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THE VALUE STREAM MAPPING METHOD IN PRODUCTION OF DENIM PANTS AND A CASE STUDY[1]

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ABSTRACT

The purpose of this study was to identify problems and to create a more efficient working method in the sewing section of the X denim company using the lean manufacturing system instead of conventional production techniques. In this way, it will be possible to identify bottlenecks, lost times, non-value added phases and to focus on valued activities with less sources.

For this purpose, the value stream mapping method- a lean production technique- was employed. Before applying these techniques, we made observations at the sewing section of the company and collected data in order to map the current state and reveal the problems. Using the lean manufacturing methods, potential solutions were determined for the problems identified and a road map was determined. Thereafter, a new working plan was put into practice.

The findings obtained though these application studies demonstrated irregular fabric transfer from the cutting section, complicated work stream, unnecessary transfer of products, excessive number of processing steps and employees, bottlenecks, and time losses.

Ultimately, the implementation of the value stream mapping method enabled the optimum use of the resources in the sewing department, created a better organized working environment, eliminated unnecessary operations, provided a new single-line work stream, eliminated bottlenecks and waiting periods and reduced the number of workers from 72 to 67. With a %66 improvement, the manufacturing time was decreased from 16 minutes 131 seconds to 10 minutes 756 seconds.

Keywords: Lean Manufacturing, Value Stream Mapping, Efficiency, Denim Trousers.

ÖZ

Bu çalışmanın amacı X denim firmasının dikim bölümünde uygulanan klasik üretim tekniklerinden sıyrılarak yalın üretim sistemi ile problemleri belirlemek ve daha verimli bir çalışma yöntemi oluşturmaktır. Bu sayede dar boğazlar, kayıp zamanlar, katma değeri olmayan aşamalar belirlenip, daha az kaynakla değer teşkil edecek faaliyetlere odaklanılacaktır.

Bu amaç için yalın üretim tekniklerinden değer akış haritalandırma yöntemi kullanılmıştır. Bu işlemler için öncelikli olarak firmanın dikim bölümünde gözlemler yapılıp veriler toplanarak mevcut durumu haritası çizilmiştir, problemler ortaya konulmuştur. Yalın üretim yöntemleri ile bu problem çözümleri belirlenerek gelecek durum haritası çizilmiş ve sonrasında yeni iş planı uygulama aşamasına geçilmiştir.

Yapılan bu uygulama çalışmaları sonrası; kesimhaneden düzensiz gelen mallar, karmaşık iş akışı, gereksiz ürün taşınması, fazla işlem aşaması ve çalışan sayısı, dar boğazlar, kayıp süreler gibi bulgular elde edilmiştir.

Sonuç olarak değer akış haritalandırma yönteminin uygulanması ile dikim bölümünde kaynaklar en iyi şekilde kullanılmış, daha düzenli çalışma ortamı oluşturulmuş, gereksiz işlemler ortadan kaldırılmış, iş akışı düzenlenmiş tek hat haline getirilmiş, dar boğazlar, beklemeler ortadan kaldırılmış bu sayede çalışan kişi sayısı 72'den 67'ye düşürülmüş. Üretim süresi 16 dakika 131 saniyeden, 10 dakika 756 saniyeye getirilerek % 66'lık bir iyileştirme elde edilmiştir

Anahtar Kelimeler: Yalın Üretim, Değer Akış haritalandırma, Verimlilik, Denim Pantolonu.

[1] This article was derived from Sibel ESER's Master's Thesis

1. INTRODUCTION

In recent years, the companies competing with the phenomenon of globalization in developed countries have been obliged to think globally. Such global competition, which put manufacturing companies' feet to the fire, is necessarily accelerating the development and adaptation to ever-changing market conditions (Lucy and Towers, 2004).

In order to develop and grow, the denim sector, which operates in this competitive environment, has to increase the variety of models and manufacture correct and high quality products in a shorter time decreasing the number of produced items. Businesses that are severely overwhelmed by today's exchange rates must eliminate waste and implement the lean manufacturing system in order to achieve lower costs (Manfredsson, 2016).

In terms of manufacturing/organizations, it means "more efficiency" and "less waste". In other words, it means the ability to achieve the optimum. The goal of lean production is to respond to customer requests at desired time and quality without error.

This article consists of four chapters: The first chapter is the introduction part of the study. The second chapter briefly explains the concepts of lean manufacturing and value stream mapping. The third chapter provides information on the X denim company; explains the applications studies performed within the scope of value stream mapping and analyzes the results and comments related to the application studies. The fourth chapter reviews the results and assessments related to the application studies; illustrates the implementation phase of the lean manufacturing system with examples from the X denim company and demonstrates the efficiency of the system with actual data.

Considering the literature addressing the lean manufacturing applied in denim production, there is only a few studies on value stream mapping. This study aims to fill this gap in this field. It is also aimed by using actual data to achieve the study correspond to the real practice and to generate a sample resource with applicable solution suggestions.

2. LEAN MANUFACTURING

Lean manufacturing is a system that does involve redundant elements, such as excess material, labor development process, errors, stock, cloth waste, long preparation period, and production area. In other words, the lean manufacturing system is a manufacturing system where such non-value added elements are minimized. The aim of lean manufacturing is to be able to respond to customers' requests with optimum use of resources (Womack et al., 1990).

Reducing flow times, increasing speed, and improving quality, cost, and terms are among the main goals of lean manufacturing. Eliminating unnecessary steps in the organizational structure and in the processes of a company is one of the roles of lean manufacturing. During the implementation of this system, it is very important that everyone in the organizational structure participates, takes responsibility and controls their areas. It is possible to achieve better results with team play at this point (Arslan, 2006)

It is vital for businesses to respond market needs promptly. That is where lean manufacturing system is needed. A company that targets excellence by implementing the slogan of continuous development and tries to implement the principle of "do it right in the first place" does not fail. Lean manufacturing has some tools that can be used to achieve a lean value chain, such as Total Quality Management, Value Stream Mapping, Kanban, Kaizen, and 5S.

The lean manufacturing system, which has various designations including "Stockless Production", "Toyota Production System", "Just in Time Production", can be applied at all kinds of private and public organizations, service industries, and non-governmental organizations. Although applied systems technically vary, the commonly used tools and methods are the same (Yılmaz, 2003).

2.1 Value Stream Mapping (VSM)

Value stream mapping is a method used to understand the value, waste and the reason of waste in value stream and to consider more factors besides the process. Value stream mapping requires you to focus on the great schemes of the things instead of considering them individually and to improve the whole work stream instead of dealing with individual processes. Value stream is an application that helps the design how an entire stream is to progress and generates a plan for lean management. Non-value added steps are more useful than several quantitative techniques that produce numerical values, such as stock level, length of term, and movement

distance. Value stream mapping is a visual tool that describes in detail how and when a company should operate to prepare the stream (Eser and Yıldız, 2017).

Value stream mapping starts with collecting information from the production area and creating a map of the current state. At this stage, every step that a final product coming from supplier to the customer is carefully mapped. After the analysis of the current state map, observed problems are demonstrated and potential solutions are determined. In line with the determined solutions, a 'future state' map is generated to indicate the new work stream. It is important to clearly express the work stream and the value (Bevilacqua et al., 2008).

Work stream plan describes when, how and by whom the transition from the current state to the new state shall be initiated. Over a certain period, as the plans for the future are realized and become the current state, the mapping process will need to be repeated in order to make a new future state value map (Pattanaik and Sharma, 2009).

Value stream mapping composes of the following 4 stages: Identifying product phase, generating a current state map, preparing a future state map, and applying the work plan. There are some important points taken into consideration in value stream mapping including: Demand, customer, supplier, and the main steps of the process, duration of the process, information stream, distribution information, and the total cycle time (Abdulmalek and Rajgopal, 2007).

3. CASE STUDY

In the present study, the case study design-one of the qualitative research models- was applied and the study data was collected through observation. The fact that we were able to access to the data from the first hand provides an advantage in the study. Case study, one of the qualitative research methods, is a research method that is used in real life situations where the boundaries between the contents are not clear and where there are multiple resources of data or evidence (Yıldırım and Şimşek, 2016).

3.1. Introducing the Company Where Lean Manufacturing Implemented

The commercial title of the analyzed company is not used in the study; it is referred as the X Company. The X Company is a denim manufacturer. Founded in 2001, the company is one of the leading international denim manufacturers in the industry. The company, with headquarters in Istanbul, established its manufacturing plant in Düzce in 2007. The company which has an open area of 37 thousand square meters and a closed area of 25 thousand square meters has the sections of fabric storage, cutting, sewing, washing, ironing-packing as of 2018. The capacity of the company with 991 employees is 3.5 million units per year.

The X Company has already achieved considerable success. It has an important potential for institutionalization and aims to put its signature under new projects. The advanced technology and excellent physical conditions that the plant possesses provide a competitive advantage. By turning this advantage into efficiency, efforts have been made to minimize the factors that negatively affect performance such as wastes, production loads, and over-cost factors. For this step, managers adopt the lean manufacturing philosophy and started lean activities.

3.2. Implementation of the Value Stream Mapping Method

The value flow mapping method was applied to prevent the waste to eliminate bottlenecks and to increase productivity in the sewing section of X Denim Company. With this aim, the present state was analyzed and a future state map was created by using the lean production system.

3.3. Value Stream Map and Layout Plan in the Current State

Following figure shows the general value stream map of the X Company.

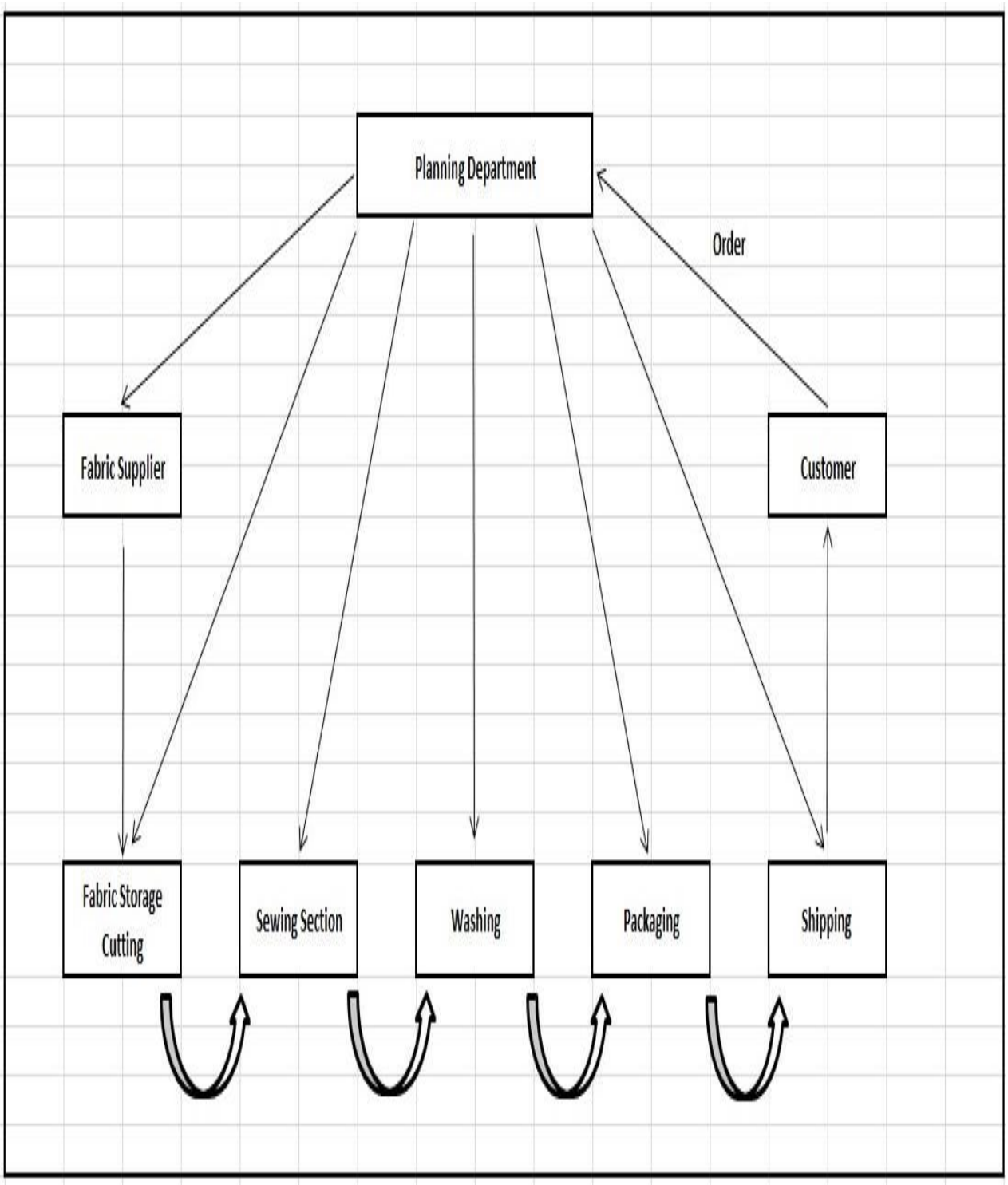

Figure 1. Current State Value Stream Map of the Sewing Section

As indicated in this figure, the trousers come from the cutting section to the sewing section and then they are sent to the washing section.

When the current state is analyzed, the following data is obtained in the sewing section:

- ✓ The number of workers is 72.
- ✓ Value added time is 16 minutes, 131 seconds.
- ✓ The daily working time is 9 hours, i.e. 9X60X60 = 32.400 seconds.

The current state operation sequence indicating the present state of the process at the sewing section is given below.

Business Plan X Company Sewing Section				Model	J&J -- Ü14 2794		
Target	1950	Piece	D	Absenteeism			
	80 %	Eficiency	E	Daily Real Min.			Min/Day
Daily Working Min	540	Minutes	F	Worker			72
Nr.			Std. Time 100	Worker	Machinery MachineType		Working Eficiency
F			H	I H * A / E	J		1950*H(sec) / 540*0,8
1	Front Knee Drawing		0,36	1,63	handwork	E	80%
2	Back Knee Drawing		0,41	1,85	handwork	E	80%
3	Pocket Drawing (2 in one thr.)		0,834	3,76	handwork	E	80%
4	Pocket Drawing (2 in one thr.)		0,874	3,95	handwork	E	80%
5	Back Pocket Iron		0,641	2,89	iron	U	80%
6	Back Pocket Mouth Iron		0,152	0,69	iron	U	80%
7	Back Right Pocket Stc.		0,098	0,44	overlock	O	80%
8	Back Left Pocket Stc.		0,1	0,45	handwork	E	80%
9	Back Right Pocket Gaze		0,112	0,51	lockstitch	S	80%
10	Back Left Pocket Gaze		0,096	0,43	lockstitch	S	80%
11	Back Pocket Bartack (1thr. 4 pieces)		0,094	0,42	lockstitch	S	80%
12	Front Regula		0,11	0,50	lockstitch	S	80%
13	Pocket Waste Cutting		0,036	0,16	lockstitch	S	80%
14	Pocket Mouth Sewing		0,33	1,49	handwork	E	80%
15	Conta Sewing		0,05	0,23	armed m.	SP	80%
16	Regula		0,032	0,14	handwork	E	80%
17	Threat Cutting		0,021	0,09	handwork	E	80%
18	Back Leg Stitching x 2		0,112	0,51	armed m.	SP	80%
19	Back Side Three Yarn Overlock		0,188	0,85	overlock	O	80%
20	Front Back Matching and Control		0,97	4,38	handwork	E	80%
21	Front Pocket Lining Stitching		0,053	0,24	lockstitch	S	80%
22	Pocket Mouth Edge Stitching		0,049	0,22	lockstitch	S	80%
23	Front Pocket Mouth Double Stitching		0,059	0,27	lockstitch	S	80%
24	Front Pocket Lining Stitching		0,055	0,25	overlock	O	80%
25	Threat Cutting		0,05	0,23	handwork	E	80%
26	Front Pocket Lining secont st.		0,09	0,41	lockstitch	S	80%
27	Pocket Lining Stitching		0,08	0,36	lockstitch	S	80%
28	Pocket Lining Secont Stitching		0,052	0,23	lockstitch	S	80%
29	Front Leg and Placket overlock		0,043	0,19	overlock	O	80%
30	Placket overlock		0,011	0,05	overlock	O	80%
31	Open Pack St.		0,012	0,05	lockstitch	S	80%
32	Middle Pocket Cutting		0,02	0,09	handwork	E	80%
33	Placket Up J Stitching		0,152	0,69	otomation	ID	80%
34	Fly Closure From Subcontractor		0,02	0,09	lockstitch	S	80%
35	Trouser Bartack Stitching		0,079	0,36	hand stitc	SP	80%
36	Front Attaching		2,33	10,52	lockstitch	S	80%
37	Label Stitching + Belt Stitching		0,1	0,45	lockstitch	S	80%
38	Front Bartack		0,045	0,20	bartack	ID	80%
39	Zip Bartack (front + back)		0,06	0,27	bartack	ID	80%
40	Front Side Three Threat		1,07	4,83	overlock	O	80%
41	Front Regola + Belt Drowing		0,13	0,59	handwork	E	80%
42	Cross Leg Stitching		0,24	1,08	overlock	O	80%
43	Cross Leg Iron		0,12	0,54	armed m.	SP	80%
44	Trouser lockstitch - overlock cutting		0,05	0,23	handwork	E	80%
45	Side Stitch		0,192	0,87	overlock	O	80%
46	Front Pocket Lining Stitching (1 tro. 2 pices)		0,136	0,61	bartack	ID	80%
47	Side Safety Frame		0,145	0,65	lockstitch	S	80%
48	Side Open Iron		0,115	0,52	iron	U	80%
49	Belt Stitching		0,116	0,52	otomation	ID	80%
50	Belt Uncut Threat Cleaning		0,05	0,23	handwork	E	80%
51	Bottom Belt Stitching (zip side)		0,14	0,63	lockstitch	S	80%
52	Upper Belt Stitching		0,154	0,70	lockstitch	S	80%
53	Belt Embroidery		0,076	0,34	lockstitch	S	80%
54	Label Stitching		0,8	3,61	lockstitch	S	80%
55	Inside Cleaning		0,31	1,40	handwork	E	80%
56	Inside Cleaning		0,34	1,53	handwork	E	80%
57	Trouser Leg Turn		0,08	0,36	handwork	E	80%
58	Legged Lock Stitch (2pcs)		0,122	0,55	hand stitc	SP	80%
59	Legged Stitch (2pcs)		0,9	4,06	lockstitch	S	80%
60	Safety Food Stitch. Watch Bartack (4 pieces barta		0,122	0,55	bartack	ID	80%
61	Bridge Preparation		0,15	0,68	lockstitch	S	80%
62	Bridge Stitching		0,11	0,50	otomation	ID	80%
63	Uncut Threat Cleaning		0,11	0,50	handwork	E	80%
64	Uncut Threat Cleaning		0,11	0,50	handwork	E	80%
65	Control		0,11	0,50	handwork	E	80%
66	Interlining Tape		0	0,00	handwork	E	80%
67	Interlining Tape		0,5	2,26	handwork	E	80%
68	Buttonhole (3 pcs)		0,112	0,51	pres	SP	80%
69	Belt Drawing		0,112	0,51	handwork	E	80%
70	Belt Insertion (sewing)		0,067	0,30	handwork	E	80%
71	Belt Folding		0,012	0,05	lockstitch	S	80%
72	Preparation of Wash Instruction		0,35	1,58	handwork	E	80%
			16,131				

Table 1. Sewing Section Current State Operation Sequence

The work stream diagram of the sewing section is demonstrated in the figure below.

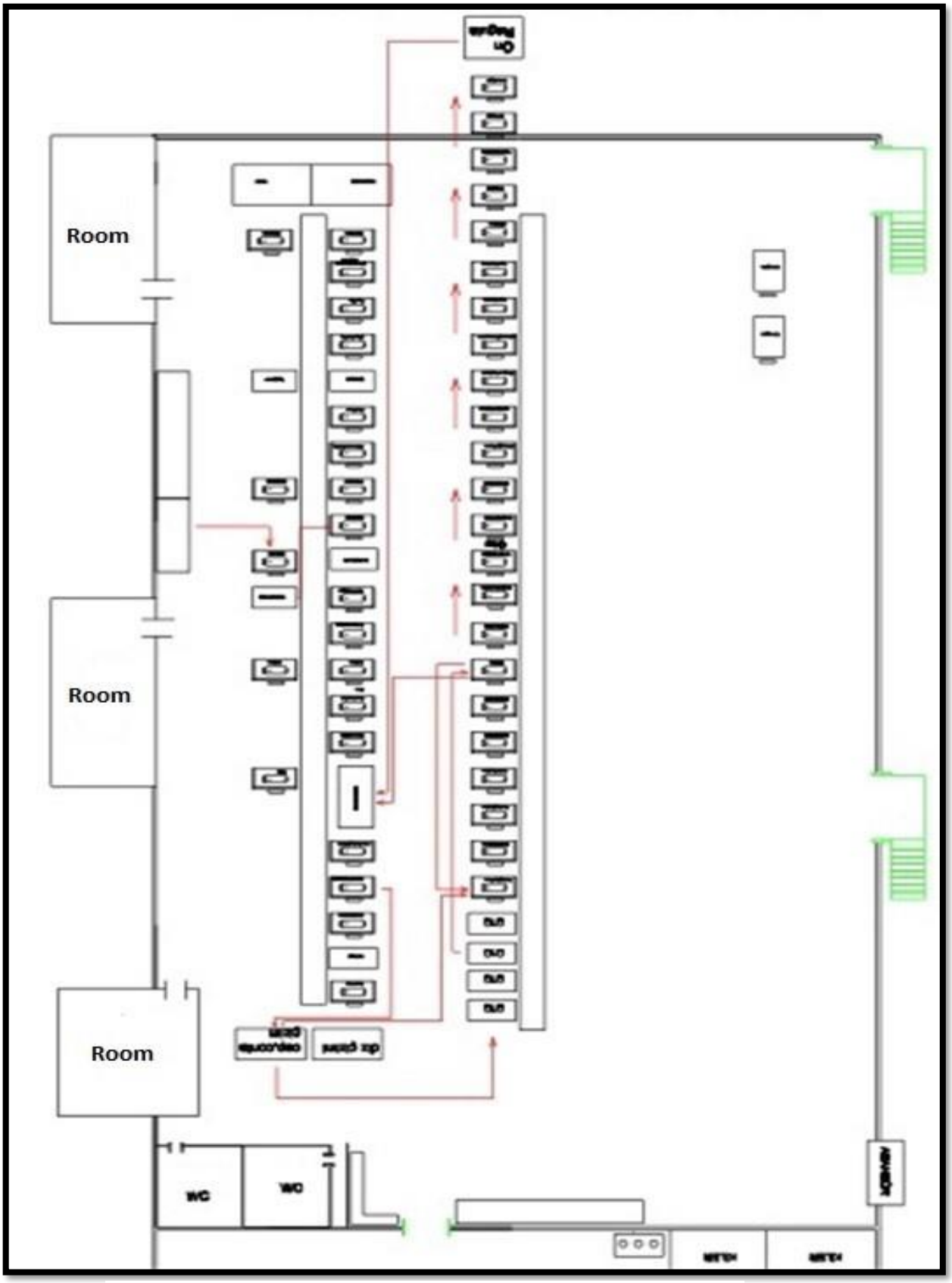

Figure 2. Current State Work Stream Map of the Sewing Section

Analyzing the current state operation sequence and drawing a work stream map gave us an opportunity to better observe the problems in the production environment. The main problems observed were revealed by the brainstorming methods and with the participation of employees and are listed below:

- ✓ Deficient and mixed fabric transfer from the fabric cutting section;
- ✓ The lack of a fabric preparation section before the sewing section;
- ✓ The fact that the denim pants work stream is not a single line;
- ✓ The fact that too much transfer of the product between the processes causes adverse effects;
- ✓ Losses caused by long distances during transfers and too many transfer stages within the process resulting in labor and time losses;
- ✓ Unnecessary processing steps;
- ✓ Staff-related time losses between the processes;
- ✓ Time losses increase the waiting time at the washing section which in turn retards production;
- ✓ Not to put the washing department in a difficult position, the sewing department has to work overtime;
- ✓ Losses delay process streams and increase the total service life.

3.4. Value Stream Map and Layout Plan for the Future State

In the next stage of the value stream mapping, it is necessary to create a future state map. The purpose of this stage is to eliminate the problems identified in the current state. The future state operation sequence and value stream map are shown in Image 1 below.

Firstly, it was ensured that the articles coming from the fabric cutting department came to the sewing department in a more regular manner. Before these adjustments, the fabrics cut used to be tossed into sacks together. And the batch numbers used to be written on the sacks. However, it was sometimes possible that the paper with the batch number gets lost or has the wrong batch number. Now, in order to prevent such disruptions, as soon as the product is cut according to the batch no, the cut pieces are regularly placed on the pallets and taken to the waiting area by the authorized person with the help of transportable working platform or elevator.

Image 1. State of the Articles Coming from the Cutting Section to the Sewing Section before the Adjustment

Image 1 shows the state of the articles transferred from the cutting section to the sewing section in sacks before adjustment.

Image 2. State of the Articles Coming from the Cutting Section to the Sewing Section After the Adjustment

Image 2 shows the state of the fabric waiting area in the sewing section when the fabric is transported to the sewing section with a transportable working platform or elevator after the adjustment.

Thanks to this adjustment, there is no shortage of articles coming from the cutting section and fabrics do not mix. Employees now work under healthier and more ergonomic conditions as they do not have to carry those big sacks anymore. The fact that the articles arriving at the sewing section does not need to be taken out of the sacks and reclassified provided saving from both workers and time.

After the observations made on the current state map, a new layout plan was formed by dividing the sewing section into five main divisions so that the employees and the product do not to go around too much. These five divisions are as follows: preparation, front side stitching, back side stitching, front-back side matching, cleaning, and quality control.

Table2. Sewing Section Processing Steps

PREPARATION	Interlining Tape
	Belt Preparation
	Buttonhole
	Front - Back Knee Drawing
	Pocket + conta Drawing
BACK SIDE STITCHING	Back Pocket Stitching
	Conta Stitching
	Back Leg Stitching
	Back Side Three Yarn Overlock
FRONT SIDE STITCHING	Front Regular
	Front Pocket Stitching
	Front Leg and Placket overlock
	Placket Up J Stitching
	Trouser Bartack Stitching
	Front Attaching
	Zip Bartack (front + back)
	Front Side Three Threat
ASSEMBLY LINE	Front - Back Side Matching and Control
	Cross Leg Iron
	Trouser lockstitch - overlock cutting
	Front Pocket Lining Stitching
	Side Stitch
	Belt Stitching
	Belt Bartack Stitching
	Label Stitching
	Trouser Leg Turn
	Safety Food Stitch Watch Bartack
	Bridge Stitching
FINISH	Inside Cleaning
	Cleaning
	Final Control

The division called “preparation phase” has been arranged to include the preparation of care instructions and label,

pocket drawing, buttonholing interlining tape, and belt preparation and this division has been set as the first stage of the sewing process. Thus, these parts are ready to be assembled immediately in the pants when required in the line low. Thanks to this step, the line flow is not interfered and there is no accumulation and waiting. The staffs who had to work here and there and move around to perform the preparation steps now work at a stationary location.

Although the X Company had enough space in the sewing area, the production line did not use to progress on a single line which resulted excessive transfer of articles, a lot of confusion and waste of time. Instead of this, a single line system has been created to ensure single line flow and the number of the foot servants has decreased. Trousers are completed by transferring them over side-by-side tables without having to make long-distance transfers.

Image 3. Distance that the Trouser Pocket is Prepared and Sent for Sewing before the Adjustment

Image 4. Distance that a Trouser Pocket is Prepared and Sent for Sewing before the Adjustment

Between these operation sequences, some worker who can be also called as foot servants had to frequently move around while carrying the articles. At this phase, they used to idle around, talk to each other, distract other workers or waste their time. As after line balancing, the production line progressed on a single line and article transfer become unnecessary, these workers were transferred to other departments and now there is no workers walking around. By adding knives to the sewing machines in the department, the need for the foot servants responsible for cutting thread was eliminated. Side thread cleaning, which used to be performed in the middle of the production line, is now carried out by a single worker at the final control stage. So the staff-related vacant lots have been eliminated.

As a result of the analysis of the current state stream map, the future state stream map and the layout plan are designed to prevent unnecessary relocation of the processed articles and workers. The new layout enables single line production. In this way, the bottlenecking times and waiting periods have been eliminated. The machinery and equipment, which were not in use, have been removed and a more well-organized working environment has been created. Eliminating time losses removed the need for overtimes, enabled on-time transfer of the articles to the washing department, and increased the worker motivation. The number of the workers decreased from 72 to 67. While the manufacturing time determined as 16 minutes and 131 seconds in the analysis of the current state map, this data decreased to 10 minutes and 756 seconds in in the future state map as a result of line balancing with the adjustment of work sequence and layout. Besides, according to the

error controls the rate of the problems including 60 pocket set errors, 52 back pocket foot stitch errors and 34 leg seams observed in the current state has been reduced by 43% in the future state stream map.

The future value stream map and the layout plan are indicated in the Figure below.

Business Plan X Company Sewing Section				Model	J&J -- Ü14 2794			
Target	2000	Piece	D	Absenteeism				
	80 %	Eficiency	E	Daily Real Min.			Min/Day	
Daily Working Min	540	Minutes	F	Worker			67	
Nr.			Std. Time 100	Worker	Machinery MachineType		Working Eficiency	2000*H(sec) / 540*0,8
F			H	I H * A / E	J	K		
1	Interlining Tape		0,4	1,85	handwork	E	80%	
2	Interlining Tape		0,1	0,46	press	SP	80%	50
3	Belt Drawing		0,067	0,31	handwork	E	80%	6,7
4	Belt Insertion (sewing)		0,012	0,06	lockstitch	S	80%	1,2
5	Belt Folding		0,35	1,62	handwork	E	80%	35
6	Buttonhole (3 pcs)		0,112	0,52	handwork	E	80%	11,2
7	Front Knee Drawing		0,16	0,74	handwork	E	80%	16
8	Back Knee Drawing		0,21	0,97	handwork	E	80%	21
9	Pocket Drawing (2 in one thr.)		0,224	1,04	handwork	E	80%	22,4
10	Pocket Drawing (2 in one thr.)		0,264	1,22	handwork	E	80%	26,4
11	Back Pocket Iron		0,061	0,28	iron	U	80%	6,1
12	Back Pocket Mouth Iron		0,052	0,24	iron	U	80%	5,2
13	Pocket Waste Cutting		0,036	0,17	overlock	O	80%	3,6
14	Pocket Mouth Sewing		0,03	0,14	handwork	E	80%	3
15	Back Right Pocket Stc.		0,098	0,45	lockstitch	S	80%	9,8
16	Back Left Pocket Stc.		0,1	0,46	lockstitch	S	80%	10
17	Back Right Pocket Gaze		0,112	0,52	lockstitch	S	80%	11,2
18	Back Left Pocket Gaze		0,096	0,44	lockstitch	S	80%	9,6
19	Back Pocket Bartack (1thr. 4 pieces)		0,094	0,44	lockstitch	S	80%	9,4
20	Conta Sewing		0,05	0,23	armed m.	SP	80%	5
21	Regula		0,032	0,15	handwork	E	80%	3,2
22	Back Leg Stitching x 2		0,112	0,52	armed m.	SP	80%	11,2
23	Back Side Three Yarn Overlock		0,188	0,87	overlock	O	80%	18,8
24	Front Regula		0,11	0,51	handwork	E	80%	11
25	Front Pocket Lining Stitching		0,053	0,25	lockstitch	S	80%	5,3
26	Pocket Mouth Edge Stitching		0,049	0,23	lockstitch	S	80%	4,9
27	Front Pocket Mouth Double Stitching		0,059	0,27	lockstitch	S	80%	5,9
28	Front Pocket Lining Stitching		0,055	0,25	overlock	O	80%	5,5
29	Front Pocket Lining secont st.		0,09	0,42	lockstitch	S	80%	9
30	Pocket Lining Stitching		0,08	0,37	lockstitch	S	80%	8
31	Pocket Lining Secont Stitching		0,052	0,24	lockstitch	S	80%	5,2
32	Front Leg and Placket overlock		0,043	0,20	overlock	O	80%	4,3
33	Placket overlock		0,011	0,05	overlock	O	80%	1,1
34	Open Pack St.		0,12	0,56	lockstitch	S	80%	12
35	Middle Pocket Cutting		0,02	0,09	handwork	E	80%	2
36	Placket Up J Stitching		0,152	0,70	otomation	ID	80%	15,2
37	Fly Closure From Subcontractor		0,02	0,09	lockstitch	S	80%	2
38	Trouser Bartack Stitching		0,079	0,37	hand stitc	SP	80%	7,9
39	Front Attaching		2,33	10,79	lockstitch	S	80%	233
40	Label Stitching + Belt Stitching		0,1	0,46	lockstitch	S	80%	10
41	Front Bartack		0,045	0,21	bartack	ID	80%	4,5
42	Zip Bartack (front + back)		0,06	0,28	bartack	ID	80%	6
43	Front Side Three Threat		1,07	4,95	overlock	O	80%	107
44	Front Regola + Belt Drowing		0,13	0,60	handwork	E	80%	13
45	Front - Back Side Matching and Control		0,07	0,32	handwork	E	80%	7
46	Cross Leg Stitching		0,24	1,11	overlock	O	80%	24
47	Cross Leg Iron		0,12	0,56	armed m.	SP	80%	12
48	Trouser lockstitch - overlock cutting		0,05	0,23	handwork	E	80%	5
49	Side Stitch		0,192	0,89	overlock	O	80%	19,2
50	Front Pocket Lining Stitching (1 tro. 2 pices)		0,136	0,63	bartack	ID	80%	13,6
51	Side Safety Frame		0,145	0,67	lockstitch	S	80%	14,5
52	Side Open Iron		0,115	0,53	iron	U	80%	11,5
53	Belt Stitching		0,116	0,54	otomation	ID	80%	11,67
54	Kemer önü iplik kesimi		0,05	0,23	handwork	E	80%	
55	Bottom Belt Stitching (zip side)		0,14	0,65	lockstitch	S	80%	14,00
56	Upper Belt Stitching		0,154	0,71	lockstitch	S	80%	15,40
57	Belt Embroidery		0,076	0,35	lockstitch	S	80%	7,60
58	Label Stitching		0,08	0,37	lockstitch	S	80%	8,00
59	Trouser Leg Turn		0,08	0,37	handwork	E	80%	8,00
60	Legged Lock Stitch (2pcs)		0,122	0,56	hand stitc	SP	80%	12,20
61	Legged Stitch (2pcs)		0,09	0,42	lockstitch	S	80%	9
62	Safety Food Stitch. Watch Bartack (4 pieces barta		0,122	0,56	bartack	ID	80%	12,2
63	Bridge Preparation		0,15	0,69	lockstitch	S	80%	15
64	Bridge Stitching		0,11	0,51	otomation	ID	80%	11
65	Inside Cleaning		0,4	1,85	handwork	E	80%	31,00
66	Cleaning		0,2	0,93	handwork	E	80%	11
67	Finish Colntrol		0,11	0,51	handwork	E	80%	11
			10,756					

Table3. Sewing Section Future State Operation Sequence

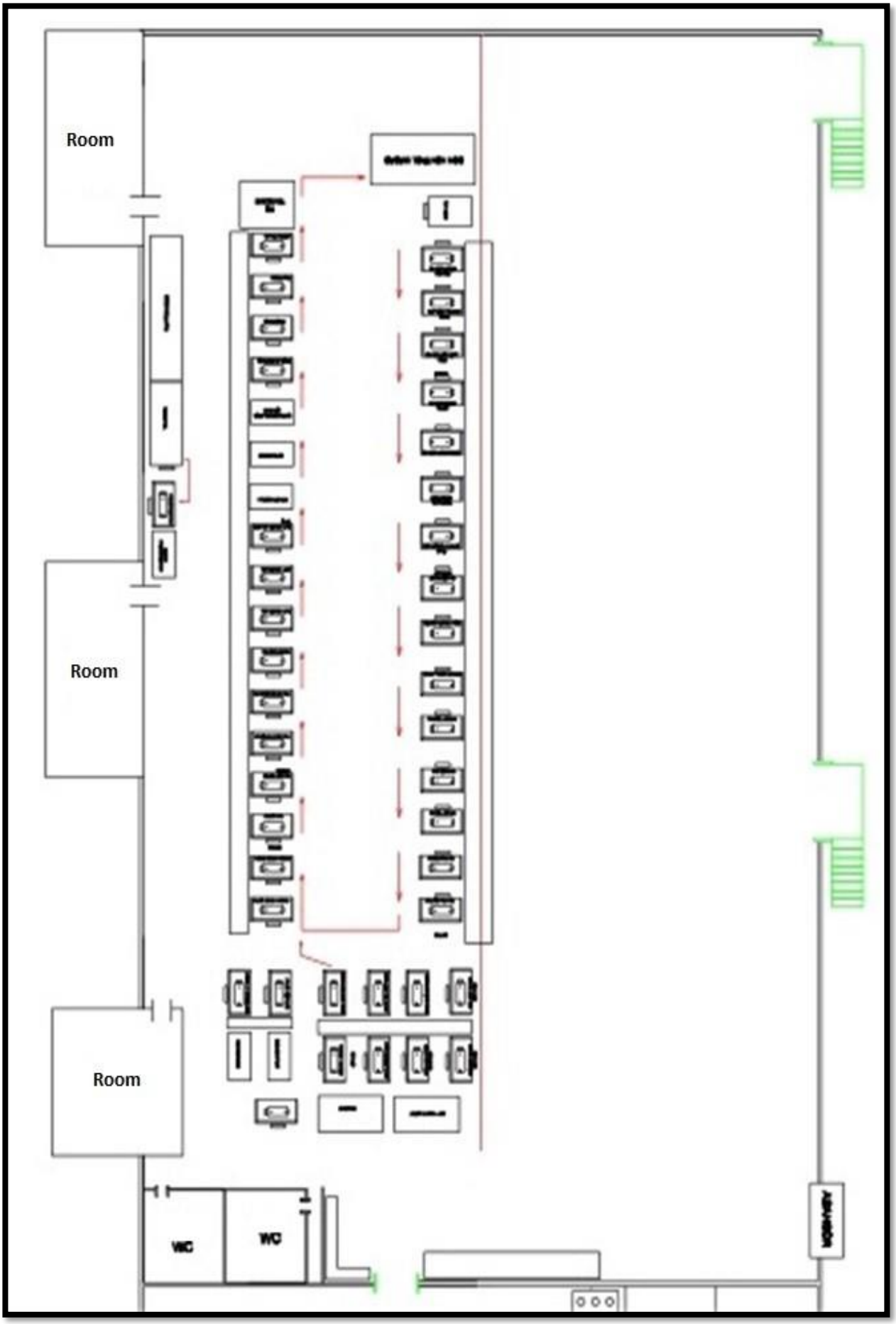

Figure 3. Sewing Section Future Value Stream Map and Layout Plan

As a result, a 66% improvement was achieved in the manufacturing time with an average improvement of 49% per piece. These adjustments removed the need for overtimes. This resulted in a more careful working environment and achieved a 43% reduction in error rates. Also, there has been a 48% increase in the revenue. We believe that these changes made in the sewing section of the X denim company have added value to the company and improved the efficiency of the process.

3.5. Analyzing the Value Stream Mapping Method

Firstly, the articles which used to be irregularly transferred from the cutting section were re-organized and were organized and started to be transported in a more organized manner with the help of transportable working platforms. So, the worker who was appointed to carry out these works can now focus on his/her own duty and does not need to spend time or energy for an unnecessary step. As the cut articles do not get lost, there is no deficiency in the numbers obtained at the end of the day.

After the Sewing Section was divided into divisions within itself, the production has started to progress on a single line. With the creation of the preparation phase, stacking particularly at the belt and buttonhole steps has been avoided. Since the assembly line is integrated in the production line, there is no need to transfer the front side of the trousers to the front-back side stitching section in the middle of the production line to be assembled. While this step used to take 0.97 seconds before the adjustments, it becomes 0.07 seconds after the adjustments. Cutting tools have been integrated to the sewing machines in the line and manual trimming has been eliminated. As cleaner products have been produced, the two processes aiming to clean the threads from the products have been removed from the production line. Thread trimming is now performed only at the quality control stage at the end of the line.

As a result of the re-arrangement of the line in line with the information above, the number of the workers working at the line decreased from 72 to 67. Whereas the time required to manufacture one pair of trousers was 16 minutes and 131 seconds, it has decreased to 10 minutes and 756 seconds. In other words, a %66 improvement has been achieved. Accordingly, a 43% reduction has been observed in the rate of errors.

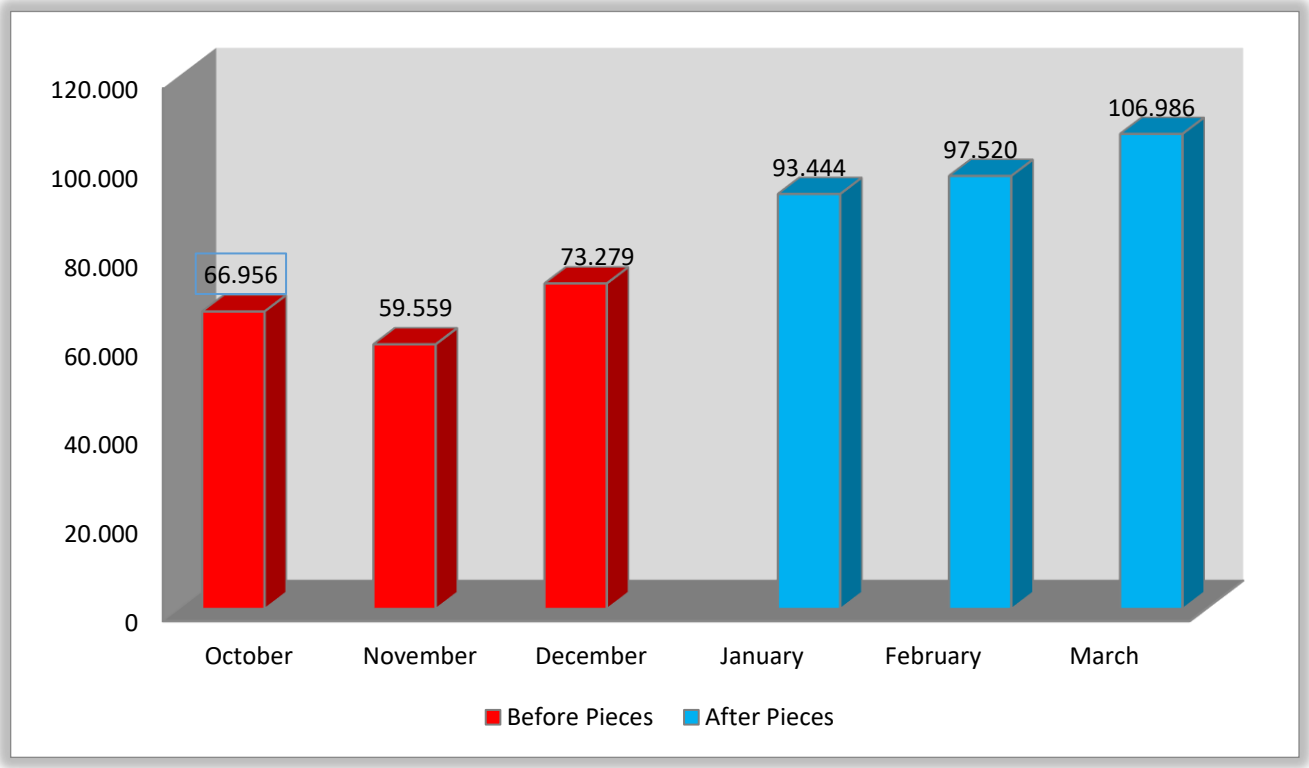

Diagram 1. Quantity Information Before and After the Implementation of the Value Stream Mapping Method

The diagram above shows the number of the trousers manufactured by 72 people before the application of the value stream mapping method and the number manufactured by 67 people after the application of the VSM method. As it can be understood from the diagram, an average improvement of 49% has been achieved per unit after the application.

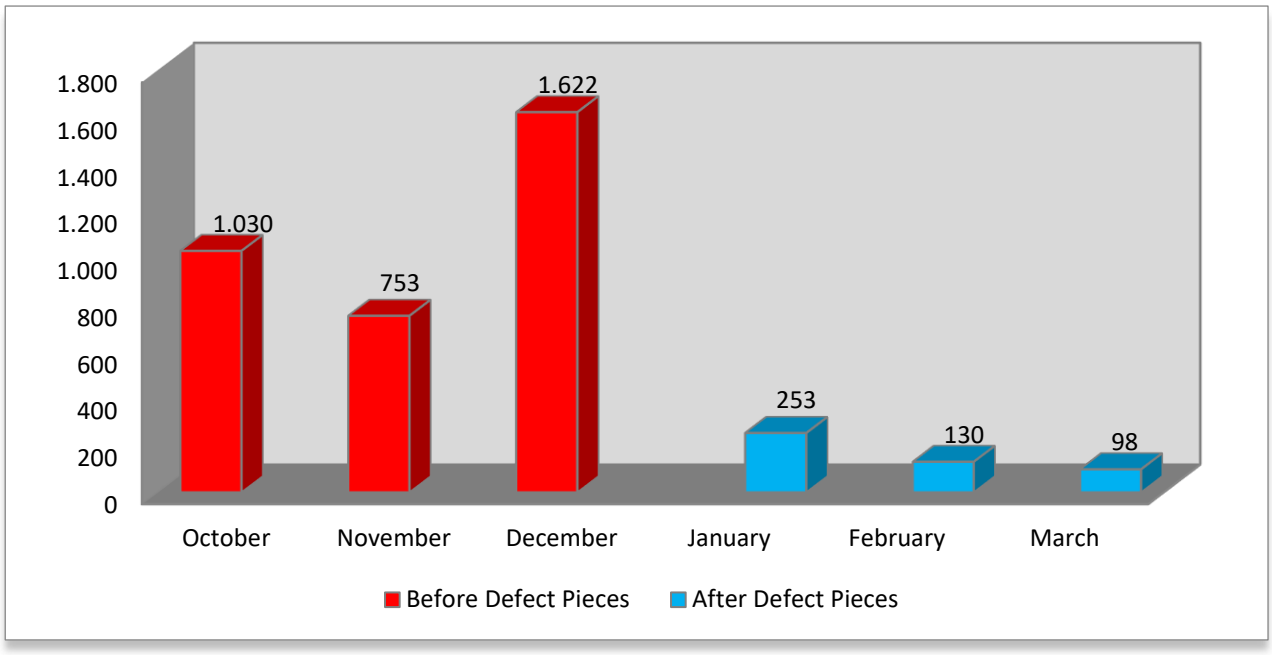

Diagram 2. Information on Error Rates Before and After the Implementation of the Value Stream Mapping Method

The diagram given above shows the number of errors that occurred before and after the implementation of the value stream mapping method. There were several of errors before the application of VSM due to irregularities, article transfers, failure of the workers to focus on the task, and the failure to analyze the error rates and take actions; however, these errors have been reduced through the actions taken after the implementation of the VSM method. The goal is to adopt continuous improvement and keep the error rate at the minimum level, even to the zero level.

The diagram indicating the total revenue before and after VSM is given below. The date is given in Turkish Lira. With the decreased error rates, increased number of manufactured articles, and elimination of overtimes, there has been a 48% rise in the income rate.

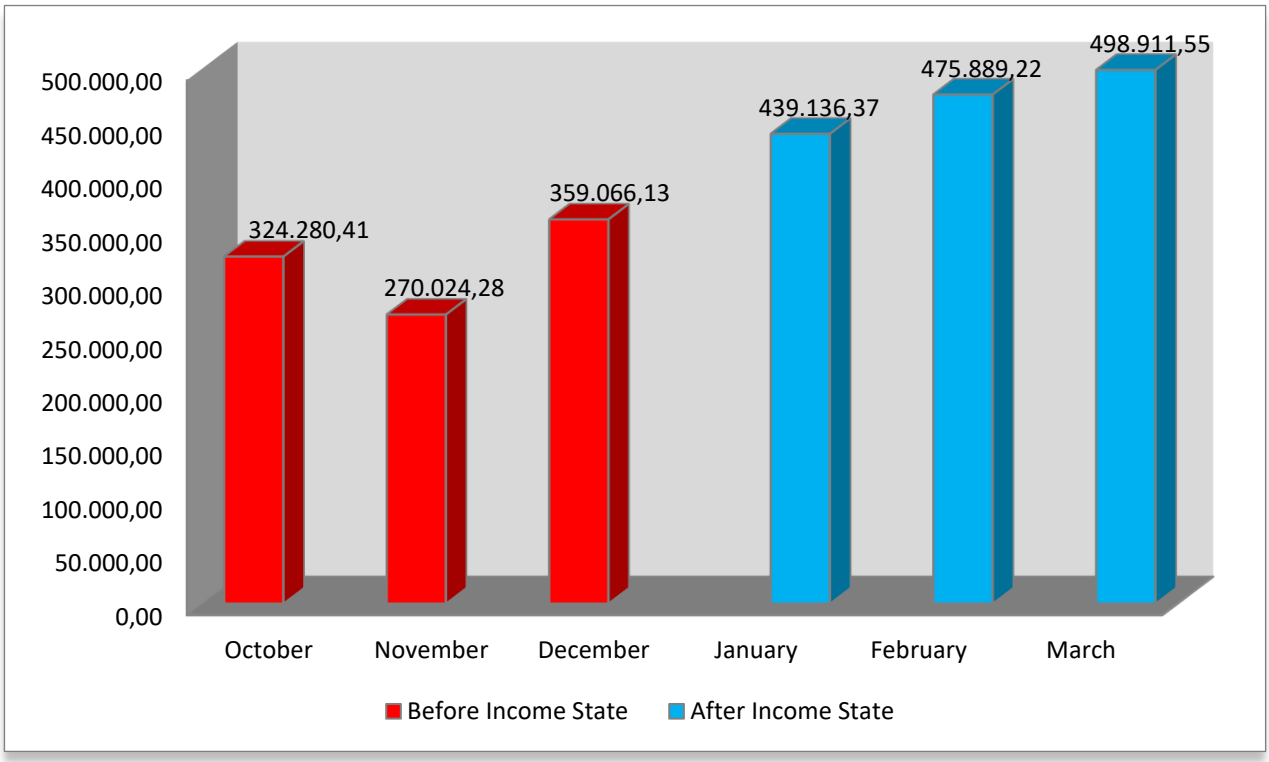

Diagram 3. Information on Total Revenue Before and After the Implementation of the Value Stream Mapping Method

4. CONCLUSION AND EVALUATION

The use of lean manufacturing systems has a strategic value for companies in order to keep up with today's competitive conditions and to continue their existence the pressure of competitive cost/pricing is felt more severely in sectors, which are diversified and variable, such as the textile industry. To be able to turn these competitive conditions into an advantage, it has become mandatory to add value to resources, make systemic developments, and implement lean manufacturing for continues enhancement.

In the present study, we provided background information on lean manufacturing and value stream mapping and then presented an application study of value stream mapping at the sewing section of the X denim company. As a result of this application study, we indicated favorable and beneficial outcomes including improved process, increased effectiveness and eliminated waste. According to these results:

A new line system was created to allow single line stream. That solved the problems of bottlenecks and waiting times. Unused machinery and equipment were removed. Currently used machines have been cleaned and serviced; missing apparatus on the machinery (e.g. knives) have been restocked. The number of the workers decreased from 72 to 67. With a %66 improvement, the manufacturing time was decreased from 16 minutes 131 seconds to 10 minutes 756 seconds. So there is no need for overtimes anymore and workers are now more motivated. As a result, there is a more careful working environment and the company achieved a 43% reduction in error rates. Decreased error rates, increased number of manufactured articles, and elimination of overtimes provided a 48% rise in the income rate.

According to our review, although there are a lot of sources related to lean manufacturing in the literature about the textile industry, there are only a few studies addressing denim manufacturing. Similarly, there are not many sources related to the application of lean manufacturing in the textile industry and denim production. For this reason, we believe that this master's thesis which has prepared including various application studies will set an example for future researches.

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