Improvement on Machine Products Output, by Optimizing the Use of the Resources

Eloy A. Nieves Muñiz
Master in Manufacturing Competitiveness
Jose A. Morales, Ph.D.
Industrial Engineering Department
Polytechnic University of Puerto Rico

Abstract *– Today's globalized world presents major challenges to maintain the competitiveness of the companies, the manufacturing industry is not the exception. Over times companies debated what will be their best strategy to increase the market share and at the same time to maximize profits on which this cemented their efficiencies, whether administrative or operational. The most powerful tool within the Industrial Engineering methodology to improve processes, reducing waste generation "MUDA", efficiency and increase in quantity of products output manufactured, maintaining the stability of associated costs and the quality of it, is known as Lean Manufacturing. This concept identifies among others the sources of waste, such as for example the loss of time, unnecessary movements, and everything that does not add value to the process, customer needs or the finish product and eliminate or minimize them to achieve the desired level of efficiency. This article will discuss the subject of operational improvements in the industry of cereal manufacturing for human consumption. This research and intervention to be an improvement project through maximizing the use of the existing resources increasing the product output, have selected a system known as DMAIC methodology.*

Key Terms *— DMAIC, Efficiency, Improvement, Lean Manufacturing, Maximize, Methodology, SIPOC, SOP.*

INTRODUCTION

In todays markets the processing industry of cereals for human consumption, strives it to increase the percent of market share by winning the acceptance of the customers, but at the same time to increase profits for stockholders. This scenario has no other direction that the continuous improvement of manufacturing operations in its origin by optimizing production capacity, reducing costs and removing process steps as for example every activity that does not add value to the final product. The goals set forth in the preceding paragraph are possible with the implementation or use of the tools of the systems associated with the Lean Manufacturing Methodology.

Research Description

This is a company that process cereals for human consumption. Our goal on this project is to increase the output of final product by maximizing the use of the machinery time and human resources. The production area, packaging division is the one where the final product is packed in primary, secondary and tertiary containers. There are 10 packing machines, working one shift of 8 hours on different format, size and packaging materials. The finish products are packing in paper and plastic materials in 2, 3,5,10,20,25,50 and 100 pounds bags. At the production floor, the 10 packaging machines are divided by market segment or production module, six of them are machines dedicated to paper bags in 3 pounds brick type, one is dedicated to 2 and 3 pounds plastic bag in brick type, one is dedicated to 5 pounds plastic bag in brick type, one is dedicated to 20, 25, 50 and 100 pounds plastic bag pillow type and the last one is dedicated to 3,5,10 and 20 pounds plastic bag in pillow type and carton box as a secondary packing material. The intervention is due to the fact that there are some machines out of this group known as "IKA" installed in a parallel setting where the possible production is 100% sold and some others with only between 40 to 60 % sold. At lunch time (30 min. plus 6 minutes of cleaning) all of the machines are shut down creating a "**MUDA"** describe as waste of production machine down time, then start up when the employees comes back

from their break time. The company is wasting production time on the machines that their output is 100% sold, also wasting time on the machines that their production output is only between 40 to 60% sold. To achieve the level of sales / demand of finished product, every other day the production area has to work overtime, to compensate the production down time on employees lunch period.

Research Objectives

The Objectives for this research and improvement project is to investigate and analyze the existing manufacturing process like the currents conditions, logistics and capacity machine utilization, to identify the mayor's offenders and opportunities to improve. Then adding value to the process by design and establish a comprehensive system to increase the finish product output, reducing the waste "MUDA" (Machine down time) without working overtime. As Joseph Juran stated in his book "Juran's Quality Handbook" creates new options, often teams approach a product design with a history of how things were done in the past. Organizations allow teams to take a fresh look at the product and create new options. [1]

Research Contributions

This research discussed on this article will contribute this cereal manufacturing company to improve their efficiency by maximizing the use of the production capacity and human resources increasing the finish product output. As a collateral benefit, will be the reduction on cost per unit due to the fact that they will use the same existing personnel and machinery to produce more units per shift. The goal of the research is to provide this company a set of powerful tools to once this intervention is establish, become more competitive among the others companies in the same industry that not had been establish a "Lean Culture".

LITERATURE REVIEW

The Cereals (grain) Industry known as Rice emerges as early as the fifth millennium, B.C.E. Rice is the seed of the grass species Oryza Sativa as a cereal grain is the most widely consumed staple food by the human population in the world mostly in Asia and Africa. As an agricultural cereal is the third largest grain produce worldwide, after sugar Cane and Corn. [2]

Before pack the Rice pass thought a process called milling, where is Hulling, clean from dust, separate from foreign materials, polish and enriched with Vitamin and Minerals. The last step at the mill is packing in different size and materials like paper and plastic. Since this is a human consumption product, currently the cereal industry is highly audited by Federal (F.D.A.) and local government (Health Department) agencies based on a Good Manufacturing Practices protocol known in the Industry as a "G.M.P'S. The annual Rice consumption per capita in Puerto Rico is approximately 90 pounds. During the last ten years the industry had been pretty much steady, except the last two years where the volume had been decrease due to the fact of the people from the Island leaving to United States of America.

Michael L. George establish in his book "Lean six sigma" the tree main purposes of the lean concept,

1. To eliminate wasted time, effort and materials.
2. Provide customers with make-to-order products.
3. To reduce cost while improving quality. [3] Knowing that is not enough to just believe "if I eliminate the non-value we will be lean". This is only one aspect of a lean organization. [1] The Lean concept that will be use on this research and intervention project to improve the production capacity level is focusing on reduce or eliminate all of the activities that not add value to the customer's needs and or process, on this case machine downtime, known as the Waste or "MUDA", also known as "MURI" in their manufacturing operations at the packing area.

There different ways to define "MUDA" for example; as Joseph Juran defined the waste in the book Juran's *Quality Handbook*, there tree types defined as MURI or Overburden, MURA or

unevenness and MUDA or non-value-added work. [1]. Then in the other hand Taiichi Onno (1912 – 1990) who was the creator of the Toyota production system and had a vision of mass production achieving economy of scale and cost reduction among others by uncover and eliminate waste "MUDA". He Identify seven classical type of "MUDA" on manufacturing process [4].

1. **Overproduction** – produces more than required.
2. **Inventory** – excess supply on raw material, working in progress or finish product.
3. **Rejects, defects** – rework or the "hidden plant".
4. **Motion** – unnecessary movement of the employees over the production floor that no add value to the final product.
5. **Processing** – do additional steps or activities that are not require by the customers.
6. **Transport** – double handling of materials and or final products.
7. **Waiting** - operation is ready for the next operation, but remains idle.

As part of the literature review, shows below a similar machine, in which we will be do the improvement project.

Figure 1
Machine for Packaging Cereals Fully Automated up to 100-Paper Bag of 3 pounds per minute [5]
Manufacture by: ICA SPA, Via Del Litografo #7 Bologna, Italy

LEAN MANUFACTURING

The lean manufacturing methodology as a tool has a focus among others reduced or try if possible eliminated the "MUDA". There two types of "MUDA":

1. **Type one** – is the waste that do not add value to the customer request, but it's necessary to the process.
2. **Type two** - is the waste that does not add value to the customer request that can be eliminated.

There are five lean manufacturing principles as shown below in figure 2.

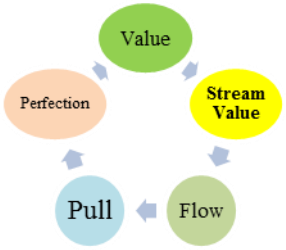


Figure 2
Lean Manufacturing Principles

Value – can be only defining by the customer needs (what are the requirements). Understanding by listening the Customer, known as Voice of the Customer "VOC".

Stream value – the activities under manufacturing (or service) The Company perform, in this case to produce a final product that had been required by a customer.

Flow – this principle is to eliminate all of the activities in the process that not add values to the product and interrupt the continuous flow.

Pull – system that allows the customers pull their needs from manufacturing.

Perfection – repeat the lean circle to continue or galvanize the improvements on the product customer wants.

METHODOLOGY

Since the goal of this project is an Improvement at manufacturing process facility, as mentioned in the abstract section the methodology tool selected from the Lean Manufacturing Concept is one of the most widely used improvement models, utilize a systematic approach trying eliminating or reducing as much as possible the waste or "MUDA". This approach is known as "DMAIC", Define, Measure, Analyze, Improve and Control.

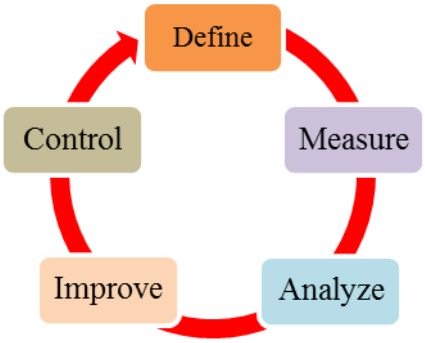


Figure 1
DMAIC Steps

Define Phase

This approach allows clarifying the goals, defining the boundaries and value of the project by using the necessary tools to assess the magnitude of the value opportunity in a given stream. Also used as a first step to determine the problem statement, the team members, project goals, projected results and the starting and finish dates. Two powerful tools had been implemented on this first phase, the first one is the Project Charter as shown on figure 4 this tool is a first step to initiating the planning and execution of the project and the second one is the SIPOC diagram.

Measure Phase

This phase is a data gathering to review the actual condition of the process, by collecting information, also establish the baseline to identify the problem.

Analyze Phase

On this phase the team review the data gathered and try to identify the possible causes of the problem. One of the most powerful tools is the Pareto chart. As shown in figure 7 this is a visual indicator of which one is the mayor offender to the manufacturing process.

Improve Phase

This is the phase when the action happened and decisions are taken. By performing changes in the process, the possible solutions or strategies are established or implemented fallowing a priority list. Applies different tools to eliminate or targeted at the confirmed causes. Examples by generate ideas, conducts experiments, decision tree as shown on figure 8 and develop action plans to implement.

Control Phase

Will be employed to lock in the benefits, create a monitoring, gauging and feedback system to instantly detect and correct trends. Make sure that the gains can be sustained. One of the tool will be implemented is a written procedure as know SOP on figure 9.

RESULTS AND DISCUSSION

During and after establish this process intervention on the manufacturing facility, results was obtained. In this section discussion and explanations will take place, again step by step of the DMAIC process.

Define Phase – Results and Discussion

As part of the Define phase a Project Charter had been develop explaining the reach and boundaries of the task to be perform.

PROJECT CHARTER		
Project Name:	Lean Six Sigma Application	Efficiency and Cost Impacted
Sponsor:	Eloy A. Nieves Muniz	Grain Processing Inc., (787) 552-1808
Master Belt:	Dr. Jose A. Morales	Polytechnic University Of P.R. (787) 622-8000
Core Team Members:	Production Supervisor	Administrative
	Manufacturing Department Employees	Machine Operators
Start Date:	November 1, 2015.	36 working days over the two
Finish Date;	December 31, 2015.	Months period
Project Description:	Improvements on Production Output	Optimizing the use of Resources
Scope:	Maximize the use of resources	Employee and Machinery
Project Goal:	Increase the Machine Output and	Capacity Utilization
Expected results:	Increase by between 6 to 10% the	Cost reduction
	the Machine Output / Capacity Utilization	

Figure 2
Project Charter

The second Tool as seen on figure 5 is the "SIPOC" diagram, utilized as a top view of the process, also can help to have a better understanding of what are the input and outputs of the process, from the Suppliers, Inputs, Process, Outputs and Customers. Shows the complete step by step process for a better understanding and quick look form the upper management to approve the project. In summary from where comes to where goes.

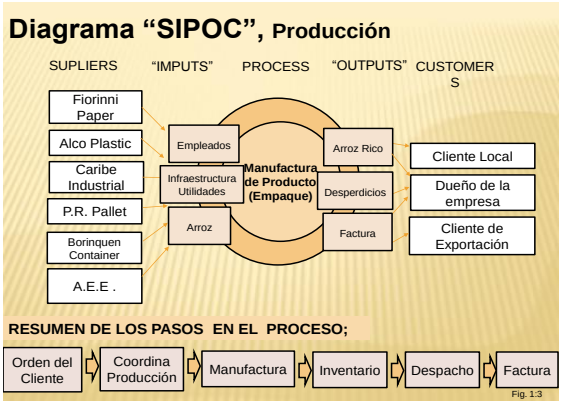


Figure 3
SIPOC Diagram

Measure Phase

On this phase the process flow is define as shown in Figure 6, the objective was to have a better understanding of the actual manufacturing process. Also at the manufacturing facilities we run "live" this intervention research for 18 working days on November and 18 working days on December 2015 to gathered a set of results on each month which are identified as Before for November and After for December. Have to mention that the table 1 had been edited shown only the total results to protect the internal document of this company. On this phase we will show the actual condition results identified as "Before".

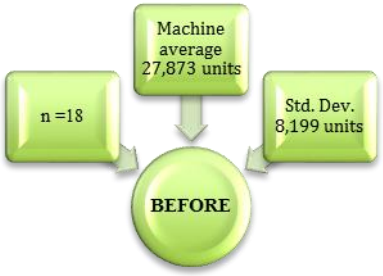


Figure 6
Before Intervention, November 2015

Analyze Phase

A Pareto Chart Analysis had been develop, to identify what are the mayor's offenders and apply the 80% - 20 % rule. As seen on the chart, we decide to make the intervention Improvement on the Lunch and Break Time which is the mayor factor over the Machine down Time" creating a "MUDA".

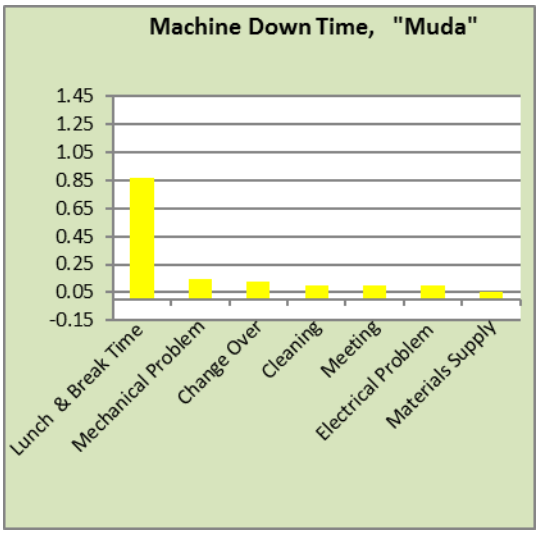


Figure 7
Pareto Charts, Majors Offenders

Improve Phase

On the Improve Phase, the decision and / or solution development phase is the one where the Owner and / or the CEO / Board of Directors of the company will evaluate and consider different options or what to do with the issue they are considering.

There are so many tools to evaluate and make decisions; one of this is called a Decision Tree, see figure 8. Compose of decision nodes with branches to and from them. A branch from the squares shows the choices available to the decision maker. In solving decision problems, the decision maker has to work from the end of the tree backward to the start of the tree.

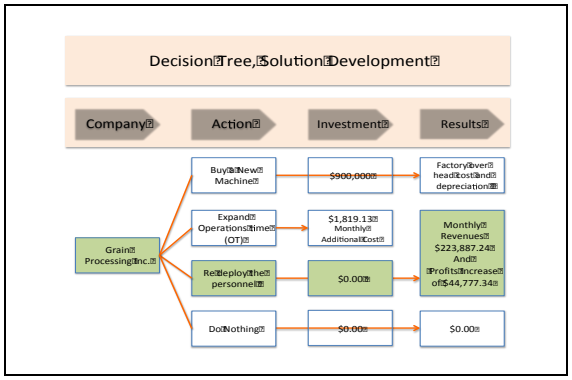


Figure 8
Decision Tree

On this scenario we face the decision either to buy a new machine with an investment of $900,000 plus hire another machine operator $1,915.83 / month also face the direct depreciation cost by $ 9,375.00 / month plus the routine maintenance, to use only the production need equivalent of 31.73% of the machine capacity utilization.

Second option to use the existing machinery with the existing machine operators in overtime to produce the extra volume of need finished product with the extra cost of $ 1,819.13 per month in overtime.

Third option to use the existing machinery with the existing machine operators by rotating them to cover the other co-worker lunch and break time to keep the machine in operational mode producing additional units per day with no extra cost.

The last option on the decision tree was do nothing.

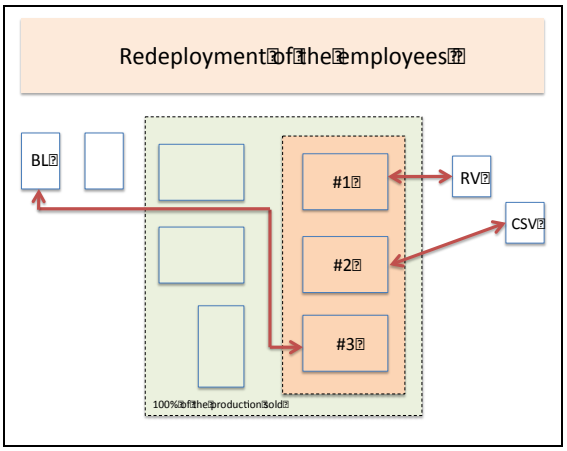


Figure 9
Redeployment of the Employees

The decision went to use the same machinery with the actual roster at no extra overtime cost or investment of the company. As shown on figures 9 and 10 there is an operator for each machine at the production floor. At lunchtime the operator for Ika 1, 2, 3 have to leave shutting down the machines for 36 minutes (6 min. to clean the glue and 30 min.). By switching their machines and redeploying the employees from Rv, CSV and BL # 2, operators for the machines with only 60% of their production sold, the Ikas 1, 2, & 3 will be producing without interruption at lunch time.

Solution Development;

	Employees	Machines	Cost	Units Output	Aditional						
Actual Scenario	6	3 icas		83,619							
Re Schedule, no Overtime	6	3 icas		93,261	9,642	Units per day		Aditional revenue of $ 12,438.18 / Day			
								With a profit of $ 2,487.63 / Day			
								$522,403.56 Total profit per Year			
								of 210 working days.			

Schedule	In	Out	In	Out	In	Out	In	Out	In	Out
Actual Scenario	5:30 AM	8:00 AM	8:15 AM	10:30 AM	11:00 AM	2:00 PM				
Re Schedule, no Overtime	5:30 AM	8:00 AM	8:15 AM	10:30 AM	11:00 AM	2:00 PM	Actual Crew, ICAS Operators			
	Actual Crew, Others Operators			10:30 AM	12:00 PM	12:15 PM	1:30 PM	2:00 PM	7:00 PM	
	Rotate to ICAS and cover lunch time									

Fig. 1:6

Figure 10
Solution Development

As a result of this employees redeploying, see figure 11, the data gathered as of December 31, 2015 (after 18 working days) the production output increase by 9,642 units per shift of 8 hour, increasing the revenues on $12,438.18 per shift with a profit of $2,487.63 per day. If this improvement is kept thought the year, our estimate is that they will increase the profit by $522,403.56. Most amazingly without spend an extra penny such an as new machine investment, payroll and overtime cost in their manufacturing operations.

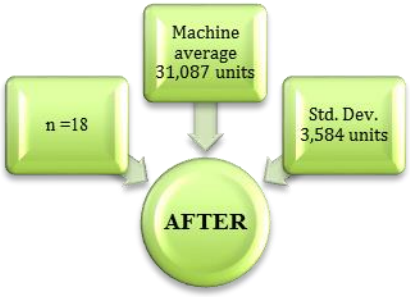


Figure 11
Results After, December 2015

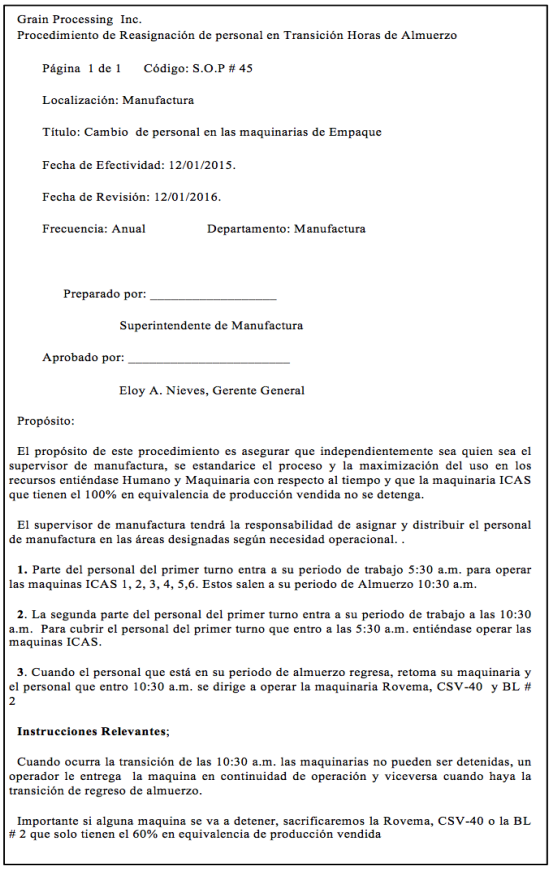
Control Phase

It's extremely important that the control phase has to be establishing to avoid the return to the previous production practices or behavior. As part of the control step, the strategy established by the team was using different tools such as, written procedures "SOPs"as seen on figure 12 and weekly results monitoring meetings. Also the team decide since different operators will be assigning to the same machine, a Kaizen program under the 5's

method will be establish to tighten the discipline at the production area. This program will provide process standardization across the production floor and visual control.

The 5's is defining by;

- **SEIRI**, to remove the unnecessary things in the area using "the red tag".
- **SEITON**, every place to accommodate everything.
- **SEISO**, Clean and organize to be use as need.
- **SEIKETSU**, to standardize and prevent the come back to the old habit.
- **SHITSUKE**, make it a day-to-day behavior.



Grain Processing Inc.
Procedimiento de Reasignación de personal en Transición Horas de Almuerzo

Página 1 de 1 Código: S.O.P # 45

Localización: Manufactura

Título: Cambio de personal en las maquinarias de Empaque

Fecha de Efectividad: 12/01/2015.

Fecha de Revisión: 12/01/2016.

Frecuencia: Anual Departamento: Manufactura

Preparado por: _____

Superintendente de Manufactura

Aprobado por: _____

Eloy A. Nieves, Gerente General

Propósito:

El propósito de este procedimiento es asegurar que independientemente sea quien sea el supervisor de manufactura, se estandarice el proceso y la maximización del uso en los recursos entiéndase Humano y Maquinaria con respecto al tiempo y que la maquinaria ICAS que tienen el 100% en equivalencia de producción vendida no se detenga.

El supervisor de manufactura tendrá la responsabilidad de asignar y distribuir el personal de manufactura en las áreas designadas según necesidad operacional. .

1. Parte del personal del primer turno entra a su periodo de trabajo 5:30 a.m. para operar las maquinas ICAS 1, 2, 3, 4, 5,6. Estos salen a su periodo de Almuerzo 10:30 a.m.

2. La segunda parte del personal del primer turno entra a su periodo de trabajo a las 10:30 a.m. Para cubrir el personal del primer turno que entro a las 5:30 a.m. entiéndase operar las maquinas ICAS.

3. Cuando el personal que está en su periodo de almuerzo regresa, retoma su maquinaria y el personal que entro 10:30 a.m. se dirige a operar la maquinaria Rovema, CSV-40 y BL # 2

Instrucciones Relevantes;

Cuando ocurra la transición de las 10:30 a.m. las maquinarias no pueden ser detenidas, un operador le entrega la maquina en continuidad de operación y viceversa cuando haya la transición de regreso de almuerzo.

Importante si alguna maquina se va a detener, sacrificaremos la Rovema, CSV-40 o la BL # 2 que solo tienen el 60% en equivalencia de producción vendida

Figure 12
Standard Operation Procedure

The implementation of the tool 5's from the lean manufacturing process was established. The SEIRI concept was introduced to the process by cleaning. The second point is the SEITON that was focused on a new way to organize the workstation of each machine. The next step SEISO that applied by cleaning and keeping on the area the tools that the workers will use as part of the task. The SEIKETSU, by develop a written procedure to make sure that all employees performs in the same way and more standardized. The last point SHITSUKE that is directly related to the supervisor, that makes him responsible for the proper application, guidance and coaching of the 5's methodology.

The other control tool that the team decides to implement was the Standard operation procedure known as the SOP's to the supervisors, will depend of the scenario they are facing any given day. As an example on figure 12 this is an actual written procedure to be fallow by the production supervisors to redeploy or rotate the employees (machines operators) from the machines that are not need to operate on certain times to the Ikas machines.

CONCLUSION

On manufacturing Industry the process by itself is dynamic, challenging and require from the top management a decisive commitment, direct Involvement, continuous improvement mind set and good communication skills. By establishing a "think out of the box" cultural behavior, every employee across the board will be at the same page and willing to embrace the continuous improvement process in their day-to-day performance

Over this intervention research process we learn that every problem represent an opportunity to improve. The actual challenge of "make more with less" that is confronting the manufacturing companies is not impossible; it's a matter of go deep into the issues, involves all of the employees from the different levels of hierarchy and comes out with a comprehensive action plan.

In conclusion on this research, was possible to "think out box" and create a system by implementing "DMAIC" principles to increase the machine output. In Fact as of December 31 (18 working days), we prove how the machine output was increase by 10.58% or 9,642 units per production day of 8 hours, while the Company

revenues increase by $12,438.18 per day with an annual profit of $ 522,403.56, most amazingly using the same production personnel lineup, without the investment on new machinery or extra employees and it pay roll cost and the use of Overtime.

REFERENCES

[1] J. M. Juran, "Lean Techniques: Improving Process Efficiency", in *Juran's Quality Handbook*, The Complete Guide to Performance Excellence, Six Edition, 2000, pp. 117-330.

[2] J. Nathan. (2012, May 27). Rice background, a Global Staple [Online]. Available: http//www.USDA.gov/topics/crops/rice/backgrounds.aspx

[3] M. L. George, *Lean Six Sigma; Combining Six Sigma Quality with Lean Speed*, The McGraw-Hill Companies, 2002, pp. 35.

[4] P. McCartney and J. Lennon, Lean Six Sigma Primer, Quality Council of Indiana (2007). PP II-18, VII-2.

[5] G. Rapparini (1983). Icaspa our History [Online]. Available: http//www.icaspa.it/macchine/dettagliohf100.