A Methodology to Determine the Level of Automation to Improve the Production Process and Reduce the Ergonomics Index

Alejandro Chan-Amaya[1, a], María Elena Anaya-Pérez[2, b] Víctor Hugo Benítez-Baltazar[3, c]

Universidad de Sonora, Blvd. Luis Encinas y Rosales Hermosillo, Sonora México. C.P. 83000

[a]alejandrochan12@gmail.com, [b]elena.anaya@unison.mx, [c]vbenitez@industrial.uson.mx

Abstract. Companies are constantly looking for improvements in productivity to increase their competitiveness. The use of automation technologies is a tool that have been proven to be effective to achieve this. There are companies that are not familiar with the process to acquire automation technologies, therefore, they abstain from investments and thereby miss the opportunity to take advantage of it. The present document proposes a methodology to determine the level of automation appropriate for the production process and thus minimize automation and improve production taking in consideration the ergonomics factor.

1. Introduction

The rapid mechanization and automation development of production process during the las century, was largely driven by human desire to reduce the proportion of manpower and thus improve the productivity of industrial facilities. The industry aims to find approaches that allow the production of high quality products at low cost [1].

Companies are constantly looking for improvements in productivity to increase their competitiveness. The use of automation technology is a tool that has been proven to achieve this, but it does not ensure advantageous results. One of the keys for a successful investment and implementation of automated equipment is the choice of the right technology, the type and level of automation that best suits the company, its needs, objectives and prerequisites. There are companies that are not familiar with this process, therefore, they abstain from investments and thereby miss the opportunity to take advantage of existing technology [2].

In the 80's there was an ambition to create factories that were totally automated, nowadays most of the automatic systems within the manufacturing are semiautomatic, consisting of the combination of automatic and manual tasks [3]. Research has demonstrated the importance of integrating human beings and technology into automated manufacturing to support sustainable and robust manufacturing systems. The relationship between humans and technology can be seen as activities that are performed entirely manually to fully automate, sharing tasks between human and technology. This concept is called levels of automation (LoA) [4].

2. Levels of Automation

Automation does not necessarily refer to modernization or technological innovation, For example, updating a computer with a powerfull system does not necessarily constitute automation, therefore, automation can be definded as a device or system that accomplishes (partially or fully) a function that was previously could be carried out by a human operator [5].

Frequently it is said that the progression from manual operations to fully automated operations is done in a single step, that is, when operators are replaced by modern robots or machines. However, this is not entirely true. Manual operations are defined as work done by hand and not by machine, and machines, in the same way are defined as instruments designed to transmit or modify the application of energy,

force or movement. The manual term can then be defined as the work done without any tool or support [3]. This implies that automation is not all or none, but can vary across a continuum of levels, from the lowest level of full manual throughput to the highest level of complete automation [5]. Therefore, giving the tools to the user or other support to achieve the task, can be seen as increasing the level of automation [3]. Table 1 shows the different levels of automation. LoA, mechanical and information levels can be interpreted as a 7x7 matrix with 49 possible combinations. The 49 possible solutions are then limited to a relative maximum and minimum level and create a framework of possible solutions (SoPI) based on company goals, ergonomics, environmental issues, investments, among others [6].

Table1. Scale automation levels for mechanical and computerized tasks

LoA	Mechanical and Equipment Level of Automation (Mechanical LoA)	Information and Control Level of Automation (Information LoA)
1	Totally manual	Totally manual
2	Static hand tool	Decision giving
3	Flexible hand tool	Teaching
4	Automated hand tool	Questioning
5	Static machine/workstation	Supervision
6	Flexible machine/workstation	Intervene
7	Totally automatic	Totally automated

3. Case Study

In areas of manual operations workers commonly make mistakes in their activities for different reasons, among them: distractions, fatigue and repetitive activities. Because of the above; has a direct impact on production and ergonomics, since in many cases the target is not achieve, thus raising the costs of manufacturing. The industrialization and process automation, especially in the industry of electric harnesses for the automotive market, must be with a very high level of quality and for this it is necessary an exhaustive supervision of each step to be realized during the manufacture.

The present work will be carried out in an automotive industry located in Mexico, the company is dedicated to carry out several processes, and one of them is the tape process of harnesses for automobiles, the process is showed in figure 1. The company seeks to increase its productivity and improve the ergonomic index through making use of technology.

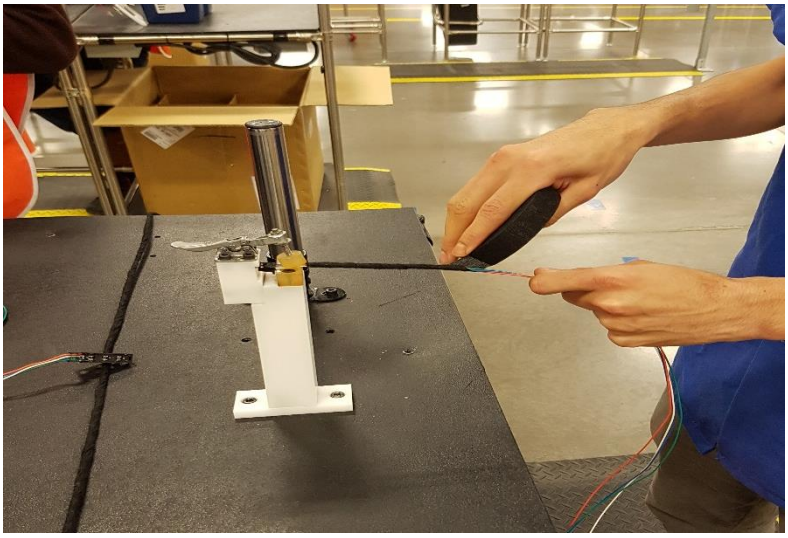

Figure 1. Tape process harness.

It is proposed a methodology that allows to make the selection of the appropriate level of automation which will lead to the result expected by the company, this methodology is based on a previous work developed by the authors Fasth et al. [7] consisting in 4 steps to develop, which is presented in figure 2.

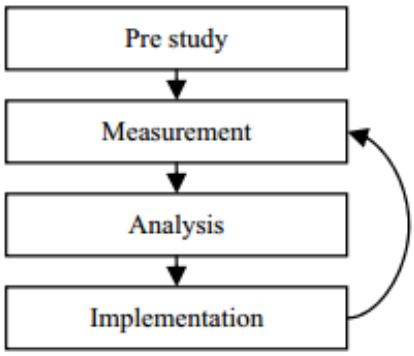

Figure 2. Phases in the measurement methodology [7].

3.1 Pre study

This step consists in defining in how it is the current situation of the process to study and to know the characteristics with which the operation is currently being carried out, the following is a list of the tasks that have to be performed in order to complete the current phase:

- Select process to study
- Walk the process and know it
- Perform Value Stream Mapping (VSM) to identify flows and parameters

3.2. *Measurement*

This phase aims to disaggregate each of the activities performed by the operators in each of the workstation stations, as well as to measure the level of automation in the process. The activities to be performed in this phase are shown:

- Ergonomic analysis
- Measurement of automation level
- Document results

3.3. *Analysis*

This phase of the methodology aims to determine the minimum and maximum level for each of the operations of the work center, with them design different proposals with the improvements that are intended to perform and finally analyze these possible improvements with respect to the parameters that were obtained in phase one, the tasks to be performed are the following:

- Conduct a workshop to determine the minimum and maximum level of automation
- Design of proposals
- Analysis of proposals

3.4. *Implementation*

The objective of the last phase is to visualize the different proposals that resulted in the previous phase based on the objectives and desire of the company, once selected the proposal will proceed to design the new work center (electrical, mechanical, Location of stations). In this phase, it is intended to make the implementation once the design is finished and to follow up to see the effect that was obtained after the implementation, it is worth mentioning that in this phase it is possible to return to phase two if necessary. This phase is divided into 4 tasks:

- View suggestions
- Station layout
- Implementation
- Tracing

4. Partial results

This chapter presents the partial results of the methodology proposed in the previous section, describing the results to date.

In order to do any work on this process, first step is to understand how it works, this is the goal that has this stage, in other words, information about the number of operators for that work center, the flow of the Parts within the process, the cycle times of each operation.

As a result of this stage was a lay out of the work center shown in figure 3, it can be observed the current design of the work center the location of the operators and the flow of the product and the VSM showing on figure 4.

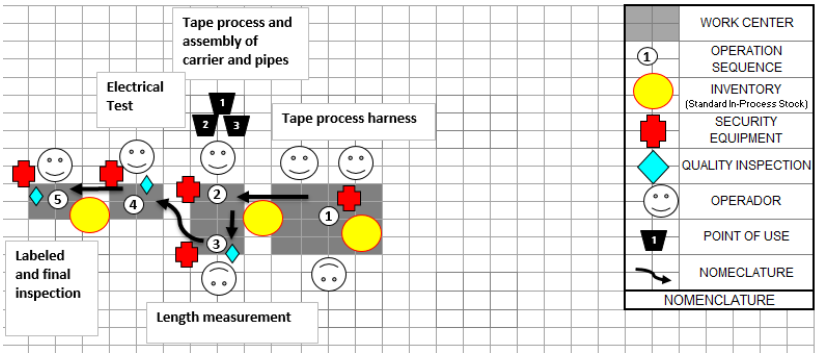

Figure 3. Plan of the work center under study (own design using company format).

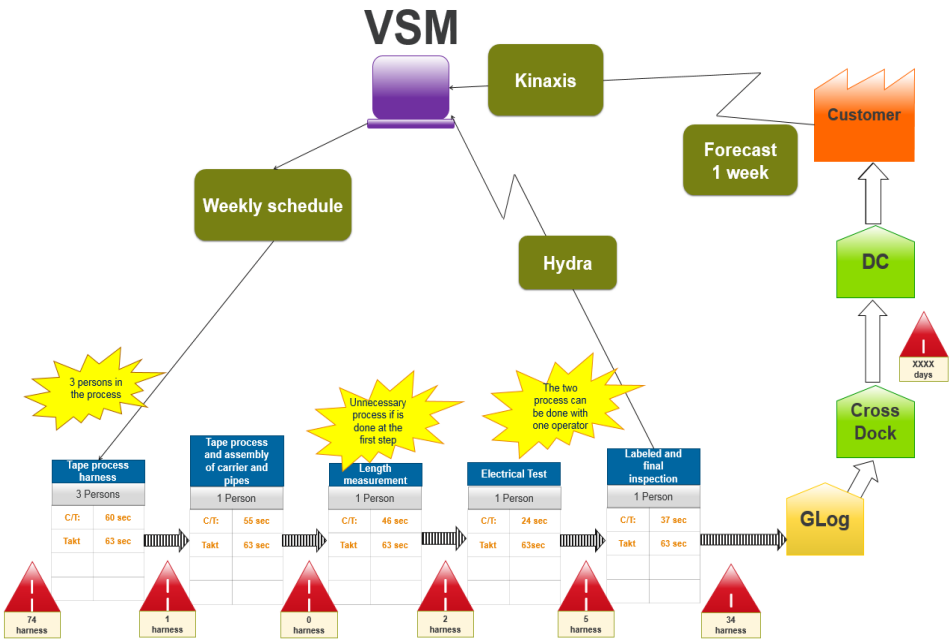

Figure 4. VSM of work center on study (own design using company format).

Developing a VSM, several possible improvements were found, and two of them are intended to be carried out with this project, in both cases reduce the number of operators and consequently the ergonomic index.
Once the process is known and the necessary parameters are obtained, the ergonomic study is carried out (this study was carried out by the Department of Safety and Hygiene), the results are showing on figure 5, where it is say the risk of performing is moderate. One of the company's goals are to improve this index.

Section I Scores	Neck	Shoulder	Back	Arm & Elbow	Wrists	Hands	Legs	Static Postures
	15	5	0	0	10	10	0	5

Risk Ranking		
	Greater than 85 = High 45 to 84 = Moderate 44 or Less = Low	45

Figure 5. Results of the ergonomic study (company format)

Currently, we are working on phase two where the measurements of automation level is carried it out and at the same time, we are looking for different ways to simulate the resulting future solutions.

Conclusion

With the implementation to a plant level of automatic systems in the different processes, the company can benefit not only production, but also performance, and product quality, as well as ergonomics. In order to obtain these desired benefits, it is necessary to determine and analyze the level of automation that the process requires for a better result and to achieve minimization of automation costs.
So that the above is possible to know the current situation of the company in terms of flow, times and automation, in order to know the areas of opportunity that has, in this way, make proposals guided by the needs and objectives of the company.

Acknowledgments
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EP0003

Time: 13:30-13:45

Effect of Deposition Speed on the Flatness and Cylindricity of Parts Produced by Three Dimensional Printing Process

Assoc. Prof. Muhammad Fahad, Mehmood Khalid, Muhammad Nauman, Maqsood Ahmed Khan
NED University (Karachi), Pakistan

The idea of layer-by-layer deposition of materials to obtain three dimensional shapes, known as three dimensional printing, has gained much popularity during the last decade. Investigations related to understanding the effect of process parameters on the output of the accuracy of parts produced by three dimensional printing processes have been performed by various researchers. This study is also aimed at investigating the effect of deposition speed on the accuracy in terms of geometric dimensions and tolerancing such as flatness and cylindricity of the parts produced by open source three dimensional printers. The repeatability of the parts printed were also investigated.

EP0004

Time: 13:45-14:00

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Mr. Alejandro Chan-Amaya, Mar á Elena Anaya-P érez, V íctor Hugo Ben ítez-Baltazar
Universidad de Sonora,Mexico

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EP0006

Time: 14:00-14:15

Reduction of Defective Products by Empiric Analysis: the Production Line Case in a Factory of Automotive Parts

Mr. Ramses Lugo-Telles; Mar á de los Ángeles Navarrete
Universidad de Sonora (UNISON)， México

As all massive line production, in the production line under study, exist the possibility of produce defective products, so like all companies based in continuous improvement, it wants to know all the facts about these defective products, for example, how many are they? in which areas do they arise? Why do they arise? And among other questions, in order to suggest and implement some solution alternatives