Streamlining Process in the Separation of Preexisting Textiles for its Reutilization in Garment Production

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***Abstract*– The study presented below had the main objective of streamlining the textile separation process for its subsequent reutilization in the production of new garments. This particular fashion design company located in Tegucigalpa, Honduras has 3 permanent employees which are trained to carry out the tasks of textile separation in the same way. Through the time-taking phase in this study, it was demonstrated that they carry out the textile separation process in approximately the same amount of time and will be considered as such during the study. For the fulfillment of the study, a video of the whole operation process was recorded and meticulosity analyzed through which 22 activities were identified which were equivalent to 88.967 minutes of production time.**

Through the analysis of the 22 activities and registration of their times, two critical activities were identified. Although multiple operations were identified to require a prolonged period, the two activities that require the greatest amount of time are the process of unstitching the seams of the right and left leg, which requires 20 minutes each, to be completed. An improvement plan was developed using SMED in which a reorganization of the activities and swap of the original tools was proposed. This decision was made under the premise that a reorganization of the operations will reduce time and unproductive actions for the operation. Thus, improving the total time of the operation but keeping costs to a minimum, resulting in a reduction of 51.1% of the total time.

***Using geometry, it was possible to calculate the area of the recovered textile from the original garment. The total area for each garment equals 9,776 +/- 5% cm²**. At the same time, the area of one yard of commercial textile was calculated and found to be equal to 8,229.6 cm². Based on the times and areas discovered, it was possible to calculate that the time required for the separation of a single yard of recovered textile following the original strategies would take 73.773 minutes. However, when implementing the improvement plan, the total time required for the separation of one yard would be reduced to 36.039 minutes.**

This data is relevant because it will facilitate the calculation of the time needed to separate additional yards. This way the company would be able to estimate the amount of time they will need to produce enough recycled textile to produce a greater number of garments.

***Keywords*– Improvement, Sustainability, Lean Manufacturing, SMED, Circular Economy, Recycled Fashion, Geometry.**

Digital Object Identifier (DOI):
http://dx.doi.org/10.18687/LACCEI2022.1.1.472
ISBN: 978-628-95207-0-5 **ISSN:** 2414-6390

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An improvement plan was developed using SMED in which a reorganization of the activities and swap of the original tools was proposed, resulting in a reduction of 51.1% of the total time.

Using geometry, it was possible to calculate the area of the recovered textile from the original garment. The total area for each garment equals 9,776 +/- 5% cm^2. At the same time, the area of one yard of commercial textile was calculated and found to be equal to 8,229.6 cm^2.

Based on the times and areas discovered, it was possible to calculate that the time required for the separation of a single yard of recovered textile following the original strategies would take 73.773 minutes. However, when implementing the improvement plan, the total time required for the separation of one yard would be reduced to 36.039 minutes.

Keywords*– Improvement, Sustainability, Lean Manufacturing, SMED, Circular Economy, Recycled Fashion, Geometry.

Resumen*– El estudio presentado a continuación tuvo como objetivo principal la agilización del proceso de separación de textiles para su reciclaje. El estudio se llevó a cabo por medio del análisis de grabaciones de la operación donde se identificó que para realizar la operación se necesitaban 22 actividades que equivalían a 88.967 minutos.

Se desarrollo un plan de mejora utilizando la herramienta de SMED en el cual se abordó una reorganización de las actividades en el proceso y un cambio de las herramientas utilizadas originalmente, estas medidas dieron como resultado la reducción del tiempo a 43.950 minutos equivaliendo a una reducción del 51.1%.

Por medio de la utilización de la geometría se logró calcular el área de textil recuperado, teniendo un área total de 9,776 +/- 5% cm^2 y el área de una yarda de textil comercial, teniendo un área de 8,229.6 cm^2.

Partiendo de los tiempos y áreas descubiertos se pudo calcular que el tiempo requerido para la separación de una yarda de textil recuperado siguiendo las estrategias originales seria 73.773 minutos mientras que al realizar la implementación del proceso mejorado el tiempo para la separación de una yarda se vería reducido a 36.039 minutos.

Palabras clave*– Mejoramiento, Sustentabilidad, Lean Manufacturing, SMED, Economía Circular, Moda Reciclada, Geometría

I. INTRODUCTION

One of the principal characteristics of Fast Fashion is short delivery times; the time from when garments are first seen on a runway to the time it takes for them to be available in stores is almost instantaneous. These short production times contribute to mass production and rapid changes in inventory, which pushes the industry to produce completely new lines of products on a biweekly basis because of the need of the consumer to have up-to-date merchandise [1]. This mentality allows consumers to satisfy their desire to dress well, with clothes that are affordable and always in fashion, thus promoting hyper-consumption.

Of course, with this level of mass production come many environmental costs, ranging from pollution from using non-renewable resources such as oil to produce affordable textiles, to supply chain problems [2]. Fast Fashion has been proven to be ethically questionable, although nowadays companies have begun to make amends for their past environmental crimes.

To address these crimes one of the methods that have been taken is the circular economy mentality. The circular economy concept is not new, some of them date to 1976 when Walter Stahel suggested an idea of a “loop economy” [3]. Theoretical contributions also come from industrial ecology [4]. The Ellen MacArthur Foundation, which popularized the term “circular economy”, defined it as "restoring and regenerating by design, and aiming to keep products, components and materials at their maximum utility and value at all times”. The heart of the circular economy focuses on the reuse and remanufacturing of products, not the utilization of new primal matter.

For the scope of this document, there will be an emphasis on the utilization of previously used textiles, thus being able to create new products from pre-existing fibers that will return to the market and thus keep the cycle in motion [5]. The separation of these preexisting fibers is not simple. This is due to the complex combinations of materials that make up our

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
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garments. This process requires time, resources, and skilled labor to be fulfilled.

Most of the struggles that come from trying to separate the textiles that form our garments come down to the materials from which our clothes are made. The fabrics we use are complex combinations of fibers and accessories which are produced from problematic blends of natural yarns, machine-made filaments, plastics, and metals. For example, a typical pair of jeans in most cases are made from cotton yarn mixed with elastic, to make them fit the body better, and other components such as zippers, buttons, and polyester sewing thread which are dyed with a wide variety of chemicals [6].

The company in which this research was carried out started to notice this problem around the year 2019.

Through their efforts, they managed to put into practice textile reutilization methodologies and start the production of garments constructed from this recovered fiber. This company currently does not have large-scale volume production for its recycled fiber garments, because of this the long processing times of the fibers have remained manageable, but as the company starts to expand and its demand grows, it has become increasingly necessary to implement an improvement plan in the separation times of the textiles.

Due to what was previously mentioned, the objective of this research arises in the need to speed up the fiber separation process. Because of this SMED has been chosen as the tool to reduce the manufacturing time of a yard of fabric produced from recovered fibers. The SMED methodology is also one of the tools of Lean Manufacturing (LM). The SMED methodology provides to reduce waste and improve flexibility in manufacturing processes reducing the nonproductive time by streamlining and standardizing the activities.

II. Methodology

A. Fast Fashion

During the last decade, the phenomenon of fast fashion has revolutionized the textile industry. "Fast fashion" is a term used to express designs and styles that capture current fashion trends [7]. Fast fashion refers to designs that reflect a rapid response to up-to-date trends or styles that move rapidly from catwalk to store, thus increasing the demand for short-cycle fashion products [8].

Fast fashion retailers aim to shorten the delivery time in the supply management chain and pursue rapid response to diverse consumer needs [9].

The standard lead time from catwalk to consumer for the mainstream fashion model is about six months, but by comparison, fast-fashion retailers such as international franchises like ZARA, H&M, and MANGO, thrive on a rapid cycle. They introduce new products as fast as trends are moving this way attracting trendy consumers. Fashion brands compete not only on price but also on their ability to offer a new and refreshing product [10].

From a consumer perspective, fast fashion is an easy way to access runway styles at affordable prices. The fast-fashion business model is characterized by not only a quick response to evolving trends but also improved design in everyday garments. These fast fashion strategies succeed in satisfying the mass market by delivering stylish products at an immediately accessible price.

The advantages of fast fashion (for example, updated styles, affordable prices, quick response to consumer demands, etc.) have allowed the industry to expand into international markets to incorporate new technologies in the supply chain and the search for new suppliers, and the reach of new consumers [11].

As the years progressed, the next group of fashion companies that followed the steps of fast fashion was "GAP" who reduced the product cycle to two months, and "ZARA" brand, which managed to reduce the delivery time to two weeks, making them at one of the world's most successful fashion retailers [9].

B. Dark Side of Fast Fashion

Previous research has questioned the ethics of the fast fashion industry [12]. The focus of fast fashion is that the latest styles we see all over social media should be in stores every week at an affordable price. Realistically the way to achieve these low prices and short production times can only be achieved by employing workers in underdeveloped nations, utilizing low-quality and dangerous materials, as well as recreation pre-made or stolen designs from designers who in many instances are unaware of thefts until it’s too late.

Excessive consumption of fast fashion has had adverse effects on the earth's natural resources and raises social and ethical issues, giving rise to the emergence of anti-fast fashion consumption. For example, a few years ago in Portugal, more than 20,000 students in 51 cities protested the current state of environmental conditions in the country. “Our future is in your hands” or “There is no planet B” were some slogans supported by Generation Z [13]. In other words, there new mentality of consumers rejecting and trying to reduce their consumption of fast fashion goods and services for social, environmental, and ethical reasons.

Fast-fashion retailers rely on low-wage workers in underdeveloped countries to keep costs down, make clothes faster, and meet deadlines. These employees are not only not paid adequate living wages, but also work in poor working conditions, and even suffer abuse from managers.

Textile production causes harmful effects on ecosystems around the world, fast fashion is one of the main culprits due to the nature of mass production and consumption. Adding to all these concerns are also intellectual property concerns. Fast fashion relies on imitating high fashion and copying ready-to-wear designs from around the world to keep up with trends and fashion styles on a daily basis.

C. Circular Economy

The circular economy concept has many variants and a rich set of ancestors [14]. Many works on the ecology behind product life extensions and their vision for "an economy of loops" [4] have been published linking the circular economy with the cycle of specific resources and products [13].

Distinguishing between "cradle to grave" and cyclical, "cradle to cradle" material flows makes a difference in the resource flow patterns that characterize circular models [4]. Furthermore, it is argued that product reuse and recycling, and waste reduction as resource-saving strategies that can be applied to production.

Based on works by Marques, A., & Ferreira, F [13], two fundamental strategies toward the resource cycle are introduced. First, to slow down the circuits of resources through the design of long-lasting goods. That it is possible to extend the period of use of the products to its maximum capacity, which results in a slowdown of the resource flow.

Second, to close the circuits of resources, where through recycling, the cycle between post-use and production is closed. The circular economy movement is increasingly inspired by the literature business model (and vice versa). The business model discourse emerged in connection with the "dot-com" boom in the 1990s, and today it is the main concept to describe and visualize the organization [15].

Although it must be recognized that the definition has been subject to academic debate, we understand this circular economy business model in general terms as: "the foundation of how the organization creates, delivers and captures value" [16].

D. Lean Manufacturing

The concept of Lean Manufacturing (LM) was pioneered by a Japanese automotive company, Toyota, during the 1950s, known as the Toyota Production System (TPS). The main objective of TPS was to reduce cost and improve productivity by eliminating waste or non-value-added activities [17]. During the 1980s there was great interest in LM implementation among Western manufacturers due to increasing Japanese imports. Becoming a serious point of interest for Western producers [18]. This concept of LM consists of a large number of tools and techniques that can be applied to any production process.

Shah, R [19] identified twenty-two LM practices that are frequently mentioned in the literature and categorized them into four packages associated with Just-in-Time, Total Quality Management, Total Preventive Management, and Resources. There have been other researchers that also categorize lean tools and techniques but across the board, in most cases, they're classified according to their area of implementation, such as lean-oriented internal practices and external practices [20].

E. SMED

Shigeo Shingo [21] developed the Single Minute Exchange or Die (SMED) methodology over 19 years, beginning in 1950. Shingo's technique refers to both the theory and practice of simplifying and improving step the setup activities in any production process to be able to be performed in less than ten minutes in total. The SMED requirement stems from the difficulties encountered in manufacturing environments due to low-volume and diversified production.

These difficulties are essentially the increased number of machine configurations required to produce a variety of products in small batches. The SMED theory [21] states that, even if the frequency of setups cannot be changed or reduced, the actual downtime or pauses caused by changes in machinery specifications can be greatly reduced, thus providing an increase in the capacity of the machine production availability. Shingo, therefore, pronounces that: SMED can be applied in any factory, to any machine [21].

An important first step in Shingo's method is to classify configuration activities into two distinct categories: internal configuration, which can only be done when a machine is down, and external configuration, which can be done while a machine is running.

F. Study Methodology

This article details the application of the Lean Manufacturing (LM) technique called SMED in the process of fiber separation within a small fashion design company in Tegucigalpa, Honduras. As a first step, extensive research was carried out on the issues of textile waste, revealing the definition of what fast fashion is and the damages it provokes not only to the ecosystem but also to the people who work every day in the manufacturing of the garments we wear.

During this research, the Circular Economy mentality came to light. Because of this, it was apparent the worth of investing resources and time in the implementation of circular models for the improvement of the separation of preexisting fibers to produce new garments from them.

Once this technical knowledge was obtained, an interview was conducted with the company owner in question, where the particularities of the company and its points of improvement were collected.

It was identified that the process of separation of fibers from previously existing garments to be used as raw material was one of the processes that consume the greatest amount of time and resources. Because of this, it was decided to focus the study on this specific area of the company.

To put in motion the input of data to be analyzed, a video recording of the complete operation of the separation of fibers from previously existing garments was taken. From these recordings, a detailed analysis was performed; from which the steps and movements that the operator had to perform to separate the fibers were extracted. As well as the step to be carried out, and the time of each of these steps was taken.

Having obtained the steps and the times of the current operation, we proceeded to apply the SMED tool.

The SMED methodology is typically applied in order to perform equipment setup (changeover) operations in fewer than 10 min. But the SMED methodology can also be used to reduce waste and improves flexibility in manufacturing processes. Thus, it helps in improving manufacturing flow. The SMED methodology reduces the nonproductive time by streamlining and standardizing the activities, using simpler techniques and easier applications [21].

Therefore, in this article, the SMED tool will be used to develop an improved plan in which a reduction in the total time of the operation was found.

Upon reaching this point in which the total operation time was reduced, the area of the recovered textile from preexisting garments was calculated and subsequently the time it would take to manufacture a single yard of textile was found. This time is relevant because it will allow the company to estimate how much time they will need to recover enough textiles to produce a specific garment.

G. Validation Methodology

The textile separation process was personally validated by comparing the current times of the operation against the times of the improved process. Through this comparison, it was possible to identify the percentage of improvement, determining if this process was significant in the performance of the operation.

III. Results / Interpretation

A. Operator Type

The fashion division of the company with which the project was carried out; currently has 3 workers, additionally, depending on the demand they have for a specific term some fashion students come as interns and give support to the full-time workers. The 3 permanent employees are trained to carry out the tasks of textile separation in the same way. Through the time-taking phase in this study, it was demonstrated that they carry out the textile separation process in approximately the same amount of time and will be considered as such during the study.

B. Operator Capacity

During a period of high demand for the company, each operator, in addition to performing their usual tasks, is assigned around 5 pairs of jeans per week to be separated into their components. After the deconstruction of the pants, they are asked to cut the pieces for the designs from these recovered textiles to be utilized to produce the new recycled garments.

These employees were trained by management following the same processes and according to the information that has been provided, they perform very similarly to each other.

C. Current Situation and Compilation of Activities

During the beginning of the data collection phase, and after discussions with management and the operators it was decided that the optimal way to collect the companies' data would be through videos of the complete operation. This was decided due to the high workflow in the last quarter of the year that the company has due to a school uniform manufacturing contract.

An operator was chosen for the convenience of the company to demonstrate the operation. This was also viable because all the full-time employees have very similar and uniform times for the separation of the pants.

Once in possession of the videos, a frame-by-frame analysis of the recording was carried out, finding that the complete separation of a woman's pair of jeans has 22 activities and takes 89.967 minutes or 1.499 hours to be completed.

The 22 activities found are expressed through short descriptions presented below.

1) Bring tools (scissors, seam ripper, ruler, chalk)
2) Measure 34cm from the waist of the pants to the right leg
3) Trace the mark with chalk and a ruler on the right pant leg
4) Cut over the mark on the right pant leg
5) Measure 34cm from the waist of the pants to the left leg
6) Trace the mark with chalk and a ruler on the left leg
7) Cut over the mark on the left pant leg
8) Reverse jean top exposing pant seams
9) Unstitching of pant zipper
10) Separate pants into two parts
11) Unstitch back pockets of pant
12) Unstitch belt loops
13) Unstitch the side seam of the upper part on the right side
14) Unstitch the side seam of the upper part on the left side
15) Cut Frontal pocket Fabric
16) Unstitch right leg side seams
17) Unstitch left leg side seams
18) Unstitch the right leg hem
19) Unstitch left leg hem
20) Set aside pieces of the leg
21) Unstitch pants waistband
22) Put aside the pants waistband

Through the analysis of the 22 activities and registration of their times, two critical activities were identified. Although multiple operations were identified to require a prolonged period, the two activities that require the greatest amount of time are the process of unstitching the seams of the right and left leg, which requires 20 minutes each, to be completed.

The subsequent time-consuming activities are the unstitching of the top left and right portion of the pant, 8 minutes each, unstitching of the pants zipper, 8 minutes, and unstitching of the pant waistband, 6 minutes.

Notably, the similarity between all these critical activities is that they all possess an unstitching process, especially on fairly thick parts of the garment.

In addition, it can be noted that the unsticking of the pant leg is performed in the largest part of the garment, which explains why this operation takes the longest.

Furthermore, from all the data collected and the observation of the process, it is evident that the instruments the operators are using, such as scissors and a seam ripper, have problems cutting some of the thickest parts of the garment. This can be attributed to the tools becoming dull over time. These findings were not found using formal instruments but were concluded through detailed observation of the recorded videos of the operation.

D. Improvement plan of Current Activities

After a thorough analysis of the video recording from the textile separation processes, the decision was made that the first step in the improvements plan would be the reorganization of the tasks to be followed during this process. This decision was made under the premise that a reorganization of the operations will reduce time and unproductive actions for the operation. Thus, improving the total time of the operation but keeping costs to a minimum.

This is a factor of vital importance for the company because this process is still very recent and currently has a fairly high cost to carry out. The only way for this project to be viable for the company would be if the costs stay manageable.

The decision of making this reorganization of the tasks at hand is supported by the analysis of the video recording. Through this examination, it was possible to notice that the operator made unnecessary movements due to the poorly thought-out process order, causing some pieces to suffer from reprocessing.

This problem was corrected through a reorganization of operations ensuring that the operator did not stop handling a piece of the garment until it was completely separated into its components, thus preventing unnecessary rework.

Next, the tasks that entail the greatest amount of time in the textile separation operation were addressed. Because the operations that entail a process of unstitching were identified as the most time-consuming, to deal with this problem it was decided that the best alternative would be to make a change in the tool used by the operation for the unstitching process.

Currently, to carry out the unstitching process, an instrument called "seam ripper” is used, this is a small instrument that has a sharp edge on only one of its sides, to be able to slide it safely into the seams of the garment to cut the treads, but this tool after a while loses its edge and sharpening it again is an almost impossible process. To address this problem, it was suggested to change the tool to a "box cutter" this tool due to its flat blade can cut through the folds and seams of the garment without damaging the fabric. In addition to this, the blades of the box cutters are replaceable, so it can be ensured that the sharpness of the tool will be always maintained.

Based on the improvements mentioned above, the following list of improved activities was designed for the textile separation process.

1) Measure 34cm from the waist of the pants to the right leg and trace with chalk
2) Measure 34cm from the waist of the pants to the left leg and trace with chalk
3) Cut over the mark on the right and left pant leg
4) Reverse the top section of the jean exposing pant seams
5) Unstitch the pants zipper
6) Separate pants into two parts
7) Unstitch belt loops
8) Unstitch pants waistband
9) Place the waistband of the pants aside
10) Unstitch back pockets of pants
11) Unstitch the side seam of the upper right side of the pant
12) Unstitch the side seam of the upper left side of the pant
13) Cut frontal pocket fabric
14) Unstitch right leg side seams
15) Unstitch the right leg hem
16) Unstitch left leg side seams
17) Unstitch the left leg hem
18) Set Leg Pieces Aside

Through the improvement process, it was possible to reduce the overall activities from 22 to 18 final activities. The previously identified critical activities, the process of unstitching the right and left leg side seams, saw a 75% reduction in time passing from being performed in 20 minutes to being performed in just 5 minutes. This is attributed to the change of tools in addition to the reorganization of operations.

Subsequently, all time-consuming activities also saw a significant reduction. For example, the unstitching of the side seam of the upper part of the right and left sides went from being carried out in 8 minutes to 4 minutes each, the unstitching of the pants zipper went from 8 minutes to 6 minutes, and the unstitching of the pants waistband went from being done in 6 minutes to 4 minutes total.

The complete textile separation process went from being carried out in 89.967 minutes (1.499 hours) to only 43.950 minutes (0.733 hours), resulting in an improvement of 51.1%.

E. Measurements and Areas of Recovered Textiles

Once the garment has gone through the fiber separation process, we are left with 8 independent pieces. The recovered pieces can be seen in Fig. 1. It's important to highlight that in Fig. 1 the front part of the garment is represented in the color blue while the back part is represented in the color red.

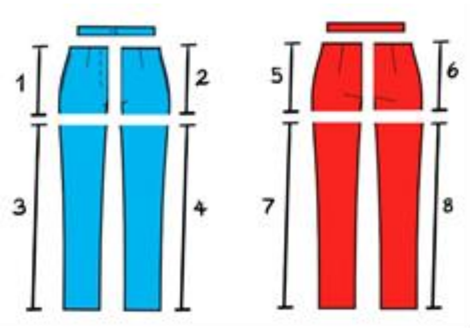

Fig. 1 Recovered pieces

As can be seen in the dismemberment of the garment in Fig.1 the front pieces on the left side of the garment (pieces 1 and 3) are symmetrical to the pieces on the right side (pieces 2 and 4). This is also true with the pieces on the backside of the garment being the pieces on the left side (pieces 5 and 7) symmetrical with those on the right side (pieces 6 and 8).

It should be emphasized that, although the dimensions are similar between the front and back sides of the garment, they are not the same, due to the need to fit a greater mass in the backside of the garment to accommodate the human body. Using the most basic area of a rectangle formula (1), the area of each recovered piece was calculated. In the formula, given a rectangle with width *b* and length *a*, the formula for the area is:

$$A = (b) * (a) \qquad (1)$$

Shown in Fig. 2 is the process of calculating the area of piece 1 of the recovered textile. All 8 pieces were calculated in the same way.

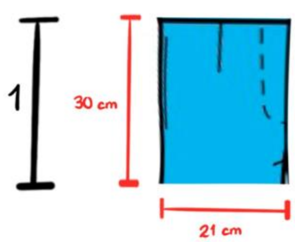

Fig. 2 Calculation of the area of recovered pieces

$$A = (b) * (a) \qquad (1)$$
$$A = (21) * (30)$$
$$A = 630cm^2$$

Through Table I, the areas of the 8 recovered pieces will be presented. It is important to mention that +/- 5% is added to the total sum of the 8 recovered pieces area. This is due to human error that can take place between the realization of the needed cuts from one operator to another.

TABLE I
AREA SUMMARY OF RECOVERED PARTS

Pieces Area (cm^2)	
Piece 1	630
Piece 2	630
Piece 3	1344
Piece 4	1344
Piece 5	930
Piece 6	930
Piece 7	1984
Piece 8	1984
Total	9776 +/- 5%

To calculate the number of garments required for the manufacture of a single yard of recycled textile, the calculation of the area of a commercial yard of textile is required. Commercial bolts of fabric measure 70 to 90cm from selvage to selvage. One yard of fabric is equivalent to 91.44cm in length. To carry out this research we will be considering that our bolts of fabric are equivalent to 90cm from edge to edge, this is because the average bolt used by the company possesses these dimensions. In Table II, the area of a commercial textile yard is presented.

TABLE II
SUMMARY OF THE AREA OF ONE COMMERCIAL YARD OF FABRIC

Area of one yard of fabric (cm^2)	
Yard of textile	8229.6

Taking Tables I and Table II into account, it can be concluded that 1.188 yards of fabric are recovered from a single pair of jeans. This implies that for each recycled garment, a remainder of 1,546.4 cm^2 of material is left after producing one yard of textile. This remainder is used to produce the subsequent yard.

F. Calculation of Time Required for Separation of a Yard of Recycled Textile

Based on all the data constructed up to this point, Table III and Table IV are produced. Table III shows the original and improved time frames for the complete separation of a pair of jeans, which are equivalent to the production of 1.188 yards of textile.

Table IV shows the times of the original and improved operation for the separation of only 1 yard of recycled textile.

The data presented in Table IV was the objective to achieve in this investigation. This data is relevant because it will facilitate the calculation of the time needed to separate additional yards. This way the company would be able to estimate the amount of time they will need to produce enough recycled textile to produce a greater number of garments.

TABLE III
RECOVERY OF 1.188 YARDS OF RECYCLE TEXTILE

	Times		
	Minutes	Hours	Yards
Current	89.967	1.499	1.188
Improved	43.950	0.733	

TABLE IV
RECOVERY OF 1 YARD OF RECYCLE TEXTILE

	Times		
	Minutes	Hours	Yards
Current	73.773	1.230	1
Improved	36.039	0.601	

IV. CONCLUSIONS

According to the time data collected from both the original and improved operations, and the calculation of the area of recovered textile, it was discovered that when implementing the improvement plan, the total separation time of one yard of recovered textile was reduced by 51.1%.

Going from separating a yard of recovered textile in 73.773 minutes (1.230 hours) to just 36.039 minutes (0.601 hours). This percentage of improvement is within the optimum results expected for the application of the SMED tool. Therefore, it is considered that the streamlining of the fiber separation process through the application of SMED was a success in the investigation.

V. EVOLUTION OF CURRENT WORK / FUTURE WORK

From the beginning of this research, it was evident that the current strategies for the recovery of previously utilized textiles are severely underdeveloped. That is why, in order to assist in the evolution of this process, it is suggested to carry out a new study that will address a new tool from the Lean Manufacturing mentality to aid in the process of fiber separation for the manufacturing of new textiles based on reused materials.

For further studies, the 5S tool is proposed, this is because the companies that are currently starting the recycling of textiles do not have the capital to make significant investments in strategies that, although effective, have a high initial cost.

This is where the advantages of the 5S tool truly shine. The application of 5S is a strategy that does not require significant investments for its application but demonstrates its long-term results in the productivity of the company.

The area of focus of the study will be the worktables of the operators, which during the conduct of this study showed that they require a severe reorganization and management. It is proposed to carry out a study of the productive space of the worktable. The area of productive space will be checked before and after the implementation of 5S by the utilization of a tape measure. With the increase of the productive space in the worktables, it is expected to be able to observe an increase in productivity.

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