Synthesis and Interaction with Waste in Trico Factory Layout and Cycle Time Analysis

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Abstract

We analyze a single replicate of experimental design using Minitab, the idea is to determine what factors affect the production of the Trico factory. form research we have four factors and they are as follows: The first factor is Guides and Guide Bar, the second factor Needle and Needle Bar, third factor Sinker and Sinker Bar, and Forth factor Pressor Bar. Using programmer productivity unites to measured responses to each of the variable combinations. we also go by starting going to a statistic from using the experimental analysis to name the factors with two-level factorial which they are either plus 1 or minus 1 and structure them by order A, B, C, and D. In this study we will determine the starting values using nonlinear regression. However, we got a result of prediction is submitted to professional workers in the company to give an exact response for each run based on the real process to Plot the data to estimate and validate the response as Y vs X to find intercepts at X equal to zero then replot the data. However, we are using Minitab to compute values pf the model by using the trial estimates and plot the predicted values versus the original data we have. We will go through that the Libyan textile company has five industrial units, Woven carpet, Tufted carpet, Needlefelt carpet, Trico, and Matters. The capacity of annual productivity for Woven carpet is 284000 m^2, Tufted carpet is 620000 m^2, Needlefelt carpet is 2000000 m^2, and Matters is 70000 matters annually. The company should implant the Layout and Cycle time analysis and we have it in three points, first is the Minimize transit time, Simplify workflow, and Functionality.

Keywords
Waste, textile, Tricot fabric, Woven, Factorial Regression, Nonlinear Regression.

1. Application of decision support and intelligent systems

1.1 Expert systems

Expert systems is a computer system that emulates the decision-making ability of a human expert. The application of expert systems in textile and apparel manufacturing can support companies to decrease environmental costs by classifying the most appropriate processes and equipment and develop more efficient and objective planning in their production. Wong and Zeng used fashion retailing, a fashion mix-and-match expert systems can be developed to automatically provide customers with professional and systematic mix-and-match recommendations, so as to enhance customer satisfaction and, sequentially, to expand sales an expert system is divided into two sub-systems: the inference engine and the knowledge base. Years later Nwigbo and his team Nwigbo et al. explained that the knowledge base represents facts and rules, the inference engine applies the rules to the known facts to deduce new facts, and inference engines can also include an explanation and debugging capabilities.

1.2 Hybrid systems

Employ a combination of several methods and techniques from artificial intelligence. In this search, we describe hybrid systems as those systems that combine any two or more of the above-mentioned decision support and intelligent systems. Recently work at Arizona State University, School of Sustainable Engineering and the Built Environment by Barzin et al. using the relationships studied, one can use the model prediction tools as a design tool and customize the material properties of the composite for any structural application. Barzzin's and his crew have investigated mechanical properties of different hybrid Textile Reinforced Concrete (TRC) composites that were correlated by comparing the experimental tension and flexural results. It is noted that simulations that use the flexural response may overestimate and underestimate the tension response under different conditions. The discrepancies in the magnitude of nominal strength obtained from the experiments could be characterized by comparing the cumulative probability distributions of the different fabric systems as shown in Figure. 1 when the test results are analyzed using a simplified linear analysis, the variability between the results of tensile and flexural strength can be as high as two hundred to three hundred percent.

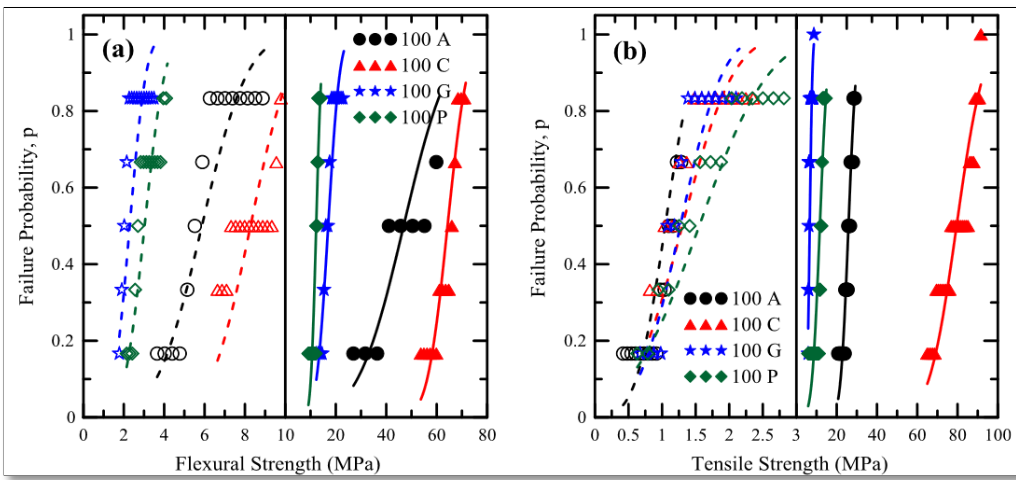

Figure. 1 Cumulative probability distributions of flexural and tensile strength

Through the combined use of these all technologies, the performance and benefits of the resulting systems can be strengthened and maximized. Thus, a growing number of applications of hybrid approaches are found in various areas in the textile and apparel industry. For example, hybrid systems were used to improve the forecasting systems of a distribution network by Thomassey et al. helped textile and apparel manufacturers achieve higher accuracy rates when evaluating their products. Researchers including Kim and Vachtsevanos have reported good results implementing hybrid systems that were used to monitor the performance of a textile product, to integrate and control major textile processes effectively also to provide 'fashion coordination' recommendations for fashion retailers. (Wong et al.) and his group used hybrid systems to assist a manufacturer in the selection of a suitable enterprise resource planning (ERP) system.

1.3 Decision support systems

Decision support systems are computer-based systems intended to help decision-makers utilize data and models to identify and solve problems, practically to automate a variety of tasks and to facilitate optimal decision-making within a given supply chain. According to Ufuk Cebeci based decision support system for selecting ERP systems have a vital role in today's organizations to realize their vision and strategies. However, they have also high costs and high implementation risks. This study presents an approach to select a suitable ERP system for the textile industry. Wong and Leung both agree that the decision support level, decision support systems can be applied to the design and control of an integrated maintenance management system for a textile mill. Tu & Yeung decision support systems can assist decision-makers of a garment manufacturer in selecting efficient ways to reduce total manufacturing costs; such as to control the cost of materials by developing feasible cutting order plans with respect to materials, machines, and labor.

1.4 Genetic algorithms

Genetic algorithms are population-based evolutionary searching techniques that use probabilistic search methods based on ideas drawn from natural genetic and evolutionary principles. ASIR "Aboratoire de Spectrochimie Infrarouge et Raman", France is currently using genetic algorithm optimization combined with partial least squares regression and mutual information variable selection procedures. Durand A. et al. their studies focus on near-infrared quantitative analysis of cotton–viscose textiles. The experiment in this paper shows on top of changes in chemical composition, many physical differences exist between the textile-finished products. Such differences might strongly affect the Near-infrared (NIR) spectra of textiles. (NIR) spectra of one hundred and ninety-nine cotton–viscose textile blends composing the data set are plotted in the Figure. 2. NIR spectra of 100% cotton (solid line) and 100% viscose samples (dash line) indeed, three types of viscose can be found on the textile market Viscose, Modal, and Lyocell

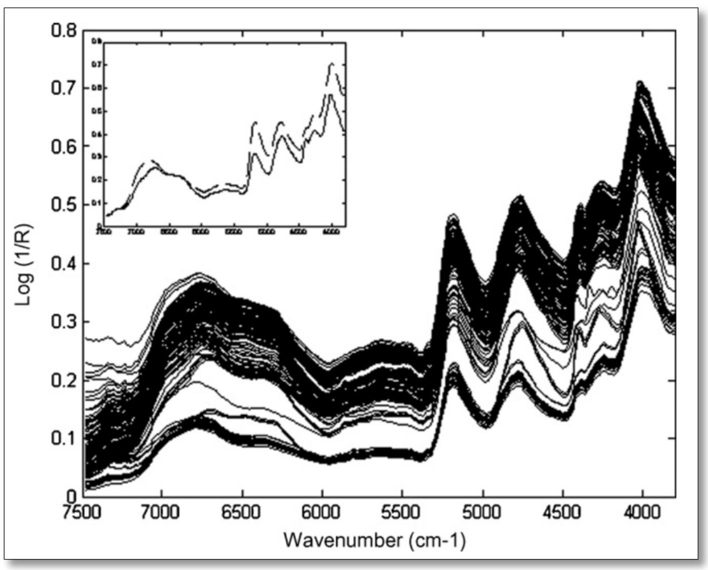

Figure. 2 Plot of the raw NIR spectra of the 199 cotton–viscose textile samples. In the inset: The pure cotton and pure viscose NIR spectra

Chan et al. define Genetic algorithms as particularly suitable in solving scheduling and machine layout problems encountered in the textile and apparel production, Particularly, Genetic algorithms can be applied to control fabric loss arising from the variance of yardage found in individual fabric rolls during the spreading process. The latest study at the National Chiao Tung University, Department of Industrial Engineering and Management, by Hsi et al. they investigate a genetic algorithm methodology for the scheduling of yarn-dyed textile production. Each subproblem is solved by a genetic algorithm, and an iteration of solving the whole sequence of sub-problems is repeated until a satisfactory solution has been obtained. Numerical experiment results indicated that the proposed approach significantly outperforms the Earliest Due Date (EDD) scheduling method-currently used in the yarn-dyed textile industry. Kim and Cho both agree that in fashion design, genetic algorithms are able to deal with the continuous changes of fashion and to reflect personal tastes using human response as a fitness value. Also, genetic algorithms are useful for product packing optimization as well as product assortment management.

2. Trico Factory Layout

The company is producing a different kind of tricot fabrics such as one face and double face cotton fabric. Tricot (pronounced tre-ko) comes from the French verb tricoter, meaning to knit. Tricot fabric has a unique zigzag weave that is textured on one side and smooth on the other. Yame, A et al. This allows the fabric to be soft and also very sturdy for activewear. Analyzing a single replicate of 2^4 experimental design using Minitab, the idea is to determine what factors affect the production of the Trico factory. We will start with the result of an experiment that we've designed in the Trico factory. The loop formation process of tricot m/c showing in Figure. 3

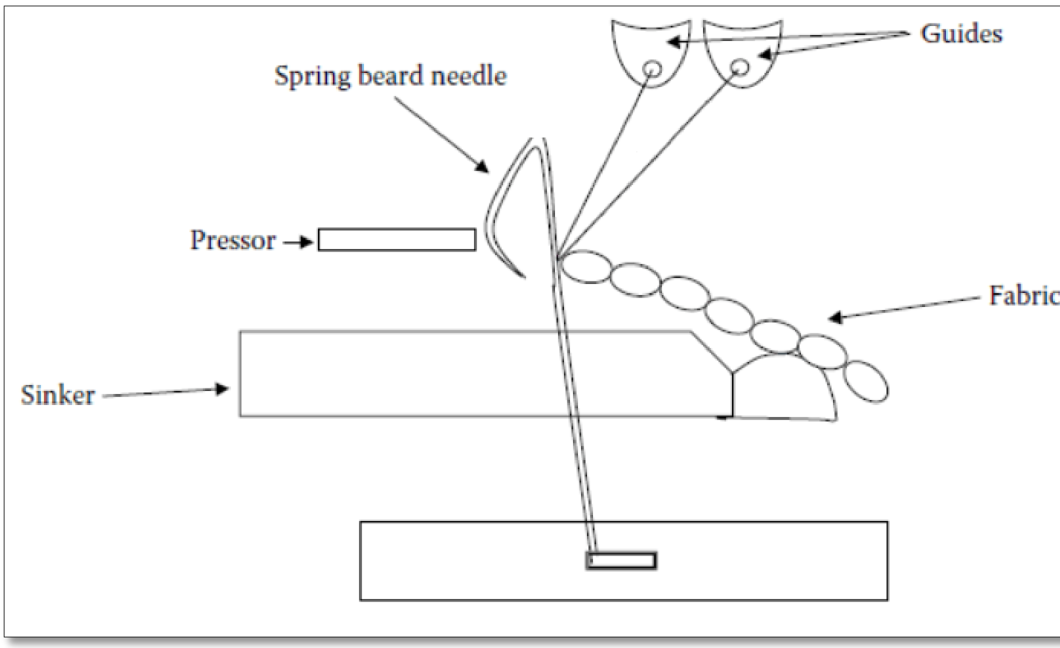

Figure 3. Loop formation process of tricot m/c

The fourth factor is Pressor Bar is whether or not you give the Loop formation process of tricot lots or little fabric. Table 1. Yame, A et al. The response to each of the variable combinations are measured in response used programmer productivity units. Using the experimental analysis by starting going to statistics and we will name factors with two-level factorial, they are either plus 1 or minus 1 and alias structure by order A, B, C, and D as showing in Table 2. The Trico machine in Libyan textile has six controls (Variables) and High and low values for factors.

Table 1. Variables and values

Alias Structure	Factors	Low	High
A	Guides and Guide Bar	-1	1
B	Needle and Needle Bar	-1	1
C	Sinker and Sinker Bar	-1	1
D	Pressor Bar	-1	1

Table 2. Factors and Response

#	Guides & Guide Bar	Needle & Needle Bar	Sinker & Sinker Bar	Pressor Bar	Response
1	-1	-1	-1	-1	7.0674
2	1	-1	-1	-1	8.2939
3	-1	1	-1	-1	27.4113
4	1	1	-1	-1	24.2858
5	-1	-1	1	-1	8.5144
6	1	-1	1	-1	5.2163
7	-1	1	1	-1	27.0472
8	1	1	1	-1	26.9339
9	-1	-1	-1	1	28.4231
10	1	-1	-1	1	29.2051
11	-1	1	-1	1	23.1549
12	1	1	-1	1	25.1231
13	-1	-1	1	1	26.8905
14	1	-1	1	1	28.3761
15	-1	1	1	1	22.7268
16	1	1	1	1	25.8064

Effects Plot for Response

These are the results that it gives me for each of the effects it gives me an estimate of factor effects as well as interaction effects, so A, B, C, and D are factors of effect and it gives me those estimates as showing in Figure. 4

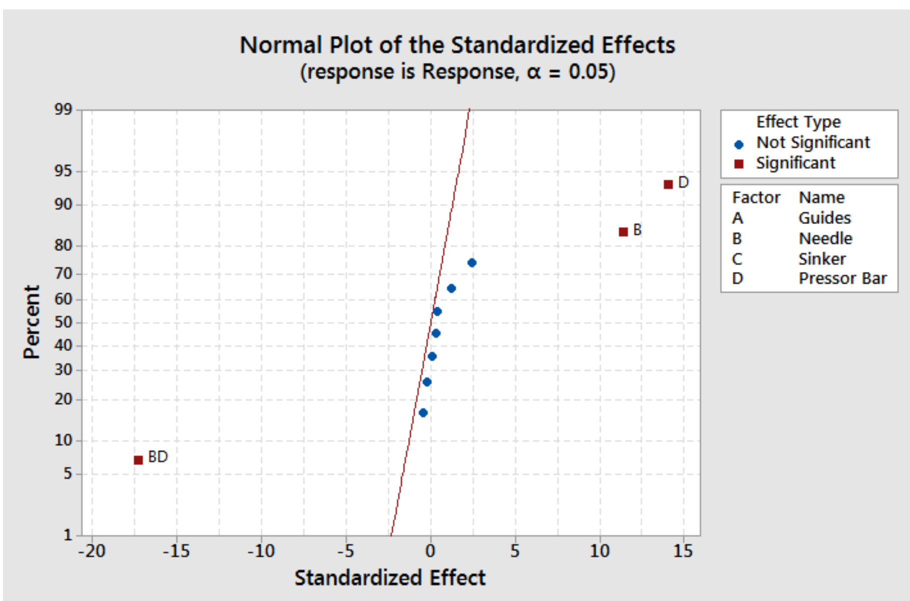

Figure 4. Normal plot of the standardized effects

Factorial Regression (Analysis of Variance)

It's also it gives me the interaction of effect for all of two factors combinations it also gives me coefficients this column and these coefficients are the linear regression coefficients for the model that we got provides a standard error estimate for these coefficients and gives me a T-Statistic which I can test for the significance of coefficients and the p-value associated with the T-Statistic. Table 3. & 4.

Table 3. Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	10	1130.13	113.013	63.55	0.000
Linear	4	580.13	145.032	81.55	0.000
Guides	1	0.25	0.251	0.14	0.722
Needle	1	228.79	228.785	128.64	0.000
Sinker	1	0.13	0.132	0.07	0.796
Pressor Bar	1	350.96	350.961	197.34	0.000
2-Way Interactions	6	550.00	91.667	51.54	0.000
Guides*Needle	1	0.16	0.163	0.09	0.775
Guides*Sinker	1	0.01	0.006	0.00	0.957
Guides*Pressor Bar	1	9.96	9.963	5.60	0.064
Needle*Sinker	1	2.67	2.666	1.50	0.275
Needle*Pressor Bar	1	536.73	536.731	301.79	0.000
Sinker*Pressor Bar	1	0.48	0.476	0.27	0.627
Error	5	8.89	1.778		
Total	15	1139.03			

Table 4. Analysis of Variance

#	Guides & Guide Bar	Needle & Needle Bar	Sinker & Sinker Bar	Pressor Bar	Response	Std Order	Run Order	Blocks	CenterPt
1	-1	-1	-1	-1	7.0674	1	1	1	1
2	1	-1	-1	-1	8.2939	2	2	1	1
3	-1	1	-1	-1	27.4113	3	3	1	1
4	1	1	-1	-1	24.2858	4	4	1	1
5	-1	-1	1	-1	8.5144	5	5	1	1
6	1	-1	1	-1	5.2163	6	6	1	1
7	-1	1	1	-1	27.0472	7	7	1	1
8	1	1	1	-1	26.9339	8	8	1	1
9	-1	-1	-1	1	28.4231	9	9	1	1
10	1	-1	-1	1	29.2051	10	10	1	1
11	-1	1	-1	1	23.1549	11	11	1	1
12	1	1	-1	1	25.1231	12	12	1	1
13	-1	-1	1	1	26.8905	13	13	1	1
14	1	-1	1	1	28.3761	14	14	1	1
15	-1	1	1	1	22.7268	15	15	1	1
16	1	1	1	1	25.8064	16	16	1	1

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.33359	99.22%	97.66%	92.01%

Coded Coefficients

Small p-values represent significant coefficients so a p-value of zero states that constant term is significant. The term B which is the Needle and Needle Bar term is significant, term D which is Pressor Bar term is significant, and the interaction term of B and D is significant all the others are not significant showing in Table 5.

Table 5. Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		21.530	0.333	64.58	0.000	
Guides	0.251	0.125	0.333	0.38	0.722	1.00
Needle	7.563	3.781	0.333	11.34	0.000	1.00
Sinker	-0.182	-0.091	0.333	-0.27	0.796	1.00
Pressor Bar	9.367	4.683	0.333	14.05	0.000	1.00
Guides*Needle	0.202	0.101	0.333	0.30	0.775	1.00
Guides*Sinker	0.038	0.019	0.333	0.06	0.957	1.00
Guides*Pressor Bar	1.578	0.789	0.333	2.37	0.064	1.00
Needle*Sinker	0.816	0.408	0.333	1.22	0.275	1.00
Needle*Pressor Bar	-11.584	-5.792	0.333	-17.37	0.000	1.00
Sinker*Pressor Bar	-0.345	-0.172	0.333	-0.52	0.627	1.00

3. Analysis, Results

By looking at the probability plot of the effect estimates, that DB and the interaction term are significant in the sense that they fall significantly away from the straight line which represents a normal distribution. In Figure.5 a plot of residuals from my regression model, these residuals will follow more or less on a straight line which means the residuals are more or less normal which means that our regression model fits the data reasonably well and we don’t need other coefficients to improve it.

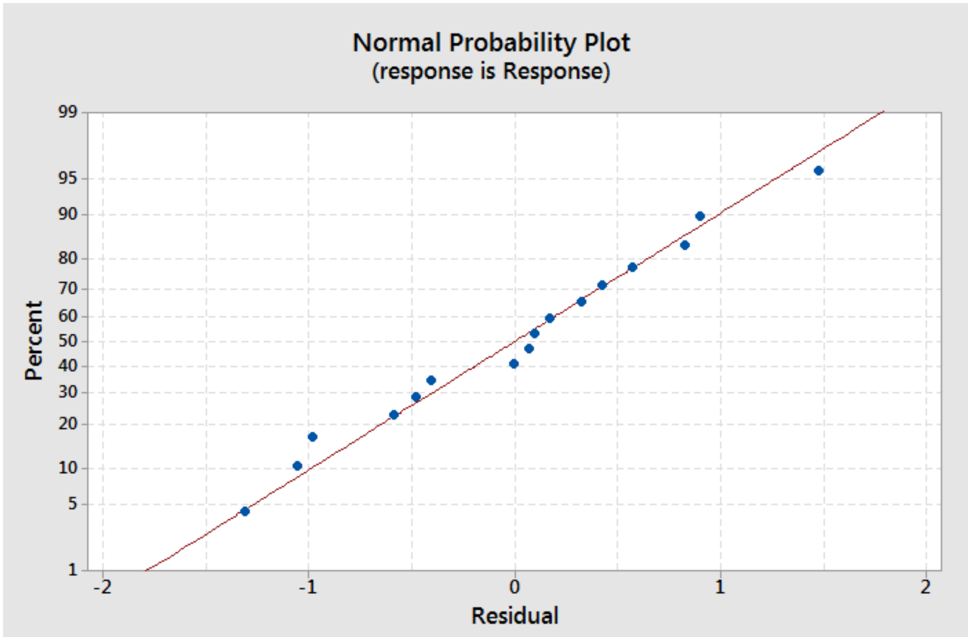

Figure 5. Norm plot of Residuals for Response

Regression Equation in Uncoded Units

Response = 21.530 + 0.125 Guides + 3.781 Needle - 0.091 Sinker + 4.683 Pressor Bar
+ 0.101 Guides*Needle + 0.019 Guides*Sinker + 0.789 Guides*Pressor Bar
+ 0.408 Needle*Sinker - 5.792 Needle*Pressor Bar - 0.172 Sinker*Pressor Bar

As a final point, if we go to the design of experiments factorial under factorial plots and interaction plot as showing in Figure. 6 We got the following interaction plot because these lines are not parallel it means that factors B and D interact with each other, which is mean that we can't optimize programmer productivity units by selection values for B and D dependently, we have to have them together. As showing in Figure 7. That giving a programmer just B and this black line corresponds to no fabric gives them the highest productivity, giving them D and B actually reduces their productivity a little but giving them B and no D. the reasonable level of productivity but it turns out the very best we can do is just give the D and no B.

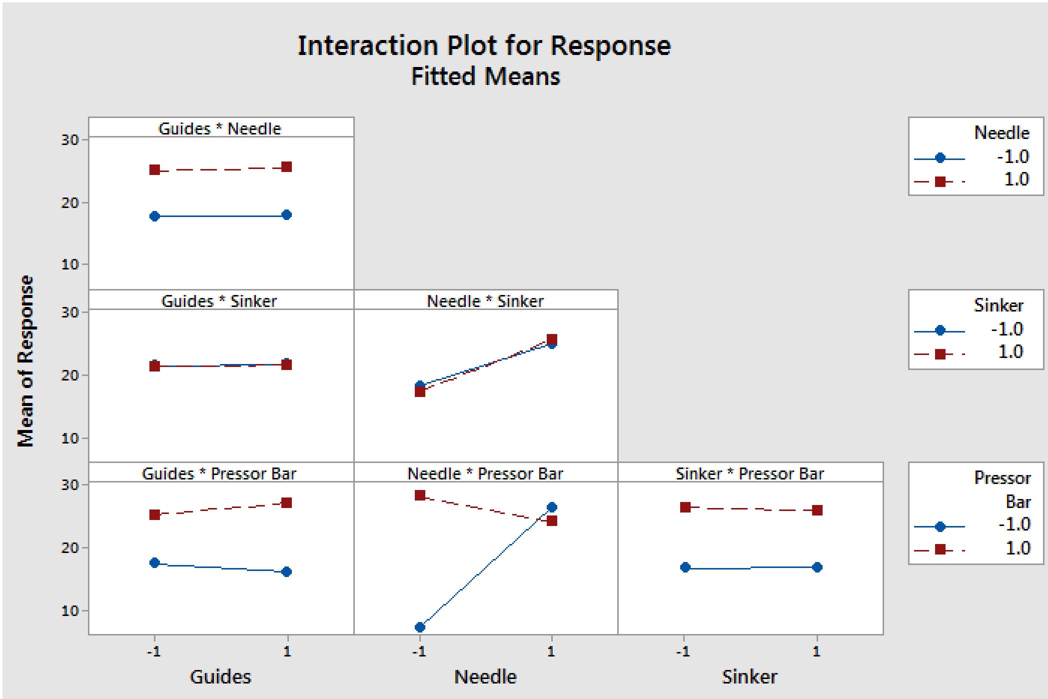

Figure 6. Interaction plot for response fitted means

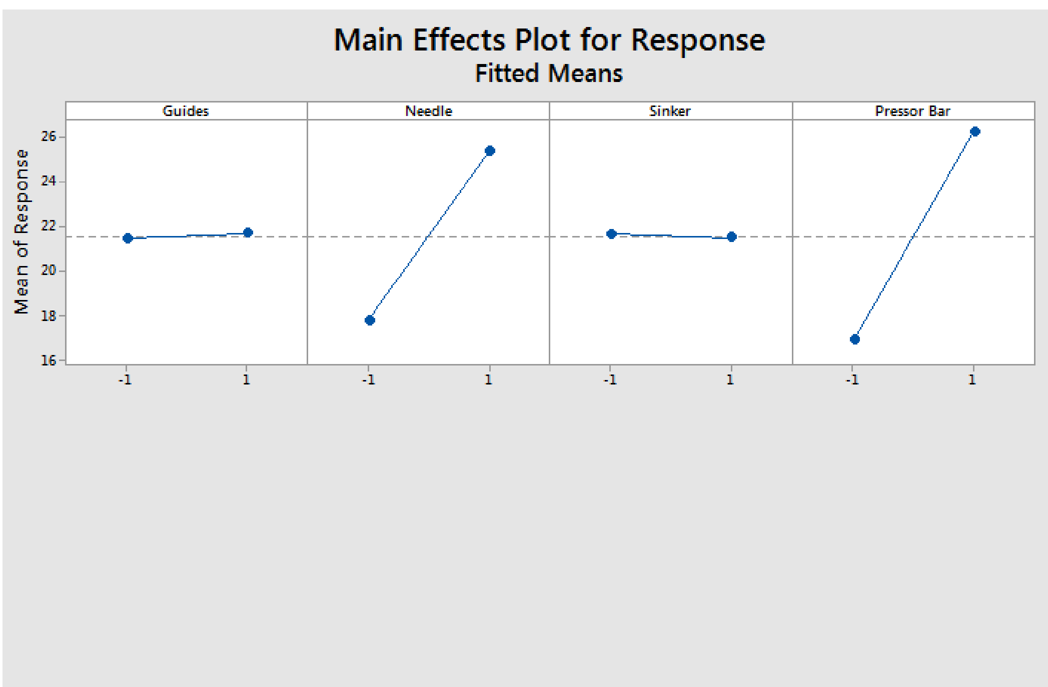

Figure 7. Main effects plot for response

The first factor is Guides and Guide Bar whether it's fast or slow in their spring beard needle. The second factor Needle and Needle Bar is whether or not you give the Loop formation process of tricot lots of fabric. The third factor Sinker and Sinker Bar is whether or not the Loop formation process of tricot has a large or small sinker.

4. The Application of Nonlinear Regression Analysis

In previous research back in 2018 by Hamaza used the extracted equation to find multiple linear regression to solve one concern in Libyan textile using the extracted equation. Now we are going to determine the starting values using nonlinear regression. The result of prediction is submitted to professional workers in the company to give an exact response for each run based on the real process. We are going to plot the data as showing in Table 6 & 7 estimate and validate the response, as (y) vs (x) to asymptotes at (x = zero), or (x = Infinity). We are going to find out intercepts at x= zero and then replot the data as:-

$$\frac{1}{y} \quad \text{vs} \quad x \qquad \text{--------------------} \ (1)$$

$$ln(y) \quad \text{vs} \quad x \qquad \text{--------------------} \ (2)$$

$$\frac{1}{y} \quad \text{vs} \quad \ln(x) \qquad \text{--------------------} \ (3)$$

$$\text{In}(y) \quad \text{vs} \quad \ln(x) \qquad \text{--------------------} \ (4)$$

Then again we going to look for the plots for indications of asymptotic values or intercepts then once we've got some idea that some of these exist, we're going to reduce the form of the equation at (x=0) and (x=infinity) to see the parameter shakes out as an asymptote or as an intercept, straight lines can be interpreted as slopes we can calculate the slope from the chart and reinterpret those in some of the models often a long (y) vs log(x) if the model is as willing can show parameter shaking out as a slope and we can get an estimate of the value from hand computing a slope. We will use Minitab to compute the values of the model using the trial estimates and plot the predicted values vs the original data. The Model equation at infinity presenting as:-

$$y = \frac{k1}{(1+exp\ (k2-k3x))^{\frac{1}{k4}}} \qquad \text{--------------------} \ (5)$$

When x goes to infinity, then exp (k2-k3x) goes to zero, , K1 the asymptote = 700

$$y = \frac{k1}{(1+0)^{\frac{1}{k4}}} = k1 \qquad \text{--------------------} \ (6)$$

By assuming for simplicity that k4=1, it probably isn't too far different and makes the math simpler, it's probably not too far different because that would make that denominator term much more powerful if (K4) were bigger or smaller than one, the equation reduces to:-

$$y = \frac{k1}{(1+exp\ (k2-k3x))} \qquad \text{--------------------} \ (7)$$

From simplicity assume k4=1

$$x=0,\ y(0) = \frac{k1}{(1+exp\ (k2-k3x))} = \frac{k1}{(1+exp\ (k2))} \qquad \text{-------------------- (8)}$$

If we assume exp (k2) is large compared to 1

$$y(0) = \frac{k1}{(1+exp\ (k2))} \quad \sim \quad \frac{k1}{exp\ (k2)} \qquad \text{-------------------- (9)}$$

$$y(0) = k1\ exp\ (-k2) \qquad \text{------------------- (10)}$$

ln (y(0))= ln(k1)+ln(exp (-2k2)) = ln(ln(k1) – k2 thus ------------------- (11)

k2-ln(k1) – ln(y(0)) ------------------- (12)

Intercept of ln(y) at x= 0 is 2,
ln (k1) = (700)= 6.55
K2 = 6.55 -2, therefore K2= 4.55

K1= 700, K2 = 4.55, K4= 1 , by assuming for simplicity that k3 = 0.75 by start using Minitab to run nonlinear regression with these home grown estimates, resultant parameter values are as precise as NIST (starting values) listed values K1= 100, K2 = 10, K4= 1, and k3 = 1

Table 6. estimate and validate the response

Estimated by equation (y)	**workers Residual**
10.651	0.0005
15.265	0.002307
17.798	-0.00051
25.331	0.000422
36.946	-0.00032
57.050	0.000494
77.357	0.000355
84.357	0.000536
144.357	0.002012
174.665	0.003349
245.769	0.000422
435.383	0.000344
452.916	0.000162
579.4	0.000422
700.064	0.000831

Under command line editor in Minitab we will submit:-

- let c3=1/c1
- name c3 '1/y'
- let c4=ln(c1)

- name c4 'ln/(y)'
- let c5= ln(c2)
- name c5 'ln(x)'

Plot 'y'*'x'

'1/y'*'x' 'ln/(y)'*'x' 'y'*'ln(x)' '1/y'*'ln(x)' 'ln/(y)'*'ln(x)';

Y	**X**	**1/y**	**ln/(y)**	**ln(x)**	**Y Predict**
10.651	1	0.0655068	2.72560	0.69315	11.987
15.265	2	0.0561836	2.87913	1.09861	19.546
17.798	3	0.0394759	3.23206	1.38629	31.652
25.331	4	0.0270662	3.60947	1.60944	50.699
36.946	5	0.0175283	4.04394	1.79176	79.837
57.050	6	0.0129269	4.34844	1.94591	122.560
77.357	7	0.0118543	4.43507	2.07944	181.458
84.357	8	0.0069272	4.97229	2.19722	256.105
144.357	9	0.0057252	5.16287	2.30259	341.252
174.665	10	0.0040689	5.50439	2.39790	427.447
245.769	11	0.0022968	6.07623	2.48491	504.781
435.383	12	0.0022079	6.11571	2.56495	566.999
452.916	13	0.0017258	6.36208	2.63906	612.813
579.4	14	0.0014284	6.55117	2.70805	644.393
700.064	15	0.0655068	2.72560	0.69315	665.184

Table 7. Validate the response

Now we want to plot these values t to the graph scatterplot with the connecting line. We can get these charts as showing in Figure 8. asymptote at x equals infinity of 700. By going back to the main Minitab interface with the idea of how to simulate the values of K3. We flip back to NIST and copy the equation # (5) of the model that we're going to use.

$$y = \frac{k1}{(1+exp\ (k2-k3x))^{\frac{1}{k4}}} \qquad \text{--------------------} \ (5)$$

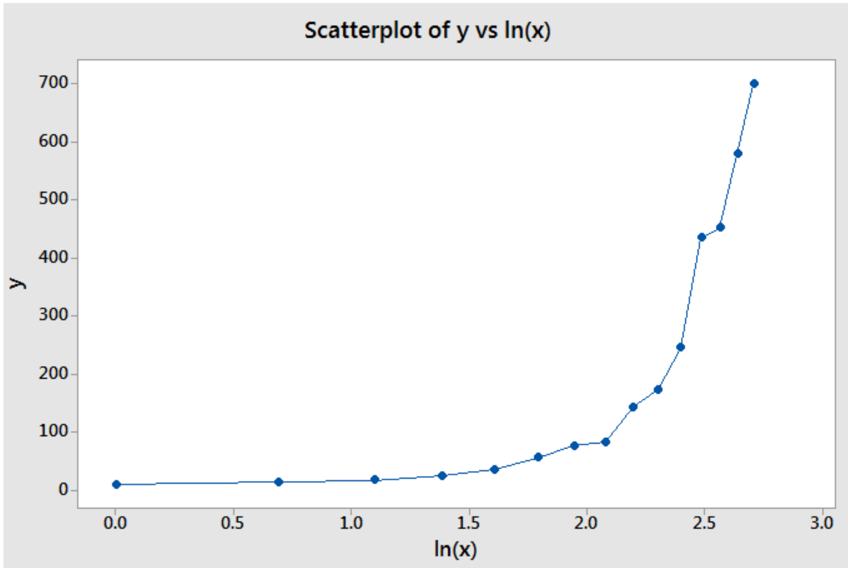

Figure 8. Scatterplot of y Vs Ln

Under command line dialog we going to add the equation # (5) and submit these commands:-
let k1=700
let k2=4.55
let k4=1
let k3=0.50
let c6= k1 / ((1+exp(k2-k3*x))**(1/k4))

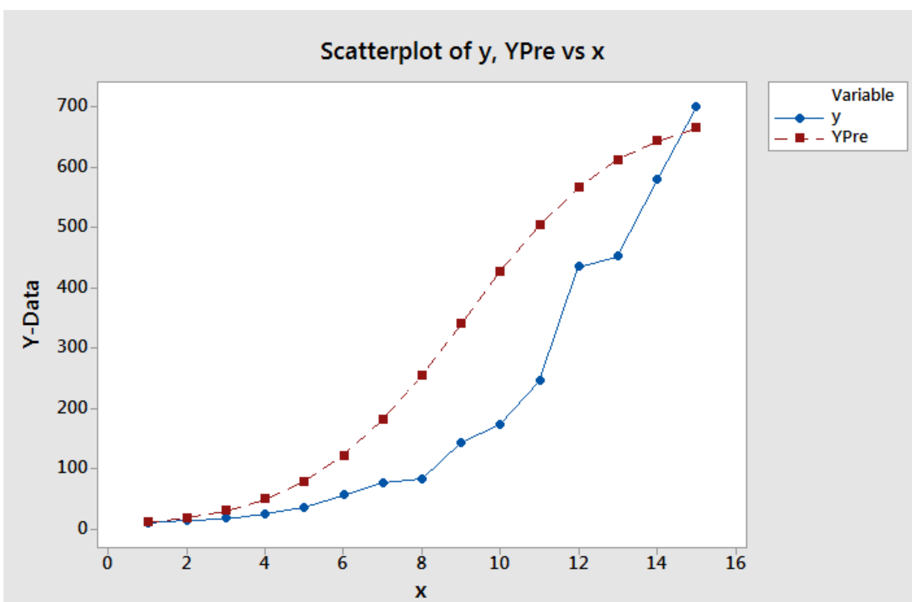

Figure 9. Scatterplot of y , yPre Vs X

As showing in Figure. 9 we plot to the graph by going to scatterplot and use with connect (Y) variables and (Y predict) versus (X) in (X) variables. The best value we had is 0.75 to estimate the parameters. For nonlinear regression, the initial objective we do is to flip back and use equation # (5) and inserted to Minitab under stat regression on linear regression and the response is going to be (Y) and insert the model value. Next object we have to insert the values of the parameters and click okay. Starting Values for Parameters showing on Table 8, 9, and 10

$$y = \frac{k1}{(1+exp\ (k2-k3x))^{\frac{1}{k4}}} \qquad \text{-------------------- (5)}$$

Table 8

Parameter	Value
K1	700
K2	4.55
K3	1
K4	0.75

Our new Equation and new parameter estimates with the same values precisely have certified as showing in Figure.10

$$y = \frac{668.433}{(1+exp\ (2.26561-0.545366*x))^{\frac{1}{0.0194529}}} \qquad \text{-------------------- (13)}$$

Table 9

Parameter	Estimate	SE Estimate
K1	668.433	354.039
K2	2.266	125.492
K3	0.545	1.006
K4	0.019	2.214

Table 10

Iterations	200
Final SSE	72929.3
DFE	11
MSE	6629.94
S	81.4244

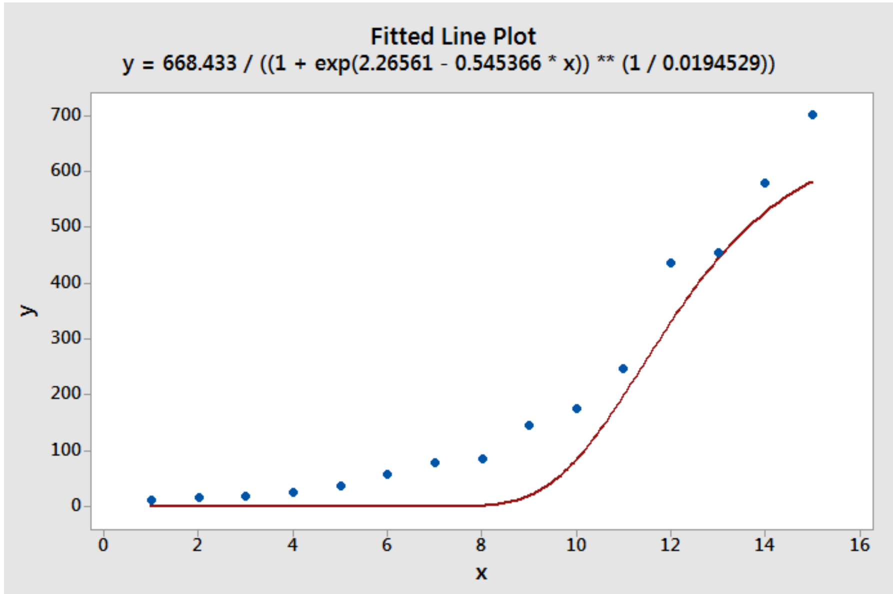

Figure. 10 Fitted line plot

5. Discussions and Conclusion

Tricot fabric has a unique zigzag weave that is textured on one side and smoothes on the other so one face and double face cotton fabric. We examine a single replicate of experimental design using Minitab, the idea is to determine what factors affect the production of the Trico factory. The first factor is Guides and Guide Bar, the second factor Needle and Needle Bar, third factor Sinker and Sinker Bar, and Forth factor Pressor Bar. We contracted a result of prediction is submitted to professional workers in the company to give an exact response for each run based on the real process to Plot the data to estimate and validate the response as Y vs X using Minitab to compute values pf the model by using the trial estimates and plot the predicted values versus the original data we have.
Woven carpet, Tufted carpet, Needlefelt carpet, Trico, and Matters. The company should implant the Layout and Cycle time analysis and we have it in three points, first is the Minimize transit time, Simplify workflow, and Functionality. This study gave us a true indication of the lost time that Libyan textile experiences, it will give an actual indication of the lost time that is occurring in individual work station and with the entire cell.

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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.