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A Study of the Basic Parameters Describing the Structure of Chenille Yarns

Abstract
The basic parameters describing the structure of chenille fancy yarns produced on a chenille yarn machine have been characterised. The effect of the properties of the component yarns, and that of machine parameters on the final count of the chenille yarns, have been studied. For this purpose chenille yarns were produced in different pile lengths, twist levels, yarn counts of component yarns, and an expression is derived to determine the final count of these chenille yarns. Correlation analysis confirmed a strong linear relationship with a high value of correlation coefficient (above 0.95) between the final count values of chenille yarn samples obtained from the expression (formula) and that obtained from the measurements.

Key words: *chenille yarn, fancy yarn, yarn count, pile yarn, pile density, retraction.*

Introduction

Textile technologies are continuously evolving with the objects both of increasing productivity and reducing processing costs, and of creating new products or variants of existing ones. In the last decade many important producers of hand knitting and upholstery-fabric yarns have become particularly sensitive to market requirements, and they therefore endeavour to cater to consumers' desires by presenting new yarns. To make the fabrics more attractive to the purchasers, their appearance is enhanced by various materials, structures, colours, patterns, finishes, and textures [1]. For fashionable fabrics, fancy yarns are used to produce a natural, rustic and attractive product.

Fancy yarns are special products of spinning, twisting, wrapping, texturing, printing, knitting, etc. Fancy yarns are and will always be up-to-date, as there is no alternative to them. The demand for yarns with structural and/or optical effects is due to their special aesthetic and high decorative appeal to the woven, knitted materials, and other textiles as well [2]. Fancy yarns display deliberately introduced irregular characteristics, in either diameter and bulk or in colour, etc. as well as virtually new structures composed of fibres, yarns or other products that differentiate them from conventional yarns [3].

Chenille yarn is a kind of fancy yarn which charms because of its gleam and softness. Chenille yarns are constructed by twisting core yarns together in chenille yarn machines, where cut pile yarns are inserted at right angles to the core yarn surface to create a surface in which the fibres contained in the pile yarns burst and form a soft pile surface to the yarn [4].

Figure 1 shows the basic structure of a chenille yarn. It consists of a cut pile (short lengths of spun yarn or filament) which may be made of a variety of fibres helically disposed around the two axial threads (highly twisted fine strong yarn)

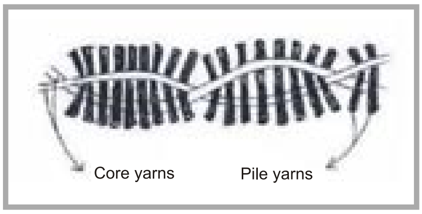

***Figure 1.** Chenille yarn structure [5].*

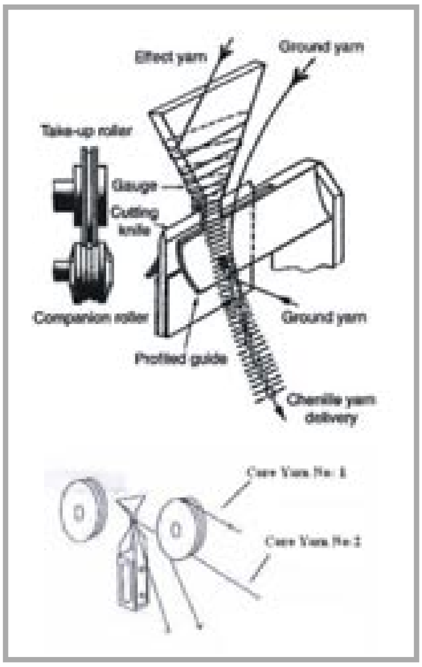

***Figure 2.** Chenille yarn production: a) Yarn-forming zone showing depth of the former [5], b) Location of gauge and plywoods [8].*

which secure it. The short lengths are called the pile, and the highly twisted yarns are called the core [5, 6].

The yarns coming from the two guides at both sides form the core yarns, and the one coming from the middle guide (rotating head) forms the piles. The pile yarns are wrapped around a calliper which is triangularly shaped at the top, narrowing towards the base to allow the pile yarn coils to slide downwards onto the cutting knife illustrated in Figure 2. The width at the bottom of the gauge determines the effect length, by maintaining the depth of the pile or 'beard' in the final yarn.

On each side of the cutting knife, there are two core yarns which may be either single or two-fold yarns. One core yarn is guided by the take-up roller, while the other is guided by the companion roller. The take-up roller is pressed against the profiled guide and intermeshes with the companion roller, allowing the two core yarns to trap the pile created by the effect yarn in between them due to the twist these yarns receive from the ring spinning spindle. The number of the pile yarns and how many of them are fed onto the core determines the count of the yarn [5, 7].

Certain parameters are of importance during production [9]:
- core and effect yarn material,
- the yarn count of the core and pile yarn,
- pile length, mm (determined by the size of the calliper),
- yarn twist, turns/metre (determined by the spindle speed and the delivery speed),
- retraction value in % (the length of yarn is reduced because of twisting core yarns),
- rotary head speed, rpm (determines pile density),
- rotary head diameter, mm,
- spindle speed, rpm (determines twist level),
- winding speed, m/min (determines production speed),
- pile density (determined by the speed of the head).

Table 1. Range of the values belonging to chenille yarn parameters.

Parameters		Range
Rotary head speed, rpm		7,500-24,000
Spindle speed, rpm		3,700-8,500
Production speed, m/min		4-24
Chenille yarn count, Nm		1-12
Core and pile yarn count, Nm		20-50
Number of pile yarns		1-3
Yarn twist, turns/metre		700-1,200
Cutting knife thickness, mm	Gillette type	0.15-0.20
	Rotary blade	0.20-1.00
Calliper size, mm		0.7-3.0
Calliper thickness, mm		0.4-0.6

Table 1 shows the range of the values belong to chenille yarn parameters

In the literature, there are few studies of the fundamental parameters that characterise fancy yarns [3, 10 - 14]. Despite the fact that chenille yarns are used to produce special fabrics with high added value, the literature survey shows that there has been no research on modelling the chenille yarns.

The purpose of this study is to fill this gap by contributing both to the examination of the most significant parameters governing chenille yarn production and to the investigation of the interrelationships and specific influences of the parameters on the final yarn count by means of mathematical expression.

Experimental

Chenille yarns were produced with a final count of Nm 4 and Nm 6 incorporating two different pile lengths (for 0.7 – 1.0 mm calliper width), two different twists (700 – 850 turns/metre in an S direction) and six different pile yarn materials (viscose, acrylic with 0.9 dtex fibre fineness, acrylic with 1.3 dtex fibre fineness, combed cotton, carded cotton and open end cotton) on a chenille fancy yarn machine. Pile and core yarn materials were spun into chenille yarn under identical conditions on this machine.

Nm 4 count chenille yarns were produced with two Ne 20/1 count (385 turns/m-Z, staple acrylic fibre) core yarns and one Ne 20/1 count pile yarn. Nm 6 count chenille yarns were produced with two Ne 24/1 count (580 turns/m-Z, staple acrylic fibre) core yarns and one Ne 30/1 count pile yarn. The core yarn material was acrylic for both the Nm 4 and the Nm 6 count chenille yarns.

The final counts of the chenille yarns were kept constant by varying the head speeds. For Nm 4 count chenille yarns, the head speeds on the machine were adjusted to 11,250 for 0.7 mm calliper width and 700 turns/m twist, 10,800 for 0.7 mm calliper width, and 850 turns/m twist, 8120 rpm for 1.0 mm calliper width and 700 and 850 turns/m twists, and the production speeds were held constant at 8.85, 8.47, and 8.45 m/min respectively. For Nm 6 count chenille yarns, head speeds were adjusted to 9120 and 7840 rpm for 0.7 and 1.0 mm calliper widths and for both twist levels respectively, and the production speed was maintained at a constant 7.20 m/min.

Yarn coding:

Yarn code: xyz
x = chenille yarn count
y = group no
z = pile yarn material

In the yarn codes:
For x: 4 - stands for Nm 4, 6 for Nm 6

For y: 1 - stands for Group 1 (pile length for 0.7 mm calliper width, 700 turns/m twist level),
2 - for Group 2 (pile length for 0.7 mm calliper width, 850 turns/m twist level),
3 - for Group 3 (pile length for 1.0 mm calliper width, 700 turns/m twist level),
4 - for Group 4 (pile length for 1.0 calliper width, 850 turns/m twist level)

For z: V - stands for viscose, A for acrylic (0.9 dtex), B for acrylic (1.3 dtex),
C - for combed cotton, D for carded cotton, O for open-end cotton

We examined the results in terms of the final yarn count for each sample type. Correlation analyses were conducted in order to observe the relationships between the measured and calculated final count values of the yarn samples.

Results and discussion

The basic parameters that influence the characteristics and appearance of chenille yarns are the component yarn types, the count of the component yarns that form the fancy yarn, the pile yarn count and core yarn count, the average number of pile yarns per metre (pile density), the circumference of the calliper (2× pile length), twist level and the retraction value in percent due to twisting.

Description of basic parameters

Nm_{ch} - Chenille yarn count, m/g
Nm_c - Core yarn count, m/g
Nm_p - Pile yarn count, m/g
n_{rh} - Rotary head speed, rev/min
n_s - Spindle speed, rev/min
L - Production speed, m/min
T - Chenille yarn twist level, turns/m
R - Retraction value in percent, %
L_{zt} - Length of zero twist yarn, m
L_t - Length of twisted yarn, m
k - Circumference of the calliper, m
c_w - Calliper width, m
c_t - Calliper thickness, m
ck_t - Cutting knife thickness, m
a - Pile density, rotation/m
h - Number of pile yarns fed into the rotary head
z - Number of pile yarns per twist of the chenille yarn
W_c - Core yarn weight for 1 metre of chenille yarn, g/m
W_p - Pile yarn weight for 1 metre of chenille yarn, g/m
W_{ch} - Chenille yarn weight for 1 metre of chenille yarn, g/m
L_p - Pile yarn length for one metre of chenille yarn, m
L_{pt} - Pile yarn length for 1/T metre of chenille yarn, m

Relation between the basic parameters

We determined the actual length of the core and pile yarns in 1 metre of chenille yarn, and then determined the weight of the component yarns.

$$W_c = \left(\frac{2}{Nm_c} \times \left(1 + \frac{R}{100}\right)\right) \qquad (1)$$

We took into account the retraction of the yarn due to the twist:

$$R = \left(\frac{L_{zt} - L_t}{L_{zt}} \times 100\right) \qquad (2)$$

$$W_p = \left(\frac{h \times n_{rh} \times k}{2 \times L \times Nm_p}\right) \qquad (3)$$

In this equation (3):

$$k = ((2 \times c_w) + (4 \times c_t) + (2 \times ck_t)) \qquad (4)$$

$$L = \frac{n_s}{T} \qquad (5)$$

$$a = \frac{n_{rh}}{L} = \frac{n_{rh}}{n_s} \times T \qquad (6)$$

The chenille yarn weight is the sum of the core yarn weight and pile yarn weight.

Hence from (1) and (3) we obtain:

$$W_{ch} = W_c + W_p \qquad (7)$$

$$W_{ch} = \left(\frac{2}{Nm_c} \times \left(1 + \frac{R}{100}\right)\right) + \left(\frac{h \times n_{rh} \times k}{2 \times L \times Nm_p}\right) \qquad (8)$$

From our measurements and computation, we obtain the following expression, Nm_{ch}, for determining the final count of the chenille yarns (Equation 9).

$$Nm_{ch} = \left(\frac{Nm_c \times Nm_p}{(2 \times (1 + (R/100)) \times Nm_p) + (0.5 \times a \times h \times k \times Nm_c)}\right) \qquad (9)$$

Equation 9.

According to equation 9, we can draw the following:

- Increasing n_{rh} and decreasing L lead to increased a, resulting in the production of coarser yarns.
- Decreasing L at constant n_s leads to increased T and R; these lead to the production of coarser yarns.

We also obtained a formula for calculating the number of pile yarns for each twist of the chenille yarn (z):

If the twist level is T for chenille yarn, the length of one twist is 1/ T metre. We also considered the number of pile yarns fed to the rotary head.

$$L_p = \left(\frac{n_{rh}}{L} \times \frac{k}{2} \times h\right) \qquad (10)$$

***Table 2.** Experimental results for chenille yarns; [1)] Calliper thickness=0.5x10-3 m. Cutting knife thickness = 0.6 x10-3 m, Calliper width: 0.7x10-3 m for yarn no: 1-12, 25-36 and 1.0 x10-3 m for yarn No.: 13-24, 37-48.*

Yarn No	Yarn Code	Nm_{ch}	Retraction (R), %	Pile density (a), rot/m	k[1)], m	Yarn No.	Yarn Code	Nm_{ch}	Retraction (R), %	Pile density (a), rot/m	k[1)], m
1	41V	4.25	11.97	1271.19	0.0046	25	61V	5.94	8.76	1266.67	0.0046
2	41A	4.29	11.82	1271.19	0.0046	26	61A	5.97	8.26	1266.67	0.0046
3	41B	4.19	11.66	1271.19	0.0046	27	61B	5.96	8.42	1266.67	0.0046
4	41C	4.24	11.66	1271.19	0.0046	28	61C	5.96	8.26	1266.67	0.0046
5	41D	4.21	11.82	1271.19	0.0046	29	61D	5.96	7.92	1266.67	0.0046
6	41O	4.14	11.82	1271.19	0.0046	30	61O	5.93	7.92	1266.67	0.0046
7	42V	4.20	14.09	1275.09	0.0046	31	62V	5.91	11.19	1266.67	0.0046
8	42A	4.23	14.09	1275.09	0.0046	32	62A	5.91	11.03	1266.67	0.0046
9	42B	4.16	13.94	1275.09	0.0046	33	62B	5.91	11.03	1266.67	0.0046
10	42C	4.18	13.94	1275.09	0.0046	34	62C	5.89	11.19	1266.67	0.0046
11	42D	4.17	13.79	1275.09	0.0046	35	62D	5.92	11.03	1266.67	0.0046
12	42O	4.17	13.79	1275.09	0.0046	36	62O	5.89	11.35	1266.67	0.0046
13	43V	4.71	11.66	960.95	0.0052	37	63V	6.15	8.76	1088.89	0.0052
14	43A	4.72	11.50	960.95	0.0052	38	63A	6.11	8.26	1088.89	0.0052
15	43B	4.69	11.35	960.95	0.0052	39	63B	6.08	8.42	1088.89	0.0052
16	43C	4.72	11.50	960.95	0.0052	40	63C	6.14	8.26	1088.89	0.0052
17	43D	4.72	11.03	960.95	0.0052	41	63D	6.07	8.09	1088.89	0.0052
18	43O	4.70	11.19	960.95	0.0052	42	63O	6.08	8.42	1088.89	0.0052
19	44V	4.72	13.94	960.95	0.0052	43	64V	6.09	11.35	1088.89	0.0052
20	44A	4.69	13.79	960.95	0.0052	44	64A	6.01	11.35	1088.89	0.0052
21	44B	4.70	13.79	960.95	0.0052	45	64B	6.03	11.19	1088.89	0.0052
22	44C	4.72	13.64	960.95	0.0052	46	64C	6.03	11.03	1088.89	0.0052
23	44D	4.68	13.94	960.95	0.0052	47	64D	6.02	11.03	1088.89	0.0052
24	44O	4.73	13.79	960.95	0.0052	48	64O	6.02	11.19	1088.89	0.0052

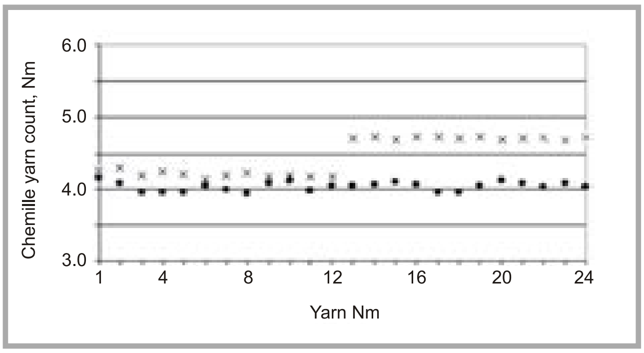

Figure 3. Calculated and measured chenille yarn count values versus yarn number; according to Table 2; × – calculated value, • – measured value.

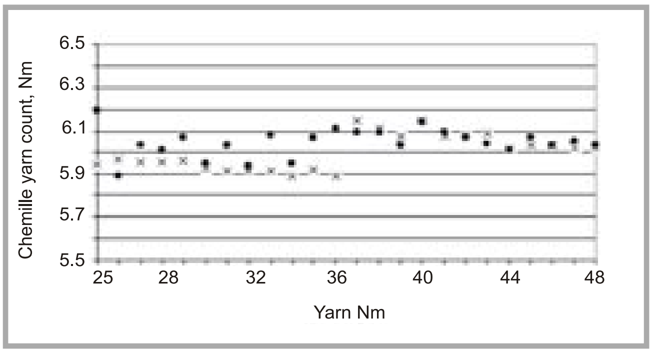

Figure 4. Calculated and measured chenille yarn count values versus yarn number; according to Table 2; × – calculated value, • – measured value.

$$L_{pt} = \left(\frac{Lp}{T}\right) = \left(\frac{n_{rh} \times k \times h}{2 \times L \times T}\right) \quad (11)$$

$$z = \left(\frac{n_{rh} \times h}{L \times T}\right) \quad (12)$$

From (5) and (12) we obtain:

$$z = \left(h \times \frac{n_{rh}}{n_s}\right) \quad (13)$$

The z parameter in equation 13 can be used for predicting the yarn's appearance before the production of chenille yarns. The border value of z can be used as a reference for the yarns, which must have sufficient pile density.

Table 2 lists the tested parameters of the chenille yarns. Two pile yarns are fed into the rotary head for the production of all types of chenille yarns.

Figures 3 and 4 illustrate the calculated and measured yarn count values versus yarn number for Nm 4 and Nm 6 count chenille yarn samples respectively.

The linear correlation coefficient was calculated in order to confirm the relationships between the values obtained from the formula and measurement. We wanted to check whether the chenille yarn count results obtained from the formula and measurements were consistent.

The border value of the correlation coefficient at a random degree n-2=46, and the significance level α=0.05, above which the correlation exists, is 0.285. According to this, there is a linear correlation between measurement and calculation. The high value of correlation coefficient which we obtained, above 0.95 (0.955), confirmed a strong linear correlation relationships between the chenille yarn count results obtained from the formula and measurements.

On the basis of the findings given above, it can be demonstrated that this new formula seems to be promising for assessing the count of chenille fancy yarns.

Figures 5, 6, 7 and 8 illustrate the changes for chenille yarn counts versus pile yarn counts for selected constant yarn and machine parameters and variables, according to expression 9.

These figures aid the monitoring of the effects of the changes on chenille yarn counts for some variables like pile length, production speed, rotary head speed and core yarn count.

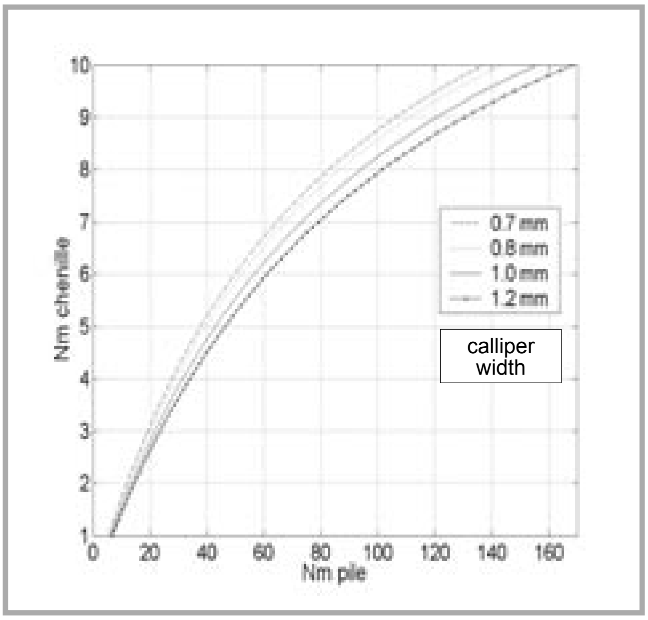

Figure 5. Chenille yarn counts versus pile yarn counts for different pile lengths (calliper widths); Constant values: n_{rh} =1,6860 rpm, ns =5130 rpm, L, = 7.12 m/min, Core yarn count = Nm 33.86, h = 1, R = 5%.

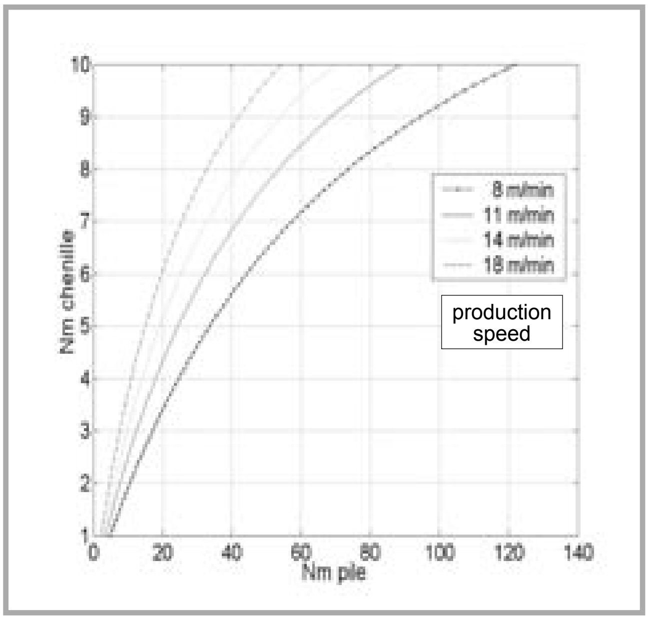

Figure 6. Chenille yarn counts versus pile yarn counts for different production speeds; Constant values: n_{rh} =16,860 rpm, Core yarn count = Nm 33.86, h = 1, R = 5%, Calliper width = 0.7×10^{-3} m, k= 4.4×10^{-3} m.

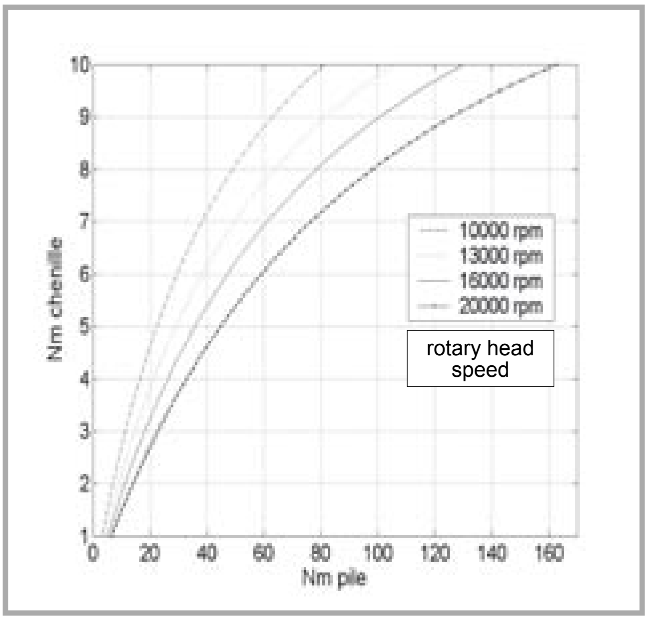

Figure 7. Chenille yarn counts versus pile yarn counts for different rotary heads speeds; Constant values: L = 7.12 m/min, Core yarn count = 33.86 Nm, h = 1, R = 5%, Calliper width = 0.7×10^{-3} m, k= 4.4×10^{-3} m.

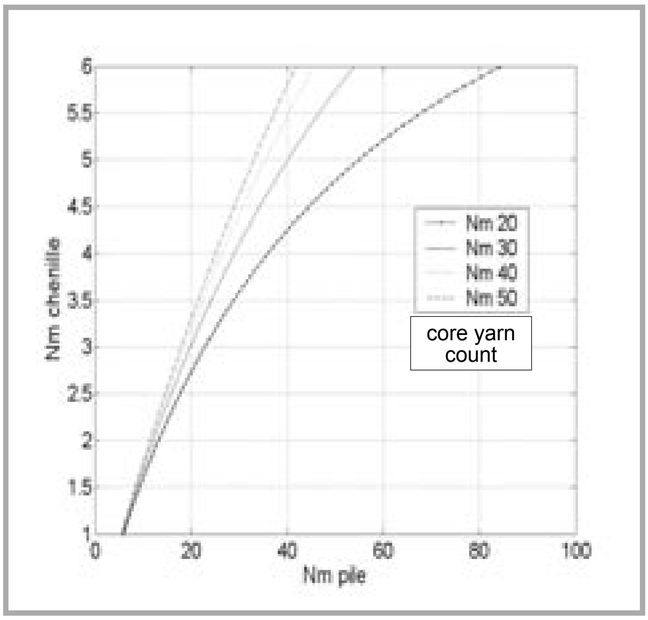

Figure 8. Chenille yarn counts versus pile yarn counts for different core yarn counts; Constant values: n_{rh} =16,860 rpm, L = 7.12 m/min, a =2367.98, h = 1, R= 5%, Calliper width = = 0.7×10^{-3} m, k= 4.4×10^{-3} m.

Graphs and equation 9 can be used both to reproduce an existing chenille yarn and to create a new type that has been merely designed on paper.

Conclusions

- Chenille yarns are used to produce value added fabrics, but the modelling of such yarns has not yet been investigated.
- In this study, the significant parameters governing chenille yarn production were examined.
- The effect of the parameters such as component yarn properties and machine parameters on the final count of the chenille yarns was studied.
- An expression was derived to determine the final count of the chenille yarns. There is a good correlation, with a high value of correlation coefficient (above 0.95), between the measured and calculated counts of the chenille fancy yarns. This result seems to be promising for assessing the count of chenille fancy yarns. It will be a practical method and enable rapid interpretation.
- An expression was derived for calculating the number of pile yarns per one twist (z). This can be used to predict yarn appearance before the production of chenille yarns, and as a reference for the yarns which must have sufficient pile density.
- Furthermore, it will be useful to carry out studies on the influence of twist setting and dyeing processes on the variation of physical properties (yarn count, yarn twist, retraction) of chenille yarns.

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