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Course Provider: University of Wales Trinity St. David
Module: Manufacturing Systems and Simulation
Date: 05/11/2021
Time: 14:00-16:00

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Question 1

Annual Demand = 55,000/unit annual (D)

production rate = ~~4,200/month~~ 4,200/month (p)

demand = 3,500/month (d)

ordering cost = £350 (C_o)

holding cost = £12/unit (C_H)

$$a) \text{ economic production quantity} = \sqrt{\frac{2 \times C_o \times D}{C_H \times \left(1 - \frac{d}{p}\right)}}$$

$$\sqrt{\frac{2 \times 350 \times 55000}{12 \times \left(1 - \frac{3500}{4200}\right)}} = 4,387.48$$

$$\text{Economic production quantity} = \boxed{4,388}$$

(2)

a)

$$\text{Total annual cost} = \left[\frac{Q}{2} \times C_H \right] + \left[\frac{D}{Q} \times C_o \right]$$

$$Q = 4,388$$

$$C_H = 12$$

$$D = 55,000$$

$$C_o = 350$$

$$\left[\frac{4,388}{2} \times 12 \right] + \left[\frac{55,000}{4,388} \times 350 \right]$$

$$= 30,714.96445$$

$$\text{total annual cost} = \boxed{\pounds 30,714.96}$$

b) Companies often decide to complete orders ahead of time for a number of reasons such as meeting future demand peaks, ensuring that due dates are met ~~for~~ for customers that order in advance and also to level out capacity requirements.

A major factor influencing the decision of what inventory to hold is whether a company selects a; Make to order, assemble to order or make to stock.

• Make to orders are often special products, and this response ~~means~~ means that the inventory will not be held (as part or fully finished items). Instead, the materials to make that item will be stored.

②

• Assemble to order businesses partly finish a product in advance and then complete it upon receipt of their order. The part completion stage reflects on the associated value of inventory and reduces lead times. (3)

• Make-to-stock businesses complete or purchase items ahead of time and then meet orders from the inventory.

Factors that affect how much stock to order and when are listed below:

- Demand forecasts and scheduling
- Reorder points
- Buffer inventory
- Service levels

The level of service in an organisation aims to maintain and establish a reasonable level of buffer inventory to yield acceptable service.

Service level = $\frac{\text{Customers served without delay}}{\text{total orders received}}$

To approach this requirement from the opposite perspective, companies can determine the risk of a stock out they are prepared to accept. This is known as the 'protection level' and is written as:

$$100 \times (1 - \text{probability of a stock out})$$

(14)
The ABC classification is often used to establish what items to keep in stock. It sorts inventory into groups dependant on how much annual expenditure they incur which depend on the estimated number of items used annually multiplied by unit cost.

Using the Pareto rule:

- 10-20% of the items account for 60-80% of expenditure. (A items to be controlled closely)
- The next 20-30% of items which require fewer inventory levels than A items, are known as B items.
- The last 50-70% items are C items that account for less than 25% of the total expenditure.

c) Costs associated with holding ~~stock~~ inventory:

- Fixed or percentage of order costs can be applied when placing the order.
- Price discount cost can be applied depending on order quantity.
- If urgent stock is needed, stockout costs can be charged.
- Storage costs are often applied to hold stock.

- ⑤
- Working capital costs can be charged
 - Obsolescence costs where reduction in the utility of an inventory item is seen.
 - Production inefficiencies will incur costs where more stock than usual is used to compensate.

Question 2

Shift = 10h - 1h of breaks shift = 540min.

downtime = 30mins run time = 510min

Cycle time = 110 pieces/min

37,600 pieces made 380 rejected.

a)
$$\text{availability} = \frac{\text{operating time}}{\text{planned production time}}$$

$$\frac{540 - 30}{540} = \boxed{0.94}$$

$$\text{performance} = \frac{\text{total pieces} - \text{operating time}}{\text{run rate}}$$

$$\frac{37,600 \div 510}{110} = \boxed{0.67}$$

$$\text{quantity} = \frac{\text{good pieces made}}{\text{total pieces made}}$$

$$\frac{37600 - 380}{37600} = \boxed{0.99}$$

$$\text{OEE} = \text{availability} \times \text{performance} \times \text{quality}$$

$$0.94 \quad \times \quad 0.67 \quad \times \quad 0.99$$

$$\text{OEE} = \boxed{0.62} \quad \text{or} \quad 62\%$$

b) 4/6 of the big losses explained:

Breakdowns

A breakdown is a downtime loss where ~~equipment~~ equipment is not in use due to an issue. For example unplanned maintenance is needed to replace a tooling failure or ~~also~~ identify a fault causing the equipment to fail completely.

Running an operation at reduced speed.

This will lose speed of an operation, reducing a machines performance. This is done sometimes start up a production line during a 'rough run' or to work with equipment wear. Sometimes it could be due to operator inefficiency.

Start-up Rejects

(7)

When machines are starting, rejects can be produced as a result of incorrect assembly and process damages that have not been identified. As a result quality is lost and the product has to be reworked or even scrapped.

Small Stops

Another loss of speed is accounted for by small stops. Small stops may be needed for cleaning and/or checking, unjamming components and unblocking sensors.

c) Five benefits of planned maintenance:

- Carrying out planned maintenance pro-long's the life of equipment through identifying faults early + rectifying them. It also prevents issues from arising, for example corrosion and stiffening of parts.
- It increases the reliability of equipment as the chance of failure is significantly lower. By checking and replacing damaged parts before they get too bad, your equipment is more reliable.
- The safety aspects are improved, carrying out planned maintenance provides the opportunity to identify hazards early. (before anyone is put at risk).

- (8)
- The machine/equipment will produce a higher quality product ~~in~~ if maintained correctly. less rejects will be produced if all components are looked after.
 - Lower operating costs will be seen if planned maintenance is carried out. less engineer call-outs, less reworks and less down-time will lower operational costs.

Question 4

a) Value stream mapping is an essential tool for process improvement because:

- It helps to visualise more than a single-process level.
- It helps to identify waste within a process, determining the sources of waste.
- It provides a universal language for talking about manufacturing processes.
- It makes decisions about the flow apparent so they can be discussed.
- It ties together lean concepts and methods to avoid cherry picking.
- It forms the basis of an implementation plan.

- (9)
- It helps with designing a flow of door-to-door operation to become a blue print of lean implementation.
 - It shows the linkage between information flow and material flow.
 - It's more useful than quantitative tools that only create a tally of non-value adding steps.
 - It's a ~~quantitative~~ qualitative tool to describe in detail how a facility should flow.
 - The numbers are good for creating a sense of urgency or as before/after measures.
 - It's good to describe what you're actually going to do to affect those numbers.

b) How to create a value stream map step-by-step.

1. Begin by considering customer requirements.
2. The customer's assembly plant will be represented by a factory icon in the upper right-hand corner of the map.
3. Underneath this icon, a data box will be drawn with the requirements of the assembly plant customer.

Customer
Assembly
Plant

Number of
components/
unit of time
Shift patterns

4. Next, a process box is drawn to represent a basic production process.
5. A process box shows in which that material flows. Indicating one area of material flow, continuously ideally.
6. The process box stops wherever processes are disconnected and the material flow stops.
(for example, one assembly with several workstations that are connect would be drawn as one process box.)
7. If one assembly has disconnected workstations then more than one process box needs to be drawn.

(10)

8. Material flow is drawn from left to right on the bottom half of the map, in the order of processing steps, not according to the physical layout of the plant.

9. As you walk this flow on the shop floor, you will need to collect data that is important for deciding the future state.

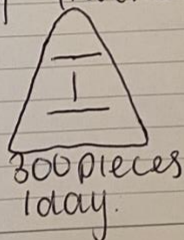
10. A data box is drawn under each process box to record this.

11. After mapping several current and future states you will know instinctively what process information you'll need.

12. As you walk the product's material flow, you'll find places where inventory accumulates.

13. These points are ~~very~~ important to draw on the current state map because they tell you where the flow is stopping.

14. We use a 'warning triangle' icon to capture the location and amount of inventory.



(11)

(12)

15. A truck icon and broad arrow indicate movement of finished goods to the customer.
16. At the other end of the map, represent the supplier with another factory icon. Use the same truck icon and broad arrow to show movement of material from the supplier to manufacturer.
17. ~~Do~~ Do not map every purchased part in your product family. Just draw the flow for 1 or 2 main raw materials.
18. The second aspect of our value-strain map is the information flow. To do this more icons and arrows are needed, in particular a narrow line to show information flow.
19. This line is modified with a lightening like line, when the information flows electronically.
20. A small box icon or node is used to label or describe different information flow arrows.

←
manual
information
flow

←
electronic
information
flow.

(13)

21. Information flow is drawn from right to left in the top half of the map space.
22. Notice there are separate lines for the forecasts and daily orders as these are different information flows.
23. The production control department is drawn with a process box.