ANSWER MODEL EXAM PRODUCTION PLANNING & QUALITY CONTROL

Question 1: Generic topics (50 points)

(a) What are (1) the main advantage, and (ii) the main disadvantage of the Shortest Processing Time rule compared to the Earliest Due Date priority rule? (5 points)

Advantage: more orders are processed

Disadvantage: there could be more jobs with a due date violation

(b) Which of the following situations can handle a change in the product mix the best? Explain why. (i) Process Layout; (ii) Pull Production; (iii) Cellular Manufacturing; (iv) Product Layout (5 points)

Process Layout, because it is much easier to create products that need their operations in a different sequence.

(c) Explain why Cellular Manufacturing could lead to lower efficiency. (5 points)

Machines might need to be duplicated to avoid interdependencies between cells, which leads to lower utilization of capacity.

(d) In which of the following is setup time reduction most important? Explain why. (i) Job Shop; (ii) Production line using pull production; (iii) Production line using line balancing; (iv) Manufacturing cell. (5 points)

Although reducing setup time is good to do in all situations, it is especially important in Pull Production. The reason is there you can have product variety, you can't schedule beforehand, and you prefer the buffers between the workstations to be small. Having time consuming setups would make the system throughput unpredictable.

(e) In their article, Sugimori et al. (1977) argue that "virtually most of the stock on hand is the result of 'over-producing' more than the amount required, and is the worst waste that can raise the production cost". What is the most common reason to over-produce in manufacturing organizations? (5 points)

Batching to reduce average setup time, without having actual orders.

The question is on ‘over-producing’. Creating inventory to buffer for demand fluctuations is not over-producing, because this is a sensible decision to reduce lead time for your customers.

(f) Which of the following theories explains best the *interpersonal role* of planners? Explain why. (i) The Resource Based View; (ii) Manufacturing Strategy; (iii) Lean Production; (iv) The planning performance criteria framework. (5 points)

Best answer: the Resource Based view, because this role is not part of the official task of a planner, so it is not part of theoretical models for planning.

Also acceptable as answer: referring to the process factors in the planning performance criteria framework.

(g) A manufacturer produces 400 units of product X per day of 8 hours. They use a two-card pull system. Each product X needs two components A, one component B, and three components C. The container size of component C is 40 pieces. Transportation of a full container of C takes 30 minutes. Transportation of the conveyance card itself takes 5 minutes, and the combined waiting time of the conveyance card (upstream and downstream) is 60 minutes. Total waiting time for the production card of C is 1 hour. Production of C takes 5 minutes per piece. Setting up the machines to produce a batch of component C takes on average 30 minutes. The organization uses a 15% safety factor. How many *production* Kanbans are needed for component C? (7 points)

LT = 5 x 40 + 30 + 60 = 290, which is 290 / (8*60) = 0.6 day

Safety factor = 1.15

(3 * 400 * 0.6 * 1.15) / 40 = 20.7, so 21 Production Kanban cards

Every mistake: -2 points

(h) Describe, in terms of competitive priorities, what IoT could mean for a bicycle manufacturer. You can address both the production process and the product. Illustrate your answer(s) with examples. (7 points)

Many options in the answer possible, e.g.,

- Product: finding a lost bike, theft detection, indicating preventive maintenance of your bike is needed on your smartphone
- Process: machines that communicate preventive maintenance is needed, tracking and tracing of parts and products in the supply chain.

Other answers are possible, however, IoT is about Internet of Things, so answers must relate to the ability of products/parts/machines to communicate. Generic Smart Manufacturing advantages without relating to communication do not get points.

(i) Explain, using the article of Gino and Pisano (2008), which behavioral factor(s) contribute(s) to algorithm aversion. (6 points)

Overconfidence: "People's tendency to be more confident in their own behaviors, opinions, attributes, and physical characteristics than they ought to be." Other biases can also be mentioned if applicable and explained.

Question 2: Case (50 points)

c. Consider the case description of the A3 assignment (Eden 3D printers). The case description was sent to you previously and is appended to this exam. Propose a suitable and contemporary *planning, scheduling, and control approach* for Eden. This includes, for example, whether and for what parts of the production process the company should use line balancing, cellular manufacturing, scheduling, pull production, etc. In your design, include principles from lean production, behavioral operations, and, when appropriate, smart manufacturing.

Structure your proposal with the following steps:

(i) Write down the characteristics of the production process that you include in your reasoning.
(ii) Write down which problems indicated in the case text (section 'waste is everywhere') can be influenced by the organization of the planning, scheduling, and control processes.
(iii) Classify the case in the product/process matrix. Note that you may also consider subsystems within the company's processes that can be classified independently.
(iv) Argue, using your answers on (i), (ii), and (iii), which approach fits best. If your proposal includes multiple approaches (e.g., for different departments, or for different hierarchical levels), make sure to clearly mention which approach is used for what part, and how they can be coordinated or synchronized.

Notes:
- Make sure you use the course literature.
- In your answers, consider both the outcome of the quick scan and the stated goals.
- The focus here is on the organization of planning and scheduling. So problems/goals that cannot be influenced by planning/scheduling, do not have to be addressed.
- Making assumptions is allowed, but please mention them explicitly.

(i)
- The 5 least expensive types (prices up to 20k dollar; about 90 percent of the printers sold) are produced to stock. Printers in the higher price range are produced to order.
- Parts are either purchased or JIT produced. Time to print all elements for one printer is between 15 and 25 hours.
- Several stages in a unidirectional flow: pre-assembly, final assembly, software installation, testing, packaging, shipping.
- Variety in assembly task times depending on the complexity of the machine.
- Long throughput times relative to task times.

(ii)

- Late deliveries
- Because of the problems with the externally supplied parts, last minutes changes in the production schedule are made.
- To not leave staff and resources unutilized (the pressure on upscaling is high), 3D printers are produced based on what materials and parts are available, rather than on the actual production planning. This results in unbalanced finished stock levels and rush orders.
- Production of the more expensive types of printers often gets priority over the cheaper types, thus interrupting production plans for the cheaper types.
- Problems are not communicated throughout the different parts of the production process. Downstream processes for example are often unaware of the reasons for delay. When defects or problems arise, the parts are sent back to the responsible process which interferes with the production planning and causes further delays.
- The value of WIP in (sub-)assembly is very high.
- During inspection one out of ten printers does not pass the test. This results in interruptions in production due to rework.
- Operators of Assembly have serious problems coping with the increased workload and are therefore often lagging behind. To avoid other operators having to wait, they have to work overtime.

(iii)

At the higher level, this is a flow shop. Each smaller department itself could be organized differently; there is not much in the text about that. Product variety is limited; only printers are made. Product volume is not really high (yet) but they would like to grow. Processes are repeated and not really intermittent. The expensive models are produced to order, but not engineered to order. So this has characteristics of mass production.

Batch production could also be an acceptable answer if the student refers to the text at the top of the assignment (“short runs and prototyping”) and the remark that “Engineers are used to continuously improve and adapt the design of the printers to individual customer needs.”

(iv): depends very much on the choice of the student.

At the top of the case it is mentioned that the company wishes to move their 3D printers for the mid-segment from short runs and prototyping toward higher production and mass manufacturing.

The questions may be answered both from the perspective of the current situation, and from the perspective of the ‘new situation’.

Generic answers in which the relation with planning/scheduling is not clear, do not get points.

---- End of the exam ----

Case Description Question 2 - Eden 3D Printers

Introduction

Eden 3D Printers develops and produces industrial 3D printers. The US-based company recently acquired a 25-million-dollar funding to move their 3D printers for the mid-segment from short runs and prototyping toward higher production and mass manufacturing. That segment, between the hobbyist and the major manufacturers already using 3D printers in their lines (printers ranging from 5k to 100k dollar), is enormous. 3D printing is globally accepted as the next industrial revolution, and there are a lot of new entrants fighting for a spot on top of the wave. With their strong R&D track-record, Eden has convinced a group of investors that they have a good chance to become market-leader in this branch.

Background information

The mid-segment 3D printers of Eden have won awards for printing capabilities, design and user-friendliness. The strength of the printed object is stronger due to the specific type of layering that is used and by the chopped carbon fiber that is added to the nylon thermoplastic. The built-in quality scanner detects deficiencies in the printed object and corrects them at the same time. The mid-segment printers are available in 8 different models, with speed and size being the main differentiators. The 5 least expensive types (prices up to 20k dollar; about 90 percent of the printers sold) are produced to stock. Printers in the higher price range are produced to order.

Production processes of the printer:

The processes required for production of the printer are:

(a) Supply of raw materials and detailed parts: these are either purchased from external suppliers (China and US) and delivered to the central warehouse, or 3D printed by Eden. Externally purchased parts and materials are delivered to the shop floor by the warehouse-personnel, and are planned and controlled with a reorder point method. The 3D printed parts are JIT produced. Time to print all elements for one printer is between 15 and 25 hours.
(b) The hot-end printer head, print slide and the printer frame (including movable elements) are pre-assembled in the sub-assembly phase and subsequently delivered to the next step in the process.
(c) The final assembly consists of 4 parts:
   - Installing hot-end printer head in printer frame
   - Installing (removable) printer sliding plate
   - Installing and connecting electrical wiring
   - Adding thermoplastic supply mechanism (including thermoplastic)
   - Install aluminum casing, including a hinged see-through protective cover at the front
(d) Software installation
(e) Testing of the machine
(f) After packaging the machine is placed in the final goods inventory, awaiting delivery

(g) Paperwork and shipping (within US 2 weeks delivery time to the customer, outside US up to 5 weeks)

Note 1: Approximately 35% of the total cost is through purchasing (buy), the other 65% is Eden production (make).

Note 2: Processes (b) and (c) each take 4 hours (could be longer or shorter, depending on the complexity of the machine). The combined throughput time of these two processes is one week. The production throughput time of all processes combined is approximately 2 weeks.

Problem background

The 3D printer market has developed quickly over the past ten years, and is expected to boom in the next ten years. Until 2030 the industrial market for 3D printers and related products is expected to grow to close to 25 billion dollars. As a result, Eden 3D is forced to broaden their focus from technology development to also being able to produce quickly, in higher volumes and at a consistently high quality. Thinking in terms of efficient production is not a default state of mind of the current engineers, who are used to continuously improve and adapt the design of the printers to individual customer needs.

Another consequence of the booming market, is the rapid rise in competition, driving prices down. It is very clear to the investors that Eden has to improve their production capabilities fast. The competition does not sit still, and in the current market you are either in or out.

Objectives

You, a team of two Manufacturing Operations Consultants from the main private investor, are sent to Eden with the following assignment: to advise the management of Eden as to how to scale production up, while at the same time achieving the following objectives:

- To reduce the total costs per printer by 20%
- To decrease the throughput time per printer with 25%
- To realize a high, constant level of quality
- This must be accomplished within 3 months

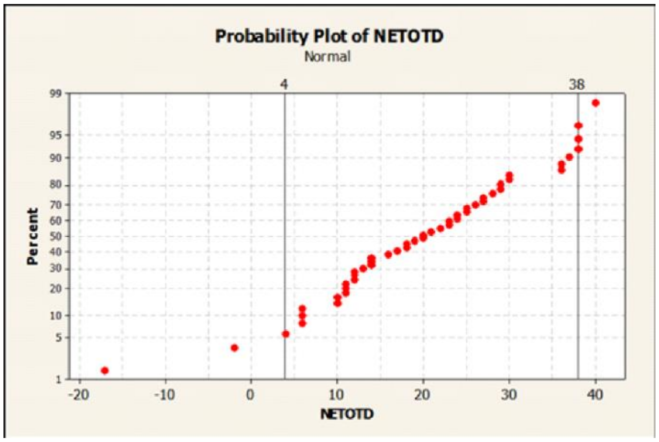
Quick scan

Knowing the pressure that is on this project, and the increase in production capabilities that is expected, it is of utmost importance to have an overview of the as-is situation as soon as possible. Therefore, you start with a *quick scan,* during which you investigate the processes to understand them better, and to try and find any *waste* (and thus potential areas for improvement). After this you will come up with a detailed action plan.

Waste is everywhere:

From the quick scan you were able to obtain the following picture:

- A large part of the detailed parts is delivered too late to the central warehouse. The supply chain is not delivering reliably. Beneath a figure of a supply chain of parts delivered to the central warehouse. Horizontal: days delivered too early (negative numbers) or too late (positive numbers). Vertical: accumulated the days OTD (On Time Delivery) in %.



- On top of that is the unexpectedly high level of quality issues in the externally supplied parts. This leads to rework & scrap.
- Because of the problems with the externally supplied parts, last minutes changes in the production schedule are made. To avoid in that case to first having to wait for the corresponding self-printed parts to be printed, a selection of frequently used self-printed parts is kept in stock.
- Engineers keep tweaking the specifications of self-printed 3D parts. Operators are not always aware of the latest changes, resulting in off-spec parts being printed.
- To not leave staff and resources unutilized (the pressure on upscaling is high), 3D printers are rather produced based on what materials and parts are available, than on the actual production planning. This results in unbalanced finished stock levels and rush orders.
- Production of the more expensive types of printers often gets priority over the cheaper types, thus interrupting production plans for the cheaper types.
- A lot of time is wasted on small quality problems in assembly such as wrongly drilled holes and incorrect cabling.
- Problems are not communicated throughout the different parts of the production process. Downstream processes for example are often unaware of the reasons for delay. When defects or problems arise, the parts are sent back to the responsible process which interferes with the production planning and causes further delays.
- The value of WIP in (sub-)assembly is very high.
- Operators on the (sub-)assembly shop floor are often searching for the right parts and tools.
- Operators that cannot find the right tool sometimes use a generic tool with which they damage the product (e.g., bolts and screws)
- During inspection one out of ten printers does not pass the test. This results in interruptions in production due to rework.
- Operators of Assembly have serious problems coping with the increased workload and are therefore often lagging behind. To avoid other operators having to wait, they have to work overtime.

- The team leader is everywhere, but not on the shop floor with his team. He is running for information, parts, the right support from staff-departments, etcetera. Support for the team leader seems to be lacking.
- In case of problems on the shop floor, everybody starts to interfere and discuss, leading to confusion, inadequate problem-solving, and delay. There is a tendency to treat every problem as a single issue.
- The production engineers were not very happy with you investigating ‘their’ process. They argue that lower cost leads to low quality and less professional freedom. The fact that there are almost no quality issues with their own printed components used in the printers, strengthens them in the opinion that they are superior to others, and that external interference should be mistrusted.