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Research Article

Sustainable Approach to Modify the CPD Process for Knit Garments and Analysis the Effect of Curing Treatment on CPD

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Abstract

The purpose of the study is to minimize the energy load of Cold pigment dyeing (CPD) process by minimizing the process steps. As a representative effort in this direction, the current paper describes the effect of curing treatment on Cold pigment dyed garments considering different properties .Samples pretreatment were done in the same bath and same method followed for both samples. In case of dyeing, two different methods i.e. existing (Pad-dry-cure) and experimental (pad-dry) were used to develop the samples. Prepared samples were evaluated in terms of $CMC_{\Delta E}$ value, color fastness properties, drape co-efficient, GSM, fabric strength and surface morphology respectively. Results of the study evinced that experimental process is better than existing process by considering process time and energy savings. Color fastness value of the experimental sample offer comparatively better values than the existing process while other results are within range. Experimental process can reduced up to 6% processing time along with 2.35 Kw power savings for each batch. The experimental (pad-dry) process of CPD will provide a strong economical benchmark for the garments dyeing industry to adopt this sustainable process.

Keywords: Garments dyeing; Cold pigment dyeing (CPD); Curing; Color fastness properties; Drape co-efficient

Introduction

In the fast fashion world when time to market is paramount, the concept of garment dyeing post make up is increasingly adopted by manufacturers [1]. Garment dyeing can be defined [2] as the "application of color to fully fashioned apparel articles, may be in the form of garments cut and sewn either prepared or unprepared knitted fabrics and then dyed, garments and / or components knitted from either prepared or unprepared yarn and then dyed, The benefits of processing good through garment dyeing procedure revolve around quick response with minimize lead time and improved inventory control [3]. It is also increased the challenges of achieving the unique ,fashionable & value added products, while remaining comparative in price similar to reduction in operating margins, the dyeing process should be more economical while producing high value product [4]. Pigments are kinds of insoluble colorants used for fibers, yarns and garments very commonly, which can retain stable chemical structure throughout the coloration process in its dispersed solution [5]. Water-based pigment systems, are eco-friendly pathways. Pigments are dispersed into water with the assist of auxiliaries, such as dispersants, emulsifiers, anti-setting agents, etc. Water-based pigment has been widely applied in coloration for textiles, paints, architecture, and wood and so on [6,7]. The Cold pigment dyeing is one kind of garments dyeing process which give an uneven look at low temperature [8].This process is also referred to as wave dyeing, top dyeing, oil wash and random dyeing. It is a simple and eco-friendly pigment dyeing process obtained by the usage of a binder, fixer along with pigments (any color) [9-11]. The specialty of this process is wide variation on shade range shall be expected and a special hangtag to inform customer this is not a defect is recommended [12]. When such process is carried out, it leads to a loss of many resources such as water, energy, chemicals and dyestuff, time, man-hour, etc. The concept of cleaner production has been practiced for many years in different countries [13]. Such activities include measures such as pollution prevention, source reduction, waste minimization and eco-efficiency. At its heart, the concept is about the prevention rather than the control of environmental pollution and minimizes the carbon footprint also [14]. In this work, the concept of cleaner production including the process modification was carried out by eliminating the curing stage at the experimental process. However, conventionally this process was done in three stages namely pad-dry-cure process which is available in most manufacturing unit. But it is possible to complete the process by two stages i.e. pad-dry, keeping the garments fastness and other properties acceptable. Hence the later process can be effective than existing process as one step is going to be eliminated which means reduction in processing time along with power and cost savings. Experimental result shows that sample developed in pad-dry process posses good properties in comparison with existing process (pad-dry-cure). Thus the experimental process can be used in a manufacturing unit to perform cold pigment dyeing. The purpose of this study is to establish a norm using experimental process which will lead to reduce cost and power in manufacturing unit. Therefore, the processes optimization and modification are the alternative procedures to get the better cold pigment dyeing (CPD) efficiency and environmentally friendly as the cleaner production concept.

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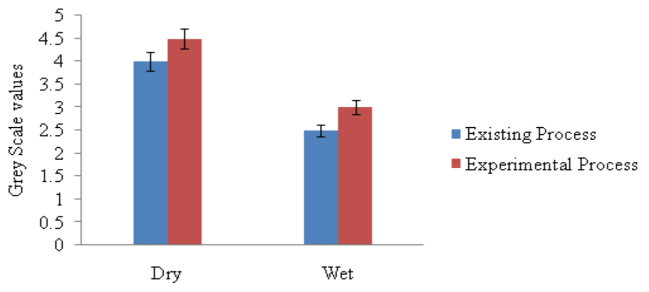

Figure 1: Analysis of Color fastness to rubbing.

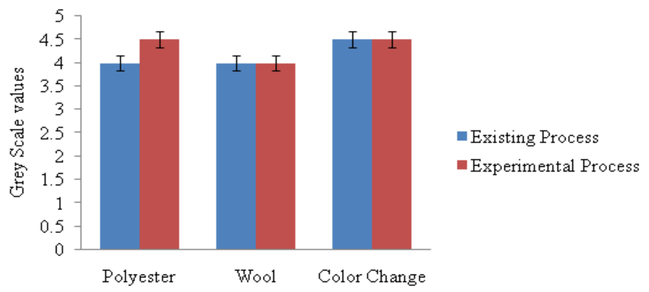

Figure 2: Analysis of Color fastness to washing.

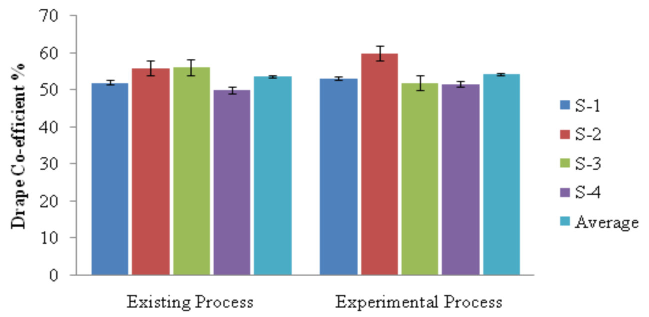

Figure 3: Change of Drape-co efficient.

Methodology

Raw materials

The investigation has been carried out with 100% cotton knit fabric with under mentioned specifications-Fabric type: Single jersey, GSM: 150-160, Yarn type: Combed, Yarn count: Ne-30/1s, Composition: 100% cotton, GG: 28, Form: RFD (Ready for dyeing).

Chemicals

Imarol PCLF. Primafast gold RSL, Acetic acid, Printofix Orange HR, Printofix Red TN, Nk binder R-5HN ,Fixarez Resin FS-465E, Sun-softener (A-300), Ultra-196, Citric acid etc.

Pre-treatment procedure

Samples were scoured and bleached in the single bath. Recipe followed to pre-treat the samples was H2O2 @ 4 g/l, NaOH @ 4 g/l, Na2CO3 @ 3 g/l, wetting agent@ 1 g/l, sequestering agent@ 1g/l, M:L-1:8, time-55 minutes and temperature 950C.

Process steps of cold pigment dyeing (CPD)

Samples were developed by following existing and experimental process where the former one comprises of fast wash → drying →padding→ drying → curing→ softening respectively and the later one followed fast wash → drying → padding → drying → softening respectively. Existing process usually known as pad-dry-cure method where curing is done for fixation of pigments through binder. On the other hand, the experimental process known as pad-dry method follow padding and drying stages only.

Conventional process for Cold pigment dyeing (CPD) (Table 1)

Experimental process for Cold pigment dyeing (CPD) (Table 2)

Testing and analysis

Treated samples were tested using Universal testing machine (Brand: Testometric, Model-M250-3CT, Origin: India); Fabric drape tester (Model-M213, Brand –SDL ATLAS, Origin-UK); Fabric drapeibility was tested according to Cusick Drape test (BS 5058) method, Color fastness to rubbing (Test Method: ISO 105x12), Color fastness to washing (Test Method: ISO 105C06C2S) and $CMC_{\Delta E}$ value was determined by spectrophotometer (Brand: Data color Spectrum, Origin: USA, Model: 650)

Results & Discussion

Measurement of color difference Value at 470nm

$CMC_{\Delta E}$ value between two different processes was estimated from the knit dyed garments. CIE color coordinates include color qualities in terms of L* (lightness and darkness), c* (chroma) and H (hue) of the fabrics are shown in (Table 3). ΔE value contains the information of color depth, shade, and the hue of a sample. ΔE value is calculated by using the CIE L*, a*, and b* values with the equation $\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$ where ΔL*,Δa*, and Δb* values were the difference between L* ,a*, and b* values of a pair of color standard and sample (Rashid et al., 2014). The larger the ΔE value, the greater will be the color difference between the pair of color standard and sample. The experiment was carried out under light source of D65 at 100 and the result shows the satisfactory result remarked as "pass". The acceptable range of $CMC_{\Delta E}$ value is always less than one. So the experimental process is within the acceptable range.

Color fastness to rubbing

Color fastness to rubbing assessment was done for both samples prepared by existing and experimental process. This test indicates the resistance of color fading during rubbing in wet and dry condition where wet rubbing for a sample remain always less than dry rub. Figure 1 shows the increased values of the sample prepared in experimental process which means color resistance to rub both in dry and wet condition of the experimental sample is much higher than existing process. This happens when shade become deeper during curing process. There were no significant changes observed between the existing and experimental process results. However the color fastness for wet condition is lower than the dry process as always pigments shows low in rubbing fastness results.

Color fastness to washing

During experiment, color fastness to wash properties of the prepared sample was determined which indicates the resistance of a color during washing. This is assessed by color staining and color change principles where sample is treated with a tertiary fabric constructed with multiple fibers. This test shows (Figure 2) good wash

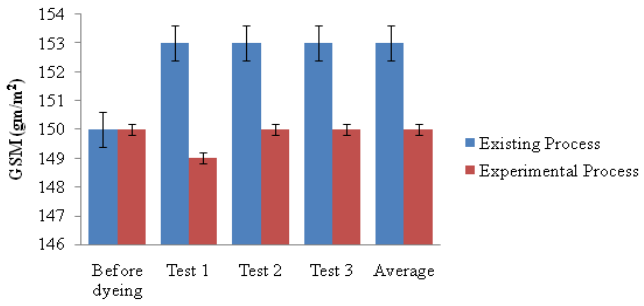

Figure 4: Measurement of fabric weight (gm/m²).

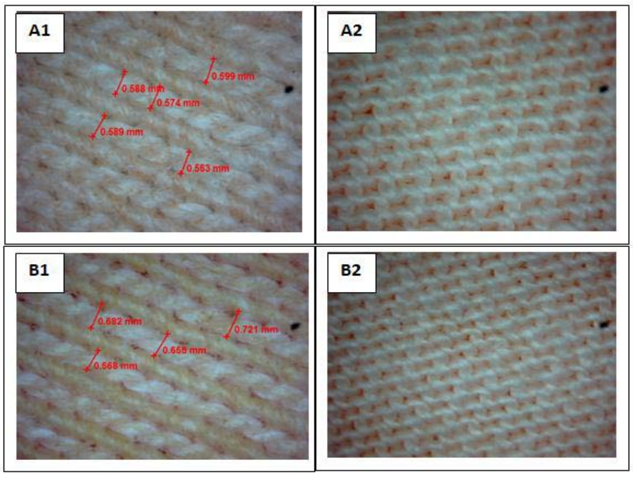

Figure 5: A1) Face side of experimental sample; A2) Back side of experimental sample; B1) Face side of conventional sample; B2) Back side of conventional sample.

fastness for color changed and staining of the experimental process compared to the existing process.

Effect on drape co-efficient values

Drape co-efficient value of the samples prepared in existing and experimental process were measured. Four samples from each side were measured during testing. Results shows that existing process sample posses lower drape co-efficient value than experimental process sample which means the former one more flexible and drapeable than the new one. This may happens due to curing operation where high temperature is applied to garments results softer garments. But the average drape co-efficient value of both samples is close to each other (Figure 3) with a variation 0.6% which is acceptable.

Effect on GSM value after dyeing

GSM value of the samples were determined which indicates that after dyeing gsm has increased in existing process as dye molecules added during dyeing process (Figure 4) results increase in fabric weight per unit area. On the other hand GSM value of the sample prepared in experimental process get down which may be the cause of bio-polishing or enzyme wash. it may also happened due to the contractions of knit loops due to the effect of curing as a results the experimental process samples shows minor variation of GSM value to the existing process . As the variance between the results was 1.9% which is less than the standard tolerance limits (5%)

Table 1: Process Time and Energy for Conventional process.

Processing stage	Temp(°C)	Process Time(min)
Fast wash	55	30 min
Hydro-extracting	Room	3 min
Drying	90	30 min
Padding	Room	
Hydro-extracting	Room	3 min
Drying	90	40 min
Curing	130	10 min
Softening	Room	10
Hydro-extracting	Room	3 min
Drying	90	40 min
		Total Time= 169 min

Table 2: Process Time and Energy for Experimental process.

Processing stage	Temp(°C)	Process Time(min)
Fast wash	55	30 min
Hydro-extracting	Room	3 min
Drying	90	30 min
Padding	Room	
Hydro-extracting	Room	3 min
Drying	90	40 min
Softening	Room	10
Hydro-extracting	Room	3 min
Drying	90	40 min
		Total Time = 159 min

Table 3: $CMC_{\Delta E}$ value analysis of CPD process.

Process	L*	C*	H*	$CMC_{\Delta E}$	Comments
Existing	73.92	39.14	41.86	0.48	Pass
Experimental	74.16	39.77	42.43		

Table 4: Measurement of bursting strength for experimental process.

No of Trial	Bursting strength (N)	Stress @ Break (N/mm²)
1	151.89	0.096
2	177.11	0.111
Min	151.89	0.096
Mean	164.50	0.103

Table 5: Measurement of bursting strength for existing process.

No of Trial	Bursting strength (N)	Stress @ Break (N/mm²)
1	167.89	0.106
2	163.65	0.103
min	163.65	0.103
mean	165.77	0.105

Bursting strength

From (Table 4,5), it can be seen that average bursting strength is 164.50 N for experimental process where as in the conventional process the sample valued 165.77N Also the stress at break keep increasing trend. In this analysis the samples of conventional process shows slightly higher strength .This can be explained that the value of conventional process samples for strength due to the contraction of loops contributing compact structure of the fabric surface. However, the extent of change is not very significant. This reveals that the physical properties of experimental samples are not affected by curing treatment significantly.

Surface morphology

Microscopy analysis was done by digital microscope at 5X zoom. The face part and back part for both experimental and existing process were analyzed. Figure 5 represents that existing samples posses sharp lines along the wales, where as experimental process reflect a relaxed fullness structure. Moreover, curing treatment also can a reason for influencing the surface difference between conventional (pad-dry-cure) and the experimental process (pad-dry).

Reduction in processing time and energy

A significant difference exists in the processing time and temperature of the existing and experimental process. Reduction in processing time means reduction in cost also. Since the experimental process offers the elimination of curing during whole process that's why it is possible to eliminate curing time. The experimental process can save up to 6% of total process time and 19% energy for each batch of production. Moreover as a curing machine consume 14.1 Kw/hrs; the experimental process can save power up to 2.35 Kw as the curing step was eliminated from the proposed process.

Conclusion

In this study a typical comparison between existing (pad-dry-cure) and experimental (pad-dry) process has been done through evaluation of different properties along with processing time and power consumption for samples prepared in both process for cold pigment dyeing. Experiment shows that the existing process posses' better result for GSM, Drape co-efficient values whereas experimental process values are within tolerance for which these are acceptable so far. For shades both samples CMCΔE value are within accepted limit. But considering color fastness properties to rubbing and washing it can be clearly stated that experimental process is better than existing one. Besides, the later one requires less power and processing time which is an indicator for cost reduction.

Acknowledgement

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