Increase Productivity in a Manufacturing Department of a Medical Devices Company

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Abstract — *In all companies the productivity is a very important metric because is the way to make sure that we optimize our resources and time. Is the way to measure if we are manufacturing as expected and with the required resources. In this project, the Six Sigma Methodology was used to obtain an increase of at least 5% in the productivity of this manufacturing department in a medical devices company. Six Sigma has a key methodology: DMAIC. DMAIC is used to improve an existing process. Consist in Define, Measure, Analyze, Improve and Control. In this article you will find the results obtained after the implementation of automation and the use of DMAIC as the correct methodology for improvement.*

Key Terms —*Automation, DMAIC, Efficiency, Productivity.*

PROBLEM STATEMENT

At this moment in this manufacturing department before take the decision of buy a new machine for comply with the demand by the costumers, the company prefer identify the improvement opportunities that the results are increase in the productivity. Productivity is a very important metric because is the way to make sure that we optimize our resources and time. Is the way to measure if we are manufacturing as expected and with the required resources. Productivity in economics refers to measures of output from production processes, per unit of input [1]. Labor productivity, for example, is typically, measured as a ratio of output per labor hour, an input.

Productivity may be conceived of as a measure of the technical or engineering of production. As such quantitative measures of input, and sometimes output, are emphasized.

OBJECTIVES

The objective of this project is identify the improvements areas to obtain an increase in productivity by 5% from the baseline of 7 machines. This productivity improvement represents also an estimated revenue of 3,000 additional units per machine and shift.

CONTRIBUTIONS

Some of the contributions of this project are the following:

- Output Increase.
- Identification of the major offender of productivity.
- Comply with the customer demand.
- Setup reduction opportunities.
- Scrap reduction opportunities.
- Cost savings.

BACKGROUND

In order to meet market demand, this company requires high levels of productivity complied with quality standards. This company plays an important role in ensuring the correct operation of each medical product chain to achieve the highest sustainable production rate without compromising quality.

Productivity can be defined in many ways, for instance, as the amount of output per unit of input obtained by the utilized resources, and can depend on many factors such as facility layout, pass design, level of automation, state of the equipment, operational staff training and maintenance. Productivity is the ratio of what is produced to what is required to produce. Productivity is the measure on production efficiency [2].

In most manufacturing plants, productivity is one of the most important metric and has the way to measure it.

Exists different ways of how we can eliminate waste in manufacturing in order to obtain productivity improvements. Lea manufacturing eliminate all activities that do not add value for your customer. The seven major forms of waste in the manufacturing process are:

- Overproduction
- Idle Time
- Unnecessary Transportation
- Over-processing
- Inventory
- Unnecessary Motion
- Scrap/Defects

Definitively, eliminating these wastes will have a direct impact and improvement in productivity.

To obtain an increase in productivity, I used the Six Sigma Methodology. Six Sigma is a set of practices originally developed by Motorola to systematically improve process by eliminating defects [3]. A defect is defined as nonconformity of a product or service to it specification.

While the particulars of the methodology were originally formulated by Bill Smith at Motorola in 1986, Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and zero defects. Like its predecessors, Six Sigma asserts the following:

- Continuous effort to reduce variation in process outputs is the key to business success.
- Manufacturing and business process can be measured, analyzed, improved and controlled.
- Succeeding at achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management.

The term “Six Sigma” refers to the ability of highly capable processes to produce output within specification. In particular, processes that operate with six sigma quality produce at defect level below 3.4 defects per million opportunities (DPMO). Six Sigma’s implicit goal is to improve all processes to that level of quality or better.

Six Sigma has a key methodology: DMAIC. DMAIC is used to improve an existing business process and consist in:

- **D**efine: Identify opportunity for improvement.
- **M**easure: Measure the actual status of the process.
- **A**nalyze: Identify root causes of the problem.
- **I**mprove: Implement solution.
- **C**ontrol: Establish controls to avoid reoccurrence.

The DMAIC Methodology

The Six Sigma methodology (DMAIC) was used in order to increase productivity. Below you will find all DMAIC stage and the details of each one [4] (Figure 1):

Figure 1
Six Sigma: DMAIC Methodology Stage

Define

The define stage consists in the following:

- Problem definition.
- Q-Diagram: Question diagram used to drive the search of data. The questions will go from general to specific.
- Project Charter: Summary of the project. Show the problem statement, CTQ, objective, financial impact, customer impact, scope of the project and the team members.

- Translate the Voice of the Customers (VOC) to the Critical to Quality (CTQ) of the process: The VOC is essential to understand the customer needs. The VOC help us to: Identify critical parts of the process or product, define critical requirements to quality, decide areas to be focus for the improvement efforts.
- General Image of the Process: SIPOC (Supplier, Input, Process, Output and Customers).
- Process Map: Visual presentation of the process flow. Helps to identify bottle necks, redundancy, key points for decision making, roles and responsibilities.

Measure

The measure stage consists in the following:

- Data collection of the actual process.
- Operational definition for productivity.
- Detail image of the process; value stream map.
- Actual status of the process using different statistical tools.

Analyze

The analyze stage consists in the following:

- Use the process data to identify the factors of the process (X's) and affect the productivity (Y's).
- Cause and Effect Diagram: Fishbone.
- Analysis of the data using different tools.

Improve

The objective of the improve stage is making the change in X's of the process to obtain productivity improvements. The improve stage consist in the following:

- Documentation of solutions.
- Plan for the implementation of solutions.

Control

The control stage consists in the following:

- Control Plan: To install mechanisms to prevent the reoccurrence of the problems. To sustain the results with the saving acquired.
- Change in procedure.
- Training evidence.

Results

Below you will find the details of the actions and results of all the DMAIC stages. Each stage was completed using different tools that were the key in the analysis.

DMAIC: Define Phase

At the beginning of the project, this manufacturing department has many manual processes during the manufacturing process. For a manufacturing department is important to know if they have the correct automation can overcome market competition.

Improve the productivity of this manufacturing department, also improve the manufacturing output and the department cost.

Some questions during the define stage are:

- What are the productivity major offenders?
- What productivity offenders can be quickly minimized?
- What is the problem in this manufacturing department?
- What is the project scope?
- What are the benefits of the productivity improvements?
- What is the actual status in terms of productivity?
- Where the production department is losing production time?

The Figure 2, translate the VOC to the CTQ of the process. In this project the critical to quality is the increase of productivity by 10%.

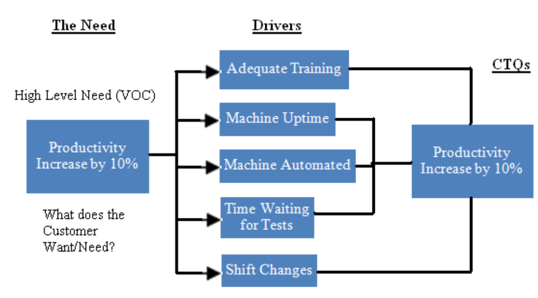

Figure 2
VOC-CTQ Tree

The SIPOC (Figure 3) is created in order to have a general view of the process. For the SIPOC diagram the supplier and the inputs are the following:

- Raw material warehouse: material
- HR department: training
- Maintenance department: machines and spare parts
- Engineering: procedures

We need raw material inspected and accepted, trained personnel, machine and spare parts in good shape and ready to use. Also the correct procedures available and updated in order to obtain the expected output (units produced). The customer wants product on time and with the expected quality.

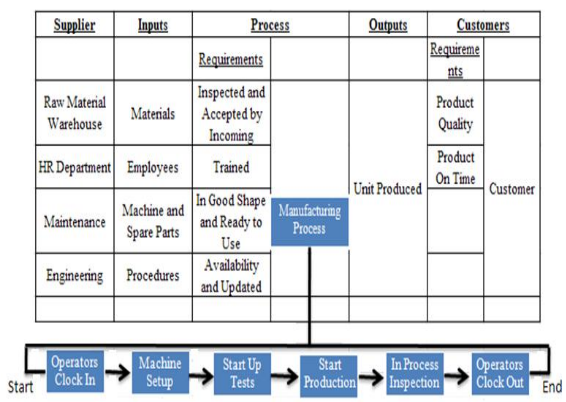

Figure 3
SIPOC Diagram

DMAIC: Measure Phase

Some questions during the measure stage are:

- What data could be collected?
- What measurement method is used?
- How to get the data?
- Is the process optimized?
- How much time is waste in non-value added activities?

During this stage, in order to understand how to increase the productivity and product quality using automation, first it is necessary to identify the process flow map (Figure 4 and 5) and typical failures in this manufacturing process that cause below nominal production rates, downtime and re-work.

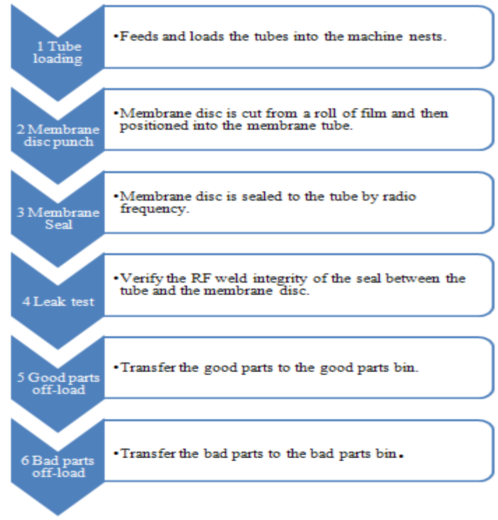

Figure 4
Operation (Machine) Process Flow Map

During the measure, a operator and machine process flow map was completed in order to have a detail of the process. The data showed that the inspection and the process of chalenge some system are the major offender of the machine downtime.

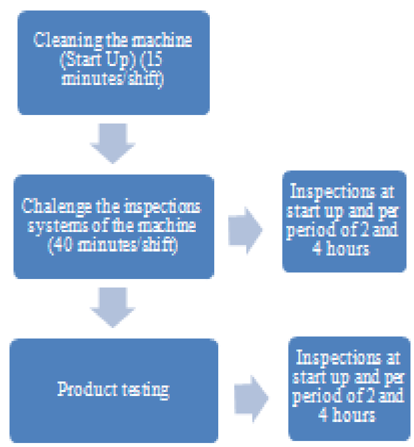

Figure 5
Operation (operator) Process Flow Map

Table 1
Findings and Actions for Downtime Improvement

Findings	Actions
Downtime associate to machine cleaning "start up"	Procedure evaluation for other alternatives
Downtime associated to "wait" for testing	Procedure evaluation for other alternatives
Downtime associate to inspection of machine component	Evaluation for automated this step

DMAIC: Analyze Phase

Some questions during the analyze stage are:

- What factors affect the output?
- Can we implement fast changes for inputs?
- What is the critical part of the process?
- The change will have a direct impact in my output?

In order to analyze all possible causes that were affecting the machine output, a cause and effect diagram (see Figure 6) was completed. The area to focus after fishbone analysis was:

- Method – Testing time.

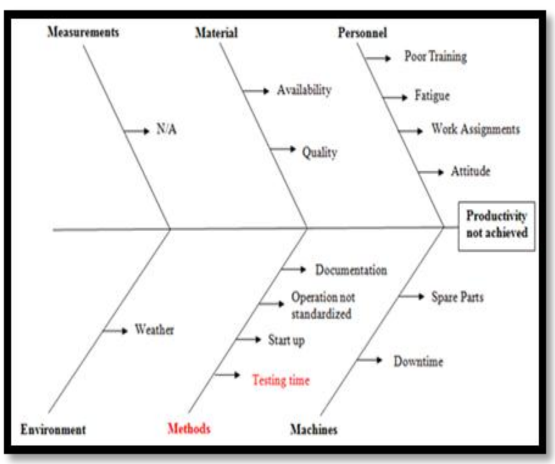

Figure 6
Cause and Effect Diagram

To finalize the analyze stage, some improvement opportunities were identified that help to increase the productivity.

DMAIC: Improve Phase

In this stage, we have the data collected and analyzed and we are ready to implement solutions.

After evaluated the manufacturing process, we found some opportunities that have a positive contribution on productivity. Basically we found that some test that the operator perform in relation with the machine, we can eliminate this implementing an automated system.

The operator perform one test every four hour (2 times per shift) that consist in verify that the pins of the machine are not blocked, this test take approximately 35 minutes per shift that represent downtime.

With the implementation of this automated system (see Figure 7) we can improve in the following aspects:

- Reduce downtime by approximately 35 minutes/shift.
- Increase productivity by approximately 7%.
- Eliminate human dependence.
- 100% time monitoring.
- Product quality.

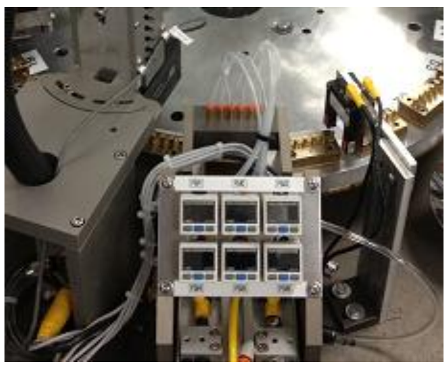

Figure 7
Implemented System

After the implementation of the automated system we can see an improvement in productivity that represent 12% (see Figure 7).

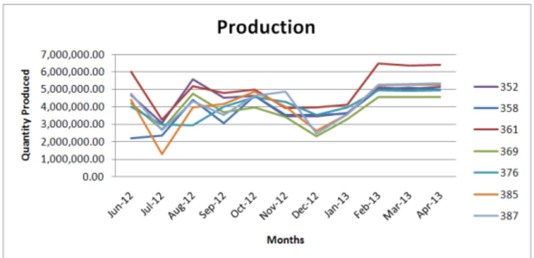

Figure 7
Production

DMAIC: Control Phase

The control stage consists in the implementation of mechanisms to prevent system damage and detect if any issue occurred. Firstly the system was included in the weekly verification by the technician in where the system is challenged, after 8 week the system no reported any issue, and by this information the system verification was excluded of weekly verification and was included in the monthly preventive maintenance of the machines.

The control mentioned before is the key for sustain and maintain the results. At the end of the project, the increase in productivity was 7% per machine and shift, resulting in an increase in productivity by 4,200 units per machine and shift.

Conclusion

Using the DMAIC methodology, you have the opportunity to make all the questions and go through an organize process using different tools for the finding of the solution. DMAIC allows you to find permanent solutions and real improvement in this case with excellent economic results and customer satisfaction. After the implementation of the automated system (sensors), we obtained a 7% increase in productivity, this improvement represent an saving of buy one new machine approximately of 0.9 million dollars and 2% of additional increase in productivity comparing with the expected results and the demand. As you can see, using the appropriate tools we can achieved more that expected.

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