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Effect of Dyeing Temperature Variation on Various Properties of Rayon Knitted Fabric Dyed with Reactive Dyes

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ABSTRACT : *The main goal of this study is to find the effect of dyeing temperature variation on various properties of rayon knitted fabric dyed with reactive dyes. Commercially scoured bleached fabric with areal density 185 gram per square meter was selected and dyed with reactive dyes and some auxiliaries by varying temperature 30, 40, 50, 60, 70, 80, 90, 100, 110, 120°C with same shade percentage as well as remaining constant all parameters. Then the fabric is subjected to soaping then dried. The color fastness to wash, perspiration, rubbing, fabric strength and color strength (K/S) value were evaluated. The color fastness properties were good to excellent. The highest value of fabric strength was 114.7 showed at 80°C and lowest value was 105.2 showed at 120°C. The highest value of color strength (K/S) was 8.7 showed at 120°C and lowest value was 4.8 showed at 30°C.*
KEYWORDS: *Dyeing, process parameter, color fastness, color strength (K/S), reactive dyes, Viscose Rayon.*

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I. INTRODUCTION

Viscose rayon is a regenerated fiber and now a days used for producing garments. First artificial fiber is artificial silk which is also known as regenerated cellulosic fiber. After that regenerated rayon was produced. It was basically produced from wood pulp [1]. At that time it was used for coating purpose. After that rayon was developed and produced thread and used for embroidery purpose. Then it was further developed and used for producing towels, tablecloth as well as high strength yarn in tyres [2]. For obtaining some exceptional properties like as abrasion resistance, dimensional stability, crease recovery, tensile strength and easy care sometimes rayon is blended with polyester, nylon, acrylic etc. [3]. Silk waste was blended with polyester, viscose rayon and acrylic fibres at a ratio of 50:50 and obtained some excellent properties like as good appearance, long durability and good other properties [4]. Viscose rayon commonly blended with cotton for reducing the cost. The blend results of softness, absorbency of water and more comfort feelings [5]. For surface ornamentation purpose the rayon fabric is subjected to dyeing process. As rayon is a cellulosic fiber it is mostly dyed with reactive dyes for capturing higher value of color fastness properties, different types of shade and ease of application [6-9]. Generally with increasing of temperature the dyeing rate also increased but depending on dyeing process the final exhaustion can be increased or decreased. Dyeing is a heat releasing process. The affinity between dye and fiber is stronger than affinity between dye and water. After absorbing more heat dyeing equilibrium condition is observed. However it moved to heat absorbing stage and the fiber release the dye that's why with the increase of temperature the final exhaustion decreased [10].

Many Scientists conducted research for dyeing of rayon with reactive dyes [11-14]. Dye exhaustion properties of rayon fiber was investigated among three alkali swollen cellulosic fiber and reported that viscose rayon fix least dye [15]. Other researchers investigated that procion type reactive dyes provide different dyeing process for producing pleasant color as well as excellent color fastness properties [16]. Lawalet. al, introduced the effect of sodium hydroxide on both viscose rayon and cotton and reported that dye take up of cotton is very good. Alcohols and water have outstanding effect on cotton fabric but less effect on viscose rayon on the other hand chloroform has more effect on viscose rayon than cotton [17]. Farzana et. al, evaluated the performance of 100% viscose rayon in terms of strength and hydrophobicity or absorbency after scouring and bleaching with two different alkalis named as NaOH and Na_2CO_3. A single stage scouring and bleaching process of the fabric was adopted using NaOH and Na_2CO_3 with varying concentration and with the same processing condition. The

result indicated that a great loss in strength with NaOH as compared to Na_2CO_3. Both alkalis were almost equally efficient for improving absorbency and whiteness [18]. Koh et al, applied two types of direct dyes to regular viscose rayon and a new regenerated cellulosic fiber (en Vix), that was prepared from cellulose acetate fiber through the hydrolysis of acetyl groups and their dyeing and fastness properties were compared. En Vix showed better dye ability and fastness than regular rayon. This phenomena was explained by the differences in the supra molecular structures of the two fibers [19]. Sardag et al, investigated by using 30 tex and 20 tex yarn bobbins consisting of 67% PES and 33% viscose by heat setting at 90°C and 110°C under pressure of 630 mmHg in order to find the effects of heat setting conditions on the properties of twisted yarns. Both heat set and unset yarns were dyed. The tensile strength properties like as tenacity and elongation at break of each yarn were measured before heat setting, after heat setting and after dyeing. The inner, middle and outer side of the yarn bobbins were measured with a spectrophotometer to find differences of color [20]. But nobody investigated the effect of dyeing temperature on properties of rayon knitted fabric dyed with reactive dye. Here an attempt is taken to investigate the effect of dyeing temperature on properties of rayon knitted fabric dyed with reactive dyes.

II. MATERIALS AND METHOD

II.1 Fabric Selection

Industrially scoured bleached single jersey 100% rayon knitted fabric was collected from factory with areal density 185 gram per square meter.

II.2 Sample Preparation

Fabric was cut into small pieces and measured the weight. Each sample was prepared by measuring 10 (±2%) gram weight of fabric. After dyeing with laboratory sample dyeing machine the sample was subjected to some test such as color fastness to wash, color fastness to perspiration, color fastness to rubbing (dry and wet), color fastness to light, bursting strength and color strength (k/S) value.

II.3 Dyeing

The 100% rayon knitted fabric was dyed at different temperature for 60 minutes with 1:10 liquor ratio with IR laboratory dyeing machine (LABORTEX Sample Dyeing machine) by following the below mentioned recipe (Table 1).

TABLE I: Dyeing recipe

Ingredient	Amount
Dychufix yellow 3RXF	1.50%
Dychufix Navy Blue FBXN	1.82%
Rema. Turquise Blue G	1.98%
Glaubar Salt	75 g/l
Soda Ash	18 g/l
Levelling Agent	3 g/l
Sequestering Agent	2 g/l

II.4 Temperature Variation

The fabric was dyed at different temperature like as 30, 40, 50, 60, 70, 80, 90, 100, 110, 120°C with same shade percentage as well as remaining constant all parameters.

II.5 After Treatment

After completing the dyeing process the fabric was subjected to hot wash for 5 times. Then neutralized with acetic acid 2 g/l at 40°C for 15 minutes after that soaping with detergent 3g/l at 85°C for 15 minutes then rinsed with normal water for 5 times and dried with woven dryer at 50°C until fully dried. Now the sample is prepared for test.

II.6 Color Fastness to Wash Measurement

All the test specimen and multi-fiber fabric were cut to 3 cm × 9 cm in size. Then the sample was sewn with multi fiber (Acetate, Cotton, Nylon, Polyester, Acrylic and Wool) fabric by keeping open one side. Solution was prepared with 4 g/l ECE detergent and 1g/l sodium perborate. The test specimen with multi-fiber fabric was put into the solution and run 60°C for 30 minutes in gyro washing machine (James Heal, James H. Heal & Co. Ltd., UK) with 10 pieces still ball. After that rinsed with hot water then by cold water several times. The drying was conducted at 60 °C until dry with woven dryer. At last measured the staining and color change by grey scale and prepared the report according to ISO 105 C06-2010 method.

II.7 Color Fastness to Perspiration Measurement

All the test specimen and multi-fiber fabric were cut to 3 cm × 9 cm in size as well as sewn together. The test specimens were wet acid and alkali medium for 30 minutes at room temperature. The specimens were placed in acrylic resin plates and put the weight on the plates with perspirometer (SDL International Ltd, UK). The specimens placed on oven and maintain the temperature 37°C for 240 minutes. The result was recorded and result was prepared according to ISO 105 E04 for both acid and alkali medium.

II.8 Color Fastness to Rubbing Measurement

Test method ISO 105 × 12 was followed. For measuring dry and wet rubbing each sample was cut into two pieces as 14 cm by 5 cm. The test specimens were rubbed 10 times with cotton rubbing cloth by a crock meter (SDL International Ltd, UK). The color change and staining was measured both for wet and dry test with the scale.

II.9 Bursting Strength Measurement

The bursting strength was measured according to ISO 2758-2003 method. The specimens were cut 50 cm diameter and clamped in a rubber diaphragm by means of an annular clamping ring and an increasing fluid pressure was applied to the underside of the diaphragm until the specimen bursts. The operating fluid was gas and increased in such a way that the specimen bust within 20 ±3 seconds. Bursting strength (Kpa), bursting area (mm) and bursting time (second) were recorded.

II.10 Color Strength Measurement

Color strength was measured with the ratio of K/S value by using Kubelka-Munk equation with data color machine by using ultraviolet radiation. By placing each sample in front of the lens of the machine a plot of each specimen was found. The plot mentioned the depth of color.

III. RESULTS AND DISCUSSION

III.1 Effect of Temperature Variation on Color Fastness to Wash

Depending on temperature variation the test result of color fastness to wash is shown below table 2.

TABLE II: Observed result for color fastness to washing test

Dyeing Temperature (°C)	Color Staining						Color Change
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
30	2-3	3	2-3	2-3	4-5	3-4	4
40	2-3	3-4	2-3	2-3	4-5	2-3	3-4
50	2-3	3-4	3	2-3	4-5	2-3	3-4
60	2-3	3	3	2	4-5	2-3	4
70	2-3	3	3	2	4-5	2-3	3-4
80	3	3	3	2-3	4-5	2	3
90	3	3	3	2-3	4-5	2-3	4
100	3	3	2	2-3	4-5	2-3	3-4
110	3	3-4	2	3	4-5	3	4
120	3	3-4	2	3	4-5	3	4

Here, Grade 5 = Excellent, Grade 4 = Good, Grade 3 = Fair, Grade 2 = Poor, Grade 1 = Very poor

Table 2 showed the result of color fastness to wash properties of rayon fabric dyed with temperature variation. The result indicate that, there is no significant changes of color fastness to wash properties due to temperature variation. The highest value was obtained for 110 and 120°C.

III.2 Effect of Temperature Variation on Color Fastness to Perspiration

Depending on temperature variation the test result of color fastness to perspiration (acid medium) is shown below table 3.

TABLE III: Observed result for color fastness to perspiration test (acidic medium)

Dyeing Temperature (°C)	Color Staining						Color Change
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
30	3-4	2-3	3	4	4	3	4
40	3-4	2-3	3-4	4	4-5	2-3	3-4
50	3-4	2-3	3-4	4	4-5	3	3-4
60	3-4	2-3	3	4	4-5	2-3	4
70	3-4	2-3	3	4	4-5	2-3	4
80	3-4	3	3-4	4-5	4	3-4	3

90	4	2	3-4	4	4-5	2-3	3-4
100	3-4	3-4	3-4	4	4	4	4
110	3-4	3-4	2-3	4	4-5	3	4
120	3-4	4	4	4-5	4-5	4-5	4

Here, Grade 5 = Excellent, Grade 4 = Good, Grade 3 = Fair, Grade 2 = Poor, Grade 1 = Very poor

Table 3 showed the result of color fastness to perspiration (acid medium) for dyeing of rayon fabric with different temperature varied from 30°C to 120°C. The result showed that the temperature affect the color fastness to perspiration (acid medium) properties. Excellent result is observed with increasing of temperature.

Depending on temperature variation the test result of color fastness to perspiration (alkali medium) is shown below table 4.

TABLE IV: Observed result for color fastness to perspiration test (alkali medium)

Dyeing Temperature (°C)	Color Staining						Color Change
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
30	3-4	2	4	4-5	4-5	4	4
40	3-5	2	4	4	4	4	4
50	3-4	2	4	4	4	4	3-4
60	3-4	2	4	4	4-5	4	4
70	3-4	2	4	4	4-5	4	3-4
80	4	3-4	4-5	4	4	4	3
90	4	2	4	4	4	4-5	4
100	4-5	3	4-5	4	4	4-5	3-4
110	4-5	3	4	4	4	4	4
120	4-5	3	4	4-5	4-5	4-5	4

Here, Grade 5 = Excellent, Grade 4 = Good, Grade 3 = Fair, Grade 2 = Poor, Grade 1 = Very poor,

Table 4 showed the result of color fastness to perspiration (alkali medium) for dyeing of rayon fabric with different temperature varied from 30°C to 120°C. The result indicated that the temperature affect the color fastness to perspiration (acid medium) properties. Excellent result is observed with increasing of temperature like as 100, 110 and 120°C.

III.3 Effect of Temperature Variation on Color Fastness to Rubbing

TABLE V: Observed result for color fastness to rubbing test

Dyeing Temperature (°C)	Dry Rubbing	Wet Rubbing
30	4-5	2-3
40	4-5	2-3
50	4-5	2-3
60	4-5	2-3
70	4-5	2-3
80	4-5	2
90	4-5	2
100	4-5	2
110	4	3
120	4	3

Here, Grade 5 = Excellent, Grade 4 = Good, Grade 3 = Fair, Grade 2 = Poor, Grade 1 = Very poor

Table 4 showed the result of color fastness to rubbing for dyeing of rayon fabric with different temperature varied from 30°C to 120°C. The result indicated that the temperature affect the color fastness to rubbing properties. Highest value is obtained with the increased temperature.

III.4 Effect of Temperature Variation on Fabric Strength

TABLE VI: Observed result for bursting strength

Dyeing Temperature (°C)	Bursting Strength		
	Strength (Kpa)	Area (mm)	Time (Sec)
30	112.2	60.2	17.2
40	112.9	61.9	17.2
50	113.2	61.2	17
60	113.5	64.9	17.5

70	114.1	65.1	18.2
80	114.7	65.8	18.9
90	109.9	63.9	17
100	107.7	62.7	16.8
110	106.3	61.2	16.9
120	105.2	59.9	16.3

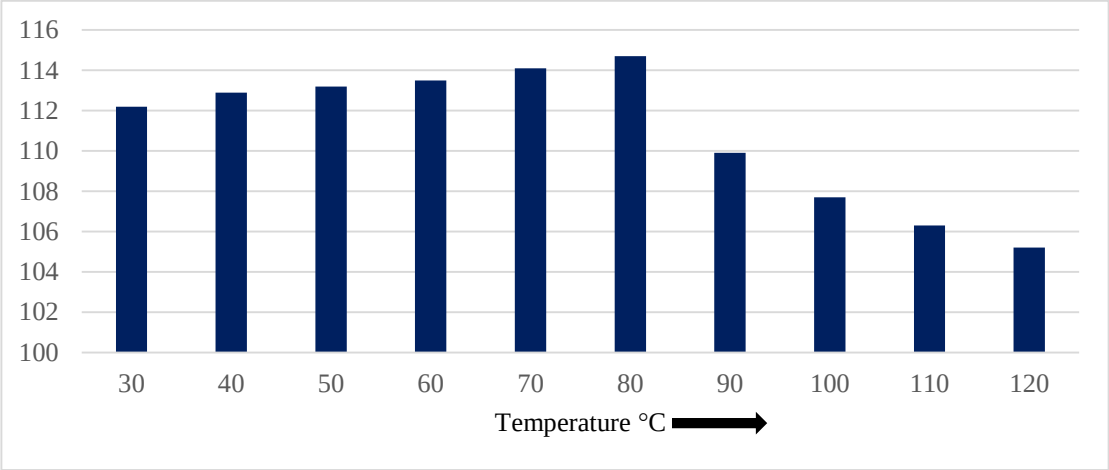

Fig.1. Effect of temperature on fabric strength

Figure 1 showed the fabric strength for dyeing of rayon fabric with different temperature varied from 30°C to 120°C. Results showed that fabric strength decreased with the increasing of temperature from 90°C as well as highest value showed 114.7 at 80°C and lowest value showed 105.2 at 120°C.

III.5 Effect of Temperature Variation on Color Strength (K/S)

TABLE VII: Observed result for color strength (K/S) value

Dyeing Temperature (°C)	Color Strength (K/S)
30	4.8
40	5.1
50	5.9
60	6.7
70	6.9
80	7.1
90	6.9
100	8.1
110	8.5
120	8.7

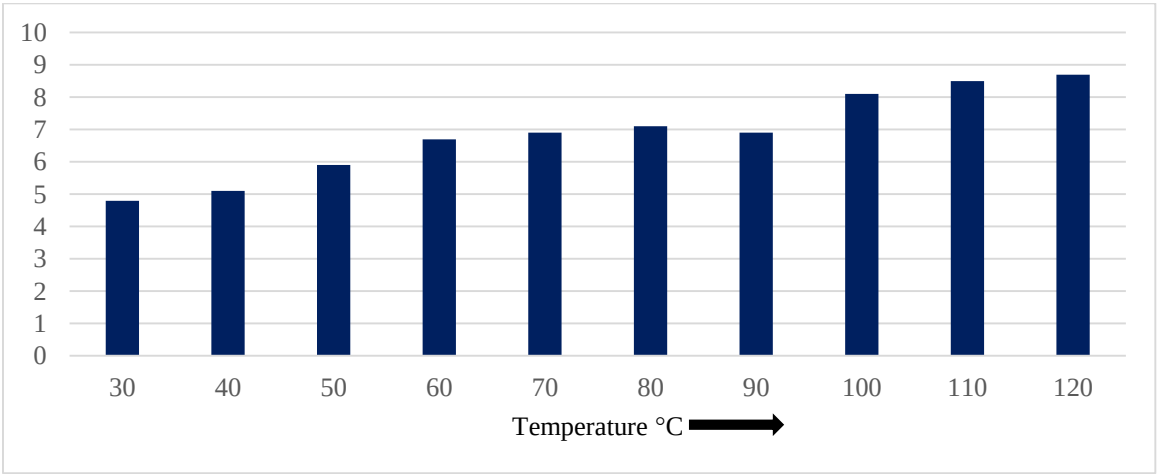

Fig.2. Effect of temperature on color strength (K/S) value

The figure 2 showed the color strength (K/S) value at different temperature. For same dye concentration using some auxiliaries maximum color strength up to 8.7 was found at 120°C and minimum value showed 4.8 at 30°C. It can be concluded that higher temperature is suitable for obtaining higher value of color strength (K/S).

IV. CONCLUSION

The single jersey rayon knitted fabric was dyed by exhaust dyeing method with reactive dye and some auxiliaries by using an Infra-red laboratory sample dyeing machine (LABORTEX Sample Dyeing machine). The temperature varied from 30 to 120 °C but all other parameters remained constant for observing the dyeing effect. Result proved that dyeing temperature has some extent affect the color fastness to wash, perspiration, rubbing as well as prominent effect showed in case of fabric strength and color strength. With increasing temperature more than 80°C the fabric strength decreased on the contrary with the increasing of temperature the color strength (K/S) value increase. This experiment will be very helpful for industrial personnel engaged with dyeing. It is suggested to conduct more work by varying other parameters.

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