ASSEMBLY LINE BALANCING USING SIMULATION TECHNIQUE IN A GARMENT MANUFACTURING FIRM

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ABSTRACT

The typical problems facing with garment manufacturing are: short product cycle for fashion articles, long production lead time, bottlenecking, and low productivity. To alleviate the problems, different types of line balancing techniques have been used for many years in the garment industry. However, garment industries which are based on manual-operations oriented system do not still gain significant results with the techniques and difficult to forecast future events when they want to change or modify the production system. The objective of this paper is to develop a simulation model which represent real production process scenarios of garment products that helps to identify the bottlenecks and enhance production system performance. The study has considered basic polo-shirt to investigate and demonstrate the application of simulation technique. For this purpose, in 2009, data are collected from real system (AAYSC-Knit wear garment in Ethiopia) and different alternative systems have been considered in order to find the best one.

Key words: *Line balancing, simulation technique, garment manufacturing firms*

INTRODUCTION

Process modeling and simulation are the techniques available to support companies like Garment manufacturing in gaining a better understanding of their manufacturing system behaviors that helps for decision making. Process modeling provides management with a static structural approach to business improvement, providing a holistic perspective on how the business operates, and provides a means of documenting the business processes. Process simulation allows management to study the dynamics of the business and to consider the effects of changes without risk. With simulation models, we can explore how an existing system might perform if altered, or how a new system might behave before the prototype is even completed, thus saving on costs [1, 2].

Nowadays garment industry makes a significant contribution to national economy in many developing countries. Those countries are exploiting this industry to earn valuable foreign exchange by exporting garment products for their economic growth [3]. Likewise, garment manufacturing firms in Ethiopia should improve overall performance to cope up with the continual stiff competition of the international market. The major stumbling block of Ethiopian garment industry for global competitiveness is low productivity performance.

In manual-operations oriented system of garment manufacturing, there are different operations, which are done manually. If the operation manager needs to develop a new system, he has to observe the real system. However, closely observing the real garment manufacturing system is difficult and expensive [4, 5].

In most cases, it is not possible to carry out experiments on the real production system for its improvement and change since it would be a costly exercise with high financial risk. A simulation model benefits the production management of a factory through gaining its critical insights in respect of resources (man-machine) utilization, production output etc.

The paper is therefore an attempt:

- To develop simulation model that visualize the existing production process of basic polo-shirt in manual-operations oriented system so as to identify the bottlenecks and enhance system performance.
- To demonstrate the method of diagnosing the imbalance status in real time production and see the effects of the system performance with an increment of effective work centers.
- To develop different alternatives (scenarios) so as to improve existing labor utilization rate.

LINE BALANCING CONCEPT

Balancing refers to the procedures of adjusting the operation times at work centers to conform as much as possible to the required CT (cycle time). Required cycle time is the production target of a process or operation that is determined by the demand for the item being produced. A balanced process is one where the actual cycle times at every stage are equal. Actual cycle time represents the actual production capability of a process or operation. In a work cell, the actual cycle time is determined by physical conditions such as the time to perform manual or automatic operations, to walk around the cell, and so on. Strictly speaking the goal of achieving a completely balanced process is appropriate only in processes that are paced, and the material moves on a conveyor or chain at constant speed past workstations [6,7].

$$\mathrm{CT}_{\mathrm{Required}} = \frac{\text{Operating Time}}{\text{Demand}} \tag{1}$$

Line balancing refers to assigning tasks (elemental units of work) to a workstation such that: the CT of the combined sequence of workstations satisfies the required $\mathrm{CT}_{\mathrm{required}}$, the tasks are assigned in the right order, and the assignment is as efficient as possible. First, the output of the sequence of workstations is adequate to meet demand. For that to happen, the CT of the slowest workstation in the line must not exceed the $\mathrm{CT}_{\mathrm{required}}$. Second, the assignments of task to workstations meet precedence requirements. Whenever a number of tasks are to be performed, there is a logical sequence or ordering that must be followed. Third, the resultant number of workstations or operations in the line is the minimum possible given the $\mathrm{CT}_{\mathrm{required}}$ and precedence relationship [8].

Total work content in line balancing

The work content performed on an assembly line consists of many separate and distinct work elements. Invariably, the sequence in which these elements can be performed is restricted, at least to some extent. And the line must operate at a specified production rate, which reduce to a required cycle time. Given these conditions, the line balancing is concerned with assigning the individual work elements so that all workers have an equal amount of work. The two important concepts in line balancing are minimum rational work element and precedence constraint which constitutes the total work content [9].

Minimum rational work element: It is a small amount of work having a specific limited objective, such as adding a component to the base part or joining two components or performing some other small portion of the total work content. A minimum rational work element cannot be subdivided any further without loss of practicality. The sum of the work element times is equal to the work content time; that is,

$$T_{wc} = \sum_{k=0}^{n_e} T_{ek} \tag{2}$$

where

T_{ek} = time to perform work element k (min),

n_e = number of work elements into which the work content is divided; that is, $k = 1, 2\ldots$

In line balancing, it is assumed that element times are constant values, and T_{ek} values are additive (the time to perform two or more work elements in sequence is the sum of the individual element times).

Different work elements require different times, and when the elements are grouped into logical tasks and assigned to workers, the station service times T_{si} are not likely to be equal. Thus, simply because of the variation among work element times, some workers will be assigned more work, while others will be assigned less. Although service times vary from station to station, they must add up to the work content time:

$$T_{wc} = \sum_{i=1}^{n} T_{si} \tag{3}$$

Precedence constraints: In addition to the variation in element times that make it difficult to obtain equal service times for all stations, there are restrictions on the order in which the work elements can be performed. Some elements must be done before others. This technological requirement is called precedence constraints. Precedence constraints can be presented graphically in the form of a precedence diagram, which indicates the sequence in which the work elements must be performed.

Effect of time variations in line balancing

In assembly line balancing, a garment manufacturer is interested in whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall. The role of a supervisor is to ensure that the tasks are allocated to each workstation as evenly as possible and to assign appropriate operatives to each station of an assembly line. The determination of the production time for each task is critical in the line balance of an assembly line. Ideally each workstation on the assembly line should receive an equal amount of work in time units; otherwise a bottleneck will occur on an assembly line. In most garment enterprises, the estimation of production time for each task is by reference to Standard Minute Value (SMV). The characteristic of SMV is deterministic in nature, derived from the method of work study. However, it cannot reflect the real production environment because a lot of factors such as the properties of fabric and sub-materials, performance of machinery, working environment and quality level of the product may cause variations on the task time. Such variations on task time cause the assembly line balancing problem in the garment industry to become more complicated [2].

Measuring effectiveness of balance in the assembly line

Modie and Young [9] proposed smoothness index (SI) for measuring the effectiveness of balance in assembly lines, i.e. defined as:

$$SI = (\sum_{K=1}(S_{\max} - S_k)^2)^{1/2} \quad k = 1,2,..,N_{stns} \tag{4}$$

Where $S_{\max}$ is the maximum station time, N_{stns} is the number of workstations and S_k is the individual station time. The station time (S_k) of each station is calculated using the relation

$$S_K = S_{mean} + \sigma(S_{\text{var}})^{1/2} \tag{5}$$

Where σ is the confidence coefficient for normally distributed work element times and S_{mean} and S_{var} are the sum of the means and the sum of the variances, respectively, of all the tasks allotted to that particular workstation. The value of σ can be varied according to the experience of the decision maker. In Eq. (4), time variance is a crucial element in measuring the effectiveness of line balancing. The smaller the *SI*, the higher is the balancing effectiveness.

In Eqs. (4) and (5) above,

If variance $\rightarrow 0$, it implies that $S_k = S_{mean}$.

$$\therefore \left(S_{\max} - S_{mean} - \sigma(S_{\text{var}})^{1/2}\right) \le (S_{\max} - S_{mean}) \tag{6}$$
$$\Rightarrow SI_{(with\ time\ \text{var}iance)} \le SI_{(without\ time\ \text{var}iance)}$$

Thus, the above computational results are the logical conclusion. Therefore, the nature of assembly line balance in the garment industry is stochastic because of the existence of task time variations. The smoothness index (*SI*) is an appropriate tool for measuring the effectiveness of assembly line balance in the apparel industry.

PROBLEM DESCRIPTION

In the knit wear garment plant, the raw materials are processed in different departments and finally the product shipped to the customers. Sewing department is the large and most important section in the garment plant and the speed of the assembly process of the components would be under strong control. The model proposed here is based on a re-configurable simulation model to meet customer requirements as well as improve system performances. In sewing department the standard time (S_t) for each operation is calculated by the sum of the base time (B_t), the fatigue allowances (F_a) and the idle time (I_t). The base time consists of the stopwatch time (S_w) and the performance rating (P_r). Thus:

$$S_t = B_t + F_a + I_t = S_w x P_r + F_a + I_t \tag{7}$$

The line balancing problem of sewing departments is solved by using S_t, and it's assumed that all of similar operations are processed simultaneously. However, in reality, all operations are completed at different times because of their stochastic structure, and the stochasticity of operations makes it almost impossible to follow a fixed time pattern.

In this study, the problem under consideration is about the production of a basic polo-shirt. The existing production diagram of a polo-shirt consists of 18 different operations (Fig. 1).

SIMULATION MODEL

The simulation model is built using Simul-8 simulation software. The construction of the model is based on a production process flow in the firm. Sewing machines are organized according to the production process flow. During straight line production each operator uses only one machine.

This study represents discrete-event modeling and the factory works for 450 minutes (7.5 hours) in a day. At the beginning of each order, the production line begins empty. This start-up condition must also be simulated. Statistics during this part of the simulation may negatively bias the final results since the line takes time to “warm up” and begin operating consistently in a steady state. When an entity arrives at a sewing machine, it waits in a first-in-first-out queue until the resource is available. The following assumptions are used to define the problem [5, 11]:

- Set-up times are not taken into consideration, because in a real system the setup process is usually accomplished at the end of the working time,
- 450 minutes working time does not include breaks,
- There is no maintenance process performed during the working period,
- All process times for sewing operations include ‘insignificant breakdowns’ like threading of thread.
- The assembly line is never starved.
- Transportation of raw materials is performed by workers who aren’t used for sewing operations.

In this study, among other products the case under consideration is the production of a basic polo-shirt. The production of a polo-shirt consists of a total of 28 operators (22 stitching operators, 4 bench workers and 2 quality inspectors). The line works for 450 minutes per shift.

PROCEDURES

To run the simulation model, the four phase procedures outlined below have been used.

i. **Problem formulation:** The clear and unambiguous description of the problem, definition of the objectives of the study, identification of alternatives to be considered and method for evaluating the effectiveness of these alternatives was identified at the first phase of this study.

ii. **Model building:** At this stage, the art of modeling was enhanced by the ability to abstract the essential features of the system, to select and modify the basic assumptions and simplification that characterize the system and then improve and elaborate the model.

iii. **Running the model:** At this stage, simulation experiment has been designed in such a way that the results obtained are optimal. Furthermore, the simulation program was tested as per the simulation design. Certain key steps were also taken to ensure validity of the model.

iv. **Summarize and analyze the result:** The final phase of this study was to summarize and analyze the overall aspect of the project. In addition, the result of the simulation run have been presented and documented. At this phase, the result facilities in SIMUL8 enable to collect and review measures of performance. This was the goal of balancing the assembly line in the garment manufacturing firm using simulation techniques.

SIMULATION MODEL INPUT

The data has been collected from Adey Ababa Yarn Share Company (AAYSC) knit wear garment section on basic polo-shirt production line. In the plant, there are 18 work elements or tasks to complete the production of the basic polo- shirt and for each of them the workstation time is recorded using the stopwatch. For each work element, the time is recorded 10 times to determine the time variability distribution and operator performance consistency.

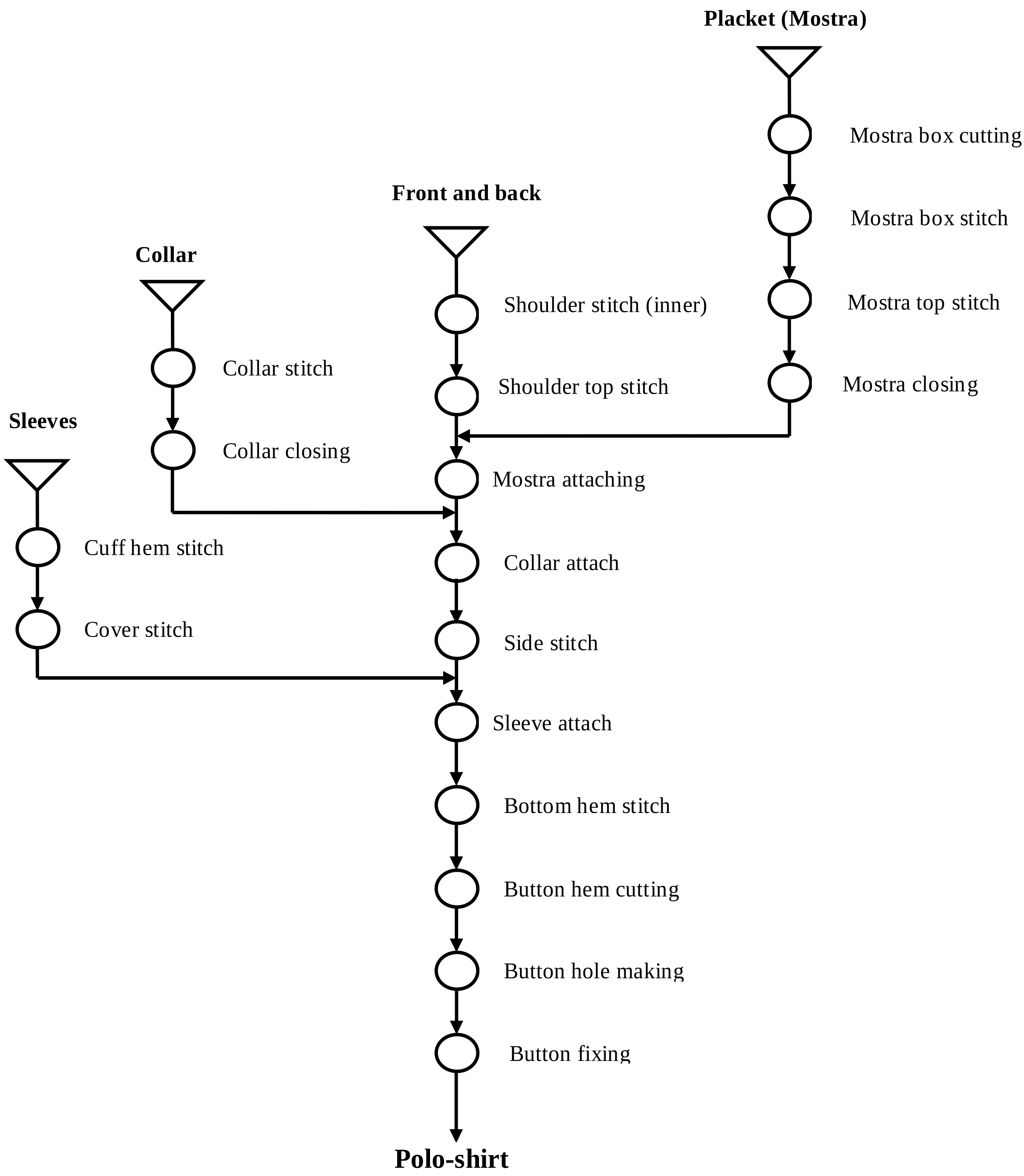


Figure 1 Existing operations of the production system of basic polo-shirt in AAYSC

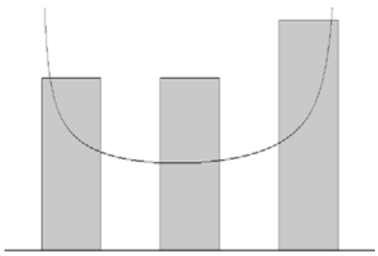
There are so many uncertain influencing factors (like sewing machine breakdown, low quality of sewing threads, absenteeism, etc) that cause the process time variability in the basic polo-shirt production process. The process time variability of a basic polo-shirt production in AAYSC-knit wear section of 10 recordings is shown on Table 1 below.

The major activities are over lock stitching (OL), lock stitching (LS), bottom hem stitching (CHS), button hole stitching (LBH), button fixing and ironing.

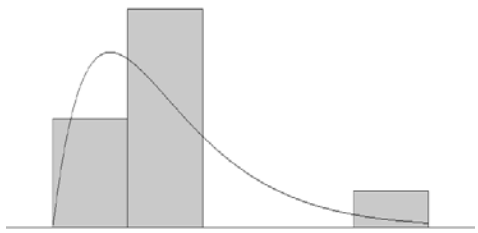
Table 1: Process time variability for Polo-Shirt production in AAYSC

No of operators	Work element (Operation)	Operation Time (Sec)									
		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
1	Cuff Hem stitching (OL)	6.58	7.83	6.66	7.93	9.27	9.41	9.62	8.11	6.96	9.54
2	Mostra attachment (LS)	27.76	22.26	21.28	20.89	22.28	19.5	21.06	22.55	19.41	20.45
1	Shoulder stitch (OL)	11.4	15.91	10.24	16.78	14.61	12.98	13.43	13.58	14.11	14.27
1	Shoulder top stitch (LS)	13.33	12.49	13.61	12.1	12.27	12.4	13.77	14.21	12.58	11.59
2	Collar attachment (LS)	27.82	35.7	36.98	28.2	34.56	27.28	40.83	25.24	26.28	30.45
1	Collar closing (OL)	20.43	24.31	20.35	18.63	17.83	18.52	23.41	20.01	19.52	18.52
1	Cover Stitch (LS)	47.54	53.73	51	61.6	52.15	49.6	51.8	46.9	45.13	51.13
2	Cover closing (LS)	49.5	39.15	45	52.33	45	45.11	42.4	42.42	46.7	45.72
2	Mostra box cutting	10	11.12	8.9	8.91	9.34	9.77	10.34	12.4	8.85	9.04
2	Mostra box stitch (LS)	34.6	37.14	33.66	31.72	23.72	23.92	26.51	21.36	33.3	32.1
1	Mostra top stitch (LS)	11.3	12.6	9.78	8.77	9.21	12.1	10.12	8.31	12.78	9.12
1	Mostra closing (LS)	29.78	30.99	25.33	25.29	24.19	18.08	19.36	21.91	19.1	20.2
2	Sleeve attaching (OL)	15.5	17.01	15.45	17.65	19.98	17.02	16.98	17.61	18.4	15.7
3	Side Stitching (OL)	45.32	41.98	53.74	43.33	43.33	59.66	41.58	44.78	44.39	45.5
1	Bottom hem stitch (CHS)	17.2	18.73	19.14	17.55	18.62	16.95	17.15	17.52	18.83	18.53
2	Button hole making (LBH)	16.5	17.61	16.88	15.93	15.91	15.57	18.52	15.4	16.78	16.7
2	Button Fixing (CB3)	18.7	19.68	21.89	19.54	18.51	18.56	19.75	15.6	18.4	19.57
1	Button hem cutting (HC)	5.45	7.89	6.9	8.07	7.01	7.56	8.05	8.31	8.574	5.4

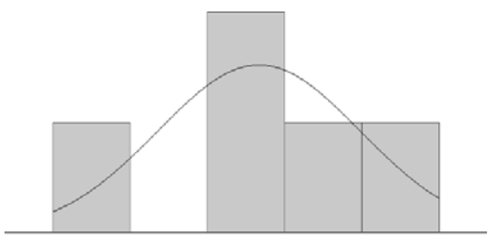
As mentioned in assumptions, insignificant breakdowns are also added to the time study data. All data are evaluated by the Arena Input Analyzer software in order to determine distribution types for each operation (Table 2). Few examples are given below.



a) Operation: Cuff hem stitching
Distribution: Beta
Expression: 6.27 + 3.66 * Beta (0.673, 0.609)
Square Error: 0.08298



b) Operation: Mostra attachment
Distribution: Erlang
Expression: 19 + ERLA(1.37, 2)
Square Error: 0.101481



c) Operation: Shoulder stitch (inner)
Distribution: Normal
Expression: NORM (13.7, 1.83)
Square Error: 0.075789

Figure 2 Examples of distribution type of operations (using Arena input Analyzer)

Table 2: Distribution types for each operation (unit: second)

S.N	Work element	Distribution Type	Expression	Square Error
1	Cuff Hem Stitching (OL)	Beta	6.27 + 3.66 * BETA(0.673, 0.609)	0.08298
2	Mostra Attachment (LS)	Erlang	19 + ERLA(1.37, 2)	0.101481
3	Shoulder Stitch (OL)	Normal	NORM(13.7, 1.83)	0.075789
4	Shoulder Top Stitch (LS)	Lognormal	11.3 + LOGN(1.58, 1.17)	0.109676
5	Collar Attachment (LS)	Beta	25 + 16 * BETA(0.464, 0.709)	0.018382
6	Collar Closing (OL)	Exponential	17.2 + EXPO(2.97)	0.034634
7	Cover Stitch (LS)	Weibull	45 + WEIB(6.45, 1.26)	0.026352
8	Cover Closing (LS)	Triangular	TRIA(39, 46, 53)	0.0416
9	Mostra box cutting	Beta	8.49 + 4.27 * BETA(0.634, 1.33)	0.005973
10	Mostra Box Stitch (LS)	Beta	21 + 17 * BETA(0.742, 0.69)	0.092221
11	Mostra Top Stitch (LS)	Beta	8 + 5 * BETA(0.612, 0.658)	0.03887
12	Mostra Closing (LS)	Beta	18 + 13 * BETA(0.491, 0.538)	0.065172
13	Sleeve Attaching (OL)	Beta	6.27 + 3.66 * BETA(0.655, 0.589)	0.073629
14	Side Stitching (OL)	Lognormal	41 + LOGN(5.47, 7.03)	0.0228
15	Bottom hem Stitch (CHS)	Beta	16.7 + 2.63 * BETA(0.766, 0.793)	0.099538
16	Button Hole (LBH)	Weibull	15.1 + WEIB(1.69, 1.72)	0.008027
17	Button Fixing (CB3)	Normal	NORM(19, 1.5)	0.045066
18	Button Hem Cutting (HC)	Triangular	TRIA(5.08, 7.99, 8.89)	0.052804

The average time and standard deviation of the collected data has been calculated. The standard deviation is very high for side stitching, collar attachment and Mostra box stitch. This indicates the inconsistency of the production process. Moreover, the average minimum and maximum cycle times are 7.32 second (for button hem cutting) and 51.1 seconds (cover stitch) respectively. This also indicates the imbalance of the time allocation for each work centers.

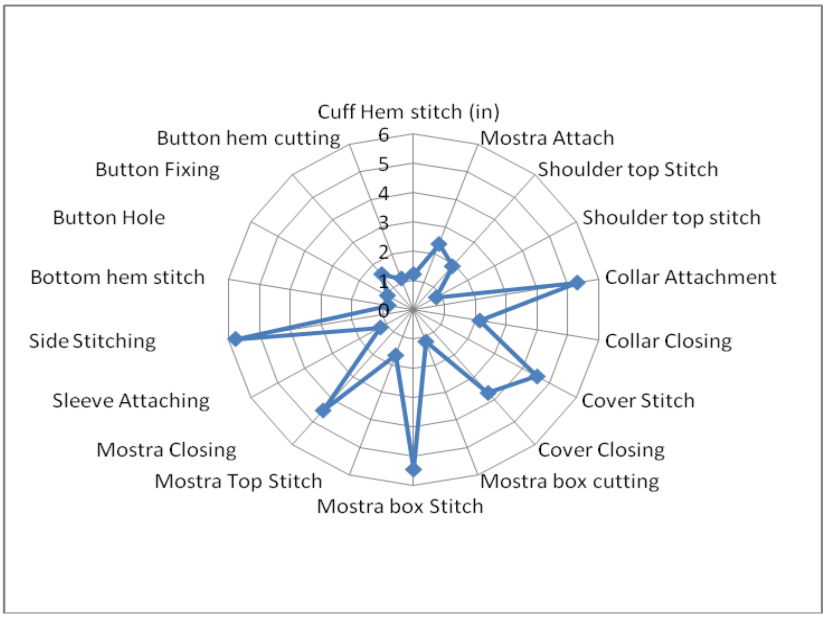


Figure 3 Standard deviation of the processing time of 18 operations

Verification/Validation

The simulation model was coded and debugged step by step. Trace and animation techniques were used to verify that each program path was correct. We made simulation trial runs under a variety of settings of the input parameters, and checked the model output results for its appropriateness. Firstly, the model has run plenty of times to check the out put with the real data obtained from the plant. We have taken the real data (i.e the plant produces 349 polo-shirts per shift) from the production manager. The simulation model output is tested to run for 450 minutes and its output is the same.

OPTION 1

In the existing system, 349 polo-shirts have been produced per 7.5 shift hours. And the productivity of each operator is about 12 polo- shirts per 7.5 shift hours. Collar attaching, Mostra attaching, cover stitching operations are the major bottleneck operations in the existing condition. Due to this, a large amount of work in process is accumulated on the line. Under the existing situation 762 items in collar attach operation, 588 items of Mostra attachment and 569 items of cover stitch has been work in process.

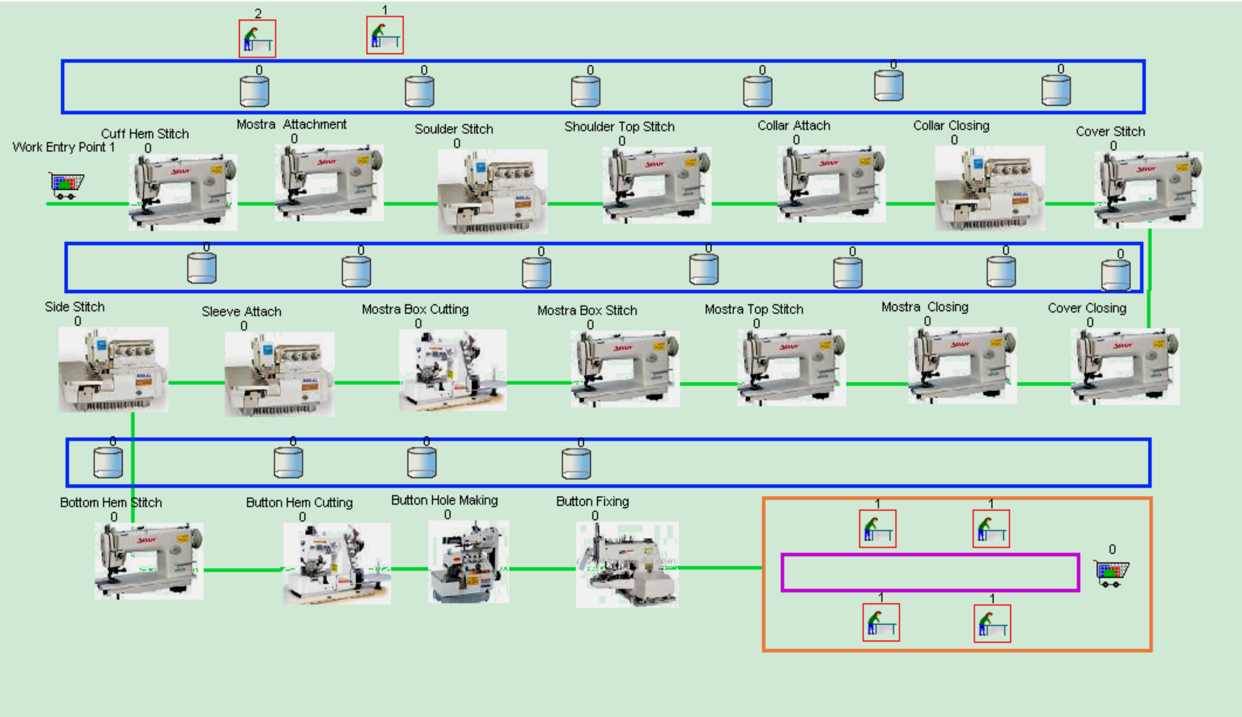


Figure 4 Snap shot of simulation model for basic polo-shirt for AAYSC

RESULTS AND DISCUSSION

Although, there are many possibilities to manipulate the developed simulation model, this study has addressed two major decision options (scenarios). The first option is manipulating the model with more effective work centers to avoid the bottlenecked process and increase the system output. The second one is to develop different alternatives of improving the existing labor utilization, assuming that the operators are cable to work in two or more work centers.

Table 3: Bottleneck operations in the existing production system

S.N	Operations	WIP (items)
1	Mostra Attach (LS)	588 items
2	Shoulder stitch (inner)	346 items
3	Collar attach	762 items
4	Collar closing	272 items
5	Cover stitch	569 items

After verification and validation process, one more effective working center is added for collar attaching process to reduce the huge amount of work in process. After simulating the process, the work in process reduces dramatically from 762 pieces to 160 pieces but the production of the finished polo-shirt remains the same. On the other hand more queues are formed at collar closing operation. Therefore, to further investigate the process, one more effective working center is added at collar closing operation and the resulting queue is reduced with increased productivity from 349 finished polo-shirts to 389 pieces. Further by adding one extra effective work center to cover closing operations the productivity of the line have significantly increased to 692 pieces of polo-shirt per shift.

Therefore, by adding three effective work centers the productivity of the line is increased from 349 to 692 pieces of finished polo-shirts. This means productivity is increased by two folds i.e. the productivity per operator is increased from 12 pieces to 19 pieces per operator per shift. The snapshot of the modified simulation model considering the three effective resource addition has shown in Fig. 6.

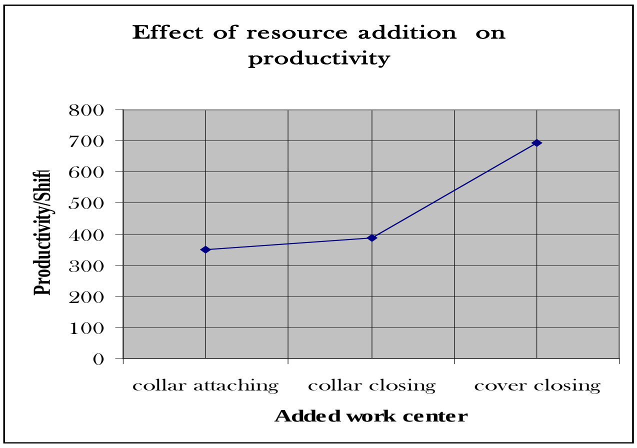


Figure 5 Effect of three extra effective work centers on productivity

Table 4: Cost of additional resources to increase productivity of the plant

Operation Type	Average operator wage	Machine type	Machine cost
Collar attaching	5760	Lock Stitch (LS)	15,000
Collar closing	5760	Over Lock (OL)	7,000
Cover closing	5760	Lock Stitch (LS)	15,000
Total	17280		37,000

Remark! *The total cost of manufacturing and unit selling price of the pieces is based on the information obtained from the company.*

If the company continues to work one shift per day for 22 days in a month, the annual production rate for the actual situation is 92,136 pieces of polo-shirts. After additional resources are added the production rate would be increased to 182,688 pieces per year. Therefore 90,552 pieces of polo-shirt would be achieved if the three effective work centers has introduced into the line. Cost benefits analysis before and after line balancing and verification has done. Before adding the three effective work centers, the profit (= Revenue- Total manufacturing cost) is 368,544 birr). After the addition of three more effective work centers, the profit would be 730,752 Birr. Hence, the net profit obtained from the excess production due to addition of the three effective work center (minimizing the WIP of the bottleneck operations) is 362, 208 birr. Total profit achieved from excess production due to additional resource = 362,208 birr. Total cost of the three work center = 54,280 birr. Therefore, the net profit due to balancing the line is equal to 307,928 birr.

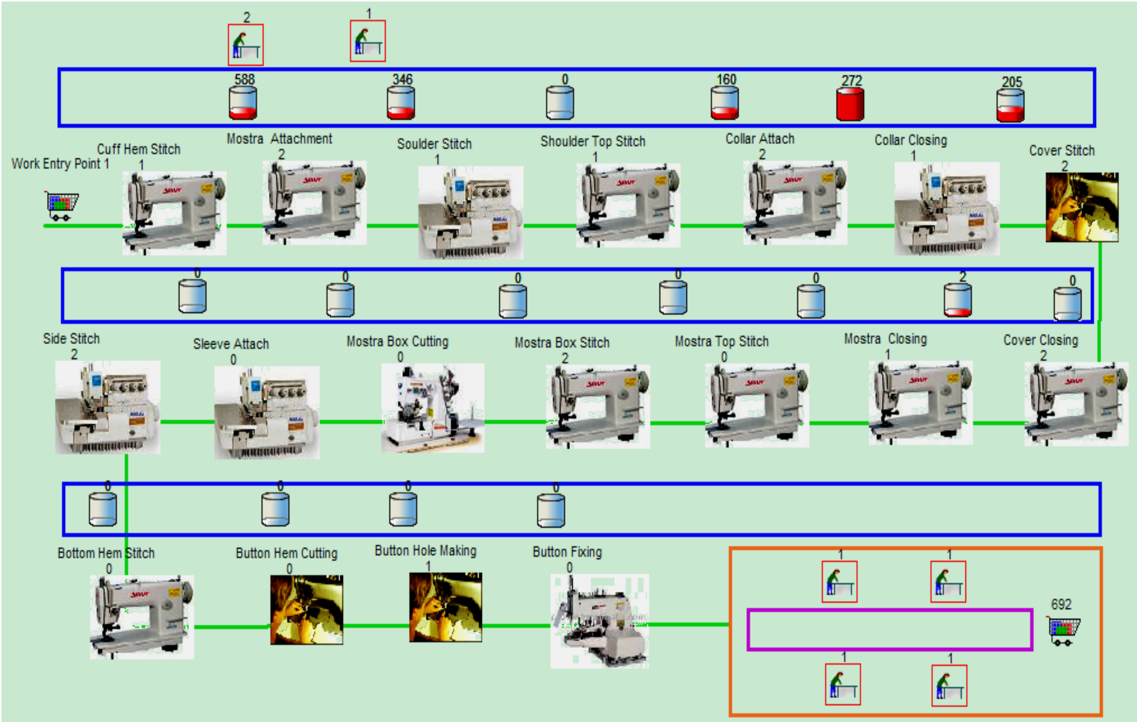


Figure 6 Simulation model of the production line after adding three work centers in the plant

OPTION 2

After the validation process was done, different decision options were evaluated for the design or reconfiguration of the assembly line. Skilled operators were added for suitable operations in order to decrease the bottleneck in the assembly line. The queue length and the utilization of each resource were also observed. Thus, five different alternative models (A1, A2, A3, A4, and A5) were developed until the best result was gained (Table 5). And the number of work centers reduced to nine. As seen in Table 5, what-if analyses led us to use some skilled operators, for instance the 13th and 14th operations in the real system model was done by three operators: two operators who could handle side stitch (OL) and one operator who could handle sleeve attach (OL). However, in A2 model 2 operators who can handle OL has used. In the garment industry there are two ways of fulfilling this purpose: to employ new workers or to retrain current workers for higher productivity. In any case, more efficient production is achieved by using alternative models. When we analyze Fig. 7, changes in utilization can easily be seen. The development of utilization is undertaken by observing the utilization of each operator after every repetition of a model. Operations which have insufficient utilization are reorganized by removing redundant operators. After developing five different alternatives, the best model is obtained according to the throughput and utilization rate. In this specific case, model A5 is best and the operators' efficiency (pieces per operator) has been improved from the existing 12.4 to 18.4 pieces/ operator.

Table 5: Number of operators for each alternative; A - alternative models

S.N	Operations	Number of operators					
		Existing system model	**A1**	**A2**	**A3**	**A4**	**A5**
1	Cuff Hem Stitching (OL)	1	3	3	3	3	2
2	Mostra Attachment (LS)	2					
3	Shoulder Stitch (OL)	1	2	2	2	2	2
4	Shoulder Top Stitch (LS)	1					
5	Collar Attachment (LS)	2	4	4	4	4	4
6	Collar Closing (OL)	1					
7	Cover Stitch (LS)	1					
8	Cover Closing (LS)	3	5	4	3	3	3
9	Mostra box cutting	2					
10	Mostra Box Stitch (LS)	2	5	4	3	3	2
11	Mostra Top Stitch (LS)	2					
12	Mostra Closing (LS)	1					
13	Sleeve Attaching (OL)	1	3	2	2	2	2
14	Side Stitching (OL)	2					
15	Bottom hem Stitch (CHS)	1	1	1	1	1	1
16	Button Hole (LBH)	2	1	1	1	1	1
17	Button Fixing (CB3)	2	4	3	3	2	2
18	Button Hem Cutting (HC)	1					
Total number of operators		***28***	***28***	***24***	***22***	***21***	***19***
Throughput		***349***	***350***	***350***	***350***	***350***	***350***
Pieces per operator		***12.46***	***12.5***	***14.58***	***15.9***	***16.67***	***18.4***

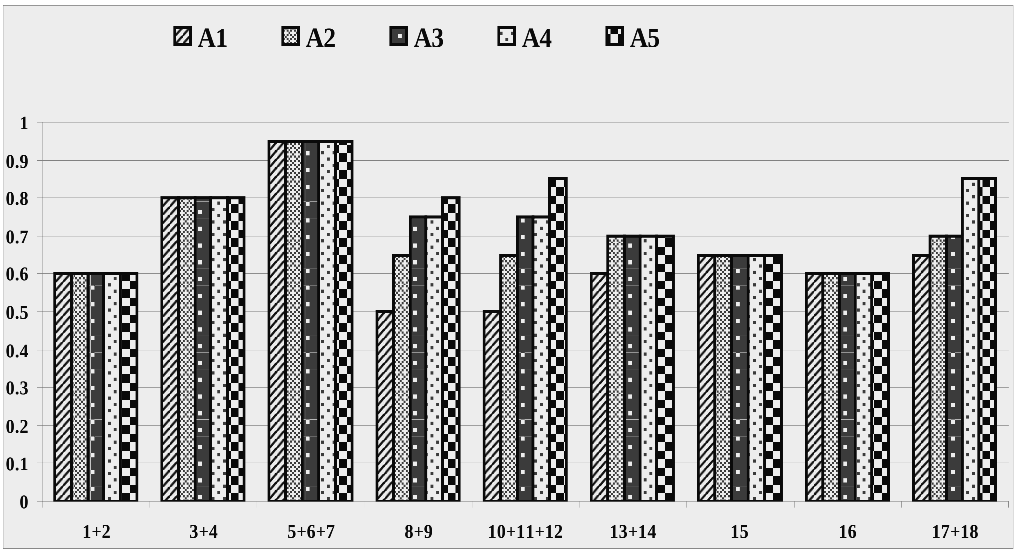


Figure 7 Utilization of each alternative

CONCLUSIONS

Nowadays, garment manufacturing firms, particularly those based upon small lots and orders, must respond rapidly to changes in style. To be flexible and to respond to the changes, it is essential to know the current situation of a system in order to process orders on time. Furthermore, in order to increase productivity, it is essential to describe the behavior of a system and to generate alternative systems. Thus, the simulation model approach developed for the garment firms enable to predict and increase total productivity.

Therefore, to alleviate the problems the proposed simulation model for the line balancing of basic polo-shirt production, provides the planning manager with a simulation based optimization tool that helps to gain information without disturbing the actual system, and improve system performance to increase productivity of the company. Moreover, the manager could test new systems before implementation without disturbing the real system of production.

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