Modelling Simulation and Performance Analysis for Footwear Manufacturing System

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Abstract
In today's dynamic world economy, corporations are often trying to reinforce themselves as much as possible in all facets of industry competitiveness. This demand for an optimized production system which enhances the company's overall productivity. The survival of every business in today's dynamic environment depends primarily on response time, cost of production, market price, and manufacturing stability. Only by managing the complexity of any manufacturing line will they accomplish these things. The assembly of any product or machine is highly complex, affecting the production time of assembly due to the order of sequence. In order to obtain the optimal line in an operation, it should be very necessary during operation to schedule to make clear which part should come in what order and what tasks will be performed together, how many work stations are needed. The number of workstations, whose task is the previous workstation, and what is in sequence will affect the time to complete the task, as well as the usage of resources, i.e. whether manpower or machines. These things motivated continuous research in modeling and performance evaluation of manufacturing systems. In parallel, different simulation software plays a significant role in developing a model of a real system and performing experiments with this model in order to explain the system's actions and test different operating or production system techniques and scenarios. As the majority of consumable and non-consumable goods are made on an assembly line basis, it is necessary to solve the line balancing issue every day. One type of good that is manufactured on the assembly line method is footwear. This paper deals with the modeling, simulation and performance assessment of assembly line balance of Jamaica-Ok footwear manufacturing company. This paper is specifically concerned with the modeling and simulation of the single assembly line within the manufacturing department: Stitching assembly line. In order to do so, Arena modeling software is used to simulate and calculate the performance of the assembly line's current production processes. Finally, the simulation result shows that the waiting time of each station of the stitching line is calculated among the longest waiting and suggested a way to avoid the issue of waiting time via the development mechanism.
Keywords: Footwear industries, assembly line, Production line balancing, Simulation, Arena.
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1. Introduction

The increasing demands for productivity, cost reduction, and optimal allocation of resources, have motivated continuous research in modelling and performance evaluation of manufacturing systems. In this domain, one of the most important manufacturing sections is assembling line system. The leather footwear industry in Ethiopia is considered as an important sub-sector that leads the whole sector modernization and that can contribute highly for the development of the country. Its value has been growing steadily since then and is expected to make a big impact on the Ethiopian economy.

In the country, the manufacturers for consumable goods are follows assembling line way of production system to produce their product and this system also used for non-consumable goods production system. Leather industry is one of the world's major industries and the footwear industry is a substantial one within the supply chain of leather industry and their goods which are manufactured on assembly line system by classifying the station in to cutting, stitching and lasting department. The production process of shoe manufacturing is most likely labour intensive process and it cannot be fully automated. It requires craftsmanship in each phase of the production. More than a hundred operations are required for making a pair of shoes. With the development of the footwear machines, the production time has been reduced and processes are performed separately. Depending on the type of shoes and material usage, the manufacturing process can vary.

Today, traditional production methods in foot wear industry are replaced with assembly line method because of demand for greater product variability and shorter life cycles. An assembly line is a flow-oriented production system where the productive units performing the operations, referred to as stations, are aligned in a serial manner. The assembly line concept was not invented at one time by one person. It has been independently redeveloped throughout history based on logic.

Any assembly line comprises a finite set of work elements sometimes called tasks. Each task is characterized by an operation processing time and a set of precedence relationships, which specify the allowable orderings of the tasks. Assembly line balancing (ALB) is the process of allocating a group of tasks to be performed on an ordered sequence of workstations in such a manner that all workstations have approximately an equal amount of assigned workload to optimize some measures of performance e.g. minimize the number of workstations, minimize cycle time minimize the balance delay, or optimize the combination of the aforementioned objectives, without violating precedence relationships. [1]

To cope with and control the assembly line effectively, it is necessary to analyse the production system to get optimal result. Good simulation representation becomes more essential and effective for designing and testing of engineering system which being increased complexity day by day. [10]

Simulation has been commonly used to study the real behaviour of manufacturing system to get useful understanding of problems. Therefore, a simulation is an easier way to build up models to represent real life problems, to identify bottlenecks, to enhance system performance in terms of productivity, efficiency, queues, resource utilization, cycle times, lead times, etc. A reconfigurable assembly line can provide flexibility for high variety low quantity manufacturing systems, which can meet growing customer demand.

This study presents simulation modelling and performance analysis and evaluation using arena simulation software to solve the assembly line balancing problem (ALBP) in a footwear industry by concentrating on the stitching assembly line which is the major bottle neck section in footwear production. It is organized as follows. Section 1 presents the introduction part, Section 2 reviews related literature. Section 3 Methodology, Next section 4 presents description of case company and problem definition then Section 5 result and discussion. Finally, Section 6 conclusions and provides future work directions.

2. Literature Review

ALBP has been an active field of research over the past decades due to its relevancy to diversified industries such as garment, footwear and electronics. [6] as well as [5] provided detailed reviews on these topics. Configurations of assembly lines for single and multiple products could be divided by three line types, single-model, mixed-model and multi-model.

These three models can be also classified according to their layout, such as U-shaped assembly lines, in-line assembly line. In Single-model assembles only one product and mixed-model assembles multiple products, whereas a multi-model produces a sequence of batches with intermediate setup operations. [2] This paper solves single-model line balancing problem with real application.

One important aspects of manufacturing system is line balancing problem. Assembly line balancing (ALBP) is the problem of assigning various tasks to workstations, while optimizing one or more objectives without violating any restrictions imposed on the line. ALBP has been an active field of research over the past decades due to its relevancy to diversified industries such as garment, footwear and electronics. [3]

Line balancing is about arrangement of production line to obtain an even flow of production from one work station to the next. Line balancing is also defined as the allocation of sequential work activities into a line called work stations along an industrial importance: the efficiency difference between an optimal and a suboptimal assignment can yield waste reaching millions of dollars per year [4]

The primary aim of the assembly line was to facilitate mass production, standardization, simplification and specialization. Besides this, assembly line was also useful in dividing complex work structures into a number of elemental tasks, which would simplify the complexity of assembly work. From the manufacturers point of view foremost advantage of ALB is the ability to keep direct labours busy doing productive work. Historically assembly line was designed for high volume production of single item or similar family of items [9]

According to Groover 2002, the assembly line must be designed to achieve a production rate Rp sufficient to satisfy demand for the product. Product demand is often expressed as an annual quantity, which can be reduced to an hourly rate. Management must decide how many shifts per week the line will operate and how many hours per shift. By assuming the plant operates 52 week/yr. then the required hourly production rate is given by [7]

$$\text{Production rate} = AD/52*S*Wh \quad \ldots\ldots\ldots\ldots\ldots (1)$$

AD = number of demand for selected model per year
S = Number of shift per week
Wh = working hour /day

This production rate must be converted to a cycle time CT, which is the time interval at which the line will be operated. The cycle time must take into account the reality that some production time will be lost due to occasional equipment failures, power outages, lack of a certain component needed in assembly, quality problems, labour problems, and other reasons. As a consequence of these losses, the line will be up and operating only a certain proportion of time out of the total shift time available; this uptime proportion is referred to as the line efficiency. The cycle time can be determined as

$$CT = 60\, e/ PR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: CT is cycle time of the line (min/cycle) and PR is required production rate (units/hr.) and e means line efficiency. Typical values of E for a manual assembly line are in the range of 0.90-0.98. [7]

Simulation is one of several alternative methods of analysing systems. There are different software's that can be used for simulation of any system whether it is a factory, bank, etc. They differ based on what they require, their flexibility, ease of use etc. simul8, witness; Arena TM, etc. are among some of the software's used to simulate any system. [8]

According to Yucesan and Fowler, (2000), simulation has several strengths including: Time compression (the potential to simulate years of real system operation in a much shorter time),Component integration (the ability to integrate complex system components to study their interactions),Risk avoidance (hypothetical or potentially dangerous systems can be studied without the financial or physical risks that may be involved in building and studying a real system, Physical scaling (the ability to study much larger or smaller versions of a system.

Other important feature of Arena Simulation modelling is determination of replication numbers. Since the individual replication results are independent and identically distributed, you could form a confidence interval for the true expected performance measures, which is assumed sample-mean across an infinite number of replications. [8]

3. Methodology

Under the term assembly line balancing (ALB) various optimization models is introduced and discussed which aims at supporting the decision maker in configuring efficient assembly systems. The data collection includes both primary and secondary source of data which include the following parameters which can be used in the measuring of the efficiency and effectiveness of the manufacturing process, such as Total number of tasks, processing times of each task and inter arrival time of the upper part of the shoe using digital clock, Manning level for each task, Precedence relationship diagram for the production processes. The diagram indicates the required physical constraints on the sequence of tasks, then the collected data will analysed by Arena input analyser to be used in simulation model development. The following assumptions are used to define the problem:

- Set-up times are not taken into consideration,
- There is no maintenance process performed during the working period,
- All process times for stitching operations include insignificant breakdowns' like threading of thread, no breaks down of stitching machine needle.
- The assembly line is never starved.

4. Description of Case Company And Problem Definition

The Company under the study is one of the footwear industries in Ethiopia, Jamaica-Ok shoes factory is a privately owned company established in 1969 and involved in producing men's, Ladies, Children and soccer shoes. The first factory was set up with a capital outlay of 650,000USD, and it was located Arada Kifle Ketema, Addis Ababa. However, this company was started its work with small and medium industry level and they output of finished products was under the production plane due to small space utilization, by considering this situation the owner of the company launched a new company in Nifas-silk Kifle ketema around Saris industry zone. After the establishment of the new company they starts manufacturing large variety of footwear, sports shoe, sandal, slippers, kids' shoes, ladies' and gents' shoes.

The current layout of the company and the layout of the entire machineries with their manpower are properly settled as shown below in figure 1, in the stitching section the assembly line is U type with a automated conveyors on which the different components or parts of the shoe are transported from one work station to another work station, but particularly in cutting and lasting section operation material transfers manually.

In this study, the problem under consideration is about assembly of soccer 01 footballs' shoe in the stitching section. The reason for chosen this model is having high complexity during manufacturing the model that compared to other model shoes and having longest production line. This section has 6 shifts per week and the line operates for 8 hours per shift.

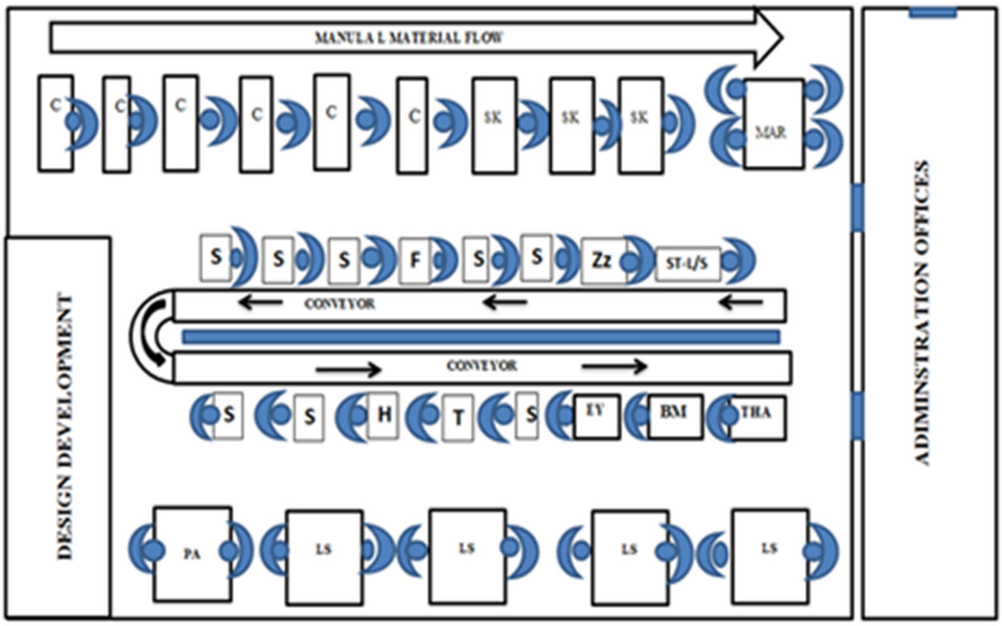


Figure 1: Current layout of the company

C = cutting	SK = Skiving
MAR = Marking	ST-L/S = Stamping for logo and shoe size number
Zz = Zigzag stitching	S = Normal Stitching
H =Hammering (Forming)	EY = Eyelet (making hole)
BM = Back molding	F = Folding
THA = Top half attaching	T = Trimming
LS = Lasting	PA = Packing

Assuming the plant operates 52 wk/yr. currently the maximum efficiency of operation 77%. During operation for selected model the problem with the stitching line was the time for each station is unknown, this also happens for other models. The second problem was the assembly of soccer 01 model shoe consists of 23 different tasks (table 1). These tasks were arranged in traditionally sequenced order which mean that one processing of a task cannot start before certain tasks are produced. However; there are some tasks can be processed simultaneously when other process are in operation

Table 1: Date collected for soccer 01 football shoe

Seq. No.	Elemental Operation	No. of worker	Average processing time
1	Printing Logo & size no	1	11
2	Zigzag stitching internally	1	55
3	Back listini stitching	1	73
4	Front tongue stitching with sponge	2	83
5	Tongue phlorescent stitching bottom side	1	28
6	Upper Toe cap zigzag stitching with tongue	1	213
7	Make strong Side Phlorescent	1	100
8	Back Phlorescent listini stitching	1	109
9	Back Phlorescent listini stitching with small piece of lather	1	73
10	Back Phlorescent stitching	1	44
11	Side Phlorescent stitching with small piece of leather	1	43
12	Back listini with toe cap jointing stitching	1	73
13	Stitching upper part with inside part	1	92
14	Tongue phlorescent brand stitching	1	280
15	Making eyelets holes	1	42
16	Trimming and burning the stitched tongue	1	34
17	Sponge attaching and stitching for quarter	1	139
18	Insert ring for eyelet holes	1	73

Seq. No.	Elemental Operation	No. of worker	Average processing time
19	Stitching tongue phlorescent with small piece of leather	1	101
20	Stitching tongue with vamp and quarter	1	83
21	Counter stitching	1	272
22	Binding outer side quarter with inside quarter vinyl collar	1	113
23	Trimming and burning whole part of the shoe	2	111
	Total	**25**	

5. Result and Discussion

5.1 Model soccer-01 football shoe balance result

As table-1 shows the total number of tasks is 23, processing times of each task and Manning level for each task also listed in the table. The company works only 8 hrs per day. The annual demand was taken from the company historical data trend in average for selected shoe, which is 28520 customers/year, this much amount pair shoes passes through in the stitching line per year;. Therefore production rate for selected model can be compute by recalling equation 1 as follow:

$$\text{Production rate} = 28520/\ 52*6*8$$
$$= 12 \text{ unit/hours}$$

The stitching line produces only 12 semi-finished upper part of the selected model/shoe or one unit of upper part can manufacture every 5 minute and this production rate is used to compute cycle time as follows

As Groover said (2000) typical values of E for a manual assembly line are in the range of 0.90-0.98. Therefore, take efficiency of the stitching line as 94% in average. Again recalling equation 2 then

$$CT = 60 \text{ min/hr.} * 0.94 \times 60 = 282 \text{ sec/unit}$$
$$= 12 \text{ units/hr.}$$

Previously, in the production line the relationship between each station(23 elements) was consequent or one task starts after completion the previous task but this production system leads to increasing make span, lower production rate and more operators required, cost of production also increased.

To prevent this problem the current system has to be rearranging by identifying which station is relate with other station logically and which station is relate with other station naturally. The following proposed precedence diagram shows the rearranged process of the production of selected model and summarized in table 2.

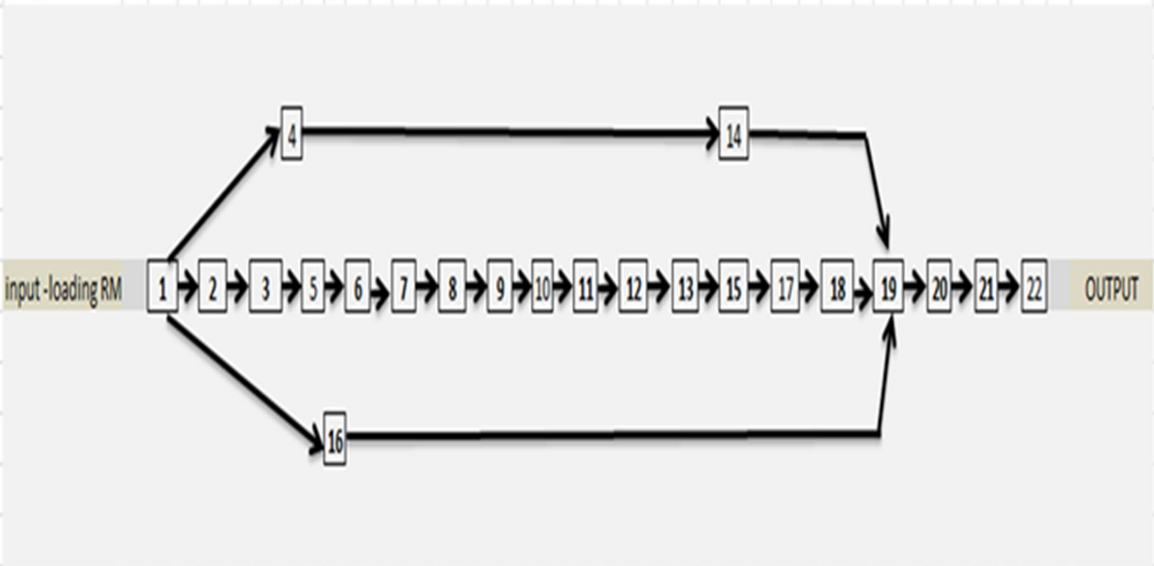


Figure 2: proposed precedence diagram model result for soccer 01 football shoe model

Table 2: interpretation of the precedence diagram

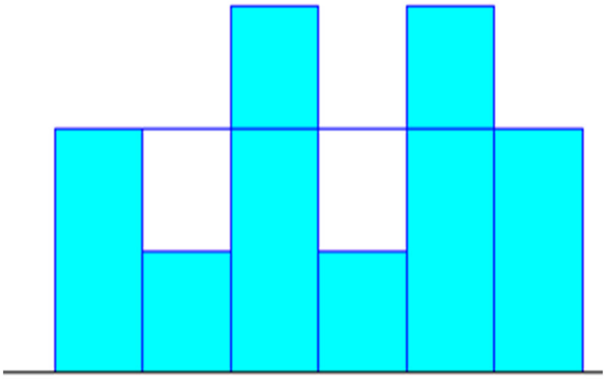
Station	Sq.no	Tasks	No. of worker	precedence	T_p
S1	1	Printing logo and size no	1	-	11
	2	Zigzag stitching internally	1	1	55
	3	Back listini stitching	1	2	73
	4	Front tongue stitching with sponge	2	1	83
	5	Tongue phlorescent stitching bottom side	1	3	28
S2	6	Upper Toe cap zigzag stitching with tongue	1	5	213
S3	7	Make strong Side Phlorescent	1	6	100
	8	Back Phlorescent listini stitching	1	7	109
	9	Back Phlorescent listini stitching with small piece of lather	1	8	73
S4	10	Back Phlorescent stitching	1	9	44
	11	Side Phlorescent stitching with small piece of leather	1	10	43
	12	Back listini with toe cap jointing stitching	1	11	73
	13	Stitching upper part with inside part	1	12	92
S5	14	Tongue phlorescent brand stitching	1	4	280
S6	15	Making eyelets holes	1	13	42
	16	Sponge attaching and stitching for quarter	1	15	139
	17	Insert ring for eyelet holes	1	1	73
S7	18	Stitching tongue phlorescent with small piece of leather	1	16	101
	19	Stitching tongue with vamp and quarter	1	14	83
S8	20	Counter stitching	1	17, 18,19	272
S9	21	Binding outer side quarter with inside quarter vinyl collar	1	20	113
	22	Trimming and burning whole part of the shoe	2	21	111
		Total	24		

The above diagram analysed the elimination of the repetition of same task (as mentioned table-1 such as task 16 and 23) both are merged together at task 22 the result presented in table 2. Due to this merging the sequence of tasks after 16th task are shifted up, therefore, the 16th task replaced by 17th task and the same for remain tasks respectively and 34 second reduced. task 4 and 14 can be processed after finishing task 1 and the same for task 16 can be processed after finishing task 1 operations, task 19th also can only starts after task 17th, 18th, 19th are finished, this rearranging lead to reduce the make span, reduce production length, and reduce number of worker due to elimination repetition of the same tasks and rearranging the tasks.

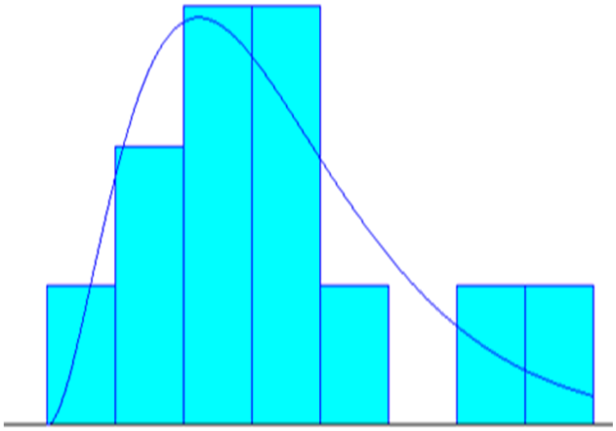
The Simulation model requires accurate data as presented in table 2; the tasks were 23 and consecutive but now only 22 tasks are required to produce the model and task 4, 14, 16 have logical relation with task 1 and they have relation naturally with others except task 20, 21, 22 and the last three task can only process after completion of tasks 1 up to station 20, however, task 4, 14, 16 can process the time between task 1-20 (which mean that 502 second reduced from previous total processing time)and totally 34+502=536 second reduced.

Average processing time (table 1) for each work tasks was determined by recording 12 times to determine the time variability distribution and operator performance consistency using digital clock. Therefore, in order to determine the distribution type the recorded raw data are required for input analyze as an input.

Few result of input analyser are given below and summarized as table 3. The inter arrival time of each upper part of the selected model shoe also recorded and summarized as in table 4. As table 2 shows the operation elements are grouped in to 9 stations base on the cycle time.



Operation: Back Phlorescent listini stitching with small piece of lather
Expression: UNIF (76.5, 82.5)
Square Error: 0.027778
Figure 3: Distribution summary for task 9



Operation: Upper Toe cap zigzag stitching with tongue
Expression: 229 + ERLA (1.11, 3)
Square Error: 0.018938
Figure 4: Distribution summary for task 6

Table 3: Distribution type summery of all tasks

S.N	**Tasks**	**Distribution Type**	**Expression**	**Square Error**
1	Printing logo and size no	Triangular	TRIA(9.5, 10.5, 13.5)	0.000000
2	Zigzag stitching internally	Triangular	TRIA(57.5, 58.5, 61.5)	0.000000
3	Back listini stitching	Lognormal	77.5 + LOGN(2.15, 1.61)	0.010628
4	Front tongue stitching with sponge	Beta	87.5 + 5 * BETA(1.54, 1.86)	0.016218
5	Tongue phlorescent stitching bottom side	Lognormal	27.5 + LOGN(2.22, 1.75)	0.015980
6	Upper Toe cap zigzag stitching with tongue	Erlang	229 + ERLA(1.11, 3)	0.018938
7	Make strong Side Phlorescent	Beta	105 + 8 * BETA(1.41, 1.35)	0.024378
8	Back Phlorescent listini stitching	Beta	115 + 7 * BETA(0.674, 0.741)	0.011735
9	Back Phlorescent listini stitching with small piece of lather	Uniform	UNIF(76.5, 82.5)	0.027778
10	Back Phlorescent stitching	Beta	29.5 + 23 * BETA(1.44, 0.553)	0.087984
11	Side Phlorescent stitching with small piece of leather	Weibull	44.5 + WEIB(2.72, 1.8)	0.062495
12	Back listini with toe cap jointing stitching	Erlang	76.5 + ERLA(0.972, 3)	0.010003

S.N	Tasks	Distribution Type	Expression	Square Error
13	Stitching upper part with inside part	Uniform	UNIF(95.5, 105)	0.027778
14	Tongue phlorescent brand stitching	Beta	300 + 11 * BETA(0.685, 0.901)	0.027507
15	Making eyelets holes	Beta	41.5 + 9 * BETA(0.794, 0.895)	0.060128
16	Sponge attaching and stitching for quarter	Lognormal	148 + LOGN(3.94, 3.68)	0.023177
17	Insert ring for eyelet holes	Normal	NORM(79.2, 1.82)	0.032470
18	Stitching tongue phlorescent with small piece of leather	Beta	105 + 11 * BETA(0.932, 1.27)	0.041329
19	Stitching tongue with vamp and quarter	Beta	86.5 + 6 * BETA(1.16, 0.928)	0.019461
20	Counter stitching	Beta	289 + 13 * BETA(0.805, 0.606)	0.052219
21	Binding outer side quarter with inside quarter vinyl collar	Beta	119 + 11 * BETA(0.755, 0.879)	0.022885
22	Trimming and burning whole part of the shoe	Beta	98.5 + 41 * BETA(0.839, 0.656)	0.070073

As processing time of operation elements the Inter arrival time at first station is taken for stitching section by using 12 data's when components loaded at first operation element.

Table 4: inter arrival time summary

No.	Inter arrival time
1	67
2	36
3	67.2
4	49.
5	57
6	58.8
7	63
8	44.4
9	60
10	34.8
11	46.6
12	56

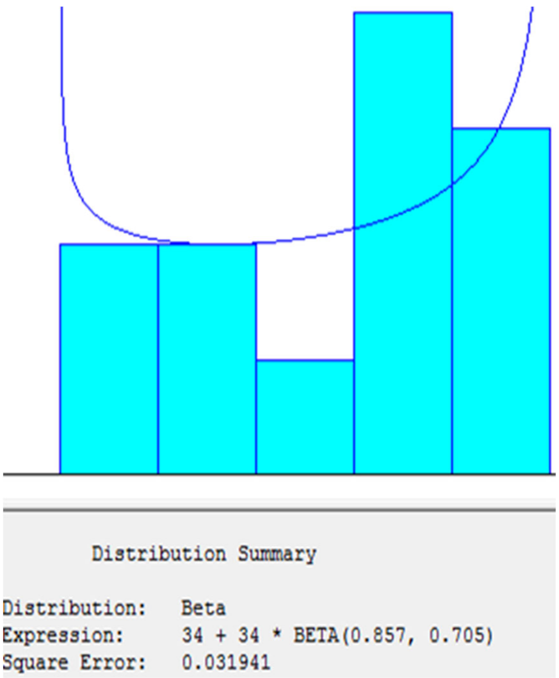


Figure 5: Distribution summary for inter arrival

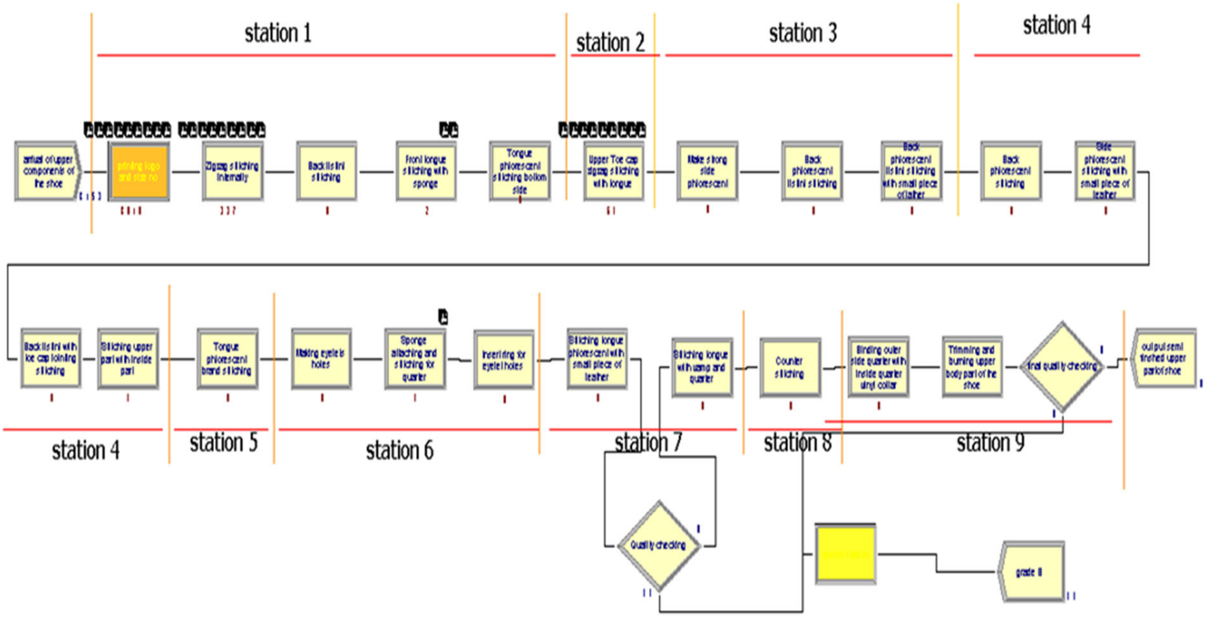


Figure 6: Modelling of soccer 01 shoe production with arena simulation

Queues

1:56:17 AM July 2, 2016

assembly line balancing for stitching department in jamica ok shoe factory

Replications: 10

Replication 1

Start Time: 0.00 Stop Time: 30,000.00 Time Units: Seconds

Queue Detail Summary

Time

	Waiting Time
Back listini stitching.Queue	35.77
Back listini with toe cap jointing stitching.Queue	36.65
Back phlorescent listini stitching with small piece of	18.91
Back phlorescent listini stitching.Queue	34.28
Back phlorescent stitching.Queue	22.52
Front tongue stitching with sponge.Queue	16.95
Insert ring for eyelet holes.Queue	11.95
Make strong side phlorescent.Queue	0.00
Making eyelets holes.Queue	0.00
printing logo and size no.Queue	14246.95
Side phlorescent stitching with small piece of	28.82
Sponge attaching and stitching for quarter.Queue	48.33
Stitching tongue phlorescent with small piece of	33.72
Stitching upper part with inside part.Queue	18.46
Tongue phlorescent brand stitching.Queue	23.42
Tongue phlorescent stitching bottom side.Queue	22.62
Upper toe cap zigzag stitching with tongue.Queue	12256.69
Zigzag stitching internally.Queue	12194.06

Figure 7: Queue report for replication 1

5.2 Model Verification and Validation
Model validation for this study is made using statistical validity by comparing the output of the real system and the simulation model output of the existing system. If there is no statistically significant difference between the data sets, then the model is considered valid. Conversely, if there is a statistically significant difference, then the model is not valid and needs additional work before further analysis may be conducted. Validation and verification process is conducted to make sure that the model is already representing the real system. The arena simulation model was running 10 times. It was proved that there is no change in throughput by repetition of the model but having many replication numbers to run the model only makes the simulation work more slowly. In this paper replication length was specified to be 10 and select the time unit for that to be seconds. Model validation was accomplished through tests using a throughput with a 95% confidence interval. From initial 10 replications, 30,000 seconds, we have a waiting time descriptive statistic for some process as follows
Table 5: Waiting time (seconds) for each replication 1-10

operation element or					Replication length					
tasks	1	2	3	4	5	6	7	8	9	10
Back listini stitching.Queue	35.77	38.14	46.83	48.67	37.20	40.68	31.29	36.66	39.89	34.31
Back listini with toe cap jointing stitching.Queue	36.65	33.79	47.00	46.57	37.35	40.63	27.59	34.58	42.67	36.17
Back phlorescent listini stitching with small piece of	18.91	22.37	35.78	41.55	28.31	31.89	14.81	20.96	24.79	18.15
Back phlorescent listini stitching.Queue	34.28	32.86	45.53	41.21	32.49	35.48	26.94	32.23	39.97	26.63
Back phlorescent stitching.Queue	22.52	23.91	34.54	36.69	24.82	31.83	15.42	19.68	24.01	18.30
Front tongue stitching with sponge.Queue	16.95	17.60	26.00	25.04	16.11	19.43	14.30	17.72	23.21	18.26
Insert ring for eyelet holes.Queue	11.95	14.50	20.86	18.93	13.32	15.17	10.76	16.50	14.81	12.73
Make strong side phlorescent.Queue	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Making eyelets holes.Queue	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
printing logo and size no.Queue	14246.95	14255.71	14257.02	14244.90	14281.85	14287.16	14255.64	14273.94	14258.49	14281.99
Side phlorescent stitching with small piece of	28.82	27.31	40.26	41.76	23.99	32.96	22.38	27.52	35.19	28.76
Sponge attaching and stitching for quarter.Queue	48.33	54.02	64.95	61.96	51.68	53.34	44.15	51.18	61.56	47.14
Stitching tongue phlorescent with small piece of	33.72	35.40	42.96	47.78	36.41	36.86	27.85	36.09	33.82	27.01
Stitching upper part with inside part.Queue	18.46	21.48	32.31	34.36	18.38	25.86	13.38	17.29	21.44	15.81
Tongue phlorescent brand stitching.Queue	23.42	28.68	42.01	47.51	27.01	33.71	20.31	26.44	30.62	24.52
Tongue phlorescent stitching bottom side.Queue	22.62	22.68	32.10	33.92	23.68	25.45	17.78	23.90	28.95	23.07
Upper toe cap zigzag stitching with tongue.Queue	12256.69	12385.59	12479.98	12346.21	12483.66	12203.49	12268.72	12220.93	12471.61	12209.31
Zigzag stitching internally.Queue	12194.06	12179.42	12174.18	12195.86	12191.94	12177.76	12190.57	12144.52	12188.54	12156.17

Table 6: Performance measures

No.	Performance Indicator	Stitching Assembly Line
1	Manning level	23
2	Annual demand for the shoe	28520/yr.
3	Production rate	17 units /hour
4	Make span or work content time (T)	1709 sec
6	Cycle time (CT)	199 sec

6. Conclusions
Simulation modelling is a powerful and an interactive technique in which we can imitate the real manufacturing system to understand how it behaves if something is altered and evaluates the performance of various strategies and scenarios of manufacturing system. This research is concerned with the modelling and performance analysis of footwear industry. Within the production department,

This paper is mainly concerned with the modelling, simulation and performance analysis of assembly line balancing of footwear manufacturing in Jamaica-Ok shoe factory with Arena simulation software, a simple shoe model called soccer-01 is selected for the study. Collecting and analysing all the necessary input data using input analyser of Arena, the simulation model was developed for the existing manufacturing system of this model shoe.

After verifying and validating the developed simulation model, it is simulated for 8 hour working time with 10 replications length. After analysing the result of the simulation run, problems of existing manufacturing system are identified. To solve these identified problems, the previous working system should rearranged according to natural and logical relationship between each taskes and the result of the rearranging reduced 536 second and the company can manufacture 17units/hour which mean that it is 5 more than the previous number of shoe per day.

This result lead to the company can manufacture 40 units per more per day, (the previous production capacity was 48 per day), the cycle time reduced by 83 second, the duplication of the same process also avoided merged together, the number of man power also reduced, the production time also decreased.

The significance of this paper includes establishing line balancing mathematical model suitable for shoe manufacturing industries, optimizing the system assembly lines for the case Company and Transferring the line balancing model and optimization techniques for company use. Therefore, a decision maker of case company can use the optimal assignment of tasks to stations as presented in this paper and can improve performance of the system without disturbing the system of shoe production.

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