A Study on the Cost-Effectiveness of a Semi-Automated Cutting Process at a Garment Manufacturing Company

Castro, Mark Daniel[1], Consolacion, Ma. Patricia[2],
Julian, Pamela Grace[3],Moong, Rienna Seara[4],
Carlos Ignacio P. Lugay, Jr. (PhD, PIE, ASEAN Eng)[5]
Department of Industrial Engineering, Faculty of Engineering, University
of Santo Tomas, Philippines
markdanielcastro@gmail.com[1], patconsolacion@gmail.com[2],
pgdjulian@gmail.com[3], searamoong@yahoo.com[4], cplugay@ust.edu.ph[5]

Abstract –*The subject of the study, Company X, has been experiencing variations in the quantity report from the cutting department and the transmittal reports. The management found that these processes are hugely affected by manual labor. To reduce the system's proneness to human error, the management decided to explore the possibility of adapting a semi-automated spreading and cutting process in the system. This research aims to evaluate the pre-sewing processes of Company X and whether introducing automation can be beneficial to the company and the garments industry. The researchers used process mapping tools, descriptive research, and process flowchart to assess the current and proposed systems, and engineering economics to evaluate the cost and benefits of implementing the semi-automated system.*

The results showed that with the implementation of the semi- automated system; the company will incur 66.61% more savings per year than the current system. In terms of cycle time, the semi-automated system eliminated the relaxation of fabric before the cutting process, thereby greatly reducing cycle time.

In addition, the researchers found that as long as the company produce more than 4,140 pieces per day for the system will be economically feasible.

Unquantifiable benefits are also identified on introducing the semi- automated system to the company. The company can have a cleaner work environment that will lead to more productivity and greater quality of goods. This will lead to a better company image that will encourage more customers to place job orders.

Keywords –*pre-sewing processes, automation, garments industry*

INTRODUCTION

In today's dynamic economic environment, there is a constant need for improvement in processes. A company cannot rest on past performance and expect to remain successful [1]. In order for an industry to remain competitive, it needs to upgrade technology, rationalize cost of production, improve product quality and speed of delivery, maintain high labor standards, and develop a domestic input base (World Trade Organization Secretariat, 2004) [2]. The subject of the study, Company X, has been in the garments industry since 1999. Because the company has thousands of job orders per year to accomplish, the company always seeks new ways to improve its processes. The focus of efficiency in the apparel industry is to reduce the material costs, which often reach up to 75% of total production costs [3]. Cutting is considered to be the most important operation in apparel manufacturing because firstly, it handles the costliest material resource- the fabric. Secondly, the spreading and cutting process is irreversible; the concept of repair or alteration does not work here [4]. About 60- 70% of the cost of a garment is in the fabric. As such, it is vital that one orders appropriately and tracks the cutting room processes to keep errors to a minimum [5].

The management of Company X discovered that there were discrepancies with their declared cut goods. The goods declared by the cutting department and with the next process did not match up. The discrepancies can come from cutting or counting errors, both of which are manually done. Because of

this, the company wants to limit the human errors since these have a corresponding monetary loss for the company. The management decided to explore the possibility of investing on a semi- automated cutting system that will lessen human intervention, therefore decreasing the cutting department's proneness to human error. The semi- automated cutting system covers two processes: spreading and cutting. The necessary fabrics are spread over long cutting tables in many layers (or plies) and a cutting knife (or laser) follows a predetermined mold unique to each style to cut the cloth and generate the components of a final garment. The fabric as it is sequentially spread, folded, spread, and folded on a cutting table to form a lay. Once a sufficient number of layers in a lay to fulfill a demand have been reached, the fabric can be cut following predetermined patterns. A lay will have as many patterns as allowed by the length of the respective cutting table. The spreading of fabric onto cutting tables in several layers, and the cutting of this fabric in the most cost- efficient manner to produce a pre- determined number of garments is the apparel manufacturing phase that precedes assembly (sewing) and finishing. Fabric spreading and cutting is a crucial component of the apparel manufacturing process preceding garment assembly because in this stage, manufacturing costs can be significantly reduced through efficient resource utilization [6]. The main objective of this study is to evaluate the present cutting process of the company and determine the effectiveness of the semi- automated system.

OBJECTIVES OF THE STUDY
Primary Objective/s
The primary objective of this study is to evaluate the pre-sewing processes of Company X and to determine the effectiveness of the new system and its benefit to the company.

Effectiveness is measured in terms of quality of output, cost, and cycle time.

Secondary Objective/s
- Assess the pre-sewing processes, both of the current and the proposed system
- Identify the expenses involved in the current cutting process and the proposed system
- Evaluate the effectiveness of the of the proposed system
- Assess the feasibility of the proposed system

MATERIALS AND METHODS
Research Design
The research design used in this study was a combination of design-demonstration and comparative research design. Design-demonstration is a type of research design wherein new systems or programs are constructed, tested, and evaluated. The new system was evaluated and comparisons were made between the two systems to determine which is more productive and cost-efficient. After the researchers determined the causes of variation in the number of outputs in the different processes, the management of the company wanted to implement a semi-automated system that will lessen the influence of human error in the process. The researchers are tested and evaluated the efficiency and effectiveness of the new process in terms of its costs, production time and cycle time, and the quality of its output. Cost-benefit analysis was used to compare the new semi-automated system with the manual system.

Data Measurement
Since the study does not require the use of measuring devices and other instruments, the data gathering was done through an interview with the management and supplier. For the acquisition of specific information on how the operations take place, the management introduced the researchers to the employees who handle each major operation. The researchers recorded notes about the processes. The management also provided historical data regarding the cutting quantity and transmittal, which includes the quantity of cut goods before transferring it to the printing, embroidery or to the sewing department. The data recorded are per job order. The researchers also conducted actual observation in the cutting department and in the other departments as well. During the observation, the person-in charge for the particular department explained the actual processes and the data recording, as well as how the different forms and charts involved are made.

Data Gathering Procedure
The researchers conducted an unstructured interview with the management regarding the whole production process. The interview was done to determine the existing problems in the production and which of these would the management want to be solved. The data needed to analyze the scope of the problem was readily handed to the researchers in the form of cut quantity reports from the months August through September. The workers involved in the

cutting process were also interviewed to gain understanding of the process that will aid the researchers in their study. The researchers were also invited to a pitch meeting of the management with the potential supplier of the cutting machine. This provided them the information needed to create a cost-benefit analysis of the automation of the cutting process and the present process. This enabled them to compare the processes and formulate a recommendation for the company.

Mode of Data Analysis

The researchers used a cost-benefit method in analyzing the feasibility of introducing the proposed system to the company. The output of the data analysis is the amount of capital investment and its associated expenditures recovered by revenue or savings, acceptability of the return on capital, and recommendations. The output will be produced by systematically analyzing key areas of interest.
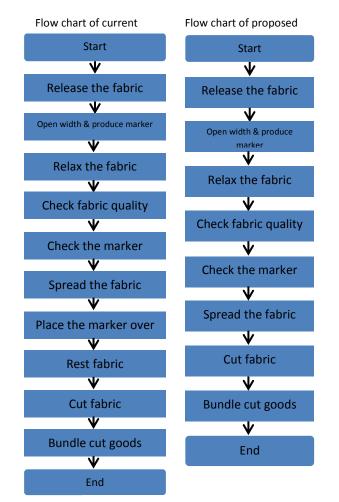
Ethical Considerations

Permission to use the available cutting quantity data was asked from the management. All the interviews conducted were done with consent from the management and the employees involved.

With the purchase of the cutting machine, multiple employees will have to be terminated because their jobs can be done by the machine. The employees working in the cutting department will be affected by this change. As industrial engineers, it is the researchers' responsibility to make sure that production is efficient but in doing so, there are times when the industrial engineer's decisions have bad consequences on the workers. The benefits of automation versus the welfare of the employees must be carefully weighed in coming up with the ideal solution to the problem.

It is therefore important to determine the number of workers that will be affected by the installation of the cutting machine and the number of workers needed to operate the machine. This is to determine the number of workers that will possibly be displaced if the automation is pushed through. Options should be explored if many workers will be affected other than termination; transferring employees to another department, job sharing, and etc. are possible solutions.

RESULTS AND DISCUSSION

To come up with a recommendation to the company, the researchers have to understand current system with the proposed system to see which one is better. This is done through comparing the process flow of the two systems and using Engineering Economic tools on the financial aspect.

Figure 1. Process Flow Comparison

Cycle time for a 10 meter marker with 100 layers: 480 minutes

Cycle time for a 10 meter marker with 100 layers: 40 minutes

The researchers did a cost- benefit analysis and sensitivity analysis to compare the current and proposed system. The purpose of doing a cost- benefit analysis on the systems is to determine if the benefits of the system outweigh the corresponding costs of implementing it. In this scenario, the benefit is the net savings per year of the company for implementing the system rather than subcontracting it. The sensitivity

analysis is done to determine the earliest time the company can pay a loan that is used for investing in the proposed system. Capacity analysis is also done to know the maximum output the proposed system can produce. The break-even point is the unquantifiable benefits of implementing the proposed system are also discussed.

Cost- Benefit Analysis

The effectiveness of the system is measured in terms of the net savings per year if the system is used instead of subcontracting the work to outside parties. The cost per piece in subcontracting is PhP2.50. The cost is then multiplied to the output per day (6,000 pieces) and the time period (313 days) to get the cost of subcontracting per year.

The effectiveness of the system is measured in terms of the net savings per year if the system is used instead of subcontracting the work to outside parties. In the current system, the total expense is computed to know the difference in the cost of subcontracting. The expenses include labor cost, consumables, and rent. Labor cost is comprised of the salary per year of an employee and 15 personnel. Consumables comprise of materials and parts that need replacement every month. In the proposed system, the same procedure in the current system is followed. The expenses include labor, consumables, utilities, and rent. Labor cost is the salary per year of an employee and 12 personnel.

Consumables include knife, grinding stone, and bearing. Utilities refer to the electricity consumption ofthe machine.

$$AW(i\%) = R - E \quad \text{(Equation 1)}$$
AW = annual worth of the project
R = Cost of outsourcing
E = Annual expense for in house production

Table 1. Cost of Subcontracting

Price per piece		PhP 2.50
Output (pieces/ day)		6,000
Period		313 days
Cost per year	(PhP 2.50x 6,000x 313)	PhP 4,695,000.00

Table 2. Detailed Cost of Current System

Labor			
Number of employees	1		
Salary/ year (13th month pay inclusive)	Rate/month: PhP 22,800	1[(PhP 22, 800x 12) + PhP 22,800]	PhP 296,400.00
Number of personnel	15		
Salary/ year (13th month pay inclusive)	Rate/day: PhP 491	15[(PhP 491x 313) + (PhP 491x 313)/12]	PhP 2,497,348.75
Total Labor Cost			PhP 2,793,748.75
Consumables			
Abrasive Belt	Piece/month: 1		
Cost/ year	Cost/ piece: PhP 350	(350x 1)(12)	PhP 4,200.00
Eastman Blade 10"	Pieces/month: 20		
Cost/ year	Cost/ piece: PhP 47	(47x 20)(12)	PhP 11,280.00
Eastman Blade 8"	Pieces/month:20		
Cost/ year	Cost/ piece: PhP 45	(45x 20)(12)	PhP 10,800.00
Kraft (special) 72" 30kg/kilo	Pieces/month: 270		
Cost/ year	Cost/ piece: PhP 35	(35x 270)(12)	PhP 113,400.00
Kraft Paper (brown) 72" 30kg/kilo	Pieces/month: 600		
Cost/ year	Cost/ piece: PhP 30	(30x 600)(12)	PhP 216,000.00
Total Consumables Cost			PhP 355, 680.00
Rent			PhP 672,000.00
Total Expenses			PhP 3,821,428.75

Table 3.Difference of the Costs of Subcontracting and the Current System

Net Savings per year	=	Cost of Subcontracting - Cost of Current System
	=	PhP 4,695,000.00 - PhP 3,821,428.75
	=	PhP 873, 571.25

Table 4. Detailed Cost of the Proposed System

Labor			
Number of employees	1		
Salary/ year (13th month pay inclusive)	Rate/month: PhP 22,800	1[(PhP 22, 800x 12) + PhP 22,800]	PhP 296,400.00
Number of personnel	12		
Salary/ year (13th month pay inclusive)	Rate/day: PhP 491	12[(PhP 491x 313) + (PhP 491x 313)/12]	PhP 1,997,879.00
Total Labor Cost			PhP 2,294,279.00
Consumables			
Knife			
Lifespan	20 hours		
Cost/year	Cost/piece:$8	[(313 daysx 4 hours cutting time/day)/20]($8)(PhP 49.1)	PhP 24,589.28

115

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 5, No. 4, November 2017

Table 4 (cont). Detailed Cost of the Proposed System

Grinding Stone			
Lifespan	6 months		
Cost/year	Cost/piece:$177	(2x $177)(PhP 49.1)	PhP 17,381.40
Bearing			
Lifespan	6 months		
Cost/year	Cost/piece:$45	(2x $45)(PhP 49.1)	PhP 4,419
Total Consumables Cost			PhP 46,389.68
Utility			
Electricity			
Consumption	12KW/hour		
Duration	8 hours/ day, 6 days/week	8 hours/dayx 6 days/weekx 52 weeks/year= 2496 hours	
Total Utility Cost	Rate: PhP 7.5749/KWh	12KW/hourx 2496 hoursxPhP 7.5749/KWh	PhP 226,883.4048
Rent			PhP 672,000.00
Total Expenses			PhP 3,239,552.085

Table 5. Difference of the Costs of Subcontracting and the Proposed System

Net Savings per year	= Cost of Subcontracting - Cost of Proposed System
	= PhP 4,695,000.00 - PhP 3,239,552.085
	= PhP 1,455,447.915

Table 6. Summary of Comparison of the Analysis

	Current System	Proposed System
Number of Process	10	8
Average Cycle Time	160 minutes	40 minutes
Net savings/ year	Php 873,571.25	Php 1,455,447. 915

Sensitivity Analysis

The capital investment for the proposed system is PhP 6,800,000.00. The money for the capital will be a loan from a bank, with a lending rate of 6.25%.

Required output per day = ((AWI + E)/ P) ÷ d (Equation 2)

AWI = annual worth of the Initial Capital Investment

$$AWI = PV \ \frac{i \ (1+i)^N}{(1+i)^N - 1} \quad \text{(Equation 2)}$$

PV = Initial Capital Investment
E = Expenses per year
i = Lending rate
P = Cost of outsourcing per piece of output
N = Study Period = Number of Payments
D = Number of working days in a year

Table 7. Capital Investment

Capital Investment	
Loan	Php 6,800,000.00
Lending Rate	6.25%

Table 8. Projection of Loan Payment per year for 10 years

Year	PMT(rate, nper, pv, [fv], [type])	Amortization/Year
0	-	PhP 6,800,000.00
1	PMT(0.0625,1,6800000)	PhP 7,225,000.00
2	PMT(0.0625,2,6800000)	PhP 3,721,969.70
3	PMT(0.0625,3,6800000)	PhP 2,555,722.15
4	PMT(0.0625,4,6800000)	PhP 1,973,668.33
5	PMT(0.0625,5,6800000)	PhP 1,625,289.81
6	PMT(0.0625,6,6800000)	PhP 1,393,746.58
7	PMT(0.0625,7,6800000)	PhP 1,228,963.94
8	PMT(0.0625,8,6800000)	PhP 1,105,904.14
9	PMT(0.0625,9,6800000)	PhP 1,010,657.00
10	PMT(0.0625,10,6800000)	PhP 934,876.14

To determine the feasible year that the loan can be paid, the minimum number of output per day is calculated. The minimum number of output per day should be less than or equal to 6,000 units, the current rate of production of the company. The proponents assumed that the production rate is constant for this analysis. To determine the minimum output per day, the minimum output per year is first calculated. The following formula is used:

Minimum Number of Output/Year = Amortization/Year + Cost of Proposed System
PhP 2.50
(Equation 4)

Table 9. Summary of Sensitivity Analysis

Year	Amortization/Year	Minimum Number of Output/Year	Minimum Number of Output/Day
0	PhP 6,800,000.00	4,015,821	12,830
1	PhP 7,225,000.00	4,185,821	13,373
2	PhP 3,721,969.70	2,784,609	8,897
3	PhP 2,555,722.15	2,318,110	7,406
4	PhP 1,973,668.33	2,085,288	6,662
5	PhP 1,625,289.81	1,945,937	6,217
6	PhP 1,393,746.58	1,853,319	5,921
7	PhP 1,228,963.94	1,787,406	5,711
8	PhP 1,105,904.14	1,738,182	5,553
9	PhP 1,010,657.00	1,700,084	5,432
10	PhP 934,876.14	1,669,771	5,335

Looking at the minimum number of output per day, the closest output to 6,000 is in the 6th year.

This means that in order for the company to pay the loan, they would have to pay PhP 1,393,746.58 each year and produce 5,921 units per day for 6 years. It can be concluded that the earliest year that the company can pay back the loan while producing the feasible number of outputs is in 6 years.

Capability Analysis of the Proposed System

Table 10. Equipment and Machineries for the Proposed System

Equipment and Machineries	Model	Quantity
Air Tables	-	3
Spreading Machines	SM- IIA	2
Auto Cutter	HY-H/ HY-HC Series	1

The researchers want to analyze first the capability of the proposed system to check if it can produce the company's desired output. In doing this analysis, the researchers would like to find out the maximum output capability of the proposed system. They made some assumptions for the basis for the computations. For the marker specifications, the assumptions are: marker length (based on the average marker length currently being used), the number of size sets (based on a 10 meter marker length), and the standard number of pieces per size.

Assumptions made on the specifications for the spreading machine are the fabric (based on the type of fabric used by the company) and the spreading duration. The researchers will get the longest spreading duration of 80 minutes in order to be conservative.

Assumptions made on the specifications on the Auto Cutter are the fabric type; layers of fabric based on marker, and cutting duration. In order to be conservative, the researchers used the longest cutting duration of 40 minutes.

Table 11. Theoretical Capacity of Proposed System

Work Station	Cycle Time/Machine	Number of Machines	Total Cycle Time
Spreading	80 minutes	2	40 minutes
Air Table	120 minutes	3	40 minutes
Cutting	40 minutes	1	40 minutes
Cycle Time of Cutting Process			40 minutes

Table 11 (cont). Theoretical Capacity of Proposed System

Capacity of 10m Marker with 100 Layers of Fab		
Average Number of Sizes	18	
Number of Pieces Per Size	4	
Average Number of Pieces Produced	18x 4x 100	7,200 pieces
Average Number of Pieces Produced/ 8- Hour Work Day	7,200x 8	57,600 pieces

Break- Even Point Analysis

In break- even analysis, the cost of subcontracting per year and the cost of proposed system per year is considered. The cost of subcontracting is used instead of the cost of the current system because the company's only goal is to produce units at a cheaper price compared to the subcontractor, regardless of what system is used. The cost of proposed system is used in this analysis because it has more net savings per year than the current system.

To compute for the break- even point, the cost of subcontracting per year is equated to the cost of proposed system per year. Since the cost of proposed system is constant, the break- even number of outputs is determined by assigning the number of outputs in the cost of subcontracting.

Required output per day $= R/E$ (Equation 5)
$R =$ Cost of outsourcing
$E =$ Annual expense for in house production

Table 12. Break-even Point between Subcontracting and the Proposed System

Break Even Point	
Cost of Subcontracting/year	= Cost of Proposed System/year
(PhP 2.50)(x)(313 days)	= PhP 3,239,552.085
	x = 4,140 pieces/day

This means that the company would have to produce greater than 4,140 pieces per day in order for the proposed system to cost less than subcontracting.

Plotting the given information in Table 13, Figure 2 shows the break- even point, in terms of cost and number of outputs per day. The x- axis represents the number of outputs per day and the y- axis represents the cost of the systems. Through this graph, it can be confirmed that the break- even point is indeed 4, 140 pieces per day or PhP 3,239,552.085.

Table 13. Projection of Costs of Subcontracting and the Proposed System Based on Output/Day

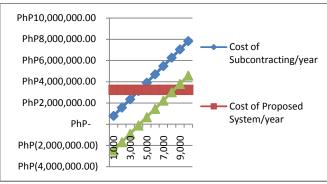| Pieces/day	Cost of Subcontracting/year	Cost of Proposed System/year	Cost of Subcontracting/year - Cost of Proposed System/year
1,000	PhP 782,500.00	PhP 3,239,552.09	PhP (2,457,052.09)
2,000	PhP 1,565,000.00	PhP 3,239,552.09	PhP (1,674,552.09)
3,000	PhP 2,347,500.00	PhP 3,239,552.09	PhP (892,052.09)
4,000	PhP 3,130,000.00	PhP 3,239,552.09	PhP (109,552.09)
5,000	PhP 3,912,500.00	PhP 3,239,552.09	PhP 672,947.92
6,000	PhP 4,695,000.00	PhP 3,239,552.09	PhP 1,455,447.92
7,000	PhP 5,477,500.00	PhP 3,239,552.09	PhP 2,237,947.92
8,000	PhP 6,260,000.00	PhP 3,239,552.09	PhP 3,020,447.92
9,000	PhP 7,042,500.00	PhP 3,239,552.09	PhP 3,802,947.92
10,000	PhP 7,825,000.00	PhP 3,239,552.09	PhP 4,585,447.92

Figure 2. Graph of the Break-Even Point Analysis

Analysis of Unquantifiable Benefits of the Proposed System

Cleaner work environment

With the current system, the cutting process produces lots of mess. The picture of the current system above shows this. Strips of fabric and paper from the process are scattered on the floor. This creates a messy work environment. With the proposed system, the fabric is shrink-wrapped before being cut. As a result, residue from cutting is contained in the plastic, making it easier to clean up and dispose of. A clean work environment increases productivity and improve quality.

Customer impact

Implementing the new technology in the company can sometimes be what it takes to get a purchase order. The management once experienced this. During a plant tour, a potential customer was shown a newly introduced automated drying machine for the printing department. The potential customer was so impressed that a purchased order was immediately placed.

Implementing the proposed system will make the production system look better. It could be the wow factor that would impress customers and bring in more purchase orders. If the customer sees that the company is well equipped, they can be convinced to entrust them with bigger orders.

CONCLUSIONS AND RECOMMENDATION

The purpose of the study is to determine the cost-effectiveness of the proposed system. It can be easily observed that the total expense that will be incurred of the semi- automated system is higher than the total expense of the current system. Also, the process flow of the proposed system is clearly shorter than the current system but it doesn't necessarily mean that it is better. To identify which system is more beneficial for the company, the proponents conducted different analyses.

In the cost-benefit analysis, the costs of both the current and proposed system are less than the cost of subcontracting. The proposed system has 66.61% more net savings per year than the current system. For this reason, it has been set as the subject of the sensitivity analysis. The loan payment per year is calculated using the PMT function in Microsoft Excel. The company needs to pay approximately PhP 1.4 million and produce the feasible amount of output which is 5,921 per day in a span of 6 years, which is the earliest time period where the company can pay back the loan based on the results of the computation. The maximum output capability of the proposed system was also determined to know how much more it can render. The capability analysis results show that, on ideal conditions, the proposed system can produce 57,600 pieces of cut goods per day, given an 8-hour workday. The output capability of the proposed system is more than capable to produce the company's required output. The approaches done are effective to determine the quantifiable benefits of the proposed system.

For the analysis of unquantifiable benefits, through the proposed system, the company will have a cleaner work environment that will lead to more productivity and greater quality of goods that will lead to a better company image, encouraging more customers to place job orders.

In conclusion, both quantifiable and unquantifiable benefits are justified through the analyses done. The results showed that the benefits

118

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 5, No. 4, November 2017

outweigh the costs incurred in purchasing the proposed system. The implementation of the semi-automated machine will be a good decision for the company.

The researchers recommend the implementation of the semi-automated system as it will significantly improve the productivity of the system. If the semi-automated system is pursued, the researchers recommend that the company produce more than 4,140 pieces per day for the system to be economically feasible. They also recommend conducting further studies such as time and motion study to help standardize the work in the new system, and a study on the effect of implementing the new system in the cutting department to the succeeding operations. Also, they would like the company to consider other automated machines that the supplier presented.

For future researchers, the researchers recommend to focus on the other processes of a garments manufacturing company. The cutting process is just one of the many essential processes in the company and improving other aspects such as transportation of the materials, sewing process, etc. will yield significant results in the improvement of the overall productivity and efficiency of the plant. The researchers also recommend benchmarking different companies in order to improve the competency of the company in the industry.

REFERENCES

[1] Vedpal & Jain, V.(2013). Basic of process control in textile manufacturing.(Indian Institute of Technology, India).

[2] Gamage J.R., Vilasini P.P.G.N., Perera H.S.C., and WijenathaL.,Impact of Lean Manufacturing on Performance and Organisational Culture: A Case Study of An Apparel Manufacturer in Sri Lanka?, The third international conference on Engineering,Project and Production Management (EPPM), United Kingdom, September 2012.

[3] Zhezova, S., Dembosk, G., &Panov, V. (2013). Optimization of Technological Process of Cutting by Use of Software Applications for Cut Order Planning. Retrieved from https://goo.gl/8K3yY4

[4] Ambastha, M. (2012,September). Performance Measurement Tools – 3 Cutting and Production Planning. Stitchworld,38-41.

[5] Nayak, R., &Padhye, R. (Eds). (2015). Garment ManufacturingTechnology.Amsterdam:Woodhead Publishing.

[6] Nascimento, D., De Figueiredo, J., Mayerle, S., Nascimento, P., &Casali, R. (2010, July). A State-space Solution Search Method for Apparel Industry Spreading and Cutting. International Journal of Production Economics, 379-392. Retrieved from https://goo.gl/uLGvHa

COPYRIGHTS