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LAYOUT OPTIMIZATION FOR A FACTORY OF A MEXICAN RECYCLING COMPANY

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Abstract:

The present format is an investigation of the principal problems found at the present time at a Mexican Recycling factory. Said problems were analyzed and the ones with greater urgency to be solved or with greater negative impact were selected. These selected problems were analyzed, measured and calculated to find the optimal solution or the best recommendation possible. A change in the current layout was done with the objective of optimizing the resources of the plant as decreasing costs and errors that create an inefficient productivity inside the plant. This recommendations in the accommodation will be replicable in the other plants the company has around the Mexican Republic.

Keywords: Optimize; Six Sigma; Lean Manufacturing; Time Reduction; Layout Design; Design and Analysis of Experiments.

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1. Introduction

1.1. Background

Mexico is a leader country in the industry of steel with a market that continues to grow with the passing time. Now a days we produce 1.13 per cent of the total steel that is sold around the world. Also, this industry represents 2.2% of mexico's gross domestic product. (milenio, 2015) given this labour is of such importance for the country, so are the enterprises that dedicate themselves to it. One of this companies is deacero which is the one in which we will focus in this article. Deacero is one of the greatest companies in the industry of mexican steel and it continues growing and proves to be a leading company in this country. But with this Design optimization for the tultitlan plant exponential growth, new responsibilities come and with them new problems hence various opportunities to optimize and improve all their operations and processes. This problem has been present since the creation of this plant and are growing each day.

To improve the cycle time of the shredder process in patio tultitlán of deacero it was decided to focus the study in the optimal change of the current layout. A layout refers to the arrangement of

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the workspace and it is important for the functioning of an enterprise, its main concern is to reduce the costs of material handling, since a poor material handling can generate problems to the business (canen, 1996).

1.2. Problem Statement

When visiting the plant of deacero in patio tultitlán we saw it was necessary to focus on the poor distribution of the layout, specifically the scrap area (annex 1). Also target the lack of monitoring of their materials that causes uncertainty in their costs.

This problems are causing inefficiency inside the process, consequently economic losses and cost increments. The poor distribution of the patio (design) creates complications in transport and movement of scrap from one side to another, which causes the cycle to be longer than the optimal. Also, the bad distribution of the inventory complicates the daily operation, generating delays.

On the other hand, they have a problem monitoring their material which complicates the measurement of costs therefore causes errors in said calculation. If they do not start to improve it now, as seen in previous history, it will continue to get worse and this will complicate its optimization in a future.

1.3. Justification

"flp (facility layout problem) is one of the most important classical problems of production management and industrial engineering that has attracted the attention of many researchers during recent decades." (hasan, 1)

Due to the current layout of the factory, some problems have arisen. Firstly, some badly positioned raw materials has caused the misuse of the current inventories generating a lack of space for required raw matter. Also, the trucks have to make u-turns in order to exit the patio this blocks the lane for other auto moviles to transit slowing down the overall production. There is also an over movement of finished products. And finally, the factory loses track of raw materials if the shredder is on, this makes the cost calculations harder since they are not able to know what types of materials entered the shredder.

At the beginning of this year the factory bought a big shipment of raw matter that required the process known as "oxicorte", given that the main activity of the patio is shredding, the most part of this batch has not been processed. Since this raw material is very big it occupies a lot of space that more useful or important materials could be using. Also, because it is positioned in a very transited area, it blocks the way for trucks and cranes limiting their mobility. This is why determining an area for this materials and any other that may arrive in the future, will allow a better storage of more utilized raw materials and the optimal operation of the trucks.

The current inventories and layout the company has, does not allow the trucks that unload on the cranes to "enter in one side and exit through the other". This is because some part of the shredder machine blocks the route forcing the trucks to make a u-turn in order to exit the patio. By

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changing the layout to create a to lanes route that the trucks can follow, it will allow a constant flow of raw materials since there will be almost always a crane available to unload a truck.

Finally, after the shredding and compacting process finishes, the finished batches have to be transported to the entrance of the patio in order to be weighed and then they are transported back to the inventories. If we can generate a layout where we avoid this transportation or at least reduce it as best as we can. Not only will the production times will be reduced but the customer services times will also be diminished since instead of using the weight for the batch it can be used by a supplier.

1.4. Objective

Solve the problems and/or optimize them always focusing in guarantee the maximum increase of productivity, maximum increase of security and the reduction of the operation costs. The solution will be obtained by using six sigma, system dynamics and muda's waste analysis. The solution must be made in a way that it can be replicable for the rest of their plants that are found throughout the mexican republic.

1.5. Investigation Questions

1) What are the principal areas of improvement inside the plant?
2) How could the efficiency and productivity of the plant be increased?
3) What numerical data about the operation of the plant could we use as decision variables and modify?
4) What numerical data about the operation of the plant can be maintained fixed and used as parameters?
5) With which tools could we minimize time and costs that help improve productivity inside the company?

1.6. Hypothesis

Before starting the experimentation and the investigation of this work, the following hypothesis were made to each one of the investigation questions (section 5):

1.6.1. The principal areas of improvement of the plant are: inventory spaces, time reduction in the two main processes of the plant, monitoring what materials go in and out of the shredding process.

1.6.2. The efficiency and productivity of the plant can be improved and optimized by making changes in its' layout, mainly in the areas of inventory, spaces where the scrap is positioned and a correct measurement and calculus of the costs of raw materials.

1.6.3. Inside the numerical data obtained from the plant, the following can be utilized as decision variables and can be modified:

→ of the shredding process:

- time a truck stays in the system
- weighing process for non-ferrous material

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- how much material is shredded
  → of the "oxicorte" process:
- where the inventory is placed

1.6.4. Inside the numerical data obtained from the plant, the following can be identified as parameters, this will not be modified:

→ of the shredding process:
shredding rate
→ of the "oxicorte" process:
time it takes to cut material (outsourced)

1.6.5. If we achieve to make significant changes in the layout and we introduce tools for measurement and analysis to each one of the variables we can modify, we will accomplish the reduction or minimization of cycle time. The changes in the layout will involve modifications of certain areas.

2. Materials and Methods

2.1. Theoretical Framework

For this investigation we will utilize some tools from the methodology of six sigma, since it is intended to optimize all the problems that were found and this methodology is characterized for reducing defects per million of events or opportunities (dpmo), understanding defect as any event in which the product or service does not achieve to comply with the lient's requirements.

As mentioned in their paper "process and quality improvement using six sigma in construction industry" megan florent tchidi, zhen he and yan bo li explain that "six sigma implementation uses a systematic procedure; a five-step dmaic (define, measure, analyze, improve, and control) methodology. Its principles are a problem-solving framework. In dmaic each stage is based on a data analysis research." (megan florent, 159) in their investigation they utilize the six sigma methodology to conduct the analysis of Construction in order to find out the main factors of the process and how to improve them. Similar to how we will analyze the main variables of the layout in order to learn how to improve them.

We will apply system dynamics to simulate the process inside the fabric, in order to test how the changes, we will propose will affect the production. Similar to the research paper "manufacturing facility layout design and optimization using simulation" made by s. M. Kadane and s. G. Bhatwadekar. In their investigation they optimize the distance traveled from machine to machine, reduce waiting times, eliminate stock out problems, amongst other things. They achieve this through a simulation software called flexim. In this platform they program all the characteristics of the factory considering variables such as time, distances, space limitations, areas, etc. After inputting all the specifications, they started to simulate the actual layout and based on the results they proposed new workstations and different positions to new ones. After their ideas were simulated, they discovered there was a great improvement in the variables. (s.m. kadane, 59-65) so, as them, we simulated the actual layout and our proposed layout in order to find out if any improvements were made.

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In their paper "case study on identification and elimination of waste through lean implementation in an automotive part manufacturing industry" ajit kumar, r. Grish kumar and others utilize the lean manufacturing methodology known as factors of the process and how to improve them. Like how we will analyze the main variables of the layout in order to learn how to improve them. "muda" to identify the key non-value-added activities areas and propose changes to improve. (kumar, 1) similar to them we will utilize the muda methodology to identify and solve wastes in the whole production process.

2.2. Methodology

2.2.1. Define

2.2.1.1.Project Charter (Annex 2)

2.2.1.2.Waste Identification

Through the muda waste identification categories, we investigated the processes of the fabric in order to find out what kind of wastes were involved. (annex 3)

2.2.2. Measure

2.2.2.1.Project Selection Matrix

A project selection matrix will be done to select which projects have more importance
Or which problems have more priority. (section 1 in results)

2.2.2.2.Ishikawa

An ishikawa diagram will be done to understand the causes that create the principal problems of the enterprise. (section 2 in results)

2.2.3. Mapping

Both processes done by the company that use scrap will be mapped:
1) Shredding (on average 90% of the scrap that enters the patio passes through this process)
2) Oxicorte (on average 10% of the scrap that enters the patio passes through this process) (section 3 in results)

3. Results and Discussions

3.1. Analize

3.1.1. Hypothesis Tests

The hypothesis tests that were raised to know if the time a truck stays in the system data and the raw material weight data were normal are:

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H0 = the date behaves according to a normal distribution
Ha= the data does not behave according to a normal distribution
The hypothesis tests raised to know if the time a truck stays in the system depends on the weight, they supplied was:
H0 = the supplied weight of the raw material does not influence the time the truck stays in the system
Ha = the supplied weight of the raw material influences the time the truck stays in the system (section 9.4 in results)

3.1.2. Analysis of Supplier's Rate And

Inventory area the company gave us an excel with all their information about the raw materials brought by the suppliers daily. Through this data a complete analysis of mean, standard deviation, standard error, range, etc. This analysis was made through the minitab tool. With this information we filter the materials that were not going to be shredded since the inventories we were going to analyze are only the one that go through that machine. With the daily weight of material that is receiving the machine we assumed that all this material was steel since everything has already been "cleaned" from any other types of materials. Through this assumption we used the density of steel to find out the volume of the materials piles. Through the derivation of some formulas, better seen in university of regina's paper "maximizing the volume of a cone" (stephen, 6) the areas of the inventories were calculated. We established A fixed height of the piles to be 5 mts since that is the approximate maximum in real life and we used the higher values of the raw materials since there was a lot variability

3.2. Results

3.2.1. Project Selection Matrix

When analyzing the different projects based on their annual savings, execution, support and success probability we obtained the results shown in (annex 4). With this we prioritize the projects and problems to solve in the following way:

1) Scrap classification (inefficiency in the classification of scrap causes that raw materials cannot be monitored).
2) Unloading area (this also causes inefficiency when monitoring raw materials but additionally it impedes an adequate production inside the plant)
3) Layout (even though it has the lowest percentage compared to the other ones we consider it to be the root of many other problems that hinder the operation of the plant).

3.2.2. Ishikawa (Annex 5)

Mapping
Shredder process (annex 6)
→ nomenclature:
* rm = raw material
* wip = work in process
* fe = ferrous material

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→ steps:

1) Rm enters the patio through supplier's trucks, with an average rate of 18,000 kg, and it is placed in an inventory of rm.
2) The cranes move the rm that will be shredded, from the rm inventory to the ready to be shredded inventory.
3) Rm is introduced into the shredder. This machine has a specific velocity in which the material will be shredded (200 tons per hour).
4) The shredded material comes out of the machine to wip. There is a small percentage of error in which the material is not shredded to the necessary dimensions. This material will go back to the ready to be shredded inventory.
5) When the process of shredding is finished the scrap is divided into two different processes; non-ferrous and ferrous.

3.2.3. Non-Ferrous Process (No Fe)

The scrap comes out of wip in an automated band to be divided. There it is Verified that it was separated correctly, if not it returns to wip. Then non-ferrous scrap is transported to the no fe inventory. The scrap is classified, divided and cleaned for it to coincide with the specifications of the client. For example, a client can request 500 kg of scrap with certain percentage of copper. The scrap that does not contain fe arrives to the final inventory and is ready to be shipped.

3.2.4. Ferrous Process (Fe)

The scrap comes out of wip in an automated band to be divided. Ferrous scrap is separated with the help of magnets. Then, the divided material goes through a process to verify it is completely fe. Workers that are part of this process will verify manually that every piece of scrap is fe, if not they will take no fe material out and it will return to wip. The ferrous scrap will arrive to the fe inventory, it is weighed at a constant velocity and it will arrive to the weighed inventory. Finally, the fe scrap will be compacted into lots that will be ready to be shipped.

3.3. *Oxicorte (Annex 7)*

→ nomenclature:
* rm = raw material
* wip = work in progress

→ steps:

1) Rm enters the patio through supplier's trucks, with an average rate of 10% of everything that gets in measured in kilograms, and it is placed in a rm inventory.
2) The cranes move the rm that will enter the "oxicorte" process from the rm inventory to the ready to be cutted inventory.
3) Once it is in this area the process gets done.
4) Once the process is finished the material is ready to be transported.

3.3.1. Hypothesis test

"is the estimate of a single study "correct"? If we repeat the study, we will not obtain the

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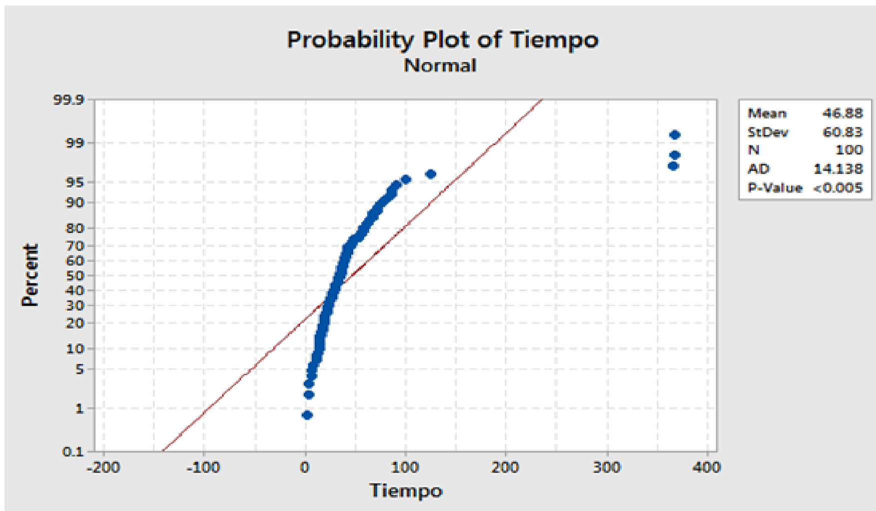
Exact same result. This is the problem of random variation. Even if there is no effect of treatment, the study can show a difference just by chance" (bland, martín. 2013) this is why we choose a goodness-of-fit test shown below.

Goodness-of-fit(hypothesis test 1)
In this goodness-of-fit test we can observe if the variables of time and stay behave in a normal way. For both tests the last 100 data provided by the company was used. We first utilized the anderson darling test, which is shown in the image 1 for each variable.



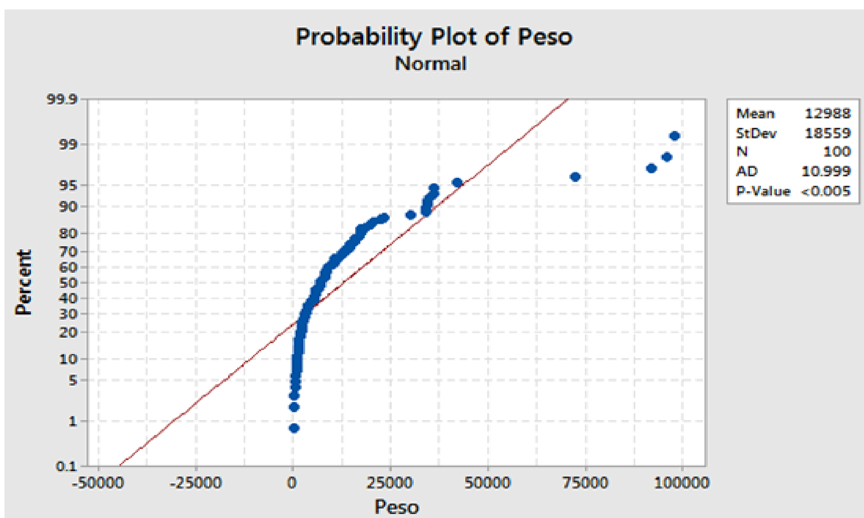


Image 1: anderson darling test

As we can observe, none of the data behaves in a normal way according to the anderson darling test, given that their respective p-values are minor than 0.05.

Because of this, we continued verifying the data by means of the method kolmogorov smirnov, the results are shown in image 2.

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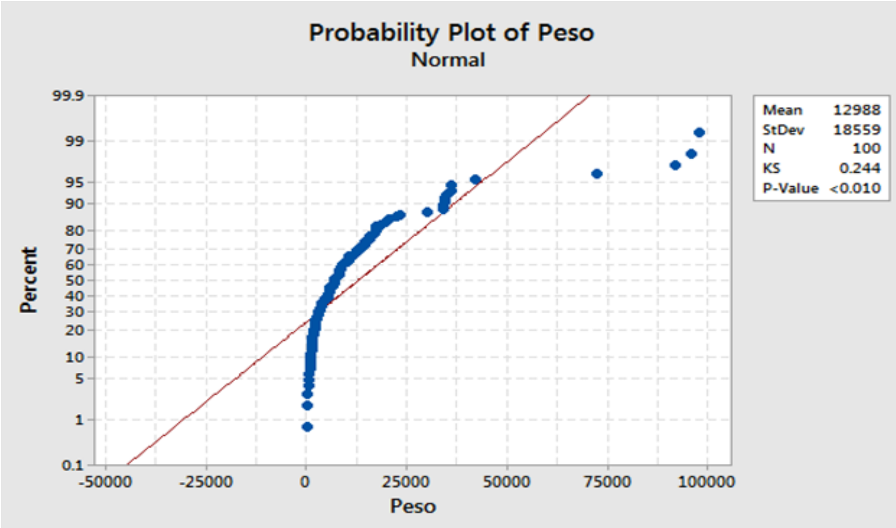

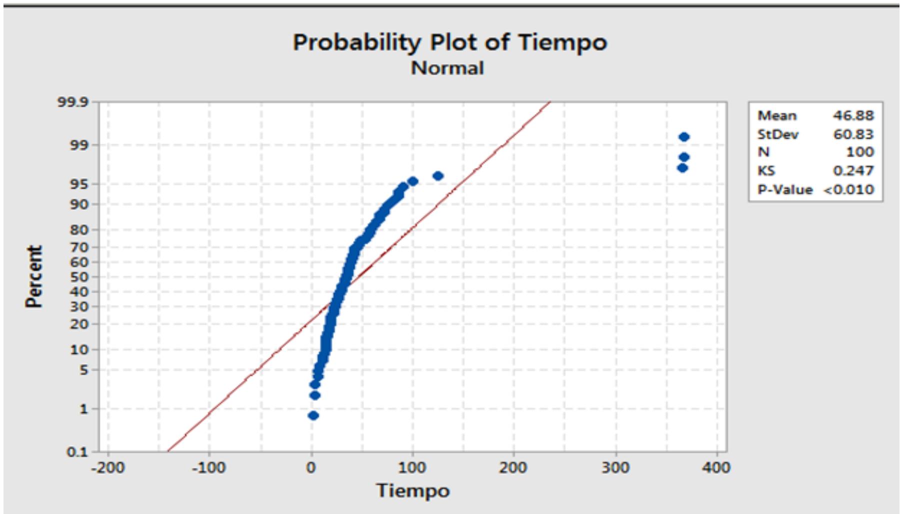

Image 2

Given both p-values are below 0.05, we can conclude that the data of time truck stays in the system and the weight of the trucks are not normal. Because both of the previous test showed the data does not behave according to a normal distribution, we proceed to transform them and convert them to normal. (annex 8)

As seen in the image the johnson transformation method is the one that best applies for this case.

Lineal Regression 1

In this regression analysis, the relevance of all the variables that were proposed in the model is tested. The hypothesis test raised in this regression can be found in the previous section 9.4 (hypothesis tests). The following regression was done with the intention of observing if the time of the truck stay in the system is being affected by the weight to unload by each of the trucks.

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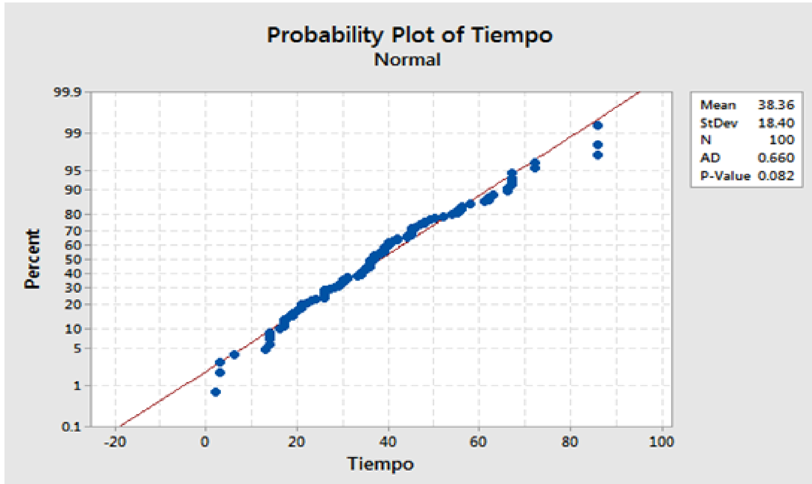

Regression Analysis: Tiempo versus Peso

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	1588.7	1588.69	5.10	0.0262306032
Peso	1	1588.7	1588.69	5.10	0.0262306032
Error	94	29278.5	311.47		
Lack-of-Fit	80	28518.0	356.47	6.56	0.0001753548
Pure Error	14	760.5	54.32		
Total	95	30867.2			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
17.6486	5.15%	4.14%	0.52%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	37.64	1.80	20.90	0.0000000000	
Peso	4.61	2.04	2.26	0.0262306032	1.00

Since we worked with a level of significance α of 0.05, in all the coefficients that show a greater p-value than α, it will fail to not reject h_0.

In this case we can observe that the p-value of the model and the variable of weight are less than 0.05, we can conclude to reject h_0, this means the weight to be unloaded does affect the time the truck stays in the system.

The equation to predict the time a truck stays in the system is:
Time = 37.64 + 4.61* weight

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Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	37.64	1.80	20.90	0.0000000000	
Peso	4.61	2.04	2.26	0.0262306032	1.00

Regression Equation

Tiempo = 37.64 + 4.61 Peso

Fits and Diagnostics for Unusual Observations

Obs	Tiempo	Fit	Resid	Std Resid	
9	2.00	43.38	-41.38	-2.38	R
10	3.00	42.01	-39.01	-2.24	R
17	86.00	39.22	46.78	2.67	R
18	86.00	39.22	46.78	2.67	R
63	86.00	45.03	40.97	2.38	R

R Large residual

3.3.2. Analysis of Supplier's Rate (Annex 10)

Discussion

After analyzing and seeing the results of the tools used, it can be said that it is convenient to make certain changes, both in the layout and the operation of the patio, said changes are presented in the following sections.

3.4. Final Recommendations

3.4.1. Scrap Classification (Annex 11)

A tool that helps classification the scrap that enters the patio to be able to monitor it throughout the process.

For this proposal it is recommended to add two more cells in their excel of ballots given it is already used by the patio today

1) ell of accumulated weight. This cell will be responsible for adding or accumulating the scrap weights that enter the patio (just the ones that will be shredded)
2) batch cell. This cell will serve as an alarm, it will have a condition in which if the cell of accumulated weight is equal or greater than 1,200 tons (1,200,000 kilograms), a new batch will be opened (explained in the following point).

3.4.2. Area of Unloading Material in Process

A new area of unloading for raw materials (rm) when the shredder is on. This zone serves the purpose of having a follow-up of what goes in and out of the machine.

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A new batch will be created that will be waiting to be shredded, this lot will be "opened" if one of the following conditions is met:

- the principal batch in the unloading zones is equal or greater than 1,2000 tons.
- the shredder is turned on.

With the new batch of raw material in process, the company will know perfectly what kind of material went into the shredder and how much was shredded.
The proposed area to accommodate this extra bunch in the current layout is shown in the annex 12

3.4.3. Trucks Lanes

To reduce the time the trucks, stay inside the plant and reduce the time they take to unload the raw materials. (annex 13)

This proposal aims to utilize the space the factory already has in a more efficient way. We propose to create a two/three lane for the truck's movement. Since there is no available space to go under the shredder a circuit was created to go around it. We take into consideration spaces to unload roll off trucks and those who need the crane, the new inventories and even the new weighting area. We tried to keep the layout simple and without changing any of the main components.

3.4.4. New Weighing Machine

To add inside the three containers of nonferrous material, three different weighing machines that weighed the material once it goes in (annex 14).

The aim of this new weighing machines is to avoid waste of transportation through the plant and overflow at the weighing machines of the entrance. Sometimes trucks have to wait for them to be dis occupied which hinders the operations inside the plant. By adding this weighing machines inside the containers there is no need of transportation and the material can continue to the next part of the process quickly.

3.4.5. Pain Points Within the Operation

Parameters or variables with high impact in the cycle time.

For the shredding and "oxicorte" process a mean time was established for the trucks to be inside the patio. Considering the new routes established on the previous point.

The equation to forecast the time a truck stays in the system:

$$\text{Time} = 37.64 + 4.61 * \text{weight}$$

For this we will utilize the mean of the weight that enters the shredder and "oxicorte"
462,511 kg daily

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With the previous result we attempted to reduce the following times to reach the desired ones:
Supplier rate (as it enters)
Crane rate (cranes time)

With the previous result we attempted to reduce the following times to reach the desired ones:
supplier rate (as it enters)
crane rate (cranes time)
Working rate (time it takes to the do the "oxicorte" process)

4. Conclusions

In conclusion only minor tweaks were made to the current layout of the fabric. The way it was accommodated did not allow the full potential of it to be reached. By creating the two lanes for the trucks to transverse we allowed a lot of unused space to be optimized. Now there is enough space for 3 to 4 clients to unload materials, there is also more mobility for cranes or other vehicles that move in the area. Some of the limitations for this recommendation is that it is impossible to put any type of markings in the ground, since it is dust, paint does not work and the bobcats that clean pullout from the ground (flags, bumps, etc).

By implementing the space for the new inventory (inventory that arrives when the shredder is on) we allowed the factory to keep better track of their monetary inputs and outputs. The limitations are similar to the previous recommendation given that making areas in the floor is difficult. In future works we should research the different ways this recommendation in order to find out which is the cheaper and easiest to apply.

The equation established has also helped the logistics of the new layout because only by knowing their weight we know how much time the truck will remain in the patio, this is useful to determine which lane they should take and were they should unload. The limitation for this proposal is that the equation does not consider if the truck is normal (needs a crane to unload) or roll off, logically a roll off truck will be faster than a normal one. In the future we could make an investigation of the types of trucks in order to find out an equation for each type.

And by adding the two new lines in the excel we complemented the new inventory and allowed a better internal tracking of the raw materials. The limitation for this recommendation is the labor training, since they are not familiar with this accommodation it may be problematic at first but in time this may be mitigated.

In general, many things can still be upgraded but it should be done step by step. In the future an evaluation of the implemented recommendations should be done in order to find out if they have been working and if they have not been rejected by the workers.

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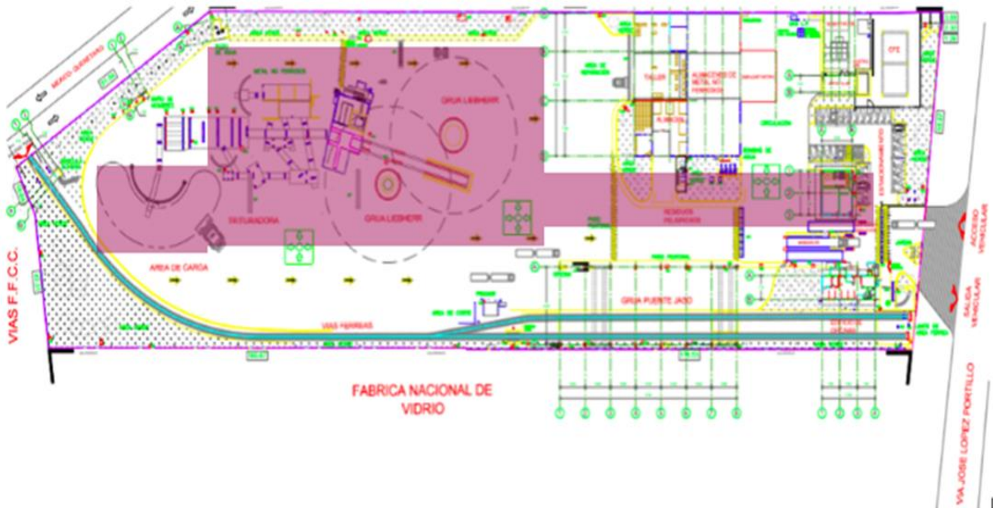
5. Appendices



Annex 1: layout deacero patio tultitlán scrap area highlighted.

Tecnológico de Monterrey

LAYOUT PLANTA DEACERO

Definición del problema:
En el Patio Tultitlan de Deacero existe un problema en la distribución de la planta que ha creado pérdidas económicas significativas. La distribución del patio (layout) complica el transporte y movimiento dentro de la misma, ocasionando un mayor tiempo de ciclo.
Además, no se cuenta con procesos para poder seguir seguir el material desde que ingresa como materia prima hasta que sale como producto terminado causando ineficiencia de procesos.

Definición del defecto:
El layout actual ocasiona retrasos, tiempo muerto y un uso ineficiente de los recursos dentro de la planta de Deacero.
No se puede medir el porcentaje de cada tipo de chatarra en PT.

Hallazgos:
- Solo se puede utilizar una báscula a la vez.
- Muchos camiones formados esperando entregar producto.
- Dificultades de movimiento dentro del patio
- Alto tiempo de proceso y tiempo de ciclo

Próximos Pasos:
- Recolectar datos históricos e información de los procesos
- Medir tiempos
- Analizar cuellos de botella y defectos del proceso
- Proponer cambios

Objetivos (CTQs):
Crear procesos para lograr el seguimiento de los materiales que ingresan a la planta para mejorar la eficiencia de la mezcla y mejorar en un 5% el tiempo de ciclo dentro de la planta para reducir los gastos y tiempos muertos significativamente.

Validación Financiera:
Inicial: Estimado
Final: Final
Contralor: Nombre

Beneficios:
El acomodo del layout facilita el proceso y reduce los tiempos de ciclo ocasionando ahorro de gastos innecesarios, tanto en tiempos como costos.

Capacidad:
Objetivo del negocio:

Final	KPI	Unidad	Sigma	Dato
Base	###	Introducir Texto	###	Introducir Texto (tipo de dato)
Objetivo	###		###	
Final	###		###	

Alcance:
Proceso Inicia: Llegada de camiones a el Patio
Proceso Termina: Inventario de materia prima lista para producción
Incluye: Introducir texto
Excluye: Introducir texto

Fase	Objetivo	Real
D	15/02/19	26/02/19
M	13/03/19	DD/MM/AA
A	27/03/19	DD/MM/AA
M	DD/MM/AA	DD/MM/AA
C	DD/MM/AA	DD/MM/AA

Champion: Blas Gonzalez
Sponsor: Blas Gonzalez
BB: Froylan Franco
Lider: Beatriz Oechler
Equipo:
1. Uriel Rovero
2. Mara Belmonte
3. Rodrigo de Icaza
4. Oscar Bravo

Comentarios:
Los datos pueden variar debido a la falta de información

Actualizado el: 7/03/2019

Educación Ejecutiva

Annex 2: project charter

Waste	Description
Transport	After classifying scrap it is transported to its respective area. After the products are separated from Fe and Non Fe. They need to be transported via

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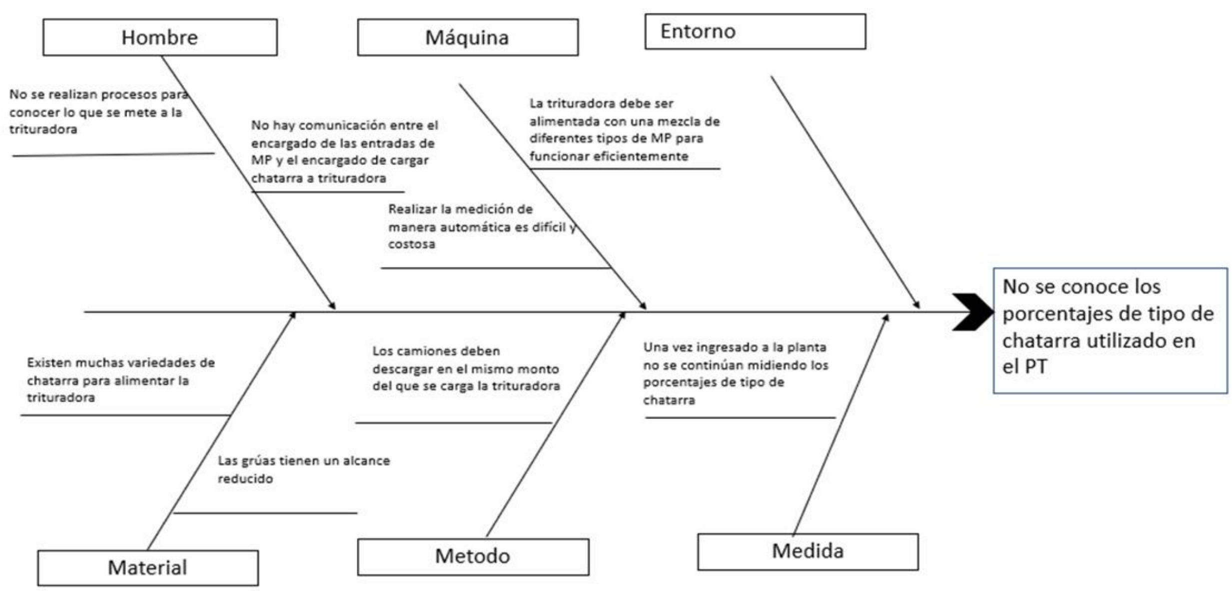
	carts to the next step of the process.
Inventory	Since the cranes take a lot of time to move the product (bottlenecks) a lot of raw material and processed material piles are generated.
Defects	The magnet does not separates correctly all the material so there is personnel in charge of finding this wrong materials.
Waiting	Some trucks are parked with non-ferrous materials because other trucks are being weighed

Annex 3: waste analysis

			5	3	4	3	
Proyecto Potencial	**Líder**	**Champion**	**Beneficio Económico**	**Aplicabilidad**	**Satisfacción de clientes**	**Probabilidad de Éxito**	**Total**
Layout	Froylan Franco	Blas Gonzalez	3	3	3	9	42%
Zona de descarga	Froylan Franco	Blas Gonzalez	6	3	6	6	54%
Entrada y salida de camiones en báscula	Froylan Franco	Blas Gonzalez	6	3	3	6	46%
Motor generador de energía	Froylan Franco	Blas Gonzalez	3	9	3	6	48%
Clasificación de Chatarra	Froylan Franco	Blas Gonzalez	9	9	3	6	68%
			Ahorros Anuales	**Ejecución**	**Soporte**	**Probabilidad**	
			3 < 250 k pesos	3 = Localmente	3 = Indirectamente	3 = Baja	
			6 < 500 k pesos	6 = En algunas locaciones	6 = Moderadamente	6 = Media	
			9 > 500 k pesos	9 = En todas las locaciones	9 = Significativamente	9 = Alta	

Annex 4: project selection matrix



Annex 5: ishikawa diagram

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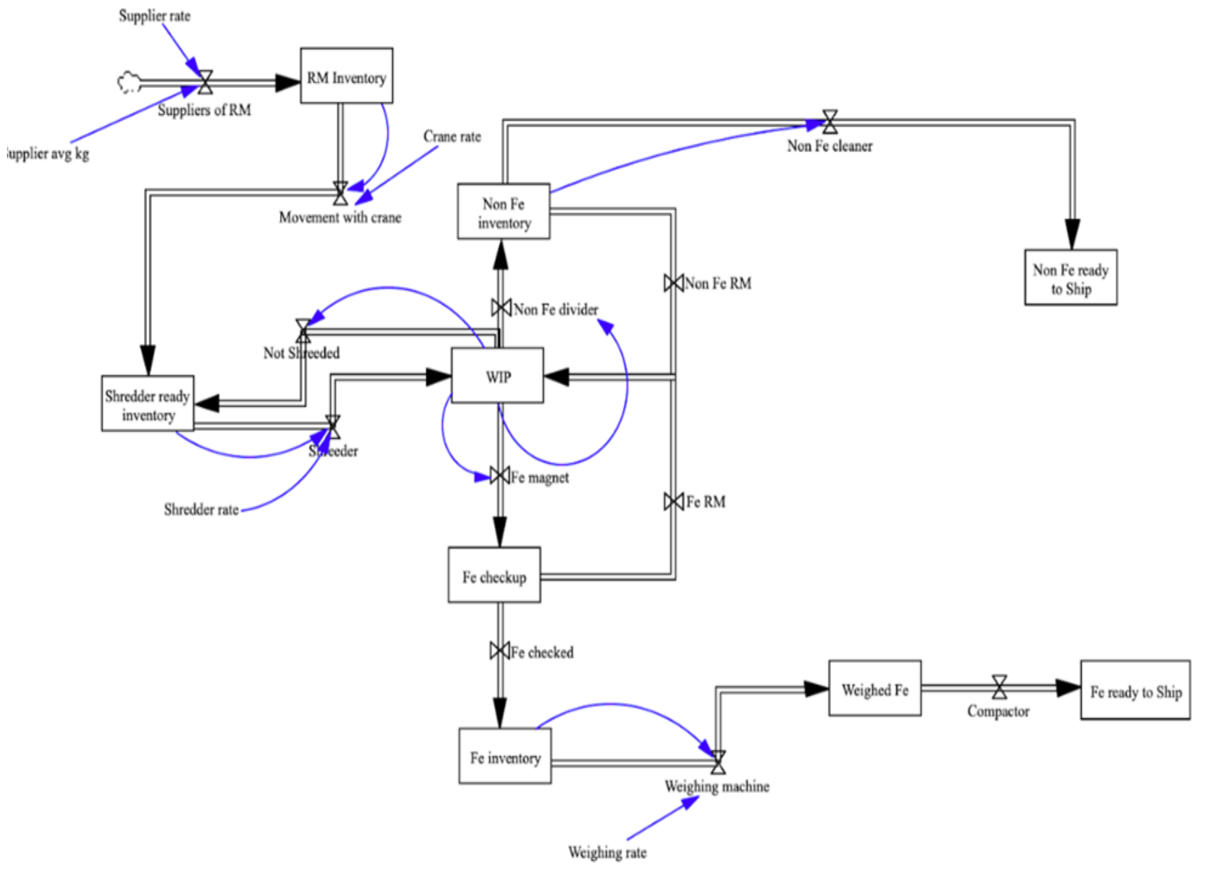
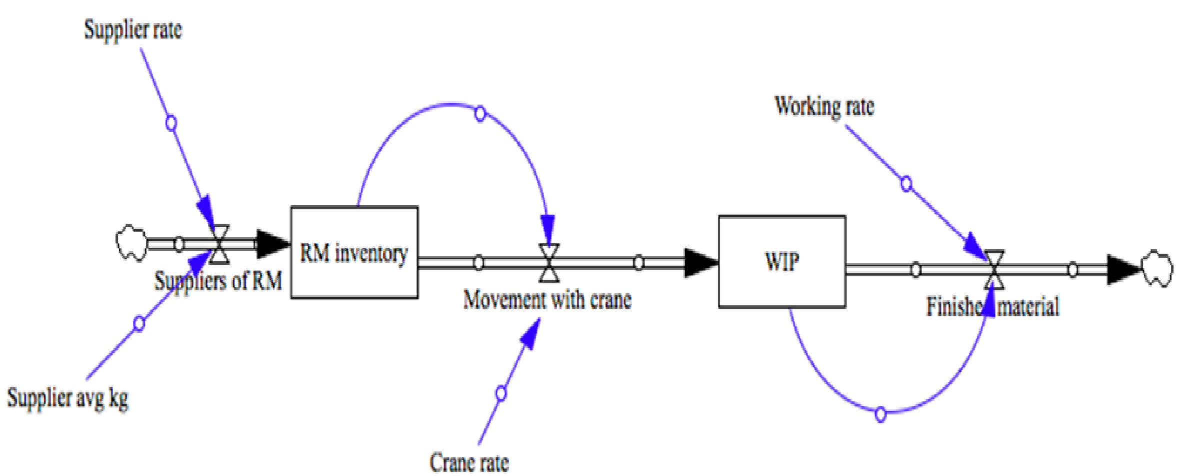


Annex 6: shredder mapping



Annex 7: "oxicorte" mapping

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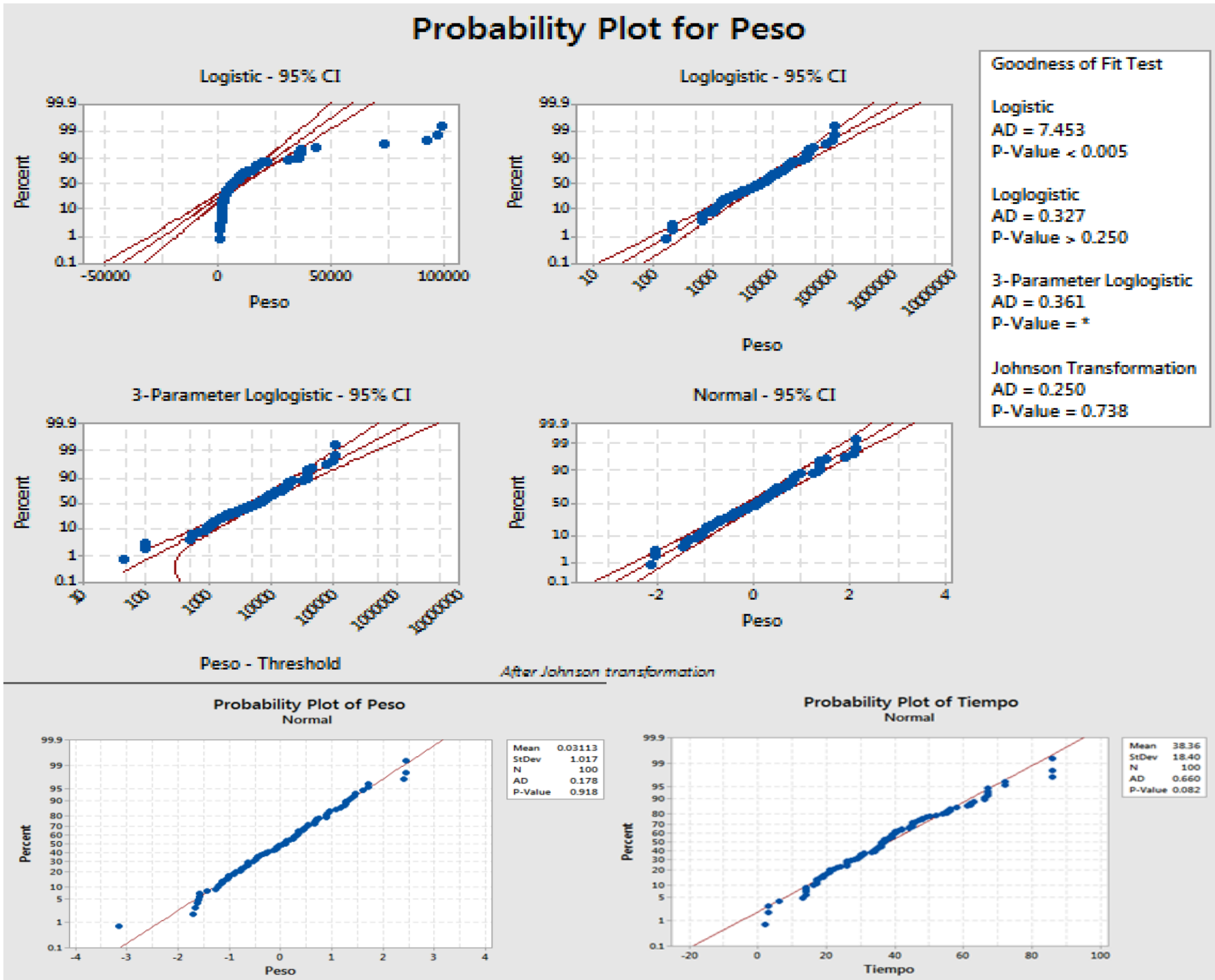
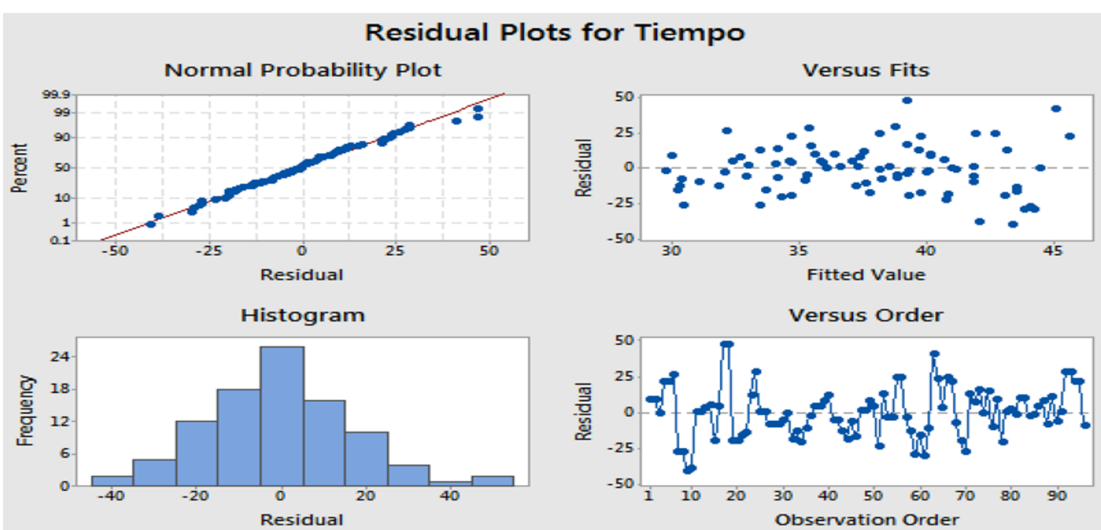


Annex 8: johnson test



Annex 9: normality test

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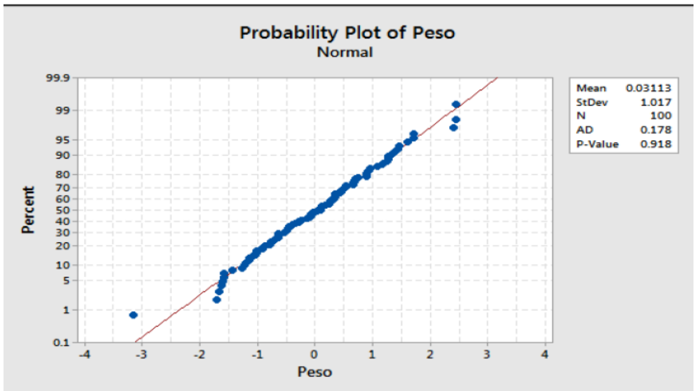

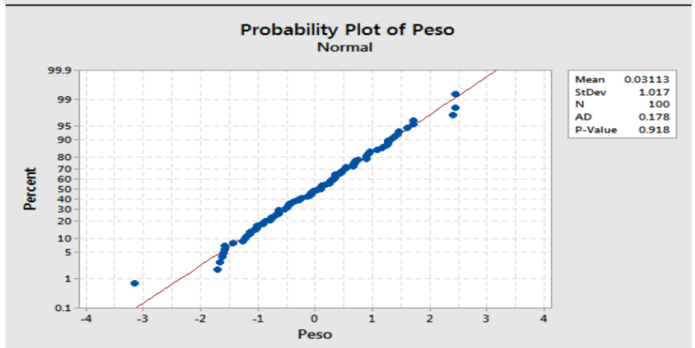

Mensual														
Variable	N	Media	Error estándar de la media	Desv.Est.	Mínimo	Q1	Mediana	Q3	Máximo	%	Volumen approx (m^3)	h (m)	r (m)	A (m^2)
MIXTO	4	878,128.00	305,390.00	610,779.00	250,745.00	320,644.00	820,990.00	1,492,751.00	1,619,788.00	70%	111.8634	10	4	51
MIXTO PARA PROCESAR	4	4,490,094.00	1,150,497.00	2,300,994.00	1,438,530.00	2,107,726.00	4,894,405.00	6,468,150.00	6,733,035.00	51%	571.9865	17	6	114
PACA DE SEGUNDA	4	693,295.00	401,162.00	802,325.00	116,725.00	154,906.00	392,603.00	1,532,376.00	1,871,250.00	116%	88.31783	9	4	51
PESADO	4	75,435.00	20,999.00	41,999.00	26,280.00	34,514.00	75,960.00	115,831.00	123,540.00	56%	9.609554	5	2	13
PESADO LARGO	4	411,543.00	249,553.00	499,105.00	66,780.00	92,405.00	214,270.00	927,953.00	1,150,850.00	121%	52.42586	8	3	29
RETORNO INDUSTRIAL PARA PROCESA	4	55,628.00	19,401.00	38,803.00	11,360.00	17,566.00	57,505.00	91,811.00	96,140.00	70%	7.086369	4	2	13

Mensual														
Variable	N	Media	Error estándar de la media	Desv.Est.	Mínimo	Q1	Mediana	Q3	Máximo	%	Volumen approx (m^3)	h (m)	r (m)	A (m^2)
MIXTO	4	878,128.00	305,390.00	610,779.00	250,745.00	320,644.00	820,990.00	1,492,751.00	1,619,788.00	70%	111.8634	10	4	51
MIXTO PARA PROCESAR	4	4,490,094.00	1,150,497.00	2,300,994.00	1,438,530.00	2,107,726.00	4,894,405.00	6,468,150.00	6,733,035.00	51%	571.9865	17	6	114
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PESADO LARGO	4	411,543.00	249,553.00	499,105.00	66,780.00	92,405.00	214,270.00	927,953.00	1,150,850.00	121%	52.42586	8	3	29
RETORNO INDUSTRIAL PARA PROCESA	4	55,628.00	19,401.00	38,803.00	11,360.00	17,566.00	57,505.00	91,811.00	96,140.00	70%	7.086369	4	2	13

Annex 10: supplier's rate analysis

Proovedor	Peso Entrada	Peso Salida	Peso Neto	Peso acumulado	Lote
1	36,990	20,725	16,265	16,265	1
2	6,295	3,440	2,855	19,120	1
3	6,295	3,440	2,855	21,975	1
4	17,150	8,810	8,340	30,315	1
5	5,505	3,585	1,920	32,235	1
6	100,000	0	100,000	132,235	1
7	1,000,000	0	1,000,000	1,132,235	1
8	37,000	0	37,000	1,169,235	1
9	150,000	0	150,000	150,000	2

Annex 11: new tool

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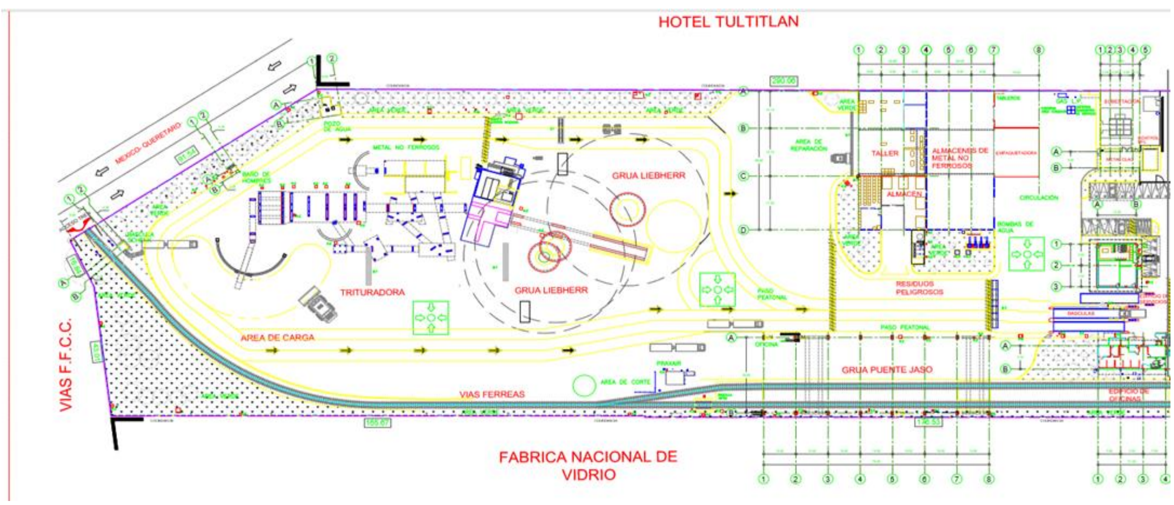
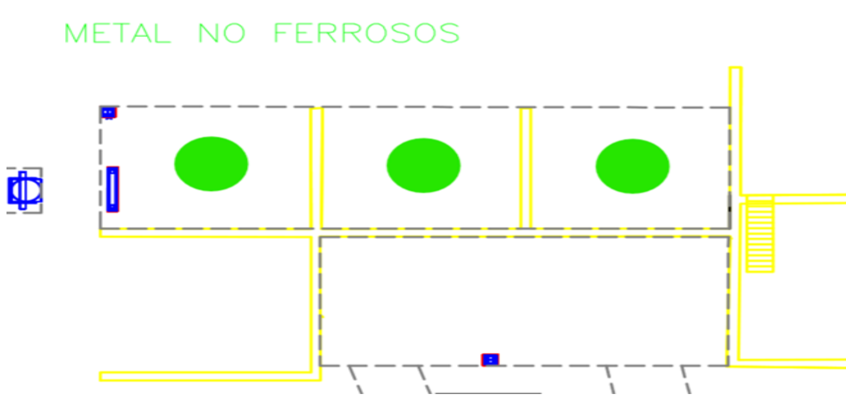
Annex 12: zonas de descarga con recomendación (orange is current unloading areas and blue is the new batch unloading area)



Annex 13: new layout



Annex 14: non ferrous containers

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