STATISTICAL ANALYSIS OF A PRODUCTION LINE FOR A TROUSER MANUFACTURING UNIT IN A GARMENT INDUSTRY USING SIMULATION MODELING

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Abstract -*The garment industry consists of series of processing units and a continuous flow of garments. Since it is a series of processing stages, the variability at one stage can have an effect on another stage.*

In a trouser manufacturing unit, the back Panel trouser unit and front Panel trouser unit are assembled at a particular stage, therefore variability at each one of unit will have an effect on assembly area. Thus the performance outcome such as throughput, WIP, cycle time could be affected. In order to understand the effects of it would be necessary to study the process time, and hence forth understand the effects of its variability at all stages. This can be achieved by analyzing the process time and simulating the system. This would provide a good insight into the manufacturing principles of garment industry in reference to performance measures such as cycle time.

Additionally there would be various situations possible for which simulation can be provide good insight. This paper focuses on all such aspects.

Key Words:**Simulation, Throughput, T Test, Cycle Time, WIP**

1.INTRODUCTION

There are many factors which affect the throughput and waiting time of a manufacturing system. A manufacturing system can be viewed as queuing system where variability arises due to Interarrival and service times. In addition availability, resource constraints, failures, rejection adds to the decrease in performance measure.

In a garment industry variability in the system arises due to the processing times of various processes involved in stitching the garment. The basic process flow of how a garment gets processed is shown in Figure 1.

Figure 1 provides an outline of the different processes of each section. The time required for each sub process in a section is not large enough, however the time required for each section for completion of a set of batch is large. For example front Panel would take to process a batch of 10 within a particular time, likewise back Panel and assembly. Hence understanding the process time based on batches would be a better way to understand the performance measures.

Typically in queuing model certain assumptions are taken which include that Inter arrival time should be exponential distributed and model should be Markovian in nature (Hiller and Liberman[5]). Modeling of such situation can be accomplished by using queuing theory models. However it is not necessary that real world scenario need to follow such kind of behavior in process or interarrival times. In such cases simulation would be better option to understand the performance measures.

There are several advantages of simulation and have been addressed by authors such as Jerry Banks [6]. One important use of simulation would be look at what if scenario and hence understand the impact of these scenarios on the performance measures.

In this paper, we use simulation with the aim of analyzing different operational conditions of the Manufacturing department resulting from the combination of several input parameters.

2. LITERATURE REVIEW

Several authors have used simulation techniques to understanding the performance measures in a garment industry.

Fatma Kalaoglu, Canan Saricam [4] analyzed a modular stitching line (U shaped) wherein the operator follow a sequence of operations and in case the operator encounters another operator the job which he was working would be handed over the other operator and would continue another job which is available at the end of U line. In order to accomplish such kind of rotation methodology the operator needs to be skilled in multitasking. They have compared two different methods with different operators combination by simulating the system to identify the bottleneck and understand the effect of these combination on performance measures such as throughput, work in process and cycle time.

Mucella G. Guner, Can Unal [7] make use of simulation to understand the various scenarios for T shirt Garment manufacturing unit. In their model they had considered processing time of every subsection and accordingly modeled using simulation techniques. The alternative scenarios used were based on changing the number of operators in each scenario and then comparing these alternatives.

Senem Kursun, Fatma Kalaoglu [9] focused on understanding the labor intensive structure of a developed a simulation model to understand on how to balance the line by identifying the bottleneck. The bottleneck were identified by simulating the garment industry scenario.

Daniel Kitawetal. [2] have used simulation to identify bottleneck machines for a polo T shirt manufacturing unit. Simulation was used to evaluate the performance of system by addition of work centers based on the bottlenecks identified. In addition various alternative scenarios such as addition of operators where included at the bottleneck work centers and evaluated using simulation.

Selin Hanife Eryuruk [8] had simulated the dress production system to understand the bottleneck in the system and accordingly used different set of line balancing method to modify the system.

It is seen from various literature in the garment industry that simulation is used to identify the bottleneck in the system and evaluate alternative scenarios. Simulation provides a faster approach to solve a queuing process and accordingly.

In the current work simulation is applied in a garment industry which manufactures trousers. Various alternative scenarios are evaluated and compared statistically.

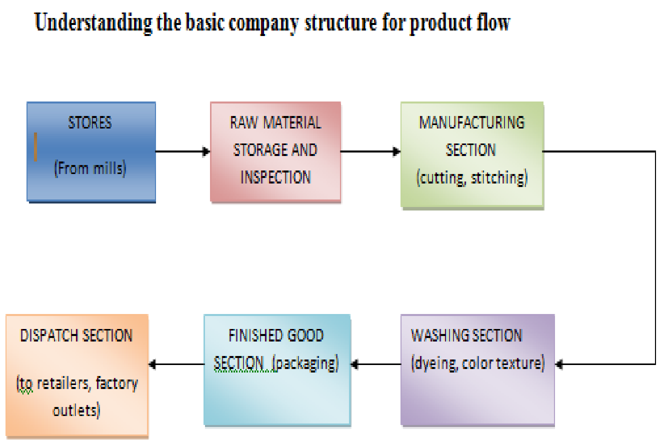


Fig -1: Process Flow of Trouser Manufacturing

3. PROBLEM DESCRIPTION

An initial study of the garment section revealed that manufacturing section has a high percent of variability when throughput and cycle time were used as performance measures.

The area of problem as observed was the improper arrangement and management of raw materials. After identifying, studying and analyzing the entire structure of the firm with respect to the main departments it was observed that one section of the company that is "Production Section" seemed to have a high variability purely because of the number of operations it had and the variations of output that was seen in the past records. It was also seen that the fluctuation of the outputs was significant at times and also it was found from previous records the production was not always achieving its target due to variation in labor strength and also due to variation of products. Due to these reasons it was decided to create a simulation model of the garment production unit to understand the bottlenecks and accordingly create alternative scenario. Process times were taken in batches and the size of this was determined through population mean to obtain N which came to 30.

4. METHODOLOGY

The process of producing the trouser is shown in Figure . In order to develop a simulation model production section, the system was analysed and categorized into different department which is Cutting, Front Panel, Back Panel and Assembly.

To conduct the simulation study and evaluate various alternatives the following steps shown in Figure 2 were conducted.

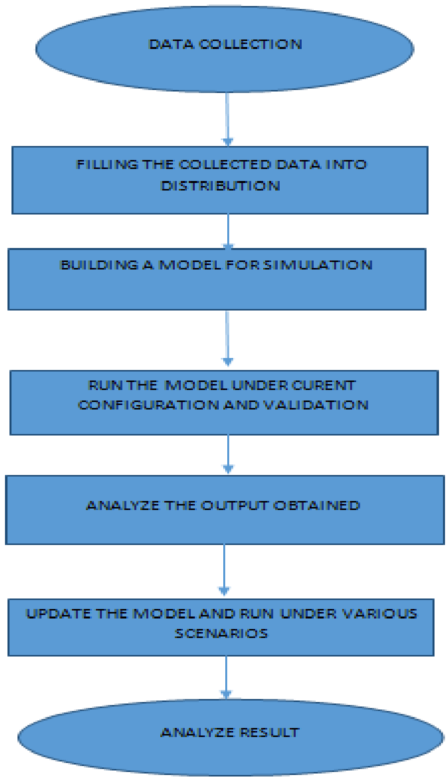


Fig -2: Methodology

4.1 DATA COLLECTION

Initially for process times data points for back Panel, front Panel and assembly were collected and the number observation required for conducting study was calculated for an accuracy of 5% and a confidence level of 95% using the following formula as mentioned in Benjamin W. Niebel[1].

$$N = \frac{Z\alpha_{/2}{}^{2}.S}{K^2\bar{X}^2}$$

$Z\alpha_{/2}$ *is* 1.96 *for* 95% *confidence level,*

K is accuracy 5%

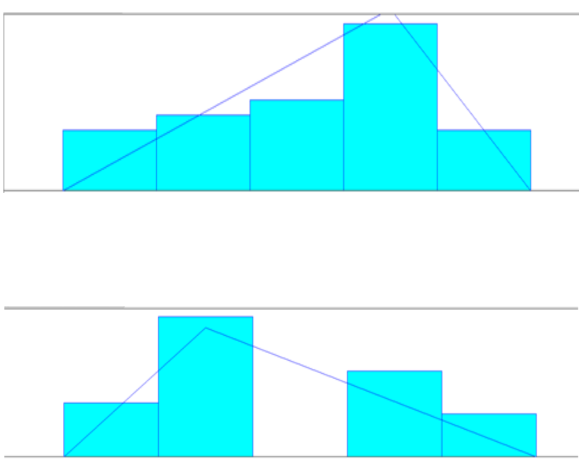
$\bar{X}$ *is sample mean*

S is sample Standard deviation

Based on the number of observation it was found that 30 data points are sufficient enough. The process times of different department were collected by considering 10 in a batch for cutting, front Panel, back Panel and 20 in the case of assembly and after calculating mean population we came to a conclusion to collect data for 30 samples.

4.2 FITTING DISTRIBUTION

The data was collected and fitted using Input Analyzer software. KS test was used for identify the exact distribution, the p values and the mean squared error was used to identify the correct distribution. Since the sample size is small enough Chi Square will not fetch good results hence use of KS test would be helpful for appropriate conclusion. Figure3 and the Table 1 shows the corresponding distribution and their values.



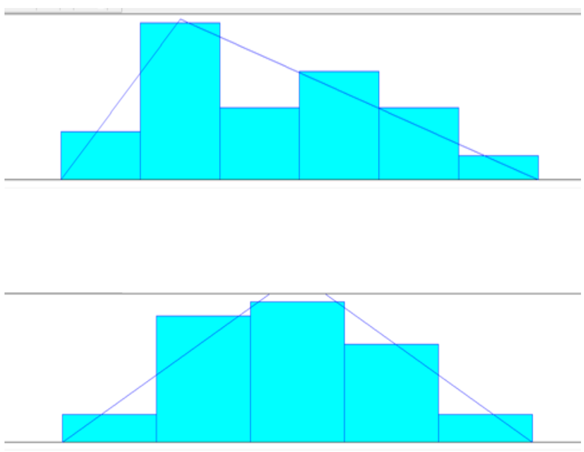


Fig -3: Assembly, Cutting, Back Paneland Front Panel Distribution's

OPERATIONS	DISTRIBUTION TYPE	Pvalue KS test	Squared Error
ASSEMBLY	TRI(12,13.5,14)	>.15	.01379
CUTTING	TRI(4,4.48,5.6)	.125	.104
BACK PANNEL	TRI(9.01,9.4,10.7)	>.15	.014
FRONT PANNEL	TRI(9.24,10.5,11.7)	.145	.0047

Table1: Assembly, Cutting, Back Panel And Front Panel Distribution Type and Parameters

4.3 MODEL BUILDING

Initially a create model was made for rolls which come in and was considered as 1 roll per hour which is followed by inspection which is made by a process module followed by cutting which is also a process module in which after the rolls are inspected goes for cutting which is done in batches of 10. The module is shown in Figure 4.

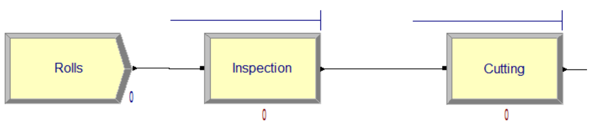


Fig -4: Create, Inspection and Cutting Module

A separate module as shown in Figure 5 is created which separates out the cutting into different Panels there after the duplicate is disposed off and the original is again furthered separated out to front Panel and back Panel.

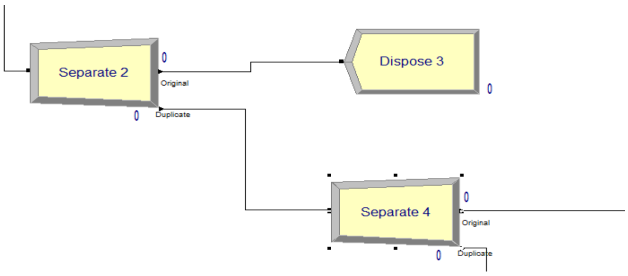


Fig -5: Separate Module

The back Panel and front Panel are processed in batches of 10 for which the batch module was used and for batchinginto 10 there was a certain amount of time delay. The processing time for the front and back Panel are used as an input to the process module.

Once the back and front Panel are processed, match module is being used to match the front and back Panel.

Once matched the trouser is being to sent to assemble, wherein the processing is based on the assembly time. After processing the batch is sent for packing. The final simulation model is shown in figure7.

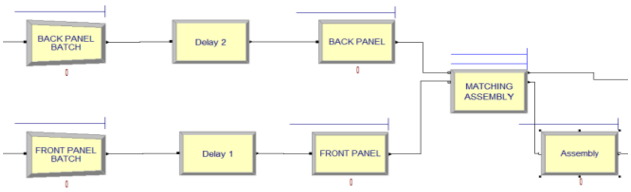


Fig -6: Back & Front Panel with Match Module

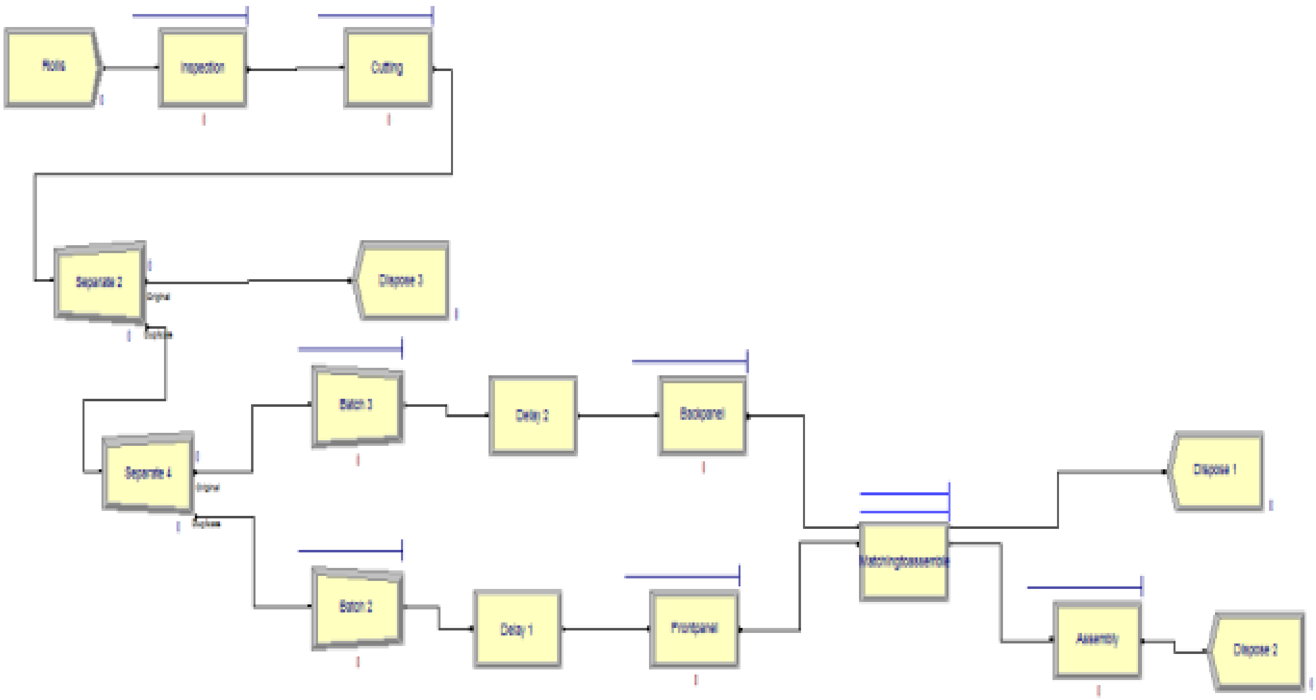


Fig -7: Simulation Model for Trouser Manufacturing of Garment Industry

4.4 MODEL VERIFICATION AND VALIDATION

By considering the above distribution, simulation model was run. Verification of model was done step by step comparing with actual system. The model statistics, number of current trousers, cycle time, server utilization percentage, waiting time of jobs, average output, and throughput value were compared with those of the actual system, and in all cases there were no significant differences between the model and the actual system.

The model was run for 30 replications with 1hour run time and results were obtained.

The result shows that for an hour 9 batches comes out which equals 90 pieces per hour and the above when calculated for 8 hours 720 pieces which is in accordance to the real life process.

4.5 EVALUATION OF MODEL FOR VARIOUS SCENARIOS

Based on the results obtained and seen from figure it is seen that the waiting time for front and back Panel is quite high. Hence it becomes a bottleneck operation.

In order to improve it is necessary to understand the combined behavior of the processing times of front and back Panel. Thus it is necessary to create various scenarios.

The scenarios for the front and back Panelwere created by changing the optimistic time, pessimistic time and most likely times by keeping the mean constant and changing the variance. The various scenarios are shown in Table 2 . For example High in the Table 2 indicates a larger variability in the process time of front Panel, likewise low indicates low variability in the process time and medium is intermediate variability of the front Panel.

The model is run for the various scenario combinations as shown in Table 3. The short form notation is given HH for High Variability of process time for front Panel and High Variability of process time for back Panel. Likewise the various short forms are created and these are used for comparing the results.

TABLE 2: Process Time for Back and FrontPanel Scenario

	SCENARIOS		
	SCENARIO HIGH	SCENARIO MEDIUM	SCENARIO LOW
FRONT PANNEL	TRI(9.24,12,15)	TRI(9.24,10.5,11.7)	TRI(9.24,10,11)
BACK PANNEL	TRI(9.01,10.5,11.5)	TRI(9.01,9.42,10.7)	TRI(9.01,9.2,10)

TABLE 3: Scenario Combinations

	SCENARIO COMBINATIONS		
BACK PANEL / FRONT PANEL	HIGH (H)	MEDIUM(M)	LOW(L)
HIGH (H)	TRI(9.01,10.5,11.5) TRI(9.24,12,15)	TRI(9.24,12,15) TRI(9.01,9.42,10.7)	TRI(9.24,12,15) TRI(9.01,9.2,10)
MEDIUM(M)	TRI(9.24,10.5,11.7) TRI(9.01,10.5,11.5)	TRI(9.24,10.5,11.7) TRI(9.01,9.42,10.7)	TRI(9.24,10.5,11.7) TRI(9.01,9.2,10)
LOW(L)	TRI(9.24,10,11) TRI(9.01,10.5,11.5)	TRI(9.24,10,11) TRI(9.01,9.42,10.7)	TRI(9.01,9.2,10) TRI(9.24,10,11)

5. RESULT& CONCLUSIONS

These are the various combinations that are obtained with average waiting time as obtained and can be referred for further detail analysis to get the best combination.

Here M refers to Medium, refers to Low, and H refers to High.

5.1 COMPARISION OF MEAN

The model was run for 30 replicates and the performance measures for various scenarioswere evaluates. The performance measures include average waiting time and throughput. The following description provides the result using T test.

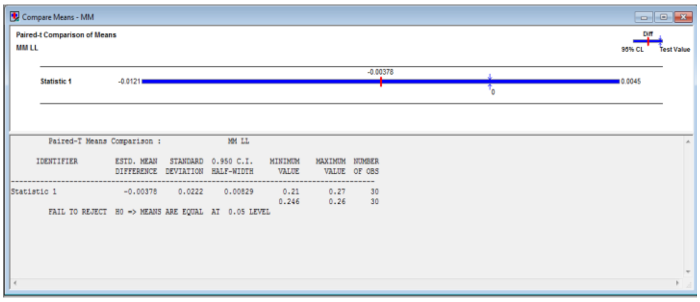


Fig -8: Pairedt - test comparison between MM & LL

From the above figure8 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

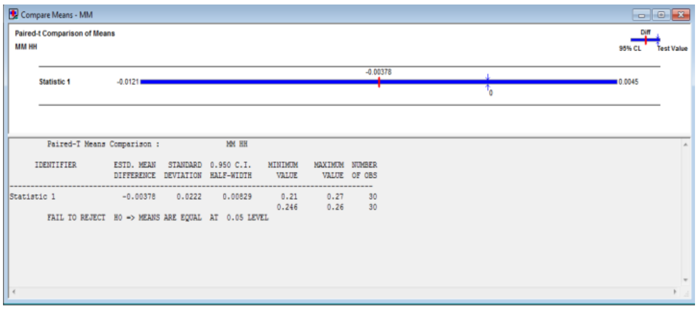


Fig -9: Paired t test comparison between MM & HH

From the above figure 9 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

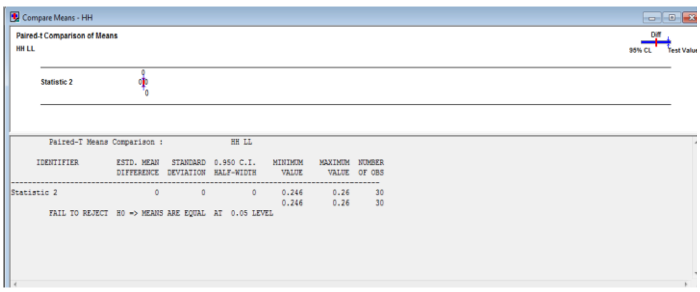


Fig -10 : Paired t test comparison between HH & LL

From the above figure 10 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

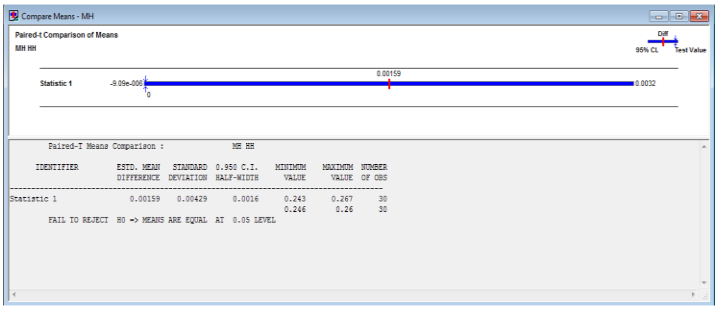


Fig -11: Paired t test comparison between MH & HH

From the above figure 11 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

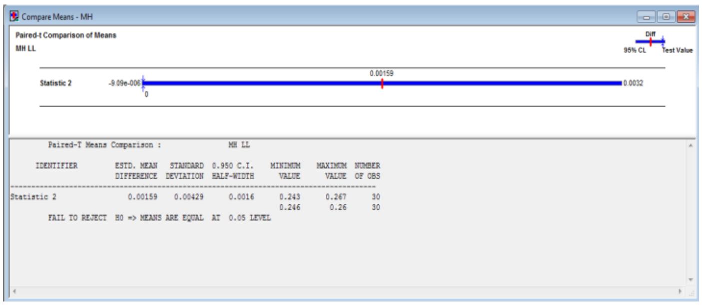


Fig -12: Paired t test comparison between MH& LL

From the above figure 12 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

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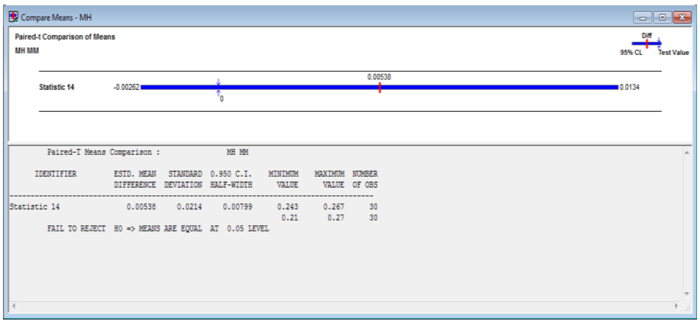

Fig -13 : Paired t test comparison between MH & MM

From the above figure 13 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

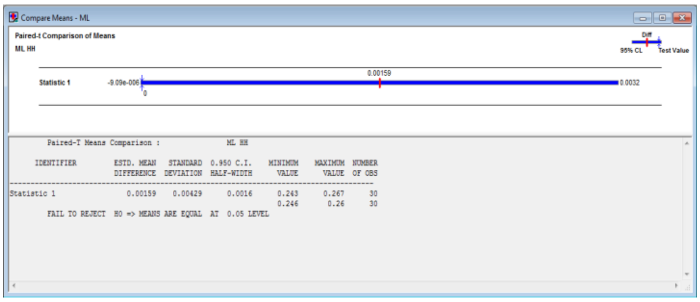

Fig -14: Paired t test comparison between ML & HH

From the above figure 14 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

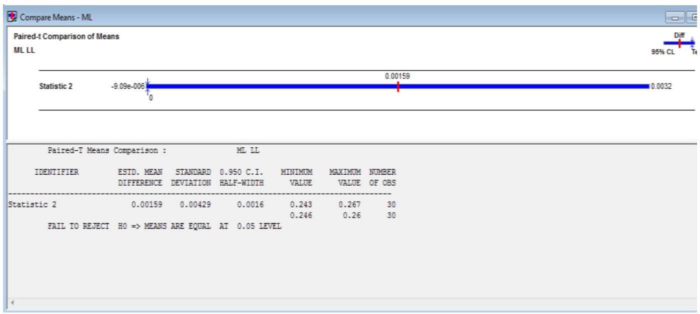

Fig -15: Paired t test comparison between ML & LL

From the above figure 15 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

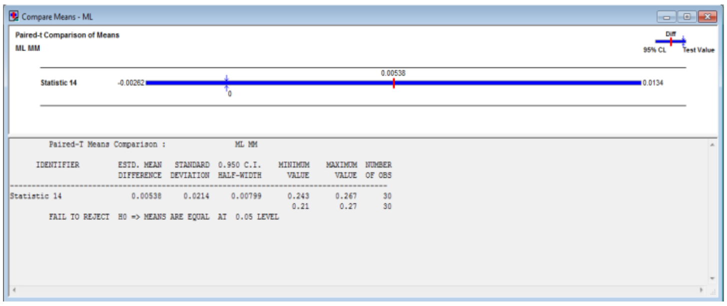

Fig -16 : Paired t test comparison between ML & MM

From the above figure 16 it can be observed that there is no significant change in the value of Average Waiting Time. Hence, null hypothesis (Ho) that is the Average Waiting Time in both scenarios are equal, hence it is accepted.

It is seen that all scenarios produce the same results statistically. Hence a nominal time value can be chosen.

5.2 COMPARISON OF NUMBER OUT OF COMBINATION (EVALUATION BY THROUGHPUT TIME)

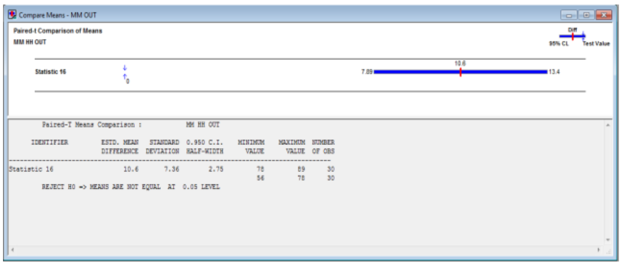

Fig -17 : Paired t test comparison between MM&HH

From the figure17 it can be observed that there is significant change in the throughput time. Hence, Null

Hypothesis (Ho) is rejected. This shows that MM combination is better than HH combination.

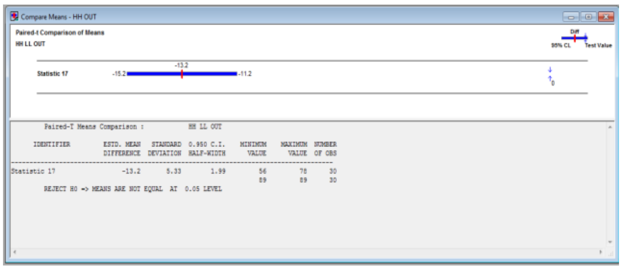

Fig -18 : Paired t test comparison between HH&LL

From the figure 18 it can be observed that there is significant change in the throughput time . Hence, Null Hypothesis (Ho) is rejected. This shows that LL produces more than HH combination.

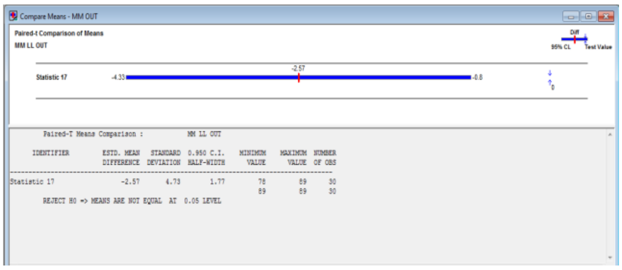

Fig -19 : Paired t test comparison between MM&LL

From the figure 19 it can be observed that there is significant change in the throughput time . Hence, Null Hypothesis (Ho) is rejected. This shows LL combination provides more throughput than MM.

It is seen from throughput results that LL, MM produces the best results.

It can be observed that from the "possible future scenarios" by means of throughput the MM&LL combination that is medium of front Panel and low of back Panel value would give the best throughput value which is 89, 89 pieces per hour compared to the existing model which gives only 86 pieces per hour.

It was observed that there was a slight variability in the system, waiting near BP, FP were not in sync to match the assembly accurately.

There was no standard procedure to understand the cycle time, throughput. The model can be taken as a reference to analyze the system for future changes.

Various scenarios are compared to find out the best combination which is analyzed through statistical data.

From output analyzer it was observed that a Low-Low Medium-Medium combination of Front Panel and Back Panel gave the best throughput which can be used for future practices.

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REFERENCES

[1] Benjamin.W.Niebel " Motion & Time Study"Richard D Irwin Publishing; 9th Edition, 1992.

[2] Daniel Kitaw, Amare Matebu and Solomon Tadesse "Assembly Line Balancing Using Simulation Technique in a Garment Manufacturing Firm" Journal of EEA, Vol. 27, 2010

[3] W. David Kelton, Randall P. Sadowski, Nancy Zupick, "Simulation with Arena", McGraw-Hill Publisher, Edition 4, 2006

[4] Fatma Kalaoglu, Caran Saricam,"Analysis of Modular Manufacturing System in Clothing Industry by Using Simulation", Fibres&Textiles in Eastern Europe, July/Spet2007, Vol15, No 3(62)

[5] Hillier, F.S and Lieberman, G.J " Introduction to Operation research"McGraw-Hill Publisher, Eight Edition, 2009

[6] Jerry Banks, John S.Carson, Barry L Nelson, David M. Nicol " Discrete Event System Simualtion" Pearson Education, Third Edition, 2004

[7] Mücella G. Güner, Can Ünal "Line Balancing in the Apparel Industry Using Simulation Techniques" Fibres&Textiles in Eastern Europe April / June 2008, Vol. 16, No. 2 (67)

[8] Selin Hanife Eryürük " Clothing Assembly Line balancing Using Simlation and Hueristic Lien Balancing Techniques" Tekstil ve Konfeksiyon 4/2012

[9] Senem Kursun, Fatma Kalaoglu "Simulation of Production Line Balancing in Apparel Manufacturing"Fibres & Textiles in Eastern Europe2009, Vol. 17, No. 4 (75) pp. 68-71

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