning efforts, which are taking place prior to the active planning.

#### **Modules of pre-planning**

The modules of prior planning are as follows:

1. **Product development and design** is the process of developing a new product with all the features, which are essential for effective use in the field, and designing it accordingly. At the design stage, one has to take several aspects of design like, design for selling, design for manufacturing and design for usage.
2. **Forecasting** is an estimate of demand, which will happen in future. Since, it is only an estimate based on the past demand, proper care must be taken while estimating it. Given the sales forecast, the factory capacity, the aggregate inventory levels and size of the work force, the manager must decide at what rate of production to operate the plant over an intermediate planning horizon.
3. **Aggregate planning** aims to find out a product wise planning over the intermediate planning horizon.
4. **Material requirement planning** is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy the master production schedule.

#### **ACTIVE PLANNING**

The modules of active planning are: Process planning and routing, Materials planning. Tools planning, Loading, Scheduling etc.

1. **Process planning and routing** is a complete determination of the specific technological process steps and their sequence to produce products at the desired quality, quantity and cost. It determines the method of manufacturing a product selects the tools and equipments, analyses how the manufacturing of the product will fit into the facilities. Routing in particular prescribes the flow of work in the plant and it is related to the considerations of layout, temporary locations for raw materials and components and materials handling systems.
2. A **material planning** is a process which determines the requirements of various raw materials/subassemblies by considering the trade-off between various cost components like, carrying cost, ordering cost, shortage cost, and so forth.

3. **Tools' planning** determines the requirements of various tools by taking process specification (surface finish, length of the job, overall depth of cut etc.), material specifications (type of material used, hardness of the material, shape and size of the material etc.) and equipment specifications (speed range, feed range, depth of cut range etc.).
4. **Loading** is the process of assigning jobs to several machines such that there is a load balance among the machines. This is relatively a complex task, which can be managed with the help of efficient heuristic procedures.
5. **Scheduling** is the time phase of loading and determines when and in what sequence the work will be carried out. This fixes the starting as well as the finishing time for each job.

#### 5.4.2 Action Phase

Action phase has the major step of **dispatching**. Dispatching is the transition from planning phase to action phase. In this phase, the worker is ordered to start manufacturing the product. The tasks which are included in dispatching are job order, store issue order, tool order, time ticket, inspection order, move order etc.

The **job order** number is the key item which is to be mentioned in all other reports/orders. **Stores issue order** gives instruction to stores to issue materials for manufacturing the product as per product specifications. As per tooling requirements for manufacturing the product, the **tool order** instruct the tool room to issue necessary tools. **Time ticket** is nothing but a card which is designed to note down the actual time taken at various processes. This information is used for deciding the costs for future jobs of similar nature and also for performing variance analysis, which helps to exercise control.

Job order is the official authorization to the shop floor to start manufacturing the product. Generally, the process sequence will contain some testing and inspection. So, these are to be instructed to inspection wing in the form of inspection order for timely testing and inspection so that the amount of rework is minimized. The manufacture of product involves moving raw materials/subassemblies to the main line. This is done by a well-designed materials handling system. So, proper instruction is given to the materials handling facilities for major movements of materials/subassemblies in the form of a move order. Movements which involve less distance and fewer loads are managed at the shop floor level based on requests from operators.

#### 5.4.3 Control Phase

The control phase has the following two major modules:

1. Progress reporting, and
2. Corrective action.

##### 1. PROGRESS REPORTING

In progress reporting, the data regarding what is happening with the job is collected. Also, it helps to make comparison with the present level of performance. The various data pertaining to materials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analyzed for the purpose of progress reporting. These data are

used for performing variance analysis, which would help us to identify critical areas that deserve immediate attention for corrective actions.

## 2. CORRECTIVE ACTION

The tasks under corrective action primarily make provisions for an unexpected event. Some examples of corrective actions are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decisions, expediting the work, pre-planning, and so on. Due to unforeseen reasons such as, machine breakdown, labour absenteeism, too much rejection due to poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear picture of the situation to progress further. Under such situation, it is to be re-examined for selecting appropriate course of action. Expediting means taking action if the progress reporting indicates deviations from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.

## 5.5 FUNCTIONS OF PRODUCTION PLANNING AND CONTROL

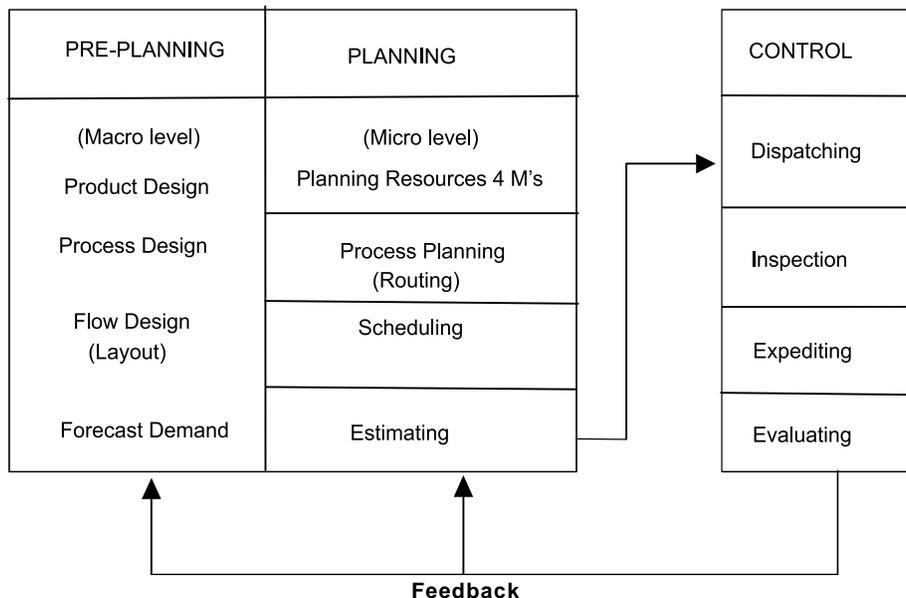
Functions of production planning and controlling is classified into:

1. Pre-planning function
2. Planning function
3. Control function

The functions of production planning and controlling are depicted in the Fig. 5.2.

### 1. PRE-PLANNING FUNCTION

Pre-planning is a macro level planning and deals with analysis of data and is an outline of the planning policy based upon the forecasted demand, market analysis and product design and



**Fig. 5.2** Functions of production planning and control

development. This stage is concerned with process design (new processes and developments, equipment policy and replacement and work flow (Plant layout). The pre-planning function of PPC is concerned with decision-making with respect to methods, machines and work flow with respect to availability, scope and capacity.

## 2. PLANNING FUNCTION

The planning function starts once the task to be accomplished is specified, with the analysis of **four M's**, *i.e.*, Machines, Methods, Materials and Manpower. This is followed by process planning (routing). Both short-term (near future) and long-term planning are considered. Standardisation, simplification of products and processes are given due consideration.

## 3. CONTROL FUNCTION

Control phase is effected by dispatching, inspection and expediting materials control, analysis of work-in-process. Finally, evaluation makes the PPC cycle complete and corrective actions are taken through a feedback from analysis. A good communication, and feedback system is essential to enhance and ensure effectiveness of PPC.

### 5.5.1 Parameters for PPC

The functions of PPC can be explained with the following parameters:

1. **Materials:** Raw materials, finished parts and bought out components should be made available in required quantities and at required time to ensure the correct start and end for each operation resulting in uninterrupted production. The function includes the specification of materials (quality and quantity) delivery dates, variety reduction (standardisation) procurement and make or buy decisions.

2. **Machines and equipment:** This function is related with the detailed analysis of available production facilities, equipment down time, maintenance policy procedure and schedules. Concerned with economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time because of breakdowns.

3. **Methods:** This function is concerned with the analysis of alternatives and selection of the best method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.

4. **Process planning (Routing):** It is concerned with selection of path or route which the raw material should follow to get transformed into finished product. The duties include:

- (a) Fixation of path of travel giving due consideration to layout.
- (b) Breaking down of operations to define each operation in detail.
- (c) Deciding the set up time and process time for each operation.

5. **Estimating:** Once the overall method and sequence of operations is fixed and process sheet for each operation is available, then the operations times are estimated. This function is carried out using extensive analysis of operations along with methods and routing and a standard time for operation are established using work measurement techniques.

6. **Loading and scheduling:** Scheduling is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations. Machines have to be

loaded according to their capability of performing the given task and according to their capacity. Thus the duties include:

- (a) Loading, the machines as per their capability and capacity.
- (b) Determining the start and completion times for each operation.
- (c) To coordinate with sales department regarding delivery schedules.

7. **Dispatching:** This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions. It authorises the start of production activities by releasing materials, components, tools, fixtures and instruction sheets to the operator. The activities involved are:

- (a) To assign definite work to definite machines, work centres and men.
- (b) To issue required materials from stores.
- (c) To issue jigs, fixtures and make them available at correct point of use.
- (d) Release necessary work orders, time tickets, etc., to authorise timely start of operations.
- (e) To record start and finish time of each job on each machine or by each man.

8. **Expediting:** This is the control tool that keeps a close observation on the progress of the work. It is logical step after dispatching which is called 'follow-up'. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts, *i.e.*, follow up of materials, follow up of work-in-process and follow up of assembly. The duties include:

- (a) Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.
- (b) To devise action plans (remedies) for correcting the errors.
- (c) To see that production rate is in line with schedule.

9. **Inspection:** It is a major control tool. Though the aspects of quality control are the separate function, this is of very much important to PPC both for the execution of the current plans and its scope for future planning. This forms the basis for knowing the limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.

10. **Evaluation:** This stage though neglected is a crucial to the improvement of productive efficiency. A thorough analysis of all the factors influencing the production planning and control helps to identify the weak spots and the corrective action with respect to pre-planning and planning will be effected by a feedback. The success of this step depends on the communication, data and information gathering and analysis.

## 5.6 OPERATIONS PLANNING AND SCHEDULING SYSTEMS

Operations planning and scheduling systems concern with the volume and timing of outputs, the utilisation of operations capacity at desired levels for competitive effectiveness. These systems must fit together activities at various levels, from top to bottom, in support of one another, as shown in Fig. 5.3. Note that the time orientation ranges from long to short as we progress from top to bottom in the hierarchy. Also, the level of detail in the planning process ranges from broad at the top to detail at the bottom.

## Components of Operations Planning and Scheduling System

### 1. THE BUSINESS PLAN

The business plan is a statement of the organization's overall level of business activity for the coming six to eighteen months, usually expressed in terms of outputs (in volume of sales) for its various product groups, a set of individual products that share or consume common blocks of capacity in the manufacturing process. It also specifies the overall inventory and backlog levels that will be maintained during the planning period. The business plan is an agreement between all functional areas—finance, production, marketing, engineering, R & D—about the level of activity and the products they are committed to support. The business plan is not concerned with all the details and specific timing of the actions for executing the plan. Instead, it determines a feasible general posture for competing to achieve its major goals. The resulting plan guides the lower-level, more details decisions.

### 2. AGGREGATE PRODUCTION (OUTPUT) PLANNING

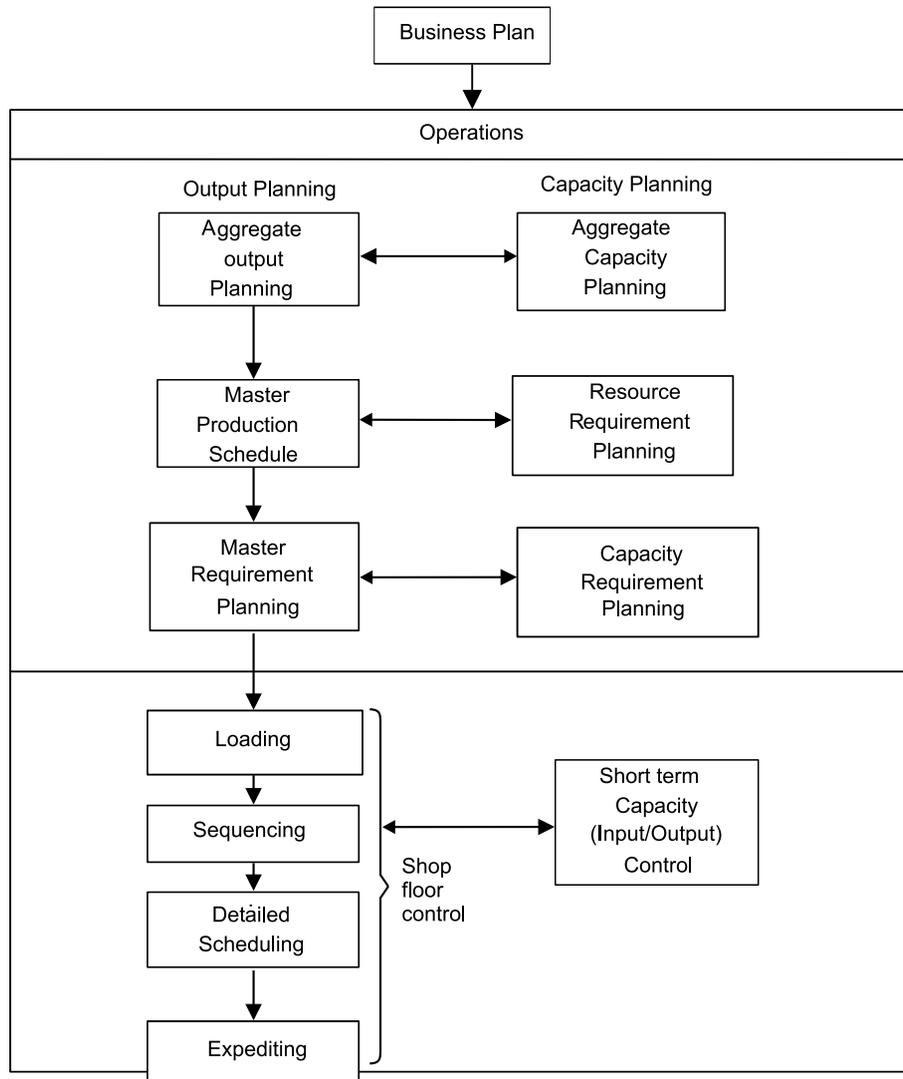
The process of determining output levels of product groups over the coming six to eighteen months on a weekly or monthly basis. It identifies the overall level of outputs in support of the business plan. The plan recognizes the division's existing fixed capacity and the company's overall policies for maintaining inventories and backlogs, employment stability and subcontracting.

### 3. AGGREGATE CAPACITY PLANNING

It is the process of testing the feasibility of aggregate output plans and evaluating overall capacity utilisation. A statement of desired output is useful only if it is feasible. Thus, it addresses the supply side of the firm's ability to meet the demand. As for aggregate output plans, each plant, facility, or division requires its own aggregate capacity plan. Capacity and output must be in balance, as indicated by the arrow between them in Fig. 5.3. A capacity plan translates an output plan into input terms, approximating how much of the division's capacity will be consumed. Although these basic capacities are fixed, management can manipulate the short-term capacities by the ways they deploy their work force, by subcontracting, or by using multiple work shifts to adjust the timing of overall outputs. As a result, the aggregate planning process balances output levels, capacity constraints, and temporary capacity adjustments to meet demand and utilise capacity at desired levels during the coming months. The resulting plan sets limits on the master production schedule.

### 4. MASTER PRODUCTION SCHEDULING (MPS)

MPS is a schedule showing week by week how many of each product must be produced according to customer orders and demand forecasts. Its purpose is to meet the demand for individual products in the product group. This more detailed level of planning disaggregates the product groups into individual products and indicates when they will be produced. The MPS is an important link between marketing and production. It shows when incoming sales orders can be scheduled into production, and when each shipment can be scheduled for delivery. It also takes into account current backlogs so that production and delivery schedules are realistic.



**Fig. 5.3** *Operations planning and scheduling system*

### 5. RESOURCE REQUIREMENT PLANNING

Resource requirement planning (rough-cut capacity planning) is the process of testing the feasibility of master production schedule in terms of capacity. This step ensures that a proposed MPS does not inadvertently overload any key department, work centre, or machine, making the MPS unworkable.

### 6. MATERIAL REQUIREMENT PLANNING

Material requirement planning (MRP) is a system of planning and scheduling the time phased material requirements for releasing materials and receiving materials that enable the master production schedule to be implemented. Thus, the master production schedule is the driving force

for material requirements planning. MRP provides information such as due dates for components that are subsequently used for shop floor control. Once this information is available, it enables managers to estimate the detailed requirements for each work centres.

### **7. CAPACITY REQUIREMENT PLANNING**

Capacity requirement planning (CRP) is an iterative process of modifying the MPS or planned resources to make capacity consistent with the production schedule. CRP is a companion process used with MRP to identify in detail the capacity required to execute the material requirement planning. At this level, more accurate comparisons of available and needed capacity for scheduled workloads are possible.

### **8. SHOP FLOOR CONTROL**

Shop floor control involves the activities that execute and control shop operations namely loading, sequencing, detailed scheduling and expediting jobs in production. It coordinates the weekly and daily activities that get jobs done. Individual jobs are assigned to machines and work centres (loading), the sequence of processing the jobs for priority control is determined, start times and job assignments for each stage of processing are decided (detailed scheduling ) and materials and work flows from station to station are monitored and adjusted (expediting).

### **9. LOADING**

Each job (customer order) may have its unique product specification and, hence, it is unique through various work centres in the facility. As new job orders are released, they are assigned or allocated among the work centres, thus establishing how much of a load each work centre must carry during the coming planning period. This assignment is known as loading (sometimes called shop loading as machine loading).

### **10. SEQUENCING**

This stage establishes the priorities for jobs in the queues (waiting lines) at the work centres. Priority sequencing specifies the order in which the waiting jobs are processed; it requires the adoption of a priority sequencing rule.

### **11. DETAILED SCHEDULING**

Detailed scheduling determines start times, finish times and work assignments for all jobs at each work centre. Calendar times are specified when job orders, employees, and materials (inputs), as well as job completion (outputs), should occur at each work centre. By estimating how long each job will take to complete and when it is due, schedulers can establish start and finish dates and develop the detailed schedule.

### **12. EXPEDITING**

Expediting is a process of tracking a job's progress and taking special actions to move it through the facility. In tracking a job's progress, special action may be needed to keep the job moving through the facility on time. Manufacturing or service operations disruptions-equipments breakdowns, unavailable materials, last-minute priority changes, require managers to deviate from plans and schedules and expedite an important job on a special handling basis.

### 13. INPUT/OUTPUT CONTROL

Input/output control related to the activities to monitor actual versus planned utilisation of a work centre's capacity. Output plans and schedules call for certain levels of capacity at a work centre, but actual utilisation may differ from what was planned. Actual versus planned utilisation of the work centre's capacity can be monitored by using input-output reports and, when discrepancies exist, adjustments can be made. The important components of operations planning and scheduling system has been explained in detail in the following paragraphs.

#### 5.7 AGGREGATE PLANNING

Aggregate planning is an intermediate term planning decision. It is the process of planning the quantity and timing of output over the intermediate time horizon (3 months to one year). Within this range, the physical facilities are assumed to be fixed for the planning period. Therefore, fluctuations in demand must be met by varying labour and inventory schedule. Aggregate planning seeks the best combination to minimise costs.

#### Aggregate Planning Strategies

The variables of the production system are labour, materials and capital. More labour effort is required to generate higher volume of output. Hence, the employment and use of overtime (OT) are the two relevant variables. Materials help to regulate output. The alternatives available to the company are inventories, back ordering or subcontracting of items.

These controllable variables constitute pure strategies by which fluctuations in demand and uncertainties in production activities can be accommodated by using the following steps:

1. *Vary the size or the workforce*: Output is controlled by hiring or laying off workers in proportion to changes in demand.
2. *Vary the hours worked*: Maintain the stable workforce, but permit idle time when there is a slack and permit overtime (OT) when demand is peak.
3. *Vary inventory levels*: Demand fluctuations can be met by large amount of inventory.
4. *Subcontract*: Upward shift in demand from low level. Constant production rates can be met by using subcontractors to provide extra capacity.

#### Aggregate Planning Guidelines

The following are the guidelines for aggregate planning:

1. Determine corporate policy regarding controllable variables.
2. Use a good forecast as a basis for planning.
3. Plan in proper units of capacity.
4. Maintain the stable workforce.
5. Maintain needed control over inventories.
6. Maintain flexibility to change.
7. Respond to demand in a controlled manner.
8. Evaluate planning on a regular base.

**5.8 MASTER PRODUCTION SCHEDULE (MPS)**

Master scheduling follows aggregate planning. It expresses the overall plans in terms of specific end items or models that can be assigned priorities. It is useful to plan for the material and capacity requirements.

Flowchart of aggregate plan and master production schedule is shown in Fig. 5.4

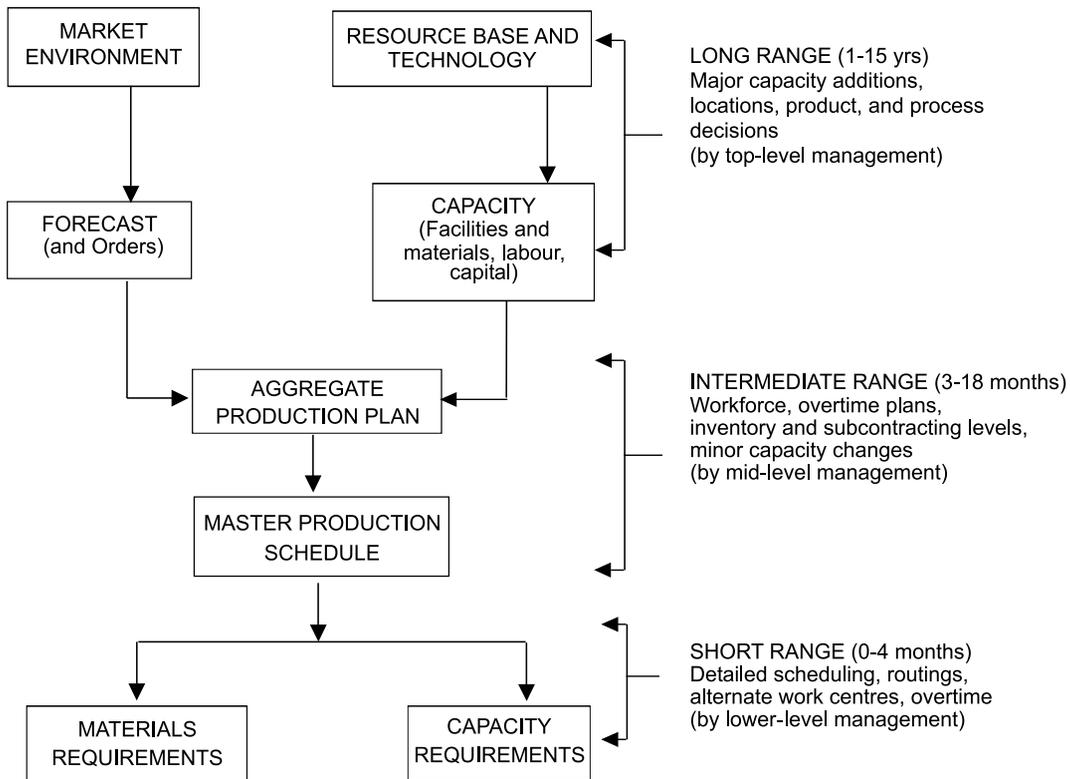
Time interval used in master scheduling depends upon the type, volume, and component lead times of the products being produced. Normally weekly time intervals are used. The time horizon covered by the master schedule also depends upon product characteristics and lead times. Some master schedules cover a period as short as few weeks and for some products it is more than a year.

**Functions of MPS**

Master Production Schedule (MPS) gives a formal details of the production plan and converts this plan into specific material and capacity requirements. The requirements with respect to labour, material and equipment is then assessed.

The main functions of MPS are:

1. *To translate aggregate plans into specific end items:* Aggregate plan determines level of operations that tentatively balances the market demands with the material, labour and equipment capabilities of the company. A master schedule translates this plan into specific number of end items to be produced in specific time period.



**Fig. 5.4** Flowchart of aggregate plan and master schedule

2. *Evaluate alternative schedules:* Master schedule is prepared by trial and error. Many computer simulation models are available to evaluate the alternate schedules.
3. *Generate material requirement:* It forms the basic input for material requirement planning (MRP).
4. *Generate capacity requirements:* Capacity requirements are directly derived from MPS. Master scheduling is thus a prerequisite for capacity planning.
5. *Facilitate information processing:* By controlling the load on the plant. Master schedule determines when the delivery should be made. It coordinates with other management information systems such as, marketing, finance and personnel.
6. *Effective utilization of capacity:* By specifying end item requirements schedule establishes the load and utilization requirements for machines and equipment.

## 5.9 MATERIAL REQUIREMENT PLANNING (MRP)

MRP refers to the basic calculations used to determine components required from end item requirements. It also refers to a broader information system that uses the dependence relationship to plan and control manufacturing operations.

*“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.”*

### 5.9.1 Objectives of MRP

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 component 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 order.

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 coordination among various work centres and hence help to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

### 5.9.2 MRP System

The inputs to the MRP system are: (1) A master production schedule, (2) An inventory status file and (3) Bill of materials (BOM).

Using these three information sources, the MRP processing logic (computer programme) provides three kinds of information (output) for each product component: order release requirements, order rescheduling and planned orders.

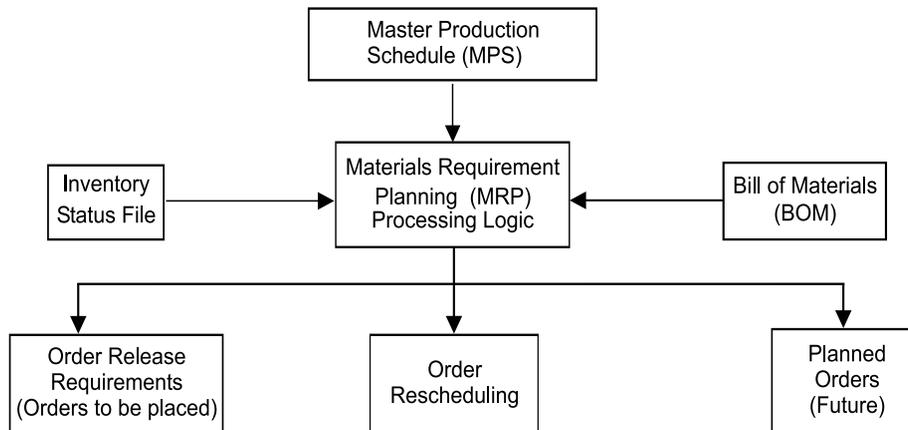


Fig. 5.5 MRP system

### 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 produced and when. MPS is initially developed from firm customer orders or from forecasts of demand before MRP system begins to operate. The MRP system whatever the master schedule demands and translates MPS end items into specific component requirements. Many systems make a simulated trial run to determine whether the proposed master can be satisfied.

### 2. INVENTORY STATUS FILE

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

### 3. BILL OF MATERIALS (BOM)

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 centres performing the build up sequence. This information is obtained from product design documents, workflow analysis and other standard manufacturing information.

## 5.10 CAPACITY PLANNING

Design of the production system involves planning for the inputs, conversion process and outputs of production operation. The effective management of capacity is the most important responsibility of production management. The objective of capacity management (*i.e.*, planning and control of capacity) is to match the level of operations to the level of demand.

**Capacity planning** is to be carried out keeping in mind future growth and expansion plans, market trends, sales forecasting, etc. It is a simple task to plan the capacity in case of stable demand. But in practice the demand will be seldom stable. The fluctuation of demand creates problems regarding the procurement of resources to meet the customer demand. Capacity decisions

are strategic in nature. Capacity is the rate of productive capability of a facility. Capacity is usually expressed as volume of output per period of time.

Production managers are more concerned about the capacity for the following reasons:

- Sufficient capacity is required to meet the customers demand in time.
- Capacity affects the cost efficiency of operations.
- Capacity affects the scheduling system.
- Capacity creation requires an investment.

Capacity planning is the first step when an organization decides to produce more or new products.

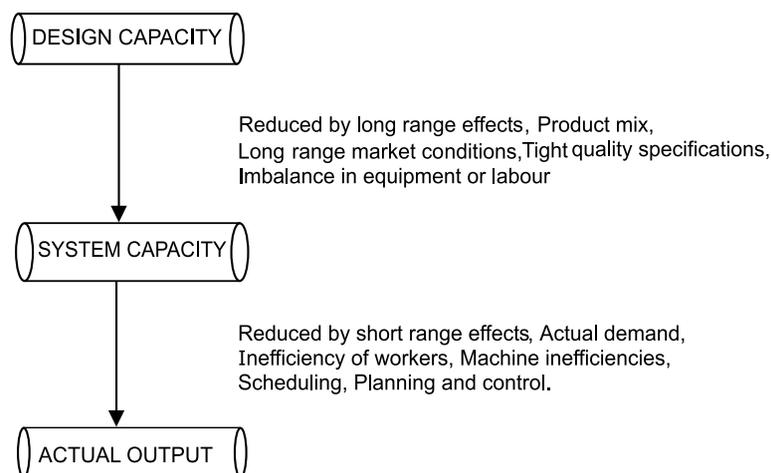
### 5.10.1 Measurement of Capacity Planning

The capacity of the manufacturing unit can be expressed in number of units of output per period. In some situations measuring capacity is more complicated when they manufacture multiple products. In such situations, the capacity is expressed as man-hours or machine hours. The relationship between capacity and output is shown in Fig. 5.6.

1. **Design capacity:** Designed capacity of a facility is the planned or engineered rate of output of goods or services under normal or full scale operating conditions.

For example, the designed capacity of the cement plant is 100 TPD (Tonnes per day). Capacity of the sugar factory is 150 tonnes of sugarcane crushing per day.

2. **System capacity:** System capacity is the maximum output of the specific product or product mix the system of workers and machines is capable of producing as an integrated whole. System capacity is less than design capacity or at the most equal, because of the limitation of product mix, quality specification, breakdowns. The actual is even less because of many factors affecting the output such as actual demand, downtime due to machine/equipment failure, unauthorised absenteeism.



**Fig. 5.6** Capacity and output relationship

The system capacity is less than design capacity because of long range uncontrollable factors. The actual output is still reduced because of short-term effects such as, breakdown of equipment, inefficiency of labour. The system efficiency is expressed as ratio of actual measured output to the system capacity.

$$\text{System Efficiency (SE)} = \frac{\text{Actual output}}{\text{System capacity}}$$

3. **Licensed capacity:** Capacity licensed by the various regulatory agencies or government authorities. This is the limitation on the output exercised by the government.

4. **Installed capacity:** The capacity provided at the time of installation of the plant is called installed capacity.

5. **Rated capacity:** Capacity based on the highest production rate established by actual trials is referred to as rated capacity.

### 5.10.2 Process of Capacity Planning

Capacity planning is concerned with defining the long-term and the short-term capacity needs of an organization and determining how those needs will be satisfied. Capacity planning decisions are taken based upon the consumer demand and this is merged with the human, material and financial resources of the organization.

Capacity requirements can be evaluated from two perspectives—long-term capacity strategies and short-term capacity strategies.

#### 1. LONG-TERM CAPACITY STRATEGIES

Long-term capacity requirements are more difficult to determine because the future demand and technology are uncertain. Forecasting for five or ten years into the future is more risky and difficult. Even sometimes company's today's products may not be existing in the future. Long range capacity requirements are dependent on marketing plans, product development and life-cycle of the product. Long-term capacity planning is concerned with accommodating major changes that affect overall level of the output in long-term. Marketing environmental assessment and implementing the long-term capacity plans in a systematic manner are the major responsibilities of management. Following parameters will affect long range capacity decisions.

1. **Multiple products:** Company's produce more than one product using the same facilities in order to increase the profit. The manufacturing of multiple products will reduce the risk of failure. Having more than one product helps the capacity planners to do a better job. Because products are in different stages of their life-cycles, it is easy to schedule them to get maximum capacity utilisation.

2. **Phasing in capacity:** In high technology industries, and in industries where technology developments are very fast, the rate of obsolescence is high. The products should be brought into the market quickly. The time to construct the facilities will be long and there is no much time as the products should be introduced into the market quickly. Here the solution is phase in capacity on modular basis. Some commitment is made for building funds and men towards facilities over a period of 3–5 years. This is an effective way of capitalising on technological breakthrough.

3. **Phasing out capacity:** The outdated manufacturing facilities cause excessive plant

closures and down time. The impact of closures is not limited to only fixed costs of plant and machinery. Thus, the phasing out here is done with humanistic way without affecting the community. The phasing out options makes alternative arrangements for men like shifting them to other jobs or to other locations, compensating the employees, etc.

## 2. SHORT-TERM CAPACITY STRATEGIES

Managers often use forecasts of product demand to estimate the short-term workload the facility must handle. Managers looking ahead up to 12 months, anticipate output requirements for different products, and services. Managers then compare requirements with existing capacity and then take decisions as to when the capacity adjustments are needed.

For short-term periods of up to one year, fundamental capacity is fixed. Major facilities will not be changed. Many short-term adjustments for increasing or decreasing capacity are possible. The adjustments to be required depend upon the conversion process like whether it is capital intensive or labour intensive or whether product can be stored as inventory.

Capital intensive processes depend on physical facilities, plant and equipment. Short-term capacity can be modified by operating these facilities more or less intensively than normal. In labour intensive processes short-term capacity can be changed by laying off or hiring people or by giving overtime to workers. The strategies for changing capacity also depend upon how long the product can be stored as inventory.

The short-term capacity strategies are:

1. **Inventories:** Stock of finished goods during slack periods to meet the demand during peak period.
2. **Backlog:** During peak periods, the willing customers are requested to wait and their orders are fulfilled after a peak demand period.
3. **Employment level (hiring or firing):** Hire additional employees during peak demand period and layoff employees as demand decreases.
4. **Employee training:** Develop multi-skilled employees through training so that they can be rotated among different jobs. The multi-skilling helps as an alternative to hiring employees.
5. **Subcontracting:** During peak periods, hire the capacity of other firms temporarily to make the component parts or products.
6. **Process design:** Change job contents by redesigning the job.

## 5.11 ROUTING

Routing may be defined as the selection of path which each part of the product will follow while being transformed from raw materials to finished products. Path of the product will also give sequence of operation to be adopted while being manufactured.

In other way, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape, which involves the following steps:

- (a) Type of work to be done on product or its parts.
- (b) Operation required to do the work.
- (c) Sequence of operation required.

(d) Where the work will be done.

(e) A proper classification about the personnel required and the machine for doing the work.

For effective production control of a well-managed industry with standard conditions, the routing plays an important role, *i.e.*, to have the best results obtained from available plant capacity. Thus routing provides the basis for scheduling, dispatching and follow-up.

### 5.11.1 Techniques of Routing

While converting raw material into required goods different operations are to be performed and the selection of a particular path of operations for each piece is termed as 'Routing'. This selection of a particular path, *i.e.* sequence of operations must be the best and cheapest to have the lowest cost of the final product. The various routing techniques are:

1. **Route card:** This card always accompanies with the job throughout all operations. This indicates the material used during manufacturing and their progress from one operation to another. In addition to this the details of scrap and good work produced are also recorded.

2. **Work sheet:** It contains

(a) Specifications to be followed while manufacturing.

(b) Instructions regarding routing of every part with identification number of machines and work place of operation.

This sheet is made for manufacturing as well as for maintenance.

3. **Route sheet:** It deals with specific production order. Generally made from operation sheets. One sheet is required for each part or component of the order. These includes the following:

(a) Number and other identification of order.

(b) Symbol and identification of part.

(c) Number of pieces to be made.

(d) Number of pieces in each lot—if put through in lots.

(e) Operation data which includes:

(i) List of operation on the part.

(ii) Department in which operations are to be performed.

(iii) Machine to be used for each operation.

(iv) Fixed sequence of operation, if any.

(f) Rate at which job must be completed, determined from the operation sheet.

4. **Move order:** Though this is document needed for production control, it is never used for routing system. Move order is prepared for each operation as per operation sheet. On this the quantity passed forward, scrapped and to be rectified are recorded. It is returned to planning office when the operation is completed.

## 5.12 SCHEDULING

Scheduling can be defined as "prescribing of when and where each operation necessary to manufacture the product is to be performed."

It is also defined as "establishing of times at which to begin and complete each event or

operation comprising a procedure". The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

### 5.12.1 Principles of Scheduling

1. **The principle of optimum task size:** Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.

2. **Principle of optimum production plan:** The planning should be such that it imposes an equal load on all plants.

3. **Principle of optimum sequence:** Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

### 5.12.2 Inputs to Scheduling

1. *Performance standards:* The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.
2. Units in which loading and scheduling is to be expressed.
3. Effective capacity of the work centre.
4. Demand pattern and extent of flexibility to be provided for rush orders.
5. Overlapping of operations.
6. Individual job schedules.

### 5.12.3 Scheduling Strategies

Scheduling strategies vary widely among firms and range from 'no scheduling' to very sophisticated approaches.

These strategies are grouped into four classes:

1. **Detailed scheduling:** Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans.

2. **Cumulative scheduling:** Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.

3. **Cumulative detailed:** Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.

4. **Priority decision rules:** Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, *i.e.*, first come first serve. These are useful in reducing Work-In-Process (WIP) inventory.

### 5.12.4 Types of Scheduling

Types of scheduling can be categorized as forward scheduling and backward scheduling.

1. **Forward scheduling** is commonly used in job shops where customers place their orders on “needed as soon as possible” basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centres in the routing. The forward method generates in the process inventory that are needed at subsequent work centres and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.

2. **Backward scheduling** is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing. Forward and backward scheduling methods are shown in Fig. 5.7.

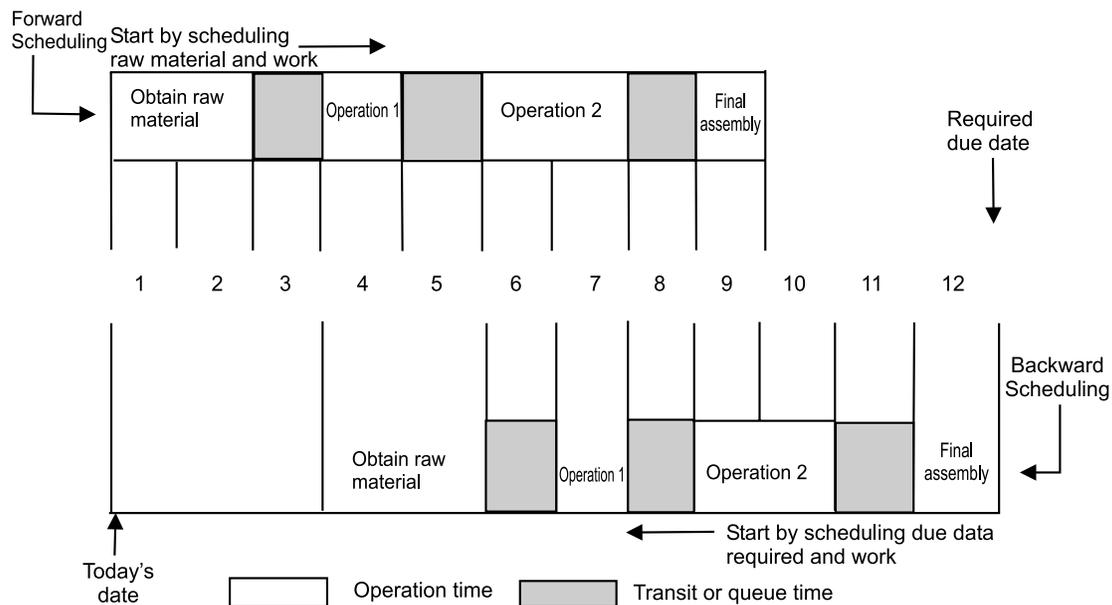


Fig. 5.7 Forward and backward scheduling

### 5.13 SCHEDULING METHODOLOGY

The scheduling methodology depends upon the type of industry, organization, product, and level of sophistication required. They are:

1. Charts and boards,

2. Priority decision rules, and
3. Mathematical programming methods.

### 1. Gantt Charts and Boards

Gantt charts and associated scheduling boards have been extensively used scheduling devices in the past, although many of the charts are now drawn by computer. Gantt charts are extremely easy to understand and can quickly reveal the current or planned situation to all concerned. They are used in several forms, namely,

- (a) Scheduling or progress charts, which depicts the sequential schedule;
- (b) Load charts, which show the work assigned to a group of workers or machines; and
- (c) Record a chart, which are used to record the actual operating times and delays of workers and machines.

### 2. Priority Decision Rules

Priority decision rules are simplified guidelines for determining the sequence in which jobs will be done. In some firms these rules take the place of priority planning systems such as MRP systems. Following are some of the priority rules followed.

<i>Symbol</i>	<i>Priority rule</i>
FCFS	First come, first served
EDO	Earliest due date
LS	Least slack (that is, time due less processing time)
SPT	Shortest processing time
LPT	Longest processing time
PCO	Preferred customer order
RS	Random selection

### 3. Mathematical Programming Methods

Scheduling is a complex resource allocation problem. Firms process capacity, labour skills, materials and they seek to allocate their use so as to maximize a profit or service objective, or perhaps meet a demand while minimizing costs.

The following are some of the models used in scheduling and production control.

(a) **Linear programming model:** Here all the constraints and objective functions are formulated as a linear equation and then problem is solved for optimality. *Simplex method*, *transportation methods* and *assignment method* are major methods used here.

(b) **PERT/CPM network model:** PERT/CPM network is the network showing the sequence of operations for a project and the precedence relation between the activities to be completed.

**Note:** Scheduling is done in all the activities of an organisation *i.e.*, production, maintenance etc. Therefore, all the methods and techniques of scheduling is used for maintenance management (Ref. Chapter 8).

## EXERCISES

### Section A

1. What do you mean by production planning and control?
2. What do you mean by aggregate planning?
3. What is master production schedule?
4. What is material requirement planning?
5. What is capacity planning?
6. What is routing?
7. What is scheduling?
8. Mention the types of scheduling.

### Section B

1. Why do you need production planning and control?
2. What are the objective of production planning and control?
3. What are the guidelines for aggregate planning?
4. Explain the functions of master production schedule.
5. Explain the objective of MRP.
6. How do you measure capacity?
7. Explain the techniques of routing.
8. What are the inputs to scheduling?
9. Explain the scheduling strategies.

### Section C

1. Discuss the phases of production planning and control.
2. Discuss the functions of PP & C.
3. Discuss the operations planning and scheduling systems.
4. Discuss the aggregate plan and master schedule.
5. Discuss the MRP system.
6. Discuss the process of capacity planning.
7. Discuss the scheduling methods.

### Skill Development

**FAST FOOD RESTAURANT VISIT:** Get the information for the following questions:

1. Phase of production planning and production control.
2. Planning for the demand fluctuation.
3. Items are prepared to order or with forecast.
4. Procedures to manufacture pizza.
5. Scheduling the orders (i.e. first come first schedule or largest proceeding time and shortest proceeding time etc.)

### CASELET

#### ESCOM-COPING WITH RUNWAY CAPACITY NEEDS

ESCOM is a producer of electronic home appliances, including VHS (Video Home System) television recorders, located in northern California. The packaged product weighs about 75 kg. ESCOM was not the innovator of the system. Rather, its managers sat back and let RCA and others develop the market, and ESCOM is currently producing under license agreements. ESCOM has a conscious strategy of being a follower with new product innovations. It does not have the financial resources to be a leader in research and development.

ESCOM's present opportunity is indicated by the fact that industry sales of VHS recorders have increased 30 per cent per year for the past two years, and forecasts for the next year and the two following are even more enticing. ESCOM has established a 10 per cent market share position and feels that it can at least maintain this position if it has the needed capacity; it could possibly improve its market share if competitors fail to provide capacity at the time it is needed.

	Year					
	0	1	2	3	4	5
Forecast, 1000 Units	100	140	195	270	350	450
Capacity (gap), or slack 1000 units	5	(35)	(90)	(165)	(245)	(345)

The forecasts and capacity gaps are indicated in Table. ESCOM regards the first year forecast as being quite solid, based on its present market share and a compilation of several industry forecasts from different sources. It is less sure about the forecasts for future years, but it is basing these forecasts on patterns for both black and white and color TV sales during their product life cycles.

ESCOM's VHS model has a factory price of Rs 600. Variable costs are 70 percent of the price. Inventory carrying costs are 20 per cent of inventory value, 15 percentage points of which represents the cost of capital. ESCOM's facility planners estimate that a 40,000 unit plant can be built for Rs. 5 million and a 200,00 unit plant, for Rs. 10 million. Land and labour are available in the area, and either size plant can be built within a year.

- (a) What capacity plans do you think ESCOM should make for next year? Why?
- (b) What longer-term capacity plans should ESCOM make? Why?
- (c) What are the implications of these plans for marketing, distribution, and production?

[Source: *Modern Production/Operations Management* by Elwood S. Buffa & Rakesh K. Sarin]