International Journal of Engineering Research and Development
ISSN: 2278-067X, Volume 1, Issue 10 (June 2012), PP.72-79
www.ijerd.com

Colour Analysis of Fancy Yarns Produced on Innovative Mechanical Crimp Texturising Apparatus

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Abstract—*Mechanical crimp texturising technique is making use of differential migration behavior of the constituent filaments during their torsional deformation as well as bending deformation. Types of yarn, yarn fineness, filament fineness, shape factor etc. are the detrimental factors for these extents of deformations. Fully drawn continuous filament yarns with contrasting colours, apart from variation in one or more contributing factors mentioned above were grouped together for the desired production of fancy yarns. Structure of fancy yarn was analyzed by microscopical examination. The colour analysis of the product yarn was also done on Hunter lab colour measurement instrument Spectra Span 9100. This has permitted in identifying apparent colour of fancy yarn scientifically, which is different than its parent yarn colour.*

Favorable transformation of cheaper and stronger flat filament feeder yarn structure to favourable crimpy/bulky yarn structure was an added gain of this production process. All the samples were also shown good crimp associated properties. Thus newly designed fancy yarn produced out of flat filament yarn found to be a good option for value addition along with added comfort to apparel textiles as well as home furnishing.

KeyWords - Fancy yarn, Fineness, Torsional rigidity, Bending rigidity, Colour analysis

I. INTRODUCTION

Fancy yarns essentially give fashion touches to a fabric, and they have therefore a broad range of end users. A significant market segment is ladies outwear. Furnishing is also an important market area particularly curtains, blinds and wall coverings and upholstery. Application of fancy yarns includes Denim, knitted wear, formal wears and home textiles ([1], [2]).

Three main methods are adopted in the commercial market for the production of fancy yarn, viz; Ring twisting method, Hollow spindle method and Open end rotor spinning method. All of them are providing fancy effect to the parent supply yarns due to their difference in fineness, colour, extension, type, functional properties etc. Parent yarns can either be staple fiber yarns or filament yarns or combination of both ([2], [3]). Thus with the depth of available technologies the range is restricted only by functional integrity. They cannot impart fancy imagination and commercial acceptance to purely flat filament supply yarns.

An innovative mechanical crimp texturising method is working on differential migration behavior of constituent flat filaments of supply yarn during texturising ([4], [5]). This phenomenon has been made use of in the present research for obtaining fancy yarn directly from flat multifilament feeder yarns with differential migration properties along with difference in colour. Hence it becomes necessary to undergo for their colour analysis of product fancy yarns in priority to evaluate value addition in terms of texture. This helps in updating theoretical record of apparent colour for the product yarn with reference to the process variables and material variables used during the production course. Apart from that all the product yarns comfort properties as well as mechanical properties were measured to identify their competency for the forthcoming processes.

II. EXPERIMENTAL

2.1 Materials

Fully drawn multifilament polyester yarns with contrasting colours, differing in fineness and denier per filament (dpf) are used in the group of two for the production of fancy yarn. All the parent yarns fineness, number of filaments per cross section, percent boiling water shrinkage and mechanical properties are reported in table 1.

Table 1: Properties of parent yarn

Parent yarn specifications	**Tenacity (g/tex)**	**Extension (%)**	**Boiling water shrinkage (%)**
Black: 50d /36fils.; 1.39 dpf; Trilobal	3.8	26	2.5
Gold : 75d /36fils.; 2.08dpf; Trilobal	3.1	25	6.1
White : 100d /48fils.; 2.08 dpf; Circular	3.6	52	1.7
Pink : 150d /72fils.; 2.08 dpf; Trilobal	4.1	14	3.1
Green : 150d /72fils.; 2.08 dpf; Trilobal	2.7	20	3.2
Mélange: 150d /16fils.; 9.38 dpf; Circular	2.4	23	2.5

- ***dpf = denier per filament***

2.2 Methods

Mechanical crimp texturising apparatus was used to produce desired fancy yarns. Earlier publications ([4], [6]) have in depth description of this innovative texturising method and apparatus. So, only the brief mention of the method adopted for the production of fancy yarns have been given here.

2.2.1 Fancy Yarn Production by Mechanical Crimp Texturising.

Two Parent yarns are grouped in two ways. In first group constituent yarns cross section is kept same (trilobal) as the base yarn irrespective of filament fineness (dpf). Whereas for the second group base yarn and constituent yarn filament fineness (dpf) as well as cross section both are varying. Details of grouping are given in table 2.

Both the constituent yarns in a group are wound parallel on assembly winder at tex/2 tension to prepare suitable supply package for mechanical crimp texturising.

Table 2: **Grouping details of parent yarns**

Group No.	**Sample code**	**Base yarn**	**Constituent yarn**
I	F1	Green	Black
	F2		Gold
	F3		Pink
II	F4	Gold	White
	F5		Mélange

Assembled fully drawn multifilament yarns were pre-twisted by two for one twister. Amount of pre-twist 200 tpm (5 tpi) was kept constant throughout the study. Pre-twisted yarns were then under fed via a system of idler feed roller system and rotating twist trapper wheel to the bulking zone. The nominal underfeed of 5% was used to prevent undue ballooning at the bulking zone in accordance with pre-tensioner. Rate of underfeed is regulated by constant extension system, where the linear speed of the yarn through the feeding device being less than the linear speed of the yarn taken up by the winding mechanism by the amount of underfeed desirable.

Mechanical tensiometer was used to measure pre-tension. Feeder yarns were then subjected to a rotating false-twist spindle to give an optimum false twist. The optimum false-twist level K (tpm) has been calculated based on assembled yarn fineness (D in denier) using equation 2.1. This expression is derived experimentally for polyester yarn for mechanical crimp texturising [6].

$K\ (tpm) = 7151.7 - 53.9\,D + 0.2\,D^2 - 0.000255\,D^3$ ----- (Equation 2.1)

Finally fancy yarn was taken up by delivery roller and wound on the bobbin. Texturising was carried out at constant 200m/min delivery speed for all the samples.

2.2.2 Testing of Fancy Yarns

a. Structural Features:

Fancy yarns were checked for their structural characteristics at 10-X magnification under PARCO Ltd. Microscope. Microscopic views of yarns were photographed by a SONY digital camera having 7.3 mega pixels.

b. Mechanical Properties:

Computer aided Lloyd tensile tester–LRX model working on CRE (constant rate of extension) method was used for the tensile strength and extension measurements. Average tenacity and percent extension values were directly obtained from the recorder on the basis of 10 tests per samples. The test specification used during study is given below,

- Gauge length: 500 mm
- Cross-head speed: 300 mm/min

c. Physical Bulk:

Wray et al. [8] have established percent water absorption as one of the measures for expressing physical bulk. It was measured according to ASTM D5701. 1 gram of each sample was taken and dried in an oven at a temperature of 100 °C ± 2°C for two hours. The oven dried samples were weighed immediately on electronic balance with 0.01 gm accuracy to get oven dried weight (w_1). Then the samples were immersed in distilled water and kept for 24 hours. After taking out the samples, the extra water was soaked by blotting papers. The wet samples were weighed on the same balance to get wet weight w_2.

$Percent\ water\ absorption = \frac{W_2 - W_1}{W_1} \times 100$ ………. (Equation 2.2)

d. Percent Instability:

The Du Pont method [9] was used to measure the instability of curls.

e. Boiling water shrinkage:

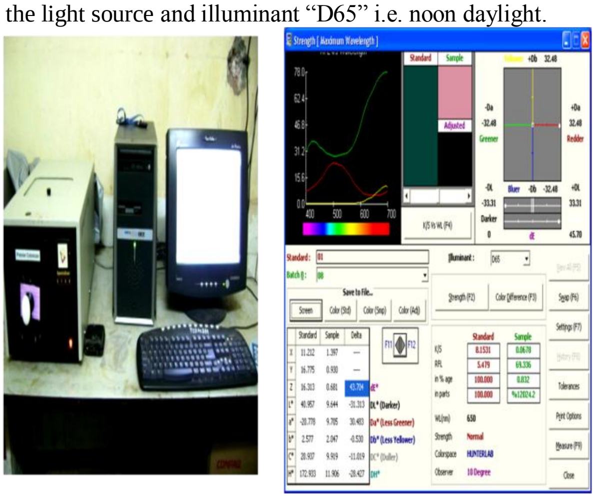
It was measured according to BISFA method [10].

f. Long term Regularity:

The yarns were wrapped on the boards (5 inch x 5 inch) using a motor driven wrapper machine manufactured at a constant tension of 0.01 gm/denier. Ten boards were prepared per sample to view the regularity of the fancy yarns over longer lengths. For confirming regularity, over longer length, boards were prepared from different layers of bobbins.

g. Colour Analysis:

Each fancy yarn composed of combination of two different colored component yarns interlocked in a peculiar pattern. Therefore the apparent colour of the product yarn must be different to that of the original ones. Colour refers to a property of dye-stuff for textile technologists. This is purely a subjective measure. Though technique has been developed to measure colour physically and it's recording for the reproduction of the same colour. The colour analysis of fancy yarns was carried out using Hunterlab Spectra scan 9100 [figure 1(a)] by using densely wrapped boards of fancy yarns. Graphs were taken using CIE L*A*B* and Hunterlab colour scale [figure 1(b)]. The measurement conditions used are given below;
Standard observer function: 10 deg
Mode: Reflectance
Formula: CIE 769, hunter,
Maximum wavelength: 650 nm
Readings were taken considering the light source and illuminant "D65" i.e. noon daylight.



a) Spectra scan 9100 b) Hunter Lab software

Figure 1: **Arrangement for colour Analysis**

Hunter lab software generated the actual colour of the product yarn in terms of X, Y, Z, L, a, b, c, H .These values fed to online colour calculator software [figure 2] and html colour code was obtained([11],[12],[13],[14]). These colour codes were then matched with the online available html colour codes to find out the correct colour of the yarn ([15], [16]).

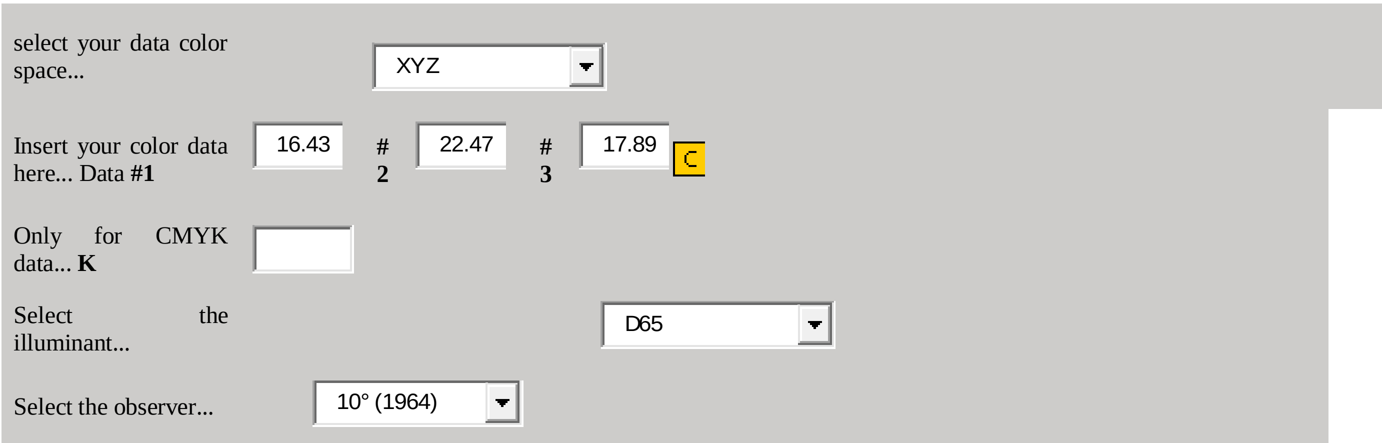


Figure 2: Outline of the software used for colour calculation.

III. RESULTS AND DISCUSSION

Fancy yarn structure in general is nothing else but mechanical crimp textured doubled (assembled) yarns. So the behaviour of the fancy yarns was expected to follow similar trend of single end textured yarns in terms of their mechanical and texturising properties.

Difference in migration and crimping pattern was observed for component yarns on texturising. This was mainly attributed to difference in their bending rigidity and torsional rigidity owing to difference in filament fineness, yarn fineness and shape factor for identical type of yarn (table 1). As a result of these one or two variations constituent flat filaments have taken the shape of a helical spring at different amplitude and frequency. The fancy effect so introduced were well locked in their position by crossed curls as well as pre-twist reinserted back on leaving the bulking zone. Crossing curls have occurred due to migration of filaments at high false-twist level from core to sheath and back again. Since component yarns were having different colour coding, their different response against deformation has apparently introduced peculiar discontinuity in the form of colour and pattern of curls formed [figure 3]. However, fancy effect introduced differs for all the samples under consideration.

Figure 3 **Microscopical Views for Fancy yarns**

Yarn constitute of finer filaments with higher extensibility [table 1] has covered the surface area of the all the product yarns under study, e.g. sample F_1 green filaments have covered more surface area. Effect of shape factor is superseded by filament fineness as well as number of filaments in both the groups. Sample F_2 in group I has both the constituent with trilobal cross section but green filaments with double in the number has covered up the surface area. Similarly for sample F4 both the constituent filaments have same fineness. White filaments although have circular cross section but more in number than trilobal cross section gold filaments, have covered the surface region.

Long term uniformity of the structure is apparently seen from the wrapping board photographic view [figure 4].

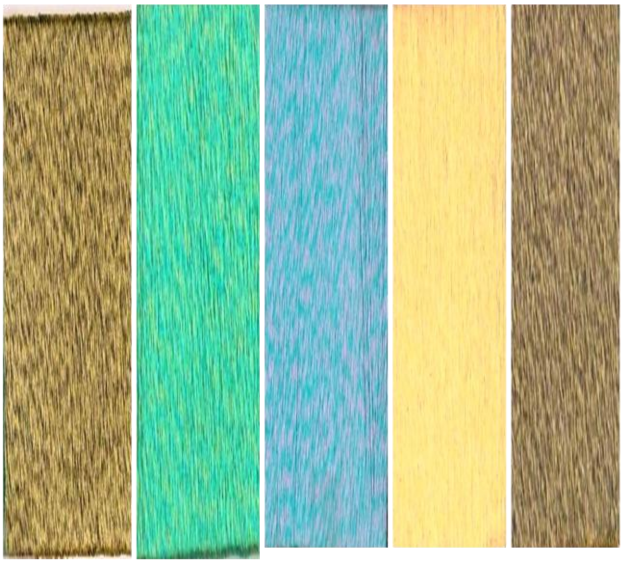


Figure 4 **Wrapping board of Fancy Yarns**

Mechanical properties of the assembled feeder yarn and fancy yarn produced out of them on texturising are reported in table 3. It is apparently seen that all the fancy yarns have executed higher tenacity as well as percent extension as compared to their feeder assembled yarns.

This is mainly due to the presence of crimps in the structure of the textured yarns. Texturising has improved inter-filament cohesion by entanglement. They have introduced due to different path lengths followed by various filaments in the yarn as they bend into different configuration. The mutual cohesion between filaments has also prevented a weak place in one filament from being extended more than the neighbouring filaments. The mutual support delayed the occurrence of rupture and so increased the breaking extension of the yarn after texturing ([17], [18]).

Table 3: Mechanical Properties of Assembled Yarn (A) and Fancy yarn (F)

Group	Sample code	Base yarn	Constituent yarn	Tenacity (g/d)		Extension (%)	
				A	F	A	F
I	F1	Green	Black	3	3.2	28	33
	F2		Gold	2.9	3.6	29	39
	F3		Pink	3.2	3.4	21	28
II	F4	Gold	White	3.2	3.8	35	53
	F5		Mélange	3	3.4	25	40

Degree of crimpiness attained on texturising attributes mainly to the texturising characteristics of the product yarn. Higher the degree of crimpiness more will be the percent boiling water shrinkage as well as physical bulk [19]. All the results have substantiated this finding (table 4). As percent water absorption is in direct proportion to the physical bulk of textured yarn appropriate rise has been recorded in the product yarn values for the same [8].

Table 4: Texturising Properties of Assembled Yarn (A) and Fancy yarn (F)

Group	Sample code	Base yarn	Constituent yarn	Boiling water shrinkage (%)		Instability (%)	Water Absorption (%)	
				A	F	F	A	F
I	F1	Green	Black	3	4	1.2	95	541
	F2		Gold	5.6	6	1.4	120	501
	F3		Pink	3.6	4.5	1.1	96	512
II	F4	Gold	White	4.5	6	1.2	126	505
	F5		Mélange	4.8	6	1.5	120	586

Each fancy yarn was composed of two different coloured component yarns interlocked in a peculiar pattern. Therefore the apparent colours of the product yarn were different to that of the original ones. So each fancy yarn was checked for its colour value in terms of X, Y, Z, a, b, c by using spectroscopy test. Here two different formulas one is CIE and other is hunter lab were used. Test results are given in table 5 and table 6 respectively. It is seen apparently that yarn colour values in terms of X, Y, Z co ordinates are almost identical for both the systems.

Table 5. Colo**ur** data taking into consideration CIE-76 formula

Formula	CIE-76			**Source**	D65			
Observer	10 deg			**Unit**				
Sample	**X**	**Y**	**Z**	**L**	**a**	**b**	**C**	**H**
A	17.94	26.93	27.71	58.91	-35.84	1.79	35.88	177.13
B	16.43	22.47	17.89	54.52	-25.22	11.52	27.72	155.46
C	12.48	12.77	9.25	42.41	2.58	12.35	12.62	78.19
D	12.96	13.11	8.42	42.94	3.55	15.99	16.38	77.46
E	42.98	40.73	23.63	69.99	13.45	27.48	30.60	63.89
F	36.41	31.31	47.05	62.76	23.92	-16.14	28.86	326.01
H	8.81	12.91	13.91	42.63	-26.26	-0.15	26.26	180.32
I	8.79	13.68	14.59	43.76	-31.32	0.20	31.32	179.64

[041710105] MS - SAM – A,
[041710157] MS - SAM – B,
[041710250] MS - SAM – C,
[041710412] MS - SAM – D,
[041710507] MS - SAM – E,
[041710551] MS - SAM – F,
[041710818] MS - SAM – H,
[041710917] MS - SAM – I.

Table 6 Colour data considering hunter lab formula.

Formula	HUNTER			**Source**	D65	
Observer	10 Degree			**Unit**		
Shade Name	**X**	**Y**	**Z**	**L**	**a**	**b**
[041710105] MS - SAM – F1	17.94	26.93	27.71	51.9	-26.56	1.42
[041710507] MS - SAM – F2	42.98	40.73	23.63	63.82	12.4	19.57
[041710551] MS - SAM – F3	36.41	31.31	47.05	55.95	21.82	-14.96
[041710157] MS - SAM – F4	16.43	22.47	17.89	47.4	-18.66	8.16
[041710818]	8.81	12.91	13.91	35.93	-	-0.11

MS - SAM – F5					17.34	
Formula	HUNTER			**Source**	D65	

Table 7 gives the html colour codes and the names of the colour obtained from the software (figure 2) for the samples under study.

Table 7: HTML codes and colour of the fancy yarn.

Sample code	**Base yarn**	**Constituent yarn**	**HTML code**	**Colour**
F1	Green	Black	#309E88	Sea green
F2	Green	Gold	#D3A179	copper
F3	Green	Pink	#B58AB4	Lavender
F4	Gold	White	#588E6D	Light golden rod
F5	Gold	Mélange	#247063	Hunter green

It is seen that colour values so obtained show good resemblance with wrapping board apparent colour [figure 4].

IV. CONCLUSION

Mechanical crimp texturising has proven its strength in creating fancy effect out of assembled flat continuous multifilament yarns by making use of bending deformation and torsional deformation. Contrasting colour parent yarns were selected with variation in terms of their yarn fineness, filament fineness, number of filaments and shape factor, the major contributing variables to bending stiffness and torsional rigidity of yarn. Filament fineness and number of filaments have played a decisive role in defining product yarn colour pattern.

Each fancy yarn composed of two different coloured component yarns interlocked in a peculiar pattern was checked for its colour value in terms of X, Y, Z, a, b, c by using spectroscopy test. Colo**ur** data taking into consideration CIE-76 formula and hunter lab formula gave the values which can be used in the software to get the exact colour html code. The name of the colour was obtained using this colour code. This makes easier for understanding the colour effect during the production of fancy yarn.

These fancy yarns have also executed good stability of the newly acquired crimpy configuration. They have also shown higher affinity to the water due to resultant bulky structure on texturising. Presence of crimps have added to the percent boiling water shrinkage of this newly engineered yarn.

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