DEVELOPING AND IMPLEMENTING AN ERGONOMIC PROCESS IN CONSTRUCTION MANUFACTURING: A CASE STUDY

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ABSTRACT

The purpose of this project was to improve the workflow process of a company that manufactures structural insulated panels (SIPS). During an initial facility walk-through and discussion with employees and management, it was determined that manual materials handling, product flow, product quality, and potential for worker injuries were issues of primary concern. The issues were addressed with the implementation of an ergonomics process, which consisted of: identification of the issue, analysis of the issue, solution development, solution implementation, and solution evaluation. This paper presents the workflow process potential improvements and discusses the solutions.

INTRODUCTION

This ergonomic evaluation was conducted at a small construction manufacturing company that specialized in structural insulated panels. The company was two years old, and had 15 employees, three of whom were office personnel. The remaining workers were manufacturers or production supervisors.

Construction manufacturing is an emerging practice in the building industry. Examples of this emerging practice are seen in prefabricated roof trusses and "kit" homes. The combination of construction and manufacturing raises concerns found in both fields, as well as new issues that result when combining the two. Concerns in the construction industry include injury reduction, while concerns in manufacturing involve product quality and production. Thus, the goal of this project was to focus on reducing manual materials handling, increasing efficient production, improving product quality, and reducing risk factors associated with musculoskeletal disorders (MSD's). Both a micro and macro ergonomic approach was taken, with the micro-ergonomic aspect pertaining to the construction portion of the process. This involved items such as workstation layout, building practices, and worker health and safety. The macro-ergonomics were assessed as the manufacturing portion, with items such as the workflow process and product output as the primary focus.

PROCEDURES

Recommendations for workplace changes were based on video and photographic assessment, as well as worker-input. Site visits were conducted in order to learn the layout and flow of the production process. Distance and weight measurements of materials were taken to determine where efficiency could be improved. The assembly floor of this facility was divided into five different areas: cutting, assembly, foam injection/press, cleaning, and quality assurance.

Areas Analyzed

Cutting. In the cutting area of this plant, workers were required to lift and move 24'x4' sheets of oriented strand board (OSB), weighing up to 150lbs each. The workers first lifted the OSB from a horizontal stack located below knee height, turned the OSB vertically, and then moved it to be cut with a vertical saw. Cutting of OSB was normally conducted by two workers, but was still a difficult task. After this activity, workers said they were very tired and wanted an easier method to move the OSB.

Management was concerned about the underutilization of a table saw which was a significant capitol expenditure. It was learned that the saw was not used due to the difficulty of supporting the long sheets of OSB on either side of the saw. A bow was created in the middle of the OSB when trying to cut, making the saw non-functional for cutting the long sheets. Due to the layout of the plant, the OSB had to be maneuvered around a corner to be placed on the saw. This movement was almost impossible with the 24' sheets. The saw was purchased with the intent of making the cutting process easier, but actually created more problems.

Assembly. The current assembly process used techniques commonly found in construction. Each panel was assembled at one station by one worker. The initial assembly process took anywhere from 0.5 to 2.0 hours, depending on the complexity and style of the panel. Workers walked up to 75' each way to gather needed materials located throughout the plant. The saw used to cut material to size was also located 5' to 25' from the workbench, depending on which workbench the worker was coming from. This could equate to a distance of over 400 feet traveled per panel. This was a conservative estimate, as it did not include the possibility of multiple trips to each destination. This excessive amount of travel ultimately cut down on time spent assembling the panel, which lead to a lower rate of production.

When workers assembled panels, there were several tasks performed which were inefficient and increased the risk of injury. The task that was of the most immediate concern was the spline installation. A spline was a formed piece of sheet metal which ran the length of the panel. To install a spline, a worker took the spline and screw it onto a rail attached to the panel. The workers used a 3" wood screw to do this, even though the thickness of the spline and the rail combined was only 0.5". To hold the spline onto the rail, workers cupped their hands over the spline and rail where they placed the screw, which resulted in a high risk for puncturing their hand.

Foam injection/press. In the foam injection and press area, a framed panel was injected with an expanding two-part polyurethane foam. The panel was then put into a press where pressure was applied on all sides to hold it together under the foam's expansion. The company had two flat presses and one corner press in which panels were injected. For the foam to properly cure, each panel had to stay in the press for 1.5-2 hours under pressure. With a small number of presses and a lengthy turn around time, this area was the bottleneck of the production process.

When workers inserted a panel into the press, they were required to "block" the panel. The blocking process consisted of surrounding the entire panel with blocks of wood to make sure that when the foam expands, it is not past allowable tolerances for a panel. If this process was done improperly, parts of the panel could come apart, rendering it unusable.

If components inside a panel were not properly installed before foam injection, quality was also a concern. Problems with pieces such as splines detaching, moving, being installed incorrectly, or not having enough foam injected could make a panel unusable. According to workers, 20% of all panels placed in the press had to be reworked. However, this actual number was unknown due to a lack of a formal quality monitoring system.

Cleaning. In the cleaning area, workers took panels from the press and removed unnecessary materials, such as the rails and screws or excess foam. Windows, doors and electrical systems were also cut from the OSB in the cleaning area. In order to get a panel within the acceptable tolerance of 1/16", workers scraped, sanded and sawed the panel. If multiple panels required cleaning due to faulty assembly, workers were pulled away from the assembly process, decreasing production.

Quality assurance. The quality assurance area was where all of the panels were test fit together to assure panels fit together, that each panel was flat, and that assembly in the field would go smoothly. Panels were lifted and carried to get them in their appropriate position to be fitted together. Each panel weighed up to 300 pounds, making this is a labor intensive process. Two people performed this task, but there was no mechanical lift assist. The panels are carried to the quality assurance area after they were cleaned and placed on the floor for storage. Workers then lifted the panels off the ground, fit them together, and then placed them back on the floor. This extra handling not only increased the risk for injury to workers, but added no value to the product.

RECOMMENDATIONS

The recommendations to the company were based on the four aforementioned goals: reduce manual materials handling, increase production, increase product quality, and decrease risk factors associated with musculoskeletal disorders (MSD). Recommendations for this company were at the micro and macro levels of ergonomics. Recommendations for each of the five areas are discussed in further detail below. In addition, a suggestion for the overall production layout is given.

Areas Analyzed

Cutting. In the cutting area, rolling carts would reduce manual materials handling and lifting of the OSB. The rolling carts also facilitate the use of the underutilized table saw. Another way to increase saw use is the implementation of a scissor lift. This maintains the OSB at a constant level equal to that of the saw, eliminating lifting by workers. Orienting the OSB in a way that keeps it going the same direction throughout the manufacturing process would also allow access to the under-used saw. Ideally, most challenges in the cutting area could be reduced with the investment of a Computer Numeric Control (CNC) saw, which would eliminate workers having to move and cut the OSB. This may not be a feasible option, however, due to the high expense of this machine.

Assembly. The first suggestion for the assembly area is to implement continuous flow manufacturing. This can be accomplished by changing the current process whereby a single person assembles a single panel at a stationary work bench (see Fig. 1). The work area would become a moveable cart which would stop at three stations for assembly of specific components of the panel with a different person at each station.

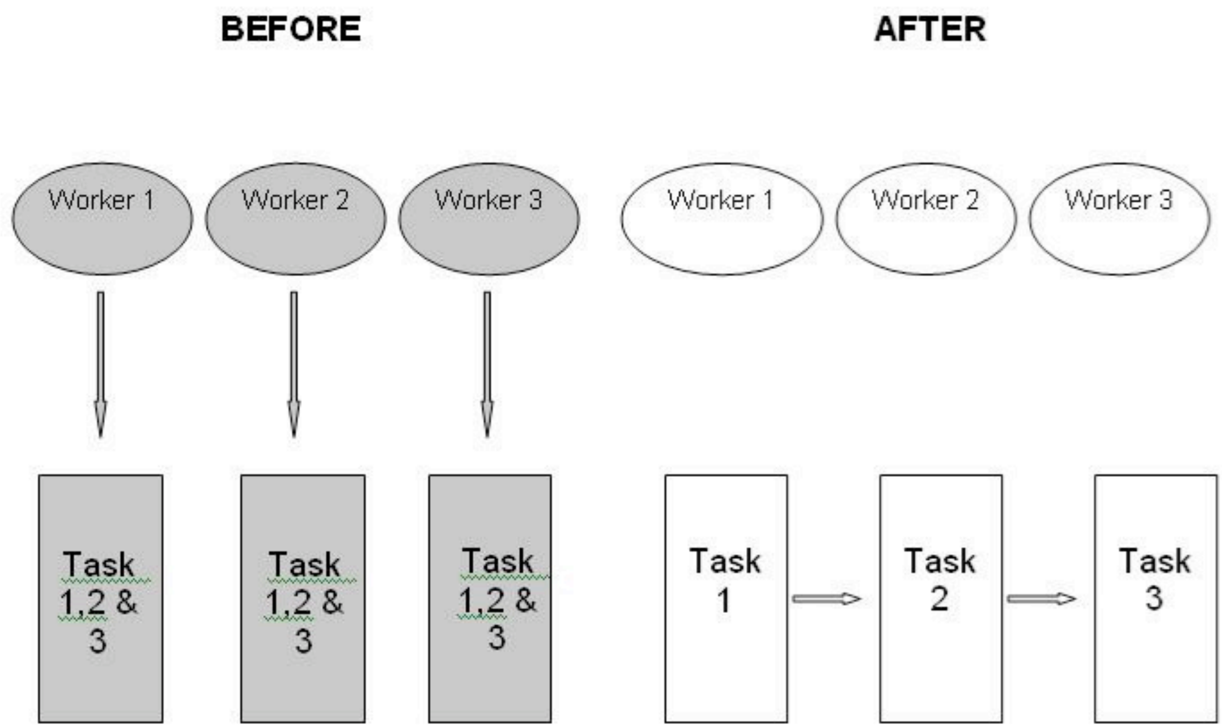

Figure 1. Conversion to continuous flow process.

The second recommendation for the assembly area is to alter the current materials storage. Material necessary for each assembly step should be conveniently stored at the corresponding station. For space saving purposes, material can also be stored vertically instead of the current horizontal layout.

Finally, the spline installation can be fixed in a very quick and effective fashion. One option is to use shorter screws. Self-tapping, ¾" sheet metal screws would sufficiently hold the spline to the rail, but would eliminate the risk of the worker injuring a hand. Another option is magnetic strips placed on both the rail and the spline. Both the spline and the rail are made of steel, so it would only be a matter of making sure the magnets purchased were strong enough to hold the two together. This option would also cut down on assembly time.

Foam injection/press. The bottleneck of the manufacturing process is the press. Ideally, a new redesigned press would be added to allow for more panels to be injected at once, reducing the bottleneck. This newly designed press could include airbags which would inflate around all sides of the panel, completely eliminating the need for blocking.

In addition to a new press, a double check system should be implemented in the press area. Workers should have a checklist to go over before foam injection takes place. This would find and prevent any problems with the panel, such as incorrect assembly, parts detaching, etc. Two employees going through a checklist would further affirm that no mistakes are made.

Cleaning. While there was no specific recommendation for the cleaning area, less cleaning and rework will be needed if the preceding recommendations are followed. The aforementioned changes will reduce errors that require cleaning, such as improper installation, and allow workers to have more time for panel assembly.

Quality assurance. The final area, quality assurance, is very labor intensive; the lifting of heavy panels is the biggest concern. Using a mechanical assist such as a scissor lift or vacuum hoist would reduce or eliminate lifting of heavy panels. Also, by checking the panels in their order of assembly, they will not need to be resorted and stacked.

Plant layout

These recommendations take a micro-ergonomics approach to this assembly process and address some of the specific steps to be taken to improve production, reduce errors, and decrease potential for worker injury. Looking at a macro-ergonomic approach, the layout of the production facility should be changed to optimize workflow and reduce travel to get materials.

The current layout can be optimized by moving materials to an area where they can be easily accessed at that particular stage of production. All of the 2’x4’s should be located next to the OSB, which should then be located next to he saws. The splines, rails and screws should be located at the first assembly “station”, and so on. Implementing a flow process would cut down on distance traveled for workers and save time during assembly.

Quality monitoring

In order to address the issue of not knowing the rework rate at this production facility, a quality monitoring system should be implemented. This system would be a detailed way to track where in the production errors occurred. By doing this, workers are able to determine what went wrong and create a proactive solution instead of a reactive repair. A basic Microsoft Excel sheet tracking panel number, date worked on, worker name, problem, solution and recommendations would be more than ample to get an idea of where quality concerns were occurring.

CONCLUSIONS

As a wrap up to this project findings and recommendations were presented to the president and top management of the company. Working with this company was beneficial for both the company and for us as students. It was a learning experience in which several challenges, including conflicting schedules, variation in workload, and money for improvements were encountered. Some of the advantages of working with this company were that they are a young company and were open to suggestions. The workers were also young, energetic, entertaining, and open-minded, making this project a great experience.

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