Empowering Teams and Implementing Single-Piece Flow Yields Rapid Improvement in Production

Liam Chalk, Sam Marquez, Sidney Taylor, Nick Zemtzov
lchalk@hmc.edu, smarquez@hmc.edu, sstaylor@hmc.edu, nzemtzov@hmc.edu
Department of Engineering
Harvey Mudd College
Claremont, California

Abstract

WePackItAll, a contract packaging company, brought in Harvey Mudd College's Riggs Fellowship team to rapidly improve their packout lines over the course of 10 weeks. Using the insight from takt time calculations and value stream mapping, the team brought single-piece flow to the line with new operating procedures, automation equipment, agile workstations, and designated production roles. The improvements to the line increased carton production by 28%, saving an estimated $1.26 million annually. The new packaging line maintained high quality, decreased inventory, and reduced changeover time which resulted in higher and more consistent throughput. The new line shows the positive impact of continuous improvement culture that can scale across the company as a whole.

Keywords
Lean manufacturing; Single-piece flow; Low takt time; Packaging

1. Introduction

WePackItAll (WPIA), a contract packaging company in Southern California, suffered from an inefficient flow of materials and poor communication between supervisors and operators. The Harvey Mudd Riggs Fellowship team worked with WPIA to reduce labor costs while improving throughput over a 10-week period.

WePackItAll has several variants of secondary packaging requests to fulfill, including cartoning single-use powder stick packs. These pouches and cartons are placed into trays, shrink-wrapped, or left as individual cartons and then packed into cardboard shipping boxes of various sizes.

Although WePackItAll produces a wide variety of finished products, the Riggs team focused on the 6 count and 10 count cartons which constitute a high proportion of the customer demand. As shown in Figure 1, the current packout line for the 6 count cartons is composed of five processes: cartoning, stickering, printing, placing cartons into a tray or directly into a shipper, and palletizing. The current packout line for the 10 count cartons is the same, varying only with the addition of optional shrink-wrapping.

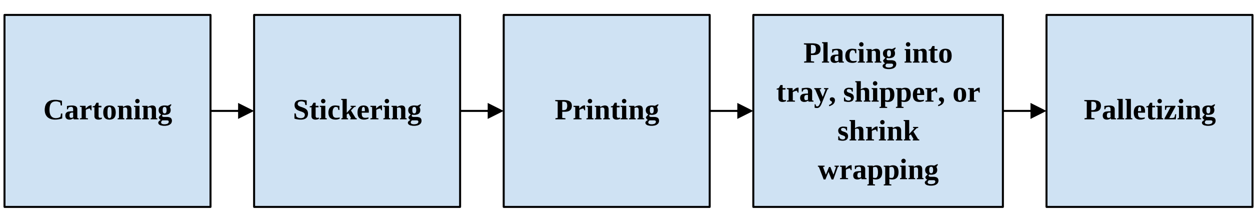

Figure 1: Carton Packout Line Process Flow

Figure 2 shows the current state floorplan of a 10 count carton line that included the shrink-wrapping process. First, the stick packs were dumped out onto tables and packed by hand into cartons by operators. Then, the packed cartons were manually carried over to one of two stickering areas where operators applied safety seals to the cartons. Both stickering stations fed into the printing station. Cartons from the far stickering station had to double back across the production floor to the stickering area nearest the printer. Once printed, the cartons were placed into intermediate cardboard boxes and staged off to the side of the production floor until substantial work in progress (WIP) was built up. Figure 3 shows an excessive quantity of the intermediate cardboard boxes wasting space and waiting to be filled. For these 10 count orders, the shrink-wrapping process began after one shift worth of cartons had been stockpiled. Once shrink-wrapped, the wraps were then packaged and palletized.

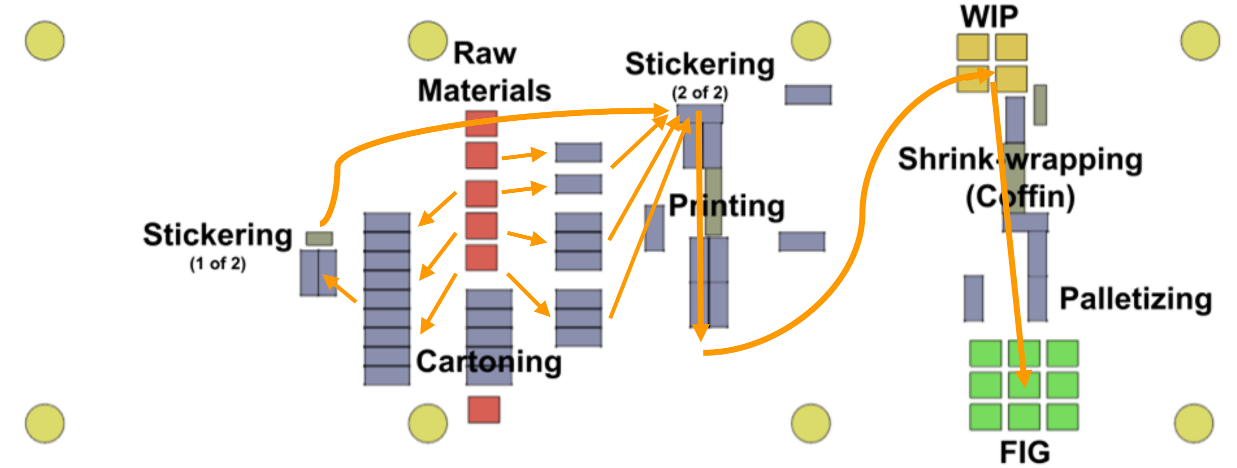

Figure 2: Spaghetti Flow of Work In Progress Across The Current State Cartoning Packout Line

Figure 3: Excessive WIP Cardboard Boxes Wasting Space

The Riggs team used time studies to characterize each process and measure the amount of work in progress at each step. The value stream map shown in Figure 4 has the results of the studies and helps identify bottlenecks in the flow of materials.

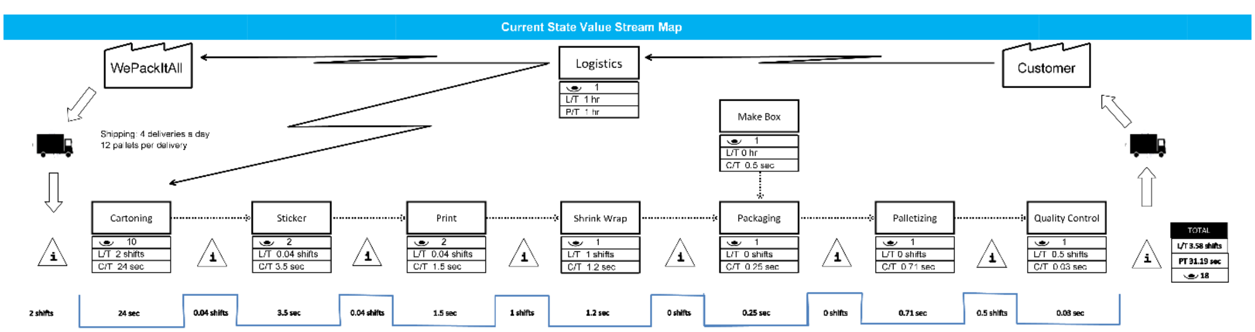

Figure 4: The Current State Cartoning Line Value Stream Map (VSM)

2. Problem Statement

With just 10 weeks, the team was tasked with resolving communication issues, increasing quality, improving efficiency, and streamlining material handling to meet customer demand of 6000 cartons per shift with a takt time of 1 carton produced every 4.25 seconds.

3. Approach

The Riggs team examined the processes of filling 6 and 10 count cartons and employed Lean manufacturing methodologies to increase throughput and reduce defects. Insight from a value stream map (VSM), takt time calculations, and the concepts of single-piece flow were the basis of the changes implemented. The introduction of single-piece flow illuminates previously hidden issues, which become areas for future improvement.

Waste due to idle operators, overproduction of cartons, double handling, and inventory buildup was identified on the current state line by observing the movement of operators and work in progress. Since the line's takt time was so short, the team realized that even small improvements to the method an operator used to perform a process would scale and generate significant savings. Thus the team took time studies for each process on the line to determine the optimal method of performing each. These studies were the basis of many of the equipment upgrades in the final solution.

Finally, the team sought to eliminate waste caused by managerial disorganization. These issues were not as apparent at first glance as the others. For example, palletizing instructions were primarily passed by word of mouth with minimal documentation, causing confusion over the correct layout of boxes on the pallet. Additionally, operators would continually switch roles, interrupting the workflow and misallocating labor for many tasks. It was only by talking to multiple operators on the line that these issues were identified, insights which concluded in a general management and organizational overhaul.

4. Solution

The new line improves upon the current state line in many ways by promoting the efficient flow of materials, reducing quality defects, increasing communication between team members, and eliminating waste due to double handling. With the new layout, designated material handlers drop off raw materials at the front of the line, the materials flow steadily through the line, and the finished goods pallet is picked up from the end of the line. Figure 5 shows the value stream map and Figure 6 shows the streamlined floorplan of the future state line.

The new line features improved material management with the introduction of a dedicated team member, called a "water spider," who is responsible for delivering stick packs and unopened cartons to each packing station. The water spider manages material distribution which allows other operators to focus on their individual tasks and cuts down on the number of operators walking around the production floor.

Additionally, quality issues are more easily revealed by the new line. The specially designed hoppers hold smaller quantities of stick packs and cartons, reducing quality defects caused by dropping overflowing sticks and cartons on the ground. Additionally, a check weigher scale confirms the mass of each carton, ensuring each carton contains the proper number of stick packs.

Communication is essential to maintain efficient flow on the new packout line. The Riggs team introduced three tools to promote better communication: designated Team Leads who promote single piece flow, Andon lights, and training materials. The Riggs team worked closely with Team Leads from both shifts and trained them on the principles of single piece flow. The Team Leads' role in maintaining the production flow after the Riggs Team left was vital to the long-term success of this project. The Andon lights are a form of visual communication that relays status information about each process in the line. The introduction of these lights empowers each operator to bring problems to the attention of the Team Lead. Training materials ensured that this new information was documented and accessible to all new team members.

Lastly, the new line eliminates both physical and temporal waste. Continuous flow was achieved as the Riggs team connected all processes and placed them next to each other. As shown in the floorplan in Figure 6, the beginning of the line features packing stations adjacent to a conveyor belt. As soon as the cartons are packed, they immediately travel to subsequent processes. Previously, boxes waiting to be shrink-wrapped were placed into boxes and staged off to the side until a substantial amount of work in progress had built up. With the future state line, the cartons now flow from beginning to end in one continuous motion, eliminating wasteful periods of waiting, double handling and WIP build up.

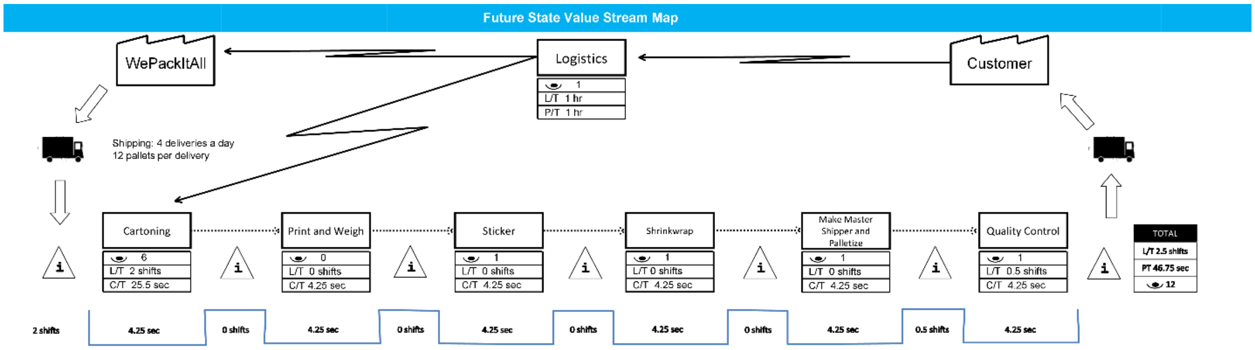

Figure 5: The Future State Cartoning Line Value Stream Map (VSM)

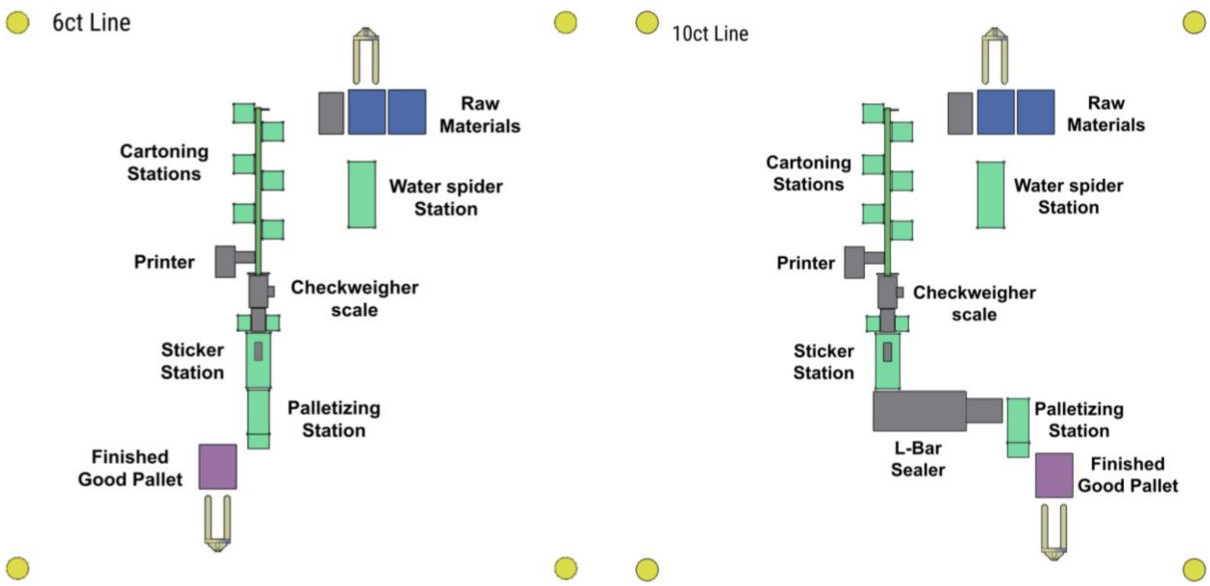

Figure 6: Future state 6 count and 10 count lines

Figure 7 shows the future state 6 count and 10 count carton lines in action out on the production floor. As described above, the material flows steadily from the front to the end of the line.

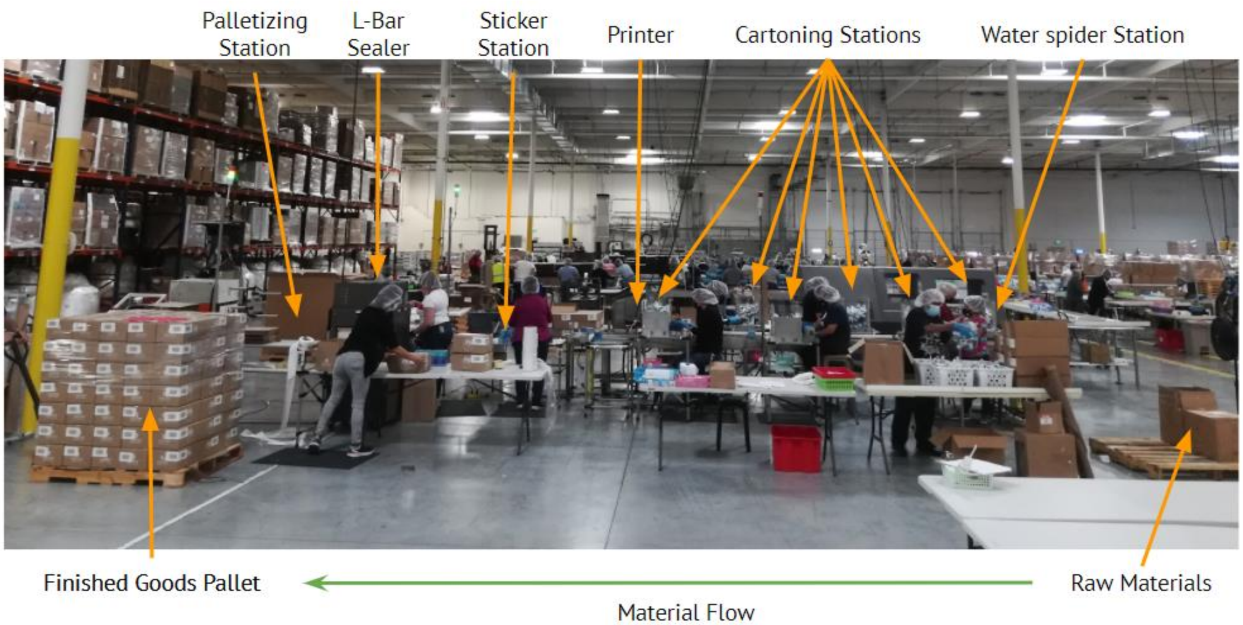

Figure 7: Image of the Future State 10 count carton Line

The projected annual savings is $1.26 million for the new line layout running across 3 production lines and 2 shifts. The new line is implemented for the production of 6 count and 10 count cartons, with the 6 count (6ct) line accounting for 62% of production and the 10 count (10ct) line accounting for 38% of production. The projected annual savings was calculated according to the values from Table 1 and the formula below:

$$\text{Annual Savings} = (\text{Labor Cost Saved 6ct} * \text{Proportion 6ct} + \text{Labor Cost Saved 10ct} * \text{Proportion 10ct}) * 3 \text{ lines} * 2 \text{ shifts} \quad (1)$$

Table 1: Table with the Breakdown of Annual Savings

	Labor Cost Saved	**Proportion of Production**	**Annual Savings (3 lines, 2 shifts)**	**Total Annual Savings**
6 Count Line	$198,000	0.62	$737,000	$1.26 million
10 Count Line	$230,000	0.38	$524,400	

5. Conclusion and Final Thoughts

Over the course of 10 weeks, the HMC Riggs Fellowship team introduced WePackItAll to the concepts of Lean manufacturing; using them as the guiding principles to transform the secondary packaging line. The line meets the production goal of 6000 cartons per shift while eliminating excess inventory, reducing line footprint, and maintaining high quality.

The introduction of a material handler and Team Lead has led to a more team-oriented work environment. Ergonomic workstations help control material flow on the line and Andon lights facilitate communication with the Team Lead, the warehouse and aisle support. Moreover, the team trained supervisors on Lean improvement strategies and received significant buy-in at every level, from individual operators to management. A culture of continuous improvement is the most important deliverable for this project and the Riggs team has confidence that supervisors and management on the floor can build upon the cultural shift that has already started.

Overall, the Riggs team successfully implemented a Lean manufacturing system on the packout line that has a predicted annual savings of $1.26 million. The introduction of Lean methodology and continuous improvement changed the culture of WePackItAll across all levels. The methods used to increase material flow, improve communication, and decrease inventory can be applied to other labor-intensive lines with low takt time.

6. Acknowledgements

The Harvey Mudd College Riggs fellowship team would like to thank Natan Bershtel, Jack Bershtel, Vanessa Jimenez, and WePackItAll for the opportunity to apply Lean manufacturing concepts to their carton packout lines. The team would also like to thank everyone involved in this project who helped make it a success. Special thanks to Greg Pagani for his invaluable contributions to the team and for his help bringing ideas to life on the line. Another special thanks are in order for Javier Lopez, Margarita Perez, Steven Placencia, John Rudolph, Nelly Perez, Diana Padilla, Katherine Agular, and the operators on the line for their time, support, feedback, and willingness to adapt to the new line flow. The team would also like to thank Troy Saunders, Rob Perhamus, and the Harvey Mudd College summer machine shop team for their help machining critical components of the implemented designs. Finally, the Riggs team would like to thank Professor Gokli for his continued support and guidance throughout the project.