Industrial Engineering & Management, 20-01-2021 18:45-21:45

Exam Production Planning & Quality Control

Name:

Student Number:

**Declaration of the Board of Examiners**

The Board of Examiners has allowed the conversion of your exam into a take-home exam. This conversion comes with the following additional provisions:

1. You are required to sign the pledge below, swearing that your work has been completed autonomously and using only the tools and aids that the examiner has allowed you to use.
2. Attempts at cheating, fraud or plagiarism will be seen as attempts to take advantage of the Corona crisis and will be dealt with very harshly by the board of examiners.
3. The board of examiners grants your examiner the right to conduct a random sampling. If you are selected for this sample, you may be required to conduct a discussion (digitally, using audio and video) in which you are asked to explain and/or rephrase (some of) the answers you submitted for the take-home exam.

I, (fill out your name) , have completed this exam myself and without help from others. I have come up with these answers myself. I understand that my fellow students and my lecturers are all doing their best to do their work as well as possible under the unusual circumstances of the Corona pandemic, and that any attempt by myself or my fellow students to use these circumstances to get away with cheating would be undermining those efforts and the necessary trust that this moment calls for.

**Please take note of the following:**

* You are required to write your answers in this document. When you have finished, upload this document on Nestor as Microsoft Word or Pdf document.
* The total number of words of this document (including questions, your answers, and the case text) may not exceed **5000**. Note that this number is not an indication of quality. Good answers could also have much less words.
* Do not forget to fill in your name and student number on the first page.
* Make sure that you have added your name in the above declaration as confirmation of your pledge.
* This exam consists of 2 questions for a total of 100 points.
* You are allowed to consult the course articles, slides, and your notes during the exam.
* You are required to answer all questions in English.
* Give precise answers to the questions. Each answer must show that you have studied the articles and the slides. Avoid superficial, generic answers.
* We advise you to explicitly refer to the article (including section and page number) and/or slides that you base your reasoning on. Otherwise, if the answer is too vague, too generic, or we do not recognize your answer from the course literature, no points will be awarded.
* It is not possible to ask questions during the exam to the teacher. If you think the exam contains errors, please mail the teacher after the exam with your remarks (w.m.c.van.wezel@rug.nl).

Good luck!!

**Question 1: Generic topics (50 points)**

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

Answer:

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

Answer:

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

Answer:

(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)

Answer:

(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? Explain why. (5 points)

Answer:

(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)

Answer:

(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? Show your calculation. (7 points)

Answer:

(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)

Answer:

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

Answer:

**Question 2: Case (50 points)**

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, how, 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 manufacturing strategy, lean production, behavioral operations, and, when appropriate, smart manufacturing.

Structure your proposal with the following steps:

1. Write down the characteristics of the production process that you include in your reasoning.
2. 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.
3. 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.
4. 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 and refer to the course literature, slides, and lectures.
* 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. Problems/goals that cannot be influenced by planning/scheduling, do not have to be addressed. If such problems would hinder your solution, you can mention that.
* Making assumptions is allowed, but please mention them explicitly, and keep them realistic.
* You are allowed to add figures/graphs to your proposal.

Answer:

---- 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:

1. 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.
2. 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.
3. 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
4. Software installation
5. Testing of the machine
6. After packaging the machine is placed in the final goods inventory, awaiting delivery
7. 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.