THE QUALITY OF FANCY YARN: PART II: PRACTICAL EXPERIMENTS AND APPLICATION

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ABSTRACT

The concepts, parameters of assessing the structure, appearance and quality of several types of fancy yarn were presented in Part I of this paper. Further, the methods, procedures and apparatus needed to apply such concepts and parameters were also detailed in Part I. In Part II of this paper, however, those methods were applied to account for the structure and quality of several overfed fancy yarns, gimp yarns and bouclé yarns. The Area of Fancy Profile, the Number of Fancy Profiles, the Shape Factor of Fancy Yarn (ShF), the Relative Shape of Fancy Yarn (RSI) and Circularity Ratio of Fancy Profile (CR) were used to account for those types of fancy yarn. Based on those methods, it was possible to assess the structure and quality of the fancy yarns and to arrange them in ascending (or descending) order in terms of their quality, e.g. texture, structure, and fancy bulkiness. Further, a comparison between those methods and the traditional subjective method of quality assessments of fancy yarns revealed high levels of agreement.

KEYWORDS: Overfed Fancy Yarn, Gimp Yarn, Bouclé Yarn, the Shape Factor of Fancy Yarn, the Relative Shape Index of Fancy Yarn, the Area of Fancy Profile, the Number of Fancy Profiles, the Circularity Ratio of Fancy Profile.

INTRODUCTION

Gimp yarn is defined as: “a compound yarn consisting of a twisted core with an effect yarn wrapped around it so as to produce wavy projections on its surface” (Gong & Wright, 2002). The effect component could be one or more strands (Tortora & Merkel, 2005), but it is usually thicker and coarser than the core component(s) (Denton & Daniels, 2002; Tortora & Merkel, 2005). Gimp yarns, bouclé yarns and loop yarns belong to the same group of fancy yarn. However, whilst the effect on the surface of gimp yarns are semi-circular corrugations, they are irregular, semi-circular loops in bouclé yarns and circular loops in loop yarns (Denton & Daniels, 2002). Regardless of the method of making them, gimp yarns have a general structure as shown in Figure 1.

Figure 1: Gimp Yarn Structure, Adapted from (Gong & Wright, 2002)

Bouclé profiles take usually the shape provided in Figure 2 in which they are open projections but not circular (Gong & Wright, 2002). The term “bouclé profile” also refers to a fancy profile which has the shape of one phase of sine wave where the height of this phase is greater than, or equal to, the width of the base of this phase. Bouclé yarns may have other profiles which is similar to bouclé profiles, and they may be called either semi-bouclé profiles or bouclé-like profiles.

They are usually semi-twisted but not completely closed and may include U-shaped profiles; elongated loop profiles, which may be semi-circular, closed profiles; and open-based, flexed bouclé profiles. Those semi-bouclé profiles may result on the fancy yarn surface due to three reasons. The first reason is winding of the bouclé yarn on packages. The second reason is internal stresses in the effect thread, e.g. when the effect thread(s) is an unbalanced ply yarn. The third reason is a defective effect thread that has at least a point having relatively low value of bending stiffness which makes the thread bends irregularly. Bouclé projections are the *apparent* bouclé profiles which protrude on the yarn surface and can be identified readily. They need no further effort to make sure they exist. They usually attract the attention of an assessor of bouclé yarns. The other types of bouclé profile which exist on the yarn surface, but they do not project over the yarn surface are called *unapparent* bouclé profiles. Those unapparent bouclé profiles lie on the yarn surface because of the winding process, unbalanced ply effect thread or due to defects in the effect thread(s) and they are not easily visible.

Due to their importance, this study will apply the objective methods, concepts and parameters suggested by the author in Part I of this paper to assess the quality of gimp yarns, boucle yarns and overfed fancy yarns (Alshukur, 2013).

Figure 2: Structure of Bouclé Yarn, adapted from (Rameshkumar)

THE APPLICATION OF THE OBJECTIVE METHODS TO ASSESS THE STRUCTURE AND QUALITY OF GIMP YARNS AND OVERFED FANCY YARNS

The Shape Factor of Fancy Yarns (ShF), measured in mm^2/m , was used to assess the quality of the gimp yarns. The $\text{ShF} = N \cdot A$ where N is the Number of Fancy Profiles, i.e. average number of the non-gimp profiles in a unit length of the gimp yarn, (measured usually in m^{-1} for gimp yarns), and A is the Area of Fancy Profile, i.e. the average area (or size) of non-gimp profile (measured usually mm^2). To use the ShF to evaluate the structure and quality of gimp yarn, one needs to follow the following procedures:

1. The normal structure of any gimp yarn is usually perfect sigmoidal as provided in Figure 1. Based on the methods of Part I of this paper, this kind of structure needs no further measurement.
2. The value of the $\text{ShF}=0 \text{ mm}^2/\text{m}$ for gimp yarns that have sigmoidal configuration of the structure.
3. Deviations from such a sigmoidal structure will appear on the surface of gimp yarn as a few non-gimp projections. Those can be fancy projections of various shapes, i.e. bouclé profiles, arches, bunches, knots, etc., and are described as abnormal projections on the gimp yarn surface.
4. Abnormal projections may be measured using the Number of Fancy Profiles, the Area of Fancy Profile, the Shape Factor of Fancy Yarn and the Circularity Ratio of Fancy Profile.
5. The smaller the value of the ShF of those non-gimp profiles the better the quality of gimp yarns.

6. Using the value of the ShF, the quality of gimp yarns may be excellent, very good, good, acceptable or poor. This last category cannot be sold as a gimp yarn, but it can be sold as a general overfed fancy yarn which does not have any specific commercial designation or name.
7. Finally, to compare the relative fancy bulkiness of several gimp yarns, one may use the value of the Relative Shape Index of Fancy Yarn (RSI). The RSI is given by the formula $RSI = ShF / T_{tex}$ where T_{tex} is the linear density of the fancy yarn in tex.

Three experiments were conducted to show the applicability of the quality methods of Part I this paper to gimp yarns and overfed fancy yarns. For all these experiments it was observed that some of the fancy yarns were overfed fancy yarns and had no any other commercial description. Therefore, they were tested within the gimp fancy yarn group. The three experiments were conducted as follows:

- Experiment I to make gimp yarns and overfed fancy yarn using various input yarns, machine settings and fancy yarn structural parameters.
- Experiment II to make three groups of fancy yarns based on three groups of input yarns.
- Experiment III to make three group of fancy yarns based on three value of the overfeed ratio.

Materials and Machine Settings of Experiment I, Experiment II and Experiment III

Types and forms of the constituent threads were used to make the gimp yarns for Experiment I are provided in Table 1.

Table 1: The Input Materials Used to Make the Gimp Yarns for Experiment I

Yarn Number	Effect Component	Core Component	Binder
1	24s/3 bamboo	20s cotton	polyester 167/34
2	30s/3 cotton	20s cotton	polyester 167/34
3	24s/3 bamboo	20s cotton	nylon 145/77
4	30s/3 cotton	20s cotton	nylon 145/77
5	24s/3 bamboo	30s/2 cotton	polyester 167/34
6	30s/3 cotton	30s/2 cotton	polyester 167/34
7	24s/3 bamboo	30s/2 cotton	nylon 145/77
8	30s/3 cotton	30s/2 cotton	nylon 145/77

The gimp yarns were made on a hollow-spindle spinning machine Gemmill & Dunsmore 3 (i.e. fancy twister G&D3). The machine settings, given in Table 2, were altered (from fancy yarn to another) so as to change the structural parameters of the resultant gimp yarns.

Table 2: Machine Settings and Main Structural Parameters Used to Make the Fancy Yarns of Experiment I

Yarn Number	Machine Settings			Main Yarn Structural parameters		
	Supply Speed (m/min)	Delivery Speed (m/min)	Rotation Speed (rpm)	The Number of Wraps (wpm)	The Overfeed Ratio (%)	Number of Core Threads
1	95	70	21000	300	135	2
2	95	60	16000	266.63	158	2
3	85	60	21000	350	141	2
4	85	70	16000	228.57	121	2
5	85	70	16000	228.57	121	1
6	85	60	21000	350	141	1
7	95	60	16000	266.63	158	1
8	95	70	21000	300	135	1

Types and forms of the constituent threads were used to make the gimp yarns for Experiment II are provided in Table 3. In this experiment, modifications were made to the structure so as to change the structure and quality of the fancy yarns. The yarns made were classified into three groups where each group of fancy yarn were made using the same input threads. For this experiment the delivery speed of the hollow-spindle spinning machine was $60 \text{ m} \cdot \text{min}^{-1}$.

Table 3: The Input Materials and Main Structural Parameters Used to Make the Gimp Yarns for Experiment II

Yarn Number	The Overfeed Ratio (%)	The Number of Wraps (wpm)	Group of Fancy Yarn	Effect Component	Core Component	Binder
1	158	266.63	Group 1	24s/3 bamboo	30s/2 cotton	nylon 14.5/77
2	158	330				
3	120	276.6	Group 2	Super soft wool 2/11.3 Nm (R177/2 tex)	Combed cotton Ne=14s/3 (R126/3 tex)	Polyester 16.7/34
4	130	300				
5	125	300	Group 3	acrylic, Ne=16s/2 (R70/2 tex)	Cotton Ne=30s/2, (R40/2 tex)	Polyester 16.7/34
6	135	300				
7	155	300				

The input materials and the type of the constituent threads were used to make the gimp yarns for Experiment III are provided in Table 4. In this experiment material type was not changed when making the gimp yarns but the yarn structural parameters, i.e. mainly the overfeed ratio ($\eta\%$) and the number of wraps(W), were altered. For this experiment the delivery speed of the hollow-spindle spinning machine was $60 \text{ m} \cdot \text{min}^{-1}$.

Table 4: The Input Materials and Main Structural Parameters Used to Make the Gimp Yarns for Experiment III

Yarn Number	The Number of Wraps (wpm)	The Overfeed Ratio (%)	Group of Fancy Yarn	Effect Component	Core Component	Binder
1	225	130	Group 1	twisted ring-spun cotton yarn, Ne=16s/2	two parallel open-end rotor-spun cotton yarns Ne=20s each	textured multi-filament yarn, 167/34
2	325					
3	225	140	Group 2			
4	280					
5	225	150	Group 3			
6	315					
7	350					

The number of specimens sampled to measure the linear density of each yarn was 6. The number of specimens used to measure the size of non-gimp profiles and their circularity ratio was 31. The number of specimens used to count the number of non-gimp profiles was 16. The specimens were preconditioned then conditioned in a standard atmosphere, i.e. temperature 20 ± 2 C° and relative humidity RH=65±4, in accordance with ISO 139:2005 (BSI). The linear density were measured in accordance with ISO 2060:1995 (BSI).

Experiment I: Results and Discussions

Images of the fancy yarns made for Experiment I are shown in Figure 3. Those yarns were tested and the results are given in Table 5. Further, the subjective assessments of the same yarns, also given in the same table, was documented against the calculations of the author's objective method of quality assessment of fancy yarn. Although it is common to obtain the viewpoints of a panel of experts when studying the aesthetics of textile materials, it was difficult to find more than one expert in fancy yarn to consult them and ask them to rate the fancy yarns of this study.

Bearing in mind that the ShF was calculated to measure non-gimp profiles and other uneven projections of the effect component on the surface of gimp yarns, so the smaller the value of the ShF the better the quality of gimp yarns. When a comparison was conducted between the subjective method and the objective method, similar results were obtained. However, the accuracy of the objective method over the subjective method was revealed when comparing those two methods for fancy yarn 2 and fancy yarn 7. The expert, who was consulted, preferred the former over the latter. The expert considered gimp yarn 2 to have an acceptable-quality while gimp yarn 7 was deemed to have "poor-quality". However, the calculations of the objective method, i.e. the value of the ShF, indicated the opposite. This is because the ShF = 322.79 mm²/m for fancy yarn 7, while it was greater for fancy yarn 2, i.e. 376.72 mm²/m.

In terms of the relative fancy bulkiness of those fancy yarns regardless of material types, machine settings or structural parameters, the values of the RSI was useful. Those values increased from 0 mm²/m·tex for yarn 1, yarn 3 and yarn 5 up to 2.09 mm²/m·tex for yarn 2. This indicates that the order of those gimp yarns in terms of the non-gimp fancy bulkiness was yarn 1, yarn 3, yarn 5, yarn 4, yarn 6, yarn 8, yarn 7 and finally yarn 2. It is important to state that this ascending order of relative fancy bulkiness is for non-gimp profiles, i.e. for distortion of the gimp yarn structure. Therefore, yarn 2 represented the gimp yarn which had the poorest quality.

Figure 3: Images of the Fancy Gimp Yarns and Overfed Fancy Yarns Made for Experiment I

Table 5: The Results of Experiment I: The Objective Assessment and the Subjective Assessment

Yarn Number	Linear Density (tex)	Number of Non-gimp Profiles (m^{-1})	Size of non-gimp Profiles (mm^2)	ShF (mm^2/m)	RSI ($mm^2/m \cdot tex$)	Subjective Assessment of Yarn Quality
1	188.99	1.40	Not applicable	Approximately 0	0	excellent
2	179.98	66.80	5.64	376.72	2.09	acceptable
3	191.27	0.00	Not applicable	0	0	very good
4	150.85	7.60	4.43	33.66	0.22	very good
5	154.79	0.80	Not applicable	0	0	excellent
6	145.60	15.80	2.95	46.61	0.32	very good
7	178.70	62.80	5.14	322.79	1.80	poor
8	138.04	3.95	28.40	112.16	0.81	good

Experiment II: Results and Discussions

Images of the fancy yarns made for this experiment are given in Figure 4. Those yarns were tested and results are given in Table 6.

Figure 4: Images of Fancy Gimp Yarns and Overfed Fancy Yarn Made for Experiment II

Table 6: The Results of Experiment II: The Objective Assessment and the Subjective Assessment

Yarn Number	Linear Density (tex)	Number of Non-gimp Profiles (m^{-1})	Size of non-gimp Profiles (mm^2)	The Circularity Ratio of Non-gimp Profiles (%)	ShF (mm^2/m)	RSI ($mm^2/m \cdot tex$)	Subjective Assessment of Yarn Quality
1	178.7	62.80	5.14	44	322.79	1.80	Poor
2	180.51	41	3.80	46	155.8	0.86	good
3	390.8	0	0	Not applicable	0	0	very good
4	413.23	0	0	Not applicable	0	0	very good
5	153	0	0	Not applicable	0	0	good
6	162.36	32	4.66	63	149.12	0.91	excellent
7	177.18	68.2	5.37	56	366.23	2.06	very good

Comparisons between yarn 1 & yarn 2, yarn 3 & yarn 4, and yarn 5 & yarn 6 & yarn 7 were followed. This table indicates that the fancy yarns of each group were different in structure and quality. The overall quality of yarns improved due to reductions in the number of non-gimp profiles. Further, the comparison between the objective method of the author and the traditional, subjective method of assessment of fancy yarn indicated high level of agreement. For example, although made using the same input materials, yarn 2 had better structure than yarn 1 because the value of ShF of yarn 2 was almost half that of yarn 1, i.e. $155.8 \text{ mm}^2/m$ versus $322.79 \text{ mm}^2/m$. Additionally, the subjective assessment indicates that the quality improved from “poor-quality” into “good-quality” gimp yarn.

In terms of accuracy, it was confirmed that the objective method suggested by the author is more accurate than the subjective method. For example, when comparing yarn 5 & yarn 6 & yarn 7 using the value of the ShF, Table 6 shows that the value of the ShF increased from 0 to 149.12 mm²/m to 366.23 mm²/m respectively. This means that yarn 5 had the best quality, then yarn 6 and finally yarn 7. However, the assessor ranked the gimp yarn of cone 6 as the “best-quality” gimp yarn and appraised it to have “excellent-quality”, while yarn 5 was appreciated to have only “good-quality” gimp yarns. It is also understood from Table 6 that:

- Yarn 5 did not have any non-gimp profiles on its surface. However, the assessor subjectively considered it to be a “good-quality” gimp yarn because the assessor believed it had a structure which was nearly closed and wavy-shaped.
- Yarn 6 represents a gimp yarn which had on average 32 non-gimp fancy projections (which were in most cases bouclé profiles) per meter on its surface, with an average size equalling 4.66 mm². In spite of the existence of several non-gimp projections, the assessor subjectively considered it to be an “excellent-quality” gimp yarn as the assessor believed that the yarn structure was more open than the previous case. However, the value of the ShF for this yarn was relatively high and therefore it cannot be considered to be an ‘excellent-quality’ gimp yarn.
- A disagreement between the objective assessment and the subjective assessment was clear for yarn 7. The assessor ranked the yarn as a ‘very good’ gimp yarn because the assessor believed that the yarn structure was “open”. Using the objective method of assessment, however, there were 68.2 non-gimp profiles per meter on average on the yarn surface, with an average size of almost 5.37 mm². Therefore, the ShF was 366.23 mm²/m for this yarn. This meant that there were 366.23 mm² of distortion to the structure, distributed on each metre of the yarn. Accordingly, the yarn structure was highly distorted from the standard structure of gimp yarns (Figure 1). Even though such a yarn is still “considered” to be fancy yarn, its structure was a combination of several profiles, mainly gimp profiles, bouclé and irregular bouclé profiles, loops, closed thin projections, closed loops, etc.
- Since there were no non-gimp profiles on the surface of yarns 3, 4 and 5, it was impractical to calculate the value of the ShF for these yarns. However, the assessor subjectively ranked the quality of these gimp yarns as “very good” or “good” but not “excellent” as the assessor thought the yarn structure of them was “so closed. The assessor also thought that they might be similar to simple wavy yarns while the resultant “closed” structure was due to the thick input threads which were used to make these gimp yarns. It is important to know that gimp yarns are defined a form of wavy yarns (Gong & Wright, 2002; Meadwell, 2004). Additionally, author of this paper also considers gimp yarns, wavy yarns, ratiné and frisé yarns as different names for the same structure. Therefore, yarn 5 may be ranked as “excellent” by the author of this paper.

Regarding the relative fancy bulkiness of the gimp yarns of Experiment II regardless of material types, machine settings or structural parameters, the value of RSI was used. The interpretation of this parameter for gimp yarns is that the higher the value of RSI the higher the abnormal bulkiness of gimp yarns and thus the lower the quality of the gimp yarn. Therefore, Table 6 indicates that the values of RSI of those yarns increased from 0 mm²/m·tex for yarn 3, yarn 4 and yarn 5 up to 2.06 mm²/m·tex for yarn 7 “best-quality” gimp yarns were yarn 3, yarn 4 and yarn 5, then yarn 2 through yarn 6 and yarn 1 while the lowest quality was for yarn 7.

Experiment III: Results and Discussions

The yarns made for Experiment III are shown in Figure 5. The results of the objective assessment and the subjective assessment of them are given in Table 7. It is clear that only one obvious disagreement between these two

methods was shown for fancy yarn 2. The assessor considered this yarn to be wavy yarn because the assessor indicated that the structure of this fancy yarn was “closed”. However, as mentioned previously, gimp yarn is defined a form of wavy yarns (Gong & Wright, 2002; Meadwell, 2004). Therefore, the author considers this fancy yarn to have an “excellent-quality”.

Figure 5: Images of Fancy Gimp Yarns and Overfed Fancy Yarn Made for Experiment III

The gimp yarns of this experiment were compared in terms of their structure and quality regardless of their thicknesses (tex), raw materials, machine settings and structural parameters (i.e. $\eta\%$ and W) using the RSI. The lowest values of the RSI, i.e. $0 \text{ mm}^2/\text{m}\cdot\text{tex}$, were for “excellent-quality” gimp yarns. The “very good-quality” gimp yarns had slightly higher values of the RSI. Further, the quality of the gimp yarns diminished when the values of the RSI were high. Therefore, the quality of those yarns decreases from yarn 2, through yarns 7, 1, 4, 5, to yarns 6 & 3 as the value of the RSI increased respectively in the same order

Table 7: The Results of Experiment III: The Objective Assessment versus the Subjective Assessment

Yarn Number	Linear Density (tex)	Number of Non-gimp Profiles (m ⁻¹)	Size of non-gimp Profiles (mm ²)	The Circularity Ratio of Non-gimp Profiles (%)	ShF (mm ² /m)	RSI (mm ² /m·tex)	Subjective Assessment of Yarn Quality
1	182	14	5.397	50.6	75.558	0.41	good to very good
2	183.65	0	0	Not applicable	0	0	poor
3	185	24	6.27	53	150.48	0.81	acceptable
4	190.65	24.4	4.18	59	102.41	0.53	very good
5	195	26	5.718	48.5	148.66	0.76	poor
6	198.19	36.4	4.38	53	159.43	0.80	excellent
7	194.18	16	4.04	53	64.64	0.33	very good to excellent

THE APPLICATION OF THE OBJECTIVE METHODS TO EVALUATE BOUCLÉ YARN STRUCTURE AND QUALITY

Bouclé projections, bouclé profiles, semi-bouclé projections and semi-bouclé profiles were considered in this study when they were not considered defects on the structure. It was possible to check the reason for obtaining the *unapparent* bouclé profiles by a manual attempt to raise such profiles. The reason that they were there was the winding process when those profiles did not collapse back to lie on the structure. Therefore, they were considered while counting the bouclé profiles and measuring their size. However, when those profiles result from defects in the effect thread(s), they normally return back to lie on the yarn surface. Those fancy profiles were not considered bouclé profiles. Subsequently, they were excluded from counting and measurements.

The Shape Factor of Fancy Yarns (ShF), measured in mm²/m, was used to assess the quality of the bouclé yarns. The $ShF = N \cdot A$ where N is the Number of Fancy Profiles, i.e. average number of the bouclé profiles in a unit length of the gimp yarn, (measured usually in dm⁻¹ or m⁻¹ bouclé yarns), and A is the Area of Fancy Profile, i.e. the average area (or size) of the bouclé profile (measured usually mm²).

Materials, Machine Settings and Yarn Structural Parameters for Experiment IV

Input materials of different types, forms and performance characteristics, were used to make the bouclé yarns needed for Experiment IV. Table 8 shows the materials selected for the different levels of the experiment. Two similar effect components in the form of ply yarns were used to make the final bouclé fancy yarns for it was impractical to obtain satisfactory structure for the bouclé yarn by using only one effect component. Additionally, one core yarn and a binder were needed. The supply speed of the effect threads was 66 m/min, the delivery speed of the whole fancy yarn was 30 m/min and the rotational speed of the hollow spindle was 8400 rpm. Therefore, the overfeed ratio of the effect threads was $(66/30) \times 100 = 220\%$ while the number of wraps of the binder was $8400/30 = 280$ wrap per metre (wpm). Since the input threads used for the effect components varied considerably in terms of their thicknesses, i.e. linear density, it was also difficult to choose a number of wraps suitable to all thicknesses. Therefore, the number of wraps used was mostly suitable for the finer and medium thicknesses rather than the thick effect components.

Table 8: Materials Used to Make Bouclé Yarns for Experiment IV

Yarn Number	Core Component	Effect Component	Binder
1	cotton, R72/3 tex	flexible acrylic, R72/2 tex	polyester Multi- Filament, R16.7/34 tex
2	cotton, R72/3 tex	purewool, R120/2 tex	
3	cotton, R72/3 tex	acrylic multi-filament, 140 tex	
4	cotton/lambswool, R120/2 tex	flexible acrylic, R72/2 tex	
5	cotton/lambswool, R120/2 tex	purewool, R120/2 tex	
6	cotton/lambswool, R120/2 tex	acrylic multi-filament, 140 tex	
7	acrylic multi-filament, 140 tx	flexible acrylic, R72/2 tex	
8	acrylic multi-filament, 140 tex	purewool, R120/2 tex	
9	acrylic multi-filament, 140 tex	acrylic multi-filament, 140 tex	

The number of specimens used to measure the linear density of the yarns was 6. The number of specimens used to measure the size of non-gimp profiles and their circularity ratio was 30. The number of specimens used to count the number of non-gimp profiles was 16. The specimens of the fancy yarns were preconditioned then conditioned in a standard atmosphere, i.e. temperature 20 ± 2 C° and relative humidity $RH = 65 \pm 4$, in accordance with ISO 139:2005 (BSI). The linear density were measured in accordance with ISO 2060:1995 (BSI).

Experiment IV: Results and Discussions

Images of the fancy yarns made for Experiment IV are given in Figure 6 and the results of testing procedure are given in Table 9. All bouclé yarns which had the value of the Circularity Ratio of Fancy (Bouclé) Profile exceeding 0.60 was considered to have good quality, e.g. yarn 1, yarn 4, yarn 7 and yarn 8. The other yarns had inferior quality and yarn 6 had the poorest quality.

In terms of the absolute fancy bulkiness for these bouclé yarns, the value of the ShF indicated that this property decreased starting from yarn 7 (the highest value of the ShF), to yarn 1, yarn 8, yarn 4, yarn 5, yarn 9, yarn 2, yarn 3 and finally yarn 6. To account for the relative fancy bulkiness of these bouclé yarns, the value of the Relative Shape Index of Fancy Yarn (RSI) was used and it indicated that the best result was obtained for yarn 1. The relative fancy bulkiness decreased for yarn 7, yarn 4, yarn 8, yarn 2, yarn 5, yarn 3 and finally yarn 9 which had the lowest fancy bulkiness.

Using the previous calculations, it was confirmed that the selected values of the structural parameters of the bouclé yarns proved to be suitable for the finer effect components, i.e. the flexible acrylic ply yarns R72/2 tex, because they had the highest values of ShF, RSI, and CR. Conversely, the values of these three parameters were the lowest for the thickest effect yarns, i.e. the acrylic multi-filament yarn that had the linear density 140 tex. These findings can be exploited to improve the structure of bouclé yarns. This can be accomplished through modifying the values selected for the structural parameters of the fancy yarn, mainly the overfeed ratio and the number of wraps, but this is outwith the scope of this study.

Figure 6: Images of Fancy Bouclé Yarns and Fancy Semi-Bouclé Yarns Made for Experiment IV

Table 9: Results of the Experiment IV: The Objective Assessment versus the Subjective Assessment

Yarn Number	Linear Density (tex)	Circularity Ratio (%)	Size of Bouclé Profiles (mm ²)	Number of Bouclé Profiles (dm ¹)	ShF (mm ² /dm)	RSI (mm ² /m.Tex)
1	411.27	60	10.29	20	205.800	5.004
2	636.03	55	11.93	12.7	151.511	2.382
3	697.46	56	14.98	9.6	143.808	2.061
4	457.31	61	9.83	16.6	163.178	3.568
5	687.19	57	10.59	15.2	160.968	2.342
6	757.67	49	14.15	9.9	140.085	1.848
7	491.53	61	12.03	20	240.600	4.894
8	713.02	64	10.24	17.8	173.056	2.427
9	792.03	55	13.15	11.8	155.170	1.959

It is important to mention that the author did not have equipment to make fancy yarns that have elongated fancy profiles so as to compare their quality characteristics using the Actual Length of Elongated Fancy Profile (AL), the Total Length of Elongated Fancy Profiles (TL) and the Fancy Length Index of Fancy Yarn (FLI). However, the application of these quality concepts for fancy yarn with elongated fancy profiles should follow a similar approach.

CONCLUSIONS

The objective methods of assessment of the structure, quality and appearance of fancy yarn were applied in Part II of this paper to test, calculate, estimate and compare the quality of several gimp yarns, overfed yarns and bouclé yarns. The values of mainly the Shape Factor of Fancy Yarn, the Relative Shape Index of Fancy Yarn and the Circularity Ratio of Fancy Profile were used to define the gimp yarns and bouclé yarns which had the best quality, amongst others made for this of research. Further, a comparison between the methods suggested in this research and the viewpoint of an expert in fancy yarn proved a high degree of agreement. Furthermore, the yarns made in for this research were arranged in ascending order of their relative fancy bulkiness. Moreover, the objective methods of in this research were more reliable and accurate than any subjective assessment of the fancy yarns. This study indicates that it is possible use the scientific, objective methods of this research to resolve disputes, related to fancy yarn structure and quality, which might arise between buyers and manufactures or sellers of fancy yarns. Additionally, those methods can even be used to resolve disputes between different experts in fancy yarn should they appear. It must be emphasised that the objective concepts, parameters and methods of this research accounts for only the aesthetic, texture and structure of fancy yarns and do not solely cover or give provision for all quality characteristics of fancy yarn such as handle, colour, etc.

REFERENCES

1. Alshukur, M. (2013). The Quality of Fancy Yarn: Part I: Methods and Concepts. *International Journal of Textile and Fashion Technology*, 3(1), 11-24.
2. BSI. Textiles- Standard atmospheres for conditioning and testing *BS EN ISO 139:2005* European Committee for Standardization.
3. BSI. Textiles- Yarn from packages-Determination of linear density (mass per unit length) by the skein method *BS EN ISO 2060:1995* European Committee for Standardization.
4. Denton, M. J., & Daniels, P. N. (Eds.). (2002) (11 ed.). Manchester, The UK: The Textile Institute.
5. Gong, R. H., & Wright, R. M. (2002). *Fancy yarns: Their manufacture and application*. Cambridge, The UK: Woodhead Publishing Limited.
6. Meadwell, E. S. (2004). *An Exploration of Fancy Yarn Creation*. Degree of Master of Science, North Carolina State University, North Carolina.
7. Rameshkumar, C. *Fancy Yarns for Fashion*. Bannari Amman Institute of Technology, PSG College of Technology. Coimbatore.
8. Tortora, P. G., & Merkel, R. S. (Eds.). (2005) (7th ed.). New York, The USA: Fairchild Publication.

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