Kiva Systems Capstone Project

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Abstract
Kiva systems uses automation technology for distribution centers to help companies automate their pick, pack and ship processes. Kiva’s main products are autonomous mobile drives (robots) and a control software that can be easily adapted to any warehouse. The quick order fulfillment utilizing the drives through the warehouse floor increases eCommerce businesses and other companies’ ability to have very fast cycle times with the advantage of reducing labor costs from receiving to picking to shipping. Because of this reason, Kiva Systems was acquired by Amazon.com in 2012, spiking the demand for drive units being manufactured in North Reading, MA. The Capstone team will look to optimize the production line and build a simulation model that helps Kiva Systems align the current resources they have in terms of material, labor, and facility space to make sure the demand forecasted by Amazon is met. By using AnyLogic, a new generation simulation software, the Capstone team provided different scenarios of material input, labor force, and space usability to meet the target monthly demand for drives. The team used Industrial Engineering tools such as block diagrams of material flow, line balancing techniques, and Kaizen events to identify and address the main causes that generated the bottlenecks reflected on the simulation models and also reduced or eliminated any non-value added waste activities that were found in the assembly line. Lastly, to make sure the efforts and the solutions provided by the Capstone team continue once the project is over, a Kiva Systems engineer was trained in how to properly use AnyLogic so they can continue to use the model and plan ahead.

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The Need for Project

Since the acquisition of Kiva Systems by Amazon in 2012, production demand for drive units increased beyond the manufacturing assembly lines original capacity. Current methods of forecasting and scheduling resources made it difficult to make strategic decisions regarding staffing, material handling, and assembly line operations. Kiva manufactures their entire line of products at their headquarters in North Reading, MA using a manually propelled assembly line. Keeping up with ever expanding demand had become increasingly challenging and Kiva was struggling to plan according to dynamically changing demand from Amazon. Kiva wanted to comprehensively understand the capacity and resource needs to meet the expected explosive demand. They were producing at a rate of 18 drives below TAKT daily, equaling just under $500,000 in lost potential revenue per day.

The Design Project Objectives and Requirements

**Design Objectives**

By designing a high rate lean production line, and by creating a robust simulation model of that assembly line, Kiva is able to feed in demand data and make informative adjustments to the manufacturing operations in order to meet future demand. The simulation model may be used to identify bottlenecks that will arise through increased future production demands. Kiva was operating at a production capacity of 32 drives per day, while their demand was 50 drives per day. The final objective of this project was to identify improvement opportunities in the assembly operations which would improve the production throughput of drives by reducing production lead time. Also provided, was a tool for operations management to implement preparatory changes ahead of demand increases.

**Design Requirements**

The simulation model must be robust enough to allow Kiva Systems to make quick changes to the following manufacturing variables: Shifts per day, hours per shift, station cycle times, operator efficiency rate, material fulfillment rate, and floor space requirements (Rep 1.3). This allows Kiva to make adjustments to these variables and enable Kiva to test the effectiveness of different operating scenarios before investing time, resources, and capital to implement those
changes. This gives Operations Management the ability to plan ahead
versus reacting to demand fluctuations when it’s too late.

**Design Concepts Considered**

- Multiple line balancing techniques, two simulation software options, and lean manufacturing methodology were considered to achieve project objectives.

**Improvement Techniques Considered**

There were two methods of improvement techniques considered in the design of the assembly line. The first was the use of lean manufacturing tools to make changes to the assembly operations, by removing anything that does not add value to the assembly. By doing repetitive time studies, the Capstone team was able to identify waste activities at each station. The team trained operators to identify and advocate for the removal of non-value added operations or movements. There are a variety of lean tools that can be used to eliminate waste and increase productivity such as: Workplace 5s, Standard Work, KanBan, etc (Rep 1.4) (Ref. 6).

The second method of operations improvement considered was line balancing techniques. The techniques considered were largest candidate rule, Kilbridge and Wester, and Ranked Positional Weight method. The goal of line balancing is to reduce the production lead time which is equivalent to the largest station’s cycle time. This is accomplished by redistributing the assembly steps required at each station, and establishing standard work for each assembly station. This must be performed while respecting part precedence in the assembly.

**Simulation Software Considered**

There were two simulation software options that were considered in the project design phase. The first option was ARENA, software that the group is trained in through the Industrial Engineering curriculum at Northeastern. Kiva Systems recommended the use of AnyLogic, a new generation simulation software that allows integration through macros of Microsoft Office programs such as Excel and Access. The design of the simulation within each program would ultimately be very similar, but the user interfaces differ in aesthetics and capabilities (Rep 3.1).
Recommended Design Concept

The simulation was created using AnyLogic as it allows for ease of use in the frontend. Line balancing techniques were used over lean methodology based on the finding that Kiva’s line was very unbalanced.

Design Description

While collecting cycle time data to feed into the simulation model it was revealed that Kiva’s current assembly line was unbalanced. Because of this the improvement methodology chosen was to use the Ranked Positional weight method in order to make improvements for rebalancing the line.

The simulation model was created using AnyLogic software because it allows for the creation of an aesthetically pleasing and functional user interface that can be used to quickly adjust the key performance variables discussed earlier (e.g. hours of operation).

Analytical Investigations

1) Time Studies and Line Balancing Efficiency - As stated above, during the assembly operation data collection phase of the project the team revealed that the assembly line was operating at less than 67% line balancing efficiency (Rep 4.2). Their Cycle Time was over 14 minutes. After implementing the Ranked Positional Weight line balancing technique a proposed solution offered a potential increase to 92% line balancing efficiency, and a cycle time of less than 8 minutes. This rebalancing solution will potentially result in an increase in production from 32 to 52 drives per day (Rep 4.2). This equates to a potential increase in daily revenue of $500,000.

Key Advantages of Recommended Concept

The key advantage of using AnyLogic is the ability to provide a user-friendly frontend interface. The tool will ultimately be used as a forecasting tool to test different production scenarios, so ease of use in creating different scenarios is extremely important. Using the tool, Operations Management can respond to future demand by hiring assemblers and increasing material order quantities accordingly. Training line workers and implementing purchase order alterations take time, and the tool will allow Management to meet these challenges.

The advantage of using the ranked positional weight technique is that it takes into consideration both total production lead time based on maximum station cycle time, and also precedence of assembly steps at each station. A shorter lead time results in an increased production capacity which is the key success driver in this project, more revenue to
Kiva. Precedence is important to consider for Kiva due to the nature of complex electronic component installation within each drive.

**Financial Issues**

The line balancing solution will cost $6.4 million in potential production losses, with a ROI of just 12.8 days, and potential annual increase in revenue of $150,000,000.

In order to implement the proposed line balancing solution Kiva will have to shut down production for 8 days. At a current production rate of 32 drives/day, these changes pose a risk of the loss of 256 possible drives that will not be produced. At the sale price of $25,000/drive (sale price approximated due to Amazon confidentiality agreements) this is a loss of upwards of $6.4 million. These are large numbers; however the return on investment is estimated at just 12.8 days because the implementation of these changes will provide 20 more drives per day. At 20 drives per day across a 6 day production week, the annual increase in drives produced is 6,000; this results in a potential $150,000,000 increase in annual revenue.

The cost of creating the simulation model is simply the cost of an AnyLogic license, which is $12,000 to be incurred annually by Kiva Systems.

**Recommended Improvements**

If given more time lean methodology would be used to continuously improve manufacturing operations in a Plan-Do-Check-Act cycle.

If the efforts are continued beyond the capstone project, there are significant opportunities to make improvements to the line using more lean manufacturing methodology and custom tooling implementation. While collecting cycle times at each station it was clear that there still is a large amount of potentially non-value added activity in the process steps. For example there is a significant amount of time spent reorienting the drive unit in steps throughout the process that can be eliminated. Ideally non-value adding activity could be decreased significantly and then the line could be rebalanced in a Plan-Do-Check-Act continuous improvement style cycle.