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Contact:
Ege University, Textile and Apparel Research-Application Center, 35100, Bornova, İzmir, TURKEY
Tel: +90 232 374 28 68 / Fax: +90 232 388 78 59
(E.Ü. Tekstil ve Konfeksiyon Araştırma-Uygulama Merkezi 35100 Bornova – İZMİR)

www.tekstilvekonfeksiyon.com

Tekstil ve Konfeksiyon has inserted into the "ISI Master Journal List" of the Institute for Scientific Information and is indexed in SCI-Expanded. The journal is also indexed in TOGA FİZ Teknik and EBSCO Publishing.

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Typesetting and Printing:
META Basım Matbaacılık Hizmetleri
+90 232 343 64 54/ E-mail: metabasim@gmail.com

Terms of Subscription:
Tekstil ve Konfeksiyon published 4 times in a year in every 3 months.
Annual subscription rate: 40 TL (VAT included)
Annual subscription rate for textile students: 15 TL
For subscription: T. C. İş Bankası Ege Üniversitesi Şubesi, Bank account: 155553
Price: 10 TL (VAT included)

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Emine UTKUN^{1*}, Mücella GÜNER²

¹ Pamukkale University, Buldan Vocational Training School, Denizli, Turkey

² Ege University, Department of Textile Engineering, İzmir, Turkey

Received: 08.04.2011

Accepted: 02.03.2012

ABSTRACT

The original name of the lean production system, "Toyota Production System", was born and developed in Japan. Later, the American automotive industry has adopted this system and "lean production" was the name applied. After the automotive industry has been spread to other sectors and has begun to be implemented. In this research, as aimed in the lean production system to rationalize the company by cutting down the cost, fast, without stock, running on time lean techniques are applied with six-step method systematic in apparel industry.

Key Words: Lean production system, Apparel industry, Six-step method, Cost-benefit analysis.

ÖZET

Yalın üretim sisteminin orijinal adı "Toyota Üretim Sistemi"dir, Japonya'da doğmuş ve geliştirilmiştir. Daha sonra Amerikan otomotiv endüstrisi bu sistemi benimsemiş ve "Yalın Üretim" adıyla uygulamıştır. Otomotiv endüstrisinden sonra ise diğer sektörlerde de yayılmış ve uygulanmaya başlamıştır. Bu çalışmada, yalın üretim sisteminin temel amacı olan işletmede maliyetleri aşağıya çekerek hızlı, stokuz, zamanında üretimin gereği olan işletme rasyonalizasyonu için yalın teknikler bir konfeksiyon işletmesinde altı kademe metodu sistematığı ile uygulanmıştır.

Anahtar Kelimeler: Yalın üretim teknikleri, Konfeksiyon sektörü, Altı kademe metodu, Fayda-maliyet analizi.

* Corresponding Author: Emine Utkun, eutkun@pau.edu.tr, Tel:+ 90 258 4318620 Fax:+90 258 4318621

1. INTRODUCTION

The fact that the greatest obstacle that companies offering products or services faced to achieve "better quality" was the variability of processes is introduced by one of the greatest quality gurus, W. Edward Deming, so many years ago. The reason behind the Japanese industry to leap forward after World War II is the philosophy of Deming "to minimize variations in production process by analyzing every aspect" (1). The name of the philosophy making the

Japanese industry to leap is the lean production system.

The book "The machine that changed the World" by Womack, J.P., Jones, D.T. and Roos, D. that published in 1990, New York has become one of the most widely cited references in history. In fact, the concept of lean production has already known long before it is introduced in the book but the book has also played an important role in expanding the system outside the Japan (2). The book discusses the philosophy of lean production system

considering the advantages and disadvantages, the success of Toyota Company and how to be successful in all sectors of production by adopting lean production system.

Yen Chun Wu compared the suppliers adopting the lean production system and the ones that don't. Research included suppliers in the field of automotive both from United States and Japan. The results drew a clear picture in which the suppliers adopting lean production system have certain advantages in production systems,

delivery performance, communication systems, consumer-supplier relations and on time product delivery over the ones that don't adopt the system (3).

Ahmad and his friends analyzed the role of infrastructure practices in the effectiveness of just in time production systems with data from a study sample of 110 businesses operating in three industries: electronics, machinery, and transportation and located in three countries: United States of America, Italy, and Japan. These infrastructural studies are quality management, product technology, work integration system and human resource management (HRM) policies. The results of the research indicate that synergy between of just in time production systems practices and infrastructure practices needs to be exploited to attain superior plant competitiveness (4).

Carnes and his colleagues have done a research on the performance of just in time inventory systems innovation and the predictability of earnings in 82 United States of America based companies. 41 of these companies have taken advantage of just in time production systems inventory practices and the rest have been using traditional methods. The results proved that the companies adopting just in time production systems practices are more successful on predicting the earnings (5).

Gündoğan and his friends are researched the benefits of the transition from the traditional production method

to a lean production method in the textile finishing companies (6).

Ahlstrom is researched about sequences in the implementation of lean production. The conclusions indicate that there are sequences in which lean production principles are implemented, but management also need to devote effort and resources to a set of principles in paralel (7).

After all those researhes the main idea is gathered as "lean production is a whole set of techniques, a system and a concept which aims to optimize the provided value of a product or service by eliminating waste in all the stages of production and thereby increasing the profit of the company".

Lean production employs a wide range of techniques. Outstanding among these are (8): Just in time production, Kaizen (continuous improvement), Multi-functional teams, Concurrent engineering, Customer focus, Operations management model, Standardization of operations, Single-piece flow, Kanban (card) system, Jidoka (automation), SMED (single minute exchange of dies), Poka-yoke (error prevention mechanisms), TPM (total productive maintenance), 5S.

Although the use of these techniques which has a lot in common by the companies is a base for the lean production concept still the boundaries of the lean production concept are not clear (9). The techniques and departments in which they are adopted in this study are as follows:

- Preparation line;
 - Kaizen (continuous improvement)
 - Workflow editing
 - Optimizations in work tools
- Assembly line;
 - Process optimization by poka-yoke (error prevention mechanisms)
- General optimizations in the workflow;
 - Single minute exchange of dies
 - Operations management model

2. MATERIAL AND METHOD

2.1. Objective

In this study, the effects of lean production techniques on company, itself and line effectiveness is discussed by adopting work flow mapping and method studies in a company manufacturing towels and bathrobes in Denizli, Turkey in order to save labor force and smooth the production. The study explains the applications carried out in the apparel department of the company and discusses the results.

2.2. Material

In apparel department of the company, one preparation line and an assembly line with an overhead conveyer is employed for bathrobe manufacture (Figure 1). The study focuses on the same operations but analyzes two different orders having distinct fabric color and properties, also distinct embroidery pattern and properties.



Figure 1. Preparation line (on the left) and assembly line with the overhead conveyer (on the right)

2.3. Method

Company currently employing mass production aimed to be upgraded to lean production and optimizations realized by steps defined in six-step method study. Optimizations explained with the six-step method study and the elements of lean production.

The first prerequisite for the success of the study is to follow the six-step one by one and not to skip any step defined in the method study. The six-step is used to optimize newly setup work systems, existing work systems or inadequate

work systems. Six-step method study is shown in Figure 2 (10).

The first step of the six-step method is to set an objective, because generally the person assigning the task sets a wider objective (e.g., optimizing the economics or smed and reduce inventory). However, planners require detailed objectives quantified within their capacity to offer alternatives.

Cutting down the costs, faster, without stock, running on time at the company are the first targets of this research, as a second step the boundaries of the tasks are determined and it is decided

to improve 9, 10 and 11th steps of the preparation line, 9th step of the assembly line. As in the third phase of the six step method called looking for ideal solutions, improvement techniques are searched, at the fourth phase for data gathering and practical solutions time and method study was carried on.

After defining the objectives, "pyramid of objectives" in Figure 3 is used for quantifying and identifying the weak points to be optimized on the current system (10).

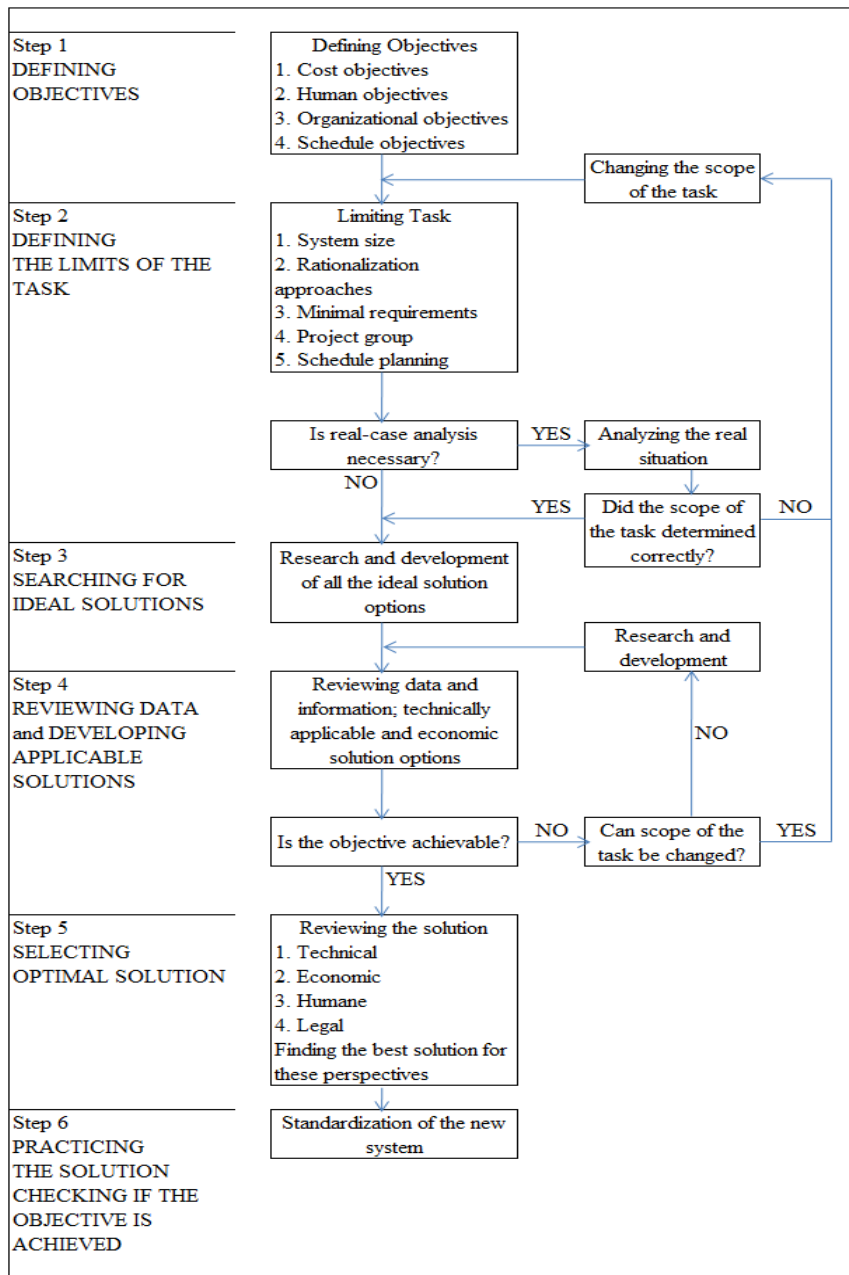


Figure 2. Six-step in method study (10)

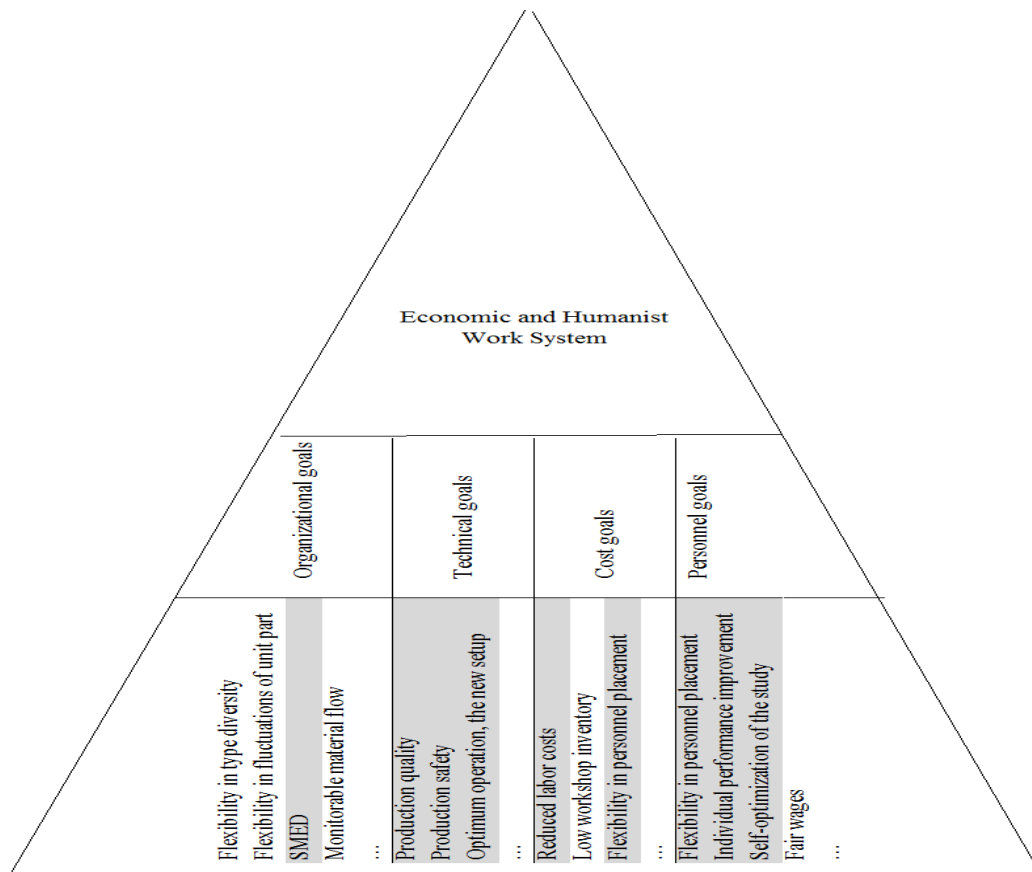


Figure 3. Pyramid of objectives (10)

The main objective of the optimization in the company is to realize the economic and humanist work system placed at top of the pyramid. Organizational, technical, cost and staff objectives defined in order to achieve this objective. Of the objectives at the lower level of the pyramid, the ones specified and applied in this study are marked in gray.

Lean production elements utilized in the optimization process are described in the findings section. Study schedule is given below:

Data for the first model are gathered;

During mass production between the dates 01.06.2009 and 06.07.2009,

Upon completion of lean production system, between the dates 07.12.2009 and 31.12.2009,

Data for the second model is gathered;

During mass production between the dates 06.07.2009 and 08.08.2009,

Upon completion of lean production system, between the dates 31.12.2009 and 25.01.2010.

At the end of the study, a cost-benefit analysis concerning the optimizations made in business between the days 01.06.2009 and 25.01.2010 and how much savings achieved through these optimizations is calculated.

2.4. Practice

In this section, lean production techniques applied according to the needs of each department of the business are explained under the "optimizations" title. Table 1 shows bathrobe production operations, those marked in gray are optimized. The table also shows the quantity of the workers for both the mass production and after the optimizations for the lean production upgrade.

2.4.1. Optimization of the Preparation Line

Whereas the number of employees working in the production line was 24 in mass production, this number reduced to 20 in the lean production and thus saving manpower of 4. These savings are achieved by applying the following techniques.

2.4.1.1. Kaizen (Continuous Improvement)

The new system requires 3 employees in the pocket stitching operation at the preparation line, instead of 4 as it was in the old system. Before this optimization, the staff working in the pocket stitching was monitored, analyzed, also the employees trained as a result of the method study providing all the employees working in this operation to perform in a similar way and thus leading to the decision that the 3 manpower is adequate.

For the pocket stitching operation:

Duration per pair (the old): 1,58 min (38 pair of pockets per hour)

Duration per pair (the new): 1,20 min. (50 pair of pockets per hour)

As a result, manpower of 1 saved in the pocket stitching operation.

2.4.1.2. Editing Workflow

There are two loops one on the right and the other on left for securing the belt by the waist of the bathrobe. The old system required 3 employees to stitch the loops upon completion of the bathrobe.

Table 1. Bathrobe production operations of both the old and the new systems and the quantity of workers

PREPARATION LINE			
	Operation	Number of Workers	
		Mass Production	Lean Production
1	Overlock stitching of the pocket edge and surroundings	1	1
2	Overlock stitching of the cuff and lapel	1	1
3	Curving the pocket edge and seaming lapel	1	1
4	Cuff affixing	1	1
5	Arm stitching	1	1
6	Arm edge stitching	2	2
7	Arm enclosure	1,5	1,5
8	Pocket ironing	1,5	1,5
9	Pocket assembly	4	3
10	Bridge assembly	3	1
11	Cutting cardboard pattern	1	0
12	Putting the body pieces together	1	1
13	Belt stitching	2	2
14	Fixing	1	1
15	Carrying the clusters	1	1
16	Foremanship works	1	1
Total Number of Employees		24	20

ASSEMBLY LINE			
	Operation	Number of Workers	
		Mass Production	Lean Production
1	Loading the bolt	1	1
2	Shoulder seaming	1,5	1,5
3	Shoulder press	1	1
4	Arm affixing	1,5	1,5
5	Arm pressure	1,5	1,5
6	Side seaming	3	3
7	Lapel affixing	2	2
8	Adjusting the edge of lapel	1	1
9	Cutting the edge of lapel	1	0
10	Lapel edge stitching	2	2
11	Skirt hem bending	1,5	1,5
12	Lapel enclosure	3	3
Total Number of Employees		20	19

Following job analysis, it is realized that loop stitching takes very long since bathrobe becomes a bigger single piece garment by the time loops to be stitched. However it is also concluded that stitching belt loops in the preparation line will take less time and will not effect other operations. With the new system, loop stitching operation tasked to the preparation line, thereby enabling the operation done before the clothing gets bigger and saving time and manpower. The operation now requires only 1 employee.

For loop stitching operation:

Duration per pair (the old): 1,20 min. (50 pair of loops per hour)

Duration per pair (the new): 0,40 min. (150 pair of loops per hour)

As a result, manpower of 2 saved in the loop stitching operation.

Another disadvantage faced in the old system was the piling of bathrobes just because the loop stitching delays packaging. Another advantage gained with this optimization besides the manpower savings, now products proceed to the next operation without waiting thereby solving the inventory piling problem.

2.4.1.3. Work Tool Optimization

Bathrobes have two pockets one on the right and the other on the left.

Before these pockets are stitched to the main garment, with the help of a pattern; their edges are curved and ironed. The cardboard pattern used in the old system was deforming by time due to iron steam requiring 1 employee to be spared for remaking of that pattern. Another disadvantage of the old cardboard material was the shrinking size due to exposure to ironing process resulting in the nonstandard pocket sizes.

In the new system, the pattern is replaced with a more durable roof isolation material. With this replacement, manpower required for preparing patterns was no longer necessary.

As a result, manpower of 1 saved in the cardboard pattern making operation.

Optimization of the working material directly resulted in monetary saving.

- Monthly cost of the iron cardboard pocket pattern;

Unit cost of the iron cardboard pocket pattern = 0,25 TL/piece,

Requirement = 264 pcs/month,

Cardboard pattern cost = 66 TL/month.

- Monthly cost of the roof isolation material;

Unit cost of roof isolation material = 0,7 TL/piece,

Requirement = 10 pcs/month, (roof isolation material is more durable and long lasting)

Roof isolation pattern cost = 7 TL/month.

This decrease in pattern cost is shown under the total benefit section in Table 2.

2.4.2. Optimizations in the Assembly Line

The number of employees working in the overhead conveyor line was 20, after transition to lean production this number was decreased to 19. Saving manpower of 1 was achieved with the application of poka-yoke (error prevention mechanisms).

2.4.2.1. Poka-Yoke (Error Prevention Mechanisms) for Working Processes

In Japanese, poka-yoke means error isolation. Poka-yoke is a technique which enables detection and prevention of simple human errors. In the old system, edges of the lapels was set and cut in case it is longer than the main garment following the attachment of the lapels. 1 employee is required for this operation in the overhead conveyor line. This operation has been entirely removed in the new

system. The departments related to cutting and patterns are warned to measure and cut accordingly. Thus, lapels transferred to the sewing department at desired measurement. Providing that lapels transferred at desired measurement, the need for the extra cutting process in the sewing department isn't required anymore.

As a result, manpower of 1 spared for the extra lapel cutting operation is gained.

2.4.3. General Optimizations in the Working System

Optimizations made in general to the working system are proved to have time-saving advantages.

2.4.3.1. Single Minute Exchange of Dies (SMED)

Lean production optimizations realized in the business aiming single minute exchange of dies are;

Old setup was based on the master designer work, therefore employees were to wait till the design was finished, additionally no single employee were aware of in which operation they were going to work. With the new setup, master designer is to work before the current design is finished and inform employees about the next assignment details as to where and which operation they are going to work or which machines they are going to use. Thus, during the design changes, every employee having informed beforehand will work accordingly and less time will be wasted. Furthermore, if there is a need for extra apparatuses for the new design, maintenance staff will make the machines ready in advance and TL them out, enabling a smooth transition without any problems. Optimizations related to SMED have important advantages for the business. As the time required for design changes reduced from 90 minutes to 30 minutes, 1 hour per design change is saved.

Considering the number of design changes in the business to be 15 per month, the gain is: $15 \times 1 = 15$ hours/month.

2.4.3.2. Operational Management-Production Model (Recommendation System)

In June, for the above mentioned optimizations to be realized a team of five people responsible in the sampling, pattern, cutting, sewing and packaging departments are grouped and the department manager lead the team. Team members made observations in other departments for three days and at the end of the three-day observation, they attended meetings and discussed their observations in two days time. During this five-day period, manufacturing operations continued smoothly, also any loss in production was not observed. Therefore, the optimization does not have any extra cost to business. To avoid unnecessary transfers and waste in production a good team work and observation is adequate. By means of this study, workers participated in the management and production system and a recommendation system is developed.

With the optimizations made in production, the old setup employing 44 employees is replaced with the new setup requiring only 39 employees which achieves the same production level, therefore saving manpower of 5 and no need to change the working hours or resulting in any production loss. Realized optimizations are put into practice with the help of a team of 5 "model recommendation team" whose leader is the department manager and thus another principle of lean production is taken advantage of.

3. RESULTS AND DISCUSSION

The monthly savings as a result of the optimizations realized is shown in Table 2.

Table 2. Cost-benefit analysis

Change in the number of manpower (in personnel quantity)				Difference	Cost of the cardboard pocket pattern (TL)			Total benefit			
Mass production		Lean production			The old setup	The new setup	Difference	Benefit by the reduced number of manpower	Benefit by pocket pattern	Benefit by SMED	Total
Prep. line	Assembly line	Prep. line	Assembly line								
24	20	20	19	5	66	7	59	TL 5.250	TL 59	TL 540	TL 5.849

If Table 2 is examined in detail;

- Cost of 1 employee 35 TL per day, The monthly cost of 5 employees: $5 \times 35 \times 30 = 5.250$ TL/month.
- Cardboard pocket pattern cost (per month) = 66 TL/ month, cost of the isolation material for pocket pattern (per month) = 7 TL/month the benefit from the change of pocket pattern material = $66 - 7 = 59$ TL/month.
- 15×1 hour = 15 hours of time savings by SMED. Considering the minute cost of the business as 0,6 TL, the benefit of this period; $15 \times 60 \times 0,6 = 540$ TL/month.
- These practices prove the savings of the business to be 5,849 TL per month.
- At the end of the study, between the dates 01.06.2009 – 31.01.2010 in a seven months time total saving is 5.849×7 months = 40.943 TL.

When the above studies is examined, it will be clear that none of the optimizations impose an additional cost to business, thus there isn't any need for the cost part of cost-benefit analysis, as it is zero.

4. CONCLUSION

Apparel businesses are also in the search of a way out through lean production. The main target of this technique is to cut down all unnecessary cost. Taking advantage of lean production techniques does not have any extra costs to the business.

As it is observed in this research study the most saving side is in the number of the employees, followed by time saving ensuring the shorter transition, this excess employees and time should be used for a new plan of targeting an increase in productivity, besides budgetary savings are gained by a change of the material.

By looking over the details of this study it is observed that improvement operations do not cost extra budget to the company, the only necessity is just the employees work more consciously and focus on the target. Eliminating even a small movement in the business will make a major contribution to profitability if considered as a whole. However, managers and employees who desire to implement these techniques are required. Particularly the engineers working in manufacturing have an important role to carry out. As they are the ones

dealing with the problems of production and have a general knowledge of operations; they are the ones to realize the waste and work for eliminating these wastes.

All the processes employed in a business should be waste-free lean processes. As a solution to these problems, small orientation programs within the body of a business would be very beneficial in which the employees work in different departments for a short period of time. Sequential departments in the apparel industry generally focus on its own job description and to complete its own task without caring or having an idea about other departments. The following department finds it self in a situation where it has to tolerate and fix the mistakes of the previous one as well as running its own task. While, there should not be any errors in the previous processes. Therefore, Employees should have knowledge of other processes as well as the one they are working on. Thus, they can make suggestions to optimize other processes and minimize both the waste and fault.

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Journal Summary List

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Sorted by:

Journals 1 - 20 (of 22)

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Ranking is based on your journal and sort selections.

Mark	Rank	Abbreviated Journal Title <i>(linked to journal information)</i>	ISSN	JCR Data						Eigenfactor [®] Metrics	
				Total Cites	Impact Factor	5-Year Impact Factor	Immediacy Index	Articles	Cited Half-life	Eigenfactor [®] Score	Article Influence [®] Score
<input type="checkbox"/>	1	AATCC REV	1532-8813	215	0.254	0.321	0.034	29	8.9	0.00020	0.065
<input type="checkbox"/>	2	AUTEX RES J	1470-9589	196	0.618		0.038	26	7.4	0.00019	
<input type="checkbox"/>	3	CELLULOSE	0969-0239	4238	3.033	3.925	0.530	268	4.8	0.00746	0.719
<input type="checkbox"/>	4	COLOR TECHNOL	1472-3581	787	1.173	1.170	0.155	58	6.8	0.00093	0.200
<input type="checkbox"/>	5	DYES PIGMENTS	0143-7208	8559	3.468	3.255	0.951	387	6.0	0.01092	0.553
<input type="checkbox"/>	6	FIBER POLYM	1229-9197	1502	1.113	1.361	0.112	313	4.3	0.00313	0.236
<input type="checkbox"/>	7	FIBRE CHEM+	0015-0541	313	0.167	0.227	0.013	80	>10.0	0.00030	0.044
<input type="checkbox"/>	8	FIBRES TEXT EAST EUR	1230-3666	832	0.541	0.712	0.050	120	5.6	0.00114	0.110
<input type="checkbox"/>	9	IND TEXTILA	1222-5347	85	0.475	0.310	0.302	53		0.00010	0.029
<input type="checkbox"/>	10	INDIAN J FIBRE TEXT	0971-0426	512	0.778		0.062	64	5.5	0.00092	
<input type="checkbox"/>	11	INT J CLOTH SCI TECH	0955-6222	329	0.333	0.493	0.031	32	9.8	0.00031	0.135
<input type="checkbox"/>	12	J AM LEATHER CHEM AS	0002-9726	467	0.714	0.739	0.087	46	8.7	0.00044	0.118
<input type="checkbox"/>	13	J ENG FIBER FABR	1558-9250	247	0.778	1.150	0.042	48	3.8	0.00076	0.252
<input type="checkbox"/>	14	J IND TEXT	1528-0837	326	1.200	1.680	0.119	42	5.8	0.00060	0.370
<input type="checkbox"/>	15	J NAT FIBERS	1544-0478	135	0.512	0.558	0.034	29	6.0	0.00021	0.103
<input type="checkbox"/>	16	J SOC LEATH TECH CH	0144-0322	283	0.414	0.392	0.056	36	9.3	0.00020	0.064
<input type="checkbox"/>	17	J TEXT I	0040-5000	1253	0.770	0.764	0.139	144	>10.0	0.00143	0.158
<input type="checkbox"/>	18	J VINYL ADDIT TECHN	1083-5601	451	1.000	1.208	0.056	36	6.5	0.00070	0.236
<input type="checkbox"/>	19	SEN-I GAKKAISHI	0037-9875	292	0.164	0.164	0.016	127	>10.0	0.00025	0.028
<input type="checkbox"/>	20	TEKST KONFEKSIYON	1300-3356	104	0.245	0.313	0.024	42	4.1	0.00027	0.063