Automate Palletization Process in a Manufacturing Company

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Abstract *— For the last 20 years, the manufacturing industry company has been revolutionized with process improvements, many methodologies like continues manufacturing, and among many others, the revolution of the automatization. This research project pursues the analyze, design and recommend an automated option for a palletization manufacturing process. The manufacturing process to be discussed is one where an associate performs the task stand and repeat the process in many instances, for the long of a shift. Repetitive and stand tasks are ones ideal to automatize. The process under evaluation in X Manufacturing Company consist of placing a predetermined quantity of tubs inside a box, record the quantity in each tub and consequently the quantity in the box and pallet in the manufacturing execution system. The methodology used in the research project is the six-sigma methodology Define, Measure, Analyze, Design and Verify (DMADV) and will be conducted till Design/Recommendation phase.*

Key Terms *— DMADV, DOF, FDA, OSHA*

INTRODUCTION

Industrial automation offered more productivity, efficiency, cost reduction, and quality to the industry. In most Industries, the path towards increased productivity is through increased automation process and control. Automating using robot systems will increase productivity, efficiency and quality control as well safety problems. During operation, robots can be controlled to accommodate more work, and even operate beyond working hours Groover [3].

There is however an inevitability of worker exhaustion which can result to a decrease in the production line.

The project pursues to redesign and automate a palletization process at X Manufacturing Company. It is important to X Manufacturing Company to constantly seek to improve the process and move toward our already automated era. Therefore, with this initiative, the company will remain competitive, with the best technology and looking to automate manual process.

PROJECT STATEMENT

The project seeks to automate a manual process. Today's date, in X Manufacturing Company, the palletization process is manually. The process requires a minimum of two associates which allocate sixteen containers inside a box in rows of four. Then, the pallet is composed of eight of these boxes. Figure 1 shows the top and side view of the arrangement.

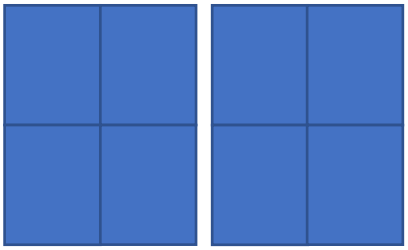


Figure 1
Top (left) and Side (tight) View

PROJECT OBJECTIVE

The objective is to automate a manual manufacturing process with a pick and place robot arm the process of fill the boxes at X Manufacturing Company.

PROJECT CONTRIBUTIONS

The contributions of this project are mainly in the technology use, near 62k of savings annually, and process improvement. It will also continue developing and using the automated systems to

increase quality, reliability, reduce cost, cycle times and made the operation more efficient.

LITERATURE REVIEW

The manufacturing process as it begins was a manual and human dependence process. In the last 20 years, the manufacturing process has been revolutionized and automated. The introduction of automated system pursues increase quality, reliability while decrease human dependency, cycle times, cost among others benefits that the introduction of automated systems and robotics bring the operation.

The X Manufacturing Company produce fill and finish products and supply them around the world. As part of their process, in one stage, the containers with the filled syringes are placed in a box by an operator. Figure 2 shows a similar container where the filled syringes are processed.

Figure 2
Container with Filled Syringes to be Handled

The next step of the process is to place the container in a box, in the box are allocated 16 containers (4 containers per row), each row is separated by a tiny paper layer. The next step of the process contains the seal of the box and placement in the pallet.

In the other hand, an industrial robot is a general-purpose, programmable machine processing certain characteristic. The most common characteristic is a mechanical arm which is used to perform various industrial tasks. Figure 3 shows an example of an industrial arm used to process boxes.

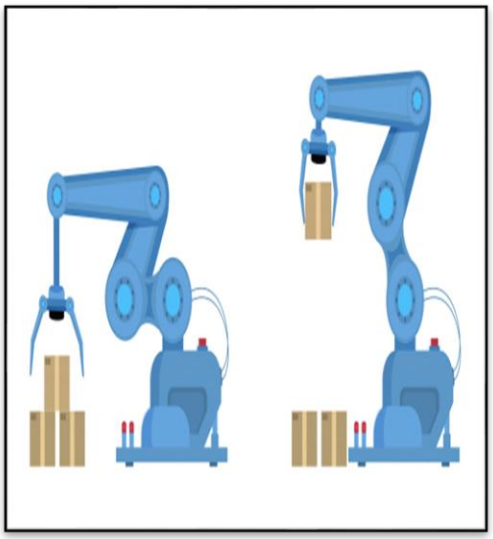


Figure 3
Representation of an Industrial Robot Arm

The objective of the project is to make a research and propose different options to automatize the palletization process. The options must include financial cost, viability implementation, installation time frame and viability, testing and commissioning and qualification if apply.

METHODOLOGY

The methodology that is going to be follow will be the Design for Six Sigma (DfSS). Six Sigma is a highly disciplined process that helps focus on developing and delivering near-perfect products. DMADV which stands for Define, Measure, Analyze, Design and Verify/Validate, Figure 4, is a well-known tool system used to develop new processes or products and, that will guide the researcher through the main project phases by Sokovic [5].

- Define – Projects leaders identify wants and needs believed to be considered most important to customers. Wants and needs are identified through historical information, customer feedback and other information sources.

- Measure – The second part of the process is to use the defined metrics to collect data and record specifications in a way that can be utilized to help drive the rest of the process.
- Analyze – The result of the manufacturing process (i.e., finished product or service) is tested by internal teams to create a baseline for improvement.
- Design – The results of internal tests are compared with customer wants and needs. Any additional adjustments needed are made.
- Verify – The last stage in the methodology is ongoing. While the products or services is being released and customer reviews are coming in, the processes may be adjusted.

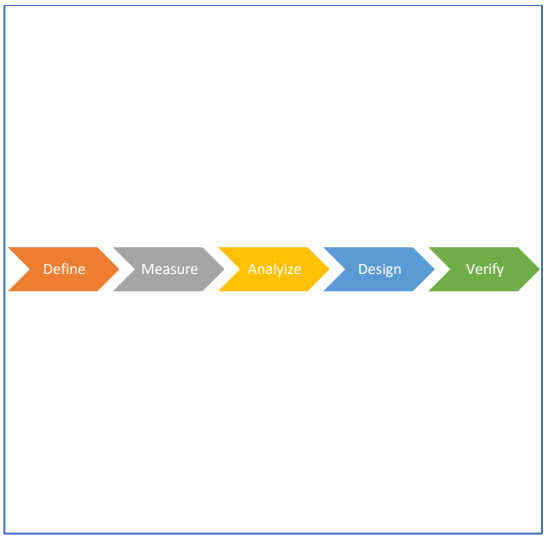


Figure 4
DMADV Methodology Flow

Those phases will be monitored against a master schedule with the final output to bring a proposal for the automation of the palletization process.

RESULTS AND DISCUSSION

This section will describe and shows each of the DMADV sections and results.

Define

The process to be redesigned is the shipper assembly process. The shipper assembly process take place at Room 3, the process consists of placing the containers, Figure 2, with the filled syringes in the plastic boxes. They are placed manually, one by one by two stand operators in a 2 x 2 x 4 array for a maximum of 16 containers. Figure 5 is a representation of the array inside the shipper.

The process described before, have been identified as a contributor to an increase in ergonomic incidents due to its repetitive and manual process. Mainly, the process is the trigger to this project but, it will bring other benefits are manpower reduction, head count and re define the downstream process in order to allocate manpower in other areas which have opportunities in the head count. Table 1 shows the project charter for this project.

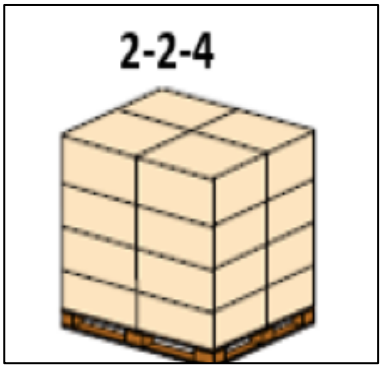


Figure 5
Containers Array Inside the Shipper

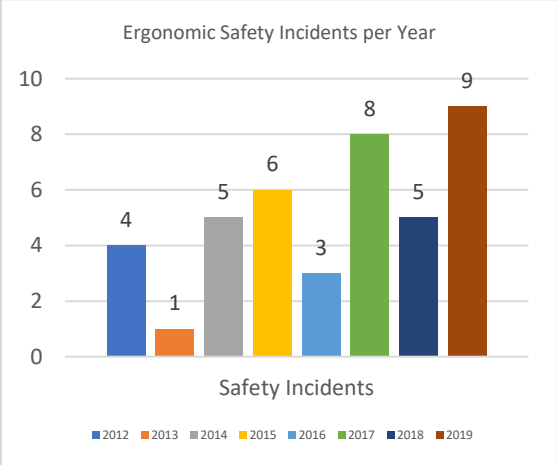
Table 1
Project Charter

Problem Statement	During the last 8 years an increase of 50% in ergonomic claims has been reported in Room 3 due to repetitive task when the shipper is built.
Goal	• Decrease to zero the ergonomic incidents. • Implement an automated solution.

Measure

The safety and ergonomic in X Manufacturing are the metrics most important along with productivity indicators. The evaluation made for the past 8 years, Table 2, shows an increase of 56% in the Ergonomic Safety Incidents (2012 and 2019).

Table 2
Ergonomic Safety Incidents



The industry is regulated by many agencies and standards are established and followed for example the Food and Drug Administration (FDA) and the International Organization for Standardization (ISO) respectively. The health and safety are regulated by the Occupational Safety and Health Administration (OSHA) and they bring the guidance for safety issues.

The process in X Manufacturing of placing the filled containers in boxes were evaluated by a safety Subject Matter Expert (SME), operators were interviewed, and a visual inspection of the process were made. The results exposed the following:

- The operators assigned to the shipper loading/creation are stand for the complete working shift.
- They perform repetitive movement for the complete shift.

Along the safety and ergonomic metric, there are others metric which will be evaluated as part of this project. The first one is the economic, in which we are going to explore how much could be sabed and use for the implementation of the new alternative and eventually a saving. Table 3 shows the rate per hour in the first column and in the last column, the spend by year of two operators which are the quantity required for the task evaluated in this project.

Table 3
Spend by Two Operators

Rate/Hour	Rate x 2	Spend/Year
$ 16.00	$ 32.00	$ 61,440

The second metric to be evaluated is the cycle time of building the plastic shipper with the sixteen (16) filled containers. Since the process is simple and it contains only one step. The cycle time of build this shipper is approximately 30 minutes, since the first filled container is received and placed into the shipper till the last filled container (16) is placed and the shipper is closed and sent to the palletization process.

Analyze

The identified manufacturing process and results identified in the measurement phase at X Manufacturing were analyzed in this section. A Cause-and-Effect analysis was developed to understand and explore the ergonomic safety incident increase over the last years. Figure 6 shows the results of the analysis. As the measurement phase data shows, it was confirmed in the major offender for the increase in safety incidents are related to the current manual manufacturing process. The process requires a minimum of two operators to execute the task of build the shipper with the 16 tubs (Figure 2). The analysis also shows that the process is completely manual and that the parts, in this scenario the tubs are processed one by one. This result in a repetitive task, which in average is performed for more than five hours, in case of bigger batches, the task could long for the entire eight-hour shift.

A process flow in Figure 7 shows the simple process executed to complete one shipper. The process described start with T=0 which is the time when the part arrives to the processing station, then, the operator spent almost two minutes (T=2) picking, inspecting and placing the part or tub inside the box, finally the operator waits near a minute for

the next part to arrive. It is important to notice that the process is repeated 16 times for each box, that every pallet has 8 boxes and depending on the lot size, one lot could have up to 10 pallets.

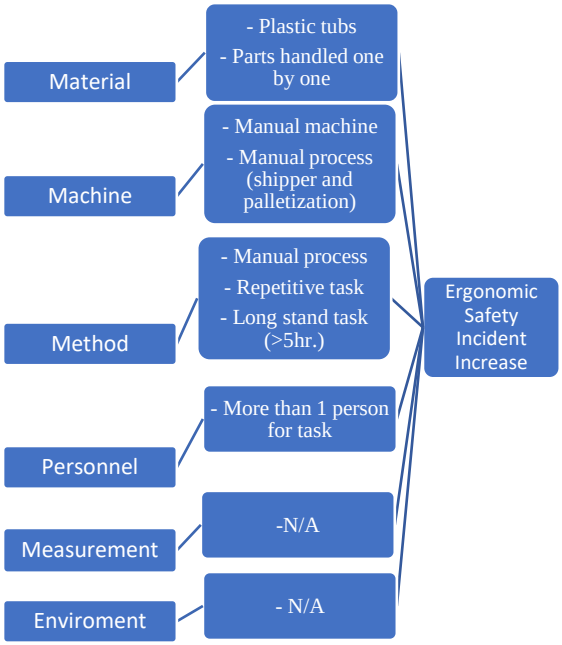


Figure 6
Cause and Effect Diagram

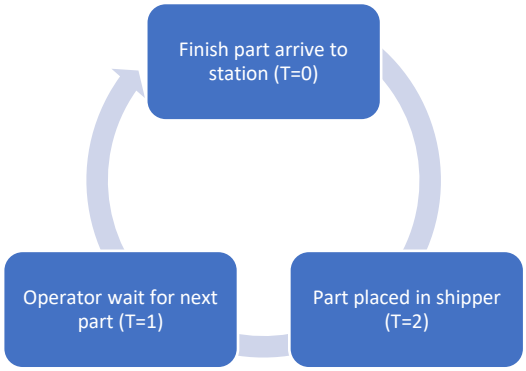


Figure 7
Pick and Place Process Flow

Finally, the analyze phase concluded with a cost benchmarking between many robotic arms companies. The exercise reveals that an arm with the specifications of 740mm (29.13“) maximal reach and a maximum weight capacity of 5kg (11 lb.) range between $25k and $45k dollars as shows Table 4 [6], [7]. It is important to mention that the cost researched is only the arm, other cost as integration, maintenance, validation among others is not included and will be discussed in the design section.

Table 4
Pick and Place Robot Arms Costs

Company	Cost
Company 1	$45,000
Company 2	$25,000
Company3	$30,000

Design

The design phase consists of the conceptual and possible design implementation of the pick and place robot for the problem statement developed in the previous sections. First, Table 5 contains the basic requirement specifications for the pick and place robot arm based in the dimensions, weight and reach that need to have so it can handle the parts or tubs from the conveyor to the box or shipper. The maximum weight that the part has is 5 pounds, the robot arm from company 2 fulfill this requirement. Also, the box heigh is 21 inches thus the arm at least should have 22 inches of reach. The part to be handled, is of a rectangular shape as showed in Figure 2, therefore the grip, depending on the form that the part is going to be handled must be of 8 or 10 inches.

Table 5
Requirements Specifications

Specification	Requirement
Weight Cap.	5 pounds
Reach Cap.	22”
Grip	8” or 10”
Degree of Freedom (DOF)	4

In every project, and always in the upgrade’s projects, the economic factor needs to be taken in consideration. The economic aspects phase for this

project is disclosed in Table 6 at a high level selecting the Company 2 since all the company evaluated fulfill the specification requirements.

Table 6
Project Costs

Category	Cost
Robot Arm	25,000
Arm Integration and Testing	$25,000
Arm Validation	$38,400
Total	$88,400

The robot arm specifications require a detail maintenance by the manufacturer that is estimated in $3,000 per year. The payback period for this project is estimated in 1.5 year per Equation (1) [8].

$$\boldsymbol{Pay\ Back} = \frac{\mathbf{88{,}400}}{\mathbf{58400}} = \mathbf{1.5} \qquad (1)$$

Company 2 robot arm have an expected live of 10 years with no salvage value. The X Manufacturing Company has a twenty percent of rate of return thus the Net Present Value (NPV) was also calculated. The NPV as shows Equation (2) [8], is $156,000.

$$NPV = -88400 + 61400(4.192) - 3000(4.192) = \$156k \qquad (2)$$

One major benefit of the robot arm beside the economic, is going to be the continuous operation without affecting operator's ergonomics. As established in the problem statement, this project pursues the reduction in a hundred percent the ergonomics claims. Figure 8 [7], shows a conceptual design from EMI company. The conceptual is a similar arrange of what could be the robot arm for X Manufacturing Company because represent a conveyor carrying parts that eventually will be picked up by the robot arm to be placed in box.

Finally, the design also seeks to reduces the cycle time of building one box or shipper by 50%.

The last section of the DMADV methodology is out of the scope of this project since the scope of the project was to design and propose a solution for the problem statement in this project. Once the design is accepted and implemented the verify phase will be developed.

Figure 8
Conceptual Design

CONCLUSION

Pick and Place robots are wide used in material handling applications. This project demonstrated how an automaton project could benefit from the ergonomic, cost, and cycle time. The DMADV methodology used in this project allow the team to design and propose the project in an easy and structured manner. First, the ergonomic incidents could be reduced in a 100% implementing this robot in the manufacturing task discussed. The robot will perform the repetitive task allowing the operators to be relocated in other tasks or jobs. The economic evaluation shows that the project is attractive with a payback of 1.5 years and NPV of $156k.

Finally, it was demonstrated that the cycle time could be reduced in a 50%.

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