Improving Layout and Efficiency of Assembly Area

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***Abstract*— Within industrial engineering, student teams are hand-picked to work on a company-sponsored project. Hoffer Plastics is sponsoring a project aimed to optimize one of their machines, which had an inefficient layout as well as high variation between processes from worker to worker. Using time and motion studies, data analysis, and 5S, we studied and analyzed the current state of the production area. Our recommendations are based on implementing lean tools like 5S+1 audit, layout improvements, and an analysis of ergonomics.**

Keywords- Lean Manufacturing, Worker efficiency, Layout Analysis

I. INTRODUCTION

Hoffer Plastics was founded in 1953 by Bob and Helen Hoffer. When creating the company, they had the goal in mind to meet four core values of family, integrity, service, and trust. Hoffer Plastics soon became a leader in custom injection molding offering a variety of injection molding services. Products produced from the molding processes range from food container caps like the twist tops for baby food, engine caps for automobiles, and even drywall screws (drywall anchors). The primary focus of the project is the assembly machine liner 7 and the areas' layout.

II. OBJECTIVE

The main objective is to increase the overall efficiency of the procedures involved with operating liner 7. More specifically, the objectives include (i) identifying and reducing the amount of waste produced and reducing the travel distance for the workers, (ii) analyzing and updating liner 7 standard procedures, and (iii) improving the layout for the area around liner 7, with proper workstations, designated areas for raw material and equipment. This will be achieved by implementing a 5S with a 5S+1 audit, that can be used to track improvements. An analysis of ergonomics will also be achieved with an added layout improvement. Lastly, the development of three layouts along with comparisons, cost analyses, and alternate configurations of the given layouts will be given to Hoffer Plastics. These layouts will not consider the moving of designated monuments by the company or consider the scheduling of machines.

III. DATA COLLECTION & ANALYSIS

A. Current State

The current layout of Liner 7 is a U-shape flow with opposite inbound and outbound sides. The flow of caps, foil, and boxes on liner 7 is shown in yellow, blue, and green in Figure 1. Totes, which are large bins of unlined caps, are loaded into Liner 7 on the tote tipper. Unlined caps are then moved by a conveyor into a sorter. The sorter orientates the caps, so they are all facing up and are ready to be stamped. The sorted caps are then moved on an in-feed to be stamped with foil, once stamped the caps are considered lined. The lined caps then go through the out-feed, into a vision station that rejects miss stamped caps. Then the acceptable caps are fed into a box or tote.

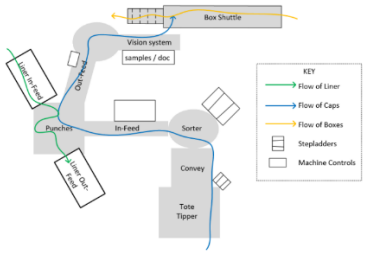

FIGURE 1. CURRENT FLOW OF CAPS IN AND OUT OF LINER 7

The Liner 7 fill rate is about 1 minute per box, and 45 minutes for totes. When accommodated to fill totes instead of boxes, the box shuttle is moved to the side, and a different attachment is used. The box shuttle is moved about 3-4 feet away and blocks the main hallway behind liner 7. There are four main target areas in liner 7: Tote loading, liner in- and outfeed, box loading, and box unloading. These areas require the operator to perform an operation at, for example, changing foil reel, or loading unlined caps into the machine.

B. Spaghetti Diagrams

Spaghetti diagrams for both tote-filling and box filling operations were used to visually represent the path of the worker operating liner 7. Video footage was taken for 15-20 minutes, for both tote-filling and box-filling configurations of liner 7. The video footage and spaghetti diagrams do not show the following: scanning finished boxes, loading new tote, changing over parts, and clearing any jams. Boxes were taped and stacked on a pallet, then where scanned in bulk.

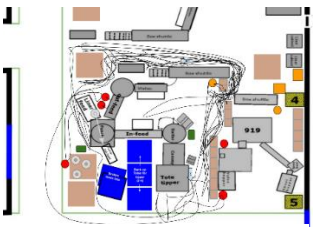

FIGURE 2. SPAGHETTI DIAGRAM OF BOX FILLING LAYOUT

A few important observations were noticed in the spaghetti diagrams. Workers would scan taped boxes in bulk from 4 to 8 boxes or they would scan one by one as they finished a box. Another important

observation is that operators often had to take multiple steps back and forth when reloading a foil-reel on Liner 7. The continuous flow of the workers also showed long travel distances because they are forced to walk around the entire machine at times. The box shuttle is used as a desk which adds to the distance of having to walk around the machine rather than having a designated workstation.

C. Flow Process Chart

A current state flow process chart was created to identify and track the tasks. For roughly 20 minutes the operator did a total of 50 tasks. The tasks were broken down into categories of operation, transportation, inspection, delay, or storage. The operations were then broken down into value-added, non-value added, and essential non-value-added work seen in Figure 3.

FIGURE 1. SUMMARIZATION OF OPERATIONS

D. Ergonomics Study

The main ergonomic risk found was the repetitive motion of the operator leaning and lifting when removing a box off the shuttle. A box on the shuttle fills up every minute and varies in weight by product but is roughly around 20lbs. The operator is required to lift the box off the box shuttle and onto a taping machine. The box is pushed on rollers to be taped shut, then lifted and brought to a pallet where it is then stacked and scanned in as finished goods with varying heights that reach ~6ft. This repetitive motion lifting, walking, and stacking boxes, is also done while attending to other parts of the liner machine. 3DSSPS software was used to analyze the postures and motions. The results state there was no critical fatigue placed on the workers, but their center of gravity was not centered which creates a falling hazard.

IV. SOLUTION APPROACH

E. Applying 5S

In the first S (*Sort*), the goal of this was to identify and tag any equipment, not in use and or waste in the area. Each tag placed was labeled with the date, item description, item type, reasoning for the tag, and any additional comments. All tags placed were later documented in a Red Tag Log which placed the items in disposition to await further removal if necessary.

Plans for *Set in Order* are the implementation of a color-coded marking on the assembly floor, an adequate storage plan, and define locations for tools and equipment. For workstations around liner 7, the goal is to have set locations for items and something to refer to the items. By implementing this, misplaced and missing items will be more obvious. After *Set in Order*, *Shine* will be started with a cleaning of the area around Liner 7. Visuals for cleaning standards in the area will be created, in addition to cleaning schedules. To implement *Standardize*, a standard inspection sheet will be created, along with the updating of standard work document for liner 7. The use of visual directions will be helpful for liner 7 because of the large number of temporary workers on shifts. Pictures of the 'right and wrong' will be displayed around liner 7 to help guide temporary workers. Lastly, to *sustain* the system, we plan on having management enforce the changes that were made during the implementation of 5S. Management will also be responsible to follow up in performing a 5S+1 audit to monitor the area.

F. Layout Proposals

The following are brief descriptions on changes from the current state to the proposed layout:

- Proposal 1: Outgoing filled boxes changes direction causing the flow of boxes shown as arrows on box shuttle. Finished boxes can share a packing area with a machine 919. Currently, machine 919 doesn't have a usable box taper area.
- Proposal 2: Machine 919 is moved out of the area, to another factory location. On Liner 7, Tote-tipper & Conveyor are rotated, along with the box shuttle. Liner 7 completes a proper U-shape flow
- Proposal 3: Machine 919 is moved out of the area, to another factory location. On Liner 7, the box shuttle is rotated 180 degrees. The layout has free space and is used for WIP and equipment storage against the back wall.

Proposal 2 was found to have the most improvements based on the current layout. Table 1 shows areas of improvement in proposal 2.

TABLE 1. PROPOSAL 2 IMPROVEMENTS FROM CURRENT STATE

	Tote Loading Area	Liner In- and Out-Feed Area	Box Loading Area	Box Unloading Area	
Process Occuring (Operator point of view)	1 Feed unlined caps into machine	3 Refill/feed in new liner reel	Label boxes	Tape box	
	2 Replace Tote	throw away stamped reels	Line boxes with bags	Stack tapped box on pallet	
			Load bag lined boxes into feeder	Scan stacked box	Box Shuttle
Floor space needed around area	4 Hour WIP totes (3-4)	1 Pallet of reels	unlined boxes	Pallet for WIP	6 Changeover storage for tote-filling equipment
			bagged boxes	7 Pallet for finished	Changeover storage for box shuttle equipment
Tools/ Equipment needed	Garbage	7 Scissors	Bags	11 Scanner for finished boxes	
		Garbage	9 Table for lining boxes	12 Skid	
		8 Sample clipboard	10 Label boxes		

V. CONCLUSION

Hoffer Plastic will pick a layout to implement once cost analysis is completed. Once 5S is complete and a layout has been implemented, a 5S+1 audit will be performed to compare the new layout to the old layout.

VI. ACKNOWLEDGEMENTS

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