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ABSTRACT

This paper entitled “Distribution and administrative improvements in a plastic industry” was made to analyze the real situation of a Mexican plastic manufacturing enterprise so that from it, and using some tools of Operations Management, could be possible to provide feasible proposals to optimize resources such as time and money.

DISTRIBUTION AND ADMINISTRATIVE IMPROVEMENTS IN A PLASTIC INDUSTRY

Nowadays we live in a competitive and globalized world, in which any enterprise in expansion process and with the growth will need to apply innovative tools which could improve its productivity, efficiency and utilities by managing some concepts, such as: stocks, processes and operations, layout manage, and resources (time, human factor, raw material, money, among others).

Capacity, capability, productivity, efficiency and stock level are key concepts looking for an **enterprise’s improvement and growth**. For example, “**productivity**” is not just a numeric value; it is also related to an enterprise’s **path looking for success**. **Productivity is a reference level that describes the target’s compliance**; basically monetary targets, such as profits or volume sold.

According to Niebel (4), productivity is the relation among inputs and outputs, this relation **basically describes an enterprise’s growth**. **Total productivity** is the rate among tangible production and total of tangible process inputs (2).

Another performance level is the efficiency. It is defined as the proper usage of resources and raw material in order to avoid or reduce scraps. Numerically, the efficiency is estimated by the following formula:

Efficacy is defined as the rate considering targets reached and estimated. For example, the quantity of finished products could be an estimator using efficacy. Mathematically:

Stock level is also a basic concept talking about money waste. If stock is in its best possible level, the holding cost **will be the minimum**. APICS dictionary defines stock as *“those (...) items used to support production (raw materials and work in process items), supporting activities (maintenance, repair, and operating supplies), and customer service (finished goods and spare parts)”* (1). There are tools which allow estimate the optimum stock level; this helps to distribute significant savings into valuable activities adding value to finished items. Planning the **company’s layout is vital for its excellent development**. There should be a specific and intelligent place for each of the items into the company, for instance machinery, offices, raw material, finished products, among others. An improper layout frequently is cause of delays in the process.

Up to now, we have reviewed some concepts related to a company’s monetary growth. We have done an analysis of some visible issues identified in **“Plásticos Polaris S.A de C.V”**. Below it is described the study about the current situation and there are stated some improvement proposals.

PLÁSTICOS POLARIS S. A. DE C. V.

“Plásticos Polaris S.A de C.V” is a family’s enterprise which produces synthetic leather. This material is used by its customers as raw material. The different uses of the synthetic leather produced by **“Plásticos Polaris S.A de C.V”** are: footballs, belts, tablecloth, covers, shoes, packs, automotive bras, among others.

Current enterprise's status

The enterprise produces about 15 different products and its derivatives, processing each one of them with different lines of production. Currently there are 42 workers and 26 labor days by month (average). This means that the company works about 2,016 human hours per week. The levels of raw material stock and finished product stock are about 23 000 and 37 000 units each one.

By analyzing each of the items produced, the Montero is the plastic with the greatest demand and production in the plant. The Montero represents the 24.8% of the total production. The average size of a Montero roll is from about 1.40 m wide and 40 m long, with a tightness of 2 mm. For the production of this product it is required about 10.4 workers (average), representing 2080 human hours per month.

Below is shown the data (TABLE 1) of human hours producing Montero in the company. The period of time considered is the last 7 months of production.

TABLE 1

Last 6 months production of Montero rolls

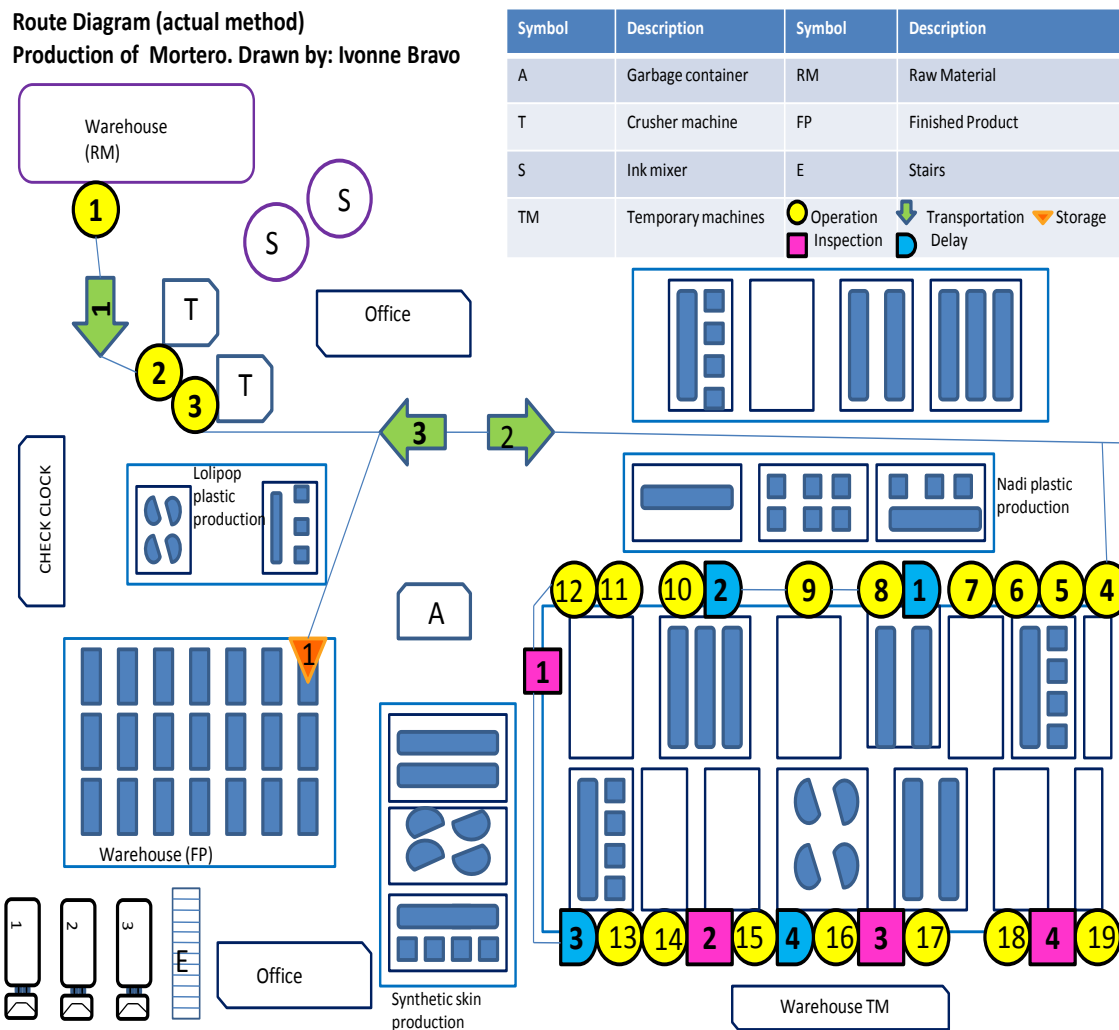
Month	Production capacity (thousands of m)	Outputs Real production (thousands of m)	Inputs (hours-labor per month)	Productivity (m per hour-labor)
January	23,607.5	20,774.6	2080	9.98778846
February	22,365.0	19,681.2	2080	9.46211538
March	19,880.0	17,494.4	2080	8.41076923
April	19,880.0	17,494.4	2080	8.41076923
May	21,122.5	18,587.8	2080	8.93644231

June	22,365.0	19,681.2	2080	9.46211538
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On the other hand, the item travels around the entire enterprise in order to reach its final step: the finished products area. The layout of the company is as shown below:

FIGURE 1

Flow chart of Montero's production (currently)



On the following image is shown an analytic flowchart (of material). There is described the activities involved in the last process. Moreover, the distance and time required for the Montero plastic production.

FIGURE 2

Flow chart of Montero's process (currently)

Flow Chart Process		Material		Abstract				
Diagram N° 1 Sheet N° 1 of 1								
Product: Plastic "Montero"		Activity		Actual	Proposed	Economy		
Activity:		Operation		19				
Route of the raw material in the process to obtain plastic "Montero"		Transportation		3				
		Delay		4				
		Inspection		4				
		Storage		1				
Method: Actual/ Proposed								
Place: "Plásticos Polaris S.A de C.V"		Distance (m)		95.36				
Labor:		Time (min. – labor/ machine)		74.08				
1. José Manuel López		Cost						
2. Francisco Figueroa		Labor						
3. Oswaldo Ruiz		Material						
Approved by: José Pantoja		Total						
Date: March 28th 2011								
Description	Quantity (kg)	Distance (m)	Time (min)	Symbol				Observations
1o. Taking raw material (plastic).	200kg		5.28	o				
1t-Routing raw material to the crushing machine.		14.36	1.62	⇔				
2o-Put plastic into crushing machine			7.15	o				
3o-Crush plastic			10					
2t-Go to the processing machine		43	4.55	⇔				
4o-Deposit crushed plastic to machine			7.30	o				
5o-Smelting of plastic			2.28					
6o-Flating plastic			1.11					
7o-Cooling plastic			2.32					
1d- Obtaining and preparation of paper "Látix"			1.26			□		
8o-Adhering paper "Látix" to plastic.			1.40	o				
9o-Entering and warming up plastic with "Látix" in baking furnace			2.40					
2d-Obtaining and preparation of foam rubber			1.15			□		
10o-Applying foam rubber			2.25	o				
11o-Entering and warming up plastic with "Látix" in baking furnace			2.38					
12o. Reclaiming paper "Látix" for new use			0.45					This step is eliminated after it is used 3 times
1i-Verifying increase of volume of foam rubber			0.20			□		
3d. Obtaining and preparation of protective adhesive			1.10			□		
13o-Applying protective adhesive			2.05	o				
14o-Entering and warming up plastic in baking furnace.			1.20					
2i. Verifying baking			0.55			□		
15o-Applying printing			1.50	o				Die can be changed
4d-Preparing and obtaining red			1.45			□		
16o-Pigmenting print			1.25	o				
3i-Verifying dyeing uniformity			0.40			□		
17o- Apply plastic "Látix"			1.40	o				
18o-Entering and to warm up plastic in baking furnace			2.20					
4i-Final inspection			2.48			□		
19o-Roll formation for sale			1.50	o				
3t-Transporting of product "Montero" to finished product warehouse		38	4.10	⇔				
1s-Store product to Montero						□		The storage is registered by meters and roll
Total		95.36	74.08					

The time and the distance required in the process are 74.07 min and 95.36 m respectively.

When we compare the real Montero production vs **the real machine's capacity**, it is easy to determine the current efficacy of production (considering just the last 7 months).

LAYOUT IMPROVEMENT PROPOSAL

Up to now some basic concepts has been described and data about Montero's plastic has been recovered and explained. Now, as the result of a meeting with the person in charge of the plant (Eng. Ernesto Castañeda) and the work team, some potential changes on each of the specific factors described before has been analyzed and are presented below.

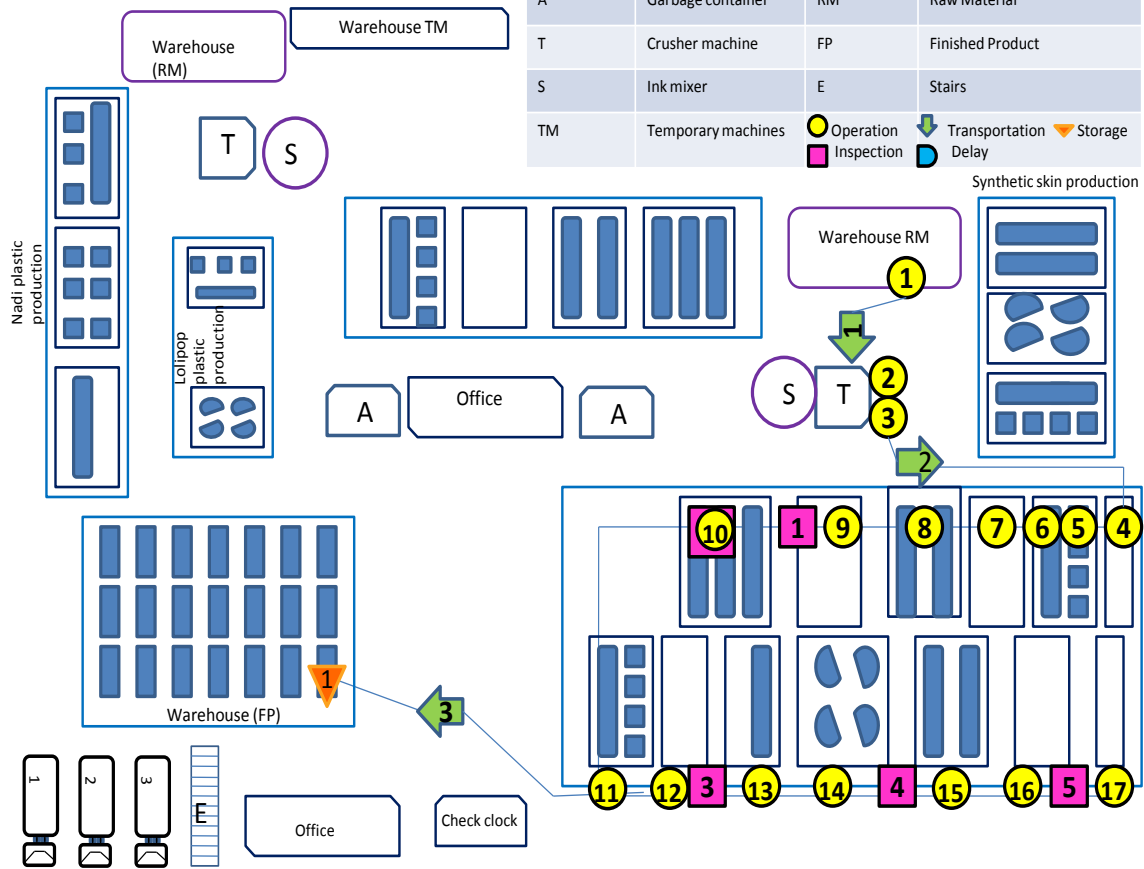
Regarding the plant's layout, it's pretty easy to move the production machines of pallet plastic, synthetic leather and Nadi plastic. Moreover, a raw material stock near to the machines could improve the process, the time and the distance required to process the materials. In FIGURE 3 it is observable the change of the distribution plant.

FIGURE 3

Flow chart of **Montero's production** (proposed)

Route Diagram (proposed method)

Production of Mortero. Drawn by: Ivonne Bravo



In the same way, the Engineer Castañeda suggested to reduce some operations that were causing delay in the process. He suggested introduce automatically the raw material into de machine in order to produce more in a reduced time. This could be seen by comparing figures 2 and 4 in the delays 1, 2 and 3 and a change in the first inspection. In those figures, are also some operations that have disappeared, such as activities 10 and 11. The reason of this change was a suggestion done by the Engineer Castañeda considering that operations 9 and 10 could be considered as a single one, and operation 11 could be done before the production begins.

In the following figure, it is shown the description, sequence and times proposed by the work team, considering the new layout and factors just mentioned about Montero’s production.

FIGURE 4

Flow chart of **Montero's** production (proposed)

Flow Chart Process		Material						
Diagram N° 1 Sheet N° 1 of 1		Abstract						
Product: Plastic "Montero"		Activity	Actual	Proposed	Economy			
Activity:		Operation	17					
Route of the raw material in the process to obtain plastic "Montero"		Transportation	3					
Method: Actual/ Proposed		Delay	0					
		Inspection	4					
		Storage	1					
Lugar: "Plásticos Polaris S.A de C.V"		Distance (m)	25.95					
Labor		Time (min. – labor/ machine)	58.77					
1. José Manuel López		Cost						
2. Francisco Figueroa		Labor						
3. Oswaldo Ruiz		Material						
Approved by: José Pantoja Date: March 30th 2011		Total						
Description	Quantity (kg)	Distance (m)	Time (min)	Symbol				Observations
				o	⇔	D	∇	
1o. Taking raw material (plastic)	200kg		5.28	o				
1t–Routing raw material to the crushing machine		5	0.56	⇔				
2o–Put plastic into crushing machine			7.15	o				
3o–Crush plastic			10	o				
2t–Go to the processing machine		10.75	1.13	⇔				
4o–Deposit crushed plastic to machine			7.30	o				
5o–Smelting of plastic			2.28	o				
6o–Flatting plastic			1.11	o				
7o–Cooling plastic			2.32	o				
8o–Adhering paper "Látix" and foam rubber to plastic			1.40	o				
9o–Entering and warming up plastic with "Látix" in baking furnace			3.45	o				
1i. Verifying increase of volume of foam rubber 10o. Reclaiming paper "Látix" for new use			1.16	o				This step is eliminated after it is used 3 times.
11o–Applying protective adhesive			2.05	o				
12o–Entering and warming up plastic in baking furnace.			1.20	o				
2i. Verifying baking			0.55	o				
13o–Applying printing			1.50	o				Die can be changed.
14o–Pigmenting print			1.25	o				
3i–Verifying dyeing uniformity			0.40	o				
15o–Apply plastic "Látix"			1.40	o				
16o–Entering and to warm up plastic in baking furnace			2.20	o				
4i–Final inspection			2.48	o				
17o–Roll formation for sale			1.50	o				
3t–Transporting of product "Montero" to finished product warehouse		10.2	1.1	⇔				
1s–Store product to Montero				o				The storage is registered by meters and roll.

Please, notice that the distance in the flow diagram proposed, was reduced by 72.78% and the total time of the process by 20.66%. Some of the benefits that could be obtain by applying this proposal are the following: delivery time reduction, optimum **usage of the plan's space and** better items and finished products flow inside the company.

OPTIMUM STOCK LEVEL FOR MONTERO'S PRODUCT

According to the data from "Plásticos Polaris **S.A de C.V**", a study about the stock level was done. Through this study it is possible to get and propose improvements about the stock administration of necessary items in order to create Montero. In the same way, it's important to mention that the fabrication of this product involves various materials processes, that is why was necessary to define well the study. The team work decided to cover only the basic materials which conforms the Montero. They are: resin of polyurethane and textile.

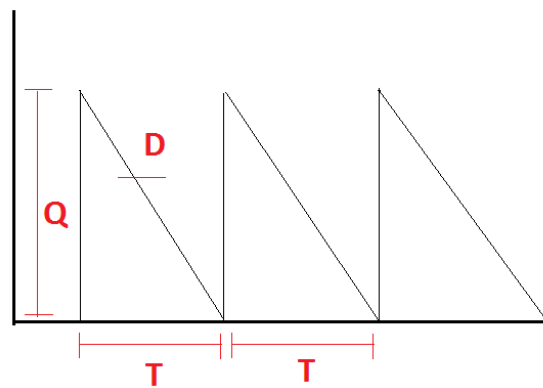
Before the required analysis, there was necessary to identify the stock model currently used in **the enterprise, this model was a "Costumer with backorders"**. **This model is characterized mainly by reduced stock's levels through time and constant orders, always allowing some backorders** (3). **Items in stock are sold at a rate named "demand" and represented with letter D. This means that there are needed D items per unit of time.**

Another possible model is the "Customer without backorders". This model also supposes that items are produced and sold at a constant rate, in the same quantity Q over time (3). The costs considered in this model are the start costs (A), or necessary costs at the beginning of the operation. Each inventory unit is purchased with a cost (C) and there is a holding cost (h) per item produced. **The model "Customer without backorders" looks for determine the frequency in**

which an order is needed to be done. Each order must be of Q^* items in order to minimize the global cost per unit. **As its name says, this model doesn't allow backorders**, this means that the customer will not to wait for the article. Below is shown a diagram in order to give an example of the model "Customer without backorders".

FIGURA 5

Inventory level



T = Time between orders

Q = Unit ordered per unit of time

D = Items demand

Below is shown the available information in order to do the analysis.

TABLE 6

Monthly production
(Montero rolls)

January	P1	23607.5
February	P2	22365
March	P3	19880

TABLE 3

Units to order of
polyurethane resin (kg)

January	Q1	356945.4
February	Q2	338158.8
March	Q3	300585.6

TABLE 4

Units to order of textile
(m)

January	Q1	23796.36
February	Q2	22543.92
March	Q3	20039.04

April	P4	19880
May	P5	21122.5
June	P6	22607.5

TABLE 5

Monthly demand
(Montero rolls)

April	Q4	300585.6
May	Q5	319372.2
June	Q6	341825.4

TABLE 6

Polyurethane resin demand
(kg/month)

April	Q4	20039.04
May	Q5	21291.48
June	Q6	22788.36

TABLE 7

Textile demand
(m/month)

January	D1	20373.3
February	D2	20933.6
March	D3	18031.2
April	D4	18508.3
May	D5	20518.4
June	D6	21974.49

January	D1	308043.9
February	D2	316516.6
March	D3	272631.1
April	D4	279845.2
May	D5	310238.2
June	D6	332254.3

January	D1	20536.25
February	D2	21101.10
March	D3	18175.40
April	D4	18656.34
May	D5	20682.54
June	D6	22150.28

TABLE 8

Important Economic Data

Synthetic Montero roll price (m ²)	73.86
Ordering cost of polyurethane resin (\$/order)	937.40
Ordering cost of textile (\$/order)	95.24
Holding cost – polyurethane resin (\$/kg-month)	0.18
Holding cost –textile (\$/m-month)	0.02
Interest rate (%)	4.86
Cost per kg of polyurethane resin (\$/kg)	3.66

Cost per m of textile (\$/m)	0.40
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This information was used to do the required calculus in order to obtain the optimum units per order (Q^*). In the following table are shown the results using the correct formula for the model Customer without backorders.

- Q^* : Optimum number of units to be ordered / Optimum lot size.

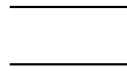


TABLE 9

(Optimal) Units to order of polyurethane resin (kg)

January	Q1*	56981.08
February	Q2*	57759.40
March	Q3*	53605.85
April	Q4*	54310.44
May	Q5*	57183.67
June	Q6*	59177.92

TABLE 10

(Optimal) Units to order of textile (m)

January	Q1*	14185.26
February	Q2*	14379.02
March	Q3*	13345.00
April	Q4*	13520.41
May	Q5*	14235.69
June	Q6*	14732.15

On the other hand, it's important to know that the company receives raw material each Monday and Tuesday of the month, that's why they schedule 8 orders per month. This lot is planned to be finished from 1 to 5 days after it arrives due to demand. Considering this statements and the Q^*

just obtained per month, below is shown the optimum number of orders to be posted and the time among them.

- T : Time between orders.
- N : Number of orders

TABLE 11

Optimal time between unit orders (month)

Polyurethane resin

January	T1*	0.184977	6
February	T2*	0.182484	5
March	T3*	0.196624	6
April	T4*	0.194073	6
May	T5*	0.184321	6
June	T6*	0.178110	5

TABLE 12

Optimal time between unit orders (month)

Textile

January	T1*	0.690742	21
February	T2*	0.681434	20
March	T3*	0.734233	22
April	T4*	0.724708	22
May	T5*	0.688294	21
June	T6*	0.665099	20

TABLE 13

Orders per month (orders/month)

January	N1	5.406
February	N2	5.480
March	N3	5.086

TABLE 14

Orders per month (orders/month)

January	N1	1.448
February	N2	1.467
March	N3	1.362

April	N4	5.153
May	N5	5.425
June	N6	5.614

April	N4	1.380
May	N5	1.453
June	N6	1.504

By analyzing the results, we could affirm that the proposed Q^* effectively reduces the number of orders from 8 to 4 orders per month. In the same way, time among orders is benefited due to its reduction. At the same time, with the program proposed, the **optimum stock's level is obtained**.

- : Average stock's level.

TABLE 15

Average inventory of polyurethane
resin (kg)

January	1 1	28490.542
February	1 2	28879.701
March	1 3	26802.923
April	1 4	27155.222
May	1 5	28591.835
June	1 6	29588.962

TABLE 16

Average inventory of textile
(kg)

January	1 1	7092.629
February	1 2	7189.509
March	1 3	6672.501
April	1 4	6760.205
May	1 5	7117.845
June	1 6	7366.077

Finally are shown below the associated costs by purchasing the optimum quantity per order as has been proposed.

$$\text{Min } Z = \text{Cost per order} + \text{Material cost} + \text{Holding cost}$$

$$\text{Min } Z = (A + C*Q + h* *T)-$$

$$\text{Min } Z = \text{---} + CD + h-$$

TABLE 17

Current cost of polyurethane resin

January	Z1	\$ 1,159,965.18
February	Z2	\$ 1,189,372.29
March	Z3	\$ 1,025,386.80
April	Z4	\$ 1,051,812.04
May	Z5	\$ 1,164,756.03
June	Z6	\$ 1,247,330.42
Six-month cost		\$ 6,838,622.77

TABLE 18

Current cost of textile

January	Z1	\$ 8,528.00
February	Z2	\$ 8,529.59
March	Z3	\$ 7,356.55
April	Z4	\$ 7,551.21
May	Z5	\$ 8,365.53
June	Z6	\$ 8,952.69
Six-month cost		\$ 49,283.56

TABLE 19

Optimal cost of polyurethane resin

January	Z1	\$ 1,137,546.33
February	Z2	\$ 1,168,694.25

TABLE 20

Optimal cost of textile

January	Z1	\$ 8,490.26
February	Z2	\$ 8,719.97

March	Z3	\$ 1,007,338.74
April	Z4	\$ 1,033,866.81
May	Z5	\$ 1,145,613.20
June	Z6	\$ 1,226,544.86
Six-month cost		\$ 6,719,604.19

March	Z3	\$ 7,529.59
April	Z4	\$ 7,725.38
May	Z5	\$ 8,549.76
June	Z6	\$ 9,146.51
Six-month cost		\$ 50,161.47

TABLE 21

Savings per month

January	\$ 22,456.58
February	\$ 20,487.66
March	\$ 17,875.01
April	\$ 17,771.06
May	\$ 18,958.61
June	\$ 20,591.75
Six-month saving	\$ 118,140.67

CONCLUSIONS

With the analysis presented the following statements could be concluded:

- Using tools as flow and layout charts, is really useful in order to detect some activities that are causing longer production times, unnecessary operations, among other activities that doesn't add any value to the final product. The improvements proposed are totally based on these studies.

- The flow and layout charts presented are totally related between them, and they show that the distribution of the machines and stocks inside “Plásticos Polaris **S.A de C.V**” is not **the best. This “mistakes” produce longer operation times.**
- One of the most important improvement proposals is the mixture of operations and/or its elimination. For instance, reducing inspection and delays at the beginning of the operation (putting the raw material in the machine).
- The location of raw material stocks and finished product stocks near to the work stations allow to reduce the transportation time in the process.
- Inventory management also can be well controlled by using mathematical models as shown in this paper. There are many options that can describe the various complexity related with warehouse behavior, so we can choose the one that best adjusted to our needs. In this case we decided to analyze inventory **by using the model “Customer without backorders” and we could obtain significant improvements that are reflected in decreasing the number of orders made and the quantity of units requested. Finally we saw an important reduction of costs related with inventory’s control; which show us an optimum solution significant enough to be applied.**

Finally, generally operations management is a huge area which allows the implementation of various types of tools in order to improve competitive factors in the industry world.

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