AMSE Association for the Advancement of Modelling & Simulation Techniques in Enterprises
IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Advances in Modelling and Analysis B
Vol. 66, No. 1-4, October, 2023, pp. 31-34
Journal homepage: http://iieta.org/journals/ama_b

Simulation with a Lean Approach in Industry 5.0

Mario Ramos Castillo[1], Luis Asuncion Perez Dominguez[1*], Roberto Romero López[1], Karla-Yoahana Sanchez-Mojica[2], Yunellis Del Carmen Burgos Pereira[3]

[1] Departamento de Ingenieria Industrial y Manufactura, Instituto de Ingenieria y Tecnologia, Universidad Autónom de Ciudad Juarez, Ciudad Juarez 32315, Mexico
[2] Facultad de Ingeniería, Programa de Ingeniería de Software, Corporación Universitaria Iberoamericana, Corporación Universitaria Iberoamericana, Bogotá 110231, Colombia
[3] Grupo de Investigaci´on CIPTEC, Fundacion Universitaria Tecnologico Comfenalco, Cra. 44 #30-91, Barrio España, Cartagena, Bolivar 130015, Colombia

Corresponding Author Email: luis.dominguez@uacj.mx

https://doi.org/10.18280/ama_b.661-405

Received: 15 August 2023
Revised: 20 September 2023
Accepted: 2 October 2023
Available online: 17 October 2023

Keywords:
industry 5.0, lean manufacturing, simulation

ABSTRACT

Lean Manufacturing is a methodology that companies from different sectors have implemented for several years, which has given significant results. Although it is a methodology that has been implement- ed since the 70's, it is still in force despite the technological era that has been advancing in recent years. The different Industrial Revolutions have brought with them important advances in terms of technology, always seeking to make life easier for human beings. From Industry 3.0, where we begin to talk about technology and intelligent machines, it has sought to automate processes and replace handmade or manual production in companies. Therefore, one might think that just as companies must adapt to these new trends, methodologies, such as Lean Manufacturing, should also transition to automation or the use of technology for their application. If Industry 3.0 already showed important signs in the advancement of technology, with Industry 4.0 it was confirmed that this technology would be present in our daily lives and in the processes of companies. In fact, in developed countries such as Japan and Germany there is already widespread talk of Industry 5.0, an industry that seeks to return to the human being as an important part of industrial processes, which in Industries 3.0 and 4.0 had passed into the background to give way and greater importance to the use of technology. With the new industrial revolution (5.0) there is even talk of new technologies and tools for improving the production processes of companies. Companies seeking to adapt to the use of technology and seek to continue competing in the market and even seek a better position against the competition must make strong capital investments to acquire the technology necessary for their processes. And those decision-makers need to have a very broad picture and make sure that those investments work and have the expected results. One of the important tools in Industry 5.0 that can help in decision making is simulation. The simulation helps in visualizing how a process works without the need for it to be already implemented in a real way, that is, adjustments and improvements can be made without these implying a change or an investment in the real process. Therefore, we can have data that approximates the data that can throw us a process that is already working physically. If you are looking to analyze data from a process that is already physically implemented, simulation helps determine which part of the process requires improvement or change.

1. INTRODUCTION

Lean manufacturing is a Japanese methodology that has been implemented for some years now by companies of different sectors giving great results, so, despite the technology that has been present for some time in the production processes, this methodology is still in force. According to Socconini [1], lean manufacturing can be defined as a continuous systematic process in which waste or excess is identified and eliminated, any activity that does not add value but increases costs and labor is understood as redundant. Industry 5.0 admits the industry's capacity to attain public goals beyond employment and growth as a source of sustainable prosperity, respecting the boundaries of the planet and placing the well-being of industrial workers at the center of the production process [2]. The products/services of industry 5.0, where human-machine collaboration occurs, empower people to realize the basic human impulse to express themselves. These custom products can also be known as the human touch [3]. Figure 1 shows the enabling technologies for Industry 5.0.

The industry demands 24/7 uninterrupted processes, 99.99% availability, process automation and simulation, dynamic designs, hyperconnectivity and decisions based on real-time data [4]. In this sense, simulation helps to make better decisions based on the analysis that is done before

implementing a change or an improvement in the real production process. Understanding that this new industrial revolution began in Europe, in Mexico, Industry 5.0 is a new topic and industrial companies continue to use manual methods or Industry 3.0 technologies; some are starting to adopt Industry 4.0. However, adoption is asymmetric or uneven, as industrial processes, investment, and government public policies are negligible [5, 6], leaving only a few companies with the opportunity to adopt modern technology through loans from development banks [7-15]. Regarding lean manufacturing, according to the study [16] about grade of implementation of lean manufacturing in Mexico, the 38.3% of companies under study are in transition, 20.3% in the stabilization stage and 42% in the maturation stage. Figure 2 shows this study graphically.

Figure 1. Enabling technologies for Industry 5.0

Figure 2. Grade of implementation of lean manufacturing in Mexico

The Mexican maquiladora industry represents one of the largest sources of employment nationwide. According to INEGI (Instituto Nacional de Estad´ıstica y Geograf´ıa) sources for the year 2018, Mexico had registered 5089 companies that had an IMMEX permit (Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportaci´on). Therefore, industrial production is one of the most important pillars of the economy, accounting for about 18% Gross Domestic Product (GDP). In 2021 alone, the Mexican manufacturing sector attracted US $12.56 billion in foreign direct investment and employed more than nine million workers [17].

2. METHODOLOGY

The methodology used to develop this document is described below:

1. Collect data. The literature available in databases such as Scholar Google and Science Direct was consulted.
2. Simulate the data in FlexSim®: From the available literature, data were obtained from a process published in a master's thesis entitled "Reducci´on del tiempo de ciclo del subensamble de motores de una empresa au-tomotriz de la ciudad de Quito" to perform the simulation of said data.
3. Get the simulation results: When performing the simulation, FlexSim® displays dashboards with different information to be analyzed.
4. Analyze the results: The data shown by the FlexSim® dashboards were analyzed to subsequently propose an improvement with a simulation model.
5. Analyze the results: The data shown by the FlexSim® dashboards were analyzed to subsequently propose an improvement with a simulation model.
6. Propose an improvement model: Having the analysis of the results of the initial model simulated an improvement proposal is made with simulation.
7. Analyze the results: The analysis of the proposed improvement was carried out to make a comparison with the results of the initial model.

This project proposes the use of the FlexSim® simulation program to analyze the data obtained from the simulation of an engine subassembly process and subsequently make an improvement proposal. FlexSim® is a typical integration between virtual reality technology and discrete object oriented simulation [10]. FlexSim® allows you to simulate and understand the basics of your system without complicated programming as it provides an easy way to develop simulation models [11]. The data was analyzed based on the statistical tools offered by FlexSim® on the dashboards of each process or operator. It is important to note that the data used in this study were obtained from a paper provided by Picho Barrionuevo [18], the process is shown in Figure 3.

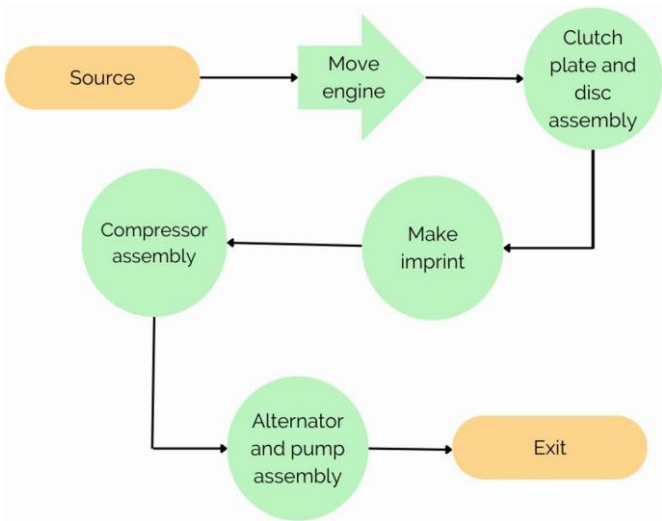

Figure 3. Process flow diagram based on literature [10]

Figure 4 shows the simulated process in FlexSim®.

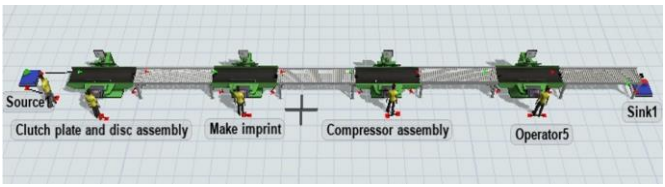

Figure 4. Simulated model of the real process

3. RESULTS

The simulation of the process was carried out with the data obtained from the document presented by Picho Barrionuevo [18] to obtain conclusions of the opportunities for improvement. Figure 5 shows the boards with the information obtained from FlexSim®, considering 8 hours of work, starting the shift at 8:00 a.m. and ending at 4:00 p.m.

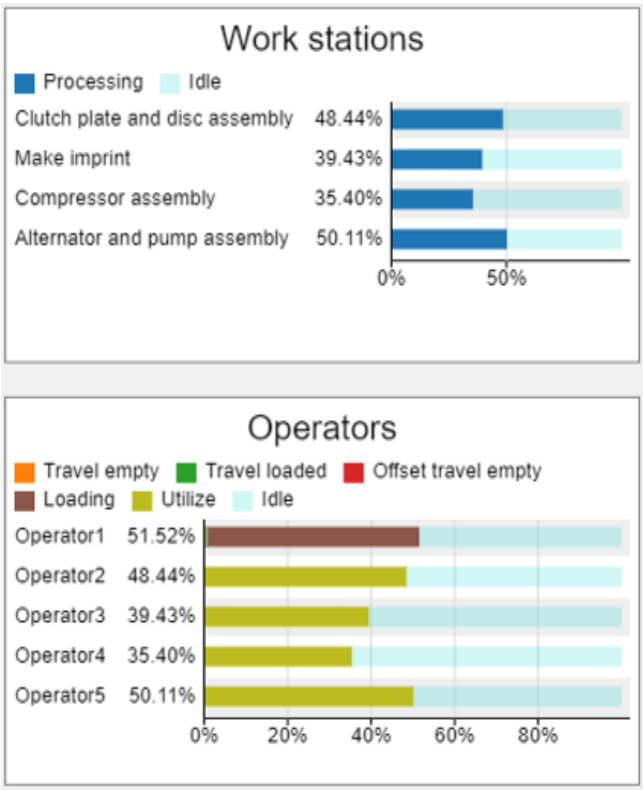

Figure 5. FlexSim® board of the initial model

The information shows that there is an opportunity for improvement in product transportation and operator and process productivity. Subsequently, a simulation was carried out to propose an improvement, showing the model proposed in Figure 6.

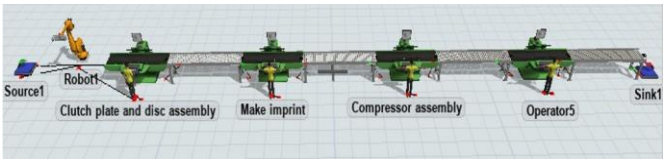

Figure 6. Proposed simulation model

The dashboard with the information of the proposed model is shown in the Figure 7.

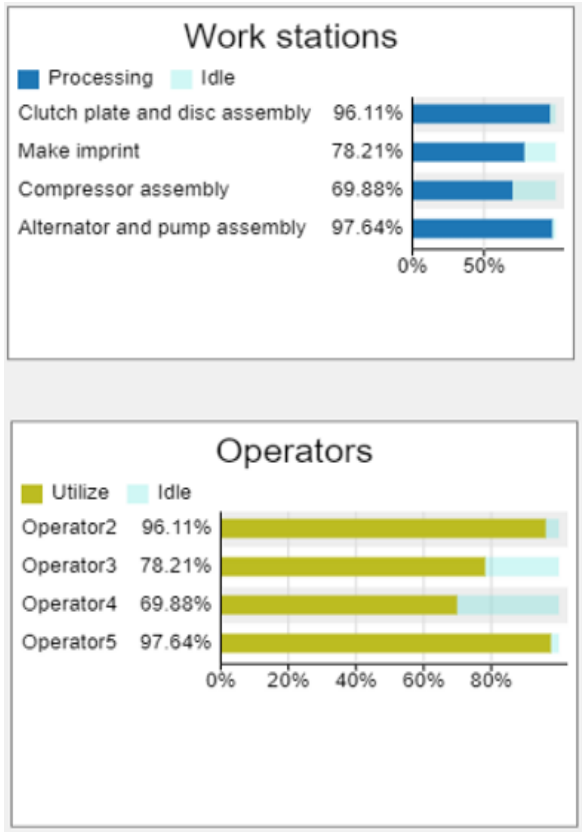

Figure 7. Dashboard of the proposed model

The proposed improvement consists of removing the operator who oversees transporting in the process and adding a robotic arm in its place. By adding the robotic arm to assist in transporting the product early in the process, operator and workstation productivity is greatly improved.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Based on the data obtained, it can be concluded that simulation can be a great tool to make improvement decisions in a process before they are implemented in the real process. Industry 5.0 demands to be able to deliver personalized items quickly, and for its part, Lean Manufacturing seeks to avoid having any type of waste. And to obtain a combination of these, simulation plays an important role in allowing the necessary changes to be made before applying them in the real process to achieve a synergy between speed, customization, technology, and a process with less waste.

4.2 Recommendations

Because Industry 5.0 has not been implemented in Mexico, more research is required to get a broader picture of how this industrial revolution will improve the productivity and competitiveness of companies established in Mexico.

It is recommended to expand the use of simulation to address issues related to decision making, especially if we talk about decision making related to investments in technology, a fundamental aspect to achieve the implementation of Industry 5.0.

4.3 Limitations

As Mexico does not have companies or industries that are implementing Industry 5.0, proposals with simulation are not made in the real process.

If you do not license the FlexSim® software, it only allows the integration of 30 elements into the simulation model.

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