

스판덱스纖維의 染色條件이 纖維品質에 미치는 影響

A Study on the Change of Spandex Quality by the Influence of Dyeing Condition.

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ABSTRACT

Spandex is a elastomeric fiber in which the-fiber-forming substance is a long chain polymer consisting of at least 85% segmented polyurethane.

In the polyurethanes there are the additional oxygen atoms in the main chains of the molecule. The effect of these oxygen atoms is to make the molecule somewhat more flexible. From a physical point of view, elasticity and recovery from stretch are the most important properties of polyurethane, so its use has now expanded into many kitting industry.

In this paper, I wish to Test the effect of dyeing condition on the quality of polyurethane.

I. 序 論

폴리우레탄纖維는 우레탄 85%를 함유하는 彈力性纖維로서 着用感이 좋기 때문에 編物이나 伸縮性 織物에 널리 利用되고 있다.^{1),4)} 特히 이 纖維의 長點은 彈性和 伸張回復性인데 精練, 漂白, 染色, 其他加工 中에 섬유内部構造에 影響을 받는다면 上記 性質뿐만 아니라 強力, 伸度, 피로도등에도 影響을 미칠 것으로 생각되어, 特히 染色加工中 作用할 수 있는 因子를 간추려 處理해 주고 그 結果를 項目別로 수집해서 統計적으로 檢定함으로써 스판덱스品質에 미치는 影響을 검토하고 反應方程式을 유도하고자 한다.

II. 材料 및 試驗方法

1. 스판덱스纖維

白色 TOYBO 에스-140을 使用함.

2. pH溶液

CH_3COOH , CH_3COONa , KH_2PO_4 , $\text{Na}_2\text{B}_4\text{O}_7$, Na_2CO_3 를 가지고 PH3.19, PH 4.4, PH6.22, PH8.0, PH 8.0, PH 9.4, PH10.4완충액을 만들어 사용함.

CO₂를 가지고 PH3.19, PH 4.4, PH6.22, PH8.0, PH 8.0, PH 9.4, PH10.4완충액을 만들어 사용함.

3. 試驗方法

溫度(°C)를 70, 80, 90, 100까지 變化시키고, pH는 3.19, 4.4, 6.22, 8.0, 9.4, 10.4로 變化, 時間(hr)은 1.5, 3, 5까지 變化시키면서 處理한 스판덱스纖維에 대해 각각 收縮率, 強度, 伸度, 疲勞度を 測定하였다. 處理前 原糸의 強度는 0.234kg, 伸도는 30.6cm이었고 收縮率에 利用한 原糸길이는 30cm이었다 疲勞도는 20cm糸에 重量 18g을 매달아 30分 경과후 길이를 測定하고 重量을 除去한 다음 다시 길이를 測定한 값이다.

III. 結果 및 考察

1. 實驗結果

上記 實驗方法으로 부터 測定한 資料들을 表 1에 기재했다. (表 1 - 1부터 表 1 - 4까지)

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Table 1 - 1 Data sheet of Shrinkage

Temp (°C)	Item Time (hr)	Shrinkage								
		Strength								
		1.5	3	5	3	5				
70	3.19	29.9	27.9	27.4	29.9	27.9	27.4	29.7	27.7	27.2
	4.4	27.02	29.02	29.52	30.0	28.0	27.5	27.4	27.9	30.0
	6.22	27.0	29.0	29.5	27.5	29.9	28.1	27.3	29.7	27.9
	8.0	27.9	27.4	30.2	29.0	29.5	30.1	27.8	27.3	30.1
	9.4	30.0	28.0	27.5	27.4	29.8	28.0	27.5	29.9	28.1
80	10.4	27.6	28.1	30.1	27.3	29.7	29.9	27.4	28.8	29.4
	3.19	29.0	29.3	28.6	27.6	27.1	29.9	28.9	29.2	26.5
	4.4	29.8	27.8	27.3	27.2	29.6	27.8	28.8	29.3	26.5
	6.22	27.4	29.8	28.0	26.8	28.8	29.3	27.3	29.7	27.9
	8.0	29.9	27.9	27.4	27.3	29.7	29.9	29.2	28.9	26.5
90	9.4	27.2	27.7	29.7	27.2	29.6	27.8	28.8	29.3	26.5
	10.4	29.8	27.8	27.3	27.5	29.3	27.8	29.5	27.9	27.2
	3.19	26.6	28.6	29.1	29.6	27.6	27.1	27.0	29.4	27.6
	4.4	29.5	27.5	27.0	27.0	29.4	27.6	27.4	26.9	29.7
	6.22	28.7	29.0	26.3	28.8	29.1	26.4	27.2	29.0	28.1
100	8.0	27.1	29.5	27.7	27.6	27.1	29.9	28.6	28.9	26.2
	9.4	27.4	26.9	29.7	29.5	27.5	27.0	28.7	29.0	26.3
	10.4	26.6	28.6	29.1	27.3	27.0	29.7	29.0	26.6	28.4
	3.19	26.9	26.5	30.3	27.4	26.9	29.7	27.08	26.78	29.48
	4.4	29.3	27.4	26.8	26.82	29.22	28.22	27.2	26.7	29.5
	6.22	26.8	29.2	27.4	28.48	28.78	26.08	26.62	29.02	28.02
	8.0	26.7	29.1	27.3	27.8	26.58	29.38	28.36	28.66	25.96
	9.4	29.2	27.2	26.7	27.22	29.22	26.72	27.04	26.45	29.32
	10.4	29.2	26.9	27.3	28.22	28.22	26.72	29.02	26.52	28.12

Table 1 - 2 Data Sheet of strength

Temp (°C)	Item Time (hr)	Strength								
		Strength								
		1.5	3	5	3	5				
70	3.19	0.152	0.117	0.132	0.190	0.255	0.170	0.234	0.099	0.284
	4.4	0.222	0.187	0.202	0.188	0.192	0.154	0.203	0.168	0.173
	6.22	0.257	0.322	0.237	0.259	0.263	0.225	0.248	0.244	0.282
	8.0	0.230	0.234	0.196	0.224	0.228	0.190	0.239	0.243	0.205
	9.4	0.226	0.230	0.192	0.213	0.237	0.199	0.279	0.213	0.175
80	10.4	0.233	0.229	0.267	0.245	0.249	0.211	0.139	0.135	0.173
	3.19	0.129	0.149	0.109	0.269	0.273	0.235	0.227	0.247	0.207
	4.4	0.162	0.166	0.128	0.289	0.295	0.269	0.258	0.278	0.308
	6.22	0.138	0.303	0.318	0.260	0.264	0.236	0.299	0.295	0.333
	8.0	0.303	0.368	0.273	0.293	0.268	0.183	0.245	0.249	0.211
90	9.4	0.107	0.272	0.187	0.276	0.280	0.242	0.228	0.224	0.262
	10.4	0.202	0.267	0.182	0.273	0.277	0.239	0.262	0.266	0.228
	3.19	0.211	0.215	0.177	0.222	0.226	0.188	0.260	0.264	0.226
	4.4	0.183	0.258	0.173	0.155	0.320	0.235	0.246	0.250	0.212
	6.22	0.294	0.298	0.260	0.270	0.274	0.236	0.314	0.318	0.280
100	8.0	0.290	0.294	0.256	0.227	0.231	0.193	0.234	0.238	0.200
	9.4	0.219	0.223	0.185	0.248	0.244	0.282	0.224	0.257	0.172
	10.4	0.260	0.260	0.240	0.270	0.274	0.236	0.210	0.214	0.176
	3.19	0.179	0.183	0.145	0.259	0.263	0.225	0.242	0.245	0.212
	4.4	0.244	0.248	0.210	0.306	0.310	0.272	0.193	0.186	0.227
	6.22	0.280	0.284	0.246	0.312	0.316	0.278	0.346	0.342	0.380
	8.0	0.337	0.341	0.303	0.279	0.283	0.245	0.258	0.252	0.224
	9.4	0.230	0.234	0.196	0.234	0.230	0.220	0.253	0.257	0.219
	10.4	0.260	0.264	0.226	0.250	0.254	0.216	0.280	0.284	0.246

Table 1 - 3 Data Sheet of Elongation

Temp (°C)	PH	Item Time (hr)	Elongation									
			1.5	3	5							
70	3.19	3.19	29.3	30.3	29.8	31.0	33.4	31.6	31.7	33.1	32.3	
			33.9	31.9	31.4	29.4	31.8	30.0	31.8	34.2	32.4	
			32.1	34.1	34.6	31.8	34.2	32.4	32.2	34.6	32.8	
	8.0	8.0	31.8	34.2	32.4	31.3	30.8	30.2	31.8	31.1	33.9	
			32.8	30.8	30.3	31.5	33.9	32.1	31.4	33.8	32.0	
			34.4	32.4	31.9	31.9	34.3	32.5	30.7	33.1	31.3	
80	3.19	3.19	31.4	29.4	28.9	31.4	33.8	32.0	31.9	31.4	34.2	
			28.6	31.0	29.2	34.7	32.7	32.2	32.1	34.5	32.7	
			33.8	31.8	31.3	31.1	33.5	31.7	33.7	33.2	36.0	
	8.0	8.0	34.4	32.4	31.9	30.7	33.1	31.3	30.4	29.9	32.1	
			33.4	31.4	30.9	31.4	32.8	32.0	32.3	31.8	34.6	
			30.4	32.8	31.0	34.7	32.7	32.2	29.7	32.1	30.3	
90	3.19	3.19	28.4	30.8	29.0	31.2	30.9	33.6	32.3	31.8	34.6	
			31.0	33.4	31.6	33.4	33.7	31.0	31.7	32.0	29.3	
			31.0	33.3	31.7	31.1	33.5	31.7	31.4	30.9	33.7	
	8.0	8.0	33.9	31.9	31.4	32.2	34.6	32.8	32.0	31.5	34.3	
			31.8	34.2	32.4	32.5	34.9	33.1	31.5	31.0	33.8	
			32.0	34.4	32.6	34.6	34.9	35.6	32.5	30.5	30.0	
100	3.19	3.19	31.0	33.4	31.6	34.7	32.7	32.2	32.0	34.4	32.6	
			31.9	31.4	34.2	33.7	34.0	31.3	32.1	31.6	34.4	
			31.0	32.4	34.6	32.5	32.0	34.8	34.1	34.4	31.7	
	8.0	8.0	28.8	28.4	32.2	32.2	31.7	34.5	33.5	33.8	31.1	
			31.8	29.8	29.3	32.8	35.2	33.4	32.7	35.1	33.3	
			30.3	32.7	30.9	32.1	31.6	34.4	33.7	34.0	31.3	

Table 1 - 4 Data sheet of Fatigue

Temp (°C)	PH	Item Time (hr)	Fatigue								
			1.5	3	5						
70	3.19	3.19	39.85	37.85	37.35	37.05	35.05	34.55	37.35	35.35	34.85
			22.05	20.05	19.35	21.75	19.95	19.25	21.65	19.85	
			36.35	34.35	33.85	35.2	33.2	32.7	34.15	33.65	36.45
	6.22	6.22	19.5	21.9	20.1	19.25	21.65	20.65	19.25	21.65	19.85
			33.12	35.52	33.72	33.3	35.7	33.4	34.75	34.25	34.95
			19.5	21.9	20.1	19.3	29.7	19.9	19.25	21.65	19.85
80	8.0	8.0	34.75	37.15	36.35	35.9	33.9	33.4	35.75	35.05	38.05
			19.35	21.75	19.95	21.8	19.8	19.3	21.7	19.7	19.2
			38.3	36.3	35.8	34.05	36.45	34.65	35.0	34.5	37.3
	10.4	10.4	19.45	21.85	20.05	19.7	19.2	20.0	19.6	19.1	21.9
			19.3	21.7	19.9	19.3	21.7	19.9	19.1	21.5	19.7
			33.8	36.2	34.43	33.3	35.7	33.9	36.3	34.9	33.8
90	3.19	3.19	19.15	21.55	19.75	19.25	21.65	19.85	19.2	21.6	19.8
			34.1	36.5	34.7	34.5	34.0	36.8	33.9	36.3	34.5
			19.15	21.55	19.75	19.6	19.1	21.9	19.25	26.65	19.85
	6.22	6.22	34.1	33.7	34.7	33.1	32.5	34.9	32.8	35.2	33.4
			19.2	21.6	19.8	19.15	21.55	19.75	19.2	21.6	19.8
			35.7	33.7	33.2	36.8	34.8	34.3	36.2	34.2	34.6
100	8.0	8.0	19.2	21.6	19.8	19.15	21.55	19.75	19.2	21.6	19.8
			36.5	34.5	34.0	33.7	36.1	33.7	35.3	38.1	
			19.1	21.5	19.7	21.7	19.7	19.2	19.3	21.7	19.9
	10.4	10.4	36.7	34.7	34.2	34.21	36.51	34.81	36.5	36.8	34.1
			19.15	21.55	20.55	19.15	21.55	22.55	19.7	19.1	23
			37.5	39.9	38.5	33.6	36.0	34.2	38.1	40.5	38.7
90	4.4	4.4	19.4	21.8	24.0	19.25	21.65	19.85	20.8	19.2	23.1
			33.4	35.8	34.0	33.2	35.6	33.8	36.8	37.1	35.4
			19.35	21.85	19.95	19.3	21.7	19.9	19.6	19	22.9
	6.22	6.22	33.3	35.7	33.9	33.7	36.1	34.3	36.5	34.5	34
			19.3	21.7	19.9	21.75	19.75	19.25	19.25	21.65	19.85
			33.9	36.3	34.5	36.5	34.5	34.0	37.75	35.75	35.25
100	9.4	9.4	21.73	19.75	19.25	19.25	21.65	19.65	19.25	21.65	19.85
			36.1	38.5	36.1	36.8	34.8	34.3	35.1	37.5	35.7
			19.35	21.75	19.95	19.3	21.7	19.9	19.2	21.6	19.8
	10.4	10.4	36.2	38.6	36.8	34.6	37.0	35.2	33.85	36.25	34.45
			19.25	21.65	19.85	19.25	21.65	19.85	19.2	21.6	19.8
			35.8	33.8	33.3	34.8	37.2	35.4	34.5	36.9	35.1
100	3.19	3.19	19.15	21.55	19.75	19.25	21.65	19.65	19.4	21.8	20.0
			36.25	34.25	33.75	34.4	36.8	35.0	34.0	36.4	34.6
			19.15	21.55	19.75	21.7	19.7	19.2	19.25	21.65	19.85
	6.22	6.22	37.55	35.35	35.05	35.05	34.55	37.35	34.9	37.3	35.5
			19.25	21.65	19.85	19.2	21.6	19.8	19.2	21.6	19.8
			38.95	33.95	33.45	34.2	36.6	34.8	36.7	34.2	34.2
8.0	8.0	19.15	21.55	19.75	19.2	21.6	19.8	21.7	19.7	19.2	
		34.6	37.0	35.2	37.6	35.9	35.4	35.5	35.0	37.8	
		19.2	21.6	19.8	19.25	21.65	19.65	19.25	21.65	19.85	
10.4	10.4	37.5	35.5	35.0	36.8	34.8	34.3	34.4	36.8	35.0	
		19.3	21.7	19.7	19.2	21.6	19.8	21.6	19.6	19.1	

Table 2 - 1. Rearranged data sheet of Shrinkage

PH Temp. °C	3.19			4.4			6.22			8.0			9.4			10.4										
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90								
	Temp. hr.	29.9	29.0	26.6	26.9	27.02	29.8	29.5	29.3	27.0	27.4	28.7	26.8	27.9	29.9	27.1	26.7	30.0	27.2	27.4	29.2	27.4	29.2	27.6	29.8	26.6
1.5	27.9	29.3	28.6	26.5	29.02	27.8	27.5	27.4	29.0	29.8	29.0	29.2	27.4	27.9	29.5	29.1	28.0	27.7	26.9	27.2	28.1	27.2	28.1	27.8	28.6	26.9
	27.4	26.6	29.1	30.3	29.52	27.3	27.0	26.8	29.5	28.0	26.3	27.4	30.2	27.4	27.7	27.3	27.5	29.7	29.7	26.7	30.1	27.3	29.1	27.3	29.1	27.3
3	29.9	27.6	29.6	27.4	30.0	27.2	27.0	26.82	27.5	26.8	28.8	28.48	29.0	27.3	27.6	27.8	27.4	27.2	29.5	27.2	29.5	27.22	27.3	27.5	27.3	28.22
	27.9	27.1	27.6	26.9	28.0	29.6	27.4	29.22	29.9	28.8	29.1	28.78	29.5	29.7	27.1	26.58	29.8	29.6	27.5	29.22	29.7	29.3	27.0	28.22	29.3	27.0
	27.4	29.9	27.1	29.7	27.5	27.8	27.6	28.22	28.1	29.3	26.4	26.08	30.1	29.9	29.9	29.38	28.0	27.8	27	26.72	29.9	27.8	29.7	26.72	29.7	26.72
	29.7	28.9	27.0	27.08	27.4	28.8	27.4	27.2	27.3	27.2	26.62	27.8	29.2	28.6	28.36	27.5	28.8	28.7	27.04	27.4	29.5	29.0	29.0	29.02	29.0	29.02
5	27.7	29.2	29.4	26.78	27.9	29.3	26.9	26.7	29.7	29.0	29.02	27.3	28.9	28.9	28.66	29.9	29.3	29.0	26.54	28.8	27.9	26.6	26.52	27.9	26.6	26.52
	27.2	26.5	27.6	29.48	30.0	26.5	29.7	29.5	27.9	28.1	28.02	30.1	26.5	26.2	25.96	28.1	26.5	26.3	29.32	29.4	27.2	28.4	18.12	27.2	28.4	18.12

Table 2 - 2. Subtotals of shrinkage

PH Temp. °C	3.19			4.4			6.22			8.0			9.4			10.4			Row Total								
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90						
	Time-hr.	85.2	84.9	84.3	83.7	85.56	84.9	84.0	83.5	85.2	84.0	83.4	85.5	84.3	83.1	85.5	84.6	84.0	83.1	85.8	84.9	84.3	83.4	513.06	509.7	504.9	500.2
1.5	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
3	85.2	84.6	84.3	84.0	85.5	84.6	82.0	84.26	85.5	84.9	84.34	86.6	84.6	83.76	85.2	84.6	84.0	83.16	86.9	84.6	84.0	83.16	516.9	510.2	503.2	501.68	
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
5	84.6	84.6	84.0	83.34	85.3	84.6	84.0	83.4	84.9	84.3	83.66	85.2	84.6	83.7	82.98	85.5	84.6	82.90	85.6	84.6	84.0	83.66	511.1	503.9	504.0	449.94	
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
Column total	255.0	254.1	252.6	251.04	256.36	254.1	250.0	251.16	255.9	252.6	250.40	259.3	258.7	252.6	249.84	256.2	253.8	252.0	249.16	258.3	254.1	252.3	250.22	1541.06	1527.8	1512.1	1501.82
	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	

Table 3 - 1. Rearranged data sheet of strength

PH Temp (°C) Time (hr)	3.19			4.4			6.22			8.0			9.4			10.4			
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	
1.5	0.152	0.129	0.211	0.222	0.162	0.183	0.244	0.257	0.138	0.294	0.280	0.230	0.303	0.290	0.337	0.226	0.107	0.219	0.24
	0.117	0.149	0.215	0.187	0.166	0.258	0.248	0.322	0.303	0.298	0.284	0.234	0.368	0.294	0.341	0.230	0.272	0.223	0.234
	0.132	0.109	0.177	0.202	0.128	0.173	0.270	0.237	0.318	0.260	0.246	0.196	0.273	0.256	0.303	0.192	0.187	0.185	0.196
3	0.190	0.269	0.222	0.254	0.188	0.289	0.155	0.306	0.260	0.270	0.312	0.224	0.203	0.227	0.279	0.213	0.276	0.248	0.234
	0.255	0.273	0.226	0.263	0.192	0.295	0.320	0.310	0.263	0.264	0.316	0.228	0.268	0.231	0.283	0.237	0.280	0.244	0.230
	0.170	0.235	0.188	0.225	0.154	0.269	0.235	0.272	0.225	0.236	0.278	0.190	0.183	0.193	0.245	0.199	0.242	0.282	0.242
5	0.234	0.227	0.260	0.242	0.203	0.258	0.246	0.193	0.248	0.299	0.314	0.239	0.245	0.234	0.258	0.209	0.228	0.224	0.253
	0.299	0.247	0.264	0.245	0.168	0.278	0.250	0.186	0.244	0.295	0.318	0.243	0.249	0.238	0.262	0.213	0.224	0.257	0.257
	0.284	0.207	0.226	0.212	0.173	0.308	0.212	0.227	0.292	0.333	0.280	0.216	0.211	0.200	0.224	0.175	0.262	0.172	0.219

Table 3 - 2. Subtotals of Strength

PH Temp (°C) Time (hr)	3.19			4.4			6.22			8.0			9.4			10.4			Row Total								
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90						
1.5	0.401	0.387	0.603	0.577	0.611	0.656	0.614	0.702	0.816	0.759	0.832	0.810	0.944	0.840	0.981	0.648	0.566	0.627	0.660	0.729	0.651	0.780	0.75	3.865	4.316	4.410	
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
	0.615	0.777	0.636	0.747	0.534	0.853	0.710	0.888	0.747	0.760	0.780	0.906	0.642	0.654	0.807	0.649	0.798	0.774	0.684	0.705	0.789	0.780	0.72	3.882	4.631	4.752	
3	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
	0.817	0.681	0.750	0.699	0.544	0.844	0.708	0.606	0.774	0.927	0.912	1.068	0.687	0.705	0.672	0.744	0.597	0.714	0.653	0.727	0.447	0.756	0.600	0.81	3.866	4.627	4.656
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
Column total	1.833	1.845	1.989	1.953	1.689	2.153	2.812	2.196	2.337	2.446	2.544	2.784	1.989	2.303	2.532	1.894	2.078	2.054	2.073	1.881	2.196	2.160	2.28	11.623	13.021	12.922	13.818
	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	
	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	

Table 4 - 1. Rearranged data sheet of Elongation

PH Temp (°C)	3.19			4.4			6.22			8.0			9.4			10.4							
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90					
1.5	29.3	31.4	28.4	31.0	33.9	28.6	31.0	31.9	32.1	33.8	31.0	31.8	34.4	33.9	28.8	32.8	33.4	31.8	31.8	34.4	30.4	32.0	30.3
	30.3	29.4	30.8	37.4	31.9	31.0	33.4	31.4	34.1	31.8	33.3	32.4	34.2	31.9	28.4	30.8	31.4	34.2	29.8	32.4	32.8	34.4	32.7
	29.8	28.9	29.0	31.6	31.4	29.2	31.6	34.2	34.6	31.3	31.7	34.6	32.4	31.9	32.2	30.3	30.9	32.4	29.3	31.9	31.0	32.6	30.9
3	31.0	31.4	31.2	34.7	29.4	34.7	33.4	33.7	31.8	31.1	31.1	32.5	31.3	30.7	32.2	31.5	31.4	32.5	32.8	31.9	34.7	34.6	32.1
	33.4	33.8	30.9	32.7	31.8	32.7	33.7	34.0	34.2	33.5	33.5	32.0	30.8	33.1	34.6	31.7	33.9	32.8	34.9	35.2	34.3	32.7	34.9
	31.6	32.0	33.6	32.2	30.0	32.2	31.0	31.3	32.4	31.7	31.7	34.8	30.2	31.3	32.8	34.5	32.1	32.0	33.4	32.5	30.7	32.5	34.4
5	31.7	31.9	32.3	32.0	31.8	32.1	31.7	32.1	32.2	33.7	31.4	34.1	31.8	30.4	32.0	33.5	31.4	32.3	31.5	30.7	29.7	32.5	33.7
	33.1	31.4	31.8	34.4	34.2	34.5	32.0	31.6	34.6	33.2	30.9	34.4	31.1	29.9	31.5	33.8	33.8	31.8	31.0	33.1	32.1	30.5	34.0
	32.3	34.2	34.6	32.6	32.4	32.7	29.3	34.4	32.8	36.0	33.7	31.7	33.9	32.7	34.3	31.1	32.0	34.6	33.3	31.3	30.3	30.0	31.3

Table 4 - 2. Subtotals of Elongation

PH Temp (°C)	3.19			4.4			6.22			8.0			9.4			10.4			Row Total									
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90							
1.5	89.4	89.7	88.2	100	97.2	88.8	96.0	97.5	100.8	96.9	96.0	98.0	98.4	98.7	97.2	89.4	93.9	95.7	98.4	90.9	98.7	94.2	99.0	93.9	578.4	564.0	574.8	569.7
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
	96.0	97.2	95.7	99.6	91.2	99.6	98.1	99.0	98.4	96.3	99.3	92.3	95.1	99.6	98.4	97.5	96.2	100.5	101.4	98.7	99.6	105.1	98.1	574.1	584.0	595.3	595.8	
3	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
	97.1	97.5	98.7	99.0	98.4	93.0	98.1	99.6	102.9	96.0	100.2	96.8	93.0	97.8	98.4	97.2	98.7	96.3	101.1	95.1	92.1	93.0	99.0	584.2	582.6	574.8	595.8	
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
5	282.5	284.4	282.6	286.6	286.8	287.1	294.6	298.8	296.1	288.3	297.5	287.5	286.8	294.6	286.2	286.6	290.6	285.2	293.4	292.5	285.9	297.1	291.0	1736.7	1730.6	1744.9	1761.3	
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
	Total	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	

Table 5 - 1. Rearranged data sheet of Fatigue

PH Temp (°C) Time (hr)	3.19			4.4			6.22			8.0			9.4			10.4								
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90						
1.5	17.8	14.65	18.1	16.65	14.95	14.05	17.1	13.62	14.9	14.0	18.3	15.4	16.5	12.15	16.8	18.85	17.4	16.75	15.4	15.4	14.1	13.15	16.95	13.8
	17.8	14.65	18.1	12.25	14.45	13.95	12.7	13.62	12.1	14.0	13.9	15.4	12.1	16.55	12.4	14.45	13.0	16.75	15.4	14.1	13.15	16.95	13.8	
	17.8	14.65	18.1	13.55	13.75	14.05	14.0	13.62	14.9	14.0	15.2	15.4	13.4	15.25	13.7	11.75	14.3	16.15	15.4	14.7	13.65	16.95	15.3	
3	17.7	14.05	14.35	15.55	15.95	13.9	12.7	14.0	13.95	11.95	15.85	14.1	17.65	17.25	15.0	14.35	12.0	17.5	18.35	15.1	15.06	15.35	17.6	
	13.3	14.05	14.35	15.55	11.55	14.9	17.1	16.0	11.05	16.33	12.95	14.1	13.25	12.85	15.0	17.25	16.4	13.1	14.25	12.2	15.06	15.35	13.2	
	14.6	14.05	14.35	15.75	12.05	14.9	15.8	13.5	15.15	15.05	17.55	14.1	14.55	14.15	15.0	12.45	14.5	14.4	15.75	16.8	14.26	15.35	14.5	
5	18.1	17.1	17.3	15.1	14.9	14.65	16.8	14.75	15.5	13.4	17.25	15.7	14.05	16.9	18.5	15.0	15.4	16.5	15.9	16.25	14.65	14.65	12.8	
	13.7	12.7	21.3	15.1	12.0	11.65	18.1	14.75	12.6	13.6	12.85	15.7	15.55	12.5	14.1	15.0	15.4	13.6	15.9	13.35	11.75	14.65	17.2	
	15.0	14.0	15.6	15.1	16.6	14.65	12.5	15.1	13.4	14.2	15.7	18.85	14.91	15.4	15.0	15.4	19.01	15.9	17.95	16.35	14.87	14.65	15.9	

Table 5 - 2. Subtotals of Fatigue

PH Temp (°C) Time (hr)	3.19			4.4			6.22			8.0			9.4			10.4			Row Total									
	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90							
1.5	53.4	43.95	54.3	42.45	43.05	44.85	41.9	42.0	47.4	46.2	42.0	43.95	42.9	41.05	44.7	48.65	46.2	44.2	44.65	50.85	47.3	288.8	261.7	282.6	270.05			
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)			
	45.6	42.15	43.05	46.85	39.55	44.7	41.7	45.6	43.5	40.15	43.28	46.35	42.3	45.45	44.25	45.0	44.25	42.9	45.0	48.35	44.1	44.38	46.05	47.3	259.2	259.5	263.1	277.45
3	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)			
	43.8	42.8	54.2	45.3	43.5	49.95	47.4	44.6	43.2	40.8	44.3	47.1	48.45	44.31	48.0	45	46.2	49.1	47.7	47.55	42.75	46.37	43.95	45.9	267.8	274.2	285.6	275.45
	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
5	142.9	129.9	151.5	134.6	126.0	130.5	131.2	127.5	122.85	124.5	140.85	136.9	131.76	132.9	131.4	136.71	142.4	142.1	138.1	140.85	138.5	795.8	789.82	831.3	822.95			
	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)		
	Total	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)		

2. 實驗結果의 整理

処理條件과 纖維物性사이의 關係를 알기위해 F檢定을^{5)~6)} 하려고表 1에 수록한 資料를 再整理하여 收縮率을 表 2에, 強力을 表 3에, 伸度를 表 4에 그리고 疲勞度를 表 5에 수록한다. 이들에 對한 各各 cell의 Sub total을 求해서 연속해서 副表로 기록해둔다. (예: 表 2 - 2)

단 表 5 - 1의 수치는 表 1 - 4에서 (A-B) 값을 정리 기록한 것이다.

다음 上記 表들로부터 MANOVA (Multi Variate Analysis Variance) Table을 만들어 表 6 - 1, 6 - 2, 6 - 3, 6 - 4에 정리한다.

여기서 Y^{11} 은 70°C에 關한것, Y^{21} 은 80°C, Y^{31} 은 90°C, Y^{41} 은 100°C에 關한 것이다. d.f.는 degree of freedom이다.

MANOVA Table 作成方法을 1 가지만 예를 들어 說明하면 表 6 - 1에서 RXY^{11^2} 란의 경우 表 2 - 2 Row total로부터

$$Y^{11^2} = \frac{(513.06)^2}{18} + \frac{(516.9)^2}{18} + \frac{(511.1)^2}{18} - \frac{(1541.06)}{54}$$

$$= 0.9671704 \text{가 얻어진다.}$$

다음 $Y^{11}Y^{21}$ 은 같은 表 2 - 2 Row total에서 70°C 80°C 값을 곱한 값으로

$$Y^{11}Y^{21} = \frac{(513.06)(509.7)}{18} + \frac{(516.9)(510.2)}{18}$$

$$+ \frac{(511.1)(507.9)}{18} - \frac{(1541.06)(1527.8)}{54}$$

$$= 0.3479259 \text{가 된다.}$$

나머지 값들도 다 위와 같은 方法으로 구할 수 있다.

3. F-檢定

收縮率, 70°C 일 때 만의 예를 들어 보면 M. S. E (Mean Square of Error)는 MANOVA Table 6 - 1에서

$$M. S. E. = \frac{\text{sum of square}}{d.f} = \frac{60.1066594}{36}$$

$$= 1.669629428$$

이다. 또 M. S. Sub total은 같은 表에서

$$M. S. Subtotal = \frac{4.3359481}{17} = 0.2550557706 \text{이 된다.}$$

따라서 측정값 $F = \frac{M. S. Sub total}{M. S. E} = 0.1529619$ 04, 수표에서 $F(17, 36) (0.99) = 2.5$ 이므로 유의하지 않다. 즉

Since $F < F_{0.99}(17, 36)$, We may accept H_0 at the 1% level and conclude that we can not say "at least one ≠"

다음 Row와 column과의 교호작용을 보면 M. S. R $\times C = \frac{1.9140728}{10} = 0.19140728$,

$F = \frac{M. S. R \times C}{M. S. E} = \frac{1.9140728}{1.669629428} = 1.1464728$ 이 되고 수표값 $F(10, 36) (0.99) = 2.86$ 과 比較하면 Not Significant하다. 그러나 上記 두가지 F-test는 minor effect이고 다음 두가지, 온도 70°C에서 시간變化와 PH 變化의 영향이 main effect이기 때문에 主檢對對象이 되는 것이다.

시간變化에 따른 收縮率變化 (Row)는

$$M. S. row = \frac{0.9671704}{2} = 0.4835852,$$

$$F = 0.2896362462,$$

수표값 $F(2, 36) (0.99) = 5.25$ 이므로 not significant하다.

PH變化에 의한 收縮率影響은

$$M. S. Column = \frac{1.4547049}{5} = 0.29094098$$

$$F = 0.1742548228$$

수표값 $F(5, 36) (0.99) = 3.58$ 이므로 not Significant하다.

以上과 같은 方法으로 전체 실험값에 對한 F-test를 行해서 表 7에 수록했다.

4. 反應方程式 作成

反應方程式을 만들기 위해서 表 8을 만들었다. 이 表에서 A, B, C는 각각 溫度, PH, 時間을 의미하며 table의 복잡성 때문에 PH는 3.19, 6.22, 10.4도, 溫度는 80°C, 90°C, 100°C로, 時間은 1.5, 3, 5 hr로 축소했으며 이들을 낮은 값으로 부터 L, M, H로 부호붙여 design했다.

다음 表 8을 整理하여 表 9 最終column에 反應方程式의 係數를 산출했으며 그 完成된 式은 表 10과 같다. 계산과정은 복잡하므로 문의가 있으면 個別的 答을⁷⁾ 제공하고 싶다.

Table. 6 – 1 MANOVA table of Shrinkage

Source	d.f	$Y^{(1)2}$	$Y^{(2)2}$	$Y^{(3)2}$	$Y^{(4)2}$	$Y^{(1)1} Y^{(2)}$	$Y^{(1)1} Y^{(3)}$	$Y^{(1)1} Y^{(4)}$	$Y^{(2)1} Y^{(3)}$	$Y^{(2)1} Y^{(4)}$	$Y^{(3)1} Y^{(4)}$
Row	2	0.9671704	0.16.5926	0.0803704	0.0978814	0.3479259	-0.1741482	0.3015703	-0.0198148	0.0964813	-0.068037
Column	5	1.4547049	0.6614771	0.5742593	0.3127482	0.63682	0.13397	-0.2652518	0.2274074	-0.0860742	-0.1684816
RXC	10	1.9140728	0.8663026	1.0085184	56.206652	1.14718	0.5963634	28.6526963	0.4231482	28.5081855	27.9560371
Subtotal	17	4.3359481	1.6903703	1.6631481	56.6172815	2.2319259	0.5561852	28.6890148	0.6307408	28.5185926	27.7195185
Error	36	60.1066594	65.32667	63.94667	13.4072065	-6.49666	31.49	-36.952663	4.84	-24.742222	-9.8246665
Total	53	64.4426075	67.0170371	65.609815	70.024488	-4.3647407	32.046182	-8.2636481	5.4707408	3.7743704	17.894852

Table. 6 – 2 MANOVA table of Strength

Source	d.f	$Y^{(1)2}$	$Y^{(2)2}$	$Y^{(3)2}$	$Y^{(4)2}$	$Y^{(1)1} Y^{(2)}$	$Y^{(1)1} Y^{(3)}$	$Y^{(1)1} Y^{(4)}$	$Y^{(2)1} Y^{(3)}$	$Y^{(2)1} Y^{(4)}$	$Y^{(3)1} Y^{(4)}$
Row	2	0.000026 0354	0.027776 592	0.009615 5913	0.003457 3334	0.000451 926	0.004329 2582	0.000221 7775	0.004730 37	0.009440 4438	0.005181 1108
Column	5	0.02667 .447	0.023213 202	0.032276 147	0.052353 333	0.017536 869	0.027398 704	0.030935 777	0.024143 593	0.033260 443	0.036597 443
RXC	10	0.048027 055	0.122879 632	0.017725 521	0.044598 667	0.010748 853	0.016300 519	0.004935 892	0.026712 63	0.032710 893	0.007516 224
Subtotal	17	0.074720 537	0.173869 426	0.059617 259	0.100409 333	0.028737 648	0.048028 482	0.036089 444	0.055586 593	0.075411 778	0.049294 778
Error	36	0.022429 611	0.002976 277	0.025034 741	0.014812 333	0.007348 092	0.012576 185	0.027979 444	0.015027 74	0.025561 697	0.006448 222
Total	53	0.097150 148	0.176845 703	0.084652 741	0.115221 333	0.036085 74	0.060604 666	0.064068 888	0.070614 333	0.100973 444	0.055743 444

Table. 6 - 3 MANOVA table of Elongation

Source	d. f	$Y^{(1)2}$	$Y^{(2)2}$	$Y^{(3)2}$	$Y^{(4)2}$	$Y^{(1)Y^{(2)}}$	$Y^{(1)Y^{(3)}}$	$Y^{(1)Y^{(4)}}$	$Y^{(2)Y^{(3)}}$	$Y^{(2)Y^{(4)}}$	$Y^{(3)Y^{(4)}}$
Row	2	2. 854444	13. 8503704	15. 5648148	25. 23	0. 1433334	-5. 466666	0. 725	8. 124074	18. 656	9. 9083334
Column	5	17. 3972	10. 165926	17. 8520371	11. 4172	10. 851111	5. 7205556	0. 6772	0. 8129629	2. 9266667	-11. 0916666
RXC	10	31. 796689	48. 6518518	36. 7174074	22. 8944666	12. 886666	19. 1333333	-6. 2572	19. 5592594	-20. 09666	-9. 4883334
Subtotal	17	52. 048333	72. 6681482	70. 1342593	59. 541666	23. 8811112	19. 3872223	-4. 895	28. 4962963	1. 486667	-10. 671666
Error	36	51. 54	120. 976667	63. 126666	120. 80333	34. 04	2. 01	5. 08	57. 29	136. 85	-4. 88
Total	53	103. 58833	193. 644815	133. 26093	180. 345	57. 921111	21. 397222	0. 185	85. 786296	138. 33666	-15. 551666

Table. 6 - 4 MANOVA table of Fatigue

Source	d. f	$Y^{(1)2}$	$Y^{(2)2}$	$Y^{(3)2}$	$Y^{(4)2}$	$Y^{(1)Y^{(2)}}$	$Y^{(1)Y^{(3)}}$	$Y^{(1)Y^{(4)}}$	$Y^{(2)Y^{(3)}}$	$Y^{(2)Y^{(4)}}$	$Y^{(3)Y^{(4)}}$
Row	2	3. 0948148	6. 984812	16. 58333	1. 6281481	2. 500741	6. 994442	-2. 413333	7. 613889	0. 29555	-4. 56666
Column	5	19. 069259	16. 5602569	44. 3352778	8. 27800915	-18. 058148	25. 39	2. 31222223	-12. 602777	-7. 666671	12. 14
RXC	10	37. 400522	27. 6758436	38. 3260592	13. 7755095	25. 5952145	12. 9941692	-5. 3722781	32. 0169435	15. 3283453	-8. 22284
Subtotal	17	59. 564126	51. 2208926	99. 2446667	23. 6816667	10. 0379074	45. 3786112	-5. 4733886	27. 0280555	7. 9572233	-0. 6495
Error	36	337. 98	95. 5301667	63. 2923812	157. 919166	37. 0713334	82. 8602592	122. 209259	-176. 92876	-15. 680334	-2. 035055
Total	53	397. 54413	146. 751059	162. 537048	181. 600823	47. 1092408	128. 238870	116. 735870	-149. 90070	-7. 723111	-2. 684555

Table 7 Results of F-Test

Item	Sub item	Table value	Comparison	Statistic value	Judgement
Shrinkage Y ⁽¹⁾	Sub total	2.5	>	0.153	Not significant
	R * C	2.86	>	0.115	"
	Row	5.25	>	0.290	"
	column	3.58	>	0.174	"
Y ⁽²⁾	Sub total	2.5	>	0.052	"
	R * C	2.86	>	0.048	"
	Row	5.25	>	0.045	"
	Column	3.58	>	0.073	"
Y ⁽³⁾	Sub total	2.5	>	0.055	"
	R * C	2.86	>	0.057	"
	Row	5.25	>	0.023	"
	Column	3.58	>	0.065	"
Y ⁽⁴⁾	Sub total	2.5	<	8.943	Significant
	R * C	2.86	<	15.092	Very significant
	Row	5.25	>	0.131	Not significant
	column	3.58	>	0.168	"
Strength Y ⁽¹⁾	Sub total	2.5	<	7.055	Significant
	R * C	2.86	<	7.708	"
	Row	5.25	>	0.021	Not significant
	Column	3.58	<	8.560	Significant
Y ⁽²⁾	Sub total	2.5	<	123.710	Very significant
	R * C	2.86	<	148.631	"
	Row	5.25	<	167.98	"
	Column	3.58	<	56.155	"
Y ⁽³⁾	Sub total	2.5	>	5.043	Significant
	R * C	2.86	<	2.549	Not significant
	Row	5.25	<	6.914	Significant
	Column	3.58	<	9.283	"
Y ⁽⁴⁾	Sub total	2.5	<	14.355	Very significant
	R * C	2.86	<	10.840	"
	Row	5.25	>	4.201	Not significant
	Column	3.58	<	25.449	Very significant
Elongation Y ⁽¹⁾	Sub total	2.5	>	2.139	Not significant
	R * C	2.86	>	2.221	"
	Row	5.25	>	0.997	"
	Column	3.58	>	2.430	"
Y ⁽²⁾	Sub total	2.5	>	1.272	"
	R * C	2.86	>	1.448	"
	Row	5.25	>	2.061	"
	Column	3.58	>	0.605	"
Y ⁽³⁾	Sub total	2.5	>	2.353	"
	R * C	2.86	>	2.094	"
	Row	5.25	>	4.438	"
	Column	3.58	>	2.036	"
Y ⁽⁴⁾	Sub total	2.5	>	1.044	"
	R * C	2.86	>	0.682	"
	Row	5.25	>	3.759	"
	Column	3.58	>	0.680	"
Fatigue Y ⁽¹⁾	Sub total	2.5	>	0.373	"
	R * C	2.86	>	0.398	"
	Row	5.25	>	0.165	"
	Column	3.58	>	0.406	"
Y ⁽²⁾	Sub total	2.5	>	1.135	"
	R * C	2.86	>	1.043	"
	Row	5.25	>	1.316	"
	Column	3.58	>	1.248	"
Y ⁽³⁾	Sub total	2.5	<	3.321	"
	R * C	2.86	>	2.180	"
	Row	5.25	>	4.716	"
	Column	3.58	<	5.043	Significant
Y ⁽⁴⁾	Sub total	2.5	>	0.318	Not significant
	R * C	2.86	>	2.593	"
	Row	5.25	>	0.186	"
	Column	3.58	>	0.377	"

Table. 8 – 1 Design of Response Equation
(Shrinkage)

1	L L L	29.0	29.3	26.6
C	L L M	27.6	27.1	29.9
c ²	L L H	28.9	29.2	26.5
b	L M L	27.4	29.8	28.0
b c	L M M	26.8	28.8	29.3
b c ²	L M H	27.3	29.7	27.9
b ²	L H L	29.8	27.8	27.3
b ² c	L H M	27.5	29.3	27.8
b ² c ²	L H H	29.5	27.9	27.2
a	M L L	26.6	28.6	29.1
a c	M L M	29.6	27.6	27.1
a c ²	M L H	27.0	29.4	27.6
a b	M M L	28.7	29.0	26.3
a b c	M M M	28.8	29.1	26.4
a b c ²	M M H	27.2	29.0	28.1
a b ²	M H L	26.6	28.6	29.1
a b ² c	M H M	27.3	27.0	29.7
a b ² c ²	M H H	29.0	26.6	28.4
a ²	H L L	26.9	26.5	30.3
a ² c	H L M	27.4	26.9	29.7
a ² c ²	H L H	27.08	26.78	29.48
a ² b	H M L	26.8	29.2	27.4
a ² b c	H M M	28.48	28.78	26.08
a ² b c ²	H M H	26.62	29.02	28.02
a ² b ²	H H L	29.2	26.9	27.3
a ² b ² c	H H M	28.22	28.22	26.72
a ² b ² c ²	H H H	29.02	26.52	28.12

↑ ↑ ↑
A B C

Table 8 – 2 Design of Response Equation
(Strength)

1	L L L	0.129	0.149	0.109
c	L L M	0.269	0.273	0.235
c ²	L L H	0.227	0.247	0.207
b	L M L	0.138	0.303	0.318
b c	L M M	0.260	0.264	0.230
b c ²	L M H	0.299	0.295	0.333
b ²	L H L	0.202	0.267	0.132
b ² c	L H M	0.273	0.277	0.239
b ² c ²	L H H	0.262	0.266	0.228
a	M L L	0.211	0.215	0.177
a c	M L M	0.222	0.226	0.138
a c ²	M L H	0.260	0.264	0.226
a b	M M L	0.294	0.298	0.250
a b c	M M M	0.270	0.274	0.236
a b c ²	M M H	0.314	0.318	0.280
a b ²	M H L	0.260	0.280	0.240
a b ² c	M H M	0.270	0.274	0.236
a b ² c ²	M H H	0.210	0.214	0.176
a ²	H L L	0.179	0.183	0.145
a ² c	H L M	0.259	0.263	0.225
a ² c ²	H L H	0.242	0.245	0.212
a ² b	H M L	0.280	0.284	0.246
a ² b c	H M M	0.312	0.316	0.278
a ² b c ²	H M H	0.346	0.342	0.380
a ² b ²	H H L	0.260	0.264	0.226
a ² b ² c	H H M	0.250	0.254	0.216
a ² b ² c ²	H H H	0.280	0.284	0.246

↑ ↑ ↑
A B C

**Table 8 - 3 Design of Response Equation
(Elongation)**

1	LLL	31.4	29.4	28.9
c	LLM	31.4	33.8	32.0
c ²	LLH	31.9	31.4	34.2
b	LML	33.8	31.8	31.3
b c	LMM	31.1	33.5	31.7
b c ²	LMH	33.7	33.2	36.0
b ²	LHL	30.4	32.8	31.0
b ² c	LHM	34.7	32.7	32.2
b ² c ²	LHH	29.7	32.1	30.3
a	MLL	28.4	30.8	29.0
a c	MLM	31.2	30.9	33.6
a c ²	MLH	32.3	31.8	34.6
a b	MML	31.0	33.3	31.7
a b c	MMM	31.1	33.5	31.7
a b c ²	MMH	31.4	30.9	33.7
a b ²	MHL	32.0	34.4	32.6
a b ² c	MHM	34.6	34.9	35.6
a b ² c ²	MHH	32.5	30.5	30.0
a ²	HLL	31.0	37.4	31.6
a ² c	HLM	34.7	32.7	32.2
a ² c ²	HLH	32.0	34.4	32.6
a ² b	HML	31.0	32.4	34.6
a ² b c	HMM	32.5	32.0	34.8
a ² b c ²	HMH	34.1	34.4	31.7
a ² b ²	HHL	30.3	32.7	30.9
a ² b ² c	HHM	32.1	31.6	34.4
a ² b ² c ²	HHH	33.7	34.0	31.3

↑ ↑ ↑
A B C

**Table 8 - 4 Design of Response Equation
(Fatigue)**

1	LLL	14.65	14.65	14.65
c	LLM	14.05	14.05	14.05
c ²	LLH	17.1	12.1	14.0
b	LML	14.9	12.1	14.9
b c	LMM	13.95	11.05	15.15
b c ²	LMH	13.6	13.6	13.6
b ²	LHL	17.55	13.15	13.65
b ² c	LHM	15.06	15.06	14.26
b ² c ²	LHH	16.8	17.7	14.87
a	MLL	18.1	18.1	18.1
a c	MLM	14.35	14.35	14.35
a c ²	MLH	17.3	21.3	15.6
a b	MML	14.0	14.0	14.0
a b c	MMM	11.95	16.33	15.05
a b c ²	MMH	17.25	12.85	14.2
a b ²	MHL	16.95	16.95	16.95
a b ² c	MHM	15.35	15.35	15.35
a b ² c ²	MHH	14.65	14.65	14.65
a ²	HLL	16.65	12.25	13.55
a ² c	HLM	15.55	15.55	15.75
a ² c ²	HLH	15.1	15.1	15.1
a ² b	HML	18.3	13.9	15.2
a ² b c	HMM	15.85	12.95	17.55
a ² b c ²	HMH	15.7	15.7	15.7
a ² b ²	HHL	18.2	13.8	15.3
a ² b ² c	HHM	17.6	13.2	14.5
a ² b ² c ²	HHH	12.8	17.2	15.9

↑ ↑ ↑
A B C

Table 9 – 1 Preparing of Coefficient of Response Equation (Shrinkage)

Cell	T	A	B	C	D ₁	CNT	D ₂	S. S	COEF	A'	B'	C'
1	84.9	254.1	763.2	2272.36	81	28.053827	1	63748.39	28.053827	28.039259	28.00864	27.866417
c	84.6	255.0	757.5	-1.04	27	-0.0385185	2	0.02	-0.019259	0.0177785	-0.156	-27.740865
c ²	84.6	254.1	751.66	0.76	27	0.028148	6	0.003565	0.00469136	-0.0483951	0.014	27.73644
b	85.2	252.6	-0.9	-1.12	27	-0.0414815	2	0.023229	-0.02074	-0.19111111	-27.97790	-27.889131
bc	84.9	252.6	-0.3	0.62	9	0.068	4	0.010677	0.0172	0.026	0.2277	27.83896
b c ²	84.9	252.3	0.16	2.3	9	0.25	12	0.04898	0.021296	0.007	0.0092591	-27.81031
b ²	84.9	251.04	0.9	-1.64	9	-0.182	6	0.049807	-0.03037	0.0029632	28.06530839	27.70642
b ² c	84.6	250.40	-0.3	-1.82	9	-0.202	12	0.0306703	-0.0168518	0.0088	-0.296	-28.01919
b ² c ²	84.6	250.22	0.16	-0.38	9	-0.042	36	0.007705	-0.011728	0.00259191	-0.232	28.04142
a	84.3	-0.3	0	-11.54	27	-0.427407	2	2.466138	-0.2137037	-28.049136	-28.08765	-27.994195
a c	84.3	-0.3	-0.3	1.06	9	0.117	4	0.0312109	0.0294	0.0420363	0.198	27.984161
a c ²	84.0	-0.3	-0.82	-0.74	9	-0.082	12	0.0050704	-0.00685185	0.02919753	-0.0003707	-28.07753
a b	84.0	-0.3	0	-0.82	9	-0.091	4	0.01867	-0.0227	0.20685185	28.0783	28.087279
a b c	84.3	0.3	0	0.62	3	0.206	8	0.016016	0.02583	0.04638	-0.23231	-28.085401
a b c ²	84.3	-0.3	0.62	1.7	3	0.56	24	0.040138	0.02361	-0.025463	-0.0070677	28.065894
a b ²	84.3	-0.36	0	2.26	9	0.251	12	0.0472926	0.0209259	0.0059875	-28.094875	-27.96752
a b ² c	84.0	0.26	0.6	-0.62	3	-0.206	36	0.005338	-0.00861	0.0043518	0.313055	28.100214
a b ² c ²	84.0	0.26	1.7	-0.98	3	-0.326	12	0.00444563	-0.004537	-0.001080198	-0.028981	-28.148358
a ²	83.7	0.3	-1.8	-0.14	27	-0.005185	6	0.0001209	-0.000864	28.097036	27.95531	28.336417
a ² c	84.0	0.3	-0.3	-0.14	9	-0.015	12	0.0001815	-0.001296	-0.0338881	-0.236	-28.424198
a ² c ²	83.34	0.3	0.46	1.66	9	0.184	36	0.0085049	0.0051235	0.00216049	-0.012	28.626419
a ² b	83.4	-0.3	0	-0.22	9	-0.024	12	0.00044815	-0.002037	-0.2794	-28.10401	-28.485798
a ² b c	83.34	-0.3	-1.2	0.62	3	0.206	24	0.005338	0.00861	-0.05083	0.0886108	28.535885
a ² b c ²	83.66	0.3	-0.62	0.5	3	0.16	72	0.0011574	0.0023148	0.0336111	-0.003796	-28.74997
a ² b ²	83.4	-0.96	0	-0.74	9	-0.082	36	0.00169012	-0.002284	0.0068518	28.16697	28.41642
a ² b ² c	83.16	0.38	0.6	1.78	3	0.593	72	0.0146685	0.0082407	-0.01694	-0.14416	-28.28502
a ² b ² c ²	83.66	0.74	-0.98	-2.18	3	-0.726	216	0.00007469	-0.00336478	-0.02212959	0.0186111	28.47390

Table 9 - 2 Preparing of Coefficient of Response Equation (Strength)

Cell	T	A	B	C	D ₁	CNT	D ₂	S. S	COEF	A'	B'	C'
1	0.387	1.845	6.487	20.197	81	0.2493457	1	5.036035	0.2493457	0.2667778	0.2020869	0.2314208
c	0.777	2.446	6.693	1.104	27	0.0408	2	0.0225707	0.0204	0.002	0.009	-0.2080957
c ²	0.681	2.196	7.017	-0.488	27	-0.018374	6	0.00146975	-0.0030123	-0.0666909	0.02033395	0.20142
b	0.759	1.989	0.567	0.849	27	0.0314	2	0.0133482	0.01572	0.0118333	-0.21147574	-0.35975
b c	0.760	2.544	0.027	-0.648	9	-0.072	4	0.011664	-0.018	0.003	-0.00341613	0.32230
b c ²	0.927	2.160	0.510	0.462	9	0.0513	12	0.005985	0.00427	-0.00583333	-0.00002662	-0.25275
b ²	0.651	1.953	-0.491	-3.125	9	-0.3472	6	0.1808449	-0.0578704	0.00772255	0.2045865	0.17592
b ² c	0.789	2.784	0.105	-0.354	9	-0.0393	12	0.0011603	-0.00327	0.0135	0.02024996	-0.18769
b ² c ²	0.756	2.280	-0.102	-1.796	9	-0.1995	36	0.0099556	-0.00554321	-0.0008886	-0.0234156	0.0469208
a	0.603	0.294	0.351	0.53	27	0.01962963	2	0.0052018	0.0098148	-0.252358	-0.3334687	-0.18175
a c	0.636	0.168	0.171	-0.057	9	-0.0063	4	0.00009025	-0.001583	-0.0114	-0.017666	0.21145
a c ²	0.750	0.105	0.327	0.389	9	0.0432	12	0.00140112	0.00360185	0.0523272	-0.00861115	-0.22800
a b	0.852	0.147	-0.189	-0.024	9	-0.0026	4	0.000016	-0.0006	-0.006213	0.3046852	0.32486
a b c	0.780	0.060	-0.327	0.057	3	0.019	8	0.00013537	0.002375	0.00195833	0.0138838	-0.30095
a b c ²	0.912	-0.180	-0.132	0.093	3	0.031	24	0.00086113	0.00129167	0.0076708	0.0037326	0.28065
a b ²	0.780	0.192	0.315	0.484	9	-0.0537	12	0.00216904	-0.004481	-0.003206	-0.2623025	-0.21625
a b ² c	0.780	0.258	-0.261	-0.327	3	-0.109	24	0.00148513	-0.0045416	0.00265278	-0.0087916	0.16925
a b ² c ²	0.600	0.060	0.408	0.689	3	0.2296	72	0.00219778	0.0031898	0.0005266	0.01843474	-0.058877
a ²	0.507	-0.486	-0.851	0.118	27	0.00437	6	0.0000859	0.0007283	0.2054445	0.1960869	0.20442
a ² c	0.747	0.166	-0.939	1.023	9	0.1136	12	0.00969008	0.009472	0.056	0.0	-0.21833
a ² c ²	0.699	-0.171	-1.335	-0.803	9	-0.0892	36	0.0019902	-0.002478	-0.056858	-0.0201665	0.14067
a ² b	0.810	0.081	0.063	0.336	9	0.0373	12	0.00238008	0.0031	0.01658331	-0.1772308	-0.30675
a ² b c	0.906	0.204	-0.153	0.333	3	0.111	24	0.00154013	0.004625	-0.004125	-0.00245887	0.28065
a ² b c ²	1.068	-0.180	-0.264	1.245	3	1.415	72	0.01166004	0.00576389	0.00779165	-0.0079849	-0.22637
a ² b ²	0.750	-0.288	-0.989	-0.308	9	-0.0342	36	0.00029279	-0.0009506	-0.020694	0.0365865	0.17592
a b ² c	0.720	0.066	-0.507	0.105	3	0.035	72	0.00005104	0.000486	-0.000375	0.03262496	-0.18029
a ² b ² c ²	0.810	0.120	-0.300	-0.275	3	-0.0916	216	0.0001167	-0.000424	-0.0023466	-0.0222906	-0.050954

Table 9 - 3 Preparing of Coefficient of Response Equation (Elongation)

Cell	T	A	B	C	D ₁	CNT	D ₂	S. S	COEF	A'	B'	C'
1	89.7	284.4	866.4	2621.5	81	32.36419	1	84842.724	32.3641975	32.53	31.267902	32.7012349
c	97.2	296.1	868.0	22.5	27	0.83	2	9.3749	0.416	-0.616	1.15	-32.217902
c ²	97.5	285.9	887.1	-40.1	27	-1.485185	6	9.925986	-0.247531	-0.648765	0.283	30.1512346
b	96.9	282.6	11.7	8.4	27	0.31	2	1.306	0.15	0.316	-32.70864	-33.56543
b c	96.3	288.3	4.5	-20.3	9	-2.25	4	11.44694	-0.5638	0.45	-0.016	33.30154
b c ²	102.9	297.1	6.3	-22.5	9	-2.5	12	4.6875	-0.2083	0.383	0.507407	-32.49043
b ²	94.2	298.6	-12.9	-24.2	9	-2.68	6	10.8093	-0.4481	0.283	31.7679013	32.701235
b ² c	99.6	297.5	-23.3	-2.1	9	-2.03	12	0.04083	-0.0194	0.16	-0.65	-33.226235
b ² c ²	92.1	291.0	-3.9	-58.7	9	-6.52	36	10.634845	-0.1811728	0.16	-0.96	34.72623
a	88.2	7.8	1.5	20.7	27	-0.76	2	7.9349	0.383	-32.611728	-33.18209	-30.98457
a c	95.7	6.0	14.5	-5.4	9	-0.6	4	0.81	-0.15	-0.3638	0.06	33.216049
a c ²	98.7	-2.1	-7.6	9.0	9	1.0	12	0.75	0.083	0.2669753	-0.45	-32.73457
a b	96.0	10.5	-9.9	-9.1	9	-1.01	4	2.30027	-0.2527	-0.3	32.878704	32.732098
a b c	96.3	0	-16.5	16.0	3	5.3	8	10.0	0.6	0.28	0.294	-32.750308
a b c ²	96.0	-6.0	6.1	2.6	3	0.86	24	0.0938	0.0361	-0.005	0.1283953	31.890432
a b ²	99.0	-1.0	-5.7	16.5	9	1.83	12	2.52083	0.1527	-0.1604969	-31.873765	-33.33457
a b ² c	105.1	2.2	-13.7	6.0	3	2.0	24	0.5	0.083	0.41	-0.63	30.891049
a b ² c ²	93.0	5.1	-3.1	31.8	3	10.6	72	4.6816	0.1472	0.1123456	0.016	-26.359567
a ²	100.0	-7.2	-21.9	17.5	27	0.6481	6	1.8904321	0.10802469	31.283	33.1179016	29.251235
a ² c	99.6	7.2	3.1	9.0	9	1.0	12	0.75	0.083	1.075	-0.2	-32.167902
a ² c ²	99.0	-12.9	-5.4	29.8	9	3.31	36	2.740864	0.091975	-0.90432	-0.216	32.1012346
a ² b	98.0	-4.5	-6.3	-35.1	9	-3.9	12	11.4075	-0.325	0.76	-31.616975	-33.76543
a ² b c	99.3	-0.6	4.5	29.2	3	9.73	24	11.842	0.405	-1.55	-0.883	32.418210
a ² b c ²	100.2	-18.2	-0.3	18.6	3	6.2	72	1.6016	0.0861	0.13	-0.725926	-30.59043
a ² b ²	93.9	-0.2	-34.5	-33.5	9	-3.72	36	3.4637345	-0.103395	0.03	28.5429013	33.301235
a ² b ² c	98.1	-0.4	-21.5	-15.5	3	-5.2	72	1.126	-0.072	-1.05	4.0	-30.576235
a ² b ² c ²	99.0	-3.3	-2.7	5.8	3	1.93	216	0.0519136	0.0089506	0.05	2.183	22.726235

Table 9 - 4 Preparing of Coefficient of Response Equation (Fatigue)

Cell	T	A	B	C	D ₁	CNT	D ₂	S. S	COEF	A'	B'	C'
1	43.95	129.9	390.85	1235.83	81	15.25716049	1	18855.25665	15.25716049	15.471	16.4916049	15.77457
c	42.15	122.85	431.03	0.22	27	0.008148	2	0.000896296	0.004074	-0.06	-0.5783	-15.933827
c ²	43.8	138.1	413.95	34	27	1.259	6	7.13580247	0.209876543	1.0804938	-0.1387037	17.1190124
b	41.9	151.55	3.77	10.4	27	0.3851	2	2.00296	0.1925	0.2405	-16.293827	-15.058765
b c	40.15	129.63	-4.7	-5.88	9	-0.653	4	0.9604	-0.163	-0.41416	-0.087	14.765710
b c ²	40.8	149.85	1.15	-9.64	9	-1.071	12	0.860459	-0.08925	-0.40472	0.447	-14.961263
b ²	44.35	134.6	10.81	55.84	9	6.204	6	57.742696	1.03407	-0.345	17.0382716	15.474568
b ² c	44.38	140.85	24.74	-2.48	9	-0.275	12	0.056948	0.02296	0.57416	1.026	-15.996328
b ² c ²	49.37	138.5	-1.55	22.48	9	2.487	36	1.5597255	0.06938272	-0.3678704	-0.9459259	13.631512
a	54.3	-0.15	8.2	23.1	27	0.85	2	9.8816	0.427	-15.04772839	-14.390617	-16.630309
a c	43.05	-1.1	-1.7	-2.62	9	-0.291	4	0.19067	-0.0727	-0.28185	-0.64527	16.741605
a c ²	54.2	5.02	3.9	-12.36	9	-1.373	12	1.41453	-0.114	-0.96469135	-0.0228704	-17.984197
a b	42.0	-0.1	5.17	-4.3	9	-0.47	4	0.51361	-0.1194	-0.542	14.0825926	14.367746
a b c	43.33	2.3	-6.8	-9.42	3	-3.14	8	3.69735	-0.3925	0.2172	0.7794	-14.1789196
a b c ²	44.3	-6.9	-4.25	7.04	3	2.346	24	0.68835	0.097	0.2372	-0.096327	13.394413
a b ²	50.85	2.85	1.51	-30.9	9	-3.43	12	8.84083	-0.2861	0.229321	-14.309506	-18.532809
a b ² c	46.05	-0.3	-19.7	-5.02	3	-1.673	24	0.3500556	-0.06972	0.08546296	0.263	15.6396609
a b ² c ²	43.95	-1.4	8.55	-10.56	3	-3.52	72	0.51626	-0.048	0.1329938	-0.9150926	-16.601697
a ²	42.45	3.45	22.3	-57.26	27	-2.12074	6	20.238936	-0.3534568	15.458	16.6716049	17.509568
a ² c	46.85	2.4	42.14	14.32	9	1.591	12	1.8987259	0.13259	0.43	0.66416	-15.670494
a ² c ²	45.3	4.96	-8.6	-40.22	9	-4.468	36	4.9927419	-0.1241358	1.14938272	-1.8612037	14.0390124
a ² b	47.4	22.4	7.07	15.5	9	1.72	12	2.224537	0.14351852	0.458	-15.448272	-13.122932
a ² b c	46.35	-0.36	-11.6	14.52	3	4.84	24	2.9282	0.2016	0.763	-0.7394	12.427377
a ² b c ²	47.1	2.7	2.05	49.46	3	16.186	72	0.2289815	0.22898148	-0.195	0.19138	-15.751265
a ² b ²	47.3	-5.95	3.61	-70.58	9	-7.842	36	15.3751124	-0.2178395	-0.7427	15.7482716	13.482068
a ² b ² c	45.3	1.8	25.82	-14.08	3	-4.693	72	0.9178074	-0.06518	-0.03083	-1.263	-13.777994
a ² b ² c ²	45.9	2.6	-6.95	-54.98	3	-18.326	216	4.664815	-0.0848457	-0.17231483	-0.8534259	17.421512

Table 10 Response Equation

1) Shrinkage

$$\hat{Y} = 27.9 - 27.7c + 27.7c^2 - 27.9b + 27.8bc - 27.8bc^2 + 27.7b^2 - 28.0b^2c + 28.0b^2c^2 - 28.0a + 28.0ac - 28.1ac^2 + 28.1ab - 28.1abc + 28.1abc^2 - 28.0ab^2 + 28.1ab^2c - 28.1ab^2c^2 + 28.3a^2 - 28.4a^2c + 28.6a^2c^2 - 28.5a^2b + 28.5a^2bc - 2.87a^2bc^2 + 28.4a^2b^2 - 28.3a^2b^2c + 28.5a^2b^2c^2$$

2) Strength

$$\hat{Y} = 0.2 - 0.2c + 0.2c^2 - 0.4b + 0.3bc - 0.3bc^2 + 0.2b^2 - 0.2b^2c + 0.1b^2c^2 - 0.2a + 0.2ac - 0.2ac^2 + 0.3ab - 0.3abc + 0.3abc^2 - 0.2ab^2 + 0.2ab^2c - 0.1ab^2c^2 + 0.2a^2 - 0.2a^2c + 0.1a^2c^2 - 0.3a^2b + 0.3a^2bc - 0.2a^2bc^2 + 0.2a^2b^2 - 0.2a^2b^2c - 0.1a^2b^2c^2$$

3) Elongation

$$\hat{Y} = 32.7 - 32.2c + 30.2c^2 - 33.6b + 33.3bc - 32.5bc^2 + 32.7b^2 - 33.2b^2c + 34.7b^2c^2 - 31.0a + 33.2ac - 32.7ac^2 + 32.7ab - 32.8abc + 32.0abc^2 - 33.3ab^2 + 30.9ab^2c - 26.4ab^2c^2 + 29.3a^2 - 32.2a^2c + 32.1a^2c^2 - 33.8a^2b + 32.4a^2bc - 30.6a^2bc^2 + 33.3a^2b^2 - 30.6a^2b^2c + 22.7a^2b^2c^2$$

4) Fatigue

$$\hat{Y} = 15.8 - 15.9c + 17.1c^2 - 15.1b + 14.8bc - 15.0bc^2 + 15.5b - 16.0b^2c + 13.6b^2c^2 - 16.6a + 16.7ac - 18.0ac^2 + 14.4ab - 14.2abc + 13.4abc^2 - 18.5ab^2 + 15.6ab^2c - 16.6ab^2c^2 + 17.5a^2 - 15.7a^2c + 14.0a^2c^2 - 13.1a^2b + 12.4a^2bc - 15.8a^2bc^2 + 13.5a^2b^2 - 13.8a^2b^2c + 17.4a^2b^2c^2$$

5. 考 察

上記 表 7 을 볼 때 관찰하려는 major Effect가 row 와 column 이기 때문에 각 溫度에서의 PH 變化와 時間 變化에 따른 폴리우레탄 纖維의 品質에는 強度에 상당한 영향을 미칠 뿐 다른 特性에는 거의 變化를 주지 않는다는 事實이 증명되었다.

反應方程式에서 各各의 Factor에 對한 a, b, c 값을 low에는 -1, , high에는 +1로 주어 계산하면 各條件에 對한 수율의 平均값이 얻어진다.

IV. 結 論

1. 폴리우레탄 纖維의 染色條件이 收縮性, 伸度 疲勞度등에는 거의 影響을 미치지 않으나 強度에는 영향을 미친다.

2. 反應方程式은 表10과 같이 求해진다.

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