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Article

Graphic interface design as support for decision-making in the salt production process

Diseño de interfaz gráfica como apoyo para la toma de decisiones en el proceso de producción de sal

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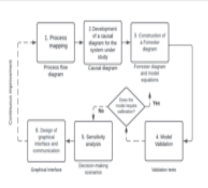
Abstract

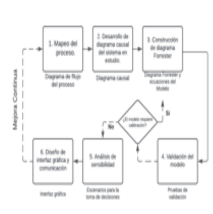
El Desarrollo del presente proyecto, se centra en el disseño de una interfaz gráfica como herramienta para la gestión de información en la toma de decisiones en el proceso de producción de sale en una empresa del giro agroalimentario en la region Sur del estado de Sonora, México. Siendo esto posible por medio de la aplicación de metodología de dinamica de sistemas con el fin de evaluar las relaciones e interacciones de los elementos presentes en el sistema bajo estudio, determinando con ello las variables y parámetros sensibles comprometidos en la producción y comercialización de sal de consumo humano.

Objetive	Methodology	Contribution
Develop a technological solution that allows for the analysis of the salt production process from the Sea of Cortez, generating quantitative data to support decision-making.		Development of a graphical interface as a tool for information management in decision making during the salt production process at a company in the agribusiness sector.

Smart Farms, Dynamical Systems, Graphic interface

Resumen

The development of this project focuses on designing a graphical interface as a tool for information management in decision making during the salt production process at a company in the agribusiness sector in the southern region of Sonora, Mexico. This is made possible through the application of systems dynamics methodology to evaluate the relationships and interactions of the elements present in the system under study, thereby determining the sensitive variables and parameters involved in the production and commercialization of human consumption salt.

Objetivo	Metodología	Contribuciones
Desarrollar una solución tecnológica que permita analizar el proceso de producción de sal mar de cortés, generando datos cuantitativos como apoyo a la toma de decisiones.		Desarrollo de una interfaz gráfica como una herramienta para la gestión de información en la toma de decisiones en el proceso de producción de sal en una empresa del giro agroalimentario.

Agroindustria, Dinámica de Sistemas, Interfaz gráfica

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Introduction

The production and marketing of salt plays a fundamental role in the global economy, given its widespread use in key industries such as food, chemicals and de-icing. This mineral is not only essential for human life, but also constitutes a crucial input for the manufacture of chemical products, food preservation and the maintenance of road infrastructure in cold climates. Leading salt-producing countries, such as China and the United States, have a significant influence on global markets, impacting salt prices and availability worldwide. In addition, international salt trade reflects economic interdependencies between nations. A notable example is Mexico, which imports large volumes of industrial salt mainly from the United States, highlighting the importance of foreign trade in securing the supply of this essential resource.

Background

During 2023, world salt production reached approximately 273.8 million metric tons. China consolidated its position as the main producer with 53 million tons, representing almost 20% of global production. Together with the United States, which produced 42 million tons, both countries accounted for 35% of world production. Although the United States was historically the largest producer, in 2019 it was surpassed by China, which produced 60 million tons, compared to the 42 million tons of the United States (Gaitán, 2024).

Meanwhile, the national production of salt, in 2019, was 8.8 million tons, with an annual growth rate of 1.7% for the period 2009-2019. It is estimated that 78% of the national production is generated by the main salt company in the country, located in Guerrero Negro, Baja California Sur, whose market is purely for export; the remaining 22% corresponds to the other salt companies, which basically supply the domestic market. The location of this activity is established in the primary sources of sodium chloride, which means that 96% of production for the domestic market is concentrated in the states of Veracruz (49%), Yucatán (28%), Sonora (10%), and Nuevo León (9%) (Secretaría De Economía, 2022).

Likewise, during the year 2023, the volume of salt production in Mexico was around 757,460 metric tons, which represents an increase of almost 23% compared to what was reported during the same month of the previous year (Statista Research Department, 2023).

On the other hand, in 2023, salt production in Sonora, remained a significant part of the salt industry in Mexico with 2.4% of national production. At the national level, the state of Baja California Sur, in particular, continues to be an important salt producer in the country. Production in this region is fundamental for the supply of salt both nationally and internationally. (Opportimes, R., 2023).

Salt has diversified commercial applications. More than 80% of global production is destined for four main markets: chlor-alkali production, synthetic soda ash manufacture, road de-icing and the food sector. These uses dominate the market, with the chemical and food industries leading demand, especially in industrialized regions such as the T-MEC bloc and Europe. In addition to these sectors, other important markets for salt include water treatment and the production of chemicals such as sodium chlorate. Salt consumption varies considerably at the regional and national level, influenced by factors such as the size of the local chemical sector, climatic conditions and population density (DOF, 2021).

The company under study belongs to the agribusiness sector, being a Mexican company that processes salt produced by evaporation in the salt mines where the organization operates, with a presence of more than 30 years in the market, where the company seeks to be a leader in the production, processing and marketing of sea salt. In turn, the organization processes different types of salt according to the requirements of consumers, which vary according to their type for human, animal, and industrial consumption, among others. However, for the purposes of this research, the product under study is focused on human consumption of food origin.

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For this, the organization faces a significant challenge in the variability of demand, which affects both the production and marketing capacity of this, where in periods of high demand, the inventory is often insufficient to meet it, revealing bottlenecks in the production process. These bottlenecks hinder the efficient production and marketing of salt, compromising the plant's capacity to meet market demands, which in turn determines that the lack of an adequate methodology to identify and visualize these bottlenecks makes it difficult to make decisions aimed at optimizing the process.

It is crucial to develop a systematic approach to simulate the plant process and generate a graphical representation of the production and marketing capacity. This will facilitate the identification and solution of bottlenecks in the process, improving the operational efficiency of the company. Taking the problem as a reference, the following research question is posed: How can a technological solution based on quantitative data help to identify and visualize bottlenecks in the production process of Sea of Cortez salt? Therefore, the following objective was proposed: To develop a technological solution that allows to analyze the production process of Sea of Cortez salt, generating quantitative data to support decision making.

Methodology

As can be seen in the previous figure, the methodology is based on the study of the dynamics of systems and continuous improvement, being this element what favors the interaction between each of the elements that contemplates it, this because it considers verification steps and with it the improvement of these according to the results obtained in each of the steps that conform it, from the mapping of the process under study to the design of the interface and its implementation for decision making, in turn in the lower part of the box of the activity is listed the main result obtained in each phase of the procedure.

The first step consists of mapping the process, identifying the elements that make up the system under study, as well as the relationship that exists between them, thereby identifying the main variables, parameters and constraints.

All this is possible through the implementation of various tools that allow the conceptualization of the system, such as the use of flow diagrams and process mapping.

Subsequently, once the system has been mapped and the elements that comprise it (variables and parameters) have been identified, a causality diagram is developed in order to visualize the relationships and feedbacks between the different variables of the system. In turn, it allows understanding how the variables influence each other through positive and negative feedback loops.

Starting from the causal diagram, flow and level diagrams are generated which allows translating the qualitative description into a mathematical model in order to simulate the real system, which includes the creation of differential equations, establishment of parameters and collection of data necessary for its simulation. Where the level variables represent the accumulation of resource during the system during a defined time interval, (Orlandoni and Ramoni, 2018). For the purposes of the development of the causal diagram, the level variables are represented by stocks, rows, bands and furnaces (processes).

While, with regard to the flow variables, these are the ones that maintain the equilibrium and operation of the system, since through them the level variables present in the system are fed, representing the input and output of materials or products over time.

Once the Forrester diagram has been constructed, it is necessary to verify the correct functionality of the model under study, for which it is necessary to simulate it and submit it to various validation tests in order to verify that it is reliable according to the results obtained, where in case it does not represent real data of the current situation, it is calibrated in order to be improved and obtain a reliable model that is in line with reality and thus allows generating quantitative data to make the decision-making process more efficient.

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Considering that the model is reliable, it is immersed in different scenarios such as optimistic scenarios where modifications are made to the parameters present in the model in favor of it and thus generate advantageous information for the organization, representing an ideal state for decision making, while otherwise in the pessimistic scenario, the modifications to the parameters represent unfavorable situations. Finally, in the implementation phase, we proceed to the construction of the graphical interface, through which the user interacts with the system and thus generates quantitative data for further analysis and timely decision making in the short, medium or long term as required, such as production scheduling, overtime, outsourcing or investment in machinery and equipment, among others as appropriate.

Box 1

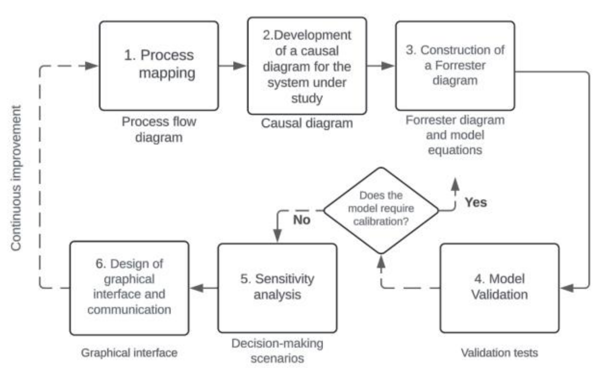

Figure 1
Methodology under study
Source [Own elaboration, (2024)]

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Results

Mapping of the process under study

In relation to the mapping of the process under study, a flow diagram was developed in which each of the processes involved in the manufacture of salt is identified, from the reception of raw material (raw salt) to the storage of the finished product (salt pallets), passing through the iodizing, packaging and palletizing process. Figure 2 below shows the representation of the aforementioned process.

Box 2

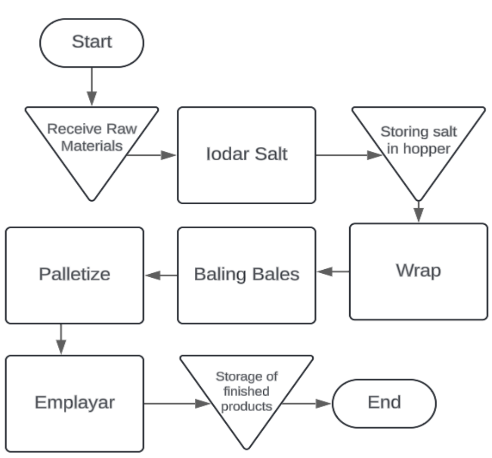

Figure 2
Flow diagram of the production process of Sea of Cortez salt.
Source [Own elaboration, (2024)]

The above flow chart shows that the process begins with the reception of raw material (raw salt), which is subjected to the iodization process as a required treatment for human consumption. Once the salt is iodized, it is stored in a hopper that supplies the product to two fillers that pack the salt in individual one-kilogram bags, to later form bales of salt and thus assemble pallets for marketing to domestic and international markets.

In addition to the development of the flow diagram, quantitative information was collected on each of the elements of the process, emphasizing data associated with production capacity and processing time. This information is shown visually in the map in Figure 3.

Box 3

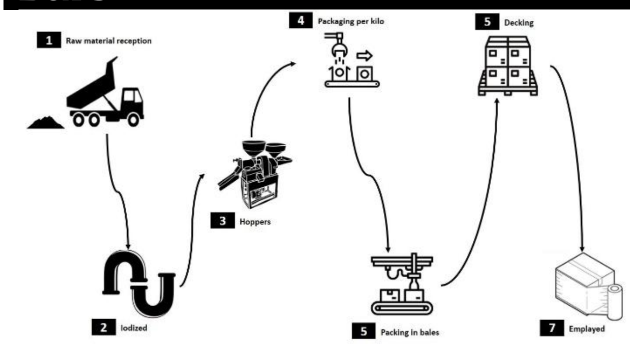

Figure 3
Mapping of the production process of Sea of Cortez salt.
Source [Own elaboration, (2024)]

In the previous map, each of the processes involved in the production of Sea of Cortez salt is graphically represented, where at first there is the reception of raw material, in which raw salt is received from the saltworks, and this is deposited in the yard of the organization, to be subsequently processed at a rate of 34 tons per shift being entered into the transformation process through a reception hopper which doses the product to pass it to the iodized process, This process consists of adding iodine to the raw salt by means of electronic devices in an elevator tube, thus generating iodized salt (product in process), which is sent to the hopper that supplies the packaging process by means of filling lines, which pack at a rate of one kilogram bag.

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The bags then go to the baling process, which consists of grouping 12 kilograms of salt, and finally being palletized at a rate of 125 bales per pallet, this being possible through the wrapping process, which lasts 2.27 minutes per pallet. Finally, the finished product is stored in the finished product warehouse, ready for marketing.

As a final part of the first step of the procedure, the variables and parameters present in the system are identified, the main variables being the amount of raw salt received by the organization and the demand for the finished product, while the parameters define the capacity and times for the reception of raw material, packaging, palletizing and wrapping.

Development of the causal diagram in the study

The causal diagram shows the variables present in the system under study and at the same time allows understanding the existing interactions between them.

Box 4

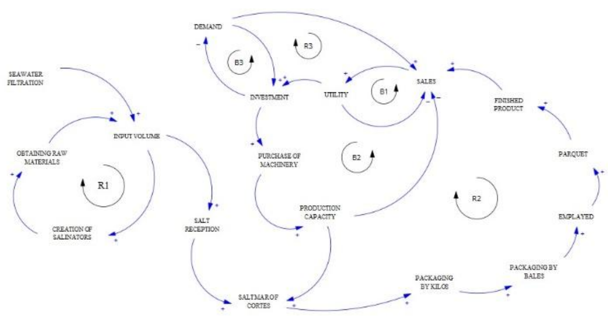

Figure 4
Causal diagram of the Cortés sea salt production process.
Source [Own elaboration, (2024). Create with Vensim ® PLE plus.]

Figure 4 presents the causal diagram that illustrates the main variables involved in the production process of Sea of Cortez salt, ranging from the procurement of raw materials to the distribution of the final product.

In this diagram, the variables are interconnected by arrows that indicate the direction of causality, representing how changes in one variable affect the others within the system.

In addition, the diagram identifies and classifies feedback loops into two categories: reinforcing loops and balancing loops, which play a crucial role in the dynamics and stability of the production process.

Considering the system loops, loop R1 illustrates the initial production process: seawater filtration provides the raw material that is used to create salinizers, thus increasing the salt reception and input volume into the system. Loop R2 focuses on production capacity and how this influences the amount of finished product, which is emplayed and packaged for distribution. In loop R3, demand is crucial; an increase in demand drives sales, which increases profit. With higher profits, the company can invest in improving production capacity by acquiring new machinery.

In loop B1, the impact of sales on profit and the reinvestment of this profit back into the system is highlighted. As the company increases its investments to improve production, it may face resource constraints that could slow down growth. On the other hand, loop B2 links production capacity to the purchase of machinery. Although the acquisition of new machinery can increase production capacity, it also entails significant costs that must be considered. Finally, loop B3 shows how demand influences sales and, consequently, profit. If demand exceeds production capacity, it may be impossible to satisfy all potential sales, which could reduce profit and limit future investments.

- **Development of Forrester diagram**

Taking into account the previous results so far, we proceeded to develop the flow and level diagram (Forrester) which, as mentioned above in the methodology section, converts the qualitative conceptualization into a quantitative mathematical model for its simulation and generation of data for decision making, which is illustrated in the following figure.

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Box 5

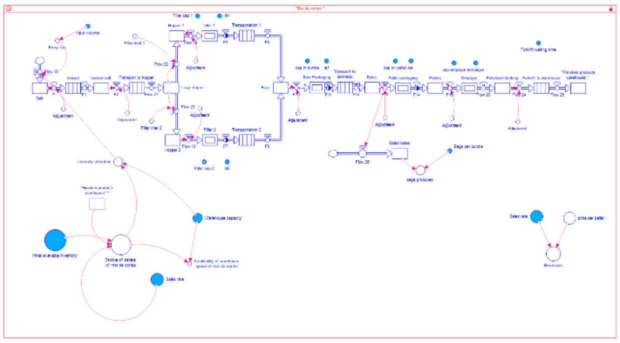

Figure 5
Forrester diagram of the Cortés sea salt production process.
Source [Own elaboration, (2024). Create with Stella® Architect, version 1.6].

The Forrester diagram is composed of several elements, including level variables, flows, variables and parameters, which are categorized according to the following table.

Box 6
Table 1
Elements present in the flow diagram and levels.

Element	Category	Type
Level	Stock	Raw salt inventory Iodized salt inventory Large hopper salt inventory Hopper 1 Hopper 2 Salt bags Salt bales Salt pallets Finished product warehouse Packed bales
	Conveyor	Iodized Transport to hopper Transport 1 Transport 2 Transport to palletizing Transport to warehouse
	Oven	Filler 1 Filler 2 Bale Packing Pallet Packing Emplaye
Flows	Flow	23 flows
Variables	Variables	-Salt input volume to the process per shift. -Filler inlet. -Filler input 2. -Initial available inventory. -Selling rate -Price per pallet. -Revenue
Parameters	Parameters	- Finished product warehouse capacity. -Filler capacity 1. -Filler 1 filling time. -Filler capacity 2- -Filler 2 filling time. -Bale packing capacity. -Bundling time. -Palletizing capacity. -Palletizing time. -Emplaye capacity. -Palletizing time. -Forklift waiting time.

Source: Own elaboration, (2024).

By way of summary, the Forrester model under study is made up of a total of 21 level variables, of which 10 correspond to the stock category, 6 to conveyor and the remaining 5 to Oven; 23 flows; 7 variables, 12 parameters and 55 mathematical equations. Being the variables and parameters possible values to be modified according to the nature of the study under development.

- **Model validation**

A crucial element of the methodology under development is the validation of the model, since its purpose is to identify the reliability of the tool according to the results it produces, so to make this possible it is required to simulate it on different occasions. For the purpose of the research, it was simulated under real production situations taking into consideration working days of one day (1,440 minutes) since the organization maintains its production process 24 hours a day sectored in three shifts of 8 consecutive hours. For validation purposes, three validation techniques were implemented: unit consistency, extreme tests and back testing.

The first test i mplemented was the unit consistency test, which in simulation methodologies, allows to evaluate the logic that exists between each of the units present in the model and the changes that these present as time passes and thus the transformation of units during the production process, where for purposes of the system under study focuses on confirming that the raw salt entering the process is converted to finished product correctly through units such as kilogram of raw salt, kilogram of iodized salt, bags of salt, bales of salt and finally pallets of salt.

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This test according to the software used Stella architect, this one emits in the screen of the same one an announcement of alert when inconsistencies are found in the present units of cutting the bar of tasks is shown clean of notifications as it is shown in the following illustration.

Box 7

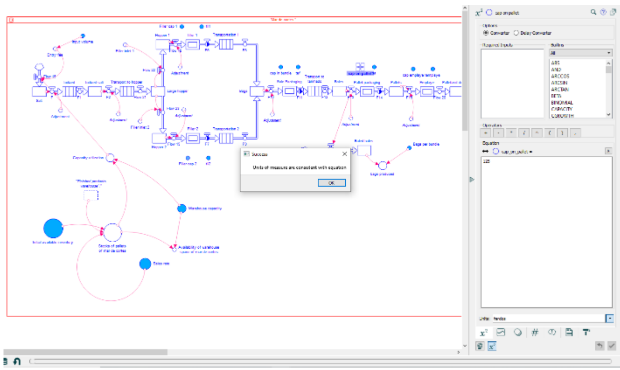

Figure 6
Application of validation test for consistency of units.
Source [Own elaboration, (2024). Create with Stella® Architect, version 1.6].

As can be seen in the illustration, it can be identified that in the lower right corner the task bar is free of notifications, which indicates that the developed model is consistent.

A second validation test is the extremes test which, as its name indicates, consists of subjecting the model to extremes in its main variables in order to evaluate its behavior. For the purposes of the study, the input volume variable was subjected to 0 kg of salt per shift, i.e. no raw material entering the processing, yielding the following result.

Box 8

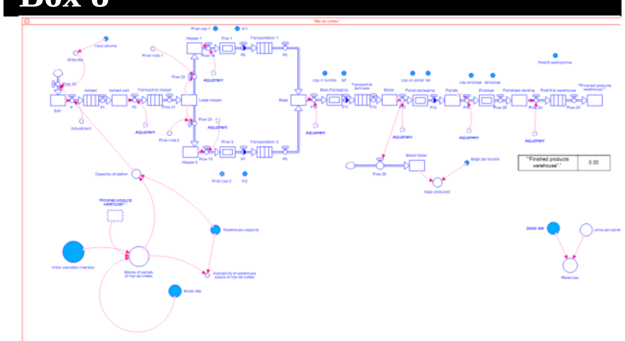

Figure 7
Model validation by extremes test
Source [Own elaboration, (2024). Create with Stella® Architect, version 1.6].

When the value of salt input to the process is modified to 0 kg per shift, a logical behavior is observed in the production system. This modification results in the absence of productive operations, which translates into zero production, with a total of 0 pallets of salt produced. Additionally, the absence of elements in the levels and flows of the process is evidenced, reflecting a complete stop in the production activity.

The third and last test is the retrospective analysis, which consists of comparing the data obtained through the simulation against the real results obtained in the organization, where it is observed that according to the simulation developed, a total of 65 pallets per day are generated, while according to the real results present in the organization, between 59 and 63 pallets per day are produced daily, which represents between 9.3% and 3.07% of the total production. 3 % and 3.07% of error, deriving at all times that the simulation is higher than the real production, this because the simulated model does not contemplate elements of line stoppage for various reasons such as meal time, operation failures, maintenance, set up, among others.

Taking into account the results obtained in the three validation tests mentioned above, it is considered that the model is valid and reliable for its implementation for decision making by the organization's management; therefore, in accordance with the continuous improvement process established in the methodology, the model did not require calibration.

- **Sensitivity analysis**

Considering that the model is valid and reliable, we proceeded to the development of the sensitivity analysis, where it was necessary to identify the sensitive variables and parameters in the model, these being those associated with the capacity of fillers 1 and 2, so three scenarios were evaluated, one of these associated with the optimal conditions of the system, the second under normal conditions (real) and the third and last one of pessimistic character, this being possible by modifying the sensitive variables and parameters in a positive and negative way, reflecting the results in the following table.

Box 9

Table 2

Scenario analysis

Parameter	Normal scenario value	Optimistic scenario value	Pessimistic scenario value
Volume of salt input to the process per shift	34000 kilograms	34000 kilograms	34000 kilograms
Filler 1 capacity	1 bag at a time	2 bag at a time	0 bags at a time
Filler 2 capacity	1 bag at a time	2 bag at a time	1 bag at a time
Bale packing capacity	12 kilograms per bale	12 kilograms per bale	12 kilograms per bale
Emplaye capacity	125 bales per pallet	125 bales per pallet	125 bales per pallet
Total pallets produced	65 pallets	139.97 pallets	43.14 pallets

Source: Own elaboration, (2024).

For the purposes of the real scenario (standard), it is modeled under current conditions which present stable processes due to the low variability in them, thanks to the standardization of these, however, they present over inventory of finished product as a result of the presence of unpredictable demands among other factors external to the organization. The current conditions can be analyzed that the salt production process has two fillers, each one with the capacity to pack one bag at a time, as well as a single bale packer, a pallet packer and a single bagging machine, producing a total of 65 pallets of salt during a working day, being this possible with the entry of 34 tons per shift according to the value assigned in the parameter of volume of salt input volume to the process per shift.

On the other hand, an optimistic scenario for the company under study would imply a significant increase in its production capacity, which translates to include an increase in the filling capacity to improve the efficiency of the process and thus optimize the supply chain, thus achieving a better sales position to meet the increased demand in the market, these changes are based on increasing the capacity of the fillers, i.e. from going from one bag at a time to two bags per filler and reducing the filling time, considerably increasing the production of salt pallets to a total of 139.

This will significantly increase salt pallet production to 139,97 pallets per day, exceeding current production by 115%, without generating bottlenecks in the subsequent processes of palletizing and emplaye.

Finally, in relation to the sensitivity analysis for the pessimistic scenario, the organization would face a significant decrease in production capacity due to various factors such as the presence of technical problems in the fillers, which results in a drastic reduction in the production of pallets per day, thus negatively impacting the amount of products available for marketing, This analysis shows that the process variables decrease, one of the fillers simulating that it is not in operation, which generates a reduction in the filling capacity and therefore reduces the total production of pallets to a total of 43 pallets per day, increasing the number of pallets per day. 14 pallets per day, thus increasing the in-process inventory (salt waiting to be packed).

- **Graphic interface design and communication**

The last result is the development of the graphic interface and its communication, which provides a simple way to interact with the model under study, by means of graphic blocks that represent different components and relationships within the system. The interface design represents the means by which the model is simplified and allows the user an accessible communication, thus facilitating the understanding and analysis of data for decision making from the variation (simulation) in the various variables and parameters present in the model, where for the purposes of the study the developed interface consists of several screens in which the start menu, control panel for interaction and display of results of both production and storage of finished product, which are presented below.

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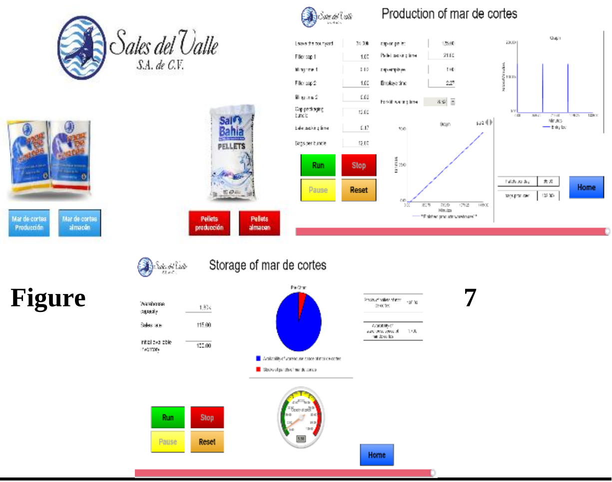
Box 10

Figure 7



Graphical interface design.

Source [Own elaboration, (2024). Create with Stella® Architect, version 1.6].

As can be seen, the main purpose of the graphic interface is based on the generation of data in graphic form for analysis and development of information of interest for decision making over time.

Conclusions

The development of this research focused on the creation of a graphical interface as a technological tool for the simulation of the production process of sea salt of Cortez of food character, with the purpose of supporting the managers of the organization to streamline the management of quantitative information for decision making.

In particular, for the purposes of the study, it is focused on determining the element of the process that compromises the production of salt, specifically the packaging process (fillers), which generates a bottleneck during the process, since it can be observed that even when a greater amount of raw salt enters in the input volume, this does not increase the production of pallets as a final result, but generates an increase in the inventory of product in process prior to packaging.

However, by increasing the packaging capacity from one bag at a time to two bags per filler, this does increase considerably the final result (production of salt pallets), without compromising the subsequent processes (baling, palletizing and wrapping), so it is determined that these processes have slack according to their design capacities.

Therefore, considering the aforementioned, the organization's managers should contemplate increasing the packaging capacity by various actions such as investment in new packaging equipment. At the same time, the tool allows generating simulations in the system prior to making any type of investment in machinery and equipment involved in the process.

Finally, it is worth mentioning that the tool developed is generated as a scalable tool that can be applied to various production processes of other types of salt present in the organization, since it only requires modification of the parameters under study.

Statements

Conflict of Interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Specify the contribution of each researcher in each of the points developed in this research.

Vega-Telles Ernesto Alonso: Contributed as technical responsible in the development of the project and documenting the results.

Bueno-Solano Alfredo: Contributed with the generation of models for the simulation of the object of study as well as documentation of results.

Acosta-Quintana Maria P.: Contributes with the documentation of results and their dissemination.

Suastegui-Ramos Francisco: Contributes with the recovery of data within the organization, and development of the model under study.

Availability of data and materials

Research data are available at ernesto.vega99367@potros.itson.edu.mx.

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References

Basic

[1] Gaitán, I. S. (2024, May 18). ¿De dónde viene la sal del mundo? China, EE. UU. e India mayores productores. Diario La República.

[2] Secretaria De Economía. (2022). Perfil de mercado de la Sal. Retrieved August 16, 2024.

[3] Statista. (2023, December 12). México: volumen de producción de sal por mes 2019-2023.

[4] Opportimes, R., & Opportimes, R. (2023, November 1). Exportadora de Sal (ESSA) expande su producción. Opportimes.

[5] Diario Oficial De La Federación. (2021). PROGRAMA INSTITUCIONAL DE EXPORTADORA DE SAL, S.A. DE C.V. 2020-2024. Retrieved August 16, 2024.

[6] Lagarda Leyva, E. A. (2019). Introducción a la dinámica de sistemas . México: Pearson .

[7] Orlandoni Merli, G., & Ramoni Perazzi, J. (2018). Ecuaciones diferenciales de la física clásica. Interpretación y solución mediante dinámic de sistemas. Revista UIS Ingenierías, 51-58.