Part 3: Acquisition & Production Control.

Ch.6 Capacity Management & Shop Floor Control.

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Capacity Management: Definition

**Capacity.**
- The capability of a workers, machine, work center, plant, or organization to produce output per period of time.

**Load**
- The capacity of a system or resource needed to produce a desired output in a particular time period.
Calculating Capacity.

Rated Capacity = Available Time × Utilization × Efficiency

1. Available Time
   - Depend on the number of machines, number of workers, and hours of operation.
   - Number of machines (or number of workers) × hours of operation.

2. Utilization
   - The percentage of time that the work center is actually active.

   \[
   \text{Utilization} = \frac{\text{Hours actually worked}}{\text{Available hours}} \times 100\% 
   \]
Calculating Capacity.

3. Efficiency

- A measure (as a percentage) of the actual output compared with the standard expected output.

Efficiency = \( \frac{\text{Standard hours of work}}{\text{Hours actually worked}} \times 100 \% \)
Calculating Capacity.

**Demonstrated Capacity**

- Proven capacity calculated from actual performance data, usually expressed as the average number of items produced multiplied by the standard hours per item.

- Demonstrated Capacity Example.
  Over the previous four weeks, a work center produced 120, 130, 150, and 140 standard hours of work. What is the demonstrated capacity of the work center?

Answer)

\[
\text{Demonstrated Capacity} = \frac{120 + 130 + 150 + 140}{4} = 135 \text{ standard hours}
\]
Capacity Planning.

Priority

- Production Plan
- Master Production Schedule
- Material Requirement Plan

Capacity

- Resource Plan (Long range)
- Rough-Cut Capacity Plan (Medium range)
- Capacity Requirement Plan (Short range)
- Capacity Control (Short range)

Plan

Implement/Control

Production Activity Control
Capacity Planning Process

**Capacity Planning Process.**

Step 1. Determine the capacity available at each work center in each time period.

Step 2. Determine the load at each work center in each time period.

Step 3. Resolve differences between available capacity and required capacity.
Production Activity Control.

Definition.

· Production activity control (PAC) represent the implementation and control phase of the production planning and control system. PAC is composed of shop scheduling and control, typically referred to as shop floor control (SFC), and supplier management systems.

· Supplier management system is responsible for establishing and controlling the flow of raw materials into the factory, and shop flow control is responsible for planning and controlling the flow of work through the factory.
Shop Flow Control.

Main Activities.

- The Major Subfunctions of SFC.
  - Assigning priority of each shop order.
  - Maintaining work-in-process quantity information.
  - Conveying shop order status information to the office.
  - Providing actual output data for capacity control purpose.
  - Providing quantity by location by shop order for work-in-process inventory and accounting purpose.
  - Providing measurement of efficiency, utilization, and productivity of the workforce and machines.
Operation Scheduling.

Scheduling.

- **Objectives of Scheduling.**
  - To meet delivery lead time and to make the best use of manufacturing resources.
  - It involves establishing start and finish dates for each operation required to complete an item.
  - To develop a reliable schedule, the planner must have information on routing, required and available capacity, competing jobs, and manufacturing lead time (MLT) at each work center.

- **Considerations of Scheduling.**
  - Manufacturing Lead time.
  - Scheduling Techniques: Backward & Forward Scheduling.
Operation Scheduling.

Scheduling.

- **Manufacturing Lead Time.**
  - The total time required to manufacture an item, exclusive of lower level purchasing lead time.

<table>
<thead>
<tr>
<th>Queue</th>
<th>Setup</th>
<th>Run</th>
<th>Wait</th>
<th>Move</th>
</tr>
</thead>
</table>

- Queue time: Time waiting before operation begins.
- Setup time: Time getting ready for operation.
- Run time: Time performing operation.
- Wait time: Time waiting after operation ends.
- Move time: Time physically moving between operations.
Operation Scheduling.

Scheduling.

- Backward Scheduling vs. Forward Scheduling.
  - Backward Scheduling. The last operation on the routing is scheduled first and is scheduled for completion at the due date. This schedules items to be available as needed and is the same logic as used in the MRP system.
Operation Scheduling.

Scheduling.

- **Backward Scheduling vs. Forward Scheduling.**
  - Forward Scheduling.
    Material procurement and operation scheduling for a component start when the order is received. Whatever the due date, and operations are scheduled forward from order received date.

```
Order received  + Manufacturing Lead time  Due Date
Start Point ------------> Finished Point
```
Operation Scheduling.

Scheduling.

- **Infinite Loading vs. Finite Loading.**
  - Infinite loading.
    It does not consider the existence of other shop orders competing for capacity at these work center.
  
  - Finite loading.
    It assumes there is a defined limit to available capacity at any workstation.
Expediting.

- Overlapping vs. Lot Splits.
  - Overlapping.

In operation overlapping, the next operation is allowed to begin before the entire lot is completed on the previous operation. This reduces the total manufacturing lead times because the second operation starts before the first operation finishes all the part in the order.

<table>
<thead>
<tr>
<th>Operation A</th>
<th>Operation B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup 1</td>
<td>Lot 1</td>
</tr>
<tr>
<td></td>
<td>Lot 2</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T : Transit Time.

<table>
<thead>
<tr>
<th>Setup 2</th>
<th>Lot 1</th>
<th>Lot 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Other Resources
Expediting.

- Overlapping vs. Lot Splits.
  
  • Lot Splits.
  
  The order is split into two or more lots and run on two or more machines simultaneously. If the lot is split in two, the run-time component of lead time is effectively cut in half, although an additional setup is incurred.

<table>
<thead>
<tr>
<th>Single Machine</th>
<th>2 Machine Operation Splitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup</td>
<td>Setup</td>
</tr>
<tr>
<td>Run</td>
<td>Run</td>
</tr>
</tbody>
</table>
Bottleneck Management.

- **Definition of Bottleneck.**
  
  - A bottleneck is defined as "a facility, function, department, or resource whose capacity is equal to or less than the demand placed upon it." Bottlenecks control the throughput of all products processed by them.

  - Some Bottleneck Principles.
    - The capacity of the system depends on the capacity of the bottleneck.
    - Using a non-bottleneck 100% of the time does not produce 100% utilization. Therefore, time saved at a non-bottleneck saves the system nothing.
    - For bottleneck management, capacity and priority must be considered together.
Bottleneck Management.

  1. Identify the bottlenecks
  2. Apply greatest efforts to improve capacity and adjust load
  3. Reduce queues at non bottleneck work center.
  4. Allow queues at bottlenecks: do not let them run out of work.
  5. Feed quality parts to bottlenecks: do not waste their time on bad parts.
     If necessary, inspect parts before the critical operations.
  6. Continue improvements until bottlenecks are relieved.
  7. Dedicate the same attention to other operations that become critical.
Operation Sequencing.

Dispatching.

- **Definition.**
  - Dispatching is a function of selecting and sequencing available jobs to be run at individual workcenters.
  - The information of dispatching list.
    1. Plant, department, and workcenter.
    2. Part number, shop order number, operation number, and operation description of jobs at the workcenter.
    3. Standard hours.
    4. Priority information.
    5. Jobs coming to the work center.
Operation Sequencing.

Dispatching.

- **Dispatching Rules.**
  - First come, first served (FCFS).
  - Earliest job due date (EDD).
  - Earliest operation due date (ODD).
  - Shortest process time (SPT).
  - Critical ratio (CR).

CR = \( \frac{\text{Due date} - \text{Present date}}{\text{Lead Time Remaining}} = \frac{\text{Actual Time Remaining}}{\text{Lead Time Remaining}} \)

<table>
<thead>
<tr>
<th>Job</th>
<th>Process Time(days)</th>
<th>Arrival Date</th>
<th>Due Date</th>
<th>Operation Due Date</th>
<th>Sequencing Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FCFS</td>
</tr>
<tr>
<td>A</td>
<td>4</td>
<td>223</td>
<td>245</td>
<td>233</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>224</td>
<td>242</td>
<td>239</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>231</td>
<td>240</td>
<td>240</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>219</td>
<td>243</td>
<td>242</td>
<td>1</td>
</tr>
</tbody>
</table>
Queuing Theory.

- General.

  - The queuing analysis, also referred to as waiting line analysis, addresses a phenomenon familiar to most people because they experience it regularly. Queueing systems can be classified either single channel queueing problems or multi-channel queueing problems. The term channel refers to the number of service stations.
The M/M/1/FCFS/$\infty$/$\infty$ model consists of a single-server, exponential service time distribution, infinite queue, and infinite calling population. In order to obtain information for the queueing problem represented by this model, we must find out the arrival rate($\lambda$) and the service rate($\mu$).

1. Average number of customer waiting in line : $L_q = \frac{\lambda^2}{\mu(\mu-\lambda)}$

2. Average number of customers in queueing system : $L_s = \frac{\lambda}{(\mu-\lambda)}$

3. Average waiting time before being served : $W_q = \frac{\lambda}{\mu(\mu-\lambda)}$

4. Average total time in system : $W_s = \frac{1}{(\mu-\lambda)}$

5. Probability of exactly $n$ customers in the queueing system :

$$P_n = \left(\frac{\lambda}{\mu}\right)^n \left(1 - \frac{\lambda}{\mu}\right)$$
Queuing Theory.

Example: \( \lambda = 6 \) per hour, \( \mu = 10 \) per hour.

1. \( L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{36}{40} = 0.90 \)

2. \( L_s = \frac{\lambda}{(\mu - \lambda)} = \frac{6}{4} = 1.50 \)

3. \( W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{6}{40} = 0.15 \text{ hrs} \)

4. \( W_s = \frac{1}{(\mu - \lambda)} = \frac{1}{4} = 0.25 \text{ hrs} \)

5. For \( n = 2 \), \( P_n = \left(\frac{\lambda}{\mu}\right)^n\left(1 - \frac{\lambda}{\mu}\right) = (0.6)^2(0.4) = 0.144 \)
Total Preventive Maintenance.

Definition.

- Total preventive maintenance (TPM) is that preventive maintenance plus continuous efforts to adapt, modify, and refine equipment to increase flexibility, reduce material handling, and promote continuous flows.
- It is operator-oriented maintenance with the involvement of all qualified employees in all maintenance activities.

Principles in TPM.

- Simplification: Keep only what is needed in the work area to perform the job.
- Organization: Everything is in its place and there is a place for everything.
- Cleanliness: Everything should be cleaned immediately after it is used.
- Discipline: Keep everything in its location and don't allow a casual "dropping" of tools.
- Participation: Everyone should clean and observe their own area.
1. Which of the following must production activity control do when planning the flow of work?
   A. Be sure the material and tooling needed are available.
   B. Advise the plant supervisor of future orders.
   C. Refer to the production plan for what orders to run.
   D. Complete a material requisition plan.

2. Which of the following is an element of manufacturing lead time?
   A. Design time.
   B. Delivery lead time.
   C. Setup time.
   D. Purchase lead time.
3. What is the name given to a scheduling system in which the last operation on a routing is scheduled first for completion on the due date?
   A. Forward scheduling.                B. Backward scheduling.
   C. Infinite scheduling.               D. Finite scheduling

4. Which of the following statements is MOST accurate?
   A. Work centers located after a bottleneck should work at full capacity.
   B. A time buffer should be established after a bottleneck.
   C. Work centers feeding a bottleneck should work at full capacity.
   D. A bottleneck will control the throughput of all products processed by it.
Performance Check.

5. Which of the following BEST describes a work center with actual output greater than planned output?
   A. Very good.                      B. Running ahead of schedule.
   C. Lacking capacity.               D. Short of material.

6. Which of the following describes finite loading?
   A. Plans how much capacity is needed.
   B. Calculates maximum resource requirements.
   C. Is performed at every level of the planning and control process.
   D. Limits load to available resources.
Performance Check.

7. Which of the following best describes mixed-model scheduling?
   A. Aims to produce some of every item every day.
   B. Randomly produces products.
   C. Produces some models for next year while making this year's models.
   D. All of the above.

8. The benefits of preventive and predictive maintenance is (are)
   I. Increased flexibility.
   II. Flow improvements.
   III. Reduced material handling.

   A. I, II         B. III         C. II, III         D. I, II, III
9. Dispatch lists
   A. May consider more than one factor to establish job sequences at a work center.
   B. Must be followed absolutely.
   C. Should be revised in 'real time.'
   D. Will not work for make-to-order products.

10. Which of the following are hurdles to effective shop floor control?
   I. Lack of valid due dates
   II. Lack of good management and measurement by shop managers
   III. Lack of valid data

   A. II     B. I, III    C. I, II, III     D. None of the above.
Performance Check.

Solutions.

1  2  3  4  5  6  7  8  9  10
A  C  B  D  B  D  A  D  A  C