Method for Producing Advanced Carpeting Using a HTC Factor

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Abstract

Technologically advanced carpets are a definition of the Needlefelt carpet. This produced through the electrostatic attraction of individual fibers which combines to produce a unique carpet. Needle felt carpet specification and we design four factors (A, B, C, and D) each factor have tow data of Low and High nominal values. However, we create the factorial design with a two-level split-plot, and with full resolution designing 32 runs. Also, we came up with three HTC factors which are Product weight, Product thickness, and the third Rolls length. Besides, we end up with seven total factors with an easy one to change and the other three are difficult to change and we established all the factors in one table to have clear data. For the easy to change factor we have the Pareto chart, the first statistically significant factor is the amount of Rolls length a product variable and the second effect is product thickness, and the last is a mixture of process and product variable. We additionally made a table for Split-Plot Factorial Regression and have data from Response versus A, B, C, D Analysis of Variance. We want from this to be able to change the normal Plot of the hard to change factor to see the effect if it's negative or positive.

Keywords
HTC, DOE, Carpet, Needlefelt

Needlefelt carpet

The needlefelt carpet is a technologically advanced carpet. It is extremely durable as it is produced through the electrostatic attraction of individual fibers that combine to form a unique carpet. This type of carpet is quite popular in venues such as business arenas, hotels, restaurants, and places that are subject to a lot of traffic. Needle felt carpet specification of the delivered product in Libyan textile showing bellow Table 1.

Table 1. Specification of delivered product in Libyan textile

Factor	Name	Low Nominal Value	High Nominal Value
A	Product weight	200g/m2	275g/m2
B	Product thickness	20mm	30mm
C	Rolls length	10m	20m

D	Rolls width	150m	200m

For this study, we will design and analyze a split-plot experiment for the specification and delivered product in Needle felt carpet at Libyan Textile Company. By creating Factorial Design with 2 level split-plot (hard to change factors) and 4 factors, with full resolution design with 32 runs as showing in below Table 4. The dialog box a great number of experiments for one heart to change and six easy to change factors, the experiments colored in green have a full resolution where Rolls width is One HTC factor as showing in Table 2.

Table 2. 1 HTC Factor - Available Split -Plot

	1 HTC Factor								
	2 WP			4 WP			8 WP		16 WP
ETC	1/4	1/2	Full	1/8	1/4	1/2	1/8	1/4	1/8
1			2 SP Full						
2			4 SP Full						
3		4 SP IV	8 SP Full			4 SP Full WP + 3FI			
4	4 SP III	8 SP V	16 SP Full		4 SP IV WP + 2FI	8 SP Full WP + 4FI		4 SP Full WP + 2FI	
5	8 SP IV	16 SP VI	32 SP Full		8 SP V WP + 3FI	16 SP Full WP + 5FI		8 SP Full WP + 3FI	
6	16 SP IV	32 SP VII	64 SP Full	8 SP III WP + 3FI	16 SP VI WP + 3FI	32 SP Full WP + 6FI	8 SP V WP + 3FI	16 SP Full WP + 3FI	8 SP Full WP + 3FI

Product weight, Product thickness, and Rolls length are Three HTC factors, we have seven total factors with four easy to change and the three hard to change factors as showing below in Table 3 the experiments colored in green meaning that the terms are not confounded with other factors or interactions.

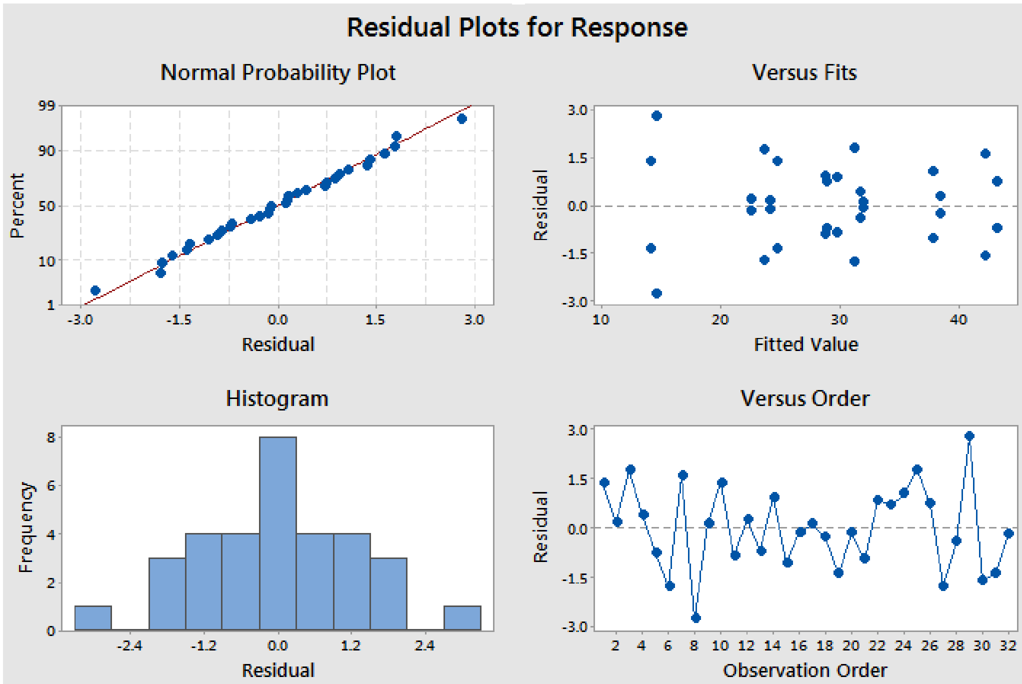
Tabl 3. 3 HTC Factor - Available Split -Plot

	3 HTC Factors		
	8 WP		16 WP
ETC	1/2	Full	1/2
1		2 SP Full	
2		4 SP Full	
3	4 SP VI	8 SP Full	4 SP Full WP + 3FI
4	8 SP VII	16 SP Full	8 SP Full WP + 4FI

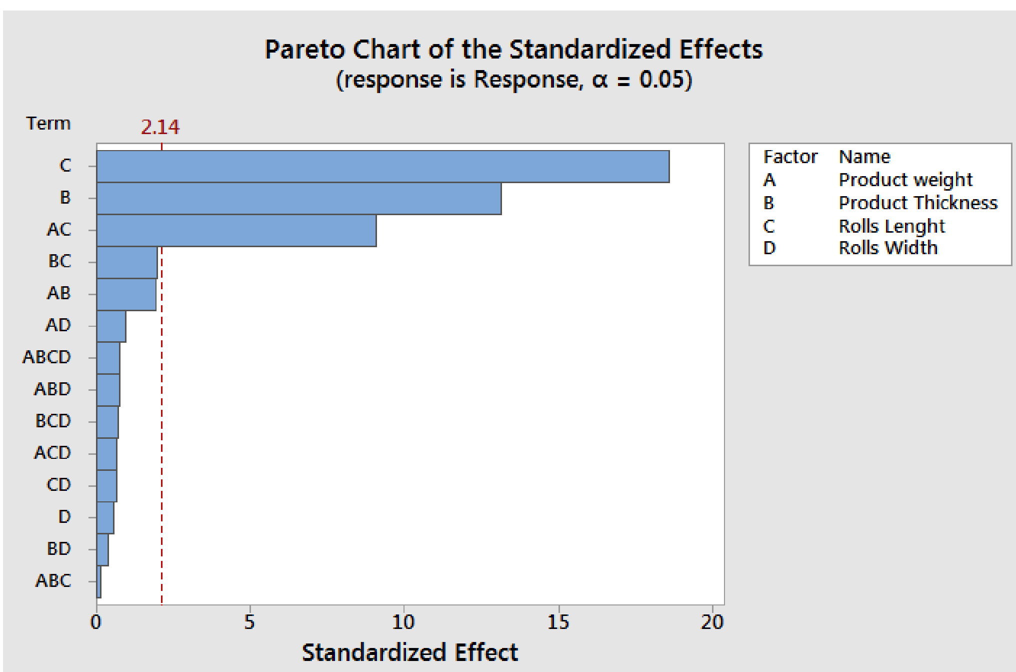
Table 4. full resolution design with 32 runs as showing in bellow

StdOrder	RunOrder	PtType	Blocks	WP	Product weight	Product thickness	Rolls length	Rolls width	Response
1	13	1	1	1	-1	-1	-1	-1	29.3
2	12	1	1	1	-1	1	-1	-1	39.9
3	9	1	1	1	-1	-1	1	-1	25.4
4	14	1	1	1	-1	1	1	-1	30.9
5	11	1	1	1	-1	-1	-1	1	30.0
6	15	1	1	1	-1	1	-1	1	37.9
7	10	1	1	1	-1	-1	1	1	27.3
8	16	1	1	1	-1	1	1	1	33
9	25	1	1	2	1	-1	-1	-1	34
10	26	1	1	2	1	1	-1	-1	44.9
11	31	1	1	2	1	-1	1	-1	13.7
12	27	1	1	2	1	1	1	-1	22.9
13	28	1	1	2	1	-1	-1	1	32.3
14	30	1	1	2	1	1	-1	1	41.6
15	29	1	1	2	1	-1	1	1	18.4
16	32	1	1	2	1	1	1	1	23.4
17	23	1	1	3	-1	-1	-1	-1	28.4
18	18	1	1	3	-1	1	-1	-1	37
19	20	1	1	3	-1	-1	1	-1	22.8
20	21	1	1	3	-1	1	1	-1	26.7
21	22	1	1	3	-1	-1	-1	1	29.4
22	24	1	1	3	-1	1	-1	1	37.7
23	19	1	1	3	-1	-1	1	1	22.2
24	17	1	1	3	-1	1	1	1	30.9
25	6	1	1	4	1	-1	-1	-1	28.4
26	5	1	1	4	1	1	-1	-1	41.4
27	1	1	1	4	1	-1	1	-1	14.4
28	3	1	1	4	1	1	1	-1	24.4
29	4	1	1	4	1	-1	-1	1	31.1
30	7	1	1	4	1	1	-1	1	42.8
31	8	1	1	4	1	-1	1	1	10.8
32	2	1	1	4	1	1	1	1	21.7

Immediately five chars appeared after interning our data, the residual plots chart showing the points on a normal probability plot and are suitably close to the straight line. The histogram chart below is symmetric and normal looking, only 32 points in the plot so the missing values are artificial Fiuger 1. and Fiuger 2.



Fiuger 1. Residual plots for response



Fiuger 2. Pareto Chart of the Standardized effects

The Pareto chart for the easy to change factors from the position of the red line, the first statistically significant factor is amount of Rolls length a product variable the next most statistically significant effect is product thickness the last statistically significant effect is mixture of process and product variables in the interaction between product weight and Rolls length. The terms of just blow A, B, and BC are below the statistically significant line and out judged to be not significant, all the rest of the terms are clearly not significant.

Split-Plot Factorial Regression:

Table 5.Analysis of Variance

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**
Product weight	1	56.71	56.71	2.98
WP Error	2	38.03	19.01	5.42
Product Thickness	1	605.52	605.52	172.53
Rolls Lenght	1	1215.24	1215.24	346.26
Rolls Width	1	1.12	1.12	0.32
Product weight*Product Thickness	1	13.52	13.52	3.85
Product weight*Rolls Lenght	1	290.41	290.41	82.74
Product weight*Rolls Width	1	3.13	3.13	0.89
Product Thickness*Rolls Lenght	1	14.31	14.31	4.08
Product Thickness*Rolls Width	1	0.55	0.55	0.16
Rolls Lenght*Rolls Width	1	1.53	1.53	0.44
Product weight*Product Thickness*Rolls Lenght	1	0.10	0.10	0.03
Product weight*Product Thickness*Rolls Width	1	2.10	2.10	0.60
Product weight*Rolls Lenght*Rolls Width	1	1.71	1.71	0.49
Product Thickness*Rolls Lenght*Rolls Width	1	1.81	1.81	0.51
Product weight*Product Thickness*Rolls Lenght*Rolls Width	1	2.21	2.21	0.63
SP Error	14	49.14	3.51	

Model Summary

S	R-sq(SP)	S(WP)	R-sq(WP)
1.87340	97.77%	1.39207	59.86%

Table 6. Coded Coefficients

Term	**Effect**	**Coef**	**SE Coef**	**T-Value**
Constant		29.219	0.771	37.91
Product weight	-2.663	-1.331	0.771	-1.73
Product Thickness	8.700	4.350	0.331	13.14
Rolls Lenght	-12.325	-6.162	0.331	-18.61
Rolls Width	0.375	0.187	0.331	0.57
Product weight*Product Thickness	1.300	0.650	0.331	1.96
Product weight*Rolls Lenght	-6.025	-3.013	0.331	-9.10
Product weight*Rolls Width	-0.625	-0.313	0.331	-0.94
Product Thickness*Rolls Lenght	-1.338	-0.669	0.331	-2.02
Product Thickness*Rolls Width	-0.262	-0.131	0.331	-0.40
Rolls Lenght*Rolls Width	0.437	0.219	0.331	0.66

Product weight*Product Thickness*Rolls Lenght	0.113	0.056	0.331	0.17
Product weight*Product Thickness*Rolls Width	-0.513	-0.256	0.331	-0.77
Product weight*Rolls Lenght*Rolls Width	-0.462	-0.231	0.331	-0.70
Product Thickness*Rolls Lenght*Rolls Width	0.475	0.238	0.331	0.72
Product weight*Product Thickness*Rolls Lenght*Rolls Width	-0.525	-0.263	0.331	-0.79

Table 7.Fits and Diagnostics for Unusual Observations

Obs	Response	Fit	Resid	Std Resid	WP Resid	
15	18.40	14.60	2.79	2.25	1.0125	R
31	10.80	14.60	-2.79	-2.25	-1.0125	R

R Large residual

Table 8. Split-Plot Factorial Regression: Response versus A, B, C, D. Analysis of Variance

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
A	1	56.71	56.71	2.98	0.226
WP Error	2	38.03	19.01	5.42	0.018
B	1	605.52	605.52	172.53	0.000
C	1	1215.24	1215.24	346.26	0.000
D	1	1.12	1.12	0.32	0.580
A*B	1	13.52	13.52	3.85	0.070
A*C	1	290.41	290.41	82.74	0.000
A*D	1	3.13	3.13	0.89	0.361
B*C	1	14.31	14.31	4.08	0.063
B*D	1	0.55	0.55	0.16	0.698
C*D	1	1.53	1.53	0.44	0.520
A*B*C	1	0.10	0.10	0.03	0.868
A*B*D	1	2.10	2.10	0.60	0.452
A*C*D	1	1.71	1.71	0.49	0.496
B*C*D	1	1.81	1.81	0.51	0.485
A*B*C*D	1	2.21	2.21	0.63	0.441
SP Error	14	49.14	3.51		
Total	31				

This first table showing lists the values of the effects against their p-value, the hard to change factor A or Product weight has 0.226 P-value greater than 0.05 and this is not statistically significant. We also see the terms included in the Pareto chart B, C, and A, C have P-values 0.000 less than 0.05 indicating statistical significance

Model Summary

S	R-sq(SP)	S(WP)	R-sq(WP)
1.87340	97.77%	1.39207	59.86%

Table 9.Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		29.219	0.771	37.91	0.001	
A	-2.663	-1.331	0.771	-1.73	0.226	*
B	8.700	4.350	0.331	13.14	0.000	1.00
C	-12.325	-6.162	0.331	-18.61	0.000	1.00
D	0.375	0.187	0.331	0.57	0.580	1.00
A*B	1.300	0.650	0.331	1.96	0.070	1.00
A*C	-6.025	-3.013	0.331	-9.10	0.000	1.00
A*D	-0.625	-0.313	0.331	-0.94	0.361	1.00
B*C	-1.338	-0.669	0.331	-2.02	0.063	1.00
B*D	-0.262	-0.131	0.331	-0.40	0.698	1.00
C*D	0.437	0.219	0.331	0.66	0.520	1.00
A*B*C	0.113	0.056	0.331	0.17	0.868	1.00
A*B*D	-0.513	-0.256	0.331	-0.77	0.452	1.00
A*C*D	-0.462	-0.231	0.331	-0.70	0.496	1.00
B*C*D	0.475	0.238	0.331	0.72	0.485	1.00
A*B*C*D	-0.525	-0.263	0.331	-0.79	0.441	1.00

Regression Equation in Uncoded Units

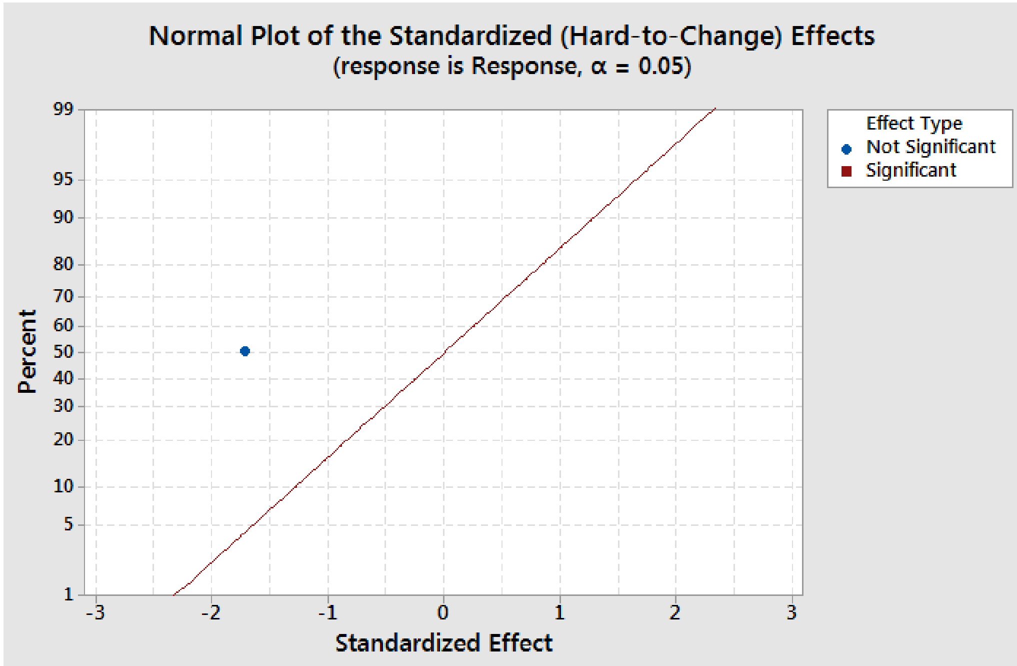
Response = -145 + 0.57 A + 6.55 B + 14.6 C + 0.73 D - 0.0173 A*B - 0.0579 A*C - 0.00243 A*D - 0.573 B*C - 0.0337 B*D - 0.0625 C*D + 0.00202 A*B*C + 0.000113 A*B*D + 0.000231 A*C*D + 0.00304 B*C*D - 0.000011 A*B*C*D

Equation averaged over whole plots.

Table 10. Fits and Diagnostics for Unusual Observations

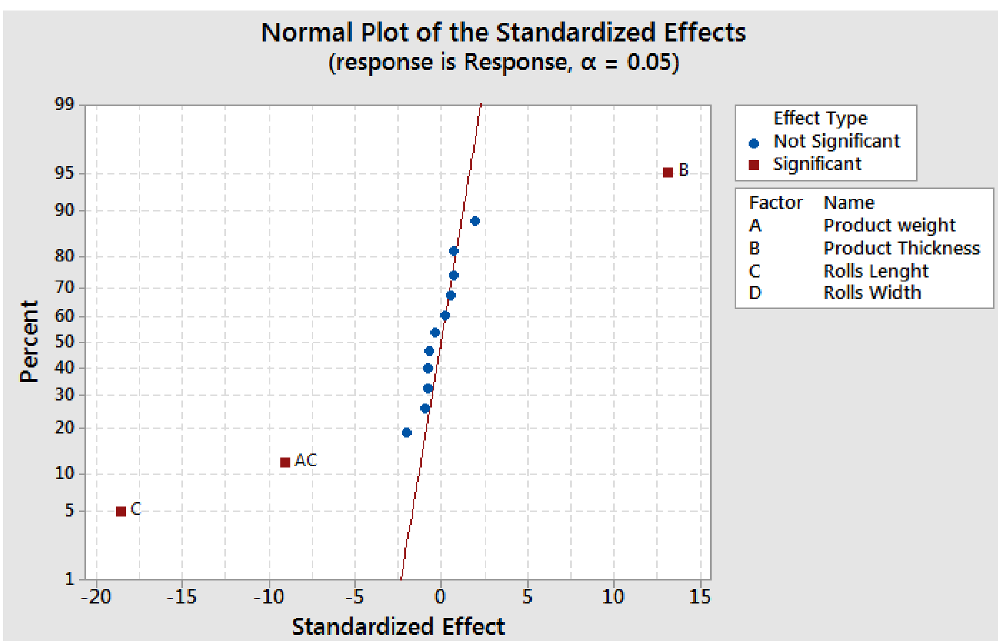
Obs	Response	Fit	Resid	Std Resid	WP Resid	
15	18.40	14.60	2.79	2.25	1.0125	R
31	10.80	14.60	-2.79	-2.25	-1.0125	R

R Large residual



Fiuger 3. Normal plot of standardixed (Hard to Change) effects & Standardized effects

The Normal plot of the hard to change factor, from the color that effect showing on fig below Fig 3 & 4 is not significant it's blown, however, we want The Normal plot of the hard to change factor to see the sign of the effect if it is negative or not. Her it's negative.



Fiuger 4. Normal plot of standardixed effects & Standardized effects

Product thickness increasing as response increase however, Rolls length increases and response decreases likewise the interaction term between product weight and amount of Rolls length is also negative. The amount of Rolls length has a negative effect on the response.

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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.