Quality and Productivity

Engineering 1281H

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1. Introduction

The Mr. Potato Head market has skyrocketed in Columbus and is projected to continue doing so over the next 5 to 10 years. In response to this increase in demand, the company Spuds Not Duds, Inc. is looking to increase their production capabilities in order to become a major company in the Mr. Potato Head Market.

To accomplish their production capability goals, Spuds Not Duds, Inc. have setup 3 separate production lines with FEH students, the Buckeye, Scarlet, and Gray lines. The 3 lines are competing to create the most profitable process for making Mr. Potato Heads for customers. Therefore, the purpose of this lab is for the FEH students to solve process issues, eliminate waste, streamline production, and increase productivity in order to find the best manufacturing model to achieve peak production line capability.

In the following lab report, the Experimental Methodology section provides the process through which the production lines were tested, and how the team could change and interact with the process. The Description and Results section includes the results for the Gray and Buckeye production lines. In the Discussion section, the questions from the post lab are answered and the results are explained in the context of the lab. In the Conclusion and Summary section, the overall lab results and purpose are summarized. The Appendices provide Tables and Figures.

2. Experimental Methodology

Before the lab, each person was assigned a team - Scarlet, Gray, or Buckeye - and a job. Initially, each team had 2 industrial systems engineers (ISE), 7 operators (o1-o7), 2 transporters (Tran), 1 final tester (FT), and a customer, in a layout as shown in Figure 1 on the next page.

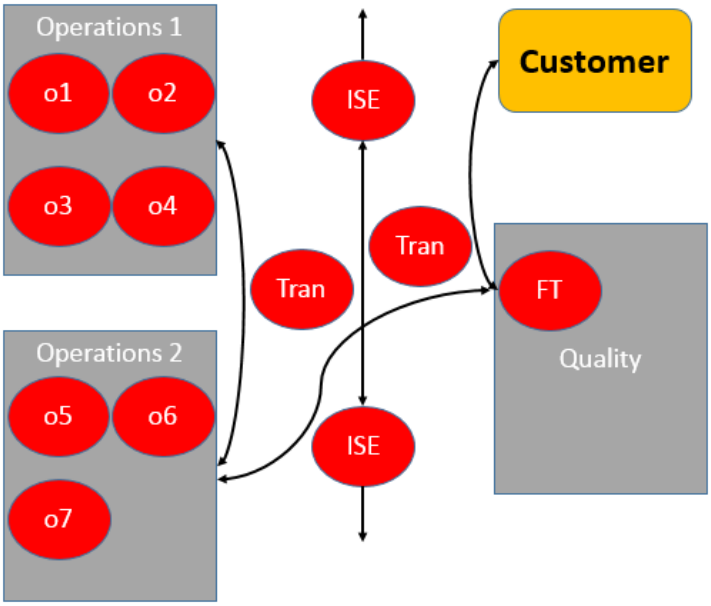

Figure 1: Initial layout and role locations for production line [1].

Generally, the ISEs supervised the entire manufacturing line and applied concepts of Lean Manufacturing and Six-Sigma throughout the system in order to maximize quality, productivity and profit. ISEs could communicate with workers, as well as customers and made observations during the process. These observations included the production line's weaknesses, issues that occurred, processes that worked well, and potential improvements that could be made. During the run, ISEs are responsible for resolving issues and guiding workers when they are needed. Before the next run, the ISEs used their notes to refine the production line by combining or condensing roles, instructing the operators and transporters, and communicating with the workers.

Each operator had a certain job in the production line to assemble each product. Depending on whether the customer orders Red, Yukon, or Spud, the operators followed the assembly instructions for their part. The assembly instructions for each model are shown by Figure A1 in Appendix A. Operators followed the instructions at their station and any instructions their ISE gave them. If a defective product reached their station, they were required to inform an ISE, since

they were not allowed to communicate with other operators. Operators were not permitted to move products between tables or in and out of the transporters' bins.

The final tester performed the last quality check before the products were delivered to the customer. If they found a defect, it was given to a transporter to take back to the proper operator. Once each product is inspected, they gave the complete order to a transporter for delivery and recorded the total number of internal defects found after each run. Final testers also worked with ISEs to improve the production line. Transporters were the only workers who could move the product between tables and to the customer. The products could only be moved by the transporters into and out of the plastic bin that they were given, and products could only be transported when they were in the bin. The customers gave orders at specific times for each run and inspected their orders to report defective and incorrect products they received.

Run 2 simulated a push process and was outlined by Table A1 in Appendix A. The ISEs decided what the products the operators should begin to make before receiving the order. After 1 minute, the order was received, and the team had another minute to deliver. There were 4 orders, with a minute to complete and deliver each one. Run 3 simulated a pull process, as outlined by Table A2 in Appendix A. The first order was received at the beginning and the team had 1 minute and 15 seconds to complete it.

Before starting run 4, the teams used the data and observations to improve their production line before the final run. ISEs made the decision to fire employees, switch employee roles, rearrange the production line, and remove tables. Run 4 was like run 3 in that the first order was received at the beginning but the ISEs could implement methods from both push and pull manufacturing processes. The timetable for run 4 is also shown by Table A2 in Appendix A.

After each run, the ISEs report number of completed orders, tables used, employees, partially assembled products (WIP), and fully assembled goods not delivered to the customer. The FT reported the number of defective products that had to be sent back to the production line. The customer reported the time it took for each order to arrive, the number of defective products, and the number of incorrect models they were given. Then, the team's profit was calculated using the revenue and costs.

3. Results and Description

During each of the rounds, operating expenses were represented by tables being used and workers, while penalties were tact on for improper deliveries and product defects, as described in Table A3, Appendix A. These expenses were added together to create the costs for each round, as seen in Table 1 below. These costs varied from each round and were used in the profit, revenue, cost analysis.

Table 1: Gray and Buckeye Cost Breakdown for Trials 2 through 4.

Gray and Buckeye Cost Breakdown						
	Gray 2 (Push)	Gray 3 (Push)	Gray 4	Buckeye 2 (Push)	Buckeye 3 (Pull)	Buckeye 4
Late ($25)	1	1	0	0	0	2
Internal Defect ($50)	1	0	0	0	0	0
External Defect ($80)	0	0	0	1	0	0
Wrong ($75)	0	0	0	0	0	0
Undelivered ($200)	3	0	0	0	0	0
Tables ($100)	3	3	1	3	3	1
Workers ($50)	11	11	6	10	10	6
Work in Progress ($10)	1	0	0	0	0	0
Finished Good Waste ($20)	1	0	0	0	0	0
Total Cost & Revenue Loss	$1,155	$875	$400	$800	$800	$450

Costs varied between each round and were analyzed within the run notes of each team member. The push run notes for the teams mentioned producing excess waste that teams had to eliminate during the run. This was noted to be caused by the ambiguity in the order alongside miscommunications in what the predicted orders should be. During the push run, works in progress and finished goods were left as waste for the Gray team. The pull run was noted to have better communication and less confusion due to clearer requirements for each run. Teams noted that team roles and tables could be condensed, without sacrificing production speed. During run 4, each team used only 6 workers and 1 table. Buckeye team noted that during run 4, transportation of the product resulted in mishandling of the product that resulted in it being broken during delivery.

The profit for each trial was calculated by subtracting the costs during each run, described in Table 1 below, from the revenue for each trial. Revenue was calculated by multiplying the number of sold units by the selling price, $200.

Table 2: Gray and Buckeye Profit Breakdown for Trials 2 through 4.

Gray and Buckeye Profit Breakdown			
Trial	Revenue	Costs	Profit
Gray 2 (Push)	$1,800	$955	$845
Gray 3 (Pull)	$2,400	$875	$1,525
Gray 4	$2,400	$400	$2,000
Buckeye 2 (Push)	$2,400	$880	$1,520
Buckeye 3 (Pull)	$2,400	$800	$1,600
Buckeye 4	$2,400	$450	$1,950

4. Discussion

Each of the 4 runs by all 3 production teams provided data that the groups used to analyze which manufacturing method was most efficient. Table 1 compared the total penalties and costs of the push and pull runs (runs 2 and 3 respectively). For each group the amount of penalties declined from run to run. This occurred because in the pull run, each group knew what type and quantity of Mr. Potato Heads they needed to make. This factor caused fewer finished products to be left at the final tester's station. In combination with the total cost and penalties declining from run 2 to 3, the revenue also remained the same or increased. Each group took these factors into consideration when they chose the run 4 manufacturing process. Each group had an increase in

profits as the trials went on because of the ability to change the procedure by reducing waste based on the Six-Sigma Manufacturing system.

The group went through 4 runs of manufacturing. After the first run, the group noticed some issues that came about. Because of the ability to only communicate to certain team members, 1 classified this run as chaotic. Run 1 was the first time each group member completed their assigned task, so they were unfamiliar with the exact specifications of their job. The group also had left over products that the customer did not order. This occurred because of the unfamiliarity of the order process.

After the first run, each group completed a second and third run. Run 2 was a push system while run 3 was a pull system. The issues observed during run 2 were not knowing how many of a product to make, having improper positioning of the parts, having trouble understanding the orders, and having 2 transporters. For run 3, the group described the assembly process as going much smoother, but the final tester could have worked more efficiently. Since it was a pull system the operators knew exactly what to make and how many to make.

Based on observations and experiences from each workers position in the production line, 1 refined the production line method and process in multiple ways. From each worker's standpoint they were able to discuss with each other what went well and what didn't. Ultimately, the focus was to decrease cost and increase the speed and quality. After the ISE from team Gray talked with the group, they made the decision of reducing the team to 3 operators, 1 ISE, 1 final tester, and 1 transporter. Reducing the number of workers decreased the cost of production. By firing 3 operators, the remaining 3 operators had to take on additional assembly tasks at their station. Operator 1 assembled the eyes, feet, and hat. These components were attached first because they were what determined 1 potato type from the other. Another operator assembled the ears and arms

because the holes of those features were next to each other. The last operator assembled the nose and mustache because the nose held the mustache to the body. All the operators, and the final tester, moved to 1 table to decrease the cost of workspace. The team chose a pull system to be the type of manufacturing line because after completing this type of system in run 3, no products were left over, the time of production was faster, and the overall process went smoother. Each of the operators also laid out each of their parts so they were easily accessible for the assembly process. With all the production happening at 1 table, the group decided to reduce to 1 transporter. The same reason applied to only having 1 ISE and final tester. Having 2 would have caused confusion and unnecessary over checking. group, the ISE also made the decision to fire workers, move to 1 table, use a pull system along with creating more of a production team bond. If the team improved their chemistry, the production flow and familiarity of tasks would also improve.

After each team made their appropriate production changes, the fourth run started. For the Gray team, the group saw a significant increase in profit. They increased from a $1,525 profit in run 3 to a $2,000 profit in run 4. The team increased profits by decreasing the total cost by $450. This occurred from minimizing team size and space. The group had the same revenue as run 3, but by decreasing the penalties and costs, the profit increased. The Buckeye group minimized total costs by having moved all the operators to 1 table. However, they added a penalty at a cost of $50. This occurred because of a late delivery. Neither group produced a defective unit.

Comparing the pull run results to the push run results, the effectiveness and profitability between each showed difference. The pull run was more effective and profitable than the push run. The profit for each production team increased between runs 2 and 3 (push to pull), by at least $80. Each group found a way to decrease the penalties, which increased efficiency. This caused an increase in profitability.

As each run went on, the team settled into more of a consistent production flow. This happened because in between runs, the team members were able to discuss the positives and negatives with the ISE to improve the running process. With communication, each member learned what they needed to change in order to improve the efficiency of the production line. When the customer gave feedback to the ISE about what they liked and didn't like about the products, the ISE relayed that information to the operators. This helped with the specific positioning of each piece. Since there was communication between the customer and the production team, the team could more easily receive maximum points for appearance.

5. Summary and Conclusions

The purpose of this lab was for the FEH students to solve process issues, eliminate waste, streamline production, and increase productivity in order to find the best manufacturing model to achieve peak production line capability. The results found from the Buckeye and Gray production lines support that the pull method was the best. The Buckeye group had an $80 increase in revenue from the push run to the pull run, while the Gray group had a $680 increase in revenue from the push run to the pull run. As for the production model, the Buckeye and Gray teams found that a mix of both Six-Sigma and Lean Manufacturing worked well for the process of making Mr. Potato Heads. The ideas of cutting down the amount of transportation, inventory, waiting, an overproduction was some of the Lean Manufacturing techniques used. And the idea of defining, measuring, analyzing, improving, and controlling were all parts from the Six-Sigma model that were used. Therefore, for the most effective production model when it comes to Mr. Potato Head creation is a Six-Sigma and Lean Manufacturing combination, with a pull ideal.

For another run of the lab, it would be most beneficial to have 3 operators, 1 final tester, 1 transporter, and 1 ISE. This way, the number of production lines required can be cut down from 3 to 1 right off the bat. Have the 1 final tester and 3 operators at 1 table. Another reason would be to cut back on the amount of transport required, and the number of workers required to assembly and check the product. This way, the cost is reduced heavily due to having nearly half as many workers.

For each experiment the Six-Sigma manufacturing method was used to improve quality by reducing waste. The metric of Six-Sigma that should be measured and improved is the lack of training. The company only gave each operator a paper with how their specific piece should look on the Mr. Potato head figure. The company did not give them a picture of the final product on that sheet so they would know how their piece fit in with all the other components. If the operators were previously trained in how their part(s) fit in with the rest of the finished potato, they would have a better understanding of how they should precisely position them.

References

[1] FEH Quality & Production Write-Up. 2019, October 20. www.carmen.osu.edu

APPENDIX A

Figures and Tables

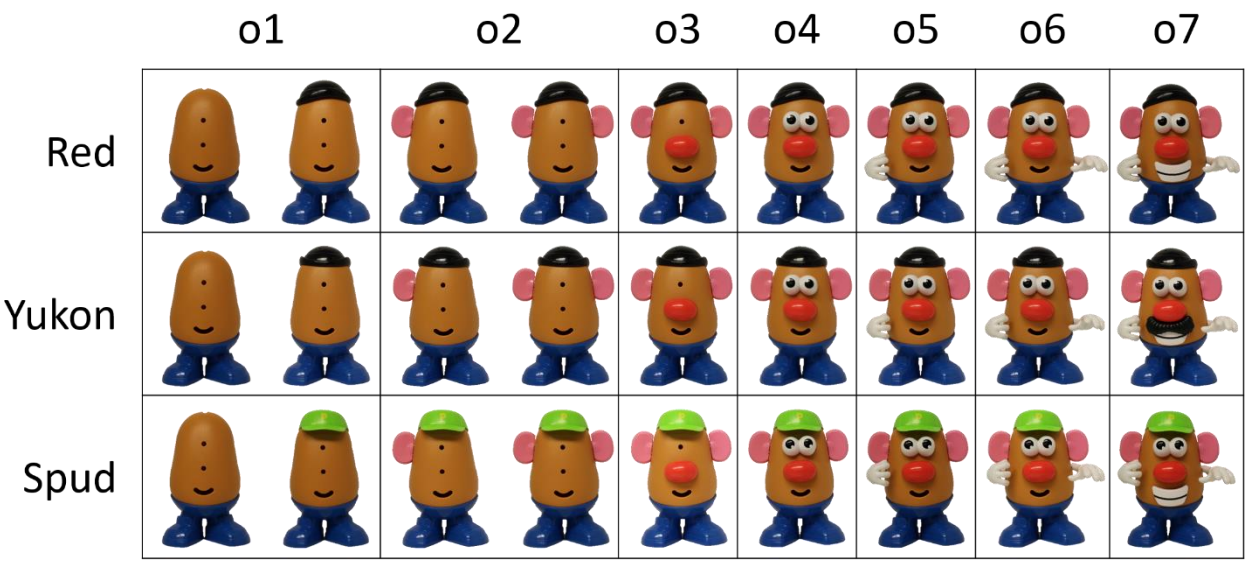

Figure A1: Manufacturing stages for each Mr. Potato Head Model [1].

Table A1: Timetable for Run 2. [1]

Time (min:sec)	
0:00	Begin Making Product
1:00	Receive Order 1
2:00	Order 1 Due, Receive Order 2
3:00	Order 2 Due, Receive Order 3
4:00	Order 3 Due, Receive Order 4
5:00	Order 4 Due, End Run

Table A2: Timetable for Run 3 and Run 4 [1].

Time (min:sec)	
0:00	Receive Order 1
1:15	Order 1 Due, Receive Order 2
2:30	Order 2 Due, Receive Order 3
3:45	Order 3 Due, Receive Order 4
5:00	Order 4 Due, End Run

Table A3: Cost associated with the different stages of processing of a Mr. Potato Head [1].

Item	**Cost (per unit)**
Tables	(-$100)
Workers	(-$50)
WIP	(-$10)
Finished Good	(-$20)
Late Arrival	(-$25)
Internal Defective Unit	(-$50)
External Defective Unit	(-$80)
Wrong Unit	(-$75)
Unit Not Delivered to Customer	(-$200)
Correctly Delivered and On-Time	**$200**