5.0 Introduction

Understanding the relationship between physical parameters of fabric with feel of fabric or hand value of fabric is always a matter of interest among various textile personnel. We all know that fabric hand value is the most significant influencing parameter to the customer preference. Customers understand the textile apparel application mainly from feel and comfort properties of fabric point of view. In fact we all want the same. The difference is matter of evaluation technique, language of expression and quantification of the evaluation.

Simple hand evaluation of fabric is subjective in nature and invariably prone to inherent variability irrespective of time and place are concern. Being a technologist we understand that hand value of the fabric is the resultant effect of various fabric parameter or particulars. Therefore, understanding the interaction of fabric particulars, fabric properties and the hand value of fabric is very important in the present context of the study.

As reported in last couple of chapters that an instrument has been developed indigenously and validated for its applicability to study fabric hand characteristics objectively using nozzle extraction method.

Therefore, in this chapter effort has been made to study the relationship between nozzle extraction parameters like extraction force i.e. axial force and radial forces – left and right with the different physical properties of fabric like GSM (gram per square metre), fabric thickness, bending length and bending rigidity of fabric, crease recovery properties, etc..

5.1 Materials and Methods

5.1.1 Materials

Twenty eight shirting and thirty suiting fabric samples were used for this purpose. The particulars of the fabric samples used are given in the following Table Nos. 5.1 and 5.2. as far as the sample coding is concern 'SH' stands for shirting fabric samples and 'SS' refers to suiting fabric samples. All the fabric samples are collected from the market.

Table No. 5.1: Shirting Fabric Sample Particulars

S No	EPI	PPI	Count (Ne)		Thick-ness (mm)	GSM	Bending Length			Bending Rigidity(G) mg.cm	Bending Modulus(q) , kg/sq cm
			Warp	Weft			Warp (cm)	Weft (cm)	Avg		
SH1	92	62	51.3	44.9	0.263	92.003	3.6	2.9	3.25	315.828	14.392
SH2	136	62	67.3	18.4	0.363	133.979	1.7	1.9	1.79	77.326	2.554
SH3	90	68	62.3	28.1	0.280	120.754	1.7	1.5	1.59	48.883	2.095
SH4	108	80	50.6	64.4	0.343	105.892	1.6	1.4	1.53	38.019	1.329
SH5	120	80	62.3	45.3	0.243	113.478	1.8	1.8	1.76	62.129	3.064
SH6	160	100	61.2	39.0	0.273	121.948	2.5	1.6	2.03	101.263	4.446
SH7	130	60	61.2	26.7	0.273	105.184	3.7	3.8	3.76	557.459	24.474
SH8	100	82	40.0	44.9	0.240	106.246	1.4	1.5	1.47	33.663	1.683
SH9	124	80	57.1	41.3	0.187	95.586	2.0	2.0	1.99	75.044	4.824
SH10	92	76	39.3	38.1	0.360	106.445	2.1	1.9	1.98	82.002	2.733
SH11	54	48	33.4	20.7	0.233	111.686	2.0	2.0	2.03	92.742	4.770
SH12	86	58	44.1	39.0	0.373	107.794	2.9	1.5	2.21	115.760	3.721
SH13	56	52	23.4	18.0	0.370	124.956	5.0	4.4	4.65	1256.363	40.747
SH14	88	72	42.4	41.0	0.273	115.004	4.0	2.7	3.34	427.538	18.770
SH15	144	72	37.3	38.1	0.267	146.032	2.1	1.7	1.88	96.262	4.332
SH16	104	90	38.9	40.3	0.280	130.286	2.1	1.6	1.84	81.659	3.500
SH17	96	72	45.3	46.5	0.330	105.405	2.1	2.0	2.02	86.718	3.153
SH18	84	72	36.7	26.2	0.297	124.690	3.6	2.6	3.09	369.223	14.935
SH19	96	82	60.1	55.1	0.207	75.770	3.0	2.8	2.88	180.056	10.455
SH20	88	72	48.1	62.8	0.207	73.248	2.0	1.7	1.84	45.444	2.639
SH21	100	88	66.7	63.4	0.230	78.401	2.3	2.0	2.10	72.608	3.788
SH22	82	68	52.7	47.2	0.217	82.869	1.8	1.6	1.70	40.713	2.255
SH23	86	80	51.3	57.6	0.213	69.865	1.7	1.8	1.71	35.087	1.974
SH24	100	88	43.2	46.5	0.267	109.298	1.7	1.5	1.59	43.727	1.968
SH25	92	76	51.3	52.7	0.273	97.001	1.5	1.5	1.47	30.734	1.349
SH26	116	56	30.9	36.7	0.283	126.526	2.5	1.7	2.09	115.096	4.875
SH27	94	54	25.4	31.1	0.287	130.065	2.9	2.0	2.46	194.217	8.130
SH28	92	72	44.1	42.8	0.210	92.312	1.4	1.3	1.34	22.087	1.262

Table No. 5.2: Suiting Fabric Sample Particulars

S No	EPI	PPI	Count (Ne)		Thick-ness (mm)	GSM	Bending Length			Bending Rigidity(G) mg.cm	Bending Modulus(q) , kg/sq cm
			Warp	Weft			Warp (cm)	Weft (cm)	Avg		
SS1	56	48	15.1	14.8	0.343	172.019	1.8	1.8	1.79	99.280	3.470
SS2	64	56	14.6	14.5	0.407	259.510	1.7	1.6	1.64	115.255	3.401
SS3	72	64	17.0	16.3	0.367	233.833	1.7	1.6	1.63	101.500	3.322
SS4	76	68	17.9	17.9	0.380	208.068	1.6	1.4	1.54	75.622	2.388
SS5	76	56	14.8	15.0	0.430	246.727	2.0	1.5	1.73	126.644	3.534
SS6	106	80	19.2	21.1	0.420	232.550	1.9	1.5	1.68	110.513	3.158
SS7	140	68	18.8	20.6	0.450	280.542	1.8	1.6	1.74	147.154	3.924
SS8	48	40	9.5	9.6	0.420	244.604	2.2	1.9	2.08	218.533	6.244
SS9	80	56	15.5	17.9	0.360	195.285	1.7	1.5	1.57	75.393	2.513
SS10	78	58	15.1	15.2	0.390	240.004	2.1	1.6	1.80	139.970	4.307
SS11	96	88	21.4	29.3	0.320	182.723	1.8	1.5	1.61	75.724	2.840
SS12	48	44	14.0	13.5	0.330	179.649	1.7	1.6	1.64	78.880	2.868
SS13	130	76	17.9	19.4	0.470	271.475	1.8	1.6	1.70	133.376	3.405
SS14	38	34	7.2	7.1	0.500	258.581	1.8	1.6	1.68	121.518	2.916
SS15	76	54	14.5	7.3	0.380	221.625	1.8	1.7	1.76	121.341	3.832
SS16	78	56	14.7	13.7	0.380	225.252	1.8	1.1	1.48	72.284	2.283
SS17	108	78	24.9	24.2	0.340	188.716	2.0	1.7	1.86	120.703	4.260
SS18	84	66	17.0	16.7	0.460	224.788	1.9	1.7	1.79	129.735	3.384
SS19	84	66	21.1	20.7	0.310	179.671	1.5	1.3	1.43	52.677	2.039
SS20	60	52	14.8	14.6	0.367	193.206	1.6	1.4	1.50	65.207	2.134
SS21	148	100	22.0	35.7	0.570	251.393	1.4	1.2	1.31	56.840	1.197
SS22	72	66	14.5	14.5	0.450	234.651	1.7	1.6	1.62	99.532	2.654
SS23	88	56	15.0	15.4	0.380	235.647	1.7	1.4	1.50	79.531	2.511
SS24	72	64	17.7	16.3	0.380	191.459	1.8	1.5	1.64	85.032	2.685
SS25	76	60	14.8	15.0	0.450	245.223	1.8	1.7	1.71	121.812	3.248
SS26	154	68	18.6	20.6	0.500	304.936	3.1	2.6	2.87	719.925	17.278
SS27	70	60	11.9	15.7	0.420	244.604	1.9	1.8	1.84	153.310	4.380
SS28	136	76	20.0	20.8	0.480	268.047	3.2	2.6	2.87	632.832	15.821
SS29	160	68	18.3	19.6	0.500	308.630	3.0	2.1	2.55	511.750	12.282
SS30	80	72	24.4	9.7	0.500	275.522	2.7	2.6	2.60	484.257	11.622

5.1.2 Method Used

All the fabric samples is first analysed for some basic physical parameters like warp and weft count, ends/inch and picks/inch, thickness, GSM(grams per square metre), bending length etc. Bending rigidity and bending modulus calculated from the abovementioned data. Fabric samples are then tested on nozzle extraction instrument. Extraction forces recorded in the instrument are then compared with the physical parameters of the fabric in the suitable tabular as well as graphical format. Observations are recorded in the results and discussions section.

5.2 Results and Discussions

The shirting and suiting fabric sample analysis report for warp and weft count, ends/inch and picks/inch, thickness, GSM(grams per square metre), bending length, bending rigidity and bending modulus are given in Table No. 5.1. and 5.2 respectively.

From the Table 5.1 and 5.2 it can be seen that for both shirting and suiting fabrics that is collected from the market in ready to use condition covered a wide range for the respective areas. In the present purpose further subgroup division is not done keeping in mind the broad spectrum and wide spread of coverage in the areas of its applications.

The above mentioned all the fabric samples were then tested on the newly developed nozzle extraction instrument as mentioned in the chapter 3. The test result for shirting fabric is given in Table 5.3 and the same for the suiting fabrics are given in Table 5.4. The Table 5.3 and 5.4 gives us the idea of various ranges of extraction forces in axial and radial directions.

Table No. 5.3: Extraction Force for Shirting Fabric Sample

S No	Extraction Force		Radial Force, Left		Radial Force, Right	
	Avg (kg)	Peak (kg)	Avg (kg)	Peak (kg)	Avg (kg)	Peak (kg)
SH1	1.08	2.29	0.887	2.4452	1.009	2.551
SH2	1.06	2.694	0.764	2.606	0.791	2.682
SH3	0.95	2.502	0.739	2.557	0.775	2.6666
SH4	0.82	2.032	0.879	2.5872	0.903	2.6678
SH5	0.66	1.96	0.459	1.922	0.483	1.991
SH6	0.93	2.462	0.638	2.478	0.645	2.529
SH7	0.93	2.112	0.533	1.7452	0.552	1.789
SH8	0.57	1.562	0.366	1.62	0.368	1.682
SH9	0.46	1.466	0.285	1.308	0.289	1.371
SH10	0.6	1.738	0.453	1.757	0.474	1.859
SH11	0.46	1.324	0.361	1.526	0.37	1.598
SH12	0.86	2.184	0.527	2.0348	0.553	2.121
SH13	1.93	3.918	1.012	3.118	1.065	3.239
SH14	1.17	2.716	0.633	2.132	0.649	2.208
SH15	1.16	3.084	0.888	3.2442	0.923	3.362
SH16	0.83	2.374	0.566	2.4036	0.586	2.493
SH17	0.71	1.86	0.49	1.877	0.51	1.914
SH18	1.08	2.578	0.751	2.352	0.774	2.4318
SH19	0.53	1.546	0.262	1.087	0.269	1.1448
SH20	0.25	0.874	0.119	0.5302	0.115	0.574
SH21	0.44	1.316	0.234	1.038	0.237	1.07
SH22	0.44	1.384	0.238	1.133	0.246	1.1752
SH23	0.38	1.18	0.175	0.808	0.183	0.848
SH24	0.55	1.706	0.354	1.579	0.368	1.64
SH25	0.38	1.136	0.232	1.133	0.231	1.196
SH26	0.68	1.936	0.54	2.1796	0.559	2.256
SH27	1.11	2.682	0.813	2.696	0.857	2.8
SH28	0.32	1.08	0.2	0.965	0.206	1.031

Table No. 5.4: Extraction Force for Suiting Fabric Sample

S No	Extraction Force		Radial Force, Left		Radial Force, Right	
	Avg (kg)	Peak (kg)	Avg (kg)	Peak (kg)	Avg (kg)	Peak (kg)
SS1	0.28	0.706	0.249	1.055	0.266	1.113
SS2	0.58	1.398	0.726	2.442	0.763	2.527
SS3	0.4	1.016	0.51	1.875	0.535	1.9404
SS4	0.29	0.882	0.392	1.554	0.413	1.619
SS5	0.58	1.782	0.809	2.814	0.858	2.987
SS6	0.46	1.224	0.66	2.364	0.681	2.45
SS7	0.7	1.722	0.966	2.926	1.006	3.027
SS8	0.48	1.344	0.718	2.377	0.745	2.457
SS9	0.31	0.822	0.319	1.299	0.325	1.323
SS10	0.41	1.056	0.585	2.1182	0.61	2.202
SS11	0.19	0.484	0.184	0.8166	0.188	0.836
SS12	0.21	0.63	0.274	1.154	0.288	1.187
SS13	0.6	1.642	0.85	2.937	0.888	3.0212
SS14	0.65	1.718	1.005	3.474	1.047	3.5804
SS15	0.38	1.04	0.485	1.929	0.507	2.028
SS16	0.33	0.968	0.652	2.181	0.67	2.247
SS17	0.29	0.726	0.353	1.176	0.365	1.23
SS18	0.57	1.538	0.792	2.7326	0.824	2.811
SS19	0.22	0.642	0.249	1.0548	0.256	1.1426
SS20	0.31	0.87	0.293	1.2878	0.305	1.3342
SS21	0.67	1.988	1.13	3.834	1.195	4.0172
SS22	0.59	1.682	0.869	3.033	0.908	3.111
SS23	0.29	0.93	0.495	1.922	0.521	1.9906
SS24	0.26	0.694	0.284	1.211	0.297	1.2596
SS25	0.49	1.34	0.741	2.457	0.773	2.544
SS26	1.11	2.634	1.688	4.5032	1.762	4.679
SS27	0.38	1.028	0.624	2.1758	0.648	2.2646
SS28	0.85	2.092	1.136	3.344	1.204	3.475
SS29	0.95	2.184	1.333	3.734	1.426	3.91
SS30	1.080	2.200	1.25	3.65	1.23	3.7

To understand the meaning of the forces recorded by the instrument mentioned in the above mentioned tables; it has to be compared with various physical parameters / properties of the respective fabrics. It is well known fact that there are many physical as well as derived properties of fabric that are always a matter of interest among various researchers. But in the present context fabric thickness, GSM of fabric and the low stress mechanical properties like bending and shear are the relevant parameters in nozzle extraction process. In this case, therefore, nozzle extraction forces average and peak both axial and radial – right and left have been correlated with the above mentioned fabric properties i.e. thickness, GSM, bending length, bending rigidity and bending modulus.

The graph plotted for average extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.1 to 5.5 respectively and the same for the suiting fabric are given in Fig 5.6 to 5.10.

The graph plotted for peak extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.11 to 5.15 respectively and the same for the suiting fabric are given in Fig 5.16 to 5.20.

The graph plotted for average radial left extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.21 to 5.25 respectively and the same for the suiting fabric are given in Fig 5.26 to 5.30.

The graph plotted for peak radial left extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.31 to 5.35 respectively and the same for the suiting fabric are given in Fig 5.36 to 5.40.

The graph plotted for average radial right extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.41 to 5.45 respectively and the same for the suiting fabric are given in Fig 5.46 to 5.50.

The graph plotted for peak radial right extraction forces with thickness, GSM, bending length, bending rigidity and bending modulus for shirting fabric are given in Fig 5.51 to 5.55 respectively and the same for the suiting fabric are given in Fig 5.56 to 5.60.

The above mentioned all the figures i.e. Fig 5.1 to 5.60 are basically a scatter diagram plot. Linear trend line (y = mx + c) have been plotted for each. The correlation coefficient R^2 value also mentioned for each plot. Both the trend line equation as well as R^2 value mentioned in each figure.

It can be seen that in case of most of the suiting fabrics the R^2 value is quite high particularly for average extension force. For shirting fabrics the same is satisfactory in many cases except few. As such statistically, it is said that R^2 value up to 0.36 indicates acceptable range of correlations.

It can be seen from the Fig 5.1 to 5.3 that R^2 values of average extraction force and the fabric physical properties like thickness, grammage, bending length of shirting variety are in the range of 0.4-0.5 and the same is in the range of 0.6 for bending modulus and bending rigidity as shown in the Fig 5.4-5.5. First three fabric properties viz. thickness, GSM and bending length are individual single fabric properties, whereas bending modulus are the derived properties of the predecessors. From the Fig 5.6 to 5.10, it can be seen that for suiting fabrics a high degree of R^2 value exist for average extraction forces to the all selected fabric properties in the present case i.e. fabric thickness, grammage, bending length,

bending modulus and bending rigidity. Therefore it is observed that high grammage and thickness fabrics like suiting fabrics exhibit better correlated with average extraction forces and fabrics physical parameters like grammage, thickness etc. than low grammage and thickness fabrics like shirting variety.

As far as peak extraction force is concern, from the Fig 5.11 to 5.20 it can be seen that fabric thickness and grammage of the fabric, both for shirting and suiting variety, exhibited high degree of correlations, but not with the bending properties. This is so, because peak extraction force is a pure function of packing coefficient of fabric in the nozzle and the packing coefficient is a direct function of fabric thickness and an indirect function of grammage of fabric.

From the Fig 5.21 to 25 and Fig 5.41 to 5.45, it can be seen that in shirting fabrics very poor correlations (R^2) have been observed for all the fabric properties like thickness, grammage, and bending properties to the average radial – left as well as right, extraction forces. As far as peak radial extraction force is concern thickness and grammage of the fabric have shown moderate to good R^2 values for shirting variety as it can be seen from Fig 5.31 to 5.35 and 5.51 to 5.55.

From the Fig 5.26 to 5.30 and 5.46 and 5.50, it can be seen that high degree of correlations (R^2) values exists for all the cases. Therefore, it can be said that for the suiting fabrics average radial extraction force – both left and right and the physical fabric parameters are correlated.

From the Fig 5.36, 5.37, 5.56 and 5.57 it can be seen that very high degree of correlations are present for peak radial – left and right extraction forces are present with thickness and grammage of the fabric. The same is moderate with bending properties of the fabric as can be seen from the Fig 5.38 to4.40 and Fig 5.58 to 5.60.

As discussed earlier that packing coefficient plays a vital role in exerting radial forces. Therefore, suiting fabrics have shown high degree of correlation in this respect than the shirting fabrics.

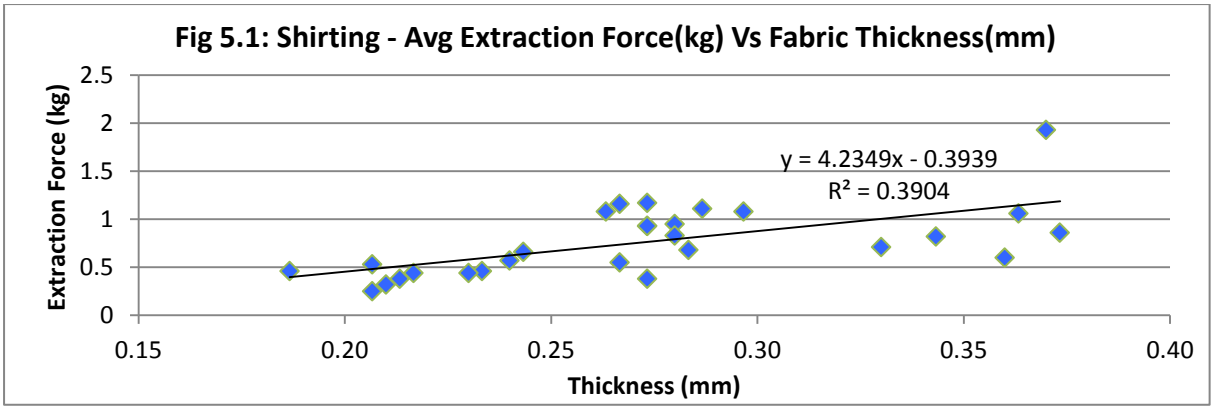
Fig 5.1: Shirting - Avg Extraction Force(kg) Vs Fabric Thickness(mm)
Extraction Force (kg)
2.5
2
1.5
1
0.5
0
y = 4.2349x - 0.3939
R² = 0.3904
0.15
0.20
0.25
0.30
0.35
0.40
Thickness (mm)

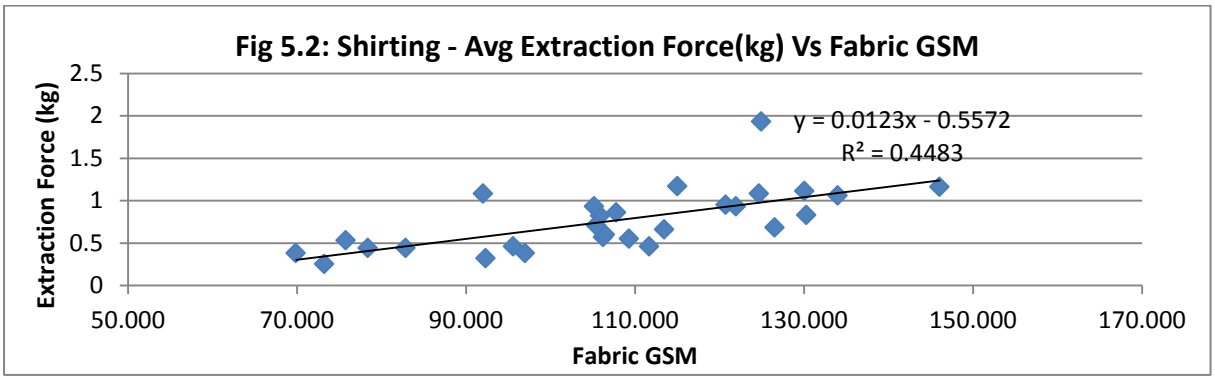
Fig 5.2: Shirting - Avg Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
2.5
2
1.5
1
0.5
0
y = 0.0123x - 0.5572
R² = 0.4483
50.000
70.000
90.000
110.000
130.000
150.000
170.000
Fabric GSM

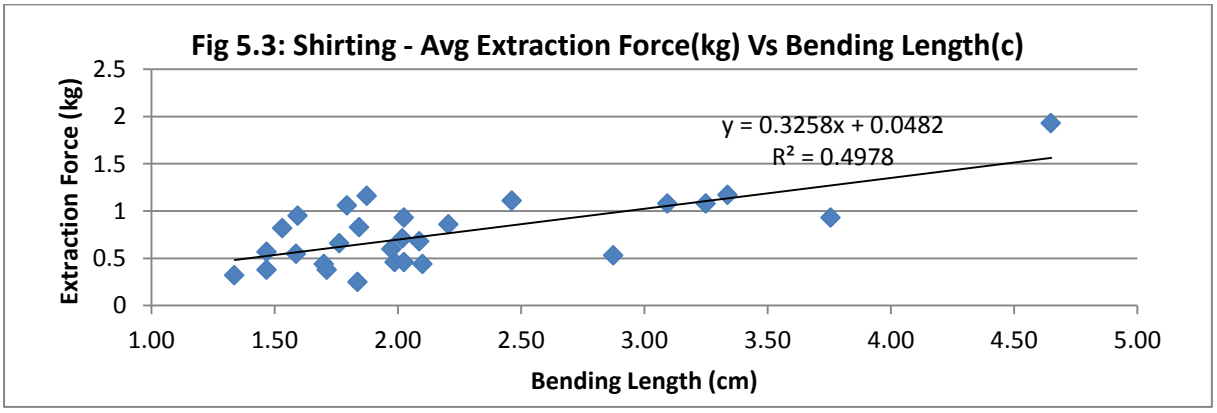
Fig 5.3: Shirting - Avg Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
2.5
2
1.5
1
0.5
0
y = 0.3258x + 0.0482
R² = 0.4978
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Bending Length (cm)

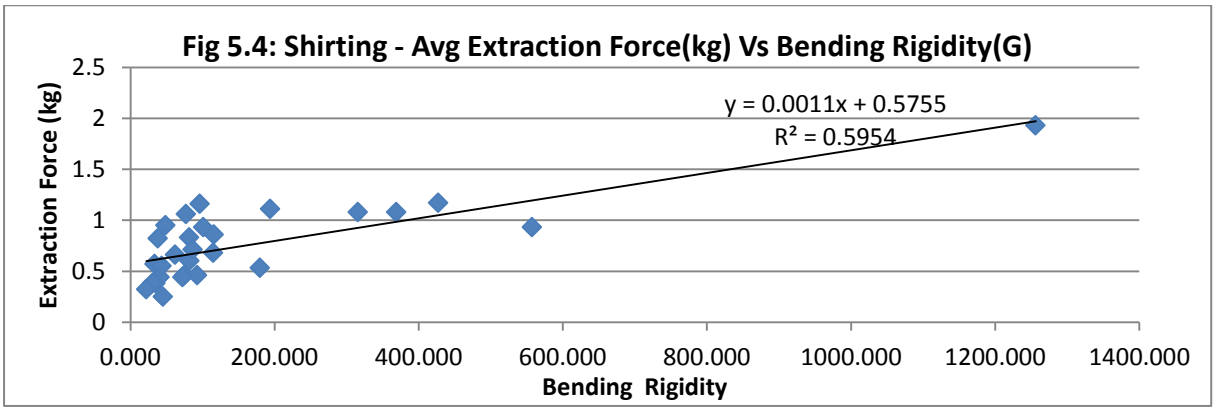
Fig 5.4: Shirting - Avg Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
2.5
2
1.5
1
0.5
0
y = 0.0011x + 0.5755
R² = 0.5954
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000
Bending Rigidity

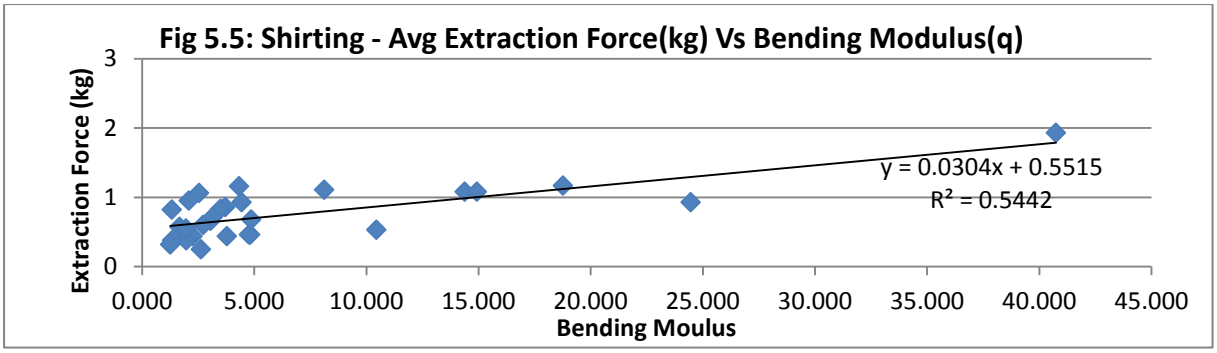
Fig 5.5: Shirting - Avg Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
Bending Moulus
y = 0.0304x + 0.5515
R² = 0.5442
0
1
2
3
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000

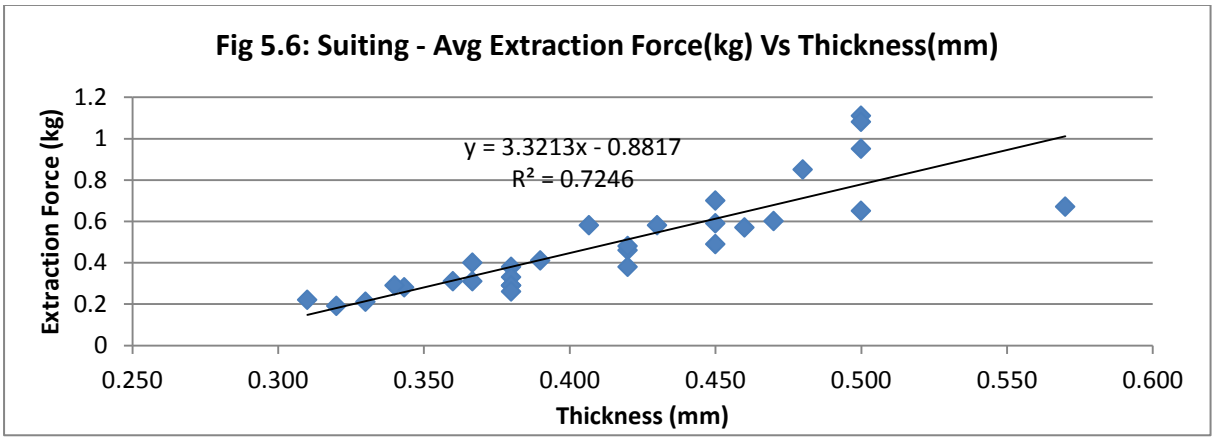
Fig 5.6: Suiting - Avg Extraction Force(kg) Vs Thickness(mm)
Extraction Force (kg)
Thickness (mm)
y = 3.3213x - 0.8817
R² = 0.7246
0
0.2
0.4
0.6
0.8
1
1.2
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600

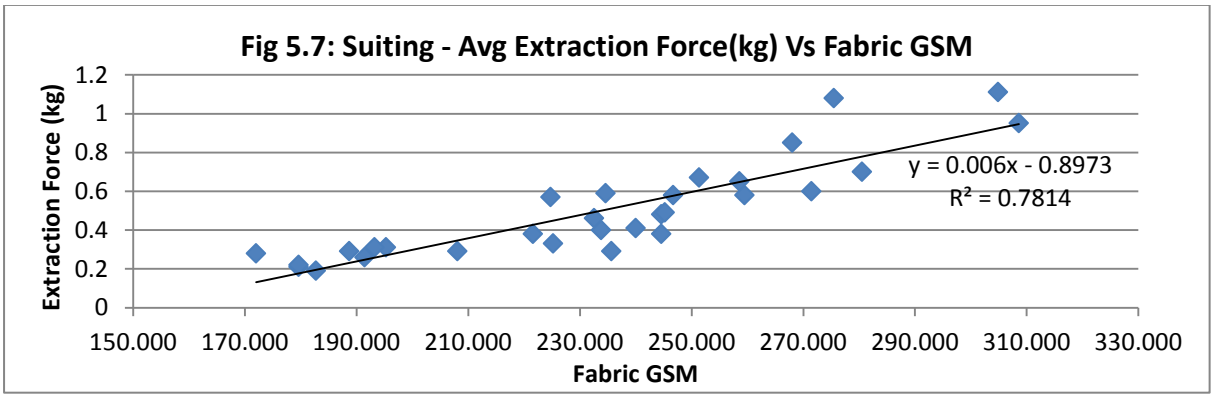
Fig 5.7: Suiting - Avg Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
Fabric GSM
y = 0.006x - 0.8973
R² = 0.7814
0
0.2
0.4
0.6
0.8
1
1.2
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000

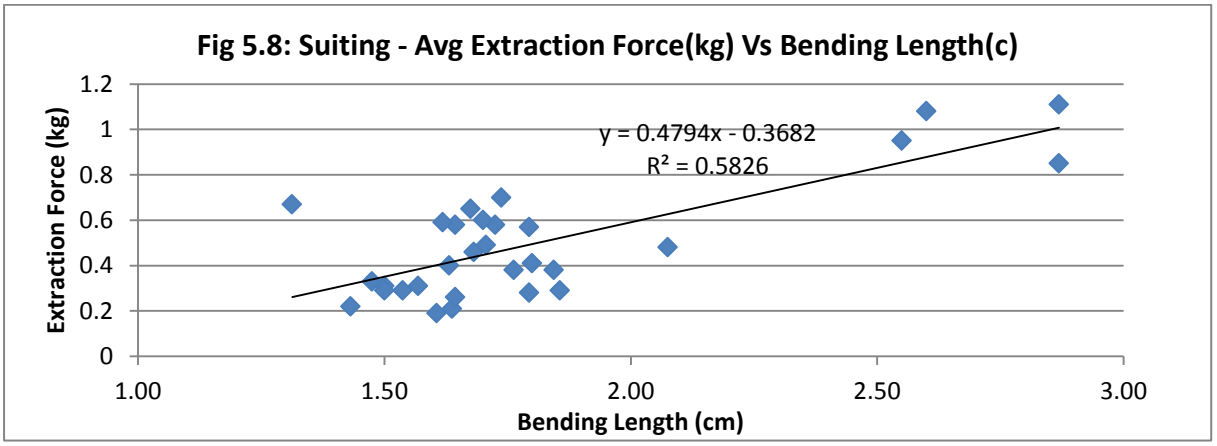
Fig 5.8: Suiting - Avg Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
Bending Length (cm)
y = 0.4794x - 0.3682
R² = 0.5826
0
0.2
0.4
0.6
0.8
1
1.2
1.00
1.50
2.00
2.50
3.00

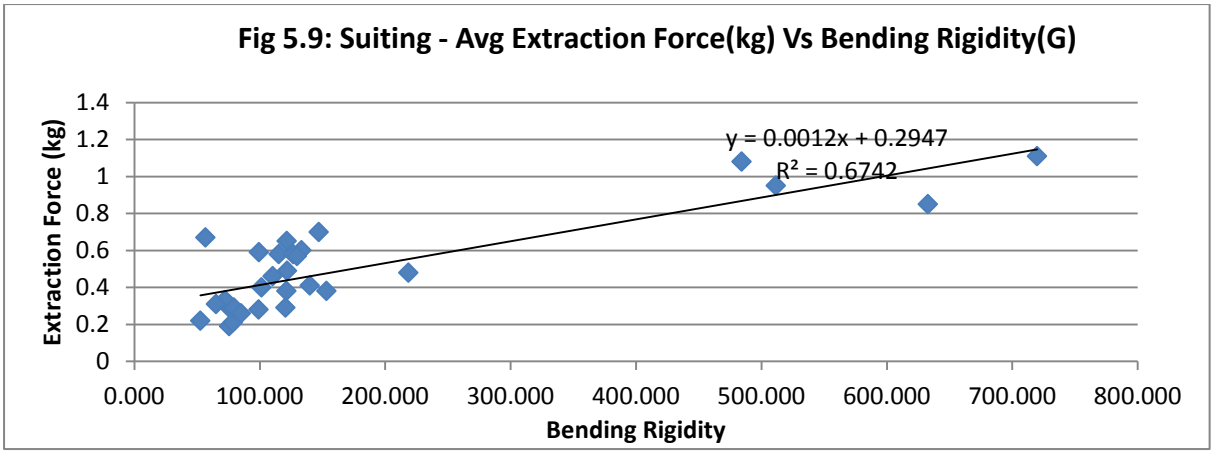
Fig 5.9: Suiting - Avg Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
y = 0.0012x + 0.2947
R² = 0.6742
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000
Bending Rigidity

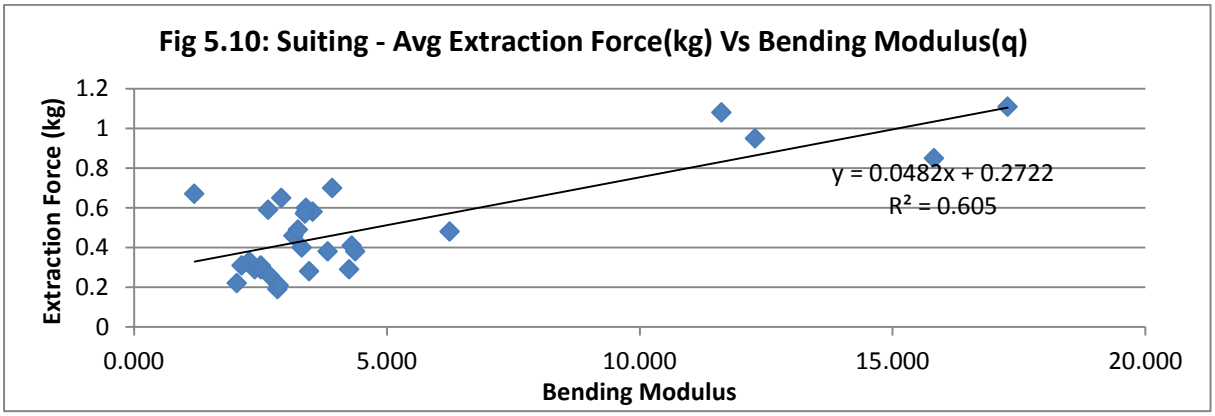
Fig 5.10: Suiting - Avg Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
y = 0.0482x + 0.2722
R² = 0.605
0.000
5.000
10.000
15.000
20.000
Bending Modulus

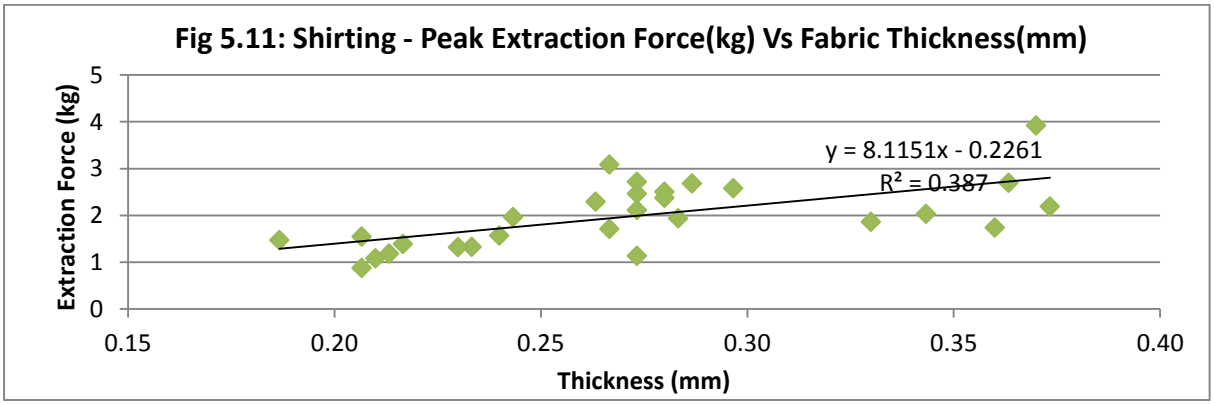
Fig 5.11: Shirting - Peak Extraction Force(kg) Vs Fabric Thickness(mm)
Extraction Force (kg)
5
4
3
2
1
0
y = 8.1151x - 0.2261
R² = 0.387
0.15
0.20
0.25
0.30
0.35
0.40
Thickness (mm)

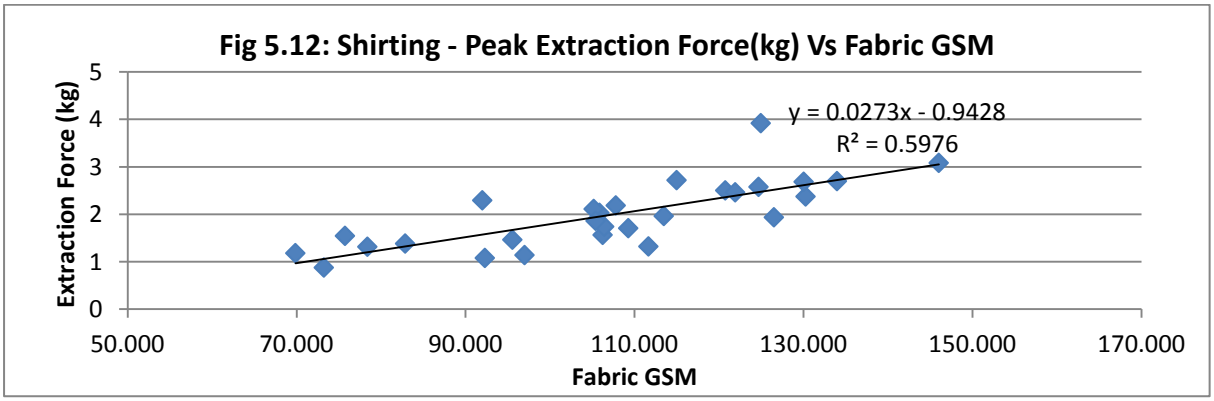
Fig 5.12: Shirting - Peak Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
5
4
3
2
1
0
y = 0.0273x - 0.9428
R² = 0.5976
50.000
70.000
90.000
110.000
130.000
150.000
170.000
Fabric GSM

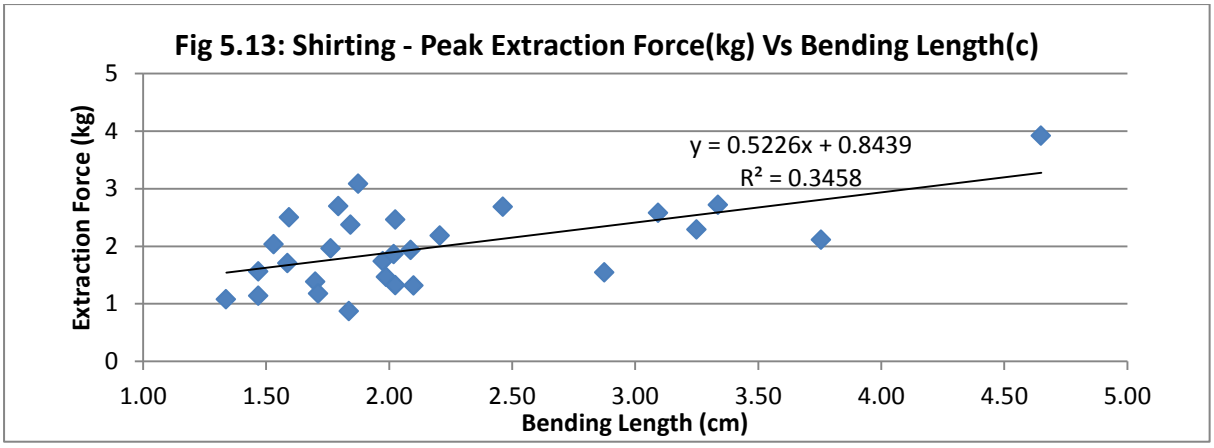
Fig 5.13: Shirting - Peak Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
Bending Length (cm)
y = 0.5226x + 0.8439
R² = 0.3458
0
1
2
3
4
5
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

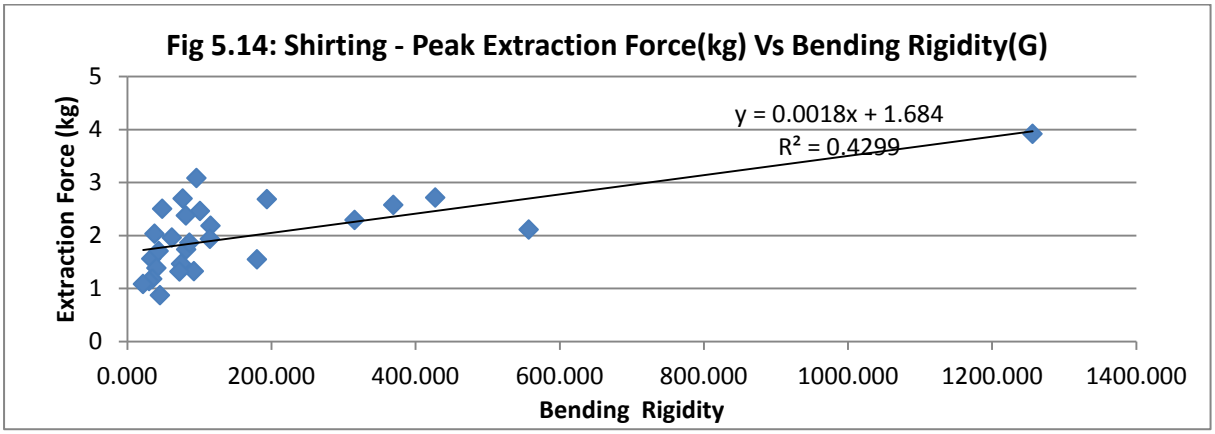
Fig 5.14: Shirting - Peak Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
Bending Rigidity
y = 0.0018x + 1.684
R² = 0.4299
0
1
2
3
4
5
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000

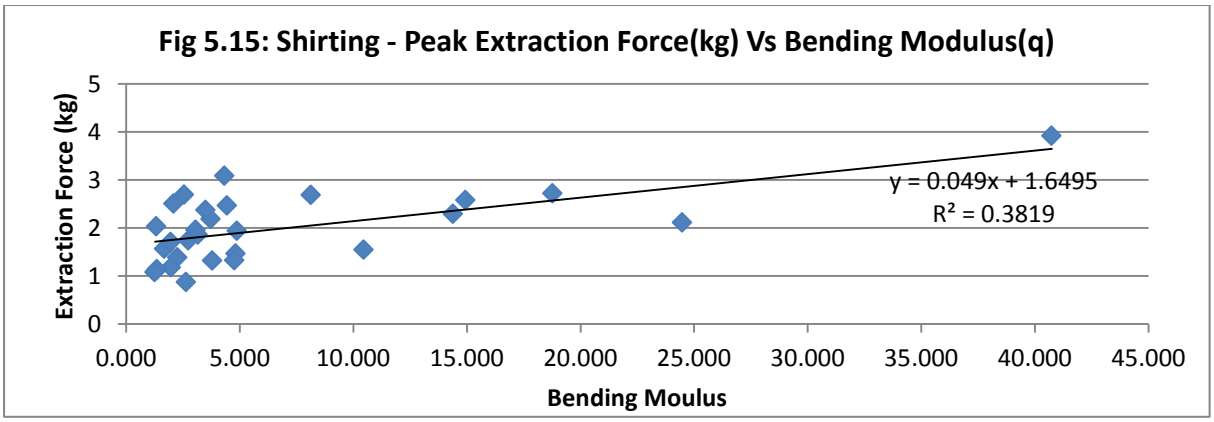
Fig 5.15: Shirting - Peak Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
Bending Moulus
y = 0.049x + 1.6495
R² = 0.3819
0
1
2
3
4
5
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000

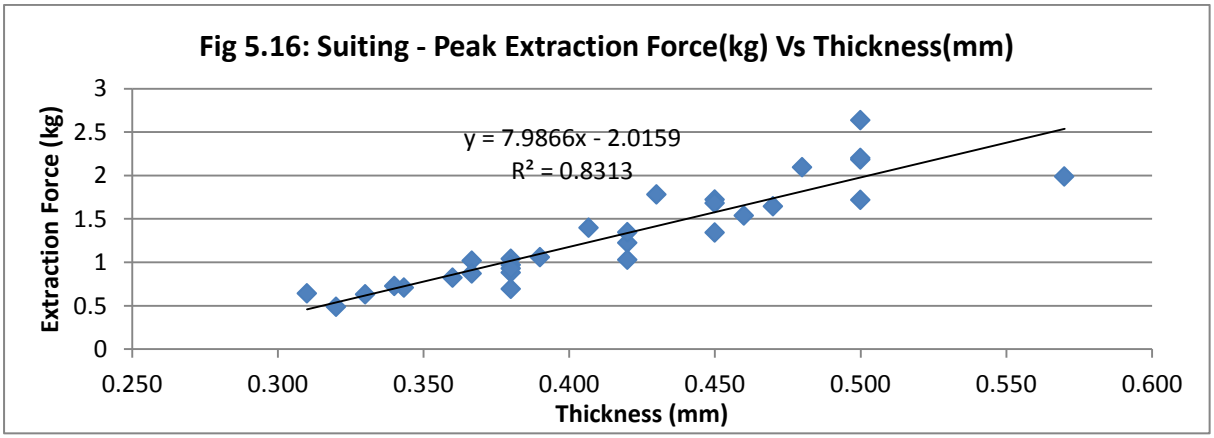
Fig 5.16: Suiting - Peak Extraction Force(kg) Vs Thickness(mm)
Extraction Force (kg)
Thickness (mm)
y = 7.9866x - 2.0159
R² = 0.8313
0
0.5
1
1.5
2
2.5
3
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600

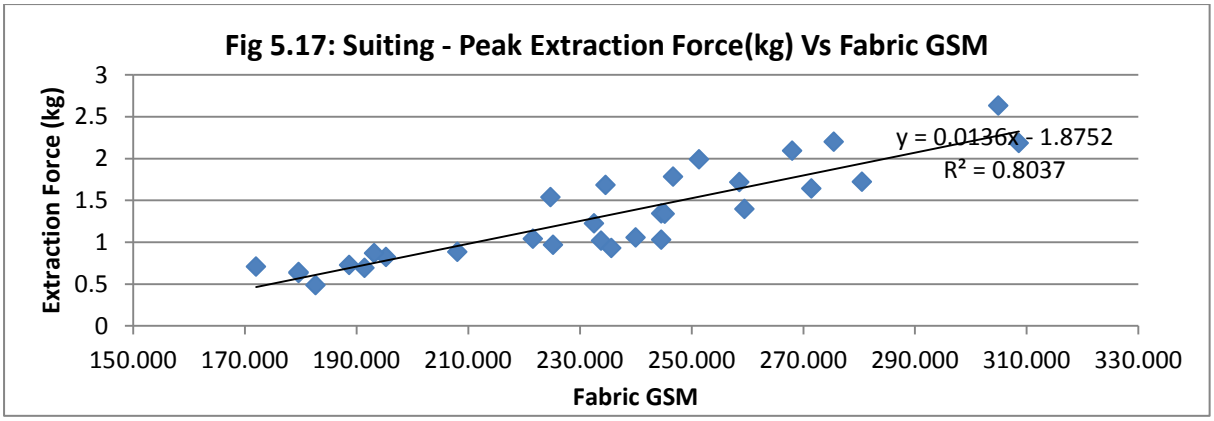
Fig 5.17: Suiting - Peak Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
Fabric GSM
y = 0.0136x - 1.8752
R² = 0.8037
0
0.5
1
1.5
2
2.5
3
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000

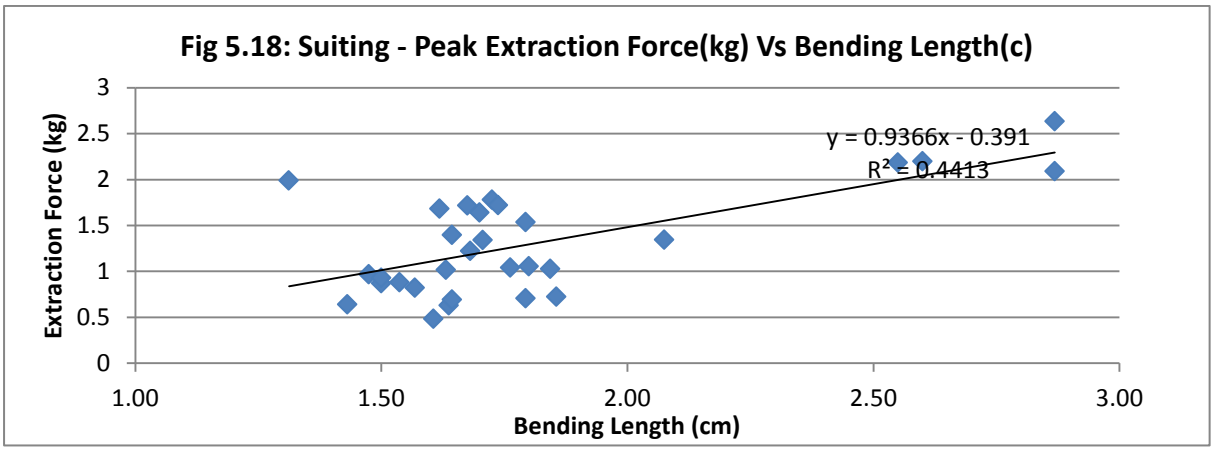
Fig 5.18: Suiting - Peak Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
Bending Length (cm)
y = 0.9366x - 0.391
R² = 0.4413
0
0.5
1
1.5
2
2.5
3
1.00
1.50
2.00
2.50
3.00

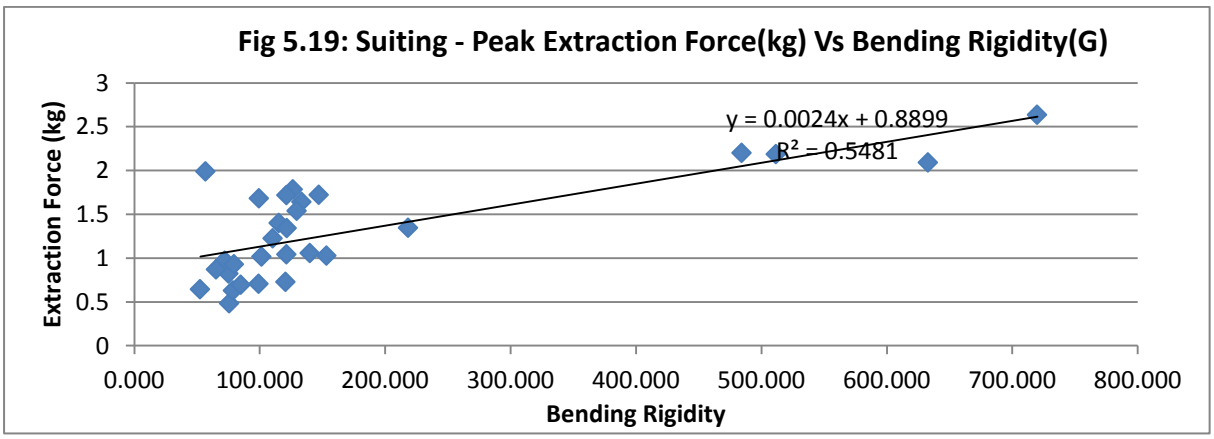
Fig 5.19: Suiting - Peak Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
Bending Rigidity
y = 0.0024x + 0.8899
R² = 0.5481
0
0.5
1
1.5
2
2.5
3
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000

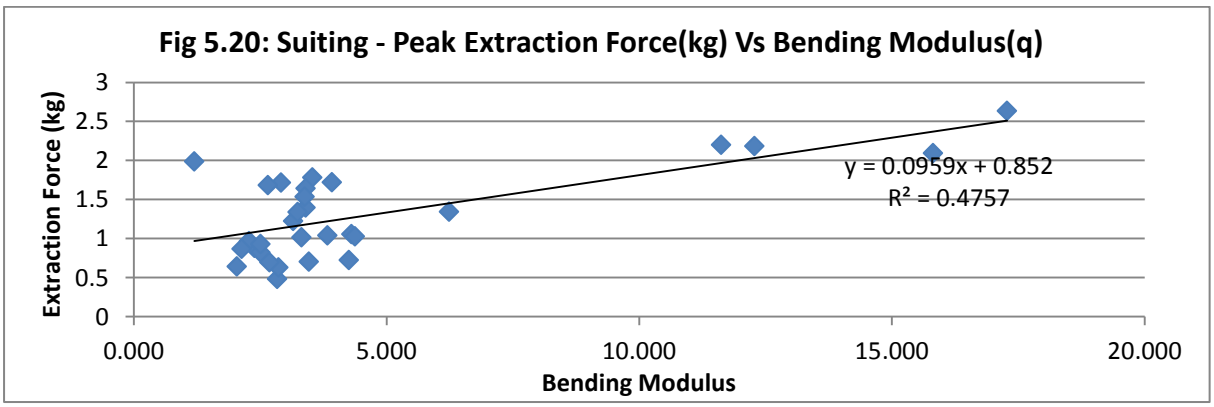
Fig 5.20: Suiting - Peak Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
Bending Modulus
y = 0.0959x + 0.852
R² = 0.4757
0
0.5
1
1.5
2
2.5
3
0.000
5.000
10.000
15.000
20.000

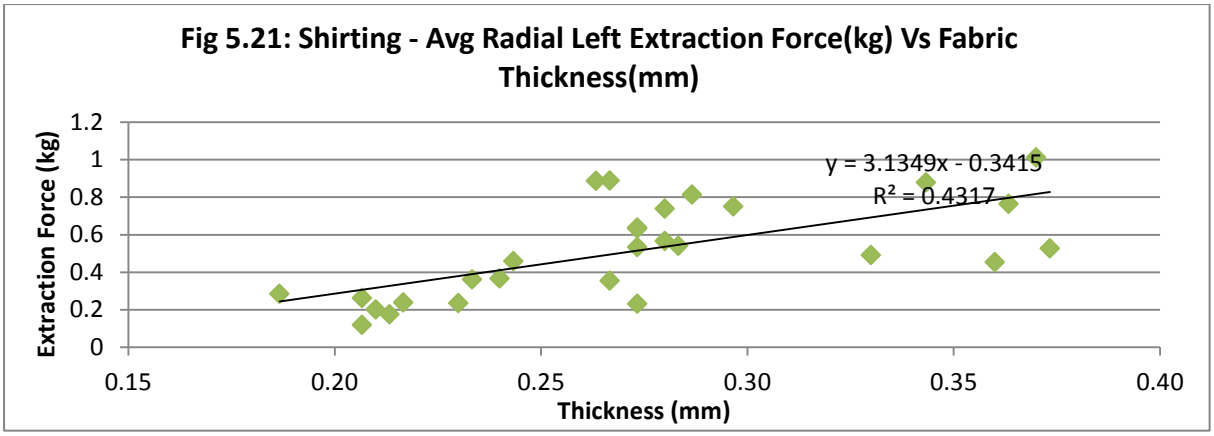
Fig 5.21: Shirting - Avg Radial Left Extraction Force(kg) Vs Fabric Thickness(mm)
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
0.15
0.20
0.25
0.30
0.35
0.40
Thickness (mm)
y = 3.1349x - 0.3415
R² = 0.4317

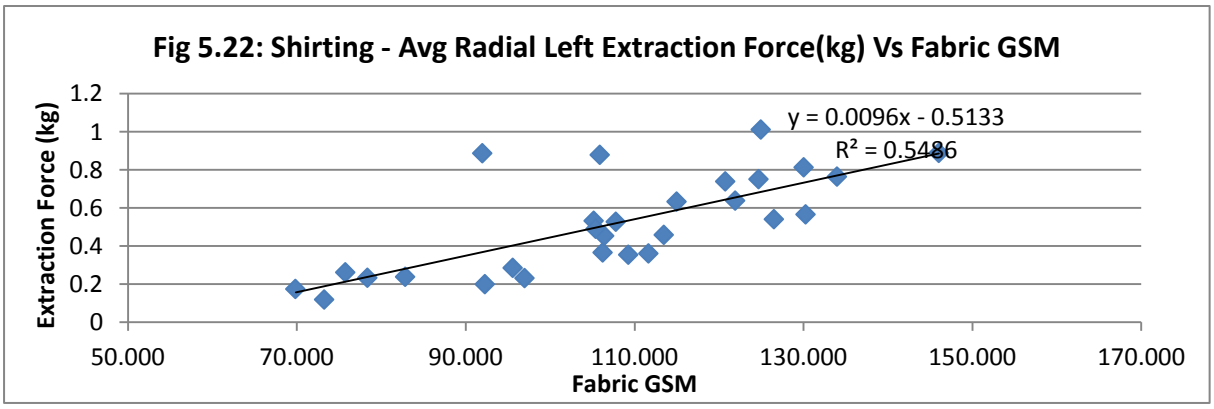
Fig 5.22: Shirting - Avg Radial Left Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
50.000
70.000
90.000
110.000
130.000
150.000
170.000
Fabric GSM
y = 0.0096x - 0.5133
R² = 0.5486

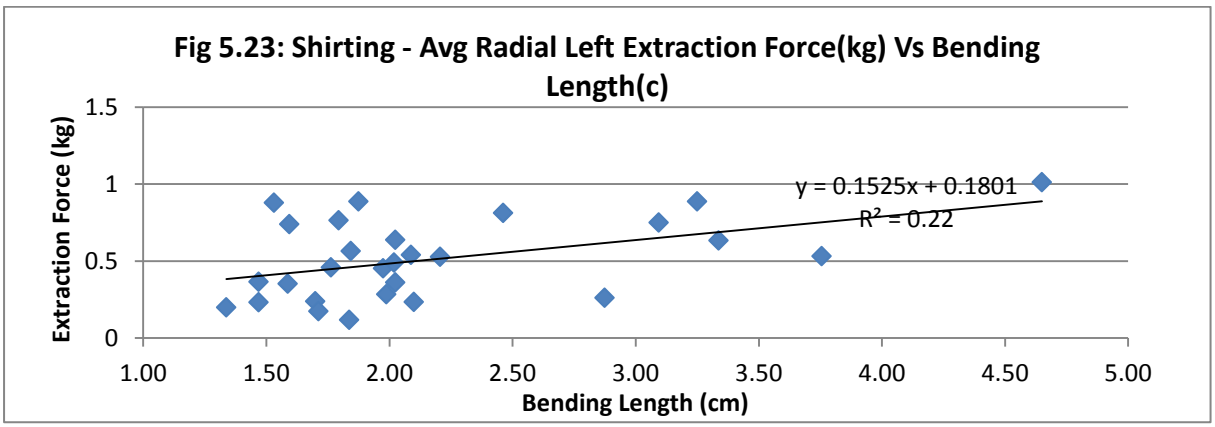
Fig 5.23: Shirting - Avg Radial Left Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
1.5
1
0.5
0
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Bending Length (cm)
y = 0.1525x + 0.1801
R² = 0.22

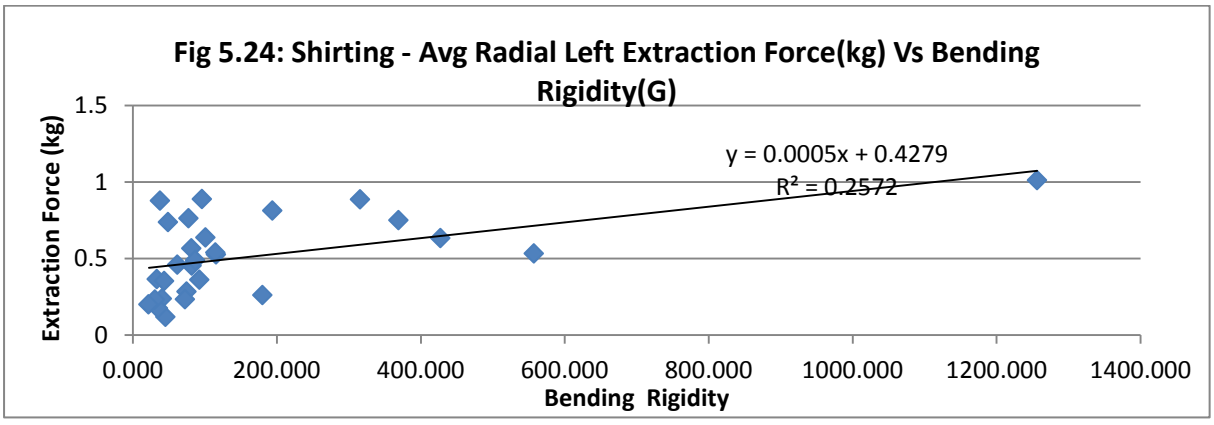
Fig 5.24: Shirting - Avg Radial Left Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
1.5
1
0.5
0
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000
Bending Rigidity
y = 0.0005x + 0.4279
R² = 0.2572

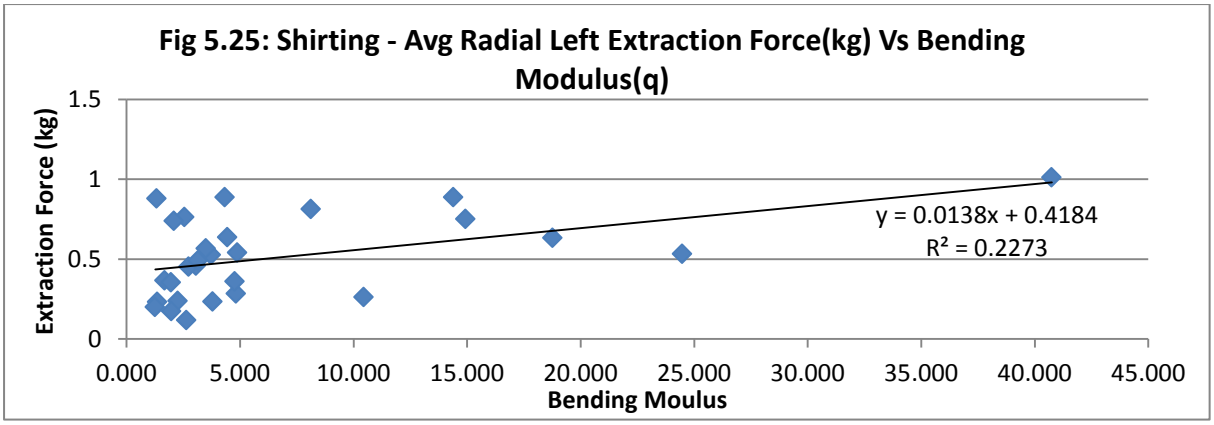
Fig 5.25: Shirting - Avg Radial Left Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
1.5
1
0.5
0
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000
Bending Moulus
y = 0.0138x + 0.4184
R² = 0.2273

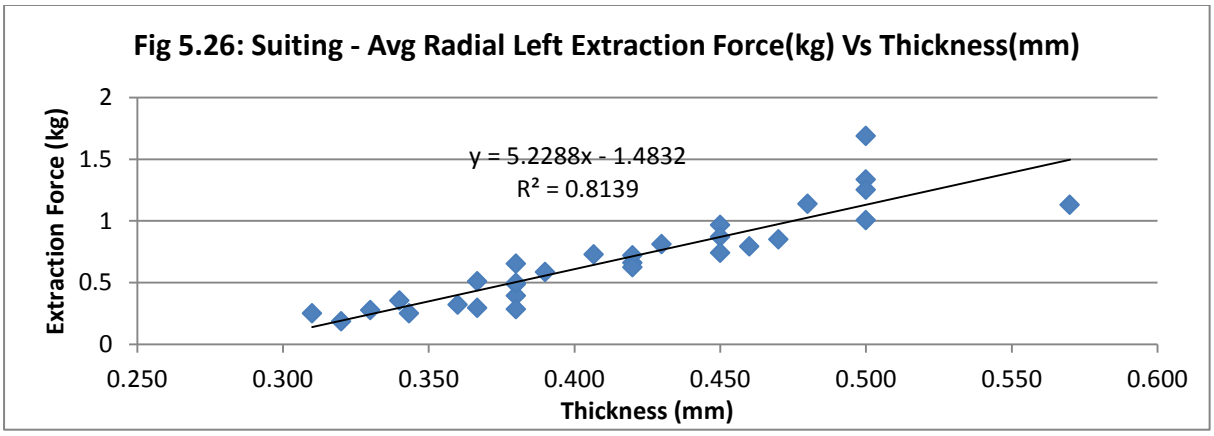
Fig 5.26: Suiting - Avg Radial Left Extraction Force(kg) Vs Thickness(mm)
Extraction Force (kg)
2
1.5
1
0.5
0
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600
Thickness (mm)
y = 5.2288x - 1.4832
R² = 0.8139

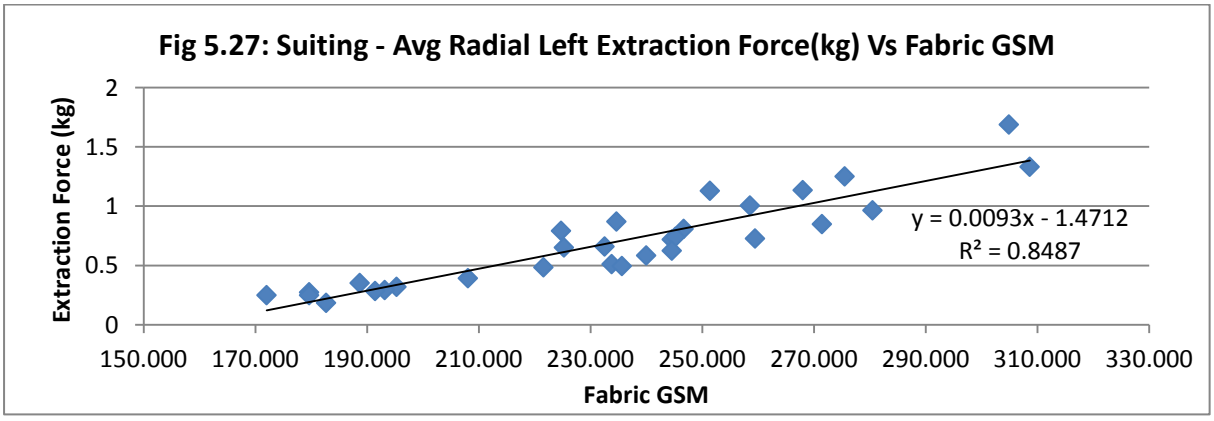
Fig 5.27: Suiting - Avg Radial Left Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
2
1.5
1
0.5
0
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000
Fabric GSM
y = 0.0093x - 1.4712
R² = 0.8487

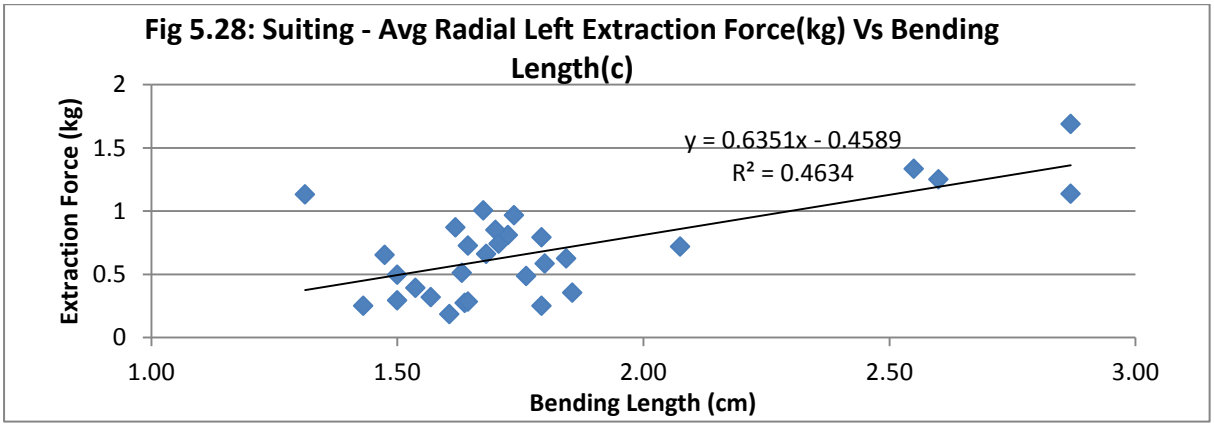
Fig 5.28: Suiting - Avg Radial Left Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
2
1.5
1
0.5
0
1.00
1.50
2.00
2.50
3.00
Bending Length (cm)
y = 0.6351x - 0.4589
R² = 0.4634

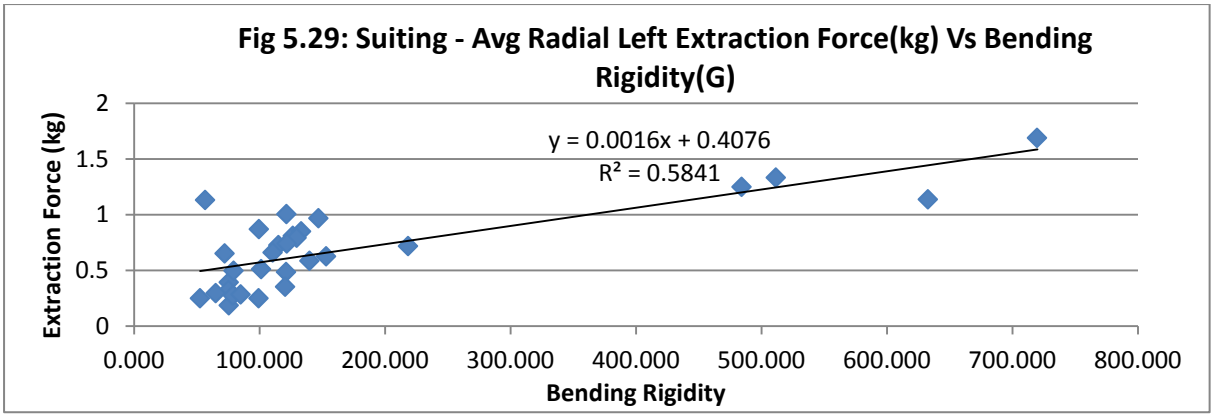
Fig 5.29: Suiting - Avg Radial Left Extraction Force(kg) Vs Bending Rigidity(G)
y = 0.0016x + 0.4076
R² = 0.5841
Extraction Force (kg)
Bending Rigidity
0
0.5
1
1.5
2
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000

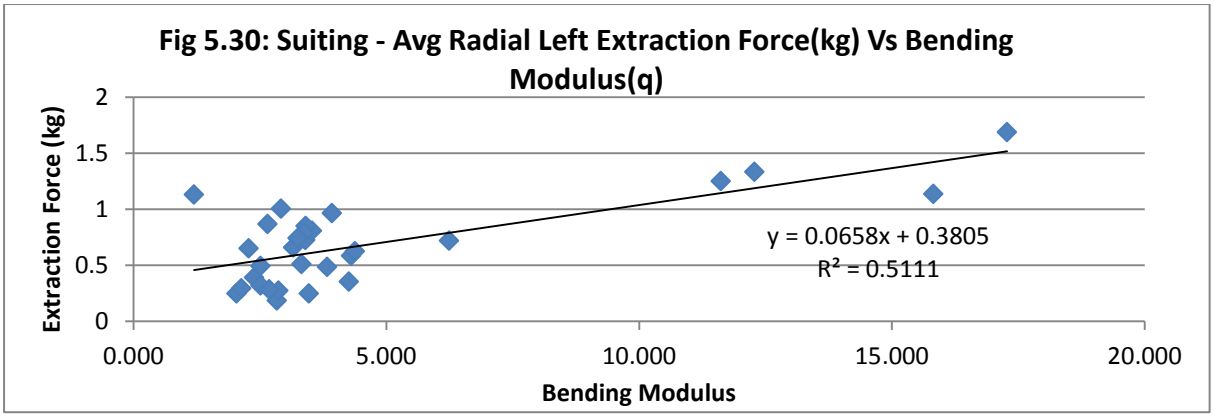
Fig 5.30: Suiting - Avg Radial Left Extraction Force(kg) Vs Bending Modulus(q)
y = 0.0658x + 0.3805
R² = 0.5111
Extraction Force (kg)
Bending Modulus
0
0.5
1
1.5
2
0.000
5.000
10.000
15.000
20.000

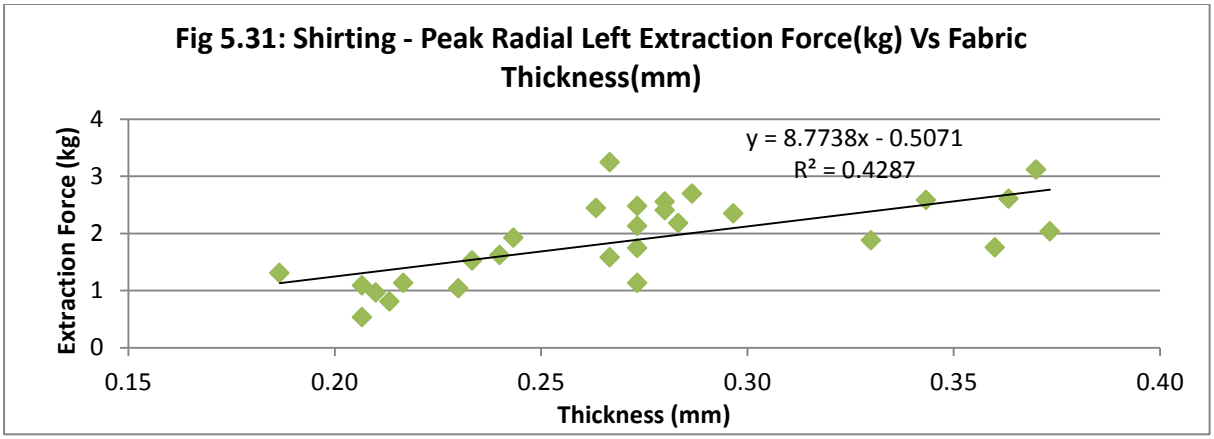
Fig 5.31: Shirting - Peak Radial Left Extraction Force(kg) Vs Fabric Thickness(mm)
y = 8.7738x - 0.5071
R² = 0.4287
Extraction Force (kg)
Thickness (mm)
0
1
2
3
4
0.15
0.20
0.25
0.30
0.35
0.40

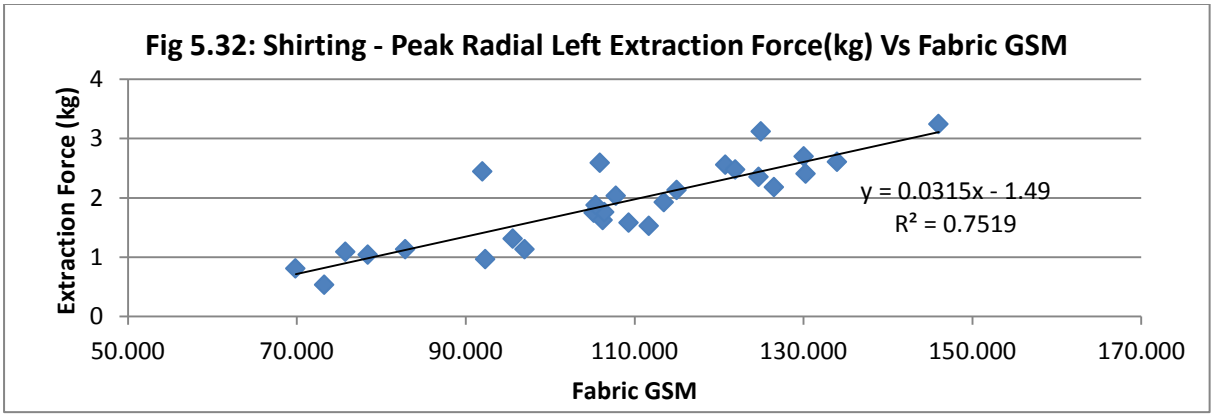
Fig 5.32: Shirting - Peak Radial Left Extraction Force(kg) Vs Fabric GSM
y = 0.0315x - 1.49
R² = 0.7519
Extraction Force (kg)
Fabric GSM
0
1
2
3
4
50.000
70.000
90.000
110.000
130.000
150.000
170.000

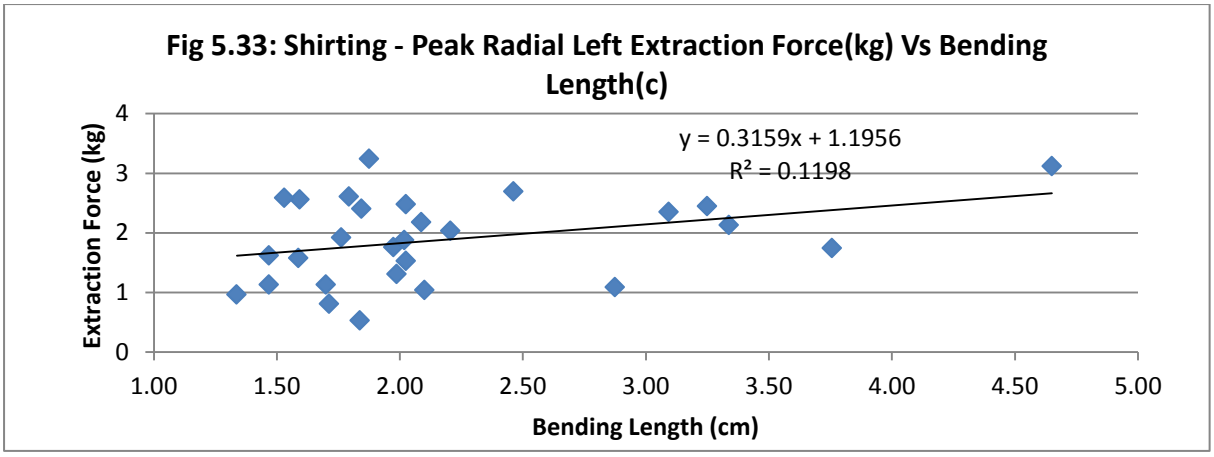
Fig 5.33: Shirting - Peak Radial Left Extraction Force(kg) Vs Bending Length(c)
y = 0.3159x + 1.1956
R² = 0.1198
Extraction Force (kg)
Bending Length (cm)
0
1
2
3
4
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

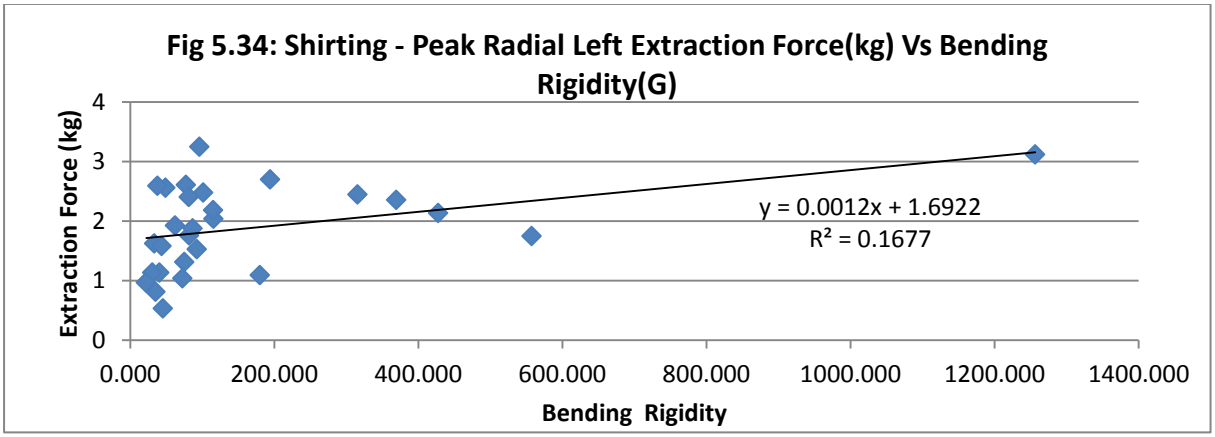
Fig 5.34: Shirting - Peak Radial Left Extraction Force(kg) Vs Bending Rigidity(G)
y = 0.0012x + 1.6922
R² = 0.1677
Extraction Force (kg)
Bending Rigidity
0
1
2
3
4
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000

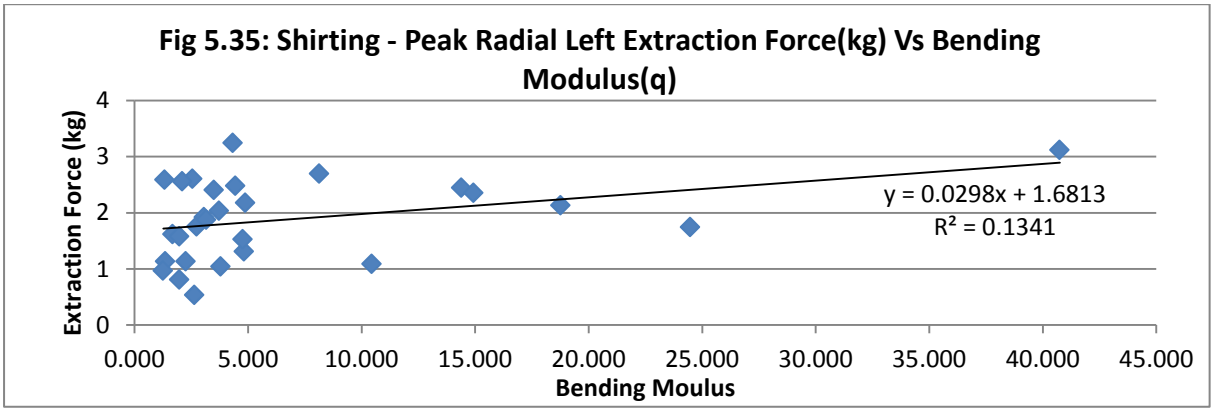
Fig 5.35: Shirting - Peak Radial Left Extraction Force(kg) Vs Bending Modulus(q)
y = 0.0298x + 1.6813
R² = 0.1341
Extraction Force (kg)
Bending Moulus
0
1
2
3
4
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000

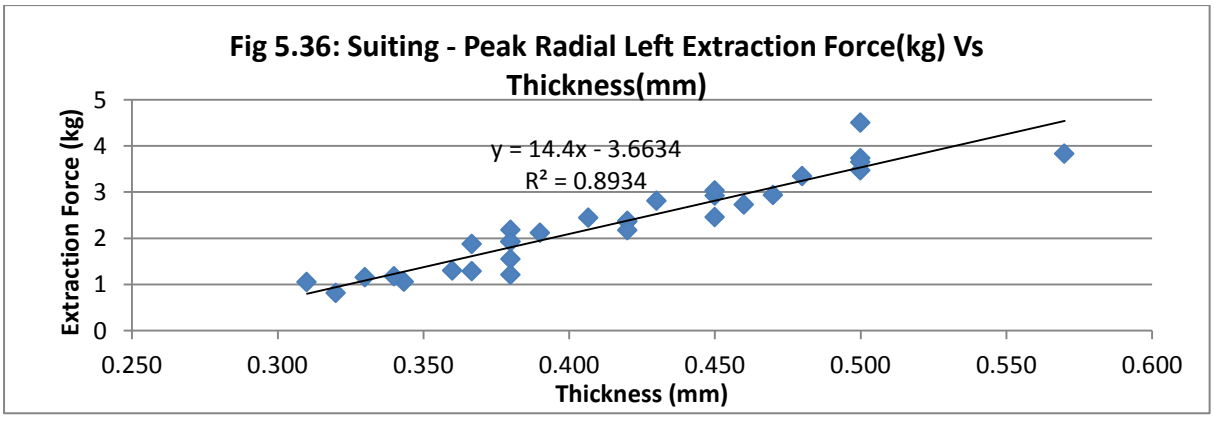
Fig 5.36: Suiting - Peak Radial Left Extraction Force(kg) Vs Thickness(mm)
y = 14.4x - 3.6634
R² = 0.8934
Extraction Force (kg)
Thickness (mm)
0
1
2
3
4
5
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600

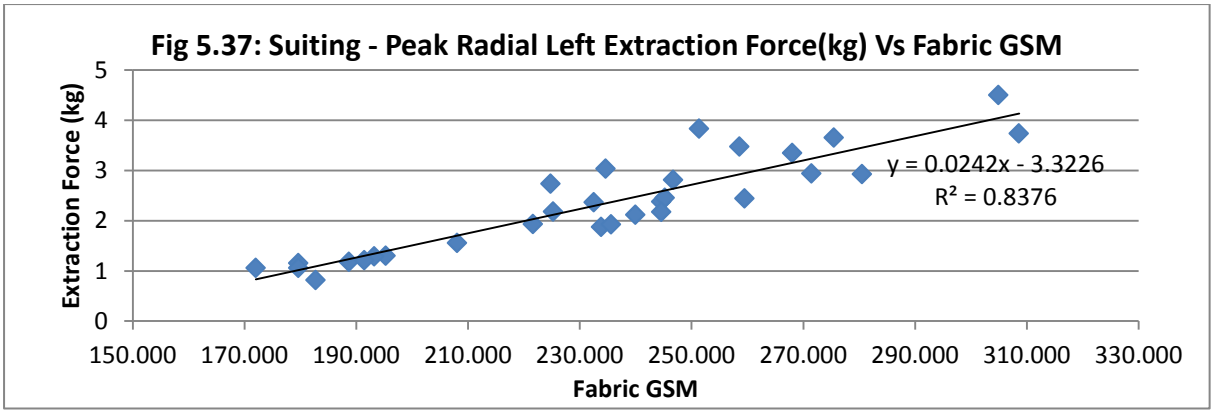
Fig 5.37: Suiting - Peak Radial Left Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
0
1
2
3
4
5
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000
Fabric GSM
y = 0.0242x - 3.3226
R² = 0.8376

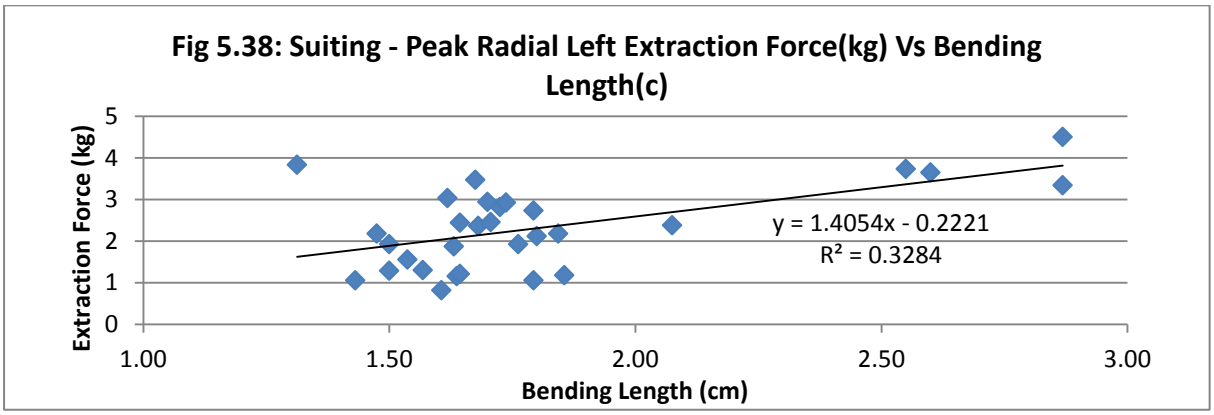
Fig 5.38: Suiting - Peak Radial Left Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
0
1
2
3
4
5
1.00
1.50
2.00
2.50
3.00
Bending Length (cm)
y = 1.4054x - 0.2221
R² = 0.3284

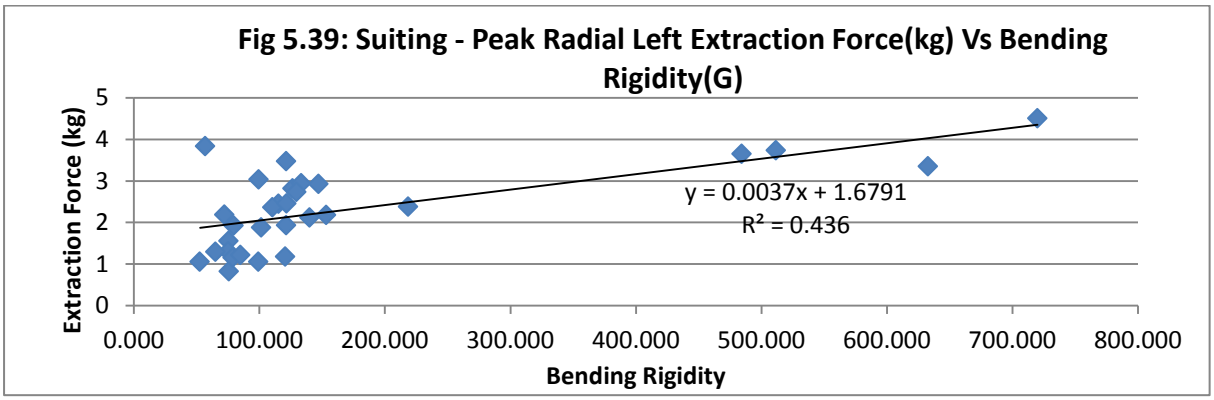
Fig 5.39: Suiting - Peak Radial Left Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
0
1
2
3
4
5
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000
Bending Rigidity
y = 0.0037x + 1.6791
R² = 0.436

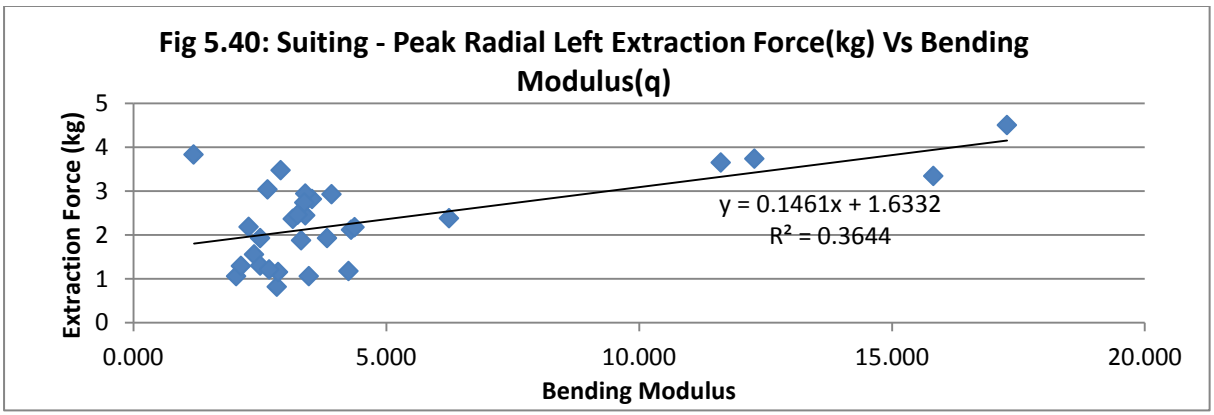
Fig 5.40: Suiting - Peak Radial Left Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
0
1
2
3
4
5
0.000
5.000
10.000
15.000
20.000
Bending Modulus
y = 0.1461x + 1.6332
R² = 0.3644

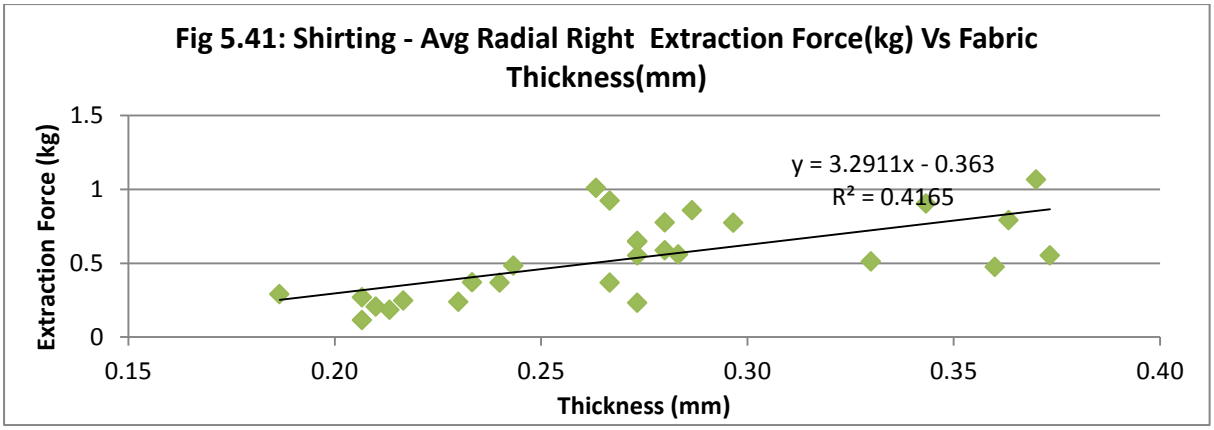
Fig 5.41: Shirting - Avg Radial Right Extraction Force(kg) Vs Fabric Thickness(mm)
Extraction Force (kg)
1.5
1
0.5
0
0.15
0.20
0.25
0.30
0.35
0.40
Thickness (mm)
y = 3.2911x - 0.363
R² = 0.4165

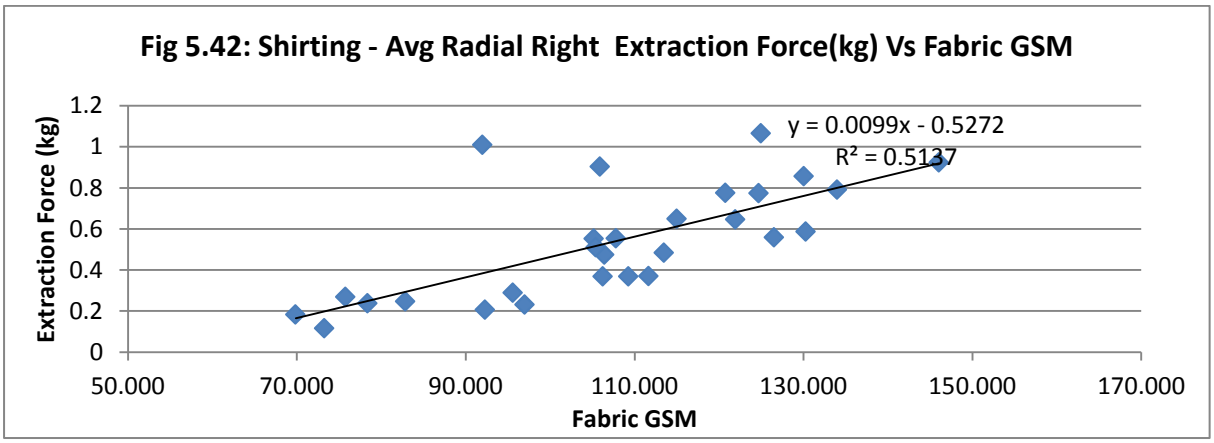
Fig 5.42: Shirting - Avg Radial Right Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
50.000
70.000
90.000
110.000
130.000
150.000
170.000
Fabric GSM
y = 0.0099x - 0.5272
R² = 0.5137

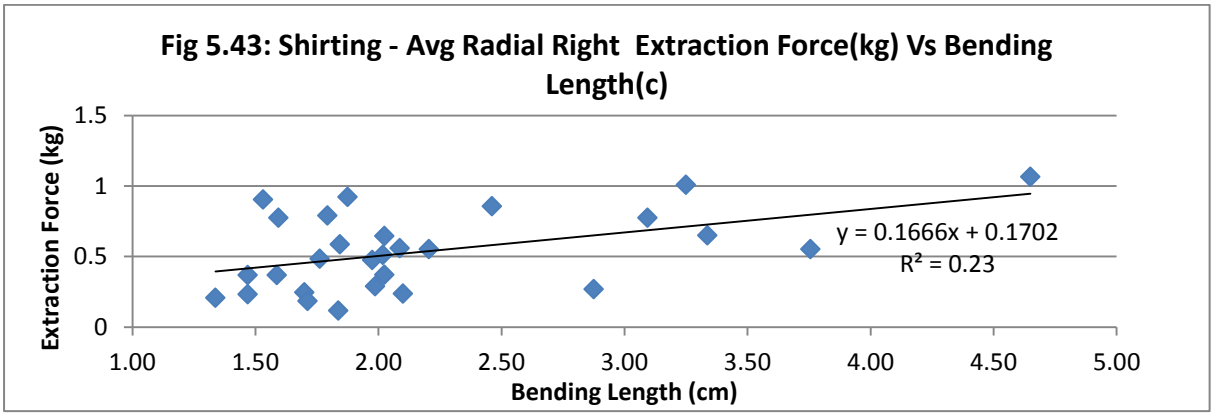
Fig 5.43: Shirting - Avg Radial Right Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
1.5
1
0.5
0
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Bending Length (cm)
y = 0.1666x + 0.1702
R² = 0.23

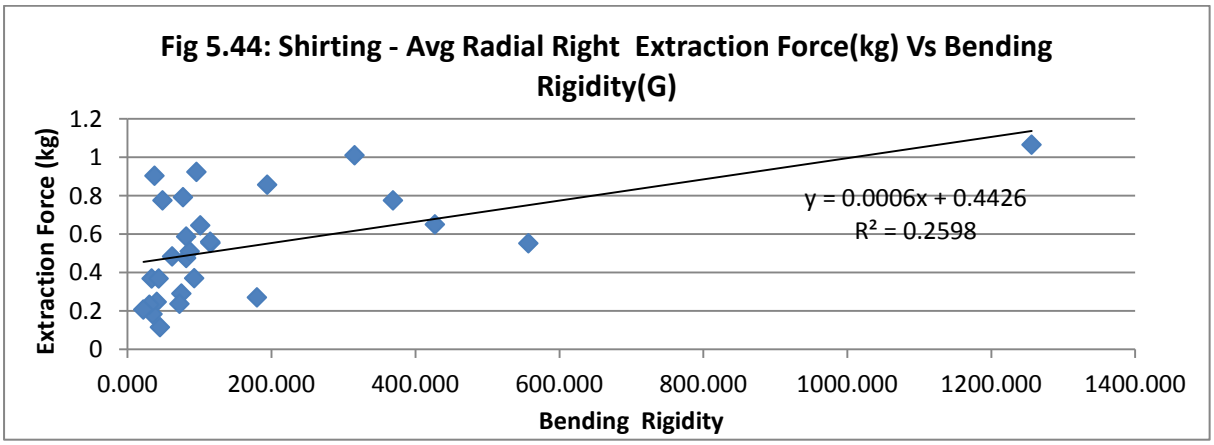
Fig 5.44: Shirting - Avg Radial Right Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000
Bending Rigidity
y = 0.0006x + 0.4426
R² = 0.2598

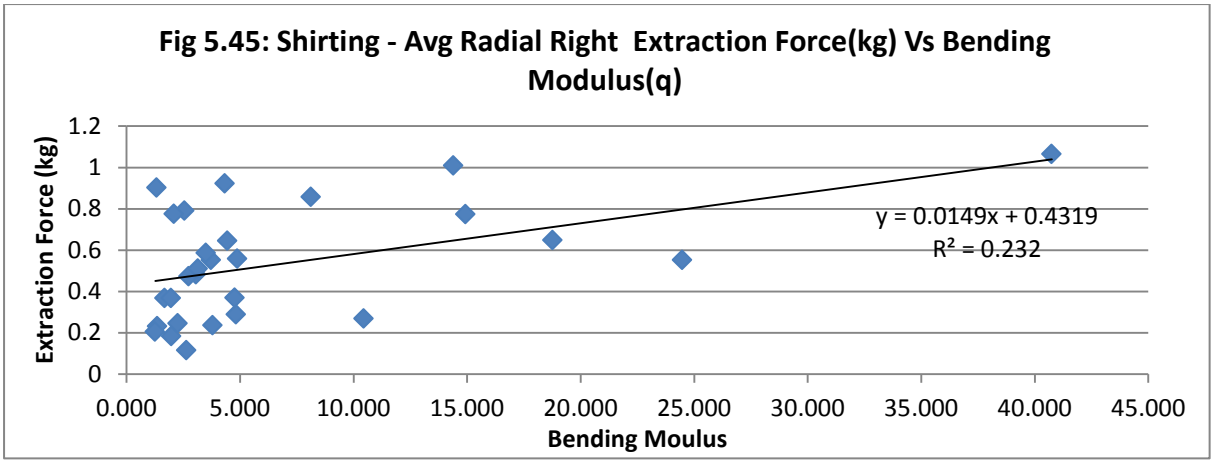
Fig 5.45: Shirting - Avg Radial Right Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
1.2
1
0.8
0.6
0.4
0.2
0
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000
Bending Moulus
y = 0.0149x + 0.4319
R² = 0.232

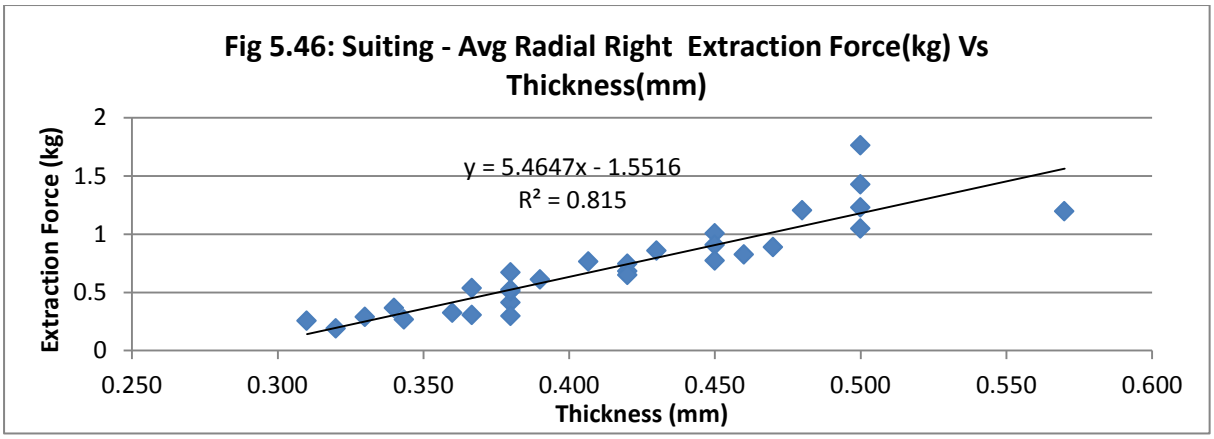
Fig 5.46: Suiting - Avg Radial Right Extraction Force(kg) Vs Thickness(mm)
Extraction Force (kg)
2
1.5
1
0.5
0
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600
Thickness (mm)
y = 5.4647x - 1.5516
R² = 0.815

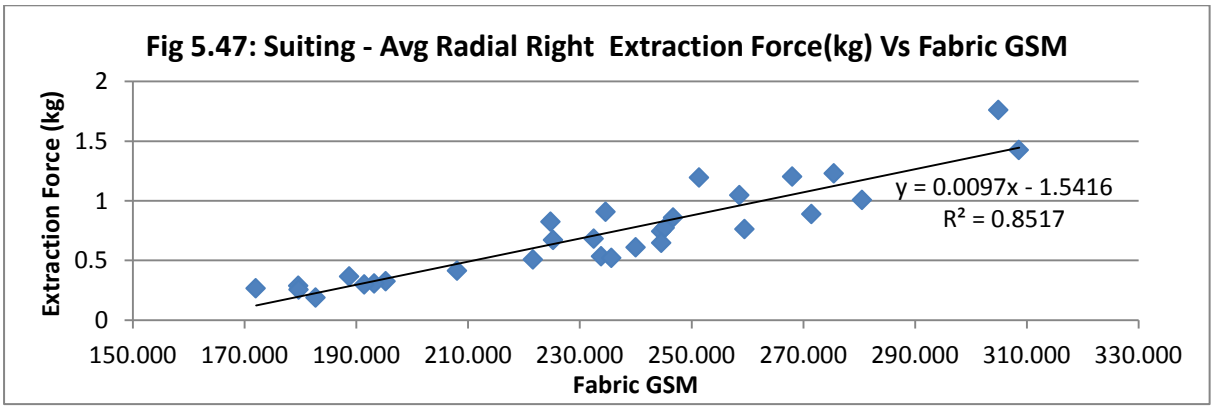
Fig 5.47: Suiting - Avg Radial Right Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
2
1.5
1
0.5
0
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000
Fabric GSM
y = 0.0097x - 1.5416
R² = 0.8517

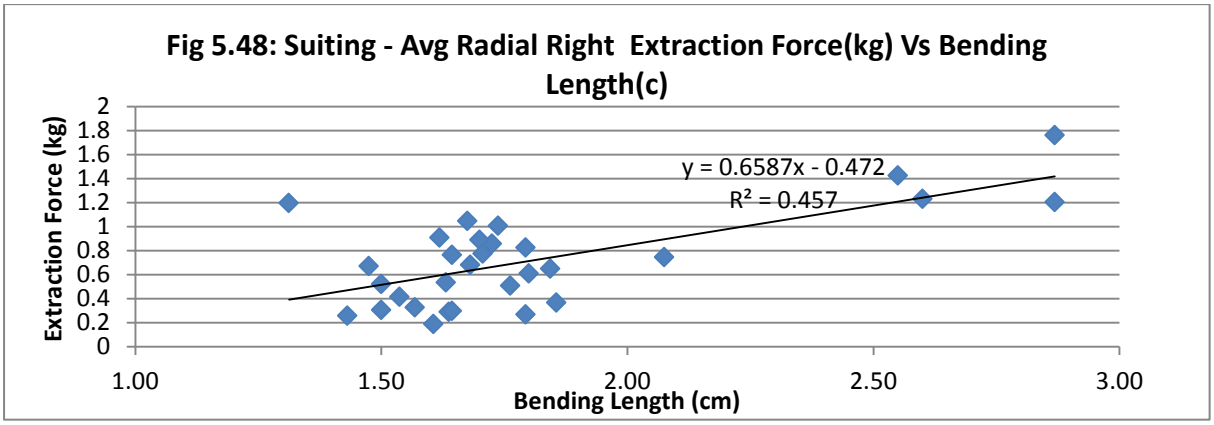
Fig 5.48: Suiting - Avg Radial Right Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.00
1.50
2.00
2.50
3.00
Bending Length (cm)
y = 0.6587x - 0.472
R² = 0.457

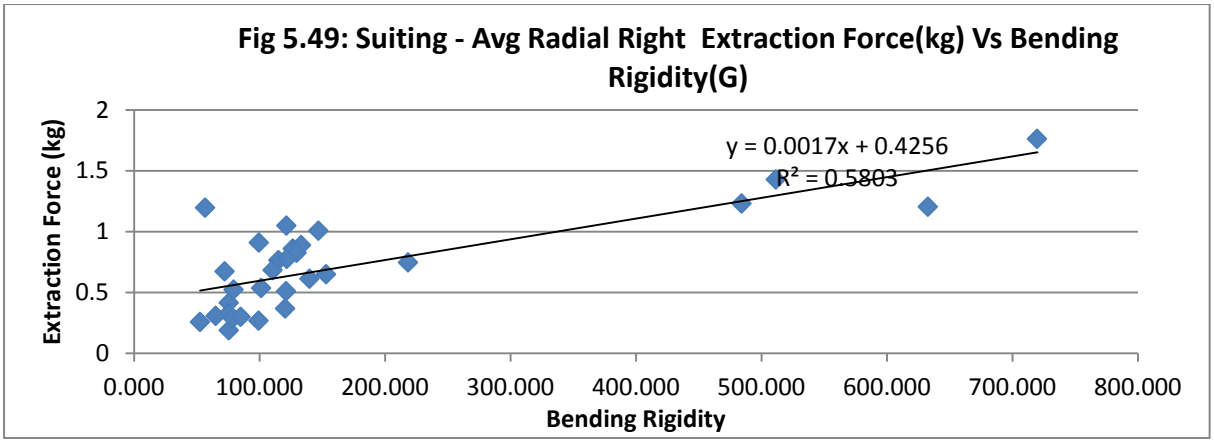
Fig 5.49: Suiting - Avg Radial Right Extraction Force(kg) Vs Bending Rigidity(G)
y = 0.0017x + 0.4256
R² = 0.5803
Extraction Force (kg)
Bending Rigidity
0
0.5
1
1.5
2
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000

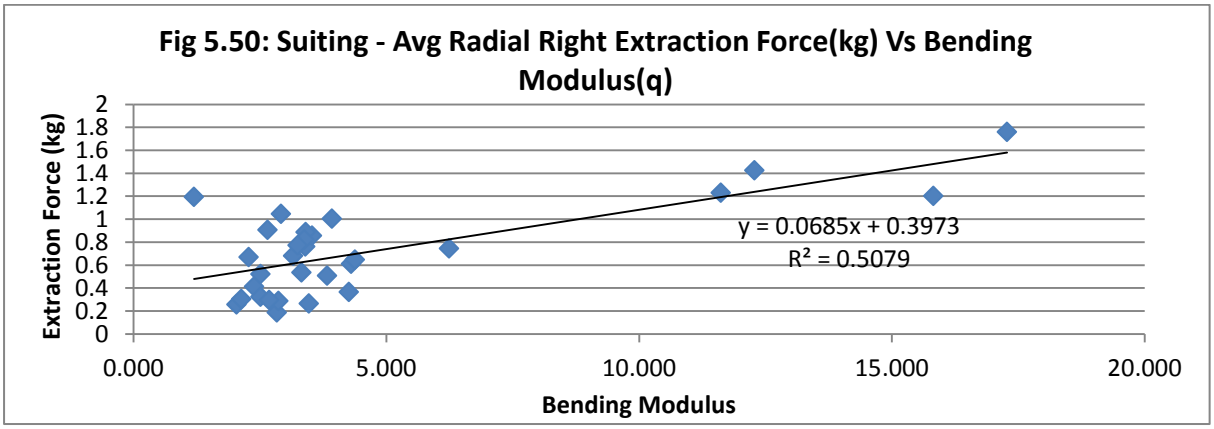
Fig 5.50: Suiting - Avg Radial Right Extraction Force(kg) Vs Bending Modulus(q)
y = 0.0685x + 0.3973
R² = 0.5079
Extraction Force (kg)
Bending Modulus
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0.000
5.000
10.000
15.000
20.000

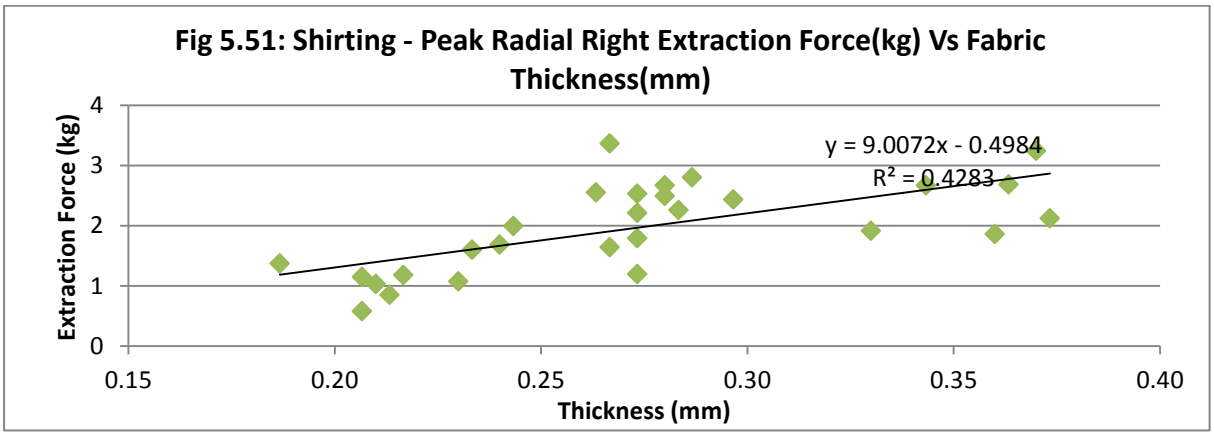
Fig 5.51: Shirting - Peak Radial Right Extraction Force(kg) Vs Fabric Thickness(mm)
y = 9.0072x - 0.4984
R² = 0.4283
Extraction Force (kg)
Thickness (mm)
0
1
2
3
4
0.15
0.20
0.25
0.30
0.35
0.40

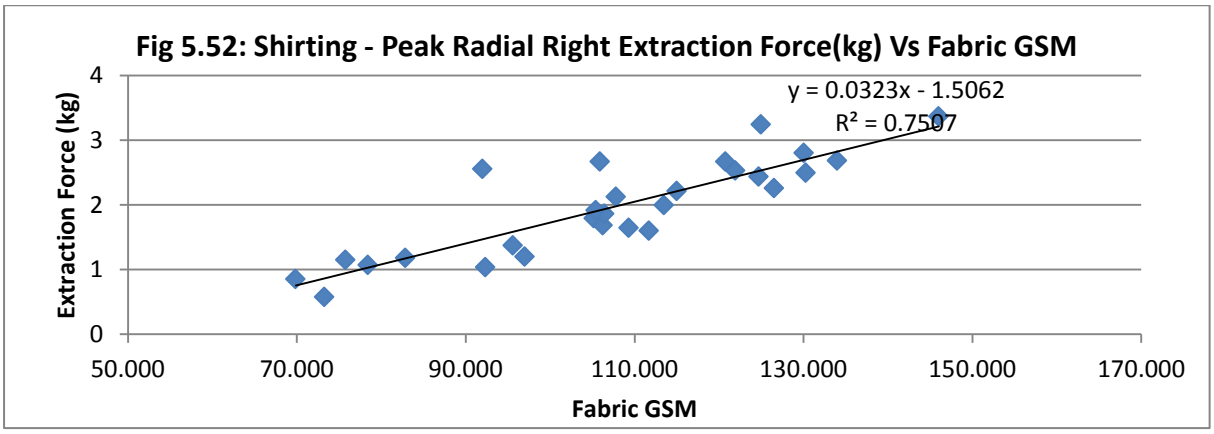
Fig 5.52: Shirting - Peak Radial Right Extraction Force(kg) Vs Fabric GSM
y = 0.0323x - 1.5062
R² = 0.7507
Extraction Force (kg)
Fabric GSM
0
1
2
3
4
50.000
70.000
90.000
110.000
130.000
150.000
170.000

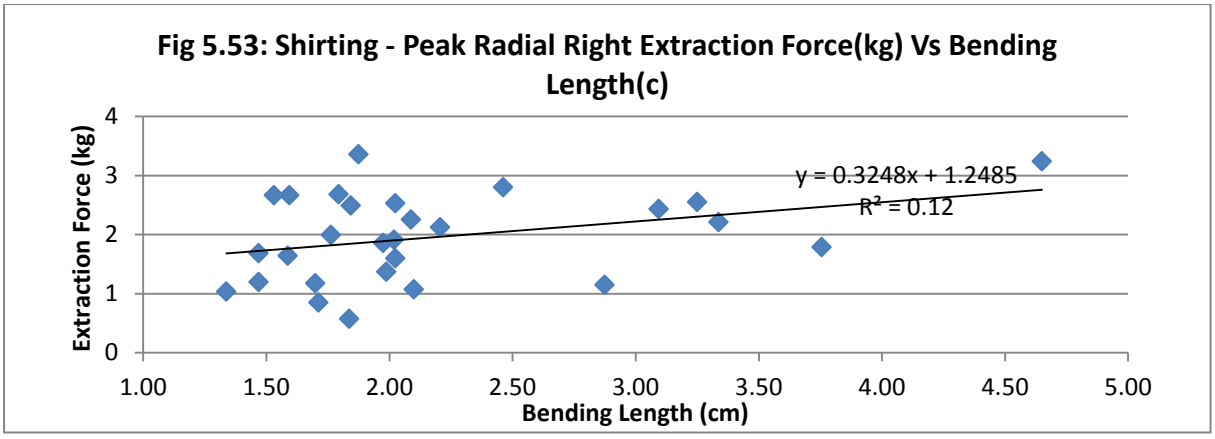
Fig 5.53: Shirting - Peak Radial Right Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
Bending Length (cm)
y = 0.3248x + 1.2485
R² = 0.12
0
1
2
3
4
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

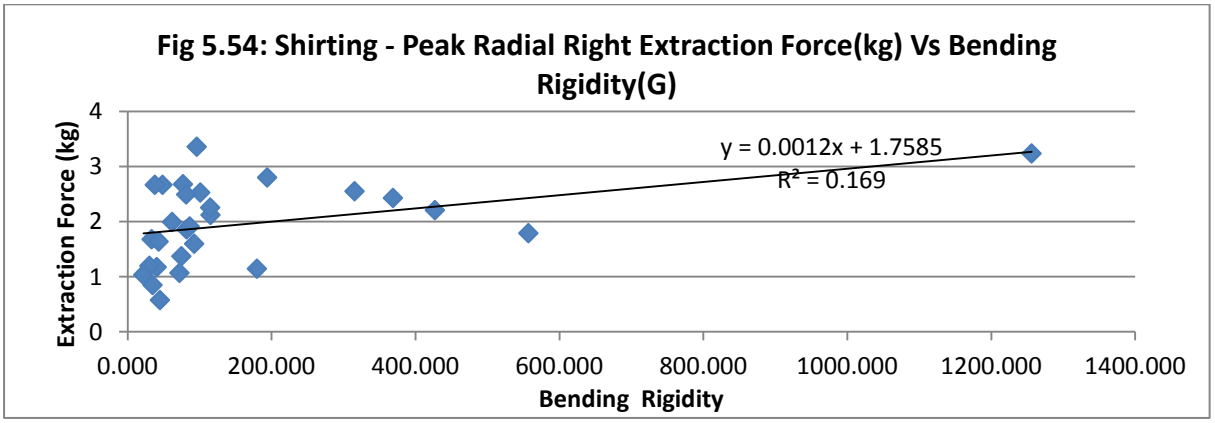
Fig 5.54: Shirting - Peak Radial Right Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
Bending Rigidity
y = 0.0012x + 1.7585
R² = 0.169
0
1
2
3
4
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000

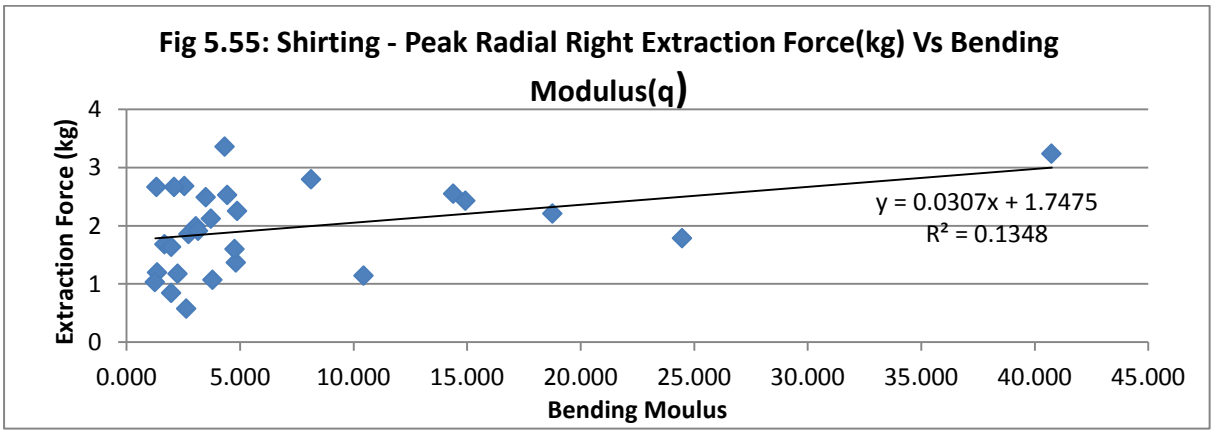
Fig 5.55: Shirting - Peak Radial Right Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
Bending Moulus
y = 0.0307x + 1.7475
R² = 0.1348
0
1
2
3
4
0.000
5.000
10.000
15.000
20.000
25.000
30.000
35.000
40.000
45.000

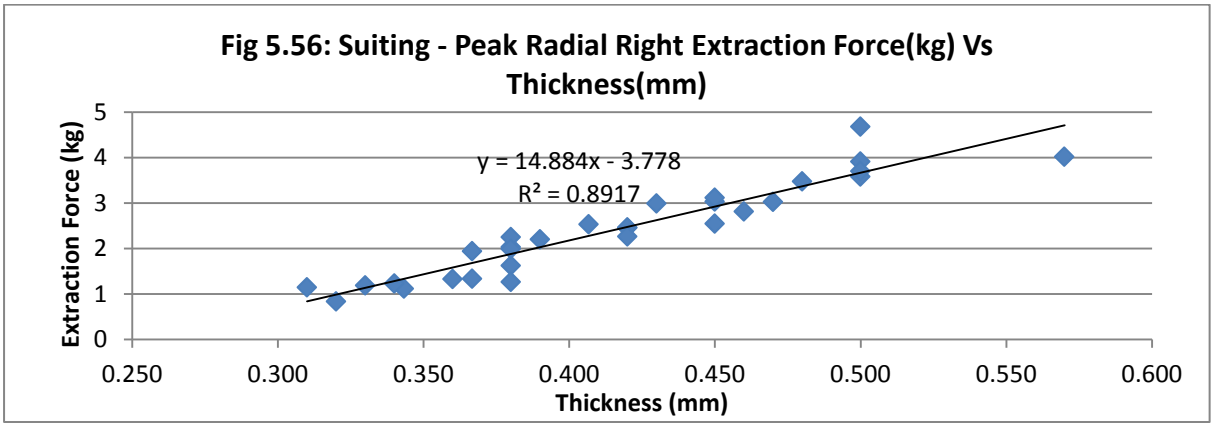
Fig 5.56: Suiting - Peak Radial Right Extraction Force(kg) Vs Thickness(mm)
Extraction Force (kg)
Thickness (mm)
y = 14.884x - 3.778
R² = 0.8917
0
1
2
3
4
5
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600

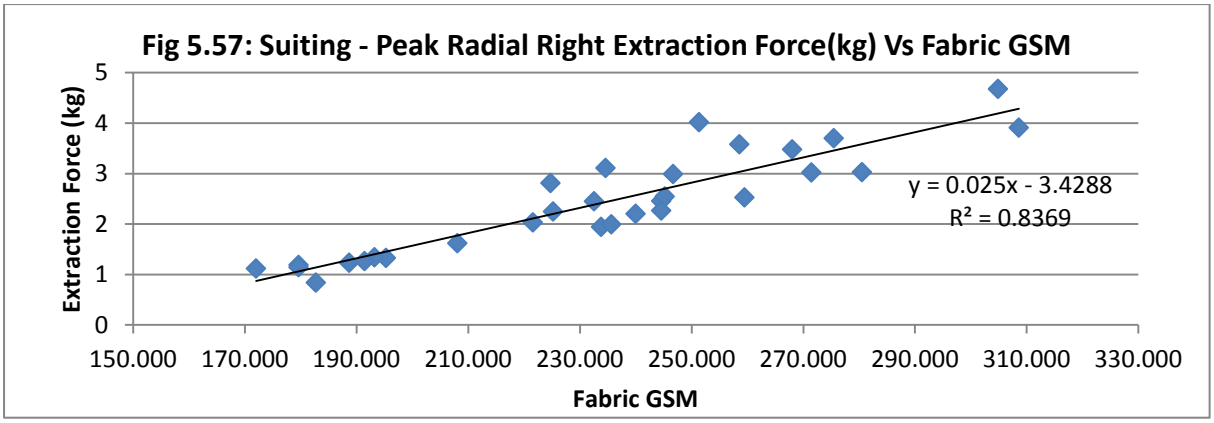
Fig 5.57: Suiting - Peak Radial Right Extraction Force(kg) Vs Fabric GSM
Extraction Force (kg)
0
1
2
3
4
5
150.000
170.000
190.000
210.000
230.000
250.000
270.000
290.000
310.000
330.000
Fabric GSM
y = 0.025x - 3.4288
R² = 0.8369

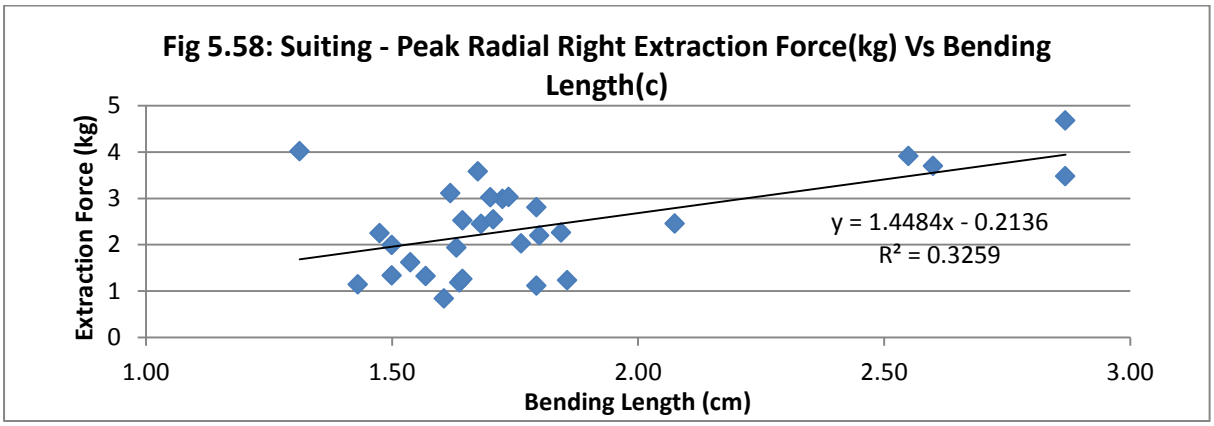
Fig 5.58: Suiting - Peak Radial Right Extraction Force(kg) Vs Bending Length(c)
Extraction Force (kg)
0
1
2
3
4
5
1.00
1.50
2.00
2.50
3.00
Bending Length (cm)
y = 1.4484x - 0.2136
R² = 0.3259

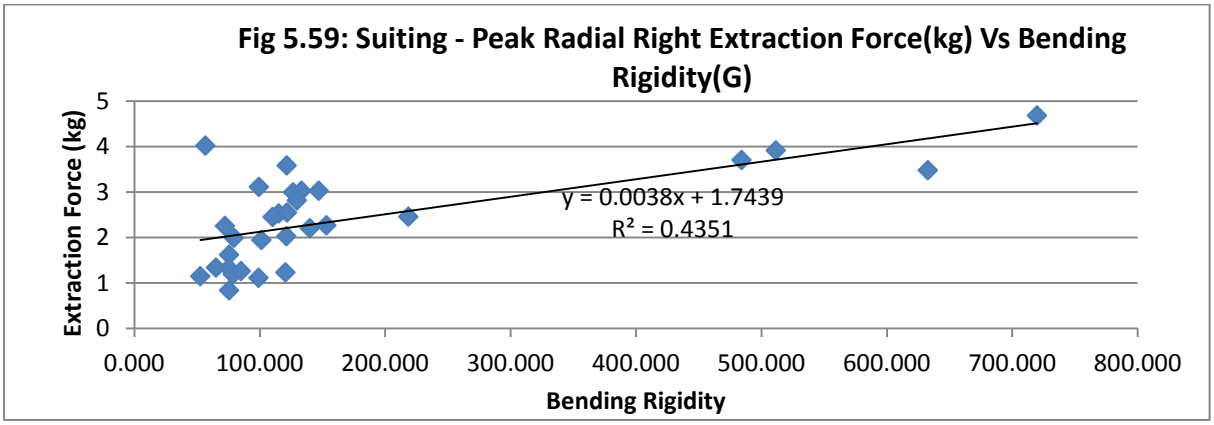
Fig 5.59: Suiting - Peak Radial Right Extraction Force(kg) Vs Bending Rigidity(G)
Extraction Force (kg)
0
1
2
3
4
5
0.000
100.000
200.000
300.000
400.000
500.000
600.000
700.000
800.000
Bending Rigidity
y = 0.0038x + 1.7439
R² = 0.4351

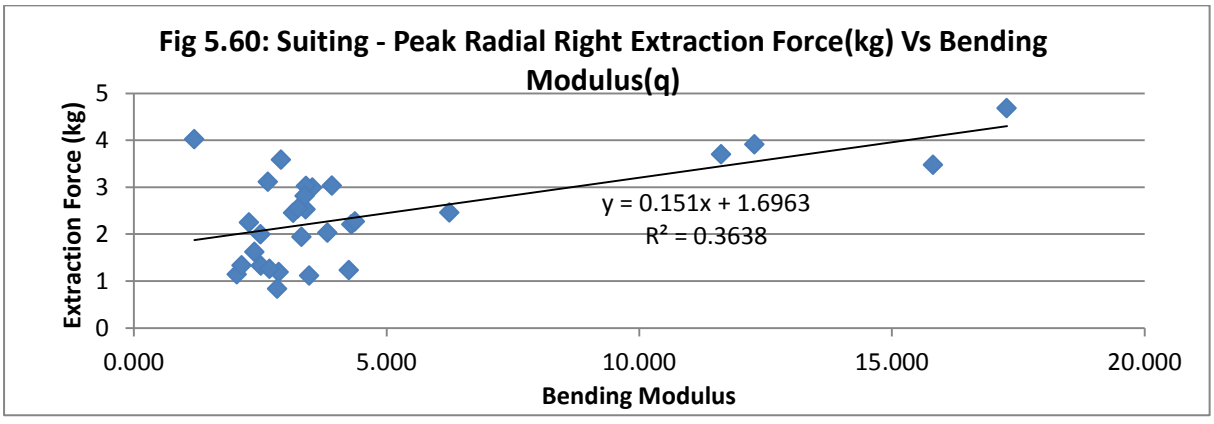
Fig 5.60: Suiting - Peak Radial Right Extraction Force(kg) Vs Bending Modulus(q)
Extraction Force (kg)
0
1
2
3
4
5
0.000
5.000
10.000
15.000
20.000
Bending Modulus
y = 0.151x + 1.6963
R² = 0.3638

5.3 Conclusion

From the abovementioned study it is hereby concluded that the newly developed fabric feel tester could be used to establish/correlate the relationship with some of the physical properties related to low stress mechanical properties with nozzle extraction forces. In the present study, a reasonable level of R^2 value observed in most of the cases, except few cases where it is low. Based on the above mentioned study and experiences it is also recommended that a data bank may be created for a specific group of fabric categories and better R^2 value definitely will be arrived and the same could used to extrapolate.