

Bottleneck Identification Using Time Study and Simulation Modeling of Apparel Industries

(Case Study on MAA Garment)

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Abstract

This study deals with bottleneck detection with simulation techniques and time study. Modeling and simulation are potential tools for analyzing assembly lines such as clothing in a garment. Thus, the researchers attempted to experiment 160 numbers of replication in the arena tool.

The experiment monitors the assembly process resources without altering the actual production scheme. In this study, the arena software and POM dedicated to modeling and measuring the performance of the existing Ronny t-shirt sewing line. The t-shirt is formed and has 12 main parts are assembled.

For each activity, the researchers took 15 sampling observations using stopwatch. All the collected data are statistically analyzed using the input analyzer in arena for statistical significance and the expression resolution to be used for the simulation model. This simulation model has considered production resources like four threads over lock machines, single needle, two flat lock needles, machine operators, quality checkers, trimmer, batch arrival time Inter lot of pieces, sequence pieces, testing Different scenarios.

Keywords: - clothing, bottle neck, study time, t-shirt, simulation models

INTRODUCTION

Ethiopian clothing industries face many problems that have not become competitive globally. These problems include; the poor performance of products in the export market, poor quality and inadequate supply of raw materials, low productivity and poor resource utilization. Because of those, most of the country's textile companies are not lucrative and most are in great loss [1]. Bottlenecks in the production regime involve long queues, long waiting times, poor performance and overall inefficiency of the system. Such a system should work under **capacity**. To maximize resource capacity and the efficiency level of operations it is desirable to have appropriately programmed workstations and disposition in available space structures, with an optimal allocation of available resources. Work-time study, balancing the assembly line and simulation can be applied to the production line to find alternative solutions to increase sewing line efficiency. A good layout design could increase the productivity by correctly balancing the assembly line [2]. Some researchers said, the simulation model is used to identify bottlenecks in the production line and evaluate a number of suggested solutions using the arena software [3]. In addition to that the productivity of the company will be improved while the company diffuses the appropriate time study of the products to be mounted on the production line, the minimum queue length on the machines, the minimum production cost and high-quality products to establish an improved clothing industry. Increase the productivity of the specific model.

Work-time study, Assembly line balancing can be applied to apparel or clothing production line to find alternative solutions to increase the efficiency of the sewing line of the garment section. In this paper, they try to show how a good layout can be designed and productivity can be increased by appropriate assembly line balancing (Mominul, et al., 2014). Some of the optimization layout design studies from balancing lines using simulation models and different approaches will be studied in this type of problem discussed in the literature. The line balancing is the assignment process of tasks or workstations so that the workstations have roughly the same time requirements. This results in minimizing stop times along the line and high use of labor and equipment and minimizing the cycle time of the production line.

Cycle time is the maximum time allowed for each workstation in the production of clothing items, clothing components or parts are collected in a finished output which is the final product of the subassembly process. And the process has a different number of workstations, operators, and installation components. Therefore, a good balance line increases the efficiency of the sewing section

production line [5]. In the production of clothing, responsible would have been able to check whether the assembly work will be completed in time for delivery, how machines and man or operators are used, if any station on the line assembly line is late it is global. To achieve this approach, the study of working time is the duration for each part to be mounted on production lines [5] and [2] activities. The assembly lines are generating production systems to meet the humanity needs that have been growing day by day. The goals of these systems produce products that have high production rates in the shortest time, in a more productive, economical and quality manner. The purpose of the case study was to design the assembly chain to achieve maximum line efficiency using the optimum machine working time for constant cycle time [6]. Line Balancing is commonly used to solve problems that have occurred in the assembly line. Line balancing is a technique to minimize the distance between workers and workload in order to achieve the desired flow rate [7]. This can be done by equating the amount of work at each station and assigning the least number of workers to the particular workstation. A line balancing can be classified into three categories according to the numbers Mounted on the line and in accordance with the rhythm of line [8] and [7] are models;

Single line Model: - can be described as a line that combines a single model. This line produces many units of an unchanged product. The tasks performed at each station are the same for all units. Products with strong demand are destined for this line [9].

Mixed model line: - Mixed model line is producing more than one model. They are made simultaneously on the same line. Once a model is running at a station, other products are made in other seasons. Therefore, each station is equipped to perform various operations necessary to produce any model that moves through it. Many consumer products are assembled in Mixed Model [3].

Batch line: - This line produces every batch model. Typically, the workstations are set to produce the required quantity of the first model then stations are rebuilt to produce another model. The products are often assembled in batches required when the average. It is cheaper to use a mounting chain to produce various batch products to build a separate line for each model. The research will take place in the field applied a mixed model line. Simulation is one of the tools that have been widely used in various sectors and manufacturing organizations. Using a valid simulation model gives numerous benefits and benefits in creating better manufacturing in order to improve system performance simulation models and is used to identify bottlenecks in the production line and evaluate a few

proposed solutions [9]. Systems simulation modeling objectives are producing products that have high production rates in the shortest time in a more productive, economical and agreed manner. An assembly line garment was selected and simulated using Arena simulation and statistical methods to solve the balanced problem [6] have been used. Most Ethiopian textile factories could have been low in productivity and therefore less competitive in the world market due to delays in delivering products to customers. The major problems facing businesses are not optimal layout design; less resource utilization is used for different products, inappropriate line balancing. Therefore, because of those problems the company has failed to meet its daily plan. In this case, the actual production of the sewing section is about 550-680 t-shirt per day with an average of 650 t-shirt its lane is 900 t-shirts per day. Overall, there is a variation between its plan and target. The issues faced in the case of study are; improper assembly balance and insufficient time standard for each product of the company generally did not use an optimal resource to achieve its goal. This study demonstrates that enough time is needed to balance line patterns and model development to increase line efficiency. In the ronny t-shirt manufacturing model there is a high WIP in some operations such as shoulder attach, sleeve attach and back top stitch and zero waiting time provided in some operations such as quality checkers, trimming and sleeve hemming in those operations the resources that assigned have below 50% utilization.

MAA Garment and textile Factory (Kebire enterprise) is a private company formed and registered in April 2001 according to the Federal Commercial Democratic Law of Ethiopia. MAA Garment Factory started its business in June 2004 in the northern part of Ethiopia, Tigray, Mekelle wholly owned kebire Enterprises plc. It is the diamond tip in combination with expatriates in Turkey, Pakistan and the Philippines, with the production of fully-equipped set-ups with the most reputable machines and equipment from renowned manufacturers in the world such as Juki, Myers, and Cie, local dynamic locals. MAA Garments is emerging as one of the leading clothing manufacturers not only in Ethiopia but also in the rest of the world. The company's recognition has reached its peak since its inception and revealed energy-producing goods in the clothing industry. The incorporation of methods and solutions for the production system allowed faster mixing in the international market, and although the main objective was to export garments internationally, the company has been committed to meeting the needs of the market national. It intends to incorporate and improve infrastructures, while maintaining concern with environmental and social responsibilities, so that the company's ultimate goals are

achieved in a short period of time.



Figure 1: sewing line

The objectives of the study

- ✚ to identify the bottlenecks of the garment line using time study and simulation analyses of the apparel industry.
- ✚ To develop a simulation model of the sewing section of the apparel industry.
- ✚ To assess performance of the existing sewing line.
- ✚ To estimate the standard time of the products.
- ✚ To analyze the causes and effects of the production areas of the sewing section for not meeting their goal.

METHODOLOGY

This study needs a lot of data like man power, machine capacity, sequence of jobs, inter arrival of parts for assembling, processing time at each machine, efficiency, quality product outputs (number of defects, rework, normal) such data are used for model the production line. Therefore; the researchers had used primary data and secondary data (documented data), and the researchers used stop watch for recording some necessary information like processing time for new products transfer time from one station to the next one. The researchers had tried to find the causes why the company did not achieve its goals is due to different material shortage like the inputs for different sections, cotton, yarn, fabric cloth or improper line balancing. So, this can be solved due to approaches like proper line balancing, time study and simulation approaches.

Simulation methodology has eight phases (onur, et al., 2002).

Step 1: Define the Problem Which Study and Why Business Reason?

Step 2: design the model that study (s) that will provide answers to who?

Step 3: Designing the Conceptual Model Which strategy model (continuous, discrete, mixed) will be used and at what level of detail?

Step 4: Formulate inputs, hypothesis, and process definition which study hypothesis is based on and what production factors and process definition will guide the model?

Step 5: Build, verify, and validate the model is the model properly built (check)? Is the correct model built (validation)?

Step 6: Experimenting with the Model

What Do Think of Modeling?

Step 7: Document and Present the Precious Experience Results What is the Basis for Future Work?

Step 8: Define the Lifecycle Model Can the model provide long-term benefits, throughout or throughout training, programming, system redesign, and system launch?

DATA COLLECTION AND ANALYSIS

The standard methodology used for this thesis is a generally accepted computer simulation model. A garment (sewing section) assembly plant producing a ronny t-shirt style with a total number of parts namely; shoulder attach, rib tacking, neck rib attaches, piping tack, piping attach, sleeve attach, back top stitch, bottom hemming, trimming, quality checking to be assembled in the production process line of sewing section was selected for the model.

Activity identification in the sewing section, process mapping how to understand how the product (entities) using built in area input analyzer, simulation model development and identification of replication numbers with the methodologies used.

A total number of 12 activities were identified for a ronny model t-shirt production assembly line. Since, the model input based on the literature review and the actual performance of the production lines the following variables which used in the measuring of efficiency and effectiveness of the garment process is collecting.

ROOT CAUSE OF THE VARIATION IN ACTUAL OUTPUT AND TARGET OR PLAN OUTPUT

The researchers have taken a discussion with the production managers of the garment section, quality assurance manager, planning and cost control manager, supervisors of the lines the production line and discussed about the causes and the effects of why the company did not meet its target output means high variation between actual output and target output. In this study, as the researcher has gotten from the discussion the main causes are as follows in the below root cause analysis diagram.

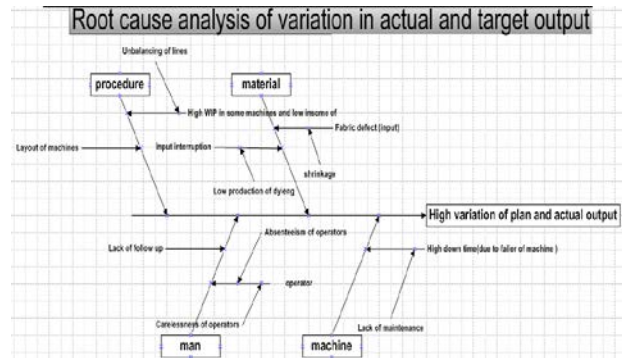


Figure 2: root cause analysis
FOR ESTABLISHING A STANDARD

The standard time of an operation can be determined using the following techniques;

1. Study time
2. Predetermined motion time system.
3. Standard Data System
4. Work Sampling

Method of calculation

The standard time is the product of three factors are; Time taken: the time measured to complete the task or activity.

Performance Evaluation Performance: - This factor is calculated by an experienced worker who is trained to observe and determine the rating.

Staff compensation, fatigue and delay: - the compensation is the adjustment of the normal for the standard time in order to recover lost time due to personal needs, tiredness and inevitable delays, providing a small increase may still be able to cover the lost time and complete the work assigned to him or her [10]. The standard time can be calculated using the formula;

Standard time (TS) = normal time (TN) + allowance time (TA)

Normal time = observed time (TO) * rating factor (RF)

Standard time = (observed time) (rating factor) (1+allowance)

Standard time = normal time * (1+ allowance)

ALLOWANCE TECHNIQUE

There are two types of interruption;

1. Interruption related to work
2. Interruption not related to work

for example, machine break down, rest break to overcome fatigue and receiving instruction from manager are the interruption related to work, but personal needs, lunch break and personal calls are the interruption not related to work. However, the two types of interruption are essential for the worker because it seems to be impossible to work continually during a regular shift.

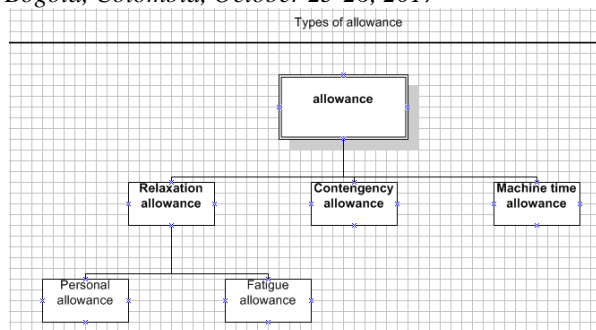


Figure 3: types of allowance

Personal needs allowance

The personal needs allowance is the time that is associated with workers daily personal needs which include restroom, phone call, going to wash room, fetching a drink etc the common figure is about 5-7 % of the basic time. And it is conditional to work environment in term of uncomfortably and temperature for example. Fatigue allowance

The fatigue allowance is intended to cover the time that the worker should give to overcome fatigue due to work related stress and conditions. There are three factors that cause fatigue: 1) physical factor like standing and use of force 2) mental and eye strain 3) environmental and work factor like poor lighting, noise and heat. Normally it is counted as 4% on basic time.

Unavoidable delays allowance

Unavoidable delays are categorized under unavoidable interruption that occurs at random times during the day in work place. They usually refer to work related events like cleaning up at the end of the shift and machine breakdowns or malfunction. Unavoidable delays occur because of many random events in work stations. Sometime garments, machines are off due to mechanical or technical problems these are applied to the total basic time for those elements which are concerned with the operation of machinery. Here are some common figures of garments sewing floor (sudar, 2015).

Single needle lock stitch machine =9%

Twin needle lock stitch machine=14%

Three tread over lock machine=7%

Four thread over lock machine= 9%

Five tread over lock machine=11%

Contingency allowance

A Small amount of allowance which is given to meet the legitimate delay of work is counted less than 5%.

Standard allowances for determining standard time of operations are;

Table 1: observation time

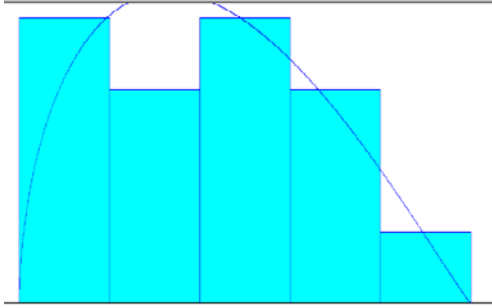
performance rate	observation time														
	1	1.1	0.9	0.9	1.15	1.2	0.95								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. shoulder attach	33	34	33.5	32	33	34	32.5	33	34	32.5	33	32.5	33.5	32	32
2. not tacking	20	20.1	20.2	19.99	19.8	20.3	19.9	20.2	20	20	20	20.2	20	19.72	20
3. neck rip attach	30	30.2	29.9	30.1	30	29.6	30.4	30	29.6	30	30	30.1	30.3	30	30
4. sleeve attach	70	71	68	69.2	69.5	68	64	65.5	66.5	66.8	68	70	72	70	70
5. piping attach	19	19.3	19	18.8	19.1	19.3	18.6	18.9	19	19.1	19	18.7	20	19	19.1
6. piping tack	24	24.2	24	24.3	23.8	23.6	24	23.8	24	24.5	24	23.78	24	24.3	23.67
7. back top stitch	75	73	75	74	73.5	74	75	73	72	70	71	70	72	71	70.5
8. side seam	63	64	64	64	63	65	66	64	63.5	63.5	63.5	64	65	66	66
9. sleeve hemming	22	23	24	23.5	24	23.6	22.5	22.6	24	22	22	22	23	24	22
10. bottom hemming	33	34	33.5	32	33	34	33	32.5	33	34	32.5	33	32.5	33.3	32
11. trimming	18	25	25	16	27	29	30	33	34	35	32	31	25	26	26
12. quality checking	23.5	21	20	22	24	25	21	23	24	24	21	22	23	23.5	22.7

Table 2: allowance

Personal and fatigue allowance	11% for sitting position work 13% for standing position
Contingency allowance	5%
Machine	Allowance rating
Single needle lockstitch machine	9%
2 thread lock stitch machine	14%
3 thread over lock machine	7%
4 thread over lock machine	9%
5 thread over lock machine	11%

DATA INPUT ANALYZER

Quality checking



Distribution Summary

Distribution: Beta

Expression: $20 + 7 * \text{BETA}(1.54, 2.1)$

Square Error: 0.013113

Kolmogorov-Smirnov Test

Test Statistic = 0.12

Corresponding p-value > 0.15

Data Summary

Number of Data Points = 15

Min Data Value = 20.3

Max Data Value = 26.4

Sample Mean = 23

Sample Std Dev = 1.61

Histogram Summary

Histogram Range = 20 to 27

Number of Intervals = 5

Table 4: data distribution function

Serial number	Operation type (activity)	Number of workers	expression	Number of machines	Type of machine
1	Shoulder attach	1	UNIF(40, 42.8)	1	4TOL
2	Rib tacking	1	NORM(27.5, 0.206)	1	SNLS
3	Neck Rib attach	2	TRIA(36.2, 36.8, 37.3)	2	4TOL
4	Sleeve attach	2	TRIA(70, 77.7, 81)	2	4TOL
5	Piping attach	1	26.5 + LOGN(0.879, 0.5)	1	SNLS
6	Piping tack	1	TRIA(32.3, 33.1, 33.8)	1	SNLS
7	Back top stitch	2	83 + 6.66 * BETA(0.668, 0.717)	2	SNLS
8	Side seam	2	77 + 4 * BETA(0.614, 0.776)	2	4TOL
9	Sleeve hemming	2	34 + 3.76 * BETA(0.494, 0.54)	2	2NFL
10	Bottom hemming	1	41.3 + 3.12 * BETA(1.37, 1.3)	1	2NFL
11	trimming	2	26 + 12 * BETA(0.663, 0.932)		
12	Quality inspection	2	20 + 7 * BETA(1.54, 2.1)		
13	Inter Arrival of parts		Cons(3600)		

SEQUENCE OF OPERATIONS FOR RONNY T-SHIRT

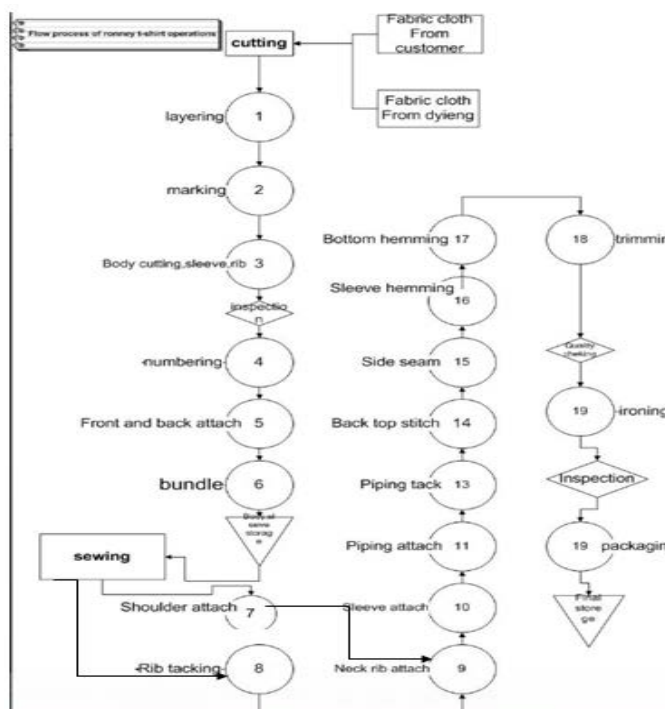


Figure 4: flow process of ronny t-shirt
DEVELOPMENT OF STANDARD
SIMULATION MODEL

This research is developing computer simulation model for the purpose of experimentation of the system “as is” or existing scheme.

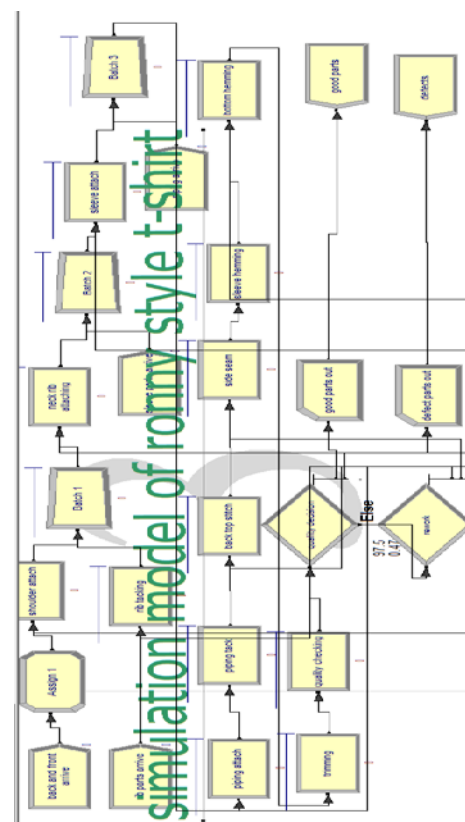


Figure 5: existing model

MODEL VERIFICATION AND VALIDATION

Model validation for this study is made using statistical validity by comparing the daily output of the real system as well as the simulation modeling outputs for the ronny model t-shirt of the existing system. If there is no statistical significance difference between the data sets, therefor, the model considered as valid model. If not the model needs additional works befor analysing the model reports. In this case the avarage outputs of ronny model t-shirt perday or working hour of eight hours is ranges from 550-680 t-shirts per day with an avarage of 650. And the simulation model output is 647 t-shirts per eight hour of a day. Therefor, the simulation model outputs is approaches to the real system outputs. In this case the simulation system representing the real system so this model is valid. In addition to this in the simulation model result some workstations have high work in progress and low work in progress in the real system as well as the simulation model.

CALCULATION OF REPLICATION NUMBER

In order to determine the number of replication for the model first the researcher has to calculate the mean, standard deviation and half width of the first ten replication. In other words half width is a sampling error

that introduce in taking sample. Therefore, the value of half width can be determined by considering a 95% confidence level where as the value of t can be read from students t probability distribution table (yemane, 2013), (gorema, et al., 2014), (herell, et al., 2004) and for initial number of replication determination it is recommended 10 number of replication for 95% confidence level and arena have 95% confidence level by default (w.david kelton, et al., 2000).

$$y(\text{mean}) \pm t - 1, 1 - \frac{\partial}{2} * s / \sqrt{n} \text{ (confidence interval)}$$

n=no of replication

y mean= sample mean

s=sample standard deviation

$$\text{half width} = t_{n-1, 1 - \frac{\partial}{2}} * s / \sqrt{n}$$

$$\text{set half width} = h, \text{ solve for } n = t_{n-1, 1 - \frac{\partial}{2}}^2 * s^2 / h^2$$

replace t by z, corresponding normal critical value

$$n \cong z_{1 - \frac{\partial}{2}}^2 * s^2 / h^2$$

easier but different approximation

$$n \cong n_o h_o^2 / h^2$$

$$s^2 = \sum_{n=1}^n \left(\frac{(y_i - y(\text{mean}))^2}{n-1} \right)$$

h_o= half width from initial number of replication t_{0.975} from the table of students t distribution is 2.262.

table :- mean, standard deviation and half width for initial 10 replication.

Table 5: number of replication

number of replication	sewing output	output-mean	
1	648	0.6	0.36
2	644	-3.4	11.56
3	648	0.6	0.36
4	649	1.6	2.56
5	653	5.6	31.36
6	651	3.6	12.96
7	641	-6.4	40.96
8	640	-7.4	54.76
9	649	1.6	2.56
10	651	3.6	12.96
Mean	647.4		18.93333
standard deviation	4.351245		4.351245
half width	3.112477		

$$h_o = t_{10-1, (1-0.05/2)} * (4.351245 / \sqrt{10})$$

$$= 3.112477$$

Therefore, the percentage error for the sewing section line of the the garment section is equal to (647.4+3.112477)/647.4= 1.0048076568=0.48076568%

Therefore, by using the replication number calculations

$$n \cong z_{1 - \frac{\partial}{2}}^2 * s^2 / h^2 \text{ and } n \cong n_o h_o^2 / h^2$$

$$n \cong n_o h_o^2 / h^2$$

$$n \cong 10 * 3.112477^2 / 0.78^2$$

$$n \cong 159.229 \cong 160$$

$$n \cong z_{1 - \frac{\partial}{2}}^2 * s^2 / h^2$$

$$n \cong 1.96^2 * 4.351245^2 / 0.78^2$$

$$n \cong 119.55 \cong 120$$

therefore, from the two alternatives the researcher has selected the maximum number of replication that is 160.

SIMULATION MODEL RUN RESULTS AND INTERPRETATION

The objective of this thesis is to model the sewing line layout and balancing the activities that assebled, analyze its performance and the finally propose an improved model to that.problems identified in this section are low throughput, high work in progress, high waiting time, which are due to low capacity utilization of resources that are machine utilization and operators utilization, unorganized flow process etc.in this case, the performance selected to analyze are entity, process, queue and resource of the sewing section.

entity performance

the following points are identified from the entity performance;

the wip is higher for rib parts, back and front parts, lower for piping parts.

Almost all of the entities that come into the department are out due to the small number of processing stations in the department

The time required for quantities to wait is higher due to the large number of of queues there and additional resource can be assigned in those stations.

Process performance

from the model run results of process performance, the following points are identified.

the accumulated waiting time for process like back top stitch, piping attach, piping tack, rib tacking, sleeve attach is higher their value added time. It also higher than waiting time of any other process.this means that entities at this station spend more time waiting than being processed.

The accumulated waiting time in quality cheeking ,trimming , sleeve hemming are zero, therefore some resources from this station can be shared.

All of quality checking,sleeve hemming, trimming stations that come to those stations are always processed fully. The least number of entities are processed in sleeve hemming station compaired to others.

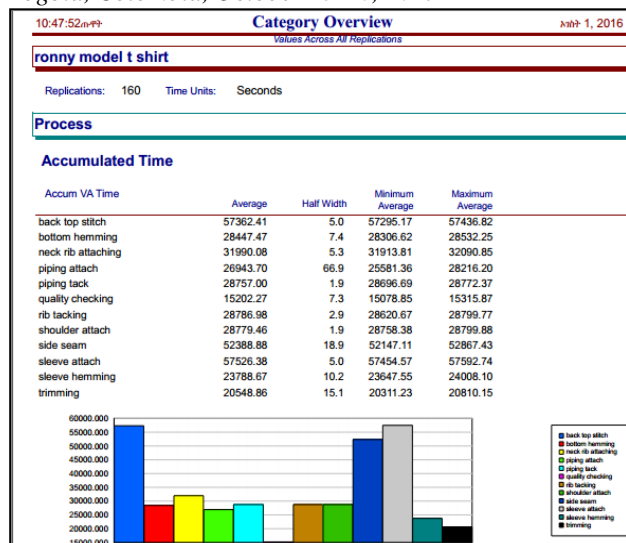


Figure 6: process accumulative time

queue performance

from the model run results of the of queue performance, the waiting time and number waiting in back top stitch, shoulder attach and sleeve attach is highest and the number waiting in of quality cheecking, sleeve hemming and trimming is zero. this result shows that, there is unbalanced allocations of resources to each station.

resource performance

The model can give us, a usage of resources this includes instantaneous utilization, number busy, number scheduled, scheduled utilization, and total number seized. Therefore the following are the instantaneous and scheduled utiliz
Number busy for 4tol 1,operator 1,4tol 3a,4tol 3b,operator 4a, operator 4b are more than one therefore, more than one resource are required in those stations.

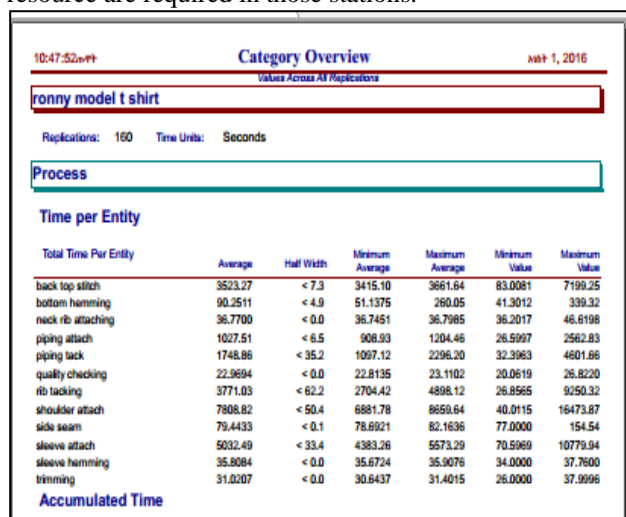


Figure 7: process time per entity

Cycle time of existing line

Line cycle time is the maximum time allowed for work at each station.

Desired cycle time (CT)= $\frac{1}{r}$, where r is production output rate.

$$\text{Desired cycle time (CT)} = \frac{8 \times 3600 \text{ sec}}{647 \text{ t-shirts}} = 44.4444 \text{ sec/t-shirt}$$

Table 6: efficiency of existing model

assembly line balance of ronny model t-shirt existing model solution				
Station	Task	Time (seconds)	Time left (seconds)	Ready tasks
				shoulder
1	shoulder attach	41.3978	3.0466	rib tacking
2	rib tacking	27.5042	16.9402	neck rib attaching
3	neck rib attaching	18.3555	26.0889	sleeve attach
4	sleeve attach	38.103	6.3414	piping attach
5	piping attach	27.4032	17.0412	piping tack
6	piping tack	33.0684	11.376	back top stitch
7	back top stitch	43.1017	1.3427	side seam
8	side seam	39.4114	5.033	sleeve hemming
9	sleeve hemming	17.4416	27.0028	bottom hemming
10	bottom hemming	41.9349	2.5095	trimming
11	trimming	15.4857	28.9587	quality checking
	quality checking	11.5127	17.446	

Summary Statistics			
Cycle time	44.4444	seconds	
Min (theoretical) # of stations	8		
Actual # of stations	11		
Time allocated (cycle time * #	488.8884	seconds/cycle	
Time needed (sum of task times)	354.7201	seconds/unit	
Idle time (allocated-needed)	134.1683	seconds/cycle	
Efficiency (needed/allocated)	72.5565%		
Balance Delay (1-efficiency)	27.4435%		

Table performance measures by running the model 'AS- IS''

Table 7: existing system performance measurement

s	Performance indicator	Model result of sewing line
1	Input	900
2	Manning level	19
3	Output(p) per 8 hour	647 t-shirts
4	Production rate(Rp)=p/480 min=648/480	1.35 t-shirts per min
5	Make span work content time(Twc)=cycle time*number of workstation	488.8884sec
6	Wip	253

7	Production efficiency(Ep)=output/input =647/900	71.89%
8	line balance efficiency= $T_{wc}/n \times ct=488.8/884/11 \times 44.444$	72.556%

CONCLUSION

In this paper, the simulation modeling of the sewing line is done by using arena software. During the analysis, the bottlenecks were identified. The bottlenecks have identified based on resource utilization, number waiting in queue. The main bottlenecks are that resources with low utilization that is below 50% utilizations like 2nfl1a, 2nfl1b, operator11a, operator11b, operator 11a, operator11b, quality checker 1 and quality checker2 and some of stations have also high waiting queue like shoulder attach, sleeve attach. The bottleneck identified are eliminated or minimized using reassigning of the existing resources the operators and machines, to optimize the resources as much as possible.

References

- [1] a. Matebu, "Model development of quality management system for Ethiopian textile industries," 2006.
- [2] i. Mominul, h. s. mehidi and m. h.m, "an optimal layout design in an apparel industry by appropriate line balancing:," 2014.
- [3] m. a. a. sudar, "Apparel analysis for layout planning in sewing section golder," 2015.
- [4] d. Hailemariam, "mixed model assembly line balancing using simulation techniques," 2009.
- [5] Bahadir and k. senem, "assembly line balancing in garment production by simulation," 2013.
- [6] s. eryuruk, "clothing assembly line design using simulation and heuristic line balancing techniques," 2012.
- [7] h. and b. hazmil, "productivity improvement through line balancing," 2008.
- [8] m. and b. azizul, "line balancing and optimization for single model assembly line at a small medium industry," 2007.
- [9] k. maheshr and j. v.s., "process flow analysis of diesel engine crankshaft machining line layout," 2014.
- [10] c. d. e. jocelyn and c. ma, "facility layout improvement model using ergonomics and layout simulation," 2015.
- [11] m. onur and e. j.williams, "Simulation methodology, tools and applications," 2002.
- [12] a. yemane, "manufacturing system modeling and performance analysis using simulation," 2013.
- [13] t. gorema and n. mulugeta, "Modeling and performance analysis of manufacturing sysystems in footwear industry," 2014.
- [14] h. g. and B. , Simulation using promodel, second edition (herell,ghosh,Bowden, 2004, 2004.
- [15] k. w.david kelton, . r. p.sadowski and D. a., Simulation with arena, 2000.
- [16] B. allen, optquest for arena, 2012.
- [17] s. and b. shahfiran, "productivity improvement through line balancing technique in a small medium enterprise (sme) manufacturing plant," 2007.
- [18] h. b. fredric and m. , "production system design and optimization," 2008.
- [19] groover, work systems: the methods, measurement and management of work, 2007.
- [20] m. asmelash, "modeling and simulation analysis of manufacturing systems using arena simulation software," 2008.
- [21] p. k. r. k. b. habibur rahman, "Effective way to estimate the standard minute value (SMV) of a t-shirt by work study," 2014.
- [22] h. ashkan, k. hamid and r. hesam, "line balancing the production line by the simulation and statistics techniques," 2014.
- [23] p. prasad and r. , "design and selection of facility layout using simulation and design of experiments," 2010.
- [24] h. b. fredric and m. , "production system design and optimization," 2008.
- [25] j. bobby and j. jenson, "analysis and simulation of factory layout using arena," 2013.

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