

**Question 1**

It is required to find the capacity of the manufacturing system producing four products according to the data given in the accompanied table:-

| Product | Quantity/<br>year | No. of parts /<br>product | Average No. of<br>operation/part | Average process<br>time/operation, Min |
|---------|-------------------|---------------------------|----------------------------------|--|
| 1       | 1500              | 12                        | 5                                | 2.5                                    |
| 2       | 2500              | 15                        | 4                                | 1.5                                    |
| 3       | 4000              | 10                        | 7                                | 1                                      |
| 4       | 3000              | 10                        | 8                                | 2                                      |

**Question 2**

A manufacturing plant having 24 machines produces a part being processed through six machines in batch of 40 parts. 30 batches of parts are launched each week. Average operation time = 7 min., average setup time per machine = 5hr, non-operation time per machine = 12 hr, and scrap rate = 3%. Determine:-

- Manufacturing lead time.
- Plant capacity.
- Plant utilization.
- How would you expect the non-operation time to be affected by the plant utilization?
- The average WIP ratio in the plant

**Question 3**

A manufacturing plant having 30 machines produces a part being processed through six machines in batch of 35 parts. 40 batches of parts are launched each week. Average operation time = 8 min., average setup time per machine = 4hr, non-operation time per machine = 10 hr, and scrap rate = 3%. Determine:-

- Manufacturing lead-time.
- Plant capacity.
- Plant utilization.
- How would you expect the non-operation time to be affected by the plant utilization?
- The average WIP ratio in the plant

**Question 4**

A plant having 18 machines produces a part being processed through six machines in batch of 25 parts. 20 batches of parts are launched each week. Average operation time = 30 min., average setup time per machine = 5hr, non-operation time per machine = 12 hr, and scrap rate = 3%. Machine and labor cost = 80 SR/hr, raw material cost 300 SR/part, holding cost rate = 35%/year. **Determine:-**

- MLT, WIP, holding cost and part cost
- If the machines are replaced by CNC machines on which operation time = 15 min., setup time per machine = 8hr, and non-productive time per machine = 8hr, and scrap rate = 1%. Machine and operation cost = 150 SR/hr and material cost is the same. What is the number of CNC machines? Then determine MLT, WIP, holding cost and part cost.

**Question 5**

A manufacturing plant having 24 machines produces a part being processed through eight machines in batch of 140 parts. 3 batches are launched each week. Average operation time = 15 min/part, average setup time per batch per machine = 5hr and non-operation time per batch per machine = 10 hr. Determine: -

- Manufacturing lead-time.

- b) Plant capacity.
- c) Plant utilization. How would you expect the plant utilization to be affected by the non-operation time?
- d) The average WIP ratio in the plant
- e) Cost per piece, assuming material cost per piece = 400 SR, operation rate = 100 SR/hr, and non-operation cost = 40 SR/ machine operations.
- f) Holding cost, assuming hold cost rate (h) =30% per year.

**Question 6**

A manufacturing plant having 20 machines produces a part being processed through eight machines in batch of 100 parts. 4 batches are launched each week. Average operation time = 20 min/part, average setup time per batch per machine = 5hr and non-operation time per batch per machine = 8 hr. Determine: -

- a) Manufacturing lead-time.
- b) Plant capacity.
- c) Plant utilization. How would you expect the plant utilization to be affected by the non-operation time?
- d) The average WIP ratio in the plant
- e) Cost per piece, assuming material cost per piece = 250 SR, operation rate = 50 SR/hr, and non-operation cost = 25 SR/ machine operations.
- f) Holding cost, assuming hold cost rate (h) =30% per year.

**Question 7**

A plant contains 15 machines and produces two products according to the data given in table (1). Determine: -

- a. MLT for each product type.
- b. The plant capacity. Is this capacity meet production? If not suggest a solution.
- c. The utilization.
- d. The average WIP for each product type.

**Table (1)**

| Product type                          | P1                         | P2 |
|---------------------------------------|----------------------------|----|
| Number of order per month             | 10                         | 15 |
| Average quantity per order, units     | 30                         | 30 |
| Number of processes                   | 7                          | 9  |
| Average operating time, min           | 8                          | 7  |
| Non operation time per order, hr      | 5                          | 5  |
| Setup time per order, hr              | 5                          | 8  |
| Average mean time between failure, hr | 235                        |    |
| Average mean time to repair, hr       | 15                         |    |
| Plant Operation time                  | 10 hr / day, 6 days / week |    |

**Question 8**

A plant contains 20 machines and produces three products according to the data given in table (4). Machine and labor cost= 80 SR/hr, raw material cost 300 SR/part, holding cost rate = 35%/year

**A) Determine:**

- a) MLT for each product type.
- b) The plant capacity.
- c) The utilization.
- d) The average WIP for each product type.
- e) Products cost for each product type.
- f) Holding cost for each product type.

**Table (4)**

| Product type                                     | P1  | P2 |
|--|-----|----|
| Number of order per month                        | 30  | 40 |
| Average quantity per order, units                | 30  | 20 |
| Number of processes                              | 10  | 12 |
| Average operating time, min                      | 12  | 15 |
| Non operation time per order, hr                 | 5   | 8  |
| Setup time per order, hr                         | 5   | 8  |
| Average mean time between failure, hr            | 250 |    |
| Average mean time to repair, hr                  | 10  |    |
| Plant Operation time =10 hr / day, 6 days / week |     |    |

**B) Comment on your for each finding in (A)**

**Question 9**

A plant contains 20 machines and produces three products according to the data given in table (1).

Determine:

- MLT for each product type.
- The plant capacity. Is this capacity meet production? If not suggest a solution.
- The utilization.
- The average WIP for each product type.

Table (1)

| Product type                                     | P1  | P2 | P3 |
|--|-----|----|----|
| Number of order per month                        | 10  | 15 | 8  |
| Average quantity per order, units                | 20  | 15 | 25 |
| Number of processes                              | 7   | 9  | 10 |
| Average operating time, min                      | 8   | 7  | 10 |
| Non operation time per order, hr                 | 5   | 5  | 5  |
| Setup time per order, hr                         | 5   | 8  | 4  |
| Average mean time between failure, hr            | 250 |    |    |
| Average mean time to repair, hr                  | 10  |    |    |
| Plant Operation time =10 hr / day, 6 days / week |     |    |    |

**Question 10**

A plant contains 12 machines and produces three products according to the data given in table (1).

Determine: -

- MLT for each product type.
- The capacity of the plant. Is this capacity meet production? If not suggest a solution.
- The utilization.
- The average WIP for each product type

TABLE (1)

| Product type                           | P1                        | P2 | P3 |
|--|---------------------------|----|----|
| Number of order per month              | 5                         | 8  | 7  |
| Average quantity per order, units      | 25                        | 30 | 35 |
| Number of processes                    | 6                         | 7  | 8  |
| Average operating time, min            | 10                        | 8  | 9  |
| Non operation time per order, hr       | 5                         | 6  | 5  |
| Setup time per order, hr               | 3                         | 4  | 3  |
| Average mean time between failure , hr | 200                       |    |    |
| Average mean time to repair, hr        | 10                        |    |    |
| Plant Operation time                   | 8 hr / day, 6 days / week |    |    |

**Question 11**

A plant contains 24 machines and produces three products according to the data given in table (1).

Determine: -

- MLT for each product type.
- The capacity of the plant. Is this capacity meet production? If not suggest a solution.
- The utilization.
- The average WIP for each product type.

TABLE (1)

| Product type                           | P1                        | P2 | P3 |
|--|---------------------------|----|----|
| Number of order per month              | 7                         | 10 | 8  |
| Average quantity per order, units      | 40                        | 20 | 30 |
| Number of processes                    | 6                         | 10 | 8  |
| Average operating time, min            | 15                        | 10 | 12 |
| Non operation time per order, hr       | 5                         | 4  | 6  |
| Setup time per order, hr               | 4                         | 3  | 5  |
| Average mean time between failure , hr | 300                       |    |    |
| Average mean time to repair, hr        | 30                        |    |    |
| Plant Operation time                   | 8 hr / day, 6 days / week |    |    |

**Question 12**

A plant contains 20 machines and produces three products according to the data given in table (1).

Determine: -

- MLT for each product type.
- The capacity of the plant. Is this capacity meet production? If not suggest a solution.
- The utilization.
- The average WIP for each product type

TABLE (1)

| Product type                           | P1                        | P2 | P3 |
|--|---------------------------|----|----|
| Number of order per month              | 10                        | 12 | 15 |
| Average quantity per order, units      | 25                        | 30 | 20 |
| Number of processes, n                 | 6                         | 8  | 6  |
| Average operating time, min            | 10                        | 8  | 10 |
| Non operation time per order, hr       | 6                         | 7  | 5  |
| Setup time per order, hr               | 3                         | 4  | 4  |
| Average mean time between failure , hr | 250                       |    |    |
| Average mean time to repair, hr        | 20                        |    |    |
| Plant Operation time                   | 8 hr / day, 6 days / week |    |    |

**Question 13**

A plant contains 18 machines and produces three products according to the data given in table (1). **Determine: -**

1. MLT for each product type.
2. The capacity of the plant. Is this capacity meet production? If not suggest a solution.
3. The utilization.
4. The average WIP for each product type.

**TABLE (1)**

| Product type                           | P1                        | P2 | P3 |
|--|---------------------------|----|----|
| Number of order per month              | 4                         | 6  | 8  |
| Average quantity per order, units      | 35                        | 30 | 25 |
| Number of processes, n                 | 6                         | 6  | 8  |
| Average operating time, min            | 12                        | 15 | 10 |
| Non operation time per order, hr       | 5                         | 5  | 5  |
| Setup time per order, hr               | 4                         | 3  | 4  |
| Average mean time between failure , hr | 250                       |    |    |
| Average mean time to repair, hr        | 20                        |    |    |
| Plant Operation time                   | 8 hr / day, 6 days / week |    |    |

**Question 14**

A plant contains 15 machines and produces four products according to the data given in table (1). **Determine: -**

- e. MLT for each product type.
- f. The plant capacity. Is this capacity meet production? If not suggest a solution.
- g. The utilization.
- h. The average WIP for each product type

**TABLE (1)**

| Product type                          | P1                         | P2 | P3 | P4 |
|---------------------------------------|----------------------------|----|----|----|
| Number of order per month             | 5                          | 8  | 7  | 6  |
| Average quantity per order, units     | 25                         | 30 | 25 | 30 |
| Number of processes, n                | 8                          | 9  | 7  | 6  |
| Average operating time, min           | 8                          | 7  | 10 | 12 |
| Non operation time per order, hr      | 5                          | 5  | 5  | 5  |
| Setup time per order, hr              | 3                          | 4  | 3  | 4  |
| Average mean time between failure, hr | 235                        |    |    |    |
| Average mean time to repair, hr       | 15                         |    |    |    |
| Plant Operation time                  | 10 hr / day, 6 days / week |    |    |    |

**Question 15**

A plant contains 12 machines and produces 4 products according to the data given in table (2). **Determine: -**

1. MLT for each product type and system.
2. The capacity of the plant. Is this capacity meet production? If not suggest a solution.
3. The utilization through 12 machines.
4. The average WIP for each product type.

**Table (2)**

| Product type                          | P1                        | P2 | P3 | P4 |
|---------------------------------------|---------------------------|----|----|----|
| Number of order per month             | 15                        | 10 | 5  | 7  |
| Average quantity per order, units     | 50                        | 60 | 40 | 25 |
| Number of processes                   | 6                         | 7  | 8  | 9  |
| Average operating time, min           | 10                        | 8  | 12 | 9  |
| Non operation time per order, hr      | 5                         | 6  | 3  | 5  |
| Setup time per order, hr              | 3                         | 4  | 2  | 3  |
| Average mean time between failure, hr | 200                       |    |    |    |
| Average mean time to repair, hr       | 10                        |    |    |    |
| Plant Operation                       | 10 hr / day, 5 days /week |    |    |    |

**Question 16**

A manufacturing plant contains 15 machines and produces four products according to the data given in table (1). **Determine: -**

- a. MLT for each product type.
- b. Average MLT of the plant.
- c. The plant capacity. Is this capacity meet production? If not suggest a solution.
- d. The plant utilization.
- e. WIP for each product type.
- f. Average WIP for the plant
- g. Cost for each product type
- h. Average holding cost.

**TABLE (1)**

| Product type                          | P1                      | P2  | P3  | P4  |
|---------------------------------------|-------------------------|-----|-----|-----|
| Number of order per month             | 15                      | 10  | 10  | 15  |
| Average quantity per order, units     | 50                      | 60  | 60  | 50  |
| Number of processes                   | 8                       | 9   | 7   | 6   |
| Average operating time, min           | 8                       | 7   | 10  | 12  |
| Non operation time per order, hr      | 5                       | 5   | 5   | 5   |
| Setup time per order, hr              | 3                       | 4   | 3   | 4   |
| Average mean time between failure, hr | 235                     |     |     |     |
| Average mean time to repair, hr       | 15                      |     |     |     |
| scrap %                               | 3                       | 3   | 3   | 3   |
| Material Cost, SR/part                | 110                     | 140 | 120 | 150 |
| Machine and operation cost, SR. hr    | 50                      |     |     |     |
| holding cost rate, %/year             | 35                      |     |     |     |
| Plant Operation time                  | 10 hr/day, 6 days/ week |     |     |     |

|   |   |   |
|---|---|---|
| $Q_a = \frac{\sum_{j=1}^{N_p} Q_j \times N_j}{\sum_{j=1}^{N_p} N_j} \quad [A.1]$ <p>where;<br/> <math>Q_a</math> = Average Batch Size<br/> <math>Q_j</math> = Average Batch Size for product <math>j</math>,<br/> <math>N_j</math> = Number of batch<br/> <math>n_p</math> = Number of Products</p> | $T_{oa} = \frac{\sum_{j=1}^{N_p} T_{oj} \times (Q_j N_j) \times n_{oj}}{\sum_{j=1}^{N_p} (Q_j N_j) \times n_{oj}} \quad [A.3]$ <p>where;<br/> <math>T_{oa}</math> = Average Operation Time<br/> <math>T_{oj}</math> = Average Operation Time for Batch <math>j</math></p> | $T_{noa} = \frac{\sum_{j=1}^{N_p} n_{oj} \times N_j \times T_{noj}}{\sum_{j=1}^{N_p} n_{oj} \times N_j} \quad [A.5]$ <p>where;<br/> <math>T_{noa}</math> = Average Non productive Time<br/> <math>T_{noj}</math> = Average Non productive Time for Batch <math>j</math></p> |
| $n_{oa} = \frac{\sum_{j=1}^{n_p} n_{oj} \times Q_j \times N_j}{\sum_{j=1}^{n_p} Q_j \times N_j} \quad [A.2]$ <p>where;<br/> <math>n_{oa}</math> = Average Number of Operations<br/> <math>n_{oj}</math> = Average Number of Operations for Batch <math>j</math></p>                                 | $T_{sua} = \frac{\sum_{j=1}^{N_p} n_{oj} \times N_j \times T_{suj}}{\sum_{j=1}^{N_p} n_{oj} \times N_j} \quad [A.4]$ <p>where;<br/> <math>T_{sua}</math> = Average Setup Time<br/> <math>T_{suj}</math> = Average Setup Time for Batch <math>j</math></p>                 |   |

**Question 17**

A manufacturing plant having 24 conventional machines produces a part being processed through six machines in batch of 30 parts. 20 batches of parts are launched each week. Average operation time = 30 min., average setup time per machine = 5hr, non-operation time per machine = 12 hr, and scrap rate =3%. Determine:-

- MLT, PC, U, WIP
- How would you expect the non-operation time to be affected by the plant utilization?
- If the machines are replaced by CNC machines on which operation time = 15 min., setup time per machine =8hr, and non-productive time per machine =10hr. What is the number of CNC machines? Then determine MLT, PC, U, WIP

**Table (1)**

| Product type                            | Conventional M/c          | CNC** M/c |
|---|---------------------------|-----------|
| Number of batch per week, N             | 20                        | 20        |
| Average quantity per batch, units, Q    | 30                        | 30        |
| Number of processes, n                  | 6                         | 6         |
| Average operating time/process, min ,To | 30                        | 15        |
| Non operation time per batch, hr, Tno   | 12                        | 10        |
| Setup time per batch, hr, Tsu           | 5                         | 8         |
| scrap %                                 | 3                         | 0         |
| Plant Operation time                    | 8 hr / day, 5 days / week |           |

\*\* Assume all processes are done in one set up

**Question 18**

- A plant having 18 machines produces a part being processed through six machines according data given in table (2). **Determine:-** MLT, WIP, holding cost and part cost.
- If the machines are replaced by CNC machines, what is the number of CNC machines? Then determine MLT, WIP, holding cost and part cost.

Table (2)

|  |      |      |
|--|------|------|
| Product type   | M/Cs | CNC* |
| Number of batch per week ,N  | 20   | 20   |
| Average quantity per batch, units,Q                                | 30   | 30   |
| Number of processes,n  | 6    | 6    |
| Average operating time, min ,To                                    | 30   | 15   |
| Non operation time per bach, hr,Tno                                | 12   | 8    |
| Setup time per batch, hr,Tsu                                       | 5    | 8    |
| scrap %  | 3    | 1    |
| Material Cost, SR/part   | 300  | 300  |
| Machine and operation cost, SR.hr                                  | 80   | 150  |
| holding cost rate, %/year  | 35   |      |
| Plant Operation time; 8 hr / day, 5 days / week                    |      |      |
| * all operations are carried out a CNC machine with the same setup |      |      |

**Question 19**

- a) A plant having 30 conventional machines produces two parts according data given in table (1). **Determine** Plant MLT, WIP, part cost and holding cost.
- b) If the machines are to be replaced by CNC machines and operation data given in table (1). What is the number of CNC machines? Then determine Plant MLT, WIP, part cost and holding cost.

Table (1) Operation data

| Plant machines   | Existing M/Cs |        | Proposed CNC* |        |
|--|---------------|--------|---------------|--------|
| Product type   | Part 1        | Part 2 | Part 1        | Part 2 |
| Number of batch per week ,N  | 10            | 10     | 10            | 10     |
| Average quantity per batch, units, Q                               | 30            | 40     | 30            | 40     |
| Number of processes, n   | 8             | 10     | 8             | 10     |
| Average operating time, min ,To                                    | 18            | 12     | 10            | 8      |
| Average Setup time per batch, hr, Tsu                              | 3             | 4      | 4             | 5      |
| Average Non operation time per batch, hr, Tno                      | 4             | 4      | 2             | 2      |
| Scrap %  | 3             | 3      | 1             | 1      |
| Mean time between failure, MTBF, min                               | 500           | 500    | 600           | 600    |
| Mean time to repair, MTTR, min                                     | 50            | 50     | 60            | 60     |
| Material Cost, SR/part   | 200           | 300    | 200           | 300    |
| Machine and operation cost, SR. hr                                 | 80            | 80     | 150           | 150    |
| Holding cost rate, %/year  | 35            |        | 35            |        |
| Plant Operation time; 10 hr / day, 6 days / week                   |               |        |               |        |
| * all operations are carried out a CNC machine with the same setup |               |        |               |        |

**Question 20**

- A) A plant having 30 machines produces two parts according data given in table (1). **Determine** the average Plant MLT, WIP, part cost and holding cost.
- B) If the machines are to be replaced by CNC machines and operation data given in table (1). What is the number of CNC machines? Then determine average Plant MLT, WIP, part cost and holding cost.

**Table (1)** Operation data

| Plant machines   | Existing M/Cs |        | Proposed CNC* |        |
|--|---------------|--------|---------------|--------|
| Product type   | Part 1        | Part 2 | Part 1        | Part 2 |
| Number of batch per week ,N  | 6             | 8      | 6             | 8      |
| Average quantity per batch, units, Q                               | 15            | 20     | 15            | 20     |
| Number of processes, n   | 5             | 7      | 5             | 7      |
| Average operating time, min ,To                                    | 20            | 12     | 8             | 7      |
| Average Setup time per batch, hr, Tsu                              | 3             | 4      | 4             | 5      |
| Average Non operation time per batch, hr, Tno                      | 4             | 4      | 2             | 2      |
| scrap %  | 3             | 3      | 1             | 1      |
| Material Cost, SR/part   | 200           | 300    | 200           | 300    |
| Machine and operation cost, SR. hr                                 | 80            | 80     | 150           | 150    |
| holding cost rate, %/year  | 35            |        | 35            |        |
| Plant Operation time; 8 hr / day, 6 days / week                    |               |        |               |        |
| * all operations are carried out a CNC machine with the same setup |               |        |               |        |

**Question 21**

- A) What are the principles, which are to be considered when developing manufacturing system laws?
- B) Discuss briefly the decision framework requirement for manufacturing system.
- C) Point out the principles of manufacturing systems. Discuss briefly, how these principles are the mild stone for designing manufacturing system?
- D) Point out the automation strategies.
- E) What are the factors taken into considerations when automating manufacturing system?
- F) Discuss briefly the mathematical models for performance measures which used to design and evaluate manufacturing system.
- G) Define: MLT, PC, U, and WIP.
- H) Explain briefly how WIP and MLT cost can be evaluated.
- I) What is meant by complexity function? Drives the equation for determine complexity function.