Lean Transformation Strategic Journey:
From an Ordinary Manufacturing Site towards a World Class Manufacturing Site

Author: Xallya Aleman Rentas
Advisor: Dr. Carlos J. Gonzalez

Abstract

The MDP Company is a global medical device leader company in musculoskeletal healthcare market. One of its primaries manufacturing facilities is located in Puerto Rico where orthopedic implants and reconstructive products are manufactured and packaged. The site consists of two (2) manufacturing buildings designed in over twenty (20) manufacturing cells divided by product families and operates three shifts a week with over 500 employees. This project was focused on the identification and implementation of different lean manufacturing tools to reduce in 3 days the lead time through all manufacturing operations and to improve the manufacturing processes, thus, reduce production costs and convert the Puerto Rico manufacturing facility in one of the most profitable sites for the company. Before project start the average manufacturing lead time was 9 days with a work in process inventory cost of $2.7 million. By the end of this project, the lead time in pilot manufacturing cell was reduced to 6 days.

Introduction

The MDP Company is a global medical device leader company in musculoskeletal healthcare market. The company offers a comprehensive and diversified portfolio of musculoskeletal solutions. One of its primaries manufacturing facilities is located in Puerto Rico where orthopedic implants and reconstructive products are manufactured and packaged.

Of all medical device sectors, orthopedics is perhaps the most difficult for a large company because each section of anatomy requires its own set of considerations. Additional challenges occur since it is a regulated industry. Based on these facts, the manufacturing facility of the MDP Company located at Puerto Rico is constantly challenging its operations to improve their manufacturing processes, reduce production costs and convert the Puerto Rico manufacturing facility in one of the most profitable sites for the company.

Background

The main purpose of this project is to study, identify and implement the best lean manufacturing tools that may fit to our operations to support our mid-term goal of increase productivity while reducing manufacturing costs without impacting the quality of our products, aiming also to our long-term goal of becoming one of the top 5 MDP manufacturing sites.

Our first step is to achieve and maintain a consistent lead time reduction in each of our manufacturing operations which will lead to increase productivity and reduce production costs related to Work In Process (WIP) inventory. The lead time reduction to be pursued by manufacturing cell will be for at least 3 days less than current lead time.

Problem Statement

Our manufacturing site has a cellular manufacturing distribution, which means that all of the required processes and tools are distributed within working cells dedicated by family of products. These self-contained cells produce our products from start to finish and then continue to packaging operations. However, the logistic of the machines layout forced wasting time on operations by the need of the operators to move from one area to another area in order to complete the assigned manufacturing lots. This was a repeated scenario through all our manufacturing cells.

Because of this, a project was started at the third quarter of 2016 for the optimization of the manufacturing areas layout with the intention of improves lead time. It was then when born the idea of a Lean Transformation Strategic Journey to take out our plant from an ordinary manufacturing site towards a world class manufacturing site.

Project Methodology

The project for our site lean transformation strategic journey was structured based on the DMAIC methodology. The problem statement was studied and analyzed as a whole. Then, different lean manufacturing tools were identified to be implemented based on better fit for current/baseline processes.

DMAIC is a structured problem-solving methodology widely used in business. The letters is an acronym for the five phases of Six Sigma improvement: Define, Measure, Analyze, Improve and Control. These phases lead a team logically from defining a problem through implementing solutions linked to underlying causes, and establishing best practices to make sure the solutions stay in place as permanent solutions of an existing problem [1] [2].

Results and Discussion

The results discussed in this section correspond to Pilot Cell improvements implemented using the DMAIC methodology and different lean manufacturing tools as identified based on the problems to be resolved. Details for the tools used and results obtained are shown below.

Define

The Define Phase was conducted by completing the project charter (Figure 1). During the Define Phase the Voice of Customer (VOC) tool was used by conducting focus groups meetings to get feedback for existing processes and propose improvement ideas. The focus groups meetings help us to clarify and define customer (manufacturing pilot cell) needs. After focus groups meetings completion, a series of Kaizen events were conducted to identify obvious waste sources that can be eliminated easily and with minimal risk.

As result of the Focus Groups and Kaizen events, the first lean tool identified to be implemented was 6S because it can easily eliminate the

DMAIC

Project Charter

Title: Lean Transformation Strategic Journey

Problem Statement:
The logistic of the machines layout forced wasting time on operations by the need of the operators to move from one area to another area in order to complete the assigned manufacturing lots. This is a repeated scenario through all manufacturing cells.

Defect Definition:
Lead-time = Time from Process Start to Finish, which means the number of days from work order (W/O) release for production until work order is closed.

Project Objective:
The intention of this project is to achieve and maintain a consistent lead time reduction in each of our manufacturing operations which will lead to increase productivity and reduce production costs related to Work In Process (WIP) inventory. The lead time reduction to be pursued by manufacturing cell will be for at least 3 days less than current lead time.

Business Case/Project Benefits/Financial Impact:
- Be one of the most cost effective sites in one to five years. Rank among the top 5 MDP Company sites.
- A reduction in 3 days of lead time through all manufacturing operations and improvements in production execution will result in (WIP) inventory cost reduction from $2.7 million to $1.8 million increasing our cash flow by $900,000.

Assumptions/Constraints:
Assumptions:
- Machines will be available at least during one or two weeks (depending on validation activities complexity) for relocation and validation activities.
- Manufacturing operations will have safety stock of products before machines intervention.

Constraints:
- Limited results availability.
- Backorder of products after Hurricane Maria.

Project Scope/Boundaries:
The project will be focused on reduction of lead time due to wasting time.

Milestones/Timeline: *Scheduled* *Actual*
Due to the complexity of the project, timeline was divided by project phases.

Milestone	Start	Finish	Status
Business Unit 1 (Phase 1)			
Define	6/1/2016	7/31/2016	Done
Measure	8/1/2016	11/30/2016	Done
Analyze	12/1/2016	2/29/2017	Done
Improve	3/1/2017	10/31/2017	Done
Control	11/1/2017	11/30/2017	Done
Business Unit 2 (Phase 2)			
Define	12/1/2017	1/31/2018	Done
Measure	2/1/2018	5/31/2018	Done
Analyze	6/1/2018	8/31/2018	Done
Improve	9/1/2018	2/28/2019	Done
Control	3/1/2019	3/30/2019	Done
Business Unit 3 (Phase 3)			
Define	4/1/2019	5/31/2019	Done
Measure	6/1/2019	9/30/2019	Done
Analyze	10/1/2019	12/31/2019	In progress
Improve	1/1/2020	8/31/2020	Not started
Control	9/1/2020	9/31/2020	Not started

Team: (Assigned By Manufacturing Cells)
Manufacturing Operators SMEs
Manufacturing Supervisors
Quality Engineers
Manufacturing Engineers
Document Control Representatives
Metrology Representatives
Facilities Representatives
Maintenance Representatives
EHS Representatives
Validation Specialist Contractors
Change Control Representatives
Technical Services Representatives

Figure 1 Project Charter

Measure

During the Measure Phase we made an analysis of the current state of the manufacturing process for the manufacturing cell selected to be the pilot cell, comparing what is happening now to what is desirable in the future.

To establish a baseline, the first step was to evaluate the manufacturing cell layout. The pilot cell has a total of 34 machines / equipment in a total work space area of 6,811 ft² for the manufacturing of 8 product families (Figure 2). An average manufacturing lead time for these product families is 9 days.

Analyze

A spaghetti diagram was conducted for each of the manufacturing operations executed in the pilot cell. Figure 3 shows an example of the spaghetti diagram obtained for one of the product families manufactured in pilot cell. The analysis conducted evidenced an operator travel of 2,564 ft per lot. The logistic of the machines layout forced wasting time on operations by the need of the operators to move from one area to another area in order to complete the assigned manufacturing lots.

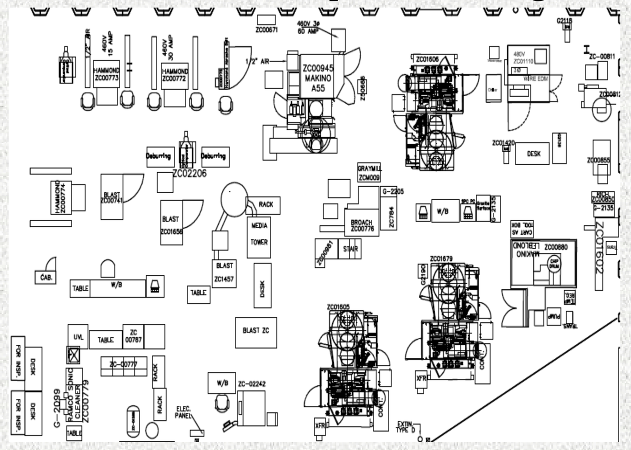

Figure 2 Current Layout

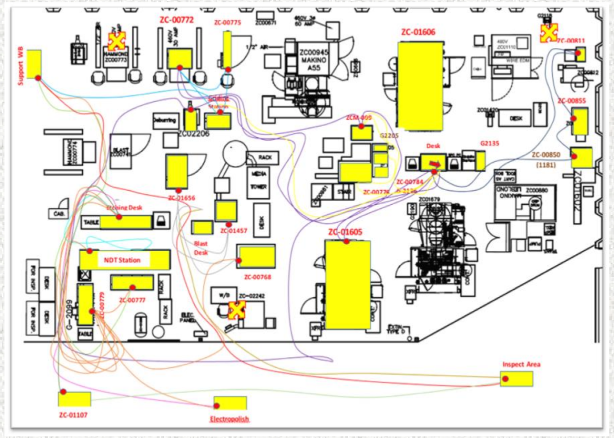

Figure 3 Spaghetti Diagram

Improve

During the Improve Phase, the possible solutions to the identified problem were developed and implemented. For this phase, we implemented some different lean manufacturing tools to obtain the expected 3 days reduction in lead time. A summary of the lean manufacturing tools/concepts implemented is included below.

5S/6S – This was the first improvement action implemented for our lean transformation strategic journey. Reduction of wasting time in simple things such as looking for tools for machine setup or gages for parts inspection was immediately visible resulting in productivity optimization and also making the workplace safer.

Continuous Flow – This tool was implemented in different ways; the most significant was the manufacturing cell re-design in U Shape to maintain a continuous process flow based on the manufacturing operations order (pilot cell have 8 product families and each product family have between 15 to 17 operations). Equipment not in use were relocated to an idle area to improve the manufacturing cell layout maximizing the workspace area only for equipment in use.

Bottleneck Analysis – As result of the analysis two legacy equipment were decommissioned and replaced by a new ones with more production capacity. Additional inspection equipment was also relocated into the pilot manufacturing cell since from the spaghetti analysis it was identified that one of the contributors to the wasting time of the operators by walking within operations was the inspection equipment which was located too far away in other manufacturing cell. In addition, manufacturing operations identified as bottleneck were split and added to subsequent operation .

Kaizen - Thru Kaizen meetings, process optimizations were identified for machining operations generally related to the machine setup and compensation / adjustments. These optimizations were implemented, validated and then the process capability statistical tool was implemented to maintain process controls on manufacturing operations. Waste elimination due to optimization and process standardization resulted in 80% inspection reduction, thus, productivity increased for multiple product families.

TPM – Total Productive Maintenance although previously implemented at the site, it was improved by the inclusion of visual factory. TPMs were revised to facilitate operators understating and also moved from a simple paper template to a detailed visual standard work sheet (Figure 4 and Figure 5).

Visual Factory – Thru a combination of signs, charts and other visual representations of information we improved things from TPMs until KPI.

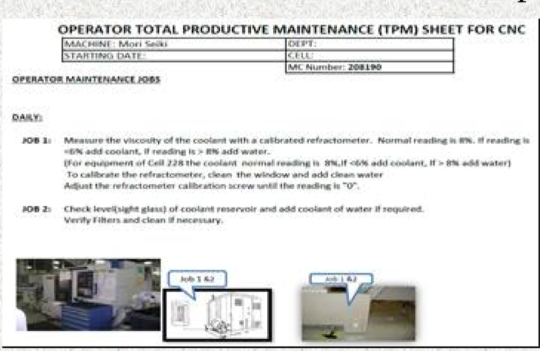

Figure 4 Old TPM Template
(no clear or specific instructions)

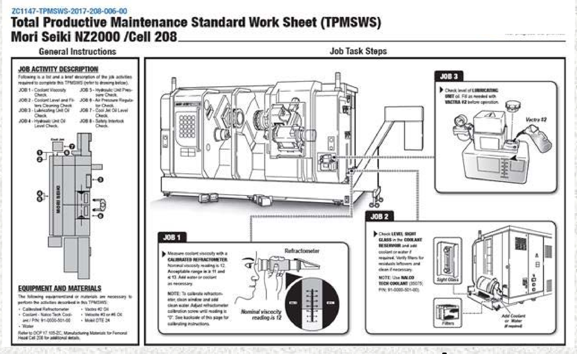

Figure 5 New TPM Template
(clear or specific instructions)

Control

The Control Phase of our project is constantly monitored at Gemba Boards. We had the culture of **Gemba** Meetings with top management, planning and supervisors on daily basis. Also, we recently implemented a second tier of Gemba Meetings to incorporate group leaders and operators.

Another way to monitor the project benefits and identify any additional required improvement is thru the monitoring of the **Key Performance Indicators** recently implemented at the company.

People – To maintain and sustain the solutions implemented and probably the most important for our lean transformation strategic journey is the people engagement. MDP Company at Puerto Rico is promoting a future state of culture driven towards culture change (Table 1).

Table 1 Culture Change

From…	To…
Bureaucracy	Agile
Victim Mentality	Empowerment
Finger Pointing	Accountability
Fear to Raise Your Hand	One Team, One Fight
Poor Decision Making	Continuous Improvement
No Commitment to Results	Drive for Results

Conclusions

To achieve the lead time reduction goal of at least 3 days less than current lead time, a DMAIC methodology was used in a pilot cell. To execute the project, different lean manufacturing tools were used for the implementation of improvements connecting each of these tools to achieve our common goal.

In our journey for re-structuring the manufacturing operations, pilot testing actions and results were as follows:

- Achieve better Operational Performance supported by a Culture-Shaping process and New Lean Design.
- Implement 5S/6S to reduce waste time for simple things such as looking for tools for machine setup or gages for parts inspection resulting in productivity optimization.
- Re-design manufacturing cell in U Shape to maintain a continuous process flow based on the manufacturing operations order.
- Relocate equipment not in use to an idle area to improve the manufacturing cell layout maximizing the workspace area only for equipment in use.
- Split manufacturing operations identified as bottleneck.
- Optimize process for machining operations related to the machine setup and compensation /adjustments.
- Implement process capability statistical tool to maintain process controls on manufacturing operations.
- Optimization and process standardization resulted in 80% inspection reduction, thus, productivity increased for multiple product families.
- Improve TPMs by the inclusion of visual factory, frequent maintenance avoids risk of unpredictable down-time due to equipment repair.
- Implement a second tier of Gemba Meetings to incorporate group leaders and operators.
- Implement KPIs for QCDP (Quality, Cost, Delivery, People) to achieve a high performing culture.
- Promote a future state of culture driven towards culture change.
- Create skill matrix or gap assessments, cross training plans and implement a Leadership Academy to encourage people development.

In conclusion, by proper deployment and use of the correct problem-solving methodology in combination with proper lean manufacturing tools we will

Research Contributions

The main contribution of this project is to reduce in 3 days the lead time through all manufacturing operations and implement improvements in production execution that will result in WIP inventory cost reduction from $2.7 million to $1.8 million increasing our cash flow by $900,000.

An additional contribution is to transform the MDP Puerto Rico manufacturing facility in one of the most profitable sites for the company. Streamlined operations, improved productivity and quality products delivery will position us as one of the best 5 cost-effective sites of the MDP Company and as result of this increases our chances of bringing new products to our manufacturing site.

Future Work

Currently we are on the Phase 3 of the project to complete the implementation of all aforementioned lean tools on our last business unit (Figure 6). Expected completion date is by the end of 3Q 2020.

Figure 6 What's Next

References

[1] Brue, Greg and Howes Rod, "The McGraw-Hill 36-Hour Course Six Sigma", *McGraw-Hill*, 2006, pp. 127-290.

[2] George, Michael L. George, et al, "The Lean Six Sigma Pocket Toolbook", *McGraw-Hill*, 2005, pp. 1-26, 61-62, 197-237.