Effect of Dyeing Parameters on Bursting Strength of Knitted Fabric

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Abstract

To produce fabric according to the requirements of the buyer is important. As bursting strength is a dominating factor for determining the property of the knitted fabric, it is a fundamental requirement of the buyer. In this research an attempt was made to measure the effect of dyeing parameters on bursting strength of knitted fabric produced from polyester and rayon blended fiber yarn. By changing temperature, dispersing agent, pH value, amount of salt and soda, different types of salt and soda; the dyeing process was carried out. After getting the final dyed knitted fabric the bursting strength was measured by following ISO 2758-2003 test method. Temperature changes showed a significant impact on the bursting strength of knitted fabric. The variation of pH value, amount of dispersing agent, amount of salt and soda as well as different types of salt and soda, all had an effect on the bursting strength of the knitted fabric to a smaller extent. The experimental data showed that the highest strength value was 116.1 kPa for dyeing of polyester part at 120°C and for rayon part dyeing, it was 108.1 kPa when the temperature was 70°C. Fluctuation of pH value vary bursting strength merely and the highest value 109.3 kPa was obtained at pH value 7, addition of 0.9 g/l dispersing agent showed the highest value of 108.1 kPa and for salt and soda amount of 40 g/l and 45 g/l resulting the highest value of 108.3 kPa and 108.1 kPa respectively. In case of using different types of alkali and salt, Potassium Hydroxide (KOH) and Calcium Sulphate (CaSO4), generated the highest value which were 110.5 kPa 110.1 kPa respectively. Consequently, the above parameters should be used for dyeing of polyester-rayon knitted fabric.

Keywords: Knitted fabric, bursting strength, polyester, rayon, dye.

1. Introduction

Knitting, like weaving, non-woven, and braiding is an important fabric manufacturing technology nowadays. Knit fabric is made by intermeshing loops in the direction of the course or wale. It is possible to alter the properties of knit fabric by adjusting various production parameters such as raw material (fiber), yarn (types of spinning), knitting process, and fabric structure, etc. (Bruer, Powell, & Smith, 2005). The bursting strength of the fabric is a very crucial property that influences other properties of the fabric. When choosing a knitted fabric for any application, the strength is an important factor to consider (Teli, Khare, & Chakrabarti, 2008). Among all other physical and mechanical properties of knitted fabric, bursting strength has the greatest influence on the end product's characteristics. For example, when selecting a knitted fabric for producing a T-shirt, fabric with very soft feel is required; however, when the knitted fabric is used for load-bearing purposes such as sacks, filter fabric, or parachutes, high strength fabric is mandatory. In bursting strength testing, the multidirectional forces are applied

to the perpendicular direction of the fabric, thus making this process more acceptable compare to measure the tensile strength in course or wale wise direction of knitted fabric separately (Mavruz & Oğulata, 2007).

Bursting strength of knitted fabric lured the attention of many researchers and motivated them to conduct much research on it (Jinlian, 2011; Onal & Candan, 2003; Toth et al., 2003). Some

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parameters are very important when producing knitted fabric, such as gauge, GSM, yarn diameter, fabric thickness, stitch length, and stitch density (Abedin, Maniruzzaman, Sina, & Khalil, 2014). Some researchers attempted to improve the dimensional stability of knitted fabric by varying the fiber, yarn, and fabric structure, as well as by surface modification with polysilocanes and polyethylene emulsions (Hussain, Safdar, Nazir, & Iqbal, 2013; Yang, Qian, & Lickfield, 2001). Some researchers also investigated the effect of compact yarns and ring-spun yarns on bursting strength and other properties of knitted fabric (Akaydin, 2009; Dönmez Kretzschmar, Özgüney, Özçelik, & Özerdem, 2007). It was found that the increase of wale per inch (WPI) and course per inch (CPI) increases the bursting strength (Skomra, 2006). Denim knitted fabric produced from yarns of bamboo, tencel, modal and viscose fibres showed higher bursting strength than fabric produced from cotton fibre (Degirmenci & Çelik, 2016).

However, no significant research was conducted to investigate the effect of dyeing parameters on the bursting strength of knitted fabric and this was the prime motivation of conducting this research.

2. Materials and methods

2.1 Preparation of the sample

The fabric was cut in such a manner that it was weighted 9 gram (±2%). The samples were dyed with the LABORTEX sample dyeing machine.

2.2 Scouring and bleaching

The fabric was produced from polyester-rayon blended yarn where rayon was a re-generated fiber and the polyester was a synthetic fiber. So mild scouring was sufficient to remove the yellowish appearance caused by the heat setting. It was done for 40 minutes at 85°C temperature. The ratio of material to liquor was 1:10. The detergent was applied at a rate of 0.60 g/l. Anticreasing agent, sequestering agent, stabilizer, hydrogen peroxide and soda ash were added following the rate of 2.00 g/l, 0.35 g/l, 0.20 g/l, 1.60 g/l and 2.00 g/l respectively.

2.3 Dyes and auxiliaries

In case of dyeing of polyester fiber portion acid buffer 1.5 g/l, dispersing agent 1 g/l, disperse dyes (Megaperse Navy NNA 0.53%, Megaperse Yellow 6GHXF 0.48%, Megaperse Turquise Blue HXF 0.53%) were used. The material to liquor ratio was 1:10.

In the case of rayon fiber portion dyeing soda ash 20 g/l, salt 70 g/l, and dyes (Dchufix Yellow 3RXF 1.48%, Rema Turquise Blue G 1.96%, Dychufix Navy Blue FBXN 1.86%) were used.

2.4 Polyester fiber portion dyeing by varying temperature

At first, the polyester fiber portion was dyed by varying temperatures. Shade % was kept the same, acid buffer 1.5 g/l, pH 5, dispersing agent 1 g/l were used. The temperature of dyeing was 100, 110, 120, 130, 140, 150, 160, 170°C and the time was 60 minutes. After that, the rayon fiber portion was dyed by keeping constant of all parameters.

2.5 Polyester fiber portion dyeing by varying pH

The same shade % was maintained, and time was 60 minutes. The dispersing agent was added at 1 g/l rate and the temperature was 130°C. The value of pH was 2, 3, 4, 5, 6, and 7. After that, the rayon fiber portion was dyed by keeping constant of all parameters.

2.6 Polyester fiber portion dyeing by varying the amount of dispersing agent

The same shade % was maintained and the polyester fiber part was dyed by varying the dispersing agent amount for 60 minutes at 130°C, pH 5. Dispersing agent amount was 0.60 g/l, 0.9 g/l, 1.20 g/l, 1.50 g/l, 1.80 g/l, and 2.10 g/l. After that, the rayon fiber portion was dyed by keeping constant of all parameters.

2.7 Rayon fiber portions dyeing by varying temperature

At first the polyester fiber portion was dyed by maintaining the same parameter. The rayon fiber portion was dyed by varying temperature but maintaining the same shade %. The other parameters were soda ash 20 g/l, salt 70 g/l, and time 60 minutes. The dyeing was carried out at temperature of 60, 65, 70, 75, 80, 85, 90°C.

2.8 Rayon fiber portions dyeing by varying the amount of salt

At first the polyester fiber portion was dyed by maintaining the same parameter. After that rayon fiber portion was dyed by varying the salt amount but maintaining the same shade % and soda ash 20 g/l at temperature 80°C for 60 minutes. Dyeing was done by varying salt amount of 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 g/l.

2.9 Rayon fiber portion dyeing by varying the amount of soda

At first the polyester fiber portion was dyed by maintaining the same parameter. The rayon fiber portion was dyed by varying soda ash amount but keeping the same shade % and the glaubar salt was 70 g/l at temperature 80°C for 60 minutes. The amount of soda ash was 5, 10, 15, 20, 25, 30, 35, 40 g/l.

2.10 Rayon fiber portion dyeing by different types of salt

At first the polyester fiber portion was dyed by maintaining the same parameter. The rayon fiber portion was dyed with the same shade %, but with different types of salt (70 g/l), soda ash 20 g/l for 60 minutes at temperature 80°C. Dyeing was done by potassium sulphate, ammonium sulphate, potassium chloride, calcium chloride, sodium sulphate, calcium sulphate, magnesium sulphate, and sodium chloride.

2.11 Rayon fiber portion dyeing by different types of alkali

At first the polyester fiber portion was dyed by maintaining the same parameter. The rayon fiber portion was dyed with the same shade % but with different types of alkali (20 g/l), salt 70 g/l at temperature 80°C for 60 minutes. Dyeing was performed with calcium carbonate, potassium hydroxide, calcium hydroxide, potassium carbonate, sodium carbonate, sodium hydroxide, sodium bi-carbonate, and magnesium carbonate.

2.12 Measurement of bursting strength

ISO 2758-2003 method was followed for measuring the tensile strength (bursting) of the samples. The diameter of the specimen was 50 cm. By using a clamping ring fabric was clamped in rubber diaphragm and until bursting of the sample, pressure was applied. The pressure was increased in

a way that the test specimen burst within 20 (±2) seconds. Bursting area (mm), bursting time (second), and bursting strength (kPa) were measured.

3. Results and discussion

3.1 Effect of temperature (polyester portion dyeing) on bursting strength

Table 1: Effect of temperature variation on bursting strength

Dyeing temperature (°C)	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
100	115.1	64.8	17.6
110	115.5	65.2	18.4
120	116.1	65.9	19.2
130	112.9	63.7	17.4
140	111.7	63.1	16.9
150	109.3	62.2	17.1
160	109.1	61.9	16.5
170	108.8	61.7	16.4

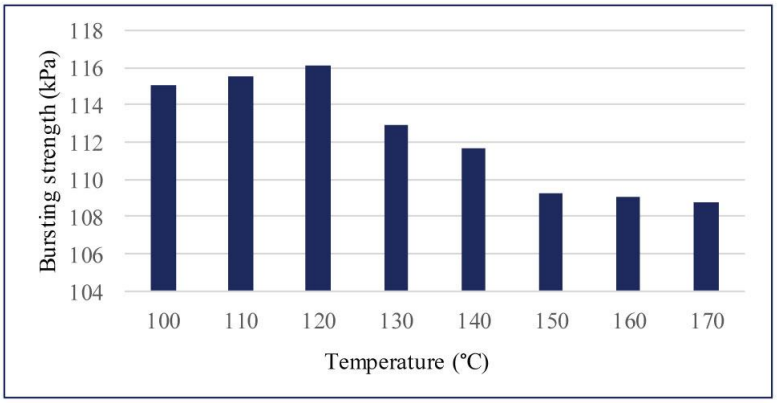

Fig. 1 Effect of temperature variation on bursting strength

Table 1 and Figure 1 indicate the bursting strength of fabric for polyester fiber portion dyeing by varying temperature from 100°C to 170°C. The result indicates that with the increased of temperature fabric strength decreased and top value 116.1 kPa was obtained at temperature 120°C.

3.2 Effect of pH value on bursting strength

Table 2 Bursting strength with pH value variation

pH value	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
2	108.1	63.9	18.9
3	108.9	59.9	18.6
4	107.1	61.5	18.1
5	109.1	63.9	18.7
6	108.9	63.4	17.9
7	109.3	63.7	18.0

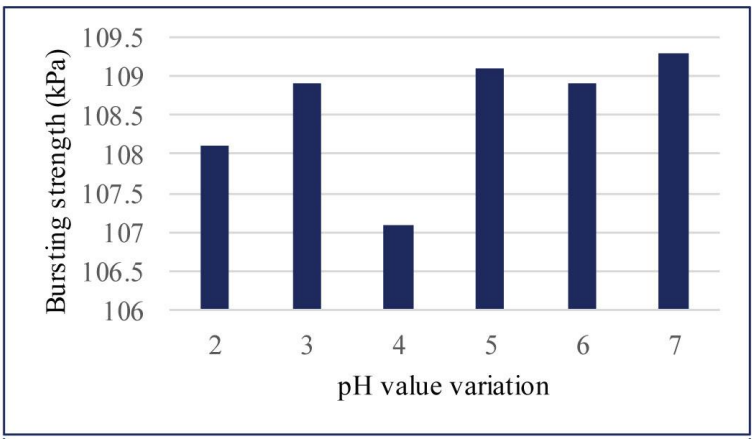

Fig. 2 Effect of pH value variation on bursting strength

Table 2 and Figure 2 show the effect of pH value variation on bursting strength of fabric. The variation of pH value affected the bursting strength to a small extent. The highest value was obtained 109.3 kPa at pH 7 and the lowest value was 107.1 kPa at pH 4.

3.3 Effect of dispersing agent amount on bursting strength

Table 3: Bursting strength with different amount of dispersing agent

Dispersing agent (g/l)	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
0.6	107.9	60.1	19.9
0.9	108.1	66.1	21.1
1.20	106.9	61.1	20.9
1.50	105.1	60.8	20.1
1.80	106.6	60.9	20.8
2.10	106.9	61.1	20.6

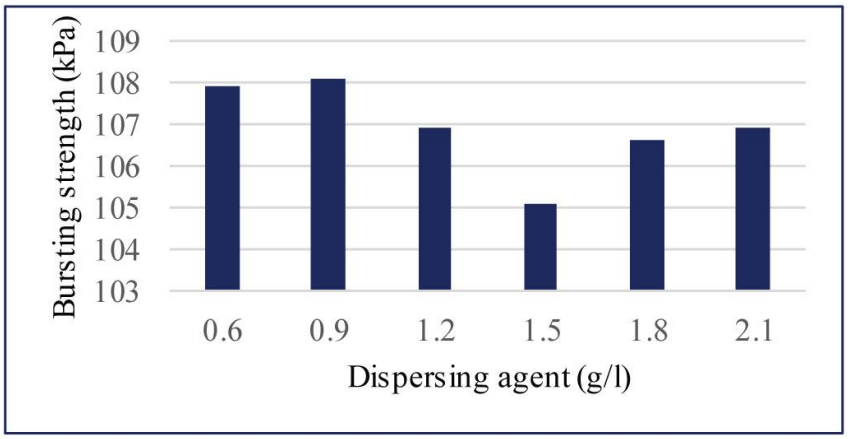

Fig. 3 Effect of dispersing agent amount on bursting strength

Table 3 and figure 3 reflect the effect of dispersing agent amount variation on bursting strength. The scenario indicates that there was no significant effect of dispersing agent amount on bursting strength.

3.4 Effect of temperature (rayon portion dyeing) on bursting strength

Table 4 Bursting strength with temperature variation of rayon portion dyeing

Dyeing temperature (°C)	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
60	106.7	59.9	19.9
65	106.4	59.5	19.6
70	108.1	61.3	19.1
75	106.9	60.8	19.8
80	106.5	59.4	19.6
85	106.2.	61.8	19.7
90	106.1	61.7	19.0

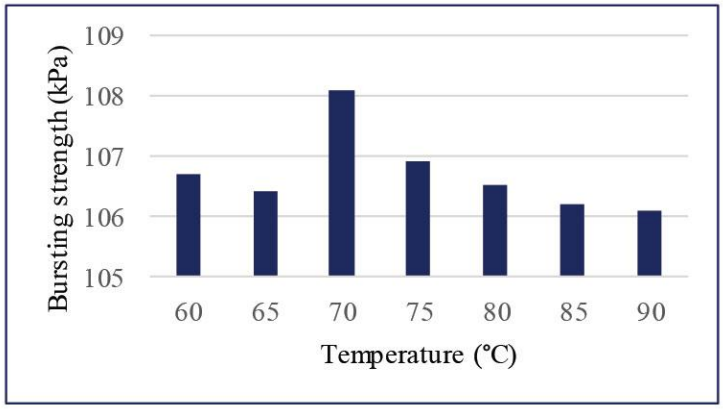

Fig. 4 Effect of temperature variation on bursting strength (rayon portion dyeing)

Table 4 and figure 4 show the bursting strength of knitted fabric when rayon part was dyed with the variation of temperature from 60 to 90°C. From the result, it is clear that there was no significant effect of temperature variation on bursting strength.

3.5 Effect of salt amount on bursting strength

Table 5 Bursting strength with the variation of salt amount

Salt dosing (g/l)	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
20	107.2	61.9	22.0
30	107.9	62	21.9
40	108.3	63.9	21.6
50	107.9	62.8	21.3
60	106.2	62.2	21.0
70	107.3	60.9	21.8
80	107.6	61	21.8
90	107.8	60.9	21.1

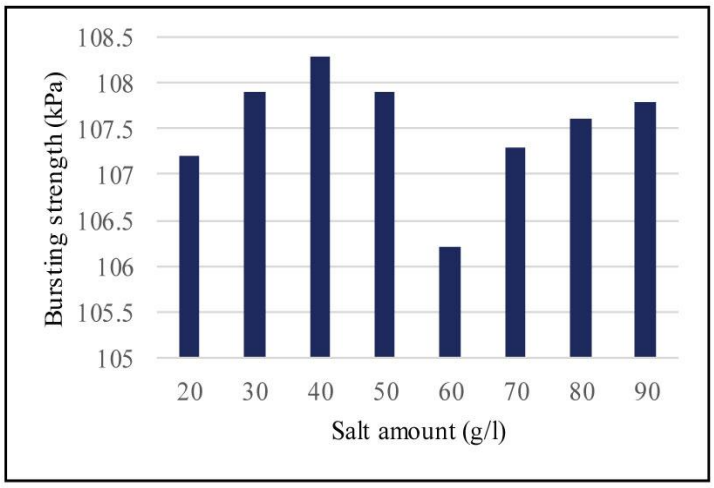

Fig. 5 Effect of salt amount on bursting strength

Table 5 and figure 5 show the bursting strength of knitted fabric when the rayon part was dyed with different amounts of salt (20 to 90 g/l). The result indicates that there was no significant effect of salt amount variation on fabric bursting strength.

3.6 Effect of soda amount on bursting strength

Table 6 Bursting strength with different amount of soda

Soda dosing (g/l)	Bursting strength		
	Strength (kPa)	Area (mm)	Time (sec)
10	106.9	60.5	19.3
15	106.5	60.9	19.8
20	106.1	61.8	19.7
25	107.3	61.2	19.6
30	107.7	61.9	19.0
35	107.9	61.1	18.9
40	108	60.8	19.2
45	108.1	60.1	19.7

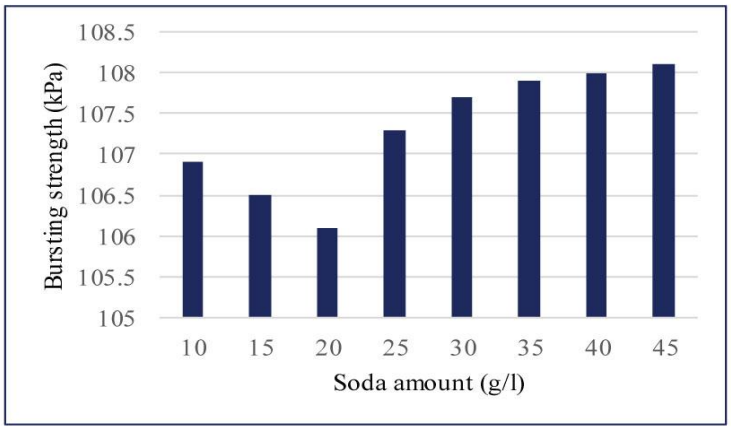

Fig. 6 Effect of soda amount on fabric bursting strength

Table 6 and figure 6 show the bursting strength of knitted fabric when the rayon part was dyed with different amounts of soda (10 to 45 g/l). The result indicates that there was no significant effect of salt amount variation on fabric strength. The range of fabric strength was from 106.1 to 108.1 kPa.

3.7 Effect of different types of salt on bursting strength

Table 7 Bursting strength with different types of salt

Salt	Bursting strength		
	Strength (kPa)	**Area (mm)**	**Time (sec)**
NH_4SO_4	104.9	59.1	19.3
$CaCl_2$	107.5	62.1	19.9
$CaSO_4$	110.1	63.2	19.6
$MgSO_4$	107.1	57.1	20.1
NaCl	106.9	64.1	20.4
Na_2SO_4	108.1	64.2	20.0

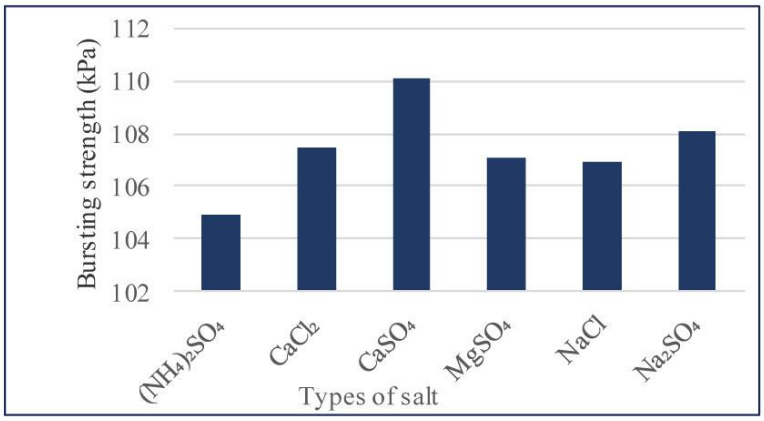

Fig. 7 Effect of different types of salt on bursting strength

The graph mentions the fabric bursting strength for different types of salt when rayon part was dyed. The highest value of fabric bursting strength was 110.1 kPa for $CaSO_4$ and the lowest value was 104.9 kPa for NH_4SO_4.

3.8 Effect of different types of alkali on bursting strength

Table 8: Bursting strength with different types of alkali

Alkali	Bursting strength		
	Strength (kPa)	**Area (mm)**	**Time (sec)**
$CaCO_3$	106.8	60.3	19.2
$MgCO_3$	109.8	63.1	19.9
K_2CO_3	106.1	65.1	20.7
KOH	110.5	67	20.5
Na_2CO_3	109.6	60	20.1
NaOH	107.1	59.7	19.9

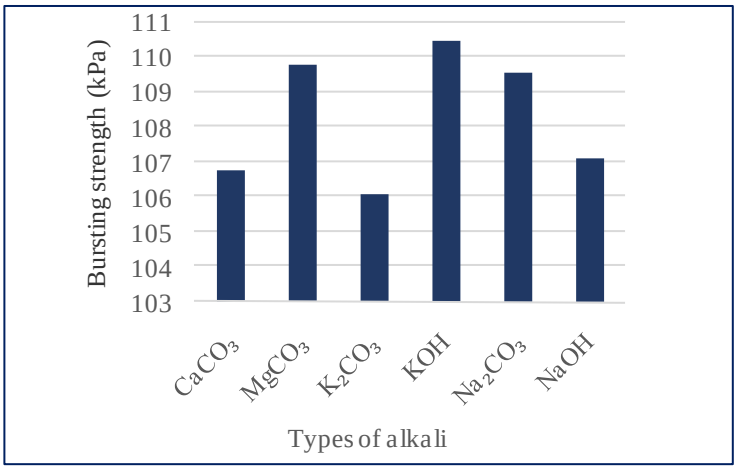

Fig. 8 Effect of different types of alkali on bursting strength

The above table 8, as well as graph 8, show the bursting strength of knitted fabric when the rayon part was dyed with different types of alkali. The highest value was 110.5 kPa for KOH and the lowest value was 106.1 kPa for K_2CO_3. By analyzing the obtained result, it can be said that there was no significant effect of different types of alkali on bursting strength.

4. Conclusions

In this experiment, a standard dyeing parameter was developed for dyeing of polyester and rayon blended fabric with disperse and reactive dye for maintaining the higher value of bursting strength. Here temperature, pH, dispersing agent, salt, soda, and alkali were considered as variable dyeing parameters. This experiment will be helpful for the researchers who are associated with fabric dyeing. It is suggested to conduct more works by varying other dyeing parameters and their effect on different properties of fabric.

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