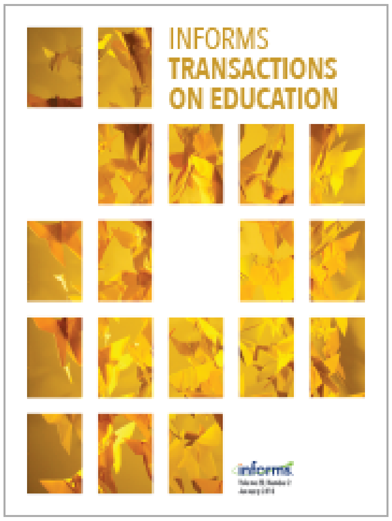

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Case Article

Agile Auto Sub Assemblies: Challenges in Managing Growth, Resource Productivity, and Demand Variability

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Abstract. The key objective of the case study is to help students understand the nuances of assembly line design without having to manage a huge problem context. The case study provides a platform for an engaging discussion on assembly line balancing and related concepts. The case is developed in a setting of an auto subassembly manufacturer that currently operates two lines. The management is confronted with a situation in which the production requirements are increased. The management needs to decide between hiring additional workers, reconfiguring the assembly lines, or both to meet the new demand. The production manager suggests a simple linear allocation of resources based on demand. Its validity and various other options are investigated to manage the projected volume. The following considerations are used to evaluate each option: capacity utilization, labor utilization and flexibility of operations, cost of overtime, cost of new recruitment, and inventory. As an extension, we also discuss the trade-offs involved in level-production strategy and a market-driven strategy when the demand profile is variable.

Supplemental Material: The Teaching Note is available at https://www.informs.org/Publications/Subscribe/Access-Restricted-Materials.

Keywords: assembly line design • level production • utilization • operations • production • critical thinking

Introduction

Production planning is one of the important concepts taught in the area of operations management. Various mathematical tools, including linear programming and statistics have been used to address problems in this area (Fisher et al. 1994, Wilson 1996, Wheelwright and Myers 2011). Assembly line design is a classic topic taught in core operations management classes in the MBA program, graduate programs, and several undergraduate business programs. Several excellent textbooks provide an in-depth and detailed coverage of this topic (Wagner 1969, Buffa 1980, Gupta and Buzacott 1989, Becker and Scholl 2006, Jacobs and Chase 2013). The design-performance measures related to an assembly design include number of workstations (decided based on the combination of volume of operations and working hours per day), target cycle time, capacity utilization, and labor utilization.

Several options are available for instructors to explain the related concepts. They can draw examples from standard textbooks. After a technical discussion, they can employ a case study to engage and enthuse the participants. Bowen et al. (2008) describe the assembly of notebook computers in Toshiba's Ome factory and include techniques such as dynamic line balancing. The impact of variability in online performance is discussed in the case Assembling Smartphones: Takt Time ≠ Cycle Time? by Shih and Bernstein (2012). Wheelwright and Yong (2011) provide a case in which an existing assembly line is analyzed, and students are expected to make recommendations to improve its efficiency. To manage the computational difficulty, instructors routinely use standard software or spreadsheet models to expose the students to the concept and details of line balancing (Weiss 2013). A case study that is applied and comprehensive and, at the same time, computationally simple is lacking in the literature, and our objective is to fill this gap.

We have designed a case study based on a simple situation to provide a platform for an engaging discussion on assembly line balancing and related concepts. Most computations can be done by hand without recourse to any software. This helps keep the students focused on key concepts.

Pedagogical Objectives

- Help configure an assembly line given task times and precedence relationships.
- Demonstrate that resource requirements in an assembly line (workstations) are not linearly proportional to volume of production.
- Illustrate the interplay between labor utilization and flexibility in operations.
- Demonstrate the trade-off between additional manpower and overtime.
- Understand and apply strategies involved in managing demand variability.

In addition, the following important insights are generated from this simple case analysis:

- Flexible configurations are possible with more work in process (WIP).
- Cellular manufacturing is a special case of the assembly line concept.

Case Details

The context is developed in a setting of an auto subassembly manufacturer supplying Original Equipment Manufacturers. There are two assembly lines: line A with seven workstations is designed to produce a volume of 315 per day, and line B with two workstations is designed to produce 140 per day. Lines A and B operate a shift of eight hours and may operate under overtime if needed.

The management is confronted with a situation in which the production requirements at lines A and B have increased to 420 (an increase of 33%) and 210 (an increase of 50%), respectively. The management can recruit additional workers to handle the increase in load. Each new worker hired requires an additional investment.

The production manager of line A reasons that an additional allocation of two workers for line A would be appropriate to meet the increase in volume requirements. The allocation rule is based on linear resource requirements based on volume. Through a conversation between the summer intern and the management (owner and line managers of A and B), we develop a set of scenarios through which the current and the projected volume can be managed. The discussion points include the following:

- Because the utilization in the current configuration is low, reconfiguring line A with one less workstation and still meeting the current volume requirements.
- Developing assembly line configurations to meet the revised demand at lines A and B.
- Exploring U-shaped configurations and adjustments required.
- Computing capacity and labor utilization for various assembly line configurations.

During the optimal selection of an assembly line configuration, the following considerations are used to evaluate each scenario: capacity utilization, labor utilization and flexibility of operations, cost of overtime, cost of new recruitment, and WIP. As an extension, we also discuss the trade-offs involved in level-production strategy and a market-driven strategy for line A when the demand profile is variable.

Classroom Experience and Suggestions

This case has been taught for several years in the core operations management course of the MBA program. Although we had not used it to teach undergrads, the case could be readily adopted for a junior- or senior-level class. The case is fairly rudimentary to be useful for a PhD-level class, and we do not recommend using the case for students at this level.

The case was discussed at the end of the process analysis module, which includes job shop, batch production, and similar topics. The basic issues related to assembly design were easily illustrated using this case. Economic considerations, operating performance measures, and the trade-offs involved in each design configuration were discussed in detail. Designing configurations with flexibility in operations and associated shop-floor control measures and the trade-off involved with investment in additional inventory were also discussed. Assembly design issues are discussed in the context of economic conditions.

The general observation is that most students do not have difficulty in arriving at a result but are not systematic in their analysis. We note here that "assembly line" is a term some of them are hearing for the first time. Because of their casual approach, they make a few mistakes in the basic calculations. These mistakes carry forward when they design and configure the assembly lines. As a result, a significant portion of class time had to be spent on going over the calculations before moving on to the discussion of other concepts. Even then, the discussion was not richer as students had not spent time in thinking about the configurations. To enable student preparation, we thought about splitting the case into two parts and discussing the case over two classes. The first class would focus on the calculations, and the second class would focus on the assembly line configurations and the criteria for choosing the best one. However, the two-part discussion would result in a significant time investment on just one of the many topics covered in the core course.

Given the short time we usually have to discuss the assembly line concept, we redesigned the case and presented the final result of all basic calculations in the case (Tables 1–4). We also included some sample assembly line configurations. Students were simply asked to verify these calculations (they were asked to submit a spreadsheet that showed how these numbers were arrived at). They were also asked to design new configurations (similar to the sample configurations presented in the case). This resulted in a superior discussion of assembly line configurations. Giving away some of the "answers" was also well received by a few students as pointed out in the feedback survey circulated. A few students wanted to discover the answers themselves, but even they appreciated that they could cross-check their answers. The following were a couple of comments from the students.

> I liked how we first went through the tables provided in the case to verify the numbers so we were able to understand how the numbers were derived. I also liked how, after we verified the numbers, we then came up with our own configurations.

> I liked the double-checking aspect. This allowed me to learn the use of the formulas with verification that I was doing it correctly.

During the class discussion, students revealed that they were quite surprised to contradict Bill (that his assembly line is managed best) and find that six workstations are enough to satisfy the current demand. They also enjoyed configuring the various scenarios.

The following were some key areas of learning difficulty:

1. More WIP being required to manage assembly line B with three workstations (modified configuration).

The U-shaped configuration was quite a revelation for many. Students were not quite sure if and how the workers would move across stations and whether this was really feasible. A visual representation followed by a class discussion was required to help the students in grasping the concept.

2. The need to adjust cycle time if an assembly line cannot be configured with the theoretical minimum cycle time.

Students were able to see for themselves how capacity is related to cycle time. When they configure the assembly lines, because splitting of activities is not always possible, they are also able to glean the difference between theoretical minimum cycle time and actual cycle time.

3. Calculation of capacity based on revised cycle time (and actual configuration) and not theoretical minimum cycle time.

Cycle time has always been a difficult concept for students to grasp. Students are always puzzled when they hear that each product requires 360 seconds (the total process time), but an item comes out every 90 seconds (cycle time). They were able to better understand these concepts when they configured assembly lines on their own supported by appropriate computations.

4. Nuances of handling variability.

Students appreciated the pros and cons of different options (just-in-time and level production) when handling variability.

Although difficulty areas 2 and 3 are mostly addressed when the students perform the calculations themselves, their understanding improves during a follow-up class discussion. We typically spend at least 90 minutes of class time (more details are presented in the teaching note) assuming students have spent enough time outside the class going over the calculations. The case can also be adopted for students in industrial engineering or with a production background in addition to management students.

Conclusion

The assembly line design case is based on a simple situation and provides a platform for an engaging discussion on assembly line balancing and related concepts. The fundamentals regarding assembly line production can be easily illustrated for both graduate and undergraduate students. The trade-off between labor utilization and operational flexibility can be demonstrated. In addition, based on the maturity of the class, several nuances related to assembly line design and handling variability in demand can also be addressed by using this case.

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