Facultad de Ingeniería en Mecánica y Ciencias de la Producción

ESCUELA SUPERIOR POLITÉCNICA DEL LITORAL

Facultad de Ingeniería en Mecánica y Ciencias de la Producción

Flexible Manufacturing Process of Plastic Bottles

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1. Description

A new company wants to set up a plastic bottle manufacturing industry, this industry has acquired several automated machineries for the raw material development process, these have already been installed and automated respectively. The following phases, which are: the mixing process, the bottle forming process and the bottle palletizing process, have not yet been automated or redirected to flexible manufacturing processes.

These processes that have been mentioned before are those to which a flexible manufacturing process will be carried out, because the industry has presented the problem of staff fatigue when carrying out the process manually, the problem occurs in the same three areas mentioned above, so it has led to low efficiency, misuse of machinery and loss of productivity capacity that the industry can perform.

Therefore, the management of the company has analyzed this problem and has proposed the automation of the last areas of the industrial site and has been carried out in a period of 1 year, they have required that the development be implemented through flexible manufacturing processes. , in order to have control and monitoring of all the areas that are affected by the problem and see the scalability that the company will take when introducing these types of systems to the industry.

2. Justification

A large amount of waste and plastic waste are thrown into the street every day, generating great pollution and increasing different risk factors such as possible floods caused by the obstruction of the sewer system with said waste, different types of diseases resulting from a unhygienic environment, home for pests or insects, which in turn could become another serious factor against public health, therefore a company "X" in order not only to increase the efficiency, flexibility and capacity that has this industry capable of developing plastic bottles, but also that it makes precise use of recyclable materials for the production of said bottles in order to reduce the amount of pollution generated by these wastes in various sectors of a city, it is proposed to develop a set of processes so that the industry is capable of fulfilling said purposes, as well as that said processes are They can change, substitute or modify without greatly affecting production, thus increasing the company's range of action considerably, being able to develop bottles of different shapes and sizes, at the request

of their potential customers or needs.
With this, a large list of beneficiaries appears, from the same owners of the company, significantly increasing their profits, and increasing the range of the public to which they can be directed, to the employees who will have a job according to different needs and labor and civil aspects that thanks to the recycling system will be able to have a much cleaner and safer environment.

3. Objectives

General goal:

- Redesign the company's bottle manufacturing system, for the reduction of production times, increased flexibility of the system and the company's profitability.

Specific goals:

- Analyze which production stages present critical times, establishing which sections show low performance and make the system inflexible.
- Propose changes based and inspired by flexible manufacturing systems, allowing the compensation or improvement of the critical phases.
- Perform a simulation of the system`s operation, allowing the exemplification of the flow and development of the process.
- Evaluate the effects of the changes, for the observation of the results, reflected in the performance of the process in different scenarios.

Beneficiaries:

Small-medium plastic bottle companies

4. Primary Research

Primary research focuses on obtaining information through direct questions to our main clients or users, this by means of the elaboration of a series of questions in the form of an online survey that seeks to know the environment in which they find themselves daily. involved in the system, this being the employees of the plastic bottle production industry, covering different points, from the effects produced by the pandemic, to recurring problems within production in specific parts of the system in which they are found, such as problems caused by the employees themselves.

4.1. Questionnaire Raised

Rate from 1 to 5 if you disagree or agree with the statement, respectively.

The pandemic has negatively affected the demand for plastic bottles. *

3

In recent months, the time in which X amount of bottles are produced is not stable. *

4

Is it easy to adapt your current production process to unforeseen events? *

2

Production decreases in the face of unexpected events. *

3

During a regular working day, the performance of the operators remains constant. *

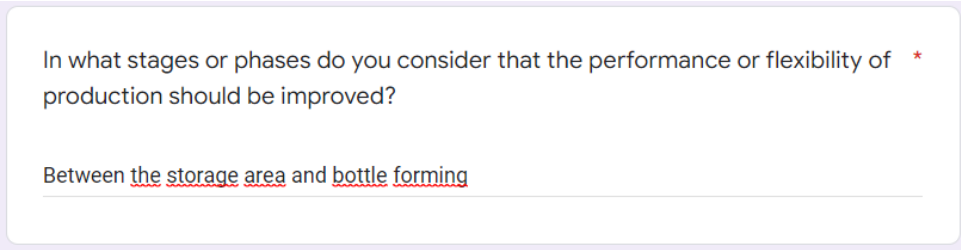
3

Operator performance declines in the face of an unexpected event. *

4

Applying the ideas or methodology of flexible manufacturing systems to your production process would have a positive impact on it. *

4



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4.2. Questionnaire Analysis

The evaluation survey was performed in order to detect strengths and weaknesses of our interest to learn more about the context of our client, such as whether the pandemic has affected the quantity of products sold. Like many other businesses the pandemic has been a point of continuous change and adaptation, for some businesses these have not been easy or possible, so looking for alternatives on how to improve are necessary even after the pandemic is over.

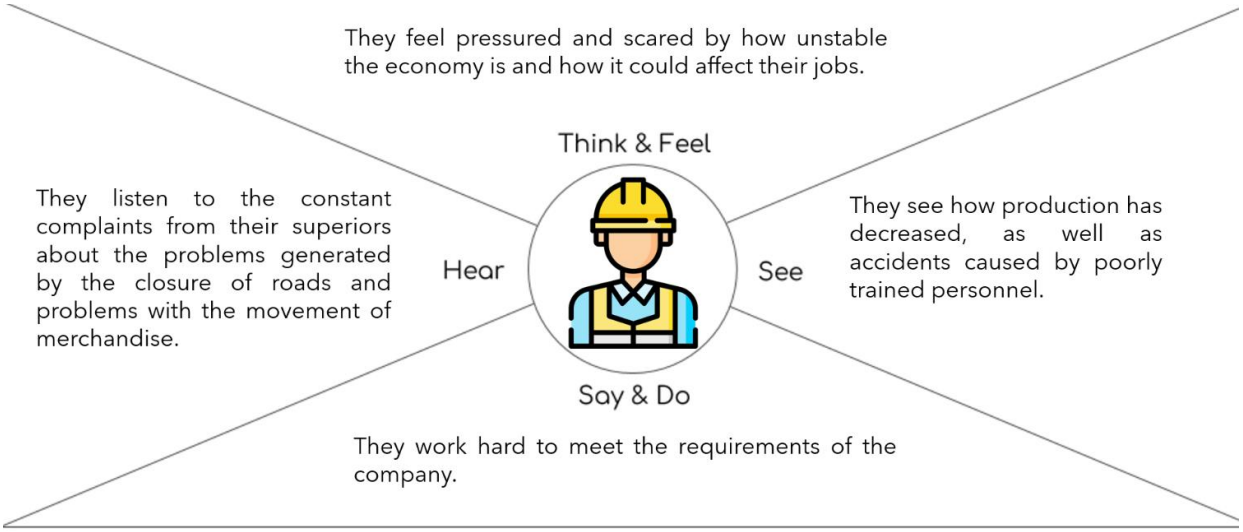
In order to understand how regular and flexible the production process is, we are interested in knowing if the quantity of goods produced has remained stable in recent months, to get an idea of how variable the market or demand for them can be, as well as to see if they are prepared for fortuitous events such as equipment breakdown, delay or lack of an operator, or other unexpected situations, as also how these affect the capacity of the workers, which as expected implies a greater load, while increasing fatigue.

Finally, we are interested in knowing how much you agree with the idea of applying flexible manufacturing systems principles to improve your current process and in which parts of the process you consider there is a greater need for improvement, from which it is understood that after the bottle has acquired its shape until it must be stored.

4.3. Empathy Map

With the information obtained with the survey carried out, an empathy map can be generated that encompasses the important factors that the employee faces within the factory, from his point of view on the different processes that must be followed to carry out a successful production. , as well as the comments that he hears recurrently, those things that the worker can visualize and the activities that the worker carries out within the company, in order to give way to the points that most disadvantage the

worker or those that generate the most discomfort, as well also as the moments that give you the most satisfaction or from which you obtain a certain profit.

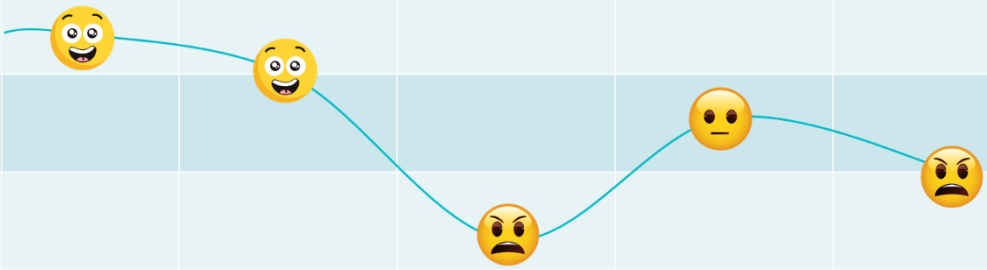


Pain	Gain
They suffer from stress and fatigue from not being able to meet the goal proposed by the company.	They obtain the security that their work will be remunerated, in addition to the fact that with a flexible system the complexity of their work will be reduced.

4.4. Experience Map

After having presented an empathy map with the worker's points of view, the turn of the experience map follows, in which the activity or activities carried out by the worker from the time they leave their home until the end of their working day are broken down into This presents five different phases that represent the agglomeration of activities that are carried out in the industry to be able to produce plastic bottles, the first being the beginning for any worker is to move to their work position, the second focuses on the transport of the raw material that is going to be used for the elaboration of the plastic bottles, the third phase tells the process of melting the materials and mixing the respective chemical compounds, the fourth phase shows the molding process where the mixture obtained from step previous for through the respective mold to finish the final product, and the last phase focuses on the packaging of said products and the transport of the m isms to end the normal day within the company.

User Segment	Scenario				
Activities:	Travel from house to the company	Process of translocated of prime material	Process of melt and combine the chemicals products	Using the mold to finalize the product	Packaging and Transport the product
Emotions: Happy					
Emotions: Neutral					
Emotions: Angry					
Pain Points:	The traffic always will be a problem.	When the inventory doesn't have sense or its not enough.	The smell and the accident are something that usually happen in this point.	It's a problem when they need to change the mold.	Traffic, gestion problems, delays are some of the common problem in this point.



5. Secondary research

As electronics and automation advance at a rapid pace, flexible manufacturing systems in the industry are essential for the control of an entire plant. One of this type of plants are the factories that make plastic bottles and at the same time they are filled with a certain liquid.

Worldwide, the most used type of plastic for the manufacture of bottles is PET, Polyethylene Terephthalate. This type of plastic is often used by companies that pack or supply mineral water, dairy products, juices and chemicals. They are resistant and unbreakable during the entire process of their manufacture, storage and transport; and at the same time a PET bottle is equivalent to 10% by weight of a glass package and the cost of transportation is reduced to 30%[1].

It is of vital importance to know the type of material with which the bottles will be manufactured, because the machines must be able to limit the tensions or efforts so that the bottles are resistant, comply with the standards and reduce the cost of production. Currently, the manufacturing process of plastic bottles in industries worldwide is divided into: 1) choice of material, 2) molding and 3) bottle customization.[2].

There are three types of molding for the manufacture of bottles.

1. **Injection and blowing:** It consists of heating the raw material to the point of melting and introducing it into a mold or matrix. Then by blowing method the proper size and shape is reached in another mold[2].

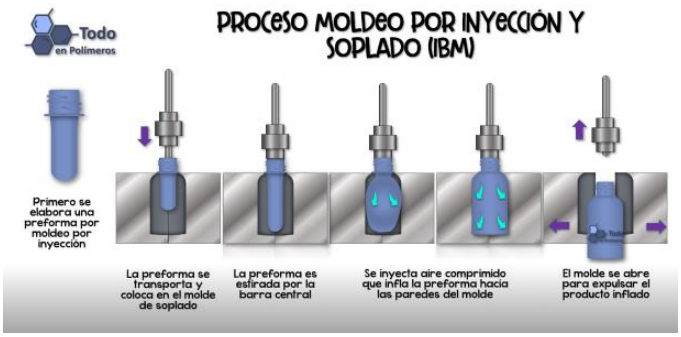


Image 1: Injection blow molding process.

2. **Extrusion and blowing:** The raw material is heated and melted, giving it the shape that is needed and then directly blowing it to reach the appropriate size. [2].

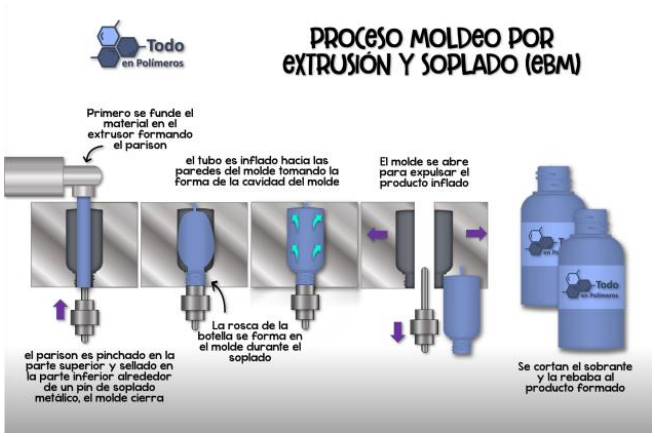


Image 2: Extrusion blow molding process.

3. **Co-extrusion and blowing:** It is carried out in the same way as the extrusion process, but this process is used when more than one type and layers of plastics are needed.

The industry with which we are executing the project has carried out the pertinent studies for the selection of its type of molding and they chose extrusion blow molding,

for which the following research will be dedicated only to this process together with customization. the process of mixing the raw material and the palletizing of bottles.

The mixing process is an automatic, complete and efficient way of combining certain quantities of products, in proportions defined by the process by default, which will be added to make the pieces.[3], in this case the plastic bottles. These mixers can mix materials by volume, weight, or by batch type.

This type of process is commonly controlled with a PLC, which monitors the opening valves of each type of product for a certain amount of time or product, the motor of the internal blades to mix all the products, buttons located on the panel of the machinery and extra valves for the expulsion of the final product.

Image 3: Automatic mixer with control panel.

At present, there are already extrusion and blow molding machines to produce plastic bottles. These equipment's consist of a plasticizer system (cylinder-screw), which allows to obtain a uniform melting at high temperatures and at an adequate speed. It also has a head that provides a tubular-shaped precursor and finally it has a blow unit and blow mold.[4].

Image 4: Extrusion blow molding machine for the manufacture of plastic bottles.

Although this process is one of the most compact worldwide for the manufacture of plastic bottles, they present common problems that have been investigated over the years. Each one of them is detailed below, since these will serve to make a much more solid and flexible system possible to handle these problems.[5]

- Rounded base and oval neck: Due to insufficient cooling or poor design, very high storage temperature, reduced cooling channels.
- Bubbles, fish eyes, cold spots: due to the high humidity of the melt and the lack of pressure or inhomogeneity.
- High roughness, pits and orange peel: Deteriorated mold surface, low blow rate, low storage temperature.
- Insufficient melting and/or burrs on parting line.
- Bending and taping: Poor tooling design, bushing-mandrel misalignment, low swell diameter, parison engagement.
- You burst.
- Degradation.
- Curling of the parison.
- Inconsistent lengths.

For these reasons and for the standardization of all the processes that are carried out for the bottle forming process, many companies have developed to carry out a flexible manufacturing project for the plastics industry and over the years it has been one of the ideas most innovative to control the entire mechanism of the plants.

Given that most of these plants also fill their products, this idea has been focused on carrying out an analysis of statistical data and costs for the company being worked on, and studies have indicated that a flexible system compensates up to 60%. % of losses and increases up to 100% productivity in an industrial plant.

A general comparison of the state of the company and what it wants to achieve is illustrated in the following graph.

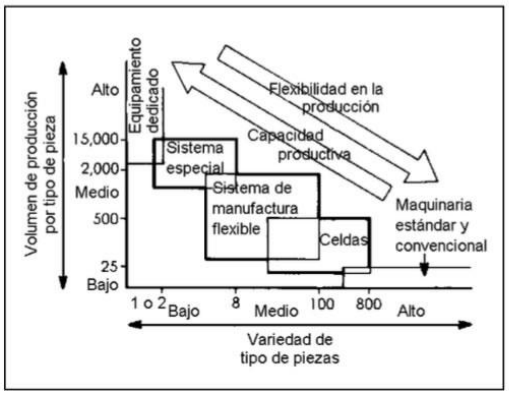


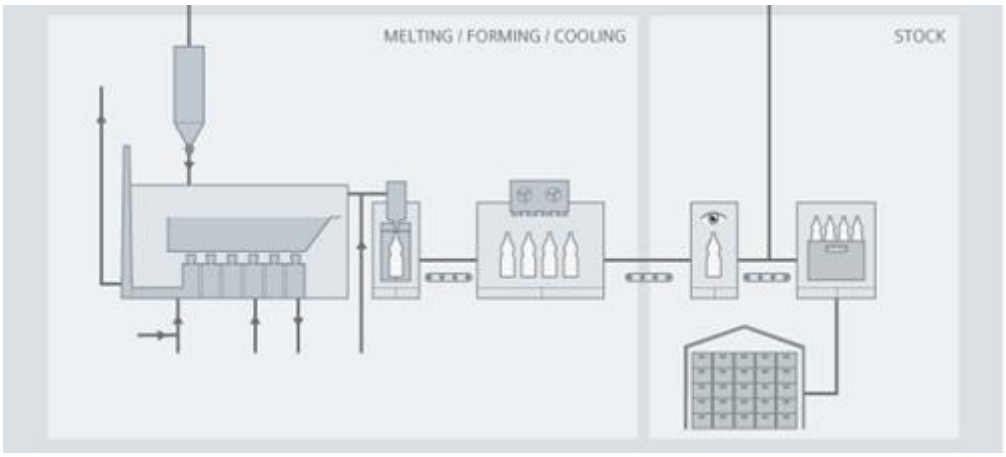
Image 5: Comparison diagram of flexible systems.

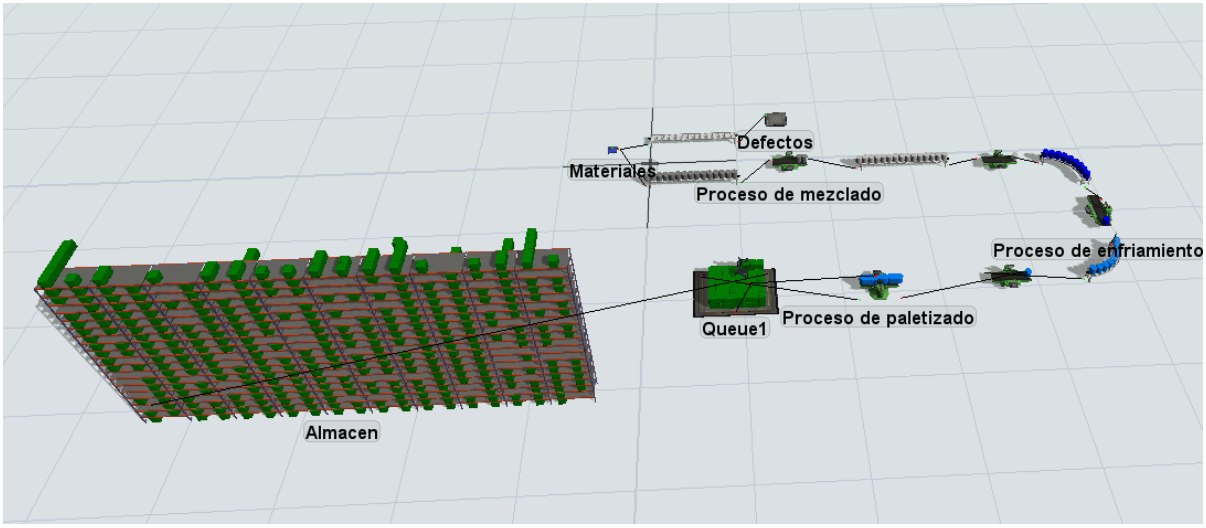
6. High resolution prototype

6.1. Information for the high resolution prototype

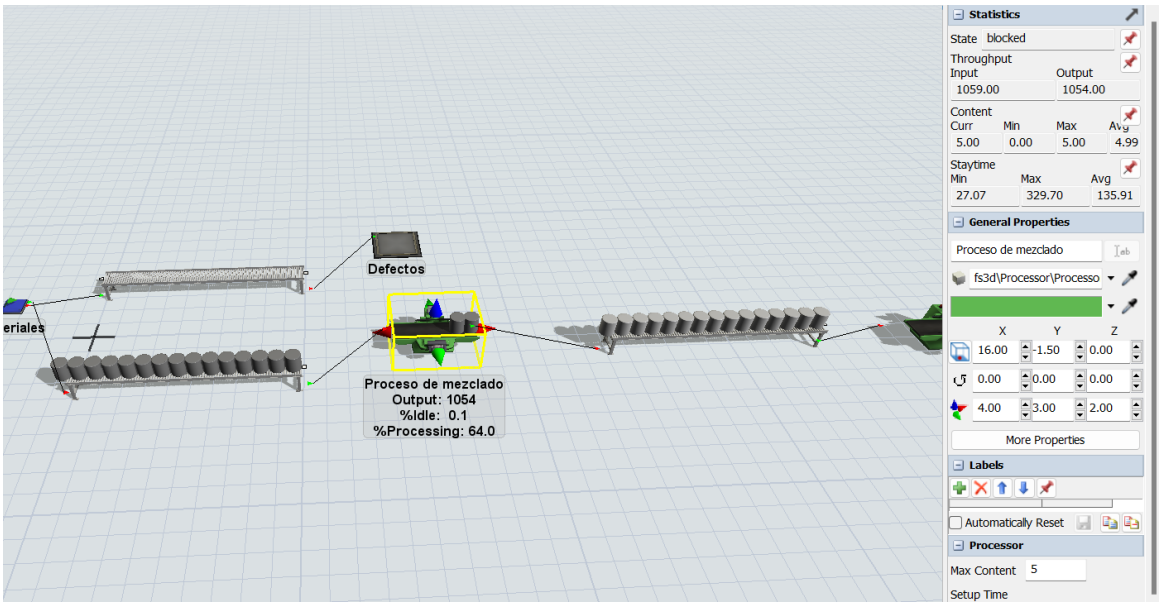
Our flexible manufacturing system consists of 5 processes (raw material mixing, high temperature bottle forming, bottle cooling, operator monitoring, bottle palletizing), each process has its own technical characteristics, which will be described below. The speed of the rollers or conveyor belt in the process is 1 m/s (value obtained from real processes). The whole process will be automated so all the machines must have preventive maintenance and the execution time is modeled through a Normal distribution (9000,1800).

6.2. High resolution prototype design

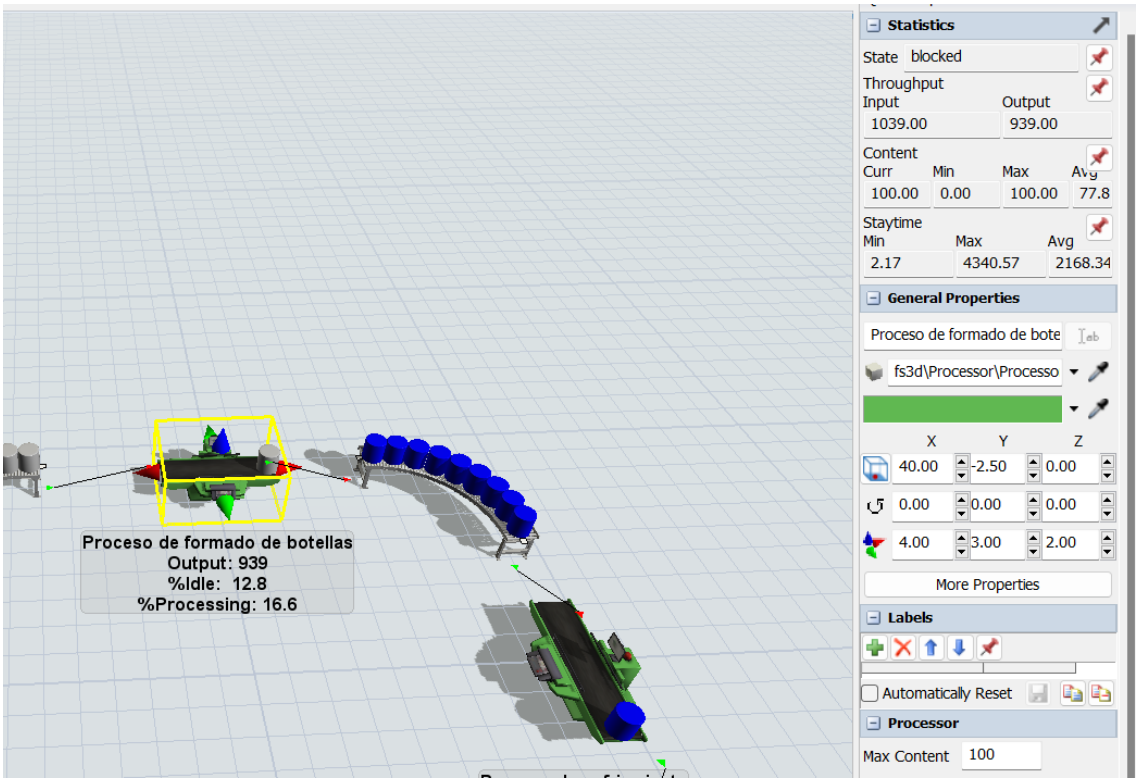




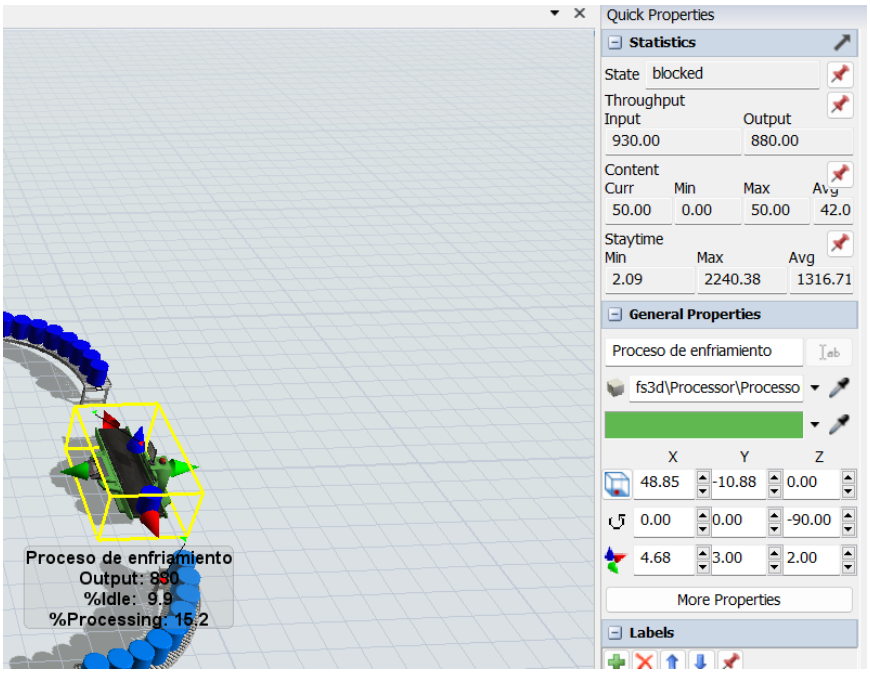
Raw material mixer: This system will be identified by a process in FlexSim, whose process is in charge of mixing the raw material, which is composed of 90% PET and 10% recycled plastic. This process will also generate the first formed bottle and pass it to the forming stage. The time it takes to carry out this process is given by a Normal distribution (20,5), since the average time is 20 seconds for mixing and generation of the first forming, but it has a standard deviation of 5 seconds. There is also an error percentage of 8% of the production, these bottles are taken to a deposit, which will be reused later.



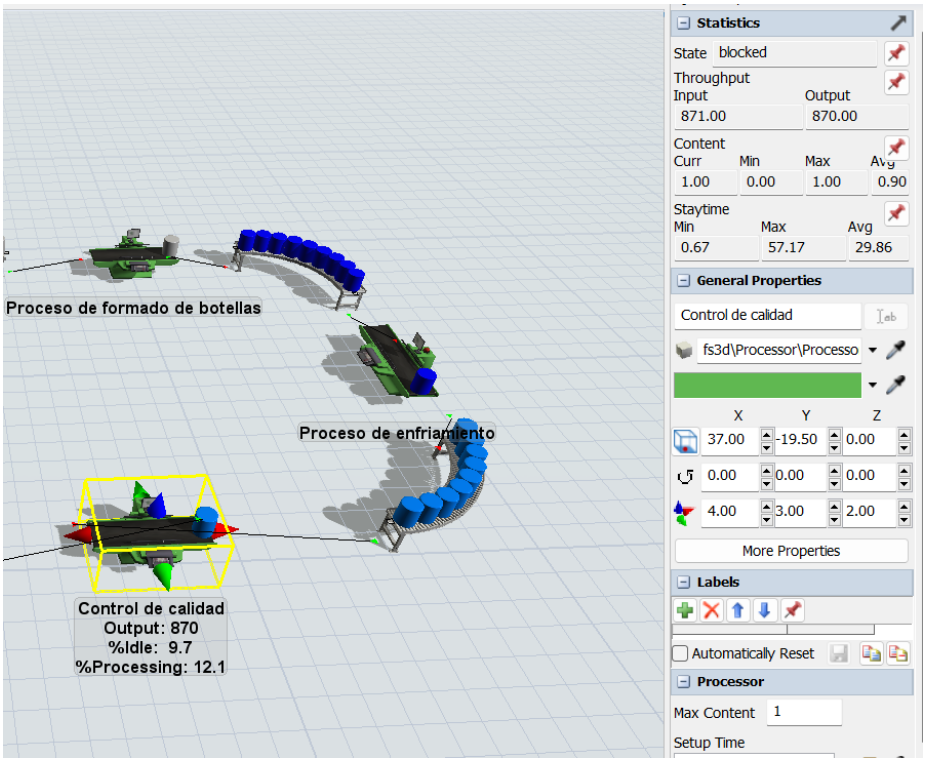
Bottle forming: This system is identified by a process in FlexSim, which is in charge of generating the final shape of the bottles through high temperatures. The total process time is given by a Normal function (5,1) for each bottle.



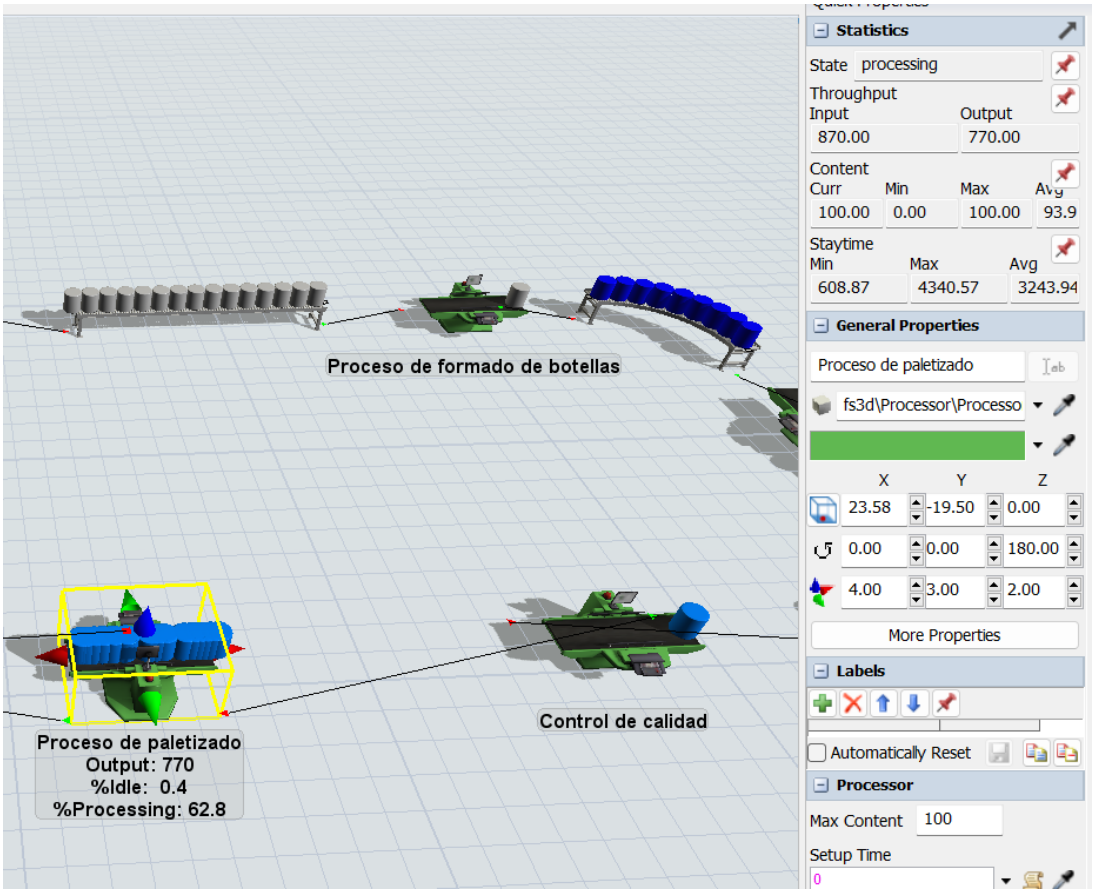
Bottle cooling: This system is given by a process in FlexSim, which is in charge of cooling the bottles, so that they are compacted and take the corresponding hardness according to the standards. The time in this process is defined by a normal function (5.1) for each bottle.



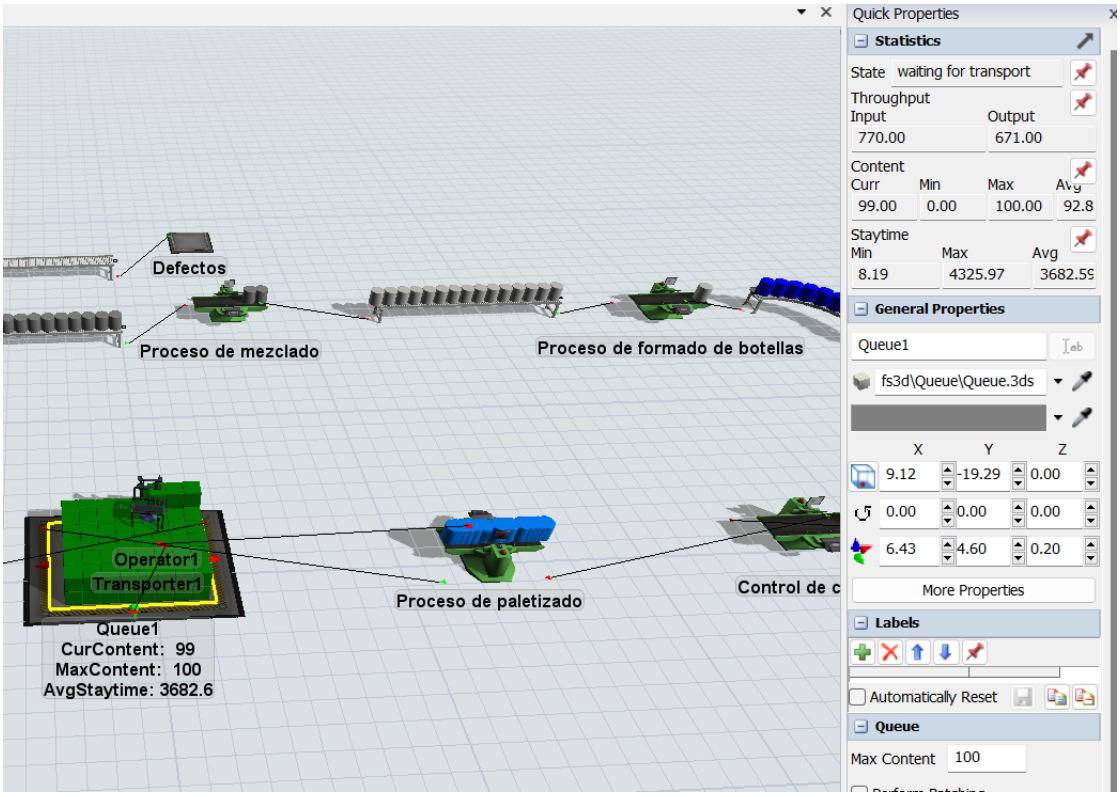
Quality control: The operator is in charge of checking the bottles and identifies if they are all correctly formed and do not have any error. In this case the operator's time will be identified through a normal function (4,1) per bottle and it is evident that 96% of the bottles are accepted by the operator.



Bottle palletizing: As a final process identified in FlexSim, the bottles will be palletized, so that when the device contains 100 bottles, it will be sealed, for which a Normal distribution (700.70) will be used.

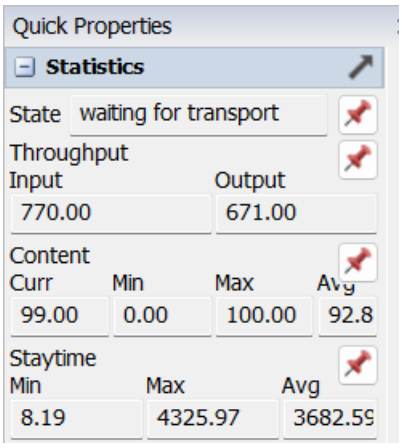


Once the bottles are palletized, they are sent to a local warehouse with a capacity of 100 packs and then to a rack, whose capacity is considered infinite.



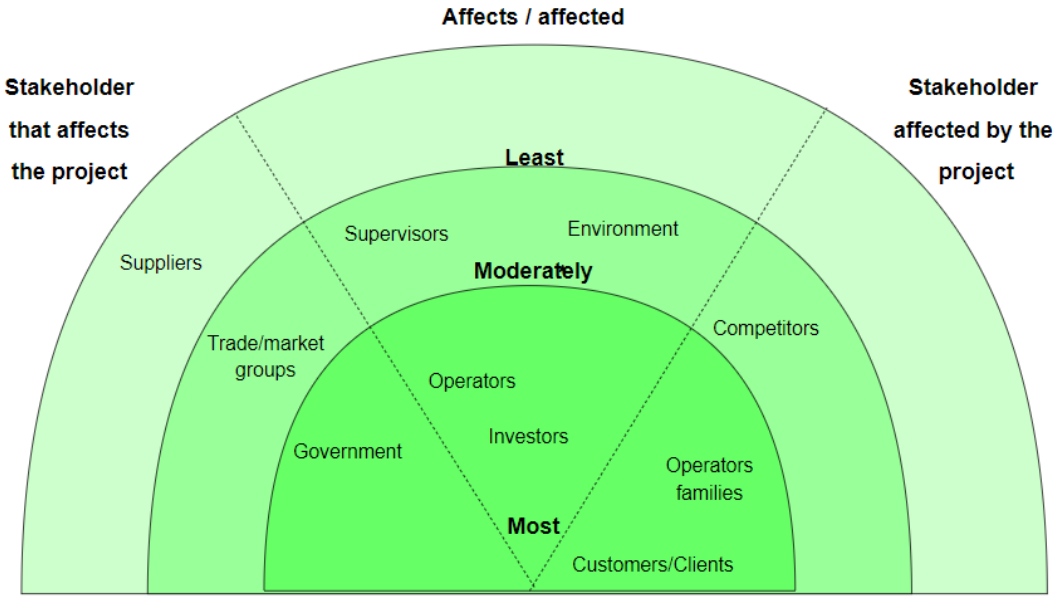
7. Results:

In a working day of 8 consecutive hours it is obtained that the process has the capacity to produce 770 bottles, of which 99 packages can be produced, observing the process it is noted that it is fluid until the moment of storage where there is a bottleneck in the local warehouse, however in terms of productivity the process could increase its production with a greater flow of materials so that the machines are better utilized and the production of bottles is increased.



8. Economic analysis

8.1. Stakeholders



Project stakeholder rainbow diagram

8.2. Description:

- **Operators:** They have a direct interest in the company in the sense that they obtain an income to support themselves, in addition to other benefits (both monetary and non-monetary). When acquiring machinery to improve the system process, some may lose their jobs, and others must adapt to a new environment or operation to optimize the process.
- **Operators' families:** They are impacted by the organization. These impacts include the time they miss out on spending with their loved ones, the operator's behavior when they return home and, of course, salary and benefits.
- **Customers/Clients:** Many would argue that companies exist to serve their customers. Customers are stakeholders of a company, in the sense that they are affected by the quality of the services/products, their value and quantity that it can provide them.
- **Government:** Are stakeholders in a few activities and projects, as they collect taxes from the company, and impose regulations, rules and regulations to be complied with within the company.
- **Trade/Market groups:** They publicize the company for the acquisition of new customers and manage the commercial and business side of the company so that there is a constant flow of profits.
- **Suppliers:** They provide the raw materials and other goods for the company's services and depend on it for revenue generation and continuity, and if an increase in production is required, more raw materials are needed.
- **Supervisors:** Are responsible for making workers fully aware of hazards that may be encountered on the job or in the workplace; ensuring that they work safely, responding to any hazards brought to their attention, including taking all reasonable precautions in the circumstances for the protection of a worker. supervisors must adapt and adapt others to the new changes.
- **Environment:** The environment can affect the process system as changing weather, machinery, or raw materials, as well as contamination levels of the process steps can affect the environment.
- **Competitors:** They can be an important stakeholder element in that they are materially affected by the successful implementation of a project. Likewise,

should a rival company bring a new product to market, the project team's parent organization could be forced to alter, delay, or even abandon their project.

- **Investors:** They include both shareholders and debtholders. Shareholders invest capital in the business and expect to earn a certain rate of return on that invested capital. Investors are commonly concerned with the concept of shareholder value. Lumped in with this group are all other providers of capital, such as lenders and potential acquirers.

8.3. Private analysis and a social analysis of the project.

Private Analysis of Bottlers in Ecuador:

In Ecuador there are various bottlers, among which is Tesalia, as one of the most recognized distributors in Ecuador, which is positioned in different sectors of the country, among which there is a factory in Machachi, south of Quito, where it is manufactured. and bottles Güitig mineral water, with more than 100 years of experience, Tesalia operates in different sectors of Central America, the Caribbean and South America, leading the beverage segment with the largest product portfolio in the region, as well as other small distributors that focus mainly on filling water drums, such as Dasani, All Natural, Pure Water, among others.

With respect to the companies that focus on the sale of specialized machinery for packaging, filling, sealing and filtering, there is the Equitek Bottler, which are experts in packaging machines, Watrop S. A. is another company focused on filtration and purification. of the water.

Social Analysis of Bottlers in Ecuador:

Over time, society has begun to become more aware of the waste that is being generated in the ecosystem, so some rejection is expected with regard to the production of plastic products, however this can change by adding a module to the company that allows you to reuse those plastic products using different chemical processes to achieve a more ecological and environmentally friendly alternative product.

In addition to an environmental factor, the job proposals that will be opened thanks to the company will be very helpful to those people who do not have a stable job or are in a low or extremely low economic position.

Also as mentioned above, with companies such as Tesalia leading the bottling market, high competition is expected due to the loyalty of buyers towards said company, being a strong adversary if the company also focuses on the manufacture of soft drinks. or drinks, or just the opposite in case that through these companies, we have an advantage by having an already established public at the time it becomes a direct distributor of Tesalia or other similar companies.

8.4. Purpose of the project.

Increase the production capacity of the process, increasing the versatility in how the processes are developed, maintaining the quality of the products delivered.
as well as to develop a flexible system capable of producing a series of plastic products focused on bottling, so that they can generate many products with the least possible expense.

8.5. Financial Economic Study

An economic feasibility study for our project will be partitioned by several key aspects, which will be defined by:

Market study: The market will be investigated in detail, to generate a value proposition that the company can offer, the need that the product can satisfy the real market, the public interested in buying it and the purchasing power of the potential customer.

Financial study.

A financial feasibility study for our project must be carried out through the initial investment values for each of the machines to be acquired, calculate the benefit to the company, identify the costs, the interests generated by the company, the depreciation of the machine in x number of years and determine if the service is optimal for the customer with the value for money.
For which it is also necessary to study the financial indicators of the return time of the initial investment, this will be achieved through the study of VAN (Net Present Value) and IRR (Internal Rate of Return), these values can be generated through of the financial cash flow of the project.

8.6. OPEX and CAPEX

CAPEX:

As it is already known, CAPEX are capital expenses, among which are different investments that the company makes with its capital, generating properties through the purchase of assets, these being with physical and tangible aspects, such as components, tools or machinery, which over time end up becoming expenses that end up being depreciated and end up in records for the balance sheet and cash flow of the financial statements, among the assets owned by the company and included in the CAPEX classification, we have:

- Raw material mixer (Acquired)
- Bottle forming
- Bottle cooling
- Bottle palletizing
- Pallet's jack
- Racks (Acquired)
- Conveyers' belts (Acquired)

OPEX:

Unlike CAPEX, OPEX are all those operational expenses that have to do with the functioning and operation of the company, this is usually represented as a continuous cost and within the financial statements they are usually deducted from taxes, within the company they can be different types of services such as those mentioned below:

- Basic services
- Maintenance services:
    - Raw material mixer
    - Bottle forming
    - Bottle cooling
    - Bottle palletizing
    - Conveyers' belts
    - Pallet's jack
- Operators:
    - Quality control
    - Other operators
    - Dispatcher

Investments of the project.

Machinery or Service	Name	Cost	Rescue	Years	Interest	Annual profit
Bottle forming	Servo Plastic Beverage Bottle Blow Molding Machine	$20.000,00	$10.000,00	6	10%	$ 37.500,00
Bottle cooling	CW-5200 Industrial Water Chiller Cooler for CNC/ Laser Engraver Engraving Machines	$3,262.50	$500,00	7	10%	$ 37.500,00
Bottle palletizing	Full automatic drinking pure mineral water bottle washing filling capping bottling machine plant production line	$12,000.00	$3.600,00	10	10%	$ 37.500,00
Pallet's jack	Patin De Carga, Pallet Jack, 2 Toneladas Nuevo	$7.768,00	$1.500,00	10	10%	$ 37.500,00

The total income of the company is $150,000 generated by the total of the company's machines, so an equal percentage will be taken for each machine so that the cash flow can be carried out correctly, in this case it will be $37,500 per year profit per machine

8.7. Description of the Net Present Value VPN

To determine the net present value or NPV of the company, it is necessary to know the values, it is necessary to know the net cash flow during a single period, where each period represents the annual profits that the company had, the number of periods or years that they will determine and the discount rate that it has for the machinery used.

For this case, a general analysis of the company was carried out, so that both the value of the net cash flow and the value of the discount rate were averaged, the first by the estimate of profits in the indicated period and the second by taking the depression of each machine used.

Recalling a little the use of the NPV, we have that this method models the financial status of a company through accountants to prepare capital budgets and thus analyze the profitability of investments and proposed projects, making it easier to analyze the advantages or parameters of a new investment.

However, this method also has clear disadvantages, among which is the reliability of the interest rate used, making it very variable, affecting the results obtained by this value, in addition to being only assumptions of annual earnings, it completely ignores other variables such as catastrophes, accidents or competitions that affect the current market, so that it has a high degree of uncertainty.

8.8. Description of the Internal rate of return TIR

The internal rate of return of the company determines the discount rate that makes the net present value or NPV of any investment equal to zero, being an effective method to determine the profitability of a project, so that initially it was obtained this value and determining the result obtained, it will be possible to decide how much profitability it has. For this case, an estimate was made of what this value would be, obtaining the following result.

SFM GENERAL OF PROYECT

Investment value	$43.030,5								
Rescue value	$15.600,0								
Useful life	8	years							
Taxes	0%								
Annual profit	$20.000								
TIO	10%	investor - board member (oportunnity interest rate)							
Depreciation	$3.428,8								
Sale of the asset	0								
years	0	1	2	3	4	5	6	7	8
cash flows	$-43.031	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000
VP	$-43.031	$18.182	$16.529	$15.026	$13.660	$12.418	$11.289	$10.263	$9.330
VPN	$63.668,02	Profitable (Valor presente neto)							
TIR	43,96%	Competitive because TIR (tasa interna de retorno) is greater than TIO (Internal rate of return)							
VPN excel	$63.668,02								
Analisis de hipotesis									

8.9. Description of the Discounted Payback

As is already known, the discounted payback is a method of evaluating investments, which seeks to determine the time it will be necessary to wait to recover the initial

investment, through the cash flows produced in each period, however, it has a disadvantage in that it be useful only to estimate the estimated result, which in this case is the investment recovery time, does not take into account the cash flow once the investment has been recovered, therefore it is a useful tool to evaluate risky investments that It allows completing the analysis carried out with profitability criteria such as the Net Present Value or the interest rate recovered.

The formula that follows is the sum of the number of the immediately preceding period until the initial disbursement is recovered, for the division between the subtraction of the initial investment of the project with the sum of the flows until the end of the period, divided by the value of the flow of cash of the year in which the investment is recovered

PAYBACK - Periodo de recuperación									
years	0	1	2	3	4	5	6	7	8
Value in books	$43.031	$39.602	$36.173	$32.744	$29.315	$25.886	$22.458	$19.029	$15.600
Depreciation		$3.429	$3.429	$3.429	$3.429	$3.429	$3.429	$3.429	$3.429
Accumulate depreciation		$3.429	$6.858	$10.286	$13.715	$17.144	$20.573	$24.002	$27.430
years	0	1	2	3	4	5	6	7	8
Asset recuperation (recuperación del activo)									
Total flows	$-43.031	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000
Payback	0	1	2	3	4	5	6	7	8
Annual payback		$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000	$20.000
Accumulate payback		$20.000	$40.000	$60.000	$80.000	$100.000	$120.000	$160.000	$220.000
recoverable value (valor por recuperar)	$43.031	$23.031	$3.031	$-16.970	$-36.970	$-56.970	$-76.970	$-116.970	$-176.970
years of recovery		1	1	0,151525					
Payback	2,151525	years							
Payback	2	years							
Payback	2	meses							
Discounted payback	0	1	2	3	4	5	6	7	8
Annual payback		$18.182	$16.529	$15.026	$13.660	$12.418	$11.289	$10.263	$9.330
Accumulate payback		$18.182	$34.711	$49.737	$63.397	$75.816	$87.105	$108.658	$139.541
recoverable value	$43.031	$24.849	$8.320	$-6.707	$-20.367	$-32.785,24	$-44.075	$-65.627	$-96.510
years of recovery		1	1	0,55367978					
Payback	2,55367978	years							
Payback	2	years							
Payback	6,64	months							

9. Conclusions and recommendations

9.1. Conclusions:

- The concept of a flexible manufacturing system applied is type III: Flexible transfer line, consists of assigning a specific operation to each stage or machine, which are

connected to transport the finished product from one stage to another, this allows a system easy to understand and control, although it limits its flexibility in terms of handling failures, it allows to perform a variety of products without major complications.

- During the study of the process stages, it was found that between stages, and in the refrigeration and quality control processes, there were critical points where bottlenecks were generated, due to the fact that the operators had to transport the product from one place to another, generating bottlenecks. For this reason, the use of conveyor belts was introduced in addition to automated devices that detect the arrival of the product, handle the bottles for processing and allow their flow to the next belt but the next process, except for quality control, which must still be performed by an operator.
- Simulating in Flexsimp the design of the proposed solution it can be observed that there is no great complexity, both the design and its execution is easy to understand and above all is fluid, there are no bottlenecks, what is more when analyzing the results of the software, in terms of production and visualization of work, there is an increase in production capacity, but a potential exists in the untapped machines, ie the capacity of the design and / or machines is not fully in its entirety, since they have a lot of waiting time or free.

9.2. Recommendations:

- It is recommended that the company include an additional section for the treatment of defective products, so that these can be reused as material for a new batch of products, and enlarge the quality control section, so that more machine capacity can be utilized, without generating delays or bottlenecks when operators review each finished product.
- Search for new potential customers, not only for the products already produced, but also for new ones, increasing the variety of possible income and thus recalculating the precise values of the minimum and maximum required amount of products that the company must generate to recover its initial investment in fewer years than already calculated.

10. Bibliografía.

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11. Annexes

11.1. Cash Flow

Annual cash flow for the machine bottle forming

Valor de impuestos anuales sin depreciación

Investment value	$ 20.000,00	Annual taxes without depreciation
Rescue value	$ 10.000,00	
Useful life	6	years
Taxes	10%	
Annual profit	$ 37.500,00	
Depreciation	$ 1.666,67	

Cash flow	Without depreciation	With depreciation
a. Annual profit	$ 37.500,00	$ 37.500,00
b. Depreciation	0	$ 1.666,67
c. Annual profit before taxes	$ 37.500,00	$ 35.833,33
d. Taxes	$ 3.750,00	$ 3.583,33

Annual cash flow	$ 33.750,00	$	33.916,67

Flujo de caja anual sin la depresiacion

Annual cash flow $ 33.750,00

Valor de la depreciacion de la maquina.

Depreciation $ 1.666,67

Valor de impuestos anuales con depreciacion

Annual profit before taxes $ 35.833,33

Flujo de caja anual con la depresiacion

Annual cash flow $ 33.916,67

Annual cash flow for the machine Bottle cooling

Valor de impuestos anuales sin depreciacion

Investment value	$ 3.262,50	Annual taxes without depretion
Rescue value	$ 500,00	
Useful life	7	years
Taxes	10%	
Annual profit	$ 37.500,00	
Depreciation	$ 394,64	

Cash flow	Without depretiation	With depretiation
a. Anual profit	$ 37.500,00	$ 37.500,00
b. Depreciation	0	$ 394,64
c. Annual profit before taxes	$ 37.500,00	$ 37.105,36
d. Taxes	$ 3.750,00	$ 3.710,54

Annual cash flow	$ 33.750,00	$	33.789,46

Flujo de caja anual sin la depresiacion

Annual cash flow $ 33.750,00

Valor de la depreciacion de la maquina.

Depreciation $ 394,64

Valor de impuestos anuales con depreciacion

Annual profit before taxes $ 37.105,36

Flujo de caja anual con la depresiacion

Annual cash flow $ 33.789,46

Annual cash flow for the machine Bottle palletizing

Valor de impuestos anuales sin depreciacion

Investment value	$ 12.000,00	Annual taxes without depretion
Rescue value	$ 3.600,00	
Useful life	10	years
Taxes	10%	
Annual profit	$ 37.500,00	
Depreciation	$ 840,00	

Cash flow	Without depretiation	With depretiation
a. Anual profit	$ 37.500,00	$ 37.500,00
b. Depreciation	0	$ 840,00
c. Annual profit before taxes	$ 37.500,00	$ 36.660,00
d. Taxes	$ 3.750,00	$ 3.666,00

Annual cash flow	$ 33.750,00	$	33.834,00

Flujo de caja anual sin la depresiacion

Annual cash flow $ 33.750,00

Valor de la depreciacion de la maquina.

Depreciation $ 840,00

Valor de impuestos anuales con depreciacion

Annual profit before taxes $ 36.660,00

Flujo de caja anual con la depresiacion

Annual cash flow $ 33.834,00

Annual cash flow for the pallet jack

Valor de impuestos anuales sin depreciacion

Investment value	$ 7.768,00	Annual taxes without depretion
Rescue value	$ 1.500,00	
Useful life	10	years
Taxes	10%	
Annual profit	$ 37.500,00	
Depreciation	$ 626,80	

Cash flow	Without depretiation	With depretiation
a. Anual profit	$ 37.500,00	$ 37.500,00
b. Depreciation	0	$ 626,80
c. Annual profit before taxes	$ 37.500,00	$ 36.873,20
d. Taxes	$3.750,00	$ 3.687,32
Annual cash flow	$ 33.750,00	$ 33.812,68

Flujo de caja anual sin la depresiacion

Annual cash flow	$ 33.750,00

Valor de la depreciacion de la maquina.

Depreciation	$ 626,80

Valor de impuestos anuales con depreciacion

Annual profit before taxes	$ 36.873,20

Flujo de caja anual con la depresiacion

Annual cash flow	$ 33.812,68