

Applications and Theoretical Research for Fabric Manufacturing and Influence of Descriptive Statistics

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Abstract

In this study, we reviewed the history of textiles in North Africa also will determine the Processes either add value or waste to the production of a good or service. Initially, we have collected all the information for Libyan Textile Company starting from overproduction, waiting, inventory, transportation, over-processing, motion, defects, workforce underutilization, and improper utilization of technology of our ten wastes in manufacturing. Analytically modeled using a comprehensive computer simulation model that has been created using Rockwell software (ARENA14.7) in order to test the solutions for experimentation and enhancing of the company. In this experiment we will compare two different colored yarns in the woven carpet factory, factors might have a cause and effect relationship in Libyan textiles. Woven carpet is very much similar to a woven cloth and is produced on a loom only. Different colored yarns are used to produce intricate designs and patterns. In this experiment, we will use repeated T-Test or paired T-Test to compare colored yarns. In this paper, we will consider these to be paired data samples (intricate designs and patterns) because each pair of values in each row represents a unique product from different colored yarns woven W1, W2, W3, and W4. To compare the mean values we will use paired T-Test.

Keywords

Textile History, North Africa, Textile, Yarn, Woven, T-Test, Wilcoxon Test, Lean

History and Textile Company

Carpet and fabric is a common floor covering in today's homes and offices. The first carpets characterized by pile surfaces were probably cured animal skins laid on the dwelling floors of early hunters. Those floor coverings served many of the functions that floor coverings serve today. It's not easy to find out the exact time where textile discover, during the 4th or 5th millennium BC, floor coverings were plaited rushes as showing on Figure.1 from Acacus Caves and Tassili Caves in Libya. Early Libyan colonists made rugs and Jarad using (Mizda) a variety of techniques including knitting, crocheting, and braiding embroidering, and hooking. Hand-knotting is carried out on a simple loom as shown in Figure 2.



Figure. 1 Weave graphics on Acacus Caves and Tassili Caves



Figure. 2 women wafing Libyan Jarad using Mizda

Now Libya has “Wool Textile Company” consists of following plants with utilities and auxiliary plants commence started work on 15th January 1983 and completed taking over a test run on 8th June 1983. This large textile complex was established in the city of Bani Walid, about 200 kilometers (124 miles) south of the capital Tripoli. The company's manager, Al-Najeh Al-Houderi believed the factory is among the few factories still operating in Libya. "The Baniwalid Wool Industries Complex is one of the largest industrial fortresses in Libya in the spinning and weaving sector. It is one of the few factories which are still operating today," he says. The factory currently offers employment but suffered extensive damage during the unrest in Libya - 2011 Figure. 3



Figure. 3 Extensive damage during the unrest in Libya – 2011

Al-Houderi says some sections are completely destroyed and estimates that overall damage affects more than 50 percent of the building as showing in the Figure.4 The remaining machinery has been restored and is now back into action. But Al-Houderi hopes the money from Libyan Fund for Economic and Social Development will help to re-establish the rest of the machines and factory floors.



Figure. 4 Heavy equipment and damage to the production equipment

From 2006, the factory became a joint-stock company until the beginning of 2017, when the Libyan Presidential Council took over and included it as a company that the fund can help. The factory now produces two types of carpets, fine luxury ones and those for everyday use. Previously some of the carpets from here were shown in a number of local and international exhibitions. Many factories in Libya suffered destruction due to their locations in areas that had been subjected to clashes over the past years. In addition, regional insecurity meant many of the foreign workers had to flee. This worsened the production and symbolized the deterioration of the Libyan economy in general, prior to 2011, the factory produced 1500 meters per day. But this has gradually declined. In 2012 it decreased to 1000 meters and in 2015 it became just 700 meters. This was due to the high prices of raw materials and the extent of damage to some of the machines. Now the factory produces 200 meters of carpet daily. There are around 50 machines currently operating and one which is used in the luxury carpet section. The repairs are difficult, especially as the factory cannot afford to import spare parts for the many machines which are made in Germany.

Libyan Textile exports its finest quality, handkerchief and table linen products to its customers not only inside the country! He has participated in many exhibitions inside and outside Libya. The main manufacturing activities are weaving, bleaching and dyeing, and embroidery. The industry products several fabric things under an administration contract. A public association whose purpose is to provide employment to persons with disabilities, the company representative interviewed said that the company is choosing to implement lean principles as a means to compete with the commercial and nonprofit contractors with whom they bid against for their government contracts. The factory produces two types of carpets, luxury carpets, and plain carpets.

Is Libyan Textile Lean? Libyan Textile Company does use batches in their production. The main reason for using batch flow instead of one-piece-flow is because the factory is usually manufacturing twenty different products at a time, which makes using a conveyor belt to transfer parts inefficient. With this great range of product variety, dividing workers into smaller groups makes scheduling a lot easier. Managers can flexibly move people and machines around as needed. This is the nature of the industry. Completely eliminating batches may be possible, but it would be a great challenge for the company. With all these constraints, the next best idea is to have smaller batches. Currently, most processes require about two minutes to complete and Libyan Textile uses batches of one hundred, which are relatively small. However, by observing the plant floor operations, managers realize that there are batches of work-in-progress (WIP) accumulating in the system. Consequently, eliminating waste and non-value added activities are the areas that Libyan Textile should focus on to improve their production system. Libyan textile has a continuous improvement team, which is comprised of plant managers, engineers and floor workers who collect and evaluate production data. They meet once a month and provide recommendations.

Floor workers at Libyan Textile are able to perform multiple tasks. Therefore, managers can flexibly rotate workers and the factory can accommodate fluctuations in demand and changes in production plans. Libyan Textile operates in a pull-based industry, and customers usually place their orders at least forty-five days in advance. Therefore, Libyan Textile seldom produces excess products. However, it takes Libyan Textile so long to complete the orders that they always miss their deadlines. Libyan Textile failure to achieve the just-in-time production system may be caused by their inability to correctly calculate production time. Thus, there may be too many non-value added processes in the system. Although managers collect statistical data about each individual task, the non-value added activities and waste in the system prevent managers from accurately determining the time needed to allocate to the whole production chain. Consequently, just-in-time production is another area that Libyan Textile needs to improve in order to be Lean. Overall, Libyan Textile is not Lean, or at least not Lean enough to meet their deadlines. The areas that Libyan Textile should focus on, are eliminating waste and zero-value added activities as well as implementing a just-in-time production system.

Woven Carpet

There are several advantages to having carpets in our homes and commercial spaces, including their aesthetic appeal, comfort, economy, temperature, and sound insulation abilities as well as safety considerations. Woven carpet is specified in commercial installations when a particularly tight construction and the dense pile is required, or a particularly intricate pattern is designed Carpet, in various forms, has been a part of interiors for hundreds of years.

Carpet variables cover; Fibers, Carpet Construction Variables, and Types of Carpet Installation Parrott, Mollet, Chen-Yu. The major steps necessary to process wool from the sheep to the fabric are: shearing, cleaning and scouring, grading and sorting, carding, spinning, weaving, and finishing Table 1.

Table 1. Carpet variables

Inputs	Carpet Variables
Fibers	Synthetic Fibers Nylon Polypropylene (Olefin) Polyester Wool
Carpet Construction Variables	Yarn Construction Tufted Carpet Other Carpet Construction Methods Carpet Backing Finishes
Types of Carpet Installation	Carpet Installation Cushions and Pads

Designed experiments have many potential uses in improving processes and products, comparing alternatives is one of the purposes of experimentation. Different colored yarns are used to produce intricate designs and patterns. In this experiment, we will use repeated T-Test or paired T-Test to compare colored yarns. Table 2. We will consider these to be paired data samples (intricate designs and patterns) because each pair of values in each row represents a unique product from different colored yarns woven W1, W2, W3, and W4. To compare the mean values we will use paired T-Test.

Table 2. Different Colored Yarns Woven

Woven	Intricate Design	Patterns
W1	7.56	7.47
W2	7.52	7.4
W3	7.7	7.49
W4	7.61	7.55

Descriptive Statistics

We have the samples in different columns and we will put the first sample as intricate design product and second sample as Patterns product. Table 3. Paired T-Test actually evaluates the difference between two samples by taking (Intricate design – Patterns) under two –Tailed test.

Table 3. Actually Evaluates the Difference Between Two Samples

Sample	N	Mean	StDev	SE Mean
Intricate design	4	7.5975	0.0776	0.0388
Patterns	4	7.4775	0.0618	0.0309

The confidence interval for the main difference (Estimation for Paired Difference) showing it's between 0.0169 and 0.2231 which is a positive difference and because we took the difference as being (Intricate design - Patterns) a positive difference suggests that intricate design product has a PH value that is significantly greater than Patterns product.

Mean	StDev	SE Mean	95% CI for μ difference
0.1200	0.0648	0.0324	(0.0169, 0.2231)

μ _difference: mean of (Intricate design - Patterns)

T-Test measures for a meaningful difference in the PH as begin either Zero or not calculates a T value of 3.70 and P-value of 0.034 because this is less than 0.05 we reject the null hypothesis. There is no difference and conclude that there is a difference between the PH of the two products.

Null hypothesis $H_0: \mu_difference = 0$
Alternative hypothesis $H_1: \mu_difference \neq 0$

T-Value	P-Value
3.70	0.034

We created a new variable as showing bellow which in Table 4. these variables are the differences between each of these paired variables to test the difference in median values (Wilcoxon Signed Rank Test)

Table 4. The Differences Between Each of These Paired Variables

Woven	Intricate design	Patterns	Intricate design - Patterns
W1	7.56	7.47	-14.85
W2	7.52	7.4	-14.68
W3	7.7	7.49	-14.77
W4	7.61	7.55	-15.04

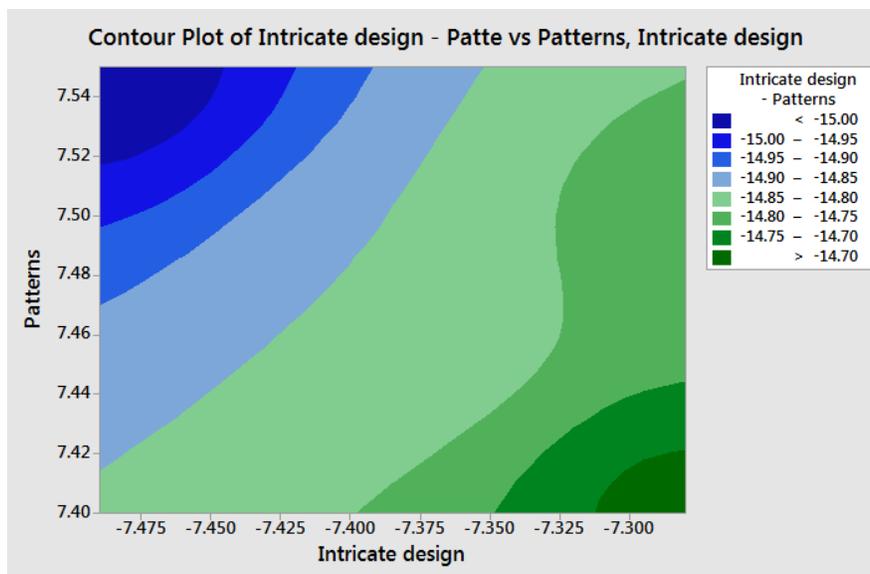


Figure 5. Contour Plot of Intricate design - Patte vs Patterns, Intricate design

Figure5. We have to do one sample Wilcoxon test to test where the median value of these differences is equal to zero or not.

Descriptive Statistics

Sample	N	Median
Intricate design - Patterns	4	-14.83

η : median of Intricate design - Patterns

Null hypothesis $H_0: \eta = 0$
Alternative hypothesis $H_1: \eta \neq 0$

Sample	N for Test	Wilcoxon Statistic	P-Value
Intricate design - Patterns	4	0.00	0.100

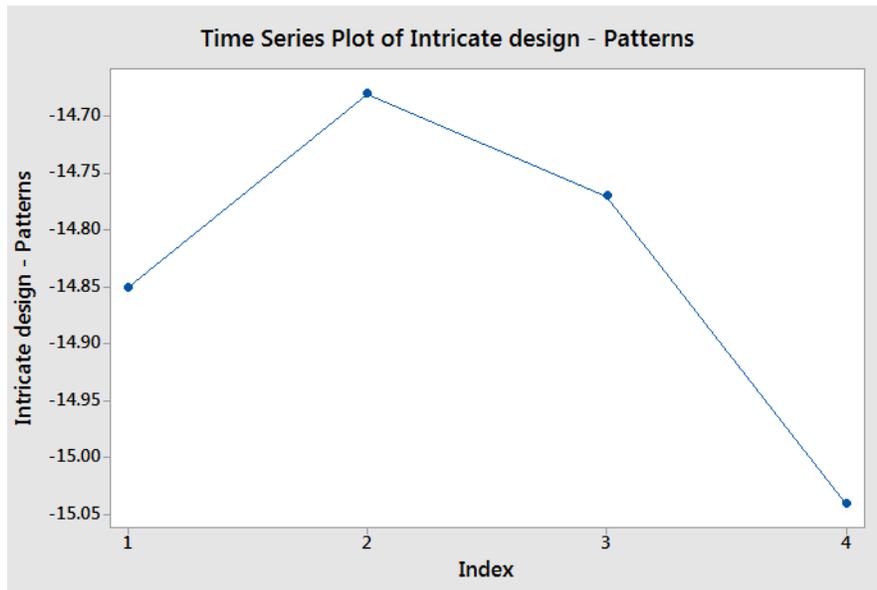


Figure 6. Time Series Plot of Intricate design – Patterns

We select out derived variables (Intricate Design - Patterns). Figure 6. The true median of the differences is Zero with the two-tailed test we got this results with statistic and p-Value of 0.100 so, the non-parametric paired Wilcoxon test is unable to detect a significant difference in the median values of the PH of two products in Libya textile company.

Response Surface Methodology (RSM)

The method was introduced by Kotzamanidis et al. RSM is a statistical experimental technique applied under appropriate experimental design to resolve multi-variable equations determines the relationship among the complaisant contributing factors (parameters) and the responses obtained. In comparison to the orthodox mathematical or one-factor optimization at a time methods, RSM is more time saving and economical. Muhammad et al. Recently there has been work done in response surface methodology was adopted using optimal design to optimize the textile industry effluent decolonization process. A previous effort by Bahadır and orbahti identified that the electrochemical treatment of textile dye wastewater was also optimized using response surface methodology.

Lean Six Sigma (LSS)

Lean and Six Sigma are improvement methodologies developed in the manufacturing industry and have been applied to healthcare settings since the 1990s. Six sigma quality is a problem-solving methodology that was first used at Motorola to represent its strategy for the lowest possible failure. Six sigma represents the mathematical calculation, 99.9996% perfection 3.4 defective products on a sample of one million, which is very close to zero defects.

Taghizadegan defines lean six sigma as a data-driven approach to find the root cause of problems, management strategy to manage lean projects to financial goals and uses the DMAIC (define, measure, analyze, improve, control) process to organize operating processes. It is a management style that relies on a tightly controlled organization dedicated to project management. As the number of Sigma is greater the production is consistent with values close to the average Figure 7.

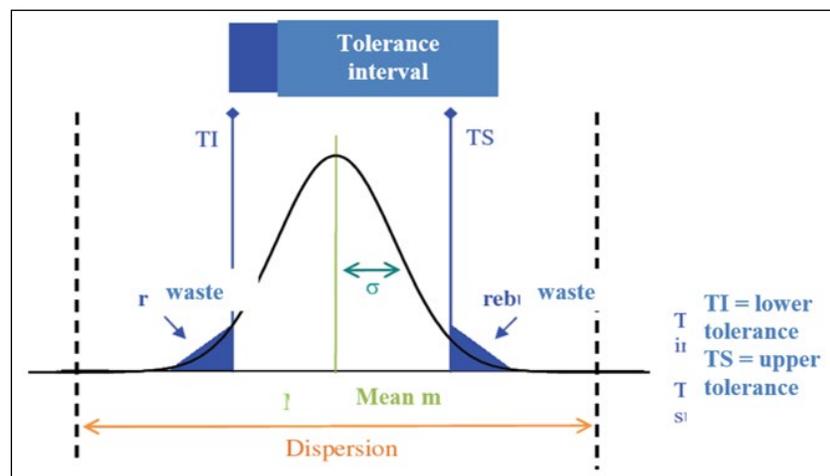


Figure. 7 Representation of areas of waste on normal dispersion

Lean focus mainly on waste elimination, using simple and visual techniques whenever possible and Six Sigma on the control and processes variability reduction, using statistical tools for this purpose. Although both Lean and Six-Sigma have been important for the improvement work in the companies.

Simulation

A variety of computer software can be utilized in the task of manufacturing and service facility design. Most simulation modeling software is now implemented using graphical user interfaces employing objects or icons that are placed on the screen to produce a model. Andrew used a simulation model to estimate the size of storage areas required for a proposed overseas textile manufacturing facility. The simulation model was built using the ARENA visual interactive modeling (VIM) system. Figure. 8 is a view of the animated model showing the proposed textile production facility. It was found to be an appropriate tool for this task through the use of its ability to carry information using entity attributes and its ability to show queuing behavior.

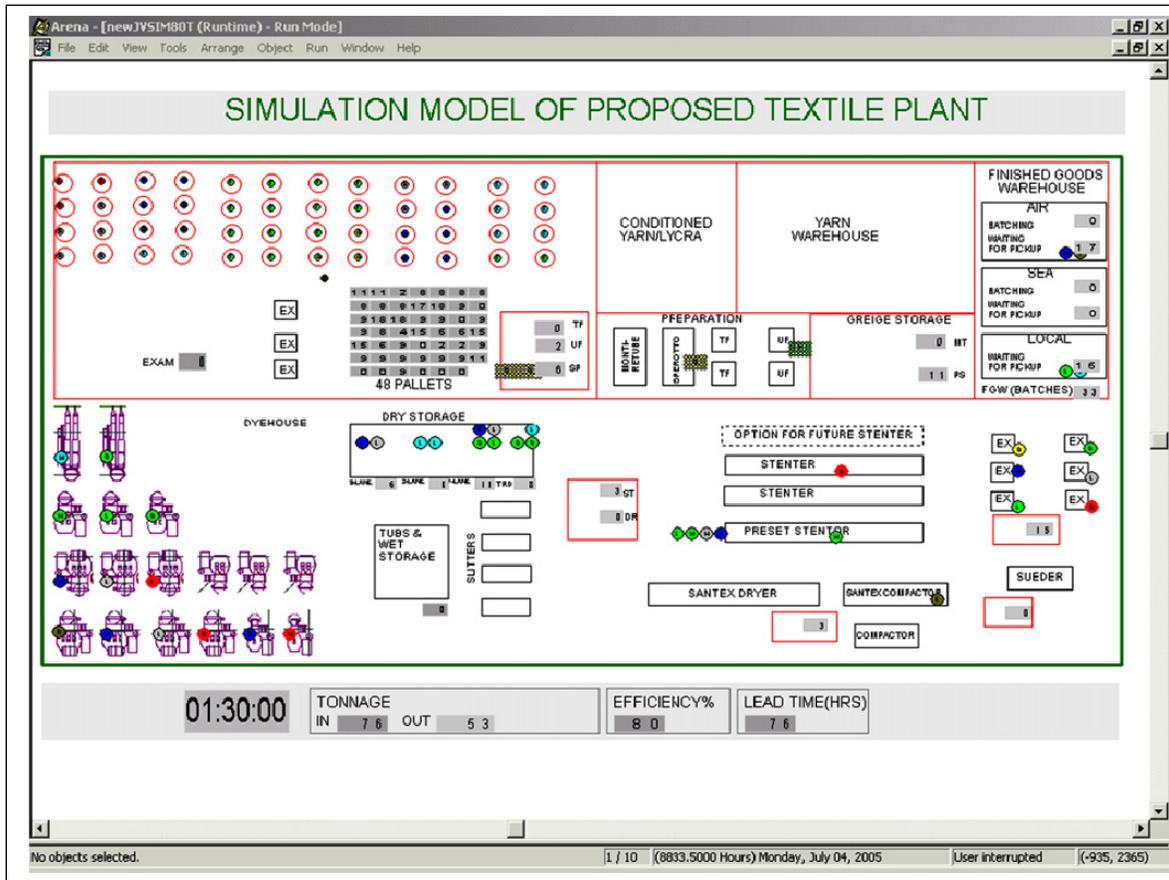


Figure. 8 Discrete event simulation of proposed textile plant

Nahimias in his paper discusses how to compete in this changing environment the producer has to improve their productivity, reactivity, flexibility, and quality. Determining the best facility design is a classical industrial engineering problem. A simulation-based comparison in textile industries is a recent study from University of Lille, North of France by Brahmadeep et al. to Manual and automatic distribution setup in a textile yarn rewinding unit of a yarn dyeing factory, with the consideration of all the global parameters a simulation logic diagram, is developed on the basis of which the actual modeling of simulation is done on the software.

Developed with the conditions and parameters of a yarn rewinding section of a dyeing factory which presents a considerable degree of detail and complexity in the textile industry. Based on experimental data Andy Vanaerschot et al. published their paper “Simulation of the cross-correlated positions of in-plane tow centroids” in 2014. Andy Vanaerschot and his team designed a framework based on the Karhunen-Loève series expansion are adopted to simulate the in-plane towpath variability of textile composites. The methodology is validated by simulating a thousand specimens of a carbon-epoxy 2/2 twill woven composite consisting of forty warp and weft tows. Simulation of thousand specimens demonstrates that the virtual in-plane position possesses the experimental standard deviation and correlation lengths on average.

Xiongqi Peng et al. developed a simple hyperelastic constitutive model to characterize the anisotropic and large deformation behavior of textile fabrics. The developed model is validated by comparing numerical results with experimental bias extension data and then applied to the simulation of a benchmark double dome forming, demonstrating that the proposed anisotropic hyperplastic constitutive model is highly suitable to predict the large deformation behavior of textile fabrics as shown in Figure. 9 is selected for a quantitative comparison between the numerical prediction and experimental data using a simulation.

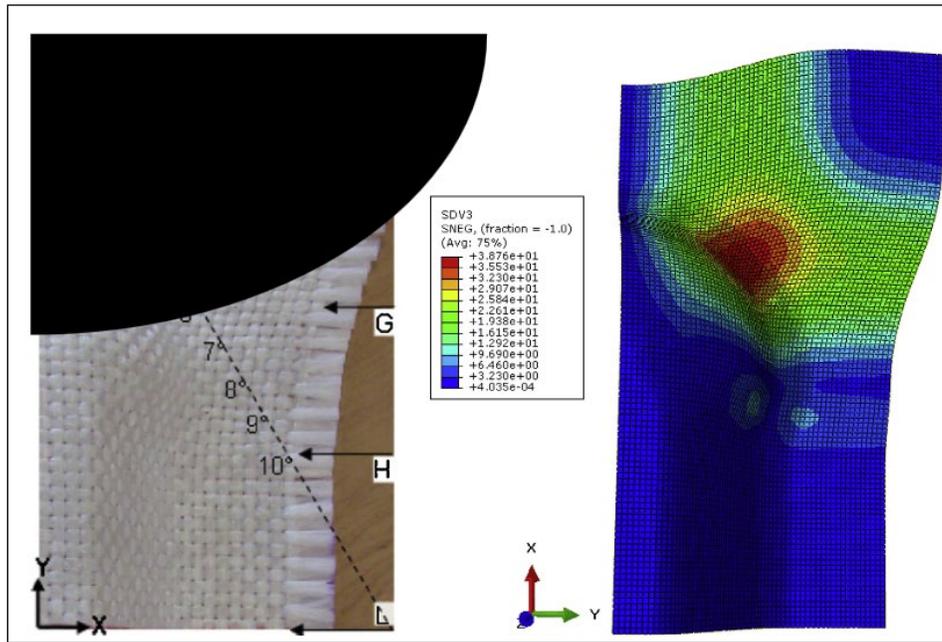


Figure.9 Deformed shape comparison of numerical and experiment outputs

Simulation Software is the heart and brain of a simulation model. To achieve the goals of the company, various simulation model alternatives are designed in order to test and compare the models and to find the most suitable result which can be implemented later. They are able to increase the number of processed customized orders twenty folds, the costs per piece decreased by eighty-four percent and obtain a high service level. It's first in the first out queue, so parts 7, 6, 5 are already in the queue and part 4 is being processed by machine then finished processing. The simple Processing System shows in Figure 10.

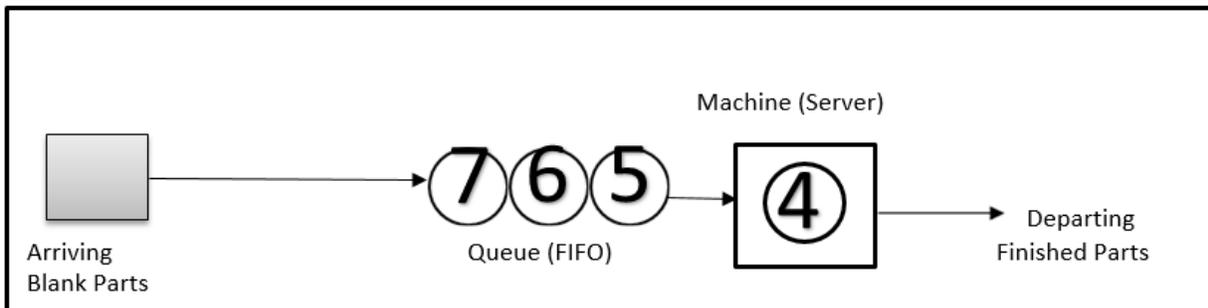


Figure 10. A Simple Processing System

Run Conditions, Output, System Throughput Optimization using Arena shows in Figure 11. For each exit point (Data Interpretation, Planning the future scopes) collect total time in system (Lead time) Cycle time. Model Assembly showing in Figure 12. And Total number seized and user-specified in Figure 13.

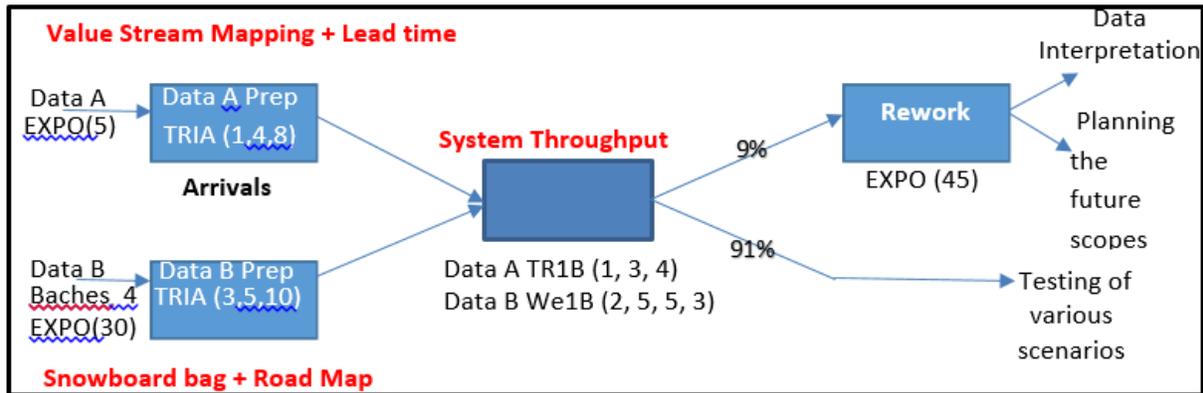


Figure 11. System Throughput Optimization using Arena

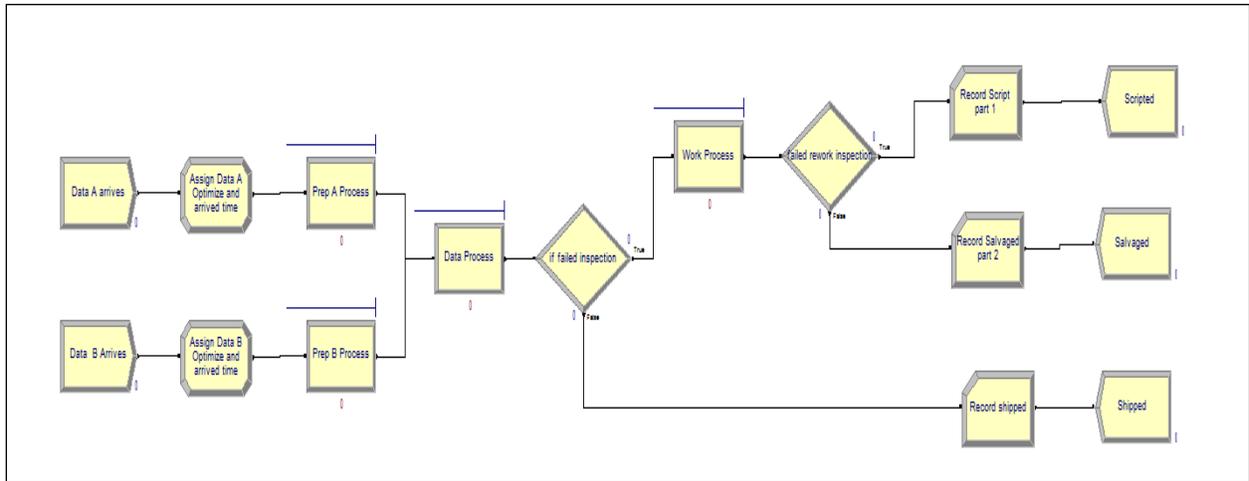


Figure 12. Model Assembly

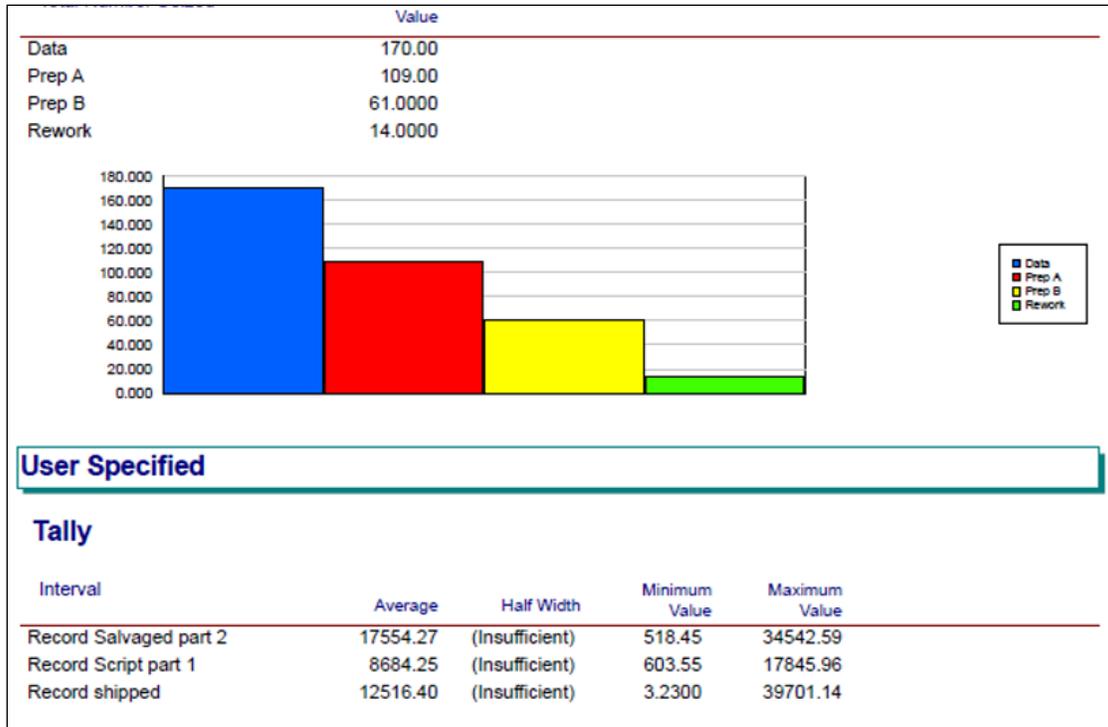


Figure 13. Total number seized and user specified

The use of optimization techniques to identify the best optimal design, and allow the textile manufacturers to improve and implement better control methods and investigate how companies across a variety of industries have used lean manufacturing strategy to enhance quality, productivity and cost.

Calculated the history of textiles in North Africa also determined the processes either add value or waste to the production of a good or service. Design experiments have many potential uses in improving processes and products, comparing alternatives is one of the purposes of experimentation.

References

Parrott, Mollet, Chen-Yu , *The Effect of Carpet Fiber on the Growth of Dermatophagoides farinae in a Controlled Environment*, Master of Science in Near Environments, Virginia Polytechnic Institute and State University, 2000

Al-Najeh Al-Houderi, *The Company's manager, Wool Textile Company*, interview 2018

Yame, A., Ali, A., Jawad, B., Nasser, D.A.W.M. and Abro, S., 2016. *Optimization of Lean Methodologies in the Textile Industry Using Design of Experiments*. World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 10(9), pp.3208-3212.

Yame, A., Alwerfalli, D., Jawad, B., Ali, A., Abro, S. and Nasser, M., 2016. *Applications of Lean methodologies and Quality improvement in the Industry* (No. 2016-01-0343). SAE Technical Paper.

Brahmadeep, F., and Thomassey, S., "A simulation based comparison: Manual and automatic vdistribution setup in a textile yarn rewinding unit of a yarn dyeing factory", 2014.

Vanaerschot, A., Brian, N., Cox, S., Lomov, V., and Vandepitte, D., “*Simulation of the cross-correlated positions of in-plane tow centroids in textile composites based on experimental data*”, Teledyne Scientific LCC, KU Leuven, Department of Mechanical Engineering, 2014.

Khan, M., Mabrouki, T., Vidal-Sallé, E., and Boisse, P., “*Numerical and experimental analyses of woven composite reinforcement forming using a hypoelastic behavior*”. Application to the double dome benchmark. *J Mater Process Technol* 210:378–88, 2010.

Yame. A. “*Survey-based statistical data and totaling long columns of numbers on Lean Manufacturing; Case Study*”. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Nahmias, S., “*Production and Operations Analysis*”, McGraw-Hill, New York, 2005.

Ahmad Yame. Advances on design and materials of solar Trombe Wall. Thesis Master of Science (MSc), University Kebangsaan Malaysia, Bangi 2007

Ahmad Yame,”System Throughput Optimization and its Interaction with Waste under Lean Manufacturing Considerations” Ph.D. dissertation, Doctor of Engineering in Manufacturing Systems (DEMS). Lawrence Technological University. 2020

Yame. A. *Tufted Woven Carpet with Enhanced Machine Mechanism Properties Using Response Surface Design Analysis*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Kotzamanidis, C., Roukas, T., Skaracis, G., “*Optimization of lactic acid production from beet molasses by Lactobacillus delbrueckii*”, NCIMB 8130. *World J.Microbiol. Biotechnol.* 18, 441–448, 2013.

Muhammad, A., Qamar, Y., Hafiz, M., and Nasir, I., “*Development of novel enzymatic bioremediation process for textile industry effluents through response surface methodology*”, 2014.

Bahadır, K. Korbahti, P., “*Response surface optimization of electrochemical treatment of textile dye wastewater*”, 2006.

Yame. A. *Synthesis and Interaction with Waste in Trico Factory Layout and Cycle time analysis*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Yame. A. *Method for Producing advanced Carpeting Using a HTC factor*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Yame. A. *An implementation of the variance analysis (ANOVA) for Mattresse factory at Fisher Pairwise Comparisons Level*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Youssof, A., Rachid, C., Ion, V., “*Contribution to the Optimization of Strategy of Maintenance by Lean Six Sigma*”, 2014.

Yame. A. *Heating and Cooling Loading Processes and Optimizes Material Properties for the Best Thermal Performances using CES*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Yame. A. *Production Stages and Data of Study are Analyzed as System Throughput Optimization*. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE, March 10-12, 2020

Taghizadegan, S. “*Essentials of Lean Six Sigma*”. Oxford, UK: Elsevier Inc, 2006

Biography

Dr. Ahmad Yame earned his Bachelor degree in Engineering Technology from the Lawrence Technological University in 2010, Mr. Yame has three master degree, the latest was in 2015 in Industrial Engineering from Lawrence Technological University, second MSc was in Engineering Management 2011 from the Lawrence Technological University and his first MSc was in Mechanical Engineering back in 2007 from the National University of Malaysia. He earned his Associate's degree in Mechanical Engineering 2004 from the Libyan Higher Professional Center for Comprehensive Professions. He primarily develops engineers but also has experience with software and testing. Dr. Yame has tested many enterprise applications for automotive MAHLE Laboratories in 2013, he working with Panasonic automotive in North America since 2016 to test vehicles for AHU/Sync and diagnostic functionalities of engine control systems. He has organized several simulations, in order to test the engine control software and the diagnostic functionality on a CANlog, respectively, through non-regression and diagnostic tests.