Small Lot Production

Chapter 5

Lot Size Basics

- Intuition leads many to believe we should manufacture products in large lots.
  - Save on setup time
  - Save on production costs

- Costs associated with Lots
  - **Setup costs**: Costs to prepare to make a batch or order a batch
    When applied to manufacturing it may include the cost of lost production and the cost of scrap associated with the changeover
  - **Order cost**: Cost of placing and receiving an order from a supplier
  - **Holding cost**: Cost of holding a unit in inventory for a given time period
Holding Costs

- Elements of holding costs
  - storage (rent, lease, mortgage, utilities, maintenance, etc.)
  - tracking and monitoring of inventory
  - damage and pilfering
  - interest on money to produce or procure the material
  - opportunity costs on the money tied up in inventory

- \[ H = r \times P \] where

  \[ P \] unit production costs or unit procurement cost, the cost of manufacturing or procuring one unit.

  \[ r \] percentage based on rates for borrowing, insuring, investing, (opportunity).

Lot Sizing and Setup Reduction

- Preference for large batches stems from the tendency to view material ordering, handling, and setup as fixed activities.

- JIT or Lean Thinking views all activities associated with setup, ordering, and handling of materials as non-value adding activities.

- Lean goal is to reduce setup time to zero.

- SMED: Every setup should be 10 minutes or less
  
  Setup reduction is a component of continuous improvement.

  As setup times and costs go down, so should lot sizes.
Types of Lots

- Production or process batch
  - The quantity of material manufactured as the result of one setup.
  - When material is purchased, it is called a purchase or order quantity.

- Transfer batch
  - The quantity moved from one operation or workstation to the next.

- Delivery quantity
  - Lot quantity shipped between customer and supplier

Lot Sizing of Process Batches

- Lot-for-lot
  - The size of the lot corresponds exactly to the amount required (ordered or forecasted) during a particular time period.
  - Works reasonably well in both pull and push scheduling systems.
  - Works well whether demand is independent or dependent.
  - Production or procurement is dictated whenever there is a non-zero demand, whether the demand is large or small.
  - Can result in high setup or ordering costs
Lot Sizing (Cont.)

- **Period Order Quantity**

  Reduces the number of setups or orders by restricting the frequency of orders.

  Starts with a predetermined order frequency, then determines the lot size based on the demand occurring between successive orders.

  Results in fewer orders being placed, but also results in some inventory being carried.

Lot Sizing (Cont.)

- **Economic order quantity**

  Gives most economical lot size for a given demand period.

  Minimizes the sum of setup cost and holding costs

  \[ TC = \frac{SD}{Q} + \frac{HQ}{2} \]

  where

  \[ S = \text{setup costs per occurrence} \]

  \[ D = \text{average demand for a specified time period} \]

  \[ Q = \text{the economic order quantity} \]

  \[ H = \text{the holding costs per unit for the specified time period} \]
Lot Sizing (Cont.)

- Formula for EOQ

\[ Q = \sqrt{\frac{2 \times D \times S}{H}} \]

Assumptions:
1. Demand is constant, continuous, and known.
2. Demand is independent.
3. Setup (order) cost is fixed, regardless of lot size.
4. Unit carrying cost \( H \) is known and constant; total carrying cost is a linear function of lot size.
5. The entire lot arrives (is produced or delivered) all at once.
6. Unit purchase (manufacturing) cost \( P \) is fixed, regardless of lot size (no quantity discounts or production economies).
7. Stockouts (or subsequent backorders) do not occur.

Economic Manufacturing Quantity

- Formula

\[ EMQ = \sqrt{\frac{2 \times D \times S}{H \times (1 - \frac{D}{p})}} \]

\( p \) = Production rate per period. Units for \( D, p, \) and \( H \) must be consistent.

The same assumptions for the EOQ are applicable.
Problems With EOQ-Based Models

- Virtually no industry has continuous, fixed demand.
- Extremely difficult to accurately determine the holding and setup costs and keep them current.
- Even when costs are known, H still understates the cost of carrying inventory because it fails to recognize the effect of inventory on quality and lead time.
- If the operation is a bottleneck, the setup cost is the COP on all lost production.
- EOQ-based lot sizing is more applicable to non-manufacturing situations (distribution and retailing).

Transfer Batches

- Can reduce WIP and lead time by using lot splitting and sending some portion of a process batch to the next operation before the entire batch is completed.
- The benefits of small transfer batches (relative to process batches) is only beneficial if the transfer batch can be processed when it arrives at the next operation (not just arrive and wait).
- The size of process batches (and small setup times) used throughout the plant must be small.
- Since reducing the size of transfer batches increases the time required for material handling, you must address the cost and time of material handling at the same time setups are addressed.
Process Batches

- Reducing the size of process batches reduces WIP and lead time.
- It could also reduce lead time variability (must assume the small batches are processed independently of each other and that the ratio of processing time to standard deviation is the same for each small batch as for the large batch).
- Small batches save on other control transactions:
  - Items are easier to track,
  - Easier to count and to see where you have overages and potential shortages,
  - Less inventory will potentially let you go to POU storage.

Small Lot Sizes and Quality

- 1994 study by Inman found a 1:1 relationship between lot size reduction and quality improvement.
- However, some companies in the study (114 manufacturing firms) experienced reductions in scrap and defect rates even when they did not reduce lot sizes.
- Suggests there is a relationship between reduced lot sizes and improved quality, but probably not in direct proportion.
Flexibility

- With small batch sizes it is easier to change job schedules, and to insert new jobs with less effect on the schedules of other jobs.

- Reinforces Little’s Law

  \[ \text{Lead Time} = \frac{\text{WIP}}{\text{Throughput}} \]

  Assuming constant throughput, lead time can be reduced by reducing WIP.

- At bottlenecks, may want to run larger batches, to avoid setups. May also want to group like orders together (ignoring priorities) to avoid setup times.

Minimal Lot Sizes

- The minimal lot size is constrained by the production capacity and setup time.

  Given operation makes 5 parts and runs 40 hours per week. After subtracting out the time for production and maintenance, there are 7.5 hours per week remaining for setups. If each setup takes 0.5 hours, then:

  \[
  \text{Number of setups} = \frac{\text{Time available for setup}}{\text{Time to perform setup}} = \frac{7.5}{0.5} = 15/\text{WK}
  \]

  Time to perform setups should only include internal setup time.

- If we wanted to spread the available setups evenly, each part would receive 3 setups.
Backing Into Lot Sizes

- Minimal lot size = \( \frac{\text{Average Weekly Demand}}{\text{Number of Setups}} \)
  
  If the average weekly demand for each part is 1500 units, the minimal process lot size = \( \frac{1500}{3} = 500 \) units

- **Internal setup** = the time the machine or operation must be stopped to perform the setup.

- **External setup** = The time devoted to perform the setup while the operation is running.

- The external setup time constrains the minimal process lot size only when it mandates a smaller number of setups than the internal setup time alone.

Backing Into Lot Sizes

- Setup time, product demand, and production rate are the major determinants of minimal process lot size.

  - Smaller demand can be satisfied for a fixed number of setups with smaller lot sizes.

  - Operations with faster production rates require less time for processing, giving more time for setups and smaller lot sizes.

  - Lot sizes can be dynamically determined given the specific situation.
Buffer Stock (Safety Stock)

- Excess inventory held between operations to make sure you do not run out of materials.

  - Uncertainty in demand. Need to level production. Will discuss in Chapter 16.

  - Lead time variability (ways to reduce)
    Preventive maintenance
    Setup improvement
    Quality control activities
    Standardized operations
    Contracts with dependable suppliers

Reducing Lot Sizes

- Process Batches
  Need to reduce setup times

- Purchase Quantities
  Reduce the cost of order placement by moving some of the responsibility for purchasing to the production department.

  Reduce the number of suppliers and develop standard agreements and partnerships with them.
  - want smaller, more frequent deliveries
  - want good incoming quality (no incoming inspection)
Transfer Batch Lot Size Reduction

- Major factor in smaller transfer batches is materials handling.
  - distance over which materials are moved.
  - number of steps or transactions involved in the move.
  - complexity or sophistication of the material handling system

- Reducing distance
  - locating equipment close together (cells, no backtracking)
  - reducing need for conveyance systems, forklifts, etc.

- Delivery and Shipping Batches

  Logistics industry are taking greater responsibility for working out the details of delivery routes and schedules, and for coordinating deliveries between suppliers and customers