PRODUCTION PLANNING AND CONTROL

- Aggregate Planning and the Master Production Schedule
- Inventory Control
- Material and Capacity Requirements Planning
- Just-In-Time and Lean Production
- Shop Floor Control

Production Planning and Control Defined
Manufacturing support function concerned with logistics problems in manufacturing
- *Production planning* - plans what products are to be produced, in what quantities, and when
  - Also considers the resources required to accomplish the plan
- *Production control* - determines whether resources to execute the plan have been provided and if not, takes action to correct the deficiency
- Activities in a Production Planning and Control System
- Aggregate production planning
- Detailed planning of material and capacity requirements
- Purchasing and shop floor control

Activities in a production planning and control system

Aggregate Planning and the Master Production Schedule
- Any manufacturing firm must have a business plan, and that plan must include:
  - What products will be produced?
  - How many
  - When
The manufacturing plan should take into account:
- Current orders and sales forecasts
- Inventory levels
- Plant capacity considerations

Long-Range Planning
- Long-range planning is the responsibility of the highest-level executives of the firm
- It is concerned with:
  - Corporate goals and strategies
  - Future product lines
  - Financial planning
  - Obtaining the resources so the company will have a future

And Then the Details
- As the planning horizon decreases, the long-range plan must be translated into medium-range and short-range plans that become increasingly specific
- At the medium-range are:
  - The aggregate production plan and the master production schedule
- In the short-range are:
  - The material and capacity requirements planning, and the detailed scheduling of the orders

Aggregate Production Plan
- Indicates production output levels for major product lines rather than specific products
  - Must be coordinated with the sales and marketing plan and must consider current inventory levels
  - Must reconcile marketing plans for current products and new products under development against the capacity resources available to make those products
  - High level corporate planning activity, but details are delegated to staff

Master Production Schedule
- Lists the products to be manufactured, when they should be completed, and in what quantities
- It is the conversion of the aggregate schedule into a very specific schedule of individual products
- Products listed in the master schedule generally divide into three categories:
  1. Firm customer orders
  2. Forecasted demand
  3. Spare parts

Inventory Control
- Concerned with achieving a balance between two competing objectives:
  1. Minimizing the cost of maintaining inventory
2. Maximizing service to customers

Types of Inventory
- Various types of inventory encountered in manufacturing:
  - Raw materials
  - Purchased components
  - In-process inventory (work-in-process)
  - Finished products
- Different inventory control procedures are appropriate, according to which type is managed

Types of Demand: Independent Demand
- Demand or consumption of the item is unrelated to demand for other items
- End products and spare parts are independent demand items
- Customers purchase end products and spare parts, and their decisions to do so are unrelated to the purchase of other items

Types of Demand: Dependent Demand
- Demand for the item is directly related to demand for something else, usually because it is a component of a product subject to independent demand
- Example: automobile – it is an end product, its demand is independent
  - However, tires on new automobiles are examples of dependent demand
  - For every car made in the final assembly plant, four tires must be supplied

Inventory Control Systems
- Two different inventory control systems are required for the two cases:
  1. Order point systems – for independent demand items
  2. Material requirements planning – for dependent demand items

Order Point Systems
- Two related issues encountered when controlling inventories of independent demand items:
  1. How much to order - often decided by means of economic order quantity formula
  2. When to order - accomplished using reorder points

Model of inventory level over time in the typical make-to-stock situation
Economic Order Quantity (EOQ) Formula

The EOQ formula minimizes the sum of inventory carrying costs and setup costs:

\[ EOQ = \sqrt{\frac{2DaC_{su}}{Ch}} \]

where \( EOQ \) = economic order quantity (number of parts that should be produced in the batch); and other terms are previously defined.

Reorder Point System

- When the inventory level for a given stock item declines to some point defined as the reorder point, this is the signal to place an order to restock the item.
- Reorder point is set at a high enough level so as to minimize the probability that a stock-out will occur during the period between when the reorder point is reached and a new batch is received.
- Reorder point policies can be implemented using computerized inventory control systems.

![Diagram of reorder point inventory system]

Operation of a reorder point inventory system

Two Alternative Techniques for Planning and Controlling Production and Inventory

- For job shop and mid-range production of assembled products:
  - Material requirements planning (MRP) and capacity requirements planning for high production:
  - Just-In-Time (JIT) and Lean Production

Material Requirements Planning (MRP)

Computational procedure to convert the master production schedule for end products into a detailed schedule for raw materials and components used in the end products:

- The detailed schedule indicates the quantities of each item, when it must be ordered, and when it must be delivered to achieve the master schedule.
- Capacity requirements planning coordinates labor and equipment resources with material requirements.
- Most appropriate for job shop and batch production of a variety of products consisting of multiple components, each of which must be purchased and/or fabricated.
- It is the proper technique for determining quantities of dependent demand items, that is, raw materials.
– purchased parts
– work-in-process
used to manufacture independent demand products

Common Use Items in MRP

- The master schedule specifies the production of final products in terms of month-by-month deliveries
- Each product may contain hundreds of components
  - These components are produced from raw materials, some of which are common among the components (e.g., sheet steel for stampings)
  - Some of the components themselves may be common to several different products
- These materials and components are called common use items in MRP

Lead Times in MRP

- The lead time for a job is the time that must be allowed to complete the job from start to finish
- Two kinds of lead times in MRP:
  - Ordering lead time - time required from initiation of the purchase requisition to receipt of the item from the vendor
  - Manufacturing lead time - time required to produce the item in the company's own plant, from order release to completion

Inputs to the MRP System

- For the MRP processor to function properly, it must receive inputs from several files:
  - Master production schedule
  - Product design data, as a bill of materials file
  - Inventory records
  - Capacity requirements planning

How MRP Works

- Based on the inputs, the MRP processor computes how many of each component and raw material will be needed in future time periods by "exploding" the end product schedule into successively lower levels in the product structure
- Complicating factors:
  - Adjustments for inventories on hand or on order
  - Common use items
  - Lead times

MRP Output Reports

- Order releases - authorize placement of orders planned by MRP system
- Planned order releases in future periods
- Rescheduling notices, indicating changes in due dates for open orders
Cancellation notices - indicate that certain orders are canceled due to changes in the master schedule

Inventory status reports

Exception reports, showing deviations from schedule, overdue orders, scrap, etc.

Benefits of MRP

- Inventory reductions
- Faster response to changes in demand
- Reduced setup and changeover costs
- Better machine utilization
- Improved ability to respond to changes in the master schedule
- Helpful in developing the master schedule

Capacity Requirements Planning

- Concerned with determining labor and equipment requirements needed to meet the master production schedule
- Also concerned with identifying the firm's long term future capacity needs
- Also serves to identify production resource limitations so that a realistic master production schedule can be planned

Lean Production and Just-In-Time

*Lean production* - an adaptation of mass production in which workers and work cells are made more flexible and efficient by adopting methods that reduce waste in all forms

*Just-in-time* (JIT) – principles and procedures aimed at reducing inventories, either directly or indirectly

–JIT is an important component of lean production

Where to Apply JIT

- Just-in-time procedures have proven most effective in high-volume repetitive manufacturing, such as the automobile industry
  
  –The potential for in-process inventory accumulation in this type of manufacturing is significant because both quantities of products and number of components per product are large
  
  –A JIT system produces exactly the right number of each component to satisfy the next operation just when that component is needed - "just in time"

Requisites of JIT

- Stable production schedules
- Small batch sizes and short setup times
- On-time delivery of defect-free components and materials
- Reliable production equipment
- Pull system of production control
- A workforce that is capable, committed, and cooperative
A dependable supplier base

Small Batch Sizes and Setup Reduction
- A requirement for minimizing inventories is small batch sizes and short setup times
  - The relationship between batch size and setup time is included in the EOQ formula
  - Instead of using it to compute batch quantities for large setup times, efforts should be focused on finding ways to reduce setup time, thereby permitting smaller batches and lower work-in-process levels

On-Time Delivery, Zero Defects, and Reliable Equipment
- Small lot sizes and parts buffers in JIT require parts to be delivered before stock-outs occur at downstream stations
  - If parts are defective, they cannot be used in assembly
  - This promotes zero defects in parts fabrication
  - Machines that break down cannot be tolerated in JIT because of low WIP (therefore no buffers)
  - This emphasizes the need for reliable equipment and preventive maintenance

Pull System of Production Control
- JIT requires a pull system of production control, in which the order to produce parts at a station comes from the downstream station that uses those parts
  - As the parts supply runs out at a given station, it "places an order" at the upstream workstation
  - This order authorizes the upstream station to produce the needed parts
- This procedure, repeated at each workstation throughout the plant, has the effect of pulling parts through the production system

A Push System by Comparison
- A push system operates by supplying parts to each station in the plant, in effect driving the work from upstream stations to downstream stations
- The risk in a push system is to overload the factory by scheduling more work than it can handle, resulting in large queues of parts in front of machines
- A poorly implemented MRP system, one that does not include capacity planning or ensure correctness of data used in the computations, manifests this risk

Shop Floor Control (SFC)
- Concerned with releasing production orders, monitoring and controlling progress of the orders, and acquiring up-to-date information on order status
- Basically, SFC is concerned with managing work-in-progress in the factory
- Most relevant in job shop and batch production, where there are a variety of orders that must be scheduled and tracked
- Purchasing department is responsible for this function among suppliers
Three Modules of a Shop Floor Control System

1. Order release
2. Order scheduling
3. Order progress
   - They are implemented by a combination of computer systems and human resources

Order Release
   - Generates the documents needed to process a production order through the factory
   - The documents are sometimes called the shop packet, which consists of:
     - Route sheet
     - Requisitions to obtain starting materials
     - Job cards to report direct labor time
     - Move tickets to transport parts
     - Parts list for assembly jobs

Order Scheduling
   - Assigns the production orders to work centers in the factory
   - A dispatch list is prepared indicating which orders should be accomplished at each work center
   - Also provides relative priorities for the jobs, e.g., by showing due dates for each job
   - Dispatch list helps the department foreman assign work and allocate resources to achieve the master schedule

Order Progress
   - Monitors the status of the orders, work-in-process, and other parameters in the plant that indicate progress and production performance
   - Various techniques are available to collect data from factory operations
     - Called the factory data collection system, the techniques range from requiring workers to submit paper forms that are later compiled, to fully automated techniques with no human participation