ABSTRACT

Regardless of industry, one of the key processes of manufacturers is material handling. A great deal of waste can often be found in the material handling processes of manufacturers. The operational management teams of firms are often tasked with the hurdle of reducing this waste to meet business goals and meet customer demand. Many times, techniques such as lean manufacturing are mandated as the methods by which operational groups must reduce this waste and create improvement opportunities, but a specific roadmap to define the objectives of the operational group is not provided. The goal of this research is to develop a methodology that will provide management groups with a tool to assist in defining the objectives of lean manufacturing implementations. The central focus of the methodology is to identify waste and prioritize solutions based on the business goals of the organization.
INTRODUCTION

Modern manufacturing facilities are faced with escalating challenges in the world market. The globalization of firms that produce manufactured goods has forced firms to re-evaluate the goals and the expectations of their managerial teams. One area that is of increasing concern in manufacturing is material handling. As the need to meet growing demand and greater customer expectation drives organizations, the need to monitor and manage the flow of materials through processes becomes increasingly important.

The proper flow of materials through processes allows firms to generate and maintain a competitive edge. This edge is the ability to meet customer demand for on time delivery, generating good customer satisfaction. The proper selection of material handling systems and manufacturing concepts such as lean manufacturing (Hobbs, 2004) help to facilitate meeting management goal, specifically increases in productivity. These tools also contribute to creating a safer and more ergonomic work environment.

Material handling is defined, simply, as moving material. This is the popular perception that many hold, but in fact material handling includes much more than simply moving material. For a significant number of manufacturers, material handling can account for more than one-half the total cost of manufacturing. The flow, movement, and storage of materials in the manufacturing processes of firms often require a great deal of resources, both employees and equipment.

Material handling is also regarded as being a non-value added function that is still necessary for the successful completion of the manufacturing process and can have a marked affect on the ability of a firm to meet managerial goals (Myers and Stephens, 2000). The cost generated by material handling systems can be reduced if steps can be taken to improve these systems. Productivity and the incidence rate of injuries, specifically lost time injuries, can also be improved by positive changes to material handling systems.

Lean manufacturing is based on the elimination of waste from the processes, both value added and non-value added, used to produce goods and services. There are five primary elements to consider when implementing lean manufacturing holistically; manufacturing flow, organization, process control, metrics and logistics. Feld (2001) has defined these elements and the specific tools that can be attributed to each of these elements.

It is the responsibility of higher level management to define the tools and concepts that operational management can use to address such problems, but it is not the responsibility of this level of management to provide a road map or specific methodology to deploy these tools. Nor is it their responsibility to define what the specific goal of individual work cells will be.

The problem addressed by this research is defining operations management objectives of implementing lean manufacturing to material handling systems of a petroleum drill bit manufacturing company. The implementation of lean manufacturing has been mandated by higher level management as a tool that will be used to assist in waste reduction. Operational management must define what the goals of lean manufacturing will be when deployed to specific work cells.

Converting the culture of an organization to lean manufacturing and lean thinking in general is a large task. A best practice of lean manufacturing implementations is to approach the event slowly by implementing in a single pilot cell and then continue to spread to other areas of the organization (Wilson, 2007). This method of implementing lean manufacturing cell by cell allows for concentration on the specific area to help ensure success, even though concurrent
implementation of multiple cells can occur. Our case study will be limited to the implementation of the developed methodology and lean manufacturing principles in a single cell to support the use of this best practice.

LEAN MANUFACTURING IN MATERIALS HANDLING

Lean manufacturing is a tool that many companies focus on for continuous improvement of processes. Long term strategies as well as short term goals of these firms involve implementation of lean manufacturing to eliminate waste and boost performance. However, many of these companies only undertake the initial strategic move of defining lean manufacturing as a philosophy and never provide functional roadmaps to daily operations teams for the implementation of lean manufacturing. Biddle (2006) indicates that the time and resources to sustain lean manufacturing are often not provided by top management to operational management teams).

One of the key areas where a sustained lean manufacturing implementation can have great affects on the performance of a company is material handling. However, not sustaining such an implementation and not approaching the implementation holistically can lead to incomplete solutions that may actually generate additional waste instead of eliminating existing waste. Flinchbaugh (2005) points out that lean manufacturing applied to material handling should encompass all available lean manufacturing tools, consist of a complete view of the technique, and not be an extension or single facet of a lean manufacturing implementation. Management should look at the problem completely and consider all key concepts and techniques. This systems approach is necessary, regardless of the focus of the lean manufacturing implementation, be it either the social or technical aspects (Cutcher-Gershenfeld, 2002).

Five key steps for implementing lean manufacturing to material handling systems are defined by Harris and Harris (2006). These steps include (1) develop a plan for every part, (2) build the purchased parts market, (3) design delivery routes, (4) implement pull signals, and (5) continuously improve the system. While these steps are valid for many material handling systems, the steps do not provide a method for determining what management’s goals are for a lean manufacturing implementation into the material handling system and do not define a method for correlating these goals back to the objectives of the business unit. Much research has been undertaken in the areas of lean manufacturing and material handling, but none prescribes a specific methodology for determining management objectives of implementations of lean manufacturing, or how to spread this methodology to more than one problem area.

Schieber (1999) approaches the specific problem of determining a more effective way of handling stock packaging materials in a food industry firm. The method used to conduct the study was focused on employee involvement and reducing the occurrence of back injuries by manually handling the stock material. The importance of the interrelationship of the product components and all parts of the process must be considered, but a specific methodology for defining management objectives and implementing lean manufacturing is not prescribed by this research.

A holistic approach is optimal, but any implementation must be linked to the objectives of the firm. Cochran et al. (2000) states that system design methods must be tied into the objectives of the system in order to be effective. The research goes on to say that piece-wise implementations are also ineffective when and if the overall objectives are not understood. This
point relates directly back to the need of developing a method to define the specific management objectives of a lean manufacturing implementation. Also, it relates to the point that these objectives must be tied into the objectives of upper management, the tools used for the implementation, and the solutions developed by the implementation. Without a clear path, the potential of developing an inadequate solution is more probable.

**METHODOLOGY**

The methodology used to determine management objectives of lean manufacturing in a material handling system of a machine cell involves several steps. These steps begin with management input to determine what the goals of the business unit are and what the goals of the operational group have been defined to be. A lean manufacturing assessment must be conducted to determine the potential locations of waste reduction. Development of a lean manufacturing strategy will help determine how lean manufacturing assists in the overall implementation strategy and how the potential solutions can be prioritized for selection and implementation.

The definition of management objectives of lean manufacturing are determined as a result of the prioritization and comparisons of possible solutions and the overall strategy. The implementation of lean manufacturing tools and solutions development assists in determining how the implementation of the tools and solutions will fit into the process and how several concepts can be followed as guidelines to help ensure the success of the implementation. Finally, the solution is implemented and monitored through selected metrics to gauge continuous improvement and reinforce objectives and goals of both the work cell and business unit. These components are displayed in Figure 1 and are further explained below.

**Management Input**

Management input includes the objectives of the organization as defined by higher management as well as the business objectives of the operational groups and teams. The primary goal of the operational management group is to define the specific tasks, processes, and resources that will be used in the production unit to meet the business goals defined by higher management (Stevenson 2002). The key focus, regardless of what tool is implemented, is meeting the goals of the operational group so that the higher level goals of the organization can be reached and customer needs met.

The input of management is very important. This input lays the basis for deployment of the methodology and affects the development of any possible solutions. Many facets of the organization beyond high level production management affect the overall performance and objectives of the operational groups. Even though these operational groups or plants report through the higher level production management group, they also take some direction and input from other functional groups such as human resources, finance and accounting, technology and research and health, safety and environmental groups.

**Lean Assessment**

Once the business unit goals of the operational group have been defined, a lean manufacturing assessment must be undertaken to determine where areas of opportunity exist for improvement.
Management Input

Lean Assessment

Development of Lean Strategy

Implementation of Lean Tools and Solution Development

Solution Implementation and Monitoring

Management Objectives of Lean Manufacturing

Figure 1: Lean manufacturing implementation procedure
With material handling being the focus of this research, the lean manufacturing assessment should focus on the way that materials flow through the processes of the organization and how this material flow affects what is expected of the operational group. The assessment must be done while keeping in mind that the focus of any lean manufacturing implementation is the removal of waste from the system. Material handling is generally considered as a non-value added activity that must be done in order to move product. Any improvements in these systems will help to eliminate waste.

The lean manufacturing assessment can be carried out in a variety of ways. The two most effective ways of assessing are value stream mapping, looking at the current process flow and what is desired in the future flow, and examining the physical arrangement and logistics used to move products in relationship to where the products originate and their destination.

A typical value stream map would look at all steps of the process as the product moves from one operation to the next, including all time that the product would spend in queue, in transport, being worked on, and waiting on set-ups and administrative work to be completed. Since the focus of this research is management objectives of lean manufacturing, value stream mapping will not be covered in much detail. The key point is that when addressing material handling, value stream mapping and analyses of facilities layouts must take into account every movement of the product regardless of the distance or time that it takes to perform the movement.

**Development of Lean Strategy**

The development of a lean manufacturing implementation strategy that is in line with operational group objectives is very important. The development of this strategy will show how lean manufacturing tools are tied into business unit objectives and thus lead to the definition of managerial objectives of lean manufacturing.

The first step in the development of the strategy is to decide the location of the initial implementation within the value stream. The area that this decision will point to will be based on the results of the value stream, the area that has exhibited the most waste, and management needs, specifically what areas can or cannot be addressed based on capital requirements or operational importance.

Once the area, or cell, of the initial implementation is identified every occurrence of material handling in the cell must be reviewed and compared against the business objectives of the operational group. This comparison will lay the foundations of management’s objectives of lean manufacturing of material handling in the cell. The business objectives of the operational group can consist of such things as specific productivity or through-put numbers, engineering and safety goals, raw materials and consumables projections, direct hours, and overtime hours worked versus those planned. Regardless of specific business unit goals, management must prioritize them and compare them against any possible solution that is presented to eliminate waste in material handling from the chosen cell. All business unit goals should be prioritized by top management.

The sum of the affects of a specific solution on each waste location should be compared and the solution with the ability to contribute to the most business unit goals should be the first solution implemented. It should be noted that any given solution may address multiple areas of waste and that these solutions should be weighted appropriately according to the need of management. By using weighing techniques on solutions that affect multiple waste location
areas, management can focus resources on solutions that affect the most waste reduction areas that contribute to meeting the most business unit goals. The use of weighing techniques forces a prioritization of what is most important in meeting the goals set by upper management.

**Definition of Management Objectives**

Once the solutions and their affects on the business goals of management have been prioritized, the decision to move forward with an implementation can be made. The selected solution will have a set of steps or processes that must be carried out for successful implementation. The process steps of the solution, their completion, and the series of metrics selected to measure them are management’s objectives of lean manufacturing in regards to material handling systems of the selected cell. These objectives of lean manufacturing are based on the operational management group and what they must accomplish to meet the greater goals.

**Selection of Lean Tools**

The selected solution should be developed using all available lean manufacturing tools. Both the equipment used as well as the process involved in material handling should be examined to determine the best steps when applying these tools to the area that has been selected to element waste. It is most beneficial when a holistic approach is used.

Feld (2001) stresses that there are five primary elements of lean manufacturing and that these elements cover the full range of issues that surface during an implementation. These elements and the tools associated with them give the basis of the tools and measurement techniques that can lead to a successful solution and implementation.

Some examples of tools that can be applied to the solution or used to implement that solution are cell layout, operational rules, total productive maintenance and 5S. Each of these tools approaches the lean manufacturing solution and implementation from either the process standpoint, such as cell layout and operational rules, or from the equipment layout, such as total productive maintenance and 5S. When combined with effective metrics for material handling and business unit goals, such as travel distance, space utilization or productivity, optimal benefits can be gained in the elimination of waste.

While there is no defined way to approach and use these tools, there are some best practices to use as guidelines. Cutcher-Gershenfeld (2002) explains that providing a learning culture, encouraging employee involvement, encouraging openness to new ideas and developing trust between employees and management all play a big role in successful lean manufacturing implementations.

If these practices can be maintained and teamwork fostered from them, then both management and employees have clarity on how their contributions to the solution and implementation can lead to success. If these practices are made important to management and not minimized, then they can also lead to a high degree of employee and management “buy-in” to lean manufacturing and the presented solution. “Buy-in” is very important due to the fact that if the appropriate effort is not put into making the solution and implementation work, then more waste can be generated than is removed.
Solution implementation and monitoring

The implementation of the specific solution must be performed by the individuals who are responsible for operations in the pilot cell. If these employees do not have responsibility for making the improvement, then they will feel that they cannot be held accountable for its success and therefore will have no vested interest in making it work. The team chartered with the implementation must keep this in mind and to maximize return assign members of the pilot cell to assisting with the implementation.

There are also five concepts reviewed by Flinchbaugh (2005) that can assist in the approach of the implementation:

1. Avoid the Information Blizzard by having real-time information from the cell fed back so that problems with the implementation of the solution can be addressed as they occur, minimizing firefighting.

2. Elimination of White Space. Remember that waste is not only in the obvious places but can be hidden between defined process steps that appear to follow one another closely.

3. Right Size Everything. Large capital expenditures and complex solutions are not always the optimal solution. Solutions that exhibit these traits can often be cumbersome and non-user friendly, creating waste through the fight to have them used by the employees.

4. One Inch is Still Transportation. A solution that may generate removal of waste over a long distance may generate much more additional waste by having employees move single parts multiple times over very short distances.

5. Eliminate Functional Tunnel Vision. It is important to remember that even though material handling is the focus, the reduction of waste and the increased ability to meet business unit goals is the primary objective of all lean manufacturing implementations.

While the five concepts help in the success of the implementation of the solution there is also an important factor that cannot be forgotten, metrics. Metrics provide a way to measure the results of the solution against management objectives of lean manufacturing. The selection of metrics will be based on the specific objectives of the cell and should therefore be tied into the business unit goals.

Metrics should be selected carefully. Each metric selected should not only correspond to the defined goals and objectives but also to the lean manufacturing tools and solution component used to meet these goals and objectives. The importance of monitoring the implementation and recording metrics plays into one of the most important factors of a lean manufacturing, continuous improvement. All metrics should be recorded and charted to show how the solution is progressing. These charted solutions need to be made available to all employees, especially to those of the work cell where the implementation is taking place. The best way to show these metrics to all employees is to post them in the location of the cell.

By posting the metrics in the work cell, several things can be accomplished. The first is that the employees in the cell can have constant visibility of how the implementation and solution are affecting their performance and reaching the objectives of the cell. The second is that confidence is built in the philosophy of lean manufacturing. The third is that all members of the organization can see how and when additional efforts may be needed to continuously improve the effort to reduce waste in the system.
Metrics must be used to show continuous improvement. There is also the possibility that any negative affects that could occur due to the selected solution will not be recognized in time to address them before additional waste is created in the process. If this is allowed to happen, then the employees will deem lean manufacturing as a fad and not as a way to improve the ability to improve processes. This negative perception can greatly affect any future implementations.

CONCLUSIONS

The manufacturing environment has had many tools available for the act of process improvement. Lean manufacturing has proved to be one of the most successful tools that manufacturing facilities can employ. However, this tool is often mandated by higher level management as a way to reduce waste from manufacturing systems without a specific road map to carry this out on a case by case basis. Providing this road map is the responsibility of operational management units.

The objective of the research was to develop a methodology that would assist management in defining their objectives of lean manufacturing. In the case of this research, the methodology would be applied to reduction of waste in the material handling system of a machine tool cell at a petroleum drill bit manufacturer.

The methodology was developed using several lean manufacturing concepts, business unit goals, and the material handling issues identified through assessing the cell selected for the implementation. Once the methodology was developed, it was applied to a case study at a research location, the leading manufacturing facility of the drill bit manufacturer. Management’s objectives of lean manufacturing were defined through careful use of the methodology and potential solution concepts identified. These concepts were prioritized based on their affects on the business goals of the facility and a project was selected for implementation.

A specific solution was developed from the selected concept and the process of implementing the project using many lean manufacturing tools began. Key metrics were determined and monitored. Once data were collected and compiled, they were compared to similar data collected before the implementation began and analyzed for the success of obtaining managerial objectives of lean manufacturing in regards to material handling in the selected cell and thus business goals.

It was clear that the solution provided a method by which to eliminate a great deal of waste from the material handling system. Due to this, the solution was carried to other facilities with cells that performed the same or similar processes. It was determined that because of the success of the methodology in providing a solution to the material handling system of the research location, the methodology could be carried to other areas of the process and even other industries with similar success. By providing a methodology for management to determine and meet goals, operational groups can move toward providing road maps for the implementation of lean manufacturing projects.
REFERENCES


