RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

The industrial improving processes in a tannery through an industrial redesign

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Abstract

The Latin American leather industry continues to be an economic driving force in the regions where this material is manufactured. However, some factors limit the optimal performance of its activities. This work focused on the fundamental aspects of production optimization in a tannery in Peru, representing the level of process and activity planning in Latin America. Therefore, this work was devoted to developing an approach to improve the company's production processes. For this purpose, an analysis was carried out based on the optimization of personnel movements and the correct study of the planning of the areas where the actions that lead to leather production are to accomplish. Furthermore, strategies that do not require costly investments in tools or software were used since the objective is to make substantial improvements without needing significant capital investments.

Keywords: Tanneries, related activities, travel optimization.

Introduction

The treatment of bovine pelt or goat skins to convert them into leather accessories and garments for everyday human use has prehistoric antecedents [1]. It has long been known that treating the hides of various animals with vegetable substances, such as tannins, prevents the leather from rotting or hardening, thus achieving durability and flexibility of the product [2].

So far, it has not been possible to produce material for the fashion industry that possesses leather's beauty, quality, and durability [3], which is why its use does not seem close to disappearing. According to FAO data [4], world leather production has increased. Chromium-based leather treatment, which shortens tanning time, has resulted in higher leather production in less time. However, this practice has led to increased pollution levels in the industry [5]. Therefore, the industry requires new practices that ensure its long-term sustainability [6] [7] and that, in turn, contribute to the economy of the producing countries [8]. For this reason, there is a growing concern in the scientific literature to address issues that focus on solving the problems associated with leather production, from managing contaminated wastewater [9] to a more integrated view of the management of waste associated with the industry [10]. Some alternatives include the elimination of chromium use through new processes [11] and the use of bio-sorbents for the treatment of contaminated water [12].

A significant percentage of the leather trade in the world comes from developing countries, as shown in Fig.1. On the other hand, the exact figure shows that among the countries receiving leather are the United States of America (USA), France, and Germany, to mention some of the most important ones.

Although emerging countries are the world's largest leather producers, many factories have low process automation levels, affecting production efficiency [13]. Another factor against this is that the personnel have low levels of qualification and, therefore, a lower level of productivity. Finally, high levels of pollution and inadequate resource management are observed in factories, resulting in low-profit margins. This scenario is compounded by external factors such as restrictive financing policies, the absence of technical training centers associated with the leather industry, and the lack of control over supply chains to ensure the supply of quality hides for subsequent use.

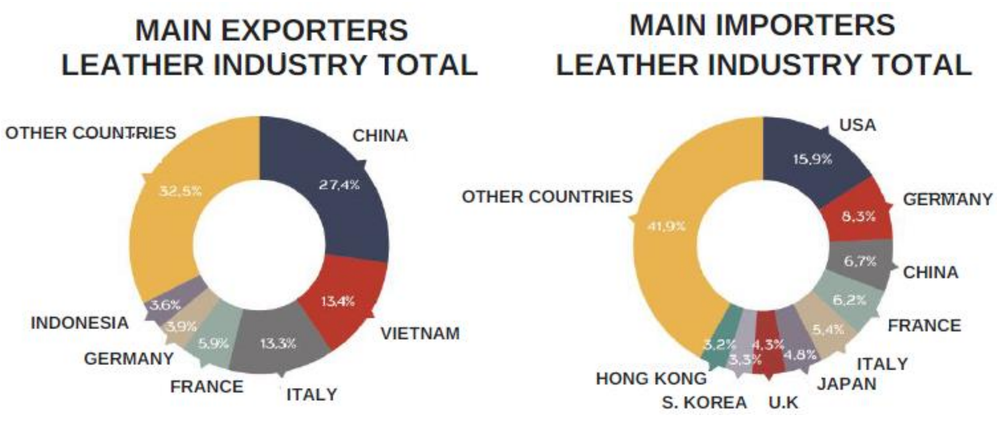

Fig.1 *Leather producing and importing countries distribution. [14].*

Although Brazil is a significant exporter of hides and skins, Latin America is not represented in Fig. 1. This is because the leather industry in that country has been declining in recent years. In addition, the region's activity faces profound sustainability challenges, where it has been losing both production [15] and competitiveness in terms of the quality of its products compared with Asian leather producers such as China or Vietnam. Under these circumstances, Latin American leather processing companies need strategies that will enable them to increase their profit margins and remain within their respective countries' value chains to compete internationally. Since there is not enough capital available to make significant investments in equipment or machinery to automate the processes, nor very sophisticated tools, this work sought to identify process optimization actions that could be implemented for this purpose. Therefore, by studying the production processes and the knowledge of the related processes associated with the elimination of toxic waste, we sought to improve production efficiency as a first step towards achieving the industry's sustainability and stabilizing production. The value proposition of this study was modeled on a leather factory in Peru.

The following work is structured by analyzing the processes involved in leather production and applying process optimization principles in the leather industry in Latin America. In this way, it is possible to identify the aspects of the production processes that can be improved through a spatial efficiency treatment in the work areas and the optimization of the process times. For this purpose, the research is based on the relationship between activities, optimization of work areas, and process sequences. The following sections correspond to the conceptual development of the processes executed in the leather industry, the variables to be measured, and the necessary procedures to measure these variables. These tools are then applied with the information gathered in the research to calculate the actions that can be implemented to improve leather manufacturing in the plant under study. From the results obtained, important conclusions were evidenced, new study approaches were proposed for the continuous improvement of production, and it is discussed which other research activities can contribute to the continuous optimization of the production processes in the leather industry. It is corroborated that a determined ditribution of the leather production areas notably improves the work rhythm and the number of products obtained. Optimal handling of material and worker movements between areas improves operator health and production speed. However, it also turned out that waste management is complex to optimize and requires studies to develop prototypes that improve waste disposal and treatment spaces.

Development

Leather production processes

The process of obtaining leather in many tanneries in Latin America still has a low level of plant automation, bringing them closer to artisanal leather production than to the developed and highly technological industries in countries such as Germany or Italy. However, there are some fundamental processes with some variations in leather processing. These typical stages are the following: pre-tanning, tanning, and post-tannage [2] and are briefly and generally explained below:

Pretanning

In the pre-tanning stage, the hides are received from slaughterhouses and are selected for tanning. In order to do this, elements unsuitable for tanning, such as hair, blood, or excrement, must be removed. Therefore, the first step is to apply salt to the hides with a concentration of between 40 and 50 percent sodium chloride [16] by weight to prevent the hides from rotting. It is followed by soaking, a step in which the hide is rehydrated with abundant water and bactericides in order to eliminate hair, blood, or other residues adhered to the hide. The next step consists of treating the hides with lime to eliminate proteins present in the hide and preserve the collagen fibers. Lime contains sulfur and sodium sulfide, essential to prevent hair from growing back on the hide. After liming, the hides are dehairing, deliming and fleshing. In mechanized factories, the fleshing is done with machinery, while in artisanal factories, the fleshing is done with a knife. The tanning of the hides is then continued.

Tanning

To be processed, the hides that have been treated in the pre-tanning stage are subjected to the pickling step for tanning. At this stage, the leather can be tanned by vegetable tanning, chrome tanning, or other techniques, depending on the characteristics of the company and its market niche. [17].

Post-Tanning

At this stage, the leather has already reached the necessary characteristics (wet blue, wet white) for the last process that consists of re-tanning the leather with vegetable substances, tannins, and resins that give the final appearance to the leather (or chrome in the case of being processed more industrially). Dyes and fatty compounds are then applied to achieve softness to the touch and resistance to mechanical stress tests. Finally, a layer of lacquer is applied as the final coating of the product. [18].

A comparison between the industrial and artisanal manufacturing processes

Despite the standard processes, the current production in the leather industry has additional stages in processing the hides that are not carried out in the artisan leather industry. Therefore, in table 1, A comparison is made between the two.

Table 1. *Compare between artisanal and actual leather manufacturing processes [1]*

Process	Artisanal	Actual
Salting (curing)	Hides are salted and dried in the sun.	Hides are salted and occasionally refrigerated.
Soaking	Hides are soaked and then washed once, for 6 to 24 hours.	Hides are soaked in water and detergents, in addition to sodium sulfide, sodium carbonate, biocides, and soaking proteases. This process can be done twice and lasts 5 to 10 hours.
Liming/Unhairing	Hides are soaked in a compound consisting of lime, wood ash, calcium carbide residue, and water for 12 to 24 hours. The skins are then dehairing using a double-handled knife.	Hides are immersed in a lime preparation composed of calcium hydroxide, sodium sulfide and sodium hydro-sulfide. Fleshing and liming are carried out simultaneously. The hair is removed and destroyed.
Deliming/Bating	Deliming and bating uses plant materials in water.	Ammonium chloride is usually used for deliming. Bating (removal of the epidermis) of the hides is achieved by applying a solution of protease enzymes (usually of bacterial or animal origin).
Fleshing	It is done with a double-handled knife to bring the leather to the right thickness.	It is performed with an industrial machine.

Splitting	It is not used.	The hides are cut into two or more longitudinal layers when they are thick.
Pickling	It is not used.	It is a step prior to the tanning of the leather and consists of a bath of the leather in a solution of sodium chloride, formic acid, and sulfuric acid.
Tanning	Vegetable tanning with tannins, extracted from acacia or chestnut, is used.	Chromium is used in 80% of the cases. In other cases, aluminum, zirconium or titanium are used.
Sammying	It is not used.	Excess water is mechanically removed.
Trimming/Shaving	It is not used.	Thick leathers are divided according to the thickness required.
Washing	It is not used.	Leathers is cleaned with water and surfactants.
Retanning	It is not used.	To better fix the tanning color, syntans and aldehydes are applied to the leather.
Neutralization	It is not used.	Sodium bicarbonate and sodium acetate are used to stabilize the Ph of the leather.
Dyeing	Vegetable and mineral products are applied to achieve colors such as red, black or brown.	Dyes are used in acid or metallic bases.
Greasing	It uses vegetable oil.	It uses oils in their emulsified phase.
Washing	It is not used.	It uses water to remove chemical residues from the leather.
Drying	Leather is dried in the sun.	In vacuum dryers, by radiation, by lever or by paste. They are usually pressed.
Finishing	They are manually stretched and trimmed with scissors.	They are smoothed, lacquered, coated, among other processes for various purposes.

Products used and wastes generated at each stage of industrial processing. A general approach

Table 2 shows, in general terms, the sub-processes that make up the pre-tanning, tanning, and post-tannage stages, as well as the inputs required in an industrial tannery today to obtain leather.

Table 2. Input products used in each process and waste generated

Input products	Process	Waste
Skins/hides	**Salting**	Saltwater and biological wastes
Salty skins/hides Water Humectants Hydrogen sulfide Calcium carbonate	**Soaking**	Wastewater
	Unhairing	Hair and lure Wastewater
Water Hydrated lime Sodium sulfide Caustic soda	**Liming**	Wastewater Solid wastes
Water	**Washing**	Wastewater
Ammonium sulfate Water Hydrochloric acid	**Deliming and Washing**	Wastewater
Sulfuric/formic acid Water Salt	**Pickling**	Wastewater
Water Chromium sulfate	**Tanning**	Wastewater
Sodium bicarbonate Water Oil	**Neutralization and Drainig**	Solid wastes Wastewater
	Splitting **Fleshing**	Carnage Leather shavings
Water Neutralizers Emulsified oils Resins and neutralizers	**Painting / Fat liquoring**	Wastewater
	Drying	Wastewater
	Blowtorching	
	Trimming **Pressing** **Polishing and finishing**	Leather scraps Leather dust Dust
	Measuring	

Related activities analysis

Some processes depend on other processes running in their proximity. Therefore, it is necessary to know which processes are closely related. For this purpose, a graph of related activities has been used [19]. The related activity graph allows one to observe whether or not an activity is adjacent to another or in the vicinity of another activity. The graph of related activities follows the pattern shown in Fig. 2.

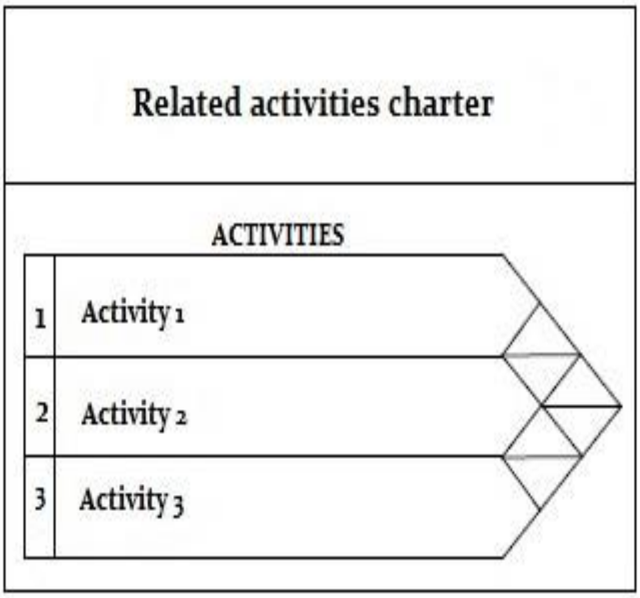

Fig. 2. *Related Activities.*

Instances in which the affinity or proximity between activities will be classified:

A: It is absolutely necessary
E: Especially important
I: Important
O: Ordinary (Adequate)
U: Unimportant
X: Undesirable Proximity

The second affinity criterion is the affinity or proximity motive or reason, which explains the need for proximity between certain activities. They are listed as follows:

1. Flow of Materials
2. Staff communication needs
3. Use of the same equipment
4. Use of the duplicate files
5. Supervise and control
6. Degrees of frequency in communication
7. Sharing the same area
8. Complementary functions
9. Execution of similar jobs
10. Noise, vibrations, fumes, hazards.
11. Convenience
12. Degree of urgency

Fig. 2. shows that the intercepts between activities represent activities that may or may not be related. These intercepts define whether the relationship is relevant, depending on whether there is some proximity between activities. So, for this study, the type of proximity

and the reason for the proximity that occurs between them were used to classify the relationships between processes within the leather factory.

Methodology

A production analysis was used through a quantitative descriptive methodology of the actions that are executed in the factory to obtain leather. In addition, first-hand information was collected in a Peruvian tannery on the production areas, the sequence of processes, the spatial location of the areas where the processes are executed, and the times required to complete the activities in each area.

Results

Production process analysis of a leather factory in Peru. Study on spatial and productive efficiency.

The leather industry in Peru represents a source of employment for communities in various regions of the country. However, it faces sustainability problems partly due to structural problems in the industry financing and technological adaptation required to reduce its environmental impact.

However, operational production problems can be solved with an approach of process analysis and industrial adaptation that would allow, without costly financial efforts, to improve the industry's productivity. To this end, by studying a particular case, it is possible to establish a set of practices that could be used in a general way to improve leather production and limit its environmental impact.

To this end, a work route was developed for the tannery located in Trujillo, Peru, which uses the following activities in the pre-tanning, tanning and post-tannage stages, as shown in Table 3.

Table 3. *Subprocesses executed*

Soak / Unhairing
Salting / Desinfecting
Liming
Deliming / Washing
Pickling
Tanning
Fleshing
Drying
Fat liquoring and Paiting
Packing / Shipping

The supplies detailed in Table 4 are used for a quantity of 600 hides and pelts, where their cost in dollars is specified.

Table 4. *Suppliers required by stage*

Process	Input	Amount	Cost Unid (USD)	Total (USD)
Soaking	Humectant	10 Kg	1.86	18.60
	Caustic Soda	4.5 Kg	1.13	5.09
	Soaking Enzymes	4.5 Kg	1.73	7.65
	Water	3 m^3	1.73	5.19
Washing 1	Water	1 m^3	1.73	1.73
(Liming/Deliming)	Sodium Sulfide	60 Kg	0.97	58.20
	Lime	90 Kg	0.21	18.90
	Peel amine	15 Kg	.77	11.55
	Water	2 m^3	1.73	3.46
Washing 2	Water	2 m^3	1.73	3.46
Tanning	Ammonium Sulfate	23 Kg	0.46	10.58
	Sodium Bisulfite	4.5 Kg	0.96	4.32
	Degreaser	2.5 Kg	2.46	6.15
	Enzilon	1.8 Kg	2.69	4.84
	Industrial Salt	105 Kg	0.1	10.5
	Formic Acid	33 Kg	1.44	47.52
	Chromium	100 Kg	2.15	215.00
	Chromene FB	6.7 Kg	2.52	16.88
	Water	1.5 m^3	1.73	2.60
Washing 3	Water	1.5 m^3	1.73	2.60
	Total cost per lot (USD)			**418.29**

The physical distribution of the work areas is detailed in Fig 3, which shows the technical plan of the facilities.

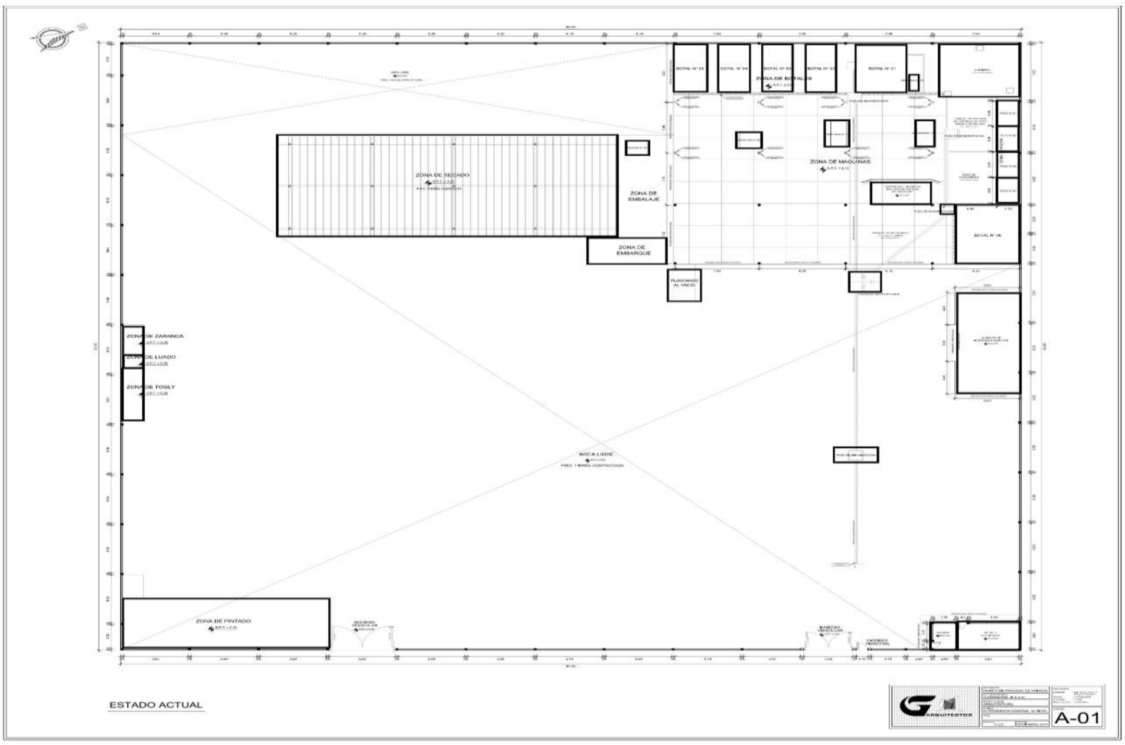

Fig. 3. *Floor plan of the tannery.*

A schematic drawing based on the factory floor plan was made to understand the factory's distribution and flow of processes. It is shown in Fig. 4.

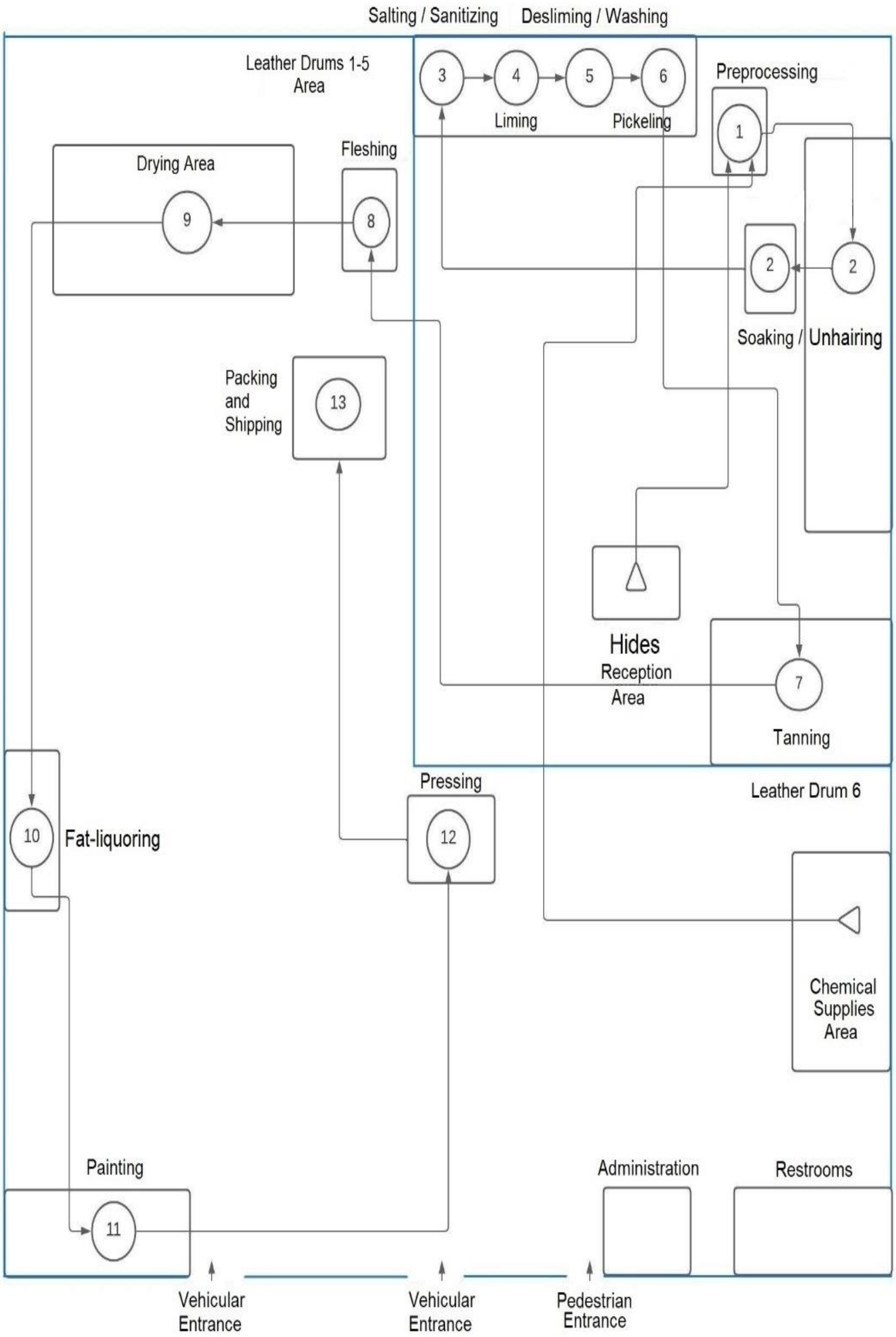

Fig. 4. *Schematic diagram of leather manufacturing for each process involved.*

It can be observed that there are processes far away from others that are supposed to be adjacent. It can also be observed that processes cross each other and do not follow a proper sequence. Therefore, related activities were calculated to corroborate the inadequate plant layout. For this purpose, an on-site report was carried out, which yielded the values shown in Table 5 regarding travel time per employee and cost per person working in the facilities.

Table 5. *Transfer time measurement*

Process	Activity	Number of hides processed per day	Number of transfers	Transfer time (seconds)	Total Time (seconds)	Labor Cost (USD/h)	Total Cost Diary (USD)
Skins/Hides and chemical supplies reception	Transfer the selected skins/hides for preprocessing.	600	3	180	540	1.01	0.15
Preprocessing of hides	Removing waste from the skin/hides, such as glue, feces, etc.	600	600	60	36000	1.01	10,08
	Removing excess skins/hides.						
	Transfer them to the Soaking / Unhairing area.						
Soaking / Unhairing	Discharge hides.	600	8	180	1440	1.01	0.40
	Skins transport to Unhairing area.	600	8	180	1440	1.01	0.40
	Skins/hides transport to Leather Drums 1-5 Area.	600	600	80	48000	1.01	13.43
Leather Drums 1-5	Discharge skins/hides.	600	600	60	36000	1.01	10,08
	Leather drums input and output.						
	Hides transport to Tanning and Retanning Area. (Leather Drum 6)	600	600	60	36000	1.01	10,08
Leather Drum 6 (Tanning) and Fleshing	Discharge hides.	600	600	80	48000	1.01	13.43
	Leathers transport to Fleshing Area	600	600	60	36000	1.01	10.08
	Leathers transport to Drying Area.	600	600	80	48000	1.01	13.43
Air Drying	Hanging leathers.						

	Unhanging leathers						
	Stacking leathers						
	Leathers transport to Softening Area	600	3	180	540	1.01	0.15
	Discharging leathers into the wheelbarrow.	600	600	60	36000	1.01	10,08
	Softening leathers(Shaking)						
	Leathers reception.						
	Stacking leathers into the wheelbarrow						
	Leathers transport to milling Area.	600	3	240	720	1.01	0.20
Fat liquoring Area (Softening shaking milling Togly machine)	Leathers discharge.	600	600	60	36000	1.01	10.08
	Leathers transport	600	200	50	10000	1.01	2.80
	Leathers milling						
	Leathers stacking						
	Leathers transpor to Togly	600	200	30	6000	1.01	1.68
	Stacking leathers.						
	Input leathers to Togly						
	Output leathers to Togly and stacking into the wheelbarrow.	600	600	60	36000	1.01	10.08
	Leathers transport to Paiting Area.	600	3	250	750	1.01	0.21
	Discharge leathers into the wheelbarrow.	600	600	80	48000	1.01	13.43
	Put leathers into the cabin						
Painting	Leather paiting						
	Unhangings leathers.						
	Leathers transport	600	200	600	120000	1.01	33.58
	Pressing leathers						
Pressing	Pressing leathers reception.						
	Leathers transport handly	600	200	600	120000	1.01	33.58
	Leathers measurement						
Measurement, Packing and Shipping	Stacking leathers in packages						
	Leathers transport to warehouse	600	200	600	120000	1.01	33.58
					825430		231.01

It takes 825430 seconds, corresponding to 9.55 days in the leather production process, and the daily cost is USD 231.01. Then, the travel time and the distribution of the work stages are analyzed to improve the efficiency of leather production. The analysis was carried out using the study of related activities, where the operations carried out in the factory were evaluated according to their proximity relationship. The relationships between activities were measured using two criteria. The first criterion is the type of relationship by affinity, and the second is the relationship by proximity.

To build the chart of relationships between activities, we must summarize the actions that are executed by associating these activities with the spaces in which they are executed. Some of them keep their process names, and others will be replaced by the areas where one or more processes are executed. In this way, we obtain the items that make up the chart of related activities:

1. Administration
2. Hides reception Area (leather)
3. Pressing Area
4. Restrooms
5. Leather Drums 1-5 Area
6. Packing and Shipping Area
7. Drying Area
8. Fleshing Area
9. Leather Drum Area 6 (Tanning Drum)
10. Open Areas
11. Chemical Supplies Area
12. Preprocessing, Soaking and Unhairing Area.
13. Fat-liquoring Area
14. Painting Area

The relationship chart shown in Fig. 5 was created from the work areas.

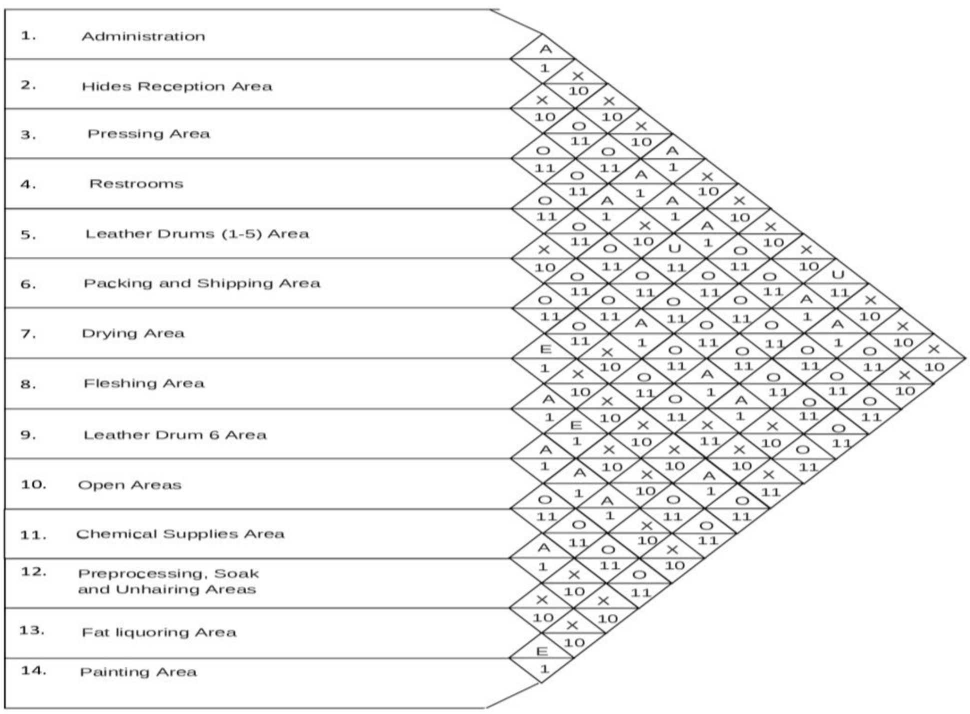

Fig. 5. *Resulting chart of related activities.*

This chart shows which areas have important relationships in terms of operational adjacency. Leather Drums 1-5 and Tanning Drum 6 should be adjacent. Similarly, the administration area should be located near the skin's reception area, and where the chemicals are stored should be adjacent to the raw materials warehouse (in this case, dispatch). It is also observed that the painting, greasing, fleshing, and drying areas should be located within their adjacencies to optimize personnel movements and production and labor effort.

We can continue to delve deeper into all the areas related to their adjacent activities. First, however, it is critical to observe the most important areas: Administration, Skin's reception area, Preprocessing Area, Leather and Tanning Drums Area, Drying Area, Fat liquoring and Painting Areas.

The areas should be regrouped according to the level of relationship. Let us see how the activities are related, which ones should be close and which ones should not be specifically related to each activity grouped in Table 6.

Table 6. *All relationships between activities.*

	Activity area: 2	
A: 6, 7, 8, 11, 12		**E:**
	Skin Reception	
	X: 3, 14	
I:		**O:** 3, 9, 10, 13
	Activity rea: 1	
A: 2,6		**E:**
	Administration	
	X: 3, 4, 5, 7, 9,10,12-14	
I:		**O:**
	Activity area: 3	
A: 6		**E:**
	Pressing	
	X: 7	
I:		**O:** 4, 5, 9,10-14
	Activity area: 4	
A:		**E:**
	Restroom	
	X: 1	
I:		**O:** 2, 3, 5-14
	Activity area: 6	
A: 1, 2, 3		**E:**
	Packing and Shipping	
	X: 5, 9, 12, 13, 14	
I:		**O:** 4, 7, 8, 10, 11
	Activity area: 5	
A: 9, 11, 12		**E:**
	Leather Drums 1-5	
	X: 1, 6, 13	
I:		**O:** 2-4, 7
	Activity area: 8	
A: 2, 9		**E:** 7, 10

Fleshing
X: 1, 11, 12
I: **O:** 4-6, 13, 14
Activity area: 7
A: 2, 13 **E:** 8

Drying
X: 1, 3, 9-11
I: **O:** 4-6, 14
Activity area: 9
A: 5,10-12,14 **E:** 8

Tanning Drum 6
X: 1, 6, 7, 13
I: **O:** 4-6, 13, 14
Activity area: 10
A: 9 **E:** 8

Open Areas
X: 1, 7
I: **O:** 2-6, 11-14
Activity area: 11
A: 2, 5, 9 **E:**

Chemical Supplies
X: 7, 8
I: **O:** 3, 4, 6, 10-14
Activity area: 12
A: 2, 5, 9, 11 **E:**

Preprocessing, Soaking and Unhairing
X: 1, 6-8, 13, 14
I: **O:** 3, 4, 10
Activity area: 13
A: 7 **E:** 14

Fat liquoring
X: 1, 5, 6, 9, 11, 12
I: **O:** 2-4, 8, 10
Activity area: 14
A: **E:** 13

Painting
X: 1, 2, 6, 9, 11, 12
I: **O:** 3-5,7, 8, 10

After this analysis, the areas can be sectorized according to affinity and which areas are not convenient to place together. From this, it follows that, as expressed in a previous paragraph:

1. Drums areas should be adjacent to each other as much as possible.
2. Pre-processing, Soaking, and Unhairing areas should be near the Drums areas.
3. Drying, Fat liquoring, and Dyeing areas should be adjacent.
4. Open areas should be in the center of the operating areas.

Schematically, the redistribution of the work areas would be as shown in Fig. 6. It is worth mentioning that there are limitations that do not allow a distribution as obtained in the calculations. The reason for this is the presence of columns, cisterns, and sewage and waste disposal routes that would have to be adapted at a high cost. It is why it was done in a schematic way and without keeping objective measurements, only for illustrative purposes and also to observe to what extent production and travel savings can be improved with the new distribution of work areas.

The new distribution shortens travel times and avoids personnel crossings in the work areas. In addition, the sequence of processes optimizes production and the workers' total effort, as seen in Fig. 6.

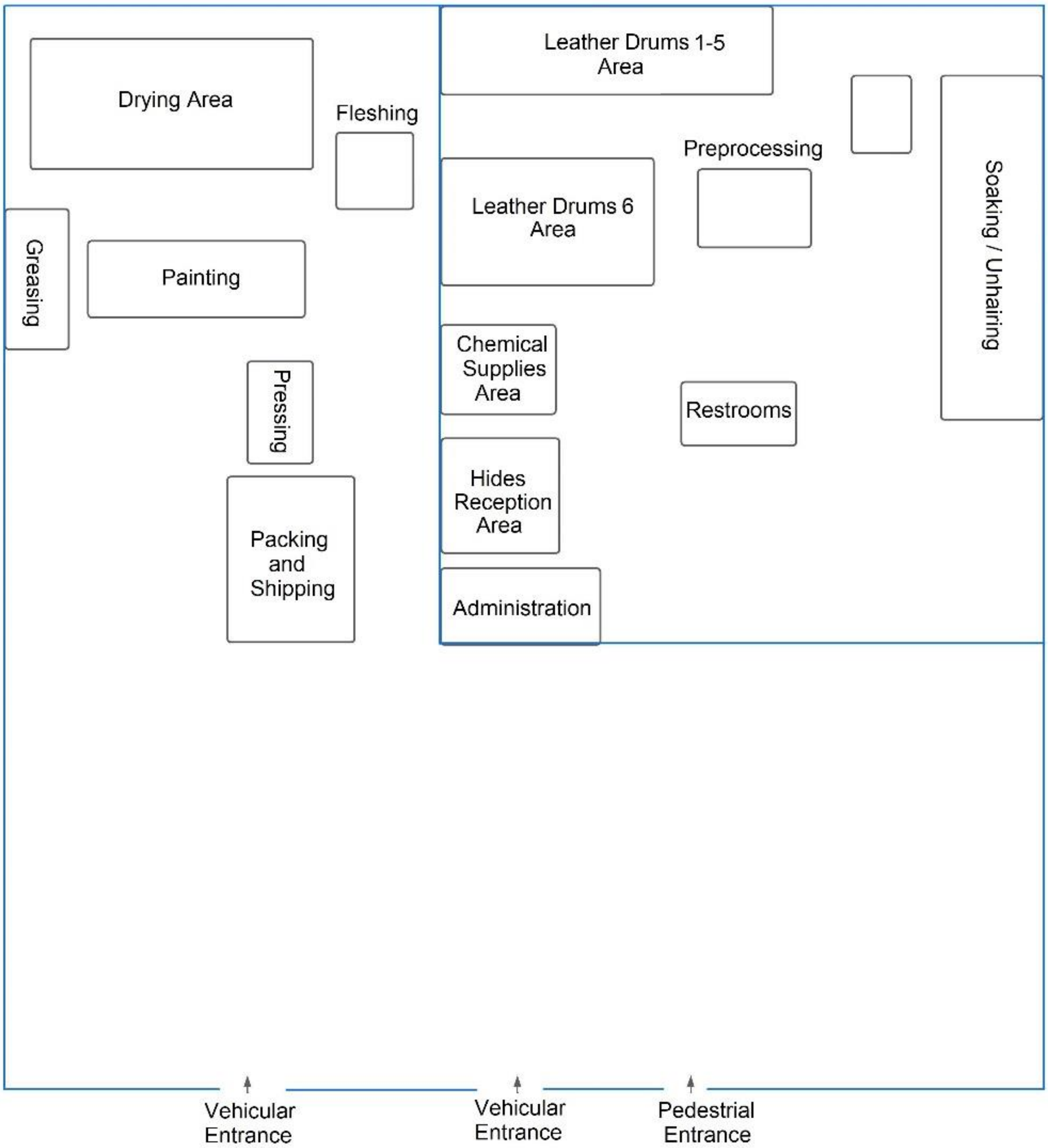

Fig. 6. *Work areas redistribution according to the analysis of the related areas.*

With this proposal, the displacement of the production processes would be as shown in Fig. 7.

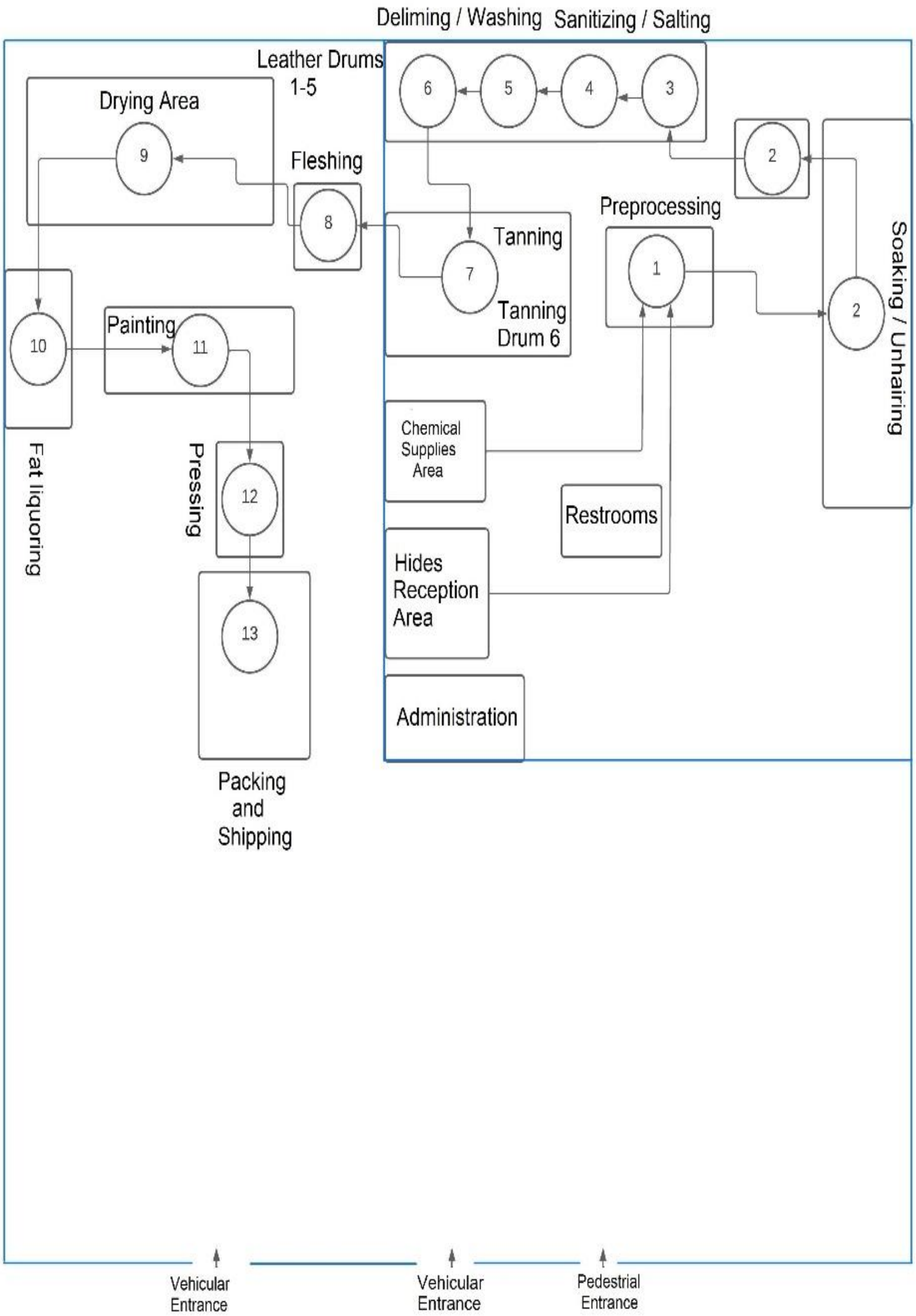

Fig. 7. *Production process reorganization.*

Now a new displacement measurement was performed to obtain the results of the studied proposal. It yielded the following results according to what was collected in the work areas and observed in Table 7.

Tabla 7. *Improved processes according to the proposed displacement study.*

Process	Activity	Number of hides processed per day	Number of transfers	Transfer time (seconds)	Total Time (seconds)	Labor Cost (USD/h)	Total Cost Diary (USD)
Skins/Hides and chemical supplies reception	Transfer the selected skins/hides for preprocessing.	600	3	60	540	1.01	0.15
Preprocessing of hides	Removing waste from the skin/hides, such as glue, feces, etc.	600	600	60	36000	1.01	10,08
	Removing excess skins/hides.						
	Transfer them to the Soaking / Unhairing area.						
Soaking / Unhairing	Discharge hides.	600	4	180	720	1.01	0.20
	Skins transport to Unhairing area.	600	8	60	480	1.01	0.14
	Skins/hides transport to Leather Drums 1-5 Area.	600	600	80	48000	1.01	13.43
Leather Drums 1-5 Activities	Discharge skins/hides.	600	600	60	36000	1.01	10,08
	Leather drums input and output.						
	Hides transport to Tanning and Retanning Area. (Leather Drum 6)	600	600	60	36000	1.01	10,08
Leather Drum 6 (Tanning) and Fleshing	Discharge hides.	600	100	80	8000	1.01	2.24
	Leathers transport to Fleshing Area	600	100	60	6000	1.01	1.68
	Leathers transport to Drying Area.	600	100	80	8000	1.01	2.24
Air Drying	Hanging leathers.						
	Unhanging leathers						
	Stacking leathers						

	Leathers transport to Softening Area	600	3	60	180	1.01	0.05
	Discharging leathers into the wheelbarrow.	600	600	60	36000	1.01	10,08
	Softening leathers(Shaking)						
	Leathers reception.						
	Stacking leathers into the wheelbarrow						
	Leathers transport to milling Area.	600	3	60	180	1.01	0.05
	Leathers discharge.						
Fat liquoring Area (Softening shaking milling Togly machine)	Leathers transport	600	200	30	6000	1.01	1.68
	Leathers milling						
	Leathers stacking						
	Leathers transpor to Togly						
	Stacking leathers.						
	Input leathers to Togly						
	Output leathers to Togly and stacking into the wheelbarrow.	600	600	60	36000	1.01	10.08
	Leathers transport to Paiting Area.	600	3	120	360	1.01	0.1
	Discharge leathers into the wheelbarrow.	600	600	80	48000	1.01	13.43
	Put leathers into the cabin						
Paiting Area	Leather paiting						
	Unhangings leathers.						
	Leathers transport						
	Pressing leathers						
Pressing Area	Pressing leathers reception.						
	Leathers transport handly	600	100	600	60000	1.01	16.83
	Leathers measurement						
Measurement, Packing and Shipping	Stacking leathers in packages						
	Leathers transport to warehouse	600	200	300	60000	1.01	16.83
					426460		119.45

With these results, we went from an estimated travel time of 825430 seconds to 426460 seconds, equivalent to a 48%-time savings. As for the money invested daily in the personnel work, it went from USD 231.01 to USD 119.45, equivalent to a savings of 93% in investment. The calculations were made as follows:

Investment (in dollars):

$$\%\text{Improv} = \frac{\text{Invest}_{\text{init}} - \text{Invest}_{\text{calc}}}{\text{Invest}_{\text{init}}} \times 100\% \ (1)$$

$$\%\text{Improv} = \frac{231.01 - 119.45}{119.45} \times 100\% = 93\% \ (2)$$

Displacement Improvement (in seconds)

$$\%\text{Improv\_time} = \frac{\text{Actual\_time} - \text{Calculated\_time}}{\text{Actual\_time}} \times 100\% \ \ (3)$$

$$\%\text{Improv\_time} = \frac{825430 - 426460}{825430} \times 100\% = 48\% \ (4)$$

Results analysis and limitations of the study

1. As mentioned in the introduction, the results obtained are conditioned by factors such as the company's budget, the spaces on the work site that cannot be modified, and the materials available to the company. Therefore, it is specified that the study only intends to show that it is possible to optimize the tannery's processes, save time in the workers' travels, and take care of the investment made for manufacturing leather.
2. The study had limited access to the plant during the two weeks of the visit. Therefore, the results had to be measured during the hours that access to the plant was available. In addition, the tours had to be resumed at the points where they had been the previous day. Therefore, for other studies, such as the optimization of waste disposal, it is advisable to measure processes continuously and thus make comparisons and know the margins of error that can be handled in the measurements.
3. The study was limited to calculating improvements in displacement and related work areas, which requires additional research on wastewater management, management of excess leather, and other by-products obtained during leather manufacturing. What measures can be taken to take advantage of these collateral by-products should be studied. It is also essential to compare research results to understand how waste management improvement studies complement the production work focused on leather manufacturing.
4. The investment to achieve the redistribution of areas to optimize production does not represent a significant outlay. However, a study of the electrical outlets and wastewater routing is needed to determine additional costs when undertaking any changes.
5. In this study of the optimization of the workers' displacements, other problems were visualized in this sense: humidity on the floor, which can be a cause of falls and injuries in the personnel. In addition, the machinery does not have protections to prevent blows when personnel are moving around, which could cause injuries, among other ergonomic problems. [20].

Conclusions

1. The objective of this study was to highlight the most common deficiencies observed in tanneries in Latin America. Processes and workflow can be improved through the redistribution of processes and a study of the movement of personnel between work areas. The result is increased production, reduced strain on employees, and optimization of financial resources.
2. In Latin American tanneries, it is common to find that the work areas are not located as would correspond to an adequate approximation of the production sequence established in the study. Therefore, the processes lack continuity to avoid unnecessary crossover of personnel and unnecessary production costs.

3. The new distributions between areas will reduce downtime and unnecessary travel.
4. Given the amount of waste created throughout the leather production stages, complementary studies are needed, such as a study on the optimal distribution of waste collectors and the necessary treatments for their use in related industries.
5. Studies on the ergonomics of the machinery used in the tanneries are required to protect the health of the operators.

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