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Factors That Resolve GSM, Diameter and Geometric Constant of Weft Knitted Fabrics

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---ABSTRACT---

This study has analyzed the factors significantly influence the grams per square meter (GSM), diameter and geometric constant of weft knitted fabric. Research has proved significant relationships with stitch length, count, the product of stitch length and count, machine with GSM and dia. Results confirm previous study and can be used in practical production. Grey diameter, finished GSM and geometric constant significantly influenced by the stitch length. Here, 41 sample plain weft knitted fabrics produced in different machine setting and specification to study the relationship among the variables considered based on the literature. The key part of this study is to identify the significant factors that can be used in production floor of the textile industry to set the desired properties of fabrics. And significant relationships among machine parameters and fabric GSM, diameter and geometric constant are found accuracy of regression model is analyzed.

KEYWORDS*-Weft Knitting, GSM, Diameter, Geometric Constant.*

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I. INTRODUCTION

The development of knitting frame from 15th century started in the hand of Williams Lee. After than continuous development in cams, needle, gauge, sinker, take-down, feeder and so on carried out throughout the century(1). Since 1978 the textile sector of Bangladesh is growing with an average 21% growth till now. And more growth happened in the knitting sector during this time. But, dimensional properties of the knitted fabric is inferior than woven fabrics. Dimensional properties mostly rely on the machine parameters, selection of yarn count and stitch length [(2), (3), (4)].

Though different mathematical and geometrical equations are used theoretically, the process parameters in the industrial production produced mixed results. To get desired fabric's GSM, the manufacturer must set stitch length, yarn count on the basis of machine specifications specially diameter and gauge [(5),(6),(7),(8)]. Due to the different process sequences after the take-down of the grey fabric from the machine, the characteristics of the plain weft knitted fabric change. But, all the parameters cannot be controlled during the manufacturing process. This study will try to find out the key predictors for GSM and the diameter of the fabrics. Geometric constant is suggested from geometry of plain weft knitted fabrics(9). This study found significant relation of finished GSM, diameter of fabric, geometrical constant with stitch length, machine diameter, resultant count and product of stitch length and resultant count. This finding will help the manufacturer to use the most significant parameters that will help to set the desired properties of fabric. Correlation and regression method is used here by manufacturing 41 plain weft knitted fabrics in a different setting, machine specification and stitch length. First correlation coefficients are analyzed and significant factors are determined at 1% and 5% level of significance. And regression models are developed for grey diameter, finished GSM and geometrical constant. Due to unobserved parameters, no significant factors are found that can predict finished diameter.

II. LITERATURE RIEVEW

Weft knitted fabric became more popular than woven fabrics due to its good air permeability conductivity and insulation properties. Economic production cost with no need of ironing; high stretch and elasticity that conform body movement; excellent resistance to bursting, crease and wear with various patterning and design it draws the attention of the modern style. Thus it replaces woven fabrics day by day(10). But, the properties of weft knitted fabrics depend on the parameters set in the machines. Due to its poor dimensional stability, many experiments have taken to establish the required parameters in the machine to limit the variation and get the desired characteristics in the finished fabrics(11).Some of them discussed effect of yarn count and machine parameter, tightness factor, relaxation, finishing process and rate of feeding on spirality. These also influence fabric width, stitch length and GSM for various counts[(12), (6), (13)]. Structural changes in knits during processing, the dimensional stability of plain knitted fabrics and the different properties related to machine parameters are studied to find out their relationships. Careful machine adjustment can alleviate difficulties caused by excessive shrinkage(14). Machine gauge influences the number of wales in the fabrics also affect physical and mechanical properties of knitted fabrics [(15), (5). According to the yarn shape and yarn path different fabric structure can be produced. The dimensional stability of knit fabrics is an essential area of the knitting industry. Stitch length, yarn count, the structure of fabric influence the dimensional stability of fabric (16). So, the fabric properties like grams per square meter (GSM), grey diameter, finished width, spirality, shrinkage varies due to those machine parameters selected(17).Many researches were performed to investigate the effect of different knitting parameters on the physical and mechanical properties of knitted fabrics[(18), (19)(20)(21), (4)]. This study is designed to determine the significant predictor for the fabric diameter, GSM, the geometric constant of plain weft knitted fabrics. This will help for further analyzing to obtain the desired dimensional properties of plain weft knitted fabrics.

III. METHOFDOLOGY

100% cotton 41 single jersey fabrics form single ply and double ply yarn of count 18/1, 20/1, 22/1, 24/1, 24/2, 26/1, 28/1, 30/1, 32/1, 34/2, 40/1, 40/2 using single jersey machines whose specifications are 24D×24G, 26D×20G, 26D×26G, 30D×20G, 30D×24G, 34D×24G, 34D×20G, 36D×20G and 38D×24Gwith a different stitch length with available facilities. Correlation and regression model has been used to establish a linear regression equation using SPSS 23 among the variables considering 1% and 5% level of significance. As single and double ply yarns are used during the experiments the resultant count in tex is used for the further mathematical analysis. To avoid the state of relaxation and other unobserved parameters geometric constant is also considered for the analysis of correlation and regression. During collection of the data the standard temperature 27 ± 2^0C and relative humidity 65±2% is considered as tropical country. The data is analyzed using SPSS 23 software to determine the correlation among the variables and develop regression equation using the highly correlated variables at 1% and 5% level of significance.

Standards used

1. BS 1932:1953forfabric width(22)
2. B.S. 2471:1954 forweight per unit length(23)

Variables

Dependent variables: GSM, grey diameter, finished width and geometric constant.

Independent variables: Machine gauge, machine diameter, stitch length, the total number of needles, yarn count in tex, number of feeders and the product of stitch length and yarn count (SL*Tex).

IV. RESULT AND DISSCUSION

From the data collected (in appendix table-8) and the correlation coefficient (in table-9), it is found that grey diameter is correlated with machine diameter, number of feeder, number of needles and finished width. But, when we see the regression coefficient of grey diameter on that parameter, only machine diameter is found to be the predictor. The data analysis reports are being discussed below-

Table 1: Grey Diameter (inch) Regression Coefficient-1

Dependent Variable: Grey Diameter (inch)		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.035	6.051		.006	.995
	Machine diameter	1.625	.290	1.098	5.608	.000
	No. of feeder	-.076	.074	-.170	-1.036	.307
	No. of needles	-.002	.003	-.135	-.958	.344
	Finished width (inch)	-.028	.110	-.028	-.251	.803

R^2=0.715, Adj R^2=0.683 and F=22.542

From table-1 it has been found that grey diameter is only correlated to machine diameter but, not with number of feeder and number of needles. The significance level is 1% and accuracy of the model is 71.5%.

Table 2: Grey Diameter (inch) Regression Coefficient-2

Dependent Variable: Grey Diameter (inch)		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-10.128	5.116		-1.979	.055
	Machine diameter	1.231	.123	.832	9.979	.000
	SL	2.819	1.170	.201	2.409	.021

R^2=0.736, Adj R^2=0.722 and F=53.019

From table-2, it has been observed that machine diameter and stitch length (SL) is highly related with grey diameter of fabrics at 1% and 5% level of significance. The degree of accuracy of this model is 73.6% shown in figure-1.

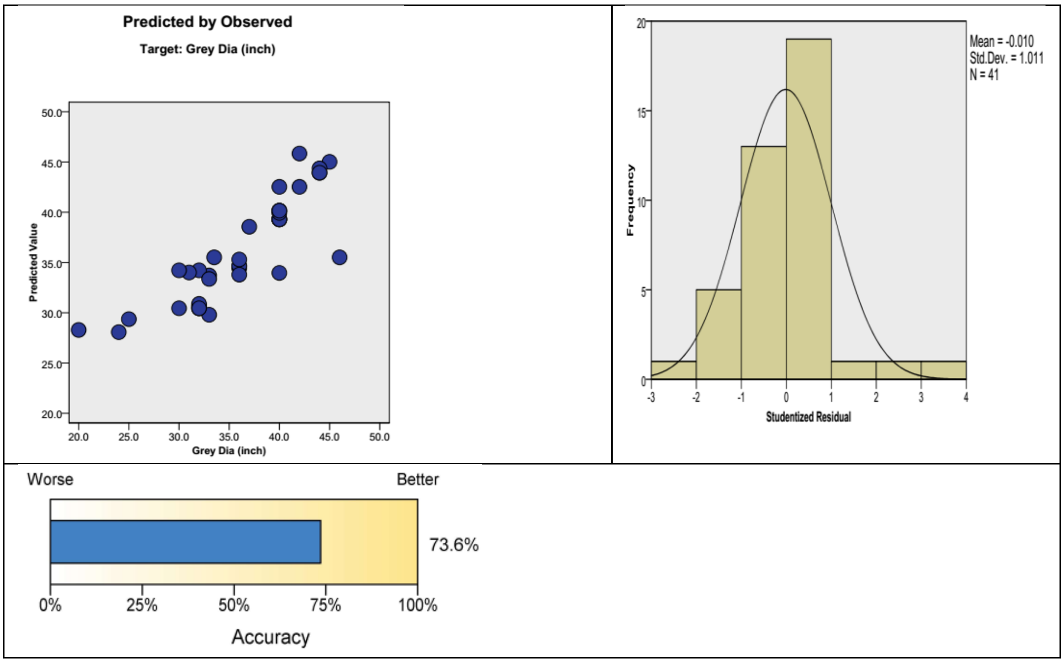

Figure 1: Graphical representation of regression model showing the relation among grey diameter, stitch length, machine dia.

Table 3: Finished Width (inch) Regression Coefficients

Dependent Variable: Finished width (inch)		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	39.992	6.267		6.382	.000
	Machine diameter	.855	.583	.560	1.467	.151
	No. of feeder	.022	.113	.048	.198	.844
	No. of needles	.002	.004	.086	.414	.682
	Grey Diameter (inch)	-.063	.252	-.061	-.251	.803

R^2=0.386, Adj R^2=0.317 and F=5.651

Although literatures suggest some correlation among machine diameter, number of feeder, number of needles and grey diameter with finished width, analyzing the correlation no significant result has been found. This caused by other hidden and unobserved parameters that are not considered in this study.

Table 4: Finished GSM Regression Coefficients-1

Dependent Variable: Finished GSM		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-342.281	124.709		-2.745	.009
	Machine Gauge	-1.503	1.505	-.085	-.999	.325
	No. of feeder	-.417	.245	-.139	-1.700	.098
	Resultant count (Tex)	19.713	5.682	2.270	3.469	.001
	SL	173.136	36.636	1.848	4.726	.000
	SL*Tex	-5.344	1.857	-2.083	-2.877	.007

R^2=0.796, Adj R^2=0.767 and F=27.287

Table-4 represents the correlation of machine gauge, number of feeder, resultant count in tex, stitch length (SL) and product of stitch length and count (SL*Tex). The model shows significant correlation with resultant count (tex), stitch length (SL) and product of stitch length and count (SL*Tex) at 1% level of significance and the degree of accuracy is 79.6%.

Table 5: Finished GSM Regression Coefficients-2

Dependent Variable: Finished GSM		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-414.290	114.094		-3.631	.001
	Resultant count (Tex)	19.363	5.760	2.229	3.362	.002
	SL	170.821	36.577	1.824	4.670	.000
	SL*Tex	-5.111	1.876	-1.992	-2.725	.010

R^2=0.775, Adj R^2=0.757 and F=42.598

After removing the insignificant variables, the model at table-5 represents the individual correlations at 1% level of significance and the degree of accuracy here is 77.5%. The linear graphical model shows 65.5% accuracy while predicting shown in figure-2.

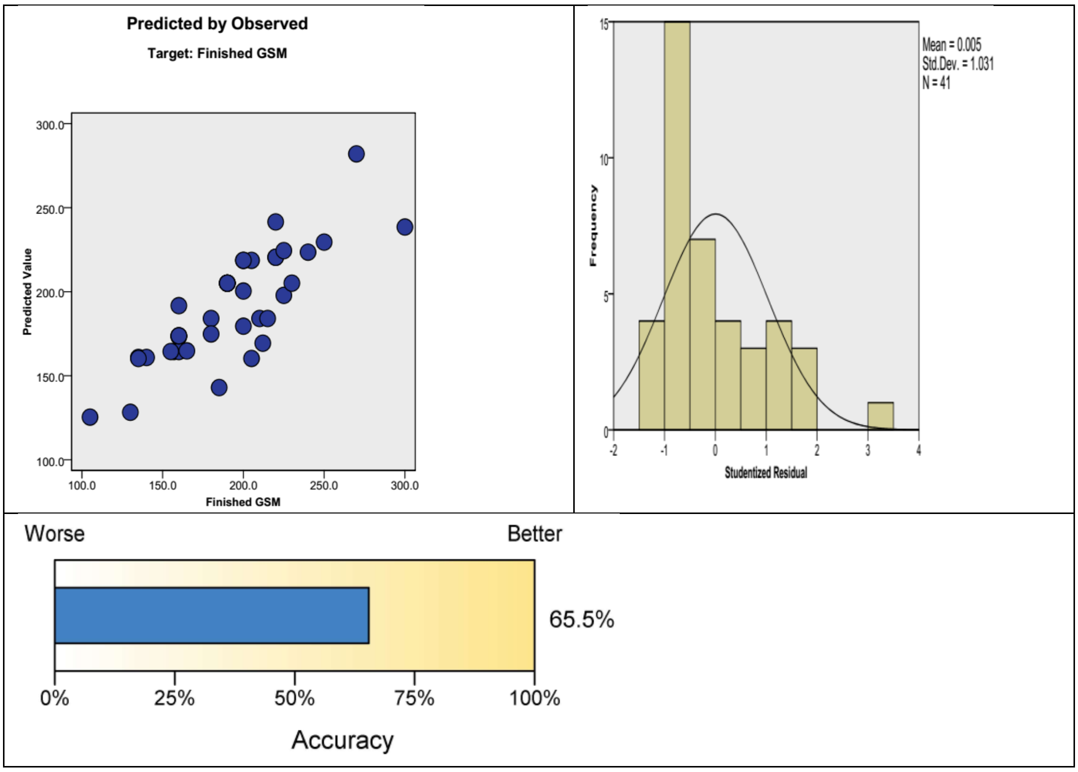

Figure 2: Graphical representation of regression model showing relation among finished gsm, stitch length, resultant count and product between stitch length and resultant count

Table 6: Geometric constant, Ks Regression Coefficients-1

Dependent Variable: Geometric constant, Ks		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-1586.041	770.461		-2.059	.047
	Machine Gauge	20.268	22.289	.035	.909	.369
	Resultant count (Tex)	-157.585	12.941	-.553	-12.178	.000
	SL	1302.018	193.680	.424	6.723	.000
	Finished GSM	18.571	2.207	.566	8.416	.000

R^2=0.957, Adj R^2=0.952 and F=200.621

From table-6 resultant count (tex), stitch length (SL) and finished GSM is showing significant correlation with geometric constant. With machine gauge, the relation is found insignificant.

Table 7: Geometric constant, Ks Regression Coefficients-2

Dependent Variable: Geometric constant, Ks		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-1037.881	478.687		-2.168	.037
	Resultant count (Tex)	-156.442	12.849	-.549	-12.175	.000
	SL	1279.362	191.621	.416	6.677	.000
	Finished GSM	18.274	2.177	.557	8.393	.000

R^2=0.956, Adj R^2=0.953 and F=268.475

Removing machine gauge from the model, the relationship is analyzed at 1% level of significance and accuracy found 95.6%. But, in predicting by this model accuracy found 93.1% shown in figure-3.

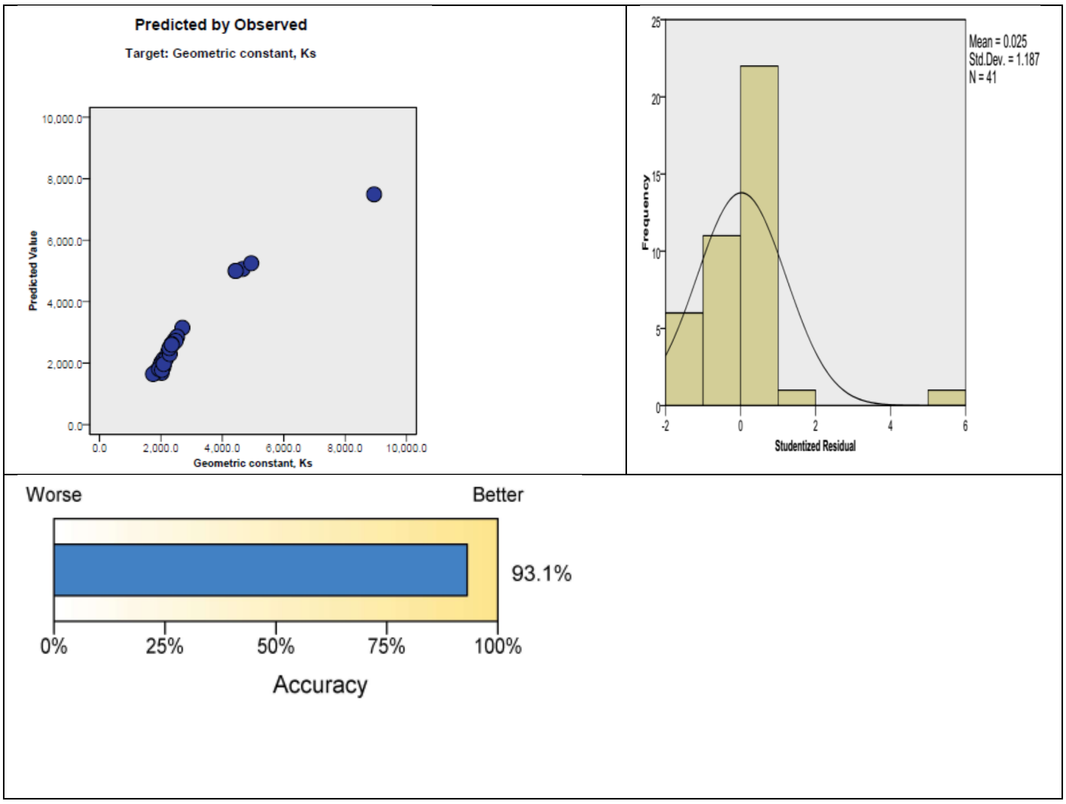

Figure 3: Graphical representation of regression model showing relation among geometric constant, finished gsm, stitch length and resultant count

V. FINDING AND DISCUSSION

Full data table-8 at appendix contains all the data of variables observed. While the regression and correlation analysis was done, the variables have shown interrelation among them in table-9. Omitting the insignificant variables the below equation found for grey diameter of weft knitted fabrics from table-2,

Grey diameter of weft knitted fabrics = (2.819×SL) + (1.231×Machine Dia) -10.128

This means grey diameter of fabric is correlated with stitch length and machine dia. The change of stitch length impacts more on grey diameter than machine dia.

In table-4 eliminating insignificant factors of finished width, the below equation can be drawn from table-5,

Finished GSM = (170.821×SL) + (19.363×Tex) – [5.111× (SL× Tex)] – 414.290

So, finished GSM of weft knitted plain fabric has positive relation with stitch length and count in tex, but negative correlation with product of stitch length and count in tex which is contradictory with the equation of GSM calculation as the stitch density is not constant in this study [(8),(7)]. Stitch length has the highest impact among them, then count in tex and least is their product.

Table-6 shows all the factors both significant and insignificant of geometric constant, whereas table 7 only illustrate the relation with significant factors. The regression equation is as below-

Geometric constant, Ks = (1279.362×SL) + (18.274×Finished GSM) – (156.442×Tex)–1037.881

Stitch length and finished GSM influences geometric constant, but the resultant count has a negative influence on that stitch length impacts most and finished GSM impact the least.

The above findings suggest that finished GSM and grey diameter of weft knitted fabric are significantly influenced by different machine parameter, i.e., stitch length, resultant count, product of stitch length and count, finished GSM etc. Grey diameter is influenced by stitch length and machine dia. The grey diameter of weft knitted fabrics needs to be increased, that can be done by increasing stitch length and machine dia.Also, finished GSM is positively influenced by stitch length and resultant count and negatively influenced by product of stitch length and count. The increase of stitch length and resultant count will increase the finished GSM. If the product of stitch length and count is increased, that will decrease the finished GSM. To achieve the desired grey diameter, finished GSM and geometric constant, proper adjustments of these parameters are necessary. Their relationships are proved and impacts have been illustrated. Proper utilization will result better efficiency in production.

Significance of the Study

This study will help to reduce to many factor consideration during resolving GSM, diameter and geometric constant. Machine setting and fabrics parameters can be predicted better by this study. High level of significance forecastes better accuracy of results predicted. Also the change in diameter, GSM and geometric constant can be investigated and corrected easily.

Limitations of the Study

- A limited number of factors were considered for the study
- Hidden factors were not observed
- The model could not established significant relation of machine diameter, number of feeder, number of needles and grey diameter with finished width of the weft knitted fabrics.

VI. CONCLUSION

To achieve a desired diameter, GSM and geometric constant, proper adjustment of stitch length, machine diameter, resultant count, GSM and the product of stitch length and resultant count is necessary. Further research considering unobserved variables in this study will resolve the existing issues regarding diameter, GSM and geometric constant. Yet, proper utilization of this study will result better efficiency in production.

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APPENDIX

Table 8: Data Table of Machine Parameters and Weft Knitted Fabrics

Sl. No.	Machine diameter	Machine Gauge	No. of feeder	No. of needles	Resultant count (Tex)	SL	SL*Tex	Grey Diameter (inch)	Finished width (inch)	Finished GSM	Geometric constant, Ks
1	38	24	114	2863	21.09	2.7	56.94	44	76	157	2010
2	34	24	102	2562	22.71	2.75	62.46	40	70	160	1937.3
3	26	26	78	2123	26.84	2.95	79.18	32	61	190	2088.2
4	26	20	78	1632	24.6	2.8	68.89	33	65	180	2048.4
5	26	20	78	1632	24.6	4.25	104.57	33	68	270	4663.8
6	34	20	102	2135	17.37	3.5	60.79	42	70	220	4433.5
7	38	24	114	2864	22.71	2.95	67	45	80	160	2078.2
8	34	24	102	2562	18.45	2.75	50.75	40	70	135	2011.9
9	34	20	102	2135	26.84	2.95	79.18	40	72	190	2088.2
10	26	20	78	1632	29.53	3	88.58	32	60	200	2032.2
11	30	20	90	1884	14.76	4.4	64.96	37	84	300	8941.6
12	36	20	108	2260	17.37	3.9	67.73	42	65	220	4940.2
13	34	20	72	2135	22.71	2.75	62.46	40	70	160	1937.3
14	34	20	102	2135	17.37	3.5	60.79	40	70	220	4433.5
15	38	20	114	2864	21.09	2.8	59.05	44	76	160	2124.3
16	38	24	114	2864	21.09	2.7	56.94	44	76	160	2048.4
17	34	24	102	2562	18.45	2.75	50.75	40	70	140	2086.4
18	26	26	78	2123	26.84	2.95	79.18	32	61	190	2088.2
19	26	24	78	1959	32.81	2.95	96.78	30	62	225	2023.3
20	30	24	90	2261	29.53	3	88.58	33.5	78	205	2083
21	30	24	90	2261	24.6	2.7	66.43	32	77	180	1975.3
22	30	24	90	2261	22.71	2.65	60.19	31	79	165	1925.2
23	26	24	78	1959	21.09	2.7	56.94	25	63	155	1984.4
24	30	24	90	2261	19.68	2.7	53.15	30	76	135	1851.8
25	26	24	78	1959	17.37	2.4	41.68	24	64	130	1796.4
26	26	24	78	1959	14.76	2.45	36.17	20	62	105	1742.6
27	30	20	90	1885	24.6	2.75	67.66	36	71	200	2235.4
28	30	20	90	1885	24.6	2.8	68.89	36	71	210	2389.8
29	30	20	90	1885	24.6	2.8	68.89	36	71	215	2446.7
30	30	20	90	1885	24.6	2.95	72.58	36	71	225	2697.7
31	34	20	72	2135	22.71	2.75	62.46	40	70	160	1937.3

Sl. No.	Machine diameter	Machine Gauge	No. of feeder	No. of needles	Resultant count (Tex)	SL	SL*Tex	Grey Diameter (inch)	Finished width (inch)	Finished GSM	Geometric constant, Ks
32	34	20	102	2135	26.84	2.95	79.18	40	70	190	2088.2
33	34	20	102	2135	26.84	2.9	77.84	40	70	200	2160.9
34	34	20	102	2135	26.84	2.95	79.18	40	70	230	2527.9
35	26	20	78	1632	29.53	3	88.58	32	60	200	2032.2
36	26	24	78	1959	29.53	3.05	90.05	32	59	240	2479.3
37	26	26	78	2123	26.84	2.95	79.18	32	61	190	2088.2
38	30	24	78	2261	32.81	3	98.42	46	71	250	2286.2
39	30	24	78	2261	24.6	2.64	64.96	40	72	212	2274.7
40	30	24	78	2261	22.71	2.6	59.05	36	69	205	2346.8
41	30	24	78	2261	19.68	2.5	49.21	33	70	185	2349.7

Table 9: Correlation Coefficient Table

		Machine diameter	Machine Gauge	No. of feeder	No. of needles	Resultant count (Tex)	SL	SL*Tex	Grey Diameter (inch)	Finished width (inch)	Finished GSM	Geometric constant, Ks
Machine diameter	Pearson Correlation	1	-.244	.837**	.770**	-.329*	.013	-.310*	.834**	.616**	-.185	.059
	Sig. (2-tailed)		.124	.000	.000	.036	.935	.049	.000	.000	.248	.715
	N	41	41	41	41	41	41	41	41	41	41	41
Machine Gauge	Pearson Correlation	-.244	1	-.174	.398**	.044	-.414**	-.169	-.300	-.116	-.374*	-.377*
	Sig. (2-tailed)	.124		.277	.010	.783	.007	.292	.057	.469	.016	.015
	N	41	41	41	41	41	41	41	41	41	41	41
No. of feeder	Pearson Correlation	.837**	-.174	1	.683**	-.308	.119	-.227	.642**	.537**	-.130	.121
	Sig. (2-tailed)	.000	.277		.000	.050	.459	.153	.000	.000	.419	.450
	N	41	41	41	41	41	41	41	41	41	41	41
		Machine diameter	Machine Gauge	No. of feeder	No. of needles	Resultant count (Tex)	SL	SL*Tex	Grey Diameter (inch)	Finished width (inch)	Finished GSM	Geometric constant, Ks
No. of needles	Pearson Correlation	.770**	.398**	.683**	1	-.273	-.271	-.398**	.580**	.515**	-.431**	-.207
	Sig. (2-tailed)	.000	.010	.000		.084	.087	.010	.000	.001	.005	.193
	N	41	41	41	41	41	41	41	41	41	41	41
Resultant count (Tex)	Pearson Correlation	-.329*	.044	-.308	-.273	1	-.102	.847**	.012	-.300	.355*	-.394*
	Sig. (2-tailed)	.036	.783	.050	.084		.525	.000	.939	.056	.023	.011
	N	41	41	41	41	41	41	41	41	41	41	41
SL	Pearson Correlation	.013	-.414**	.119	-.271	-.102	1	.431**	.212	.101	.737**	.883**
	Sig. (2-tailed)	.935	.007	.459	.087	.525		.005	.184	.530	.000	.000
	N	41	41	41	41	41	41	41	41	41	41	41
SL*Tex	Pearson Correlation	-.310*	-.169	-.227	-.398**	.847**	.431**	1	.093	-.253	.683**	.080
	Sig. (2-tailed)	.049	.292	.153	.010	.000	.005		.561	.111	.000	.619
	N	41	41	41	41	41	41	41	41	41	41	41

		Machine diameter	Machine Gauge	No. of feeder	No. of needles	Resultant count (Tex)	SL	SL*Tex	Grey Diameter (inch)	Finished width (inch)	Finished GSM	Geometric constant, Ks
Grey Diameter (inch)	Pearson Correlation	.834**	-.300	.642**	.580**	.012	.212	.093	1	.487**	.208	.169
	Sig. (2-tailed)	.000	.057	.000	.000	.939	.184	.561		.001	.193	.292
	N	41	41	41	41	41	41	41	41	41	41	41
Finished width (inch)	Pearson Correlation	.616**	-.116	.537**	.515**	-.300	.101	-.253	.487**	1	.039	.273
	Sig. (2-tailed)	.000	.469	.000	.001	.056	.530	.111	.001		.811	.085
	N	41	41	41	41	41	41	41	41	41	41	41
Finished GSM	Pearson Correlation	-.185	-.374*	-.130	-.431**	.355*	.737**	.683**	.208	.039	1	.669**
	Sig. (2-tailed)	.248	.016	.419	.005	.023	.000	.000	.193	.811		.000
	N	41	41	41	41	41	41	41	41	41	41	41
Geometric constant, Ks	Pearson Correlation	.059	-.377*	.121	-.207	-.394*	.883**	.080	.169	.273	.669**	1
	Sig. (2-tailed)	.715	.015	.450	.193	.011	.000	.619	.292	.085	.000	
	N	41	41	41	41	41	41	41	41	41	41	41

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Mohammad Mobarak Hossain" Factors That Resolve GSM, Diameter and Geometric Constant of Weft Knitted Fabrics" The International Journal of Engineering and Science (IJES), 8.5 (2019): 83-92