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The Influence of Component Yarns' Characteristics and Ring Twisting Frame Settings on the Structure and Properties of Spiral, Loop and Bunch Yarns

Abstract

The aim of this research is to provide reliable information, provided in the form of statistical models, regarding the possibilities of modifying the structure and the mechanical properties of fancy yarns by changing the component yarns' characteristics and the machine settings. Three types of fancy yarns (spiral yarns, loop yarns and bunch yarns) were produced via the ring twisting method. The statistical dependencies between (some) component yarn characteristics and machine settings as input and (some) fancy yarn characteristics and structure as output are presented in this paper.

Key words: fancy yarns, spiral, loop, bunch, ring twisting, statistical models.

Introduction

A fancy yarn is a textile yarn with virtually unlimited pattern designs. Fancy yarns present deliberate, decorative continuous or programmed effects of colour and/or form, and they are used to create some variation in the aesthetic appearance of a fabric or garment.

Generally, the yarn structure comprises a basic yarn, one or more effect yarns producing regularities or irregularities in the yarn structure, and a binder yarn to fix the basic and effect yarns. The structure, and therefore the appearance of the fancy yarns, may vary according to the processing technology, raw material, number of component yarns and machine settings.

Fancy yarns can be produced on spinning systems and twisting systems. There are three different twisting methods: (1) ring fancy twisting; (2) hollow spindle fancy twisting; (3) combinations of the hollow spindle and ring twisting processes.

The PL 31C ring twisting frame has been used in this study to produce three sets

of fancy yarns (spiral, loop and bunch yarns), according to arotal plan of experiment (5-leveled plan with $\alpha = 2$), making a total number of 56 variants (15 spiral, 15 loop and 26 bunch). Each component yarn was 100% cotton, 20 tex. The yarns were differentiated in respect of the component yarns' characteristics and machine settings as follows: linear density, twist, the angle of lap of pegs by yarn on the slat of the ring twisting frame (the input only for spiral yarns), overfeed of components (the input only for loop yarns and bunch yarns) and the frequency of the rocker's action in the ring twisting frame (the input only for bunch yarns). The following parameters were measured as output parameters: the linear density of the fancy yarns, tensile properties, bending rigidity, air index, snarling ability and the distribution of effects along the yarn.

Processing the yarns

Spiral yarn

In a spiral yarn, one component binds the other (which is straighter), thus creating spirals along the whole length (Figure 1). A spiral yarn is created as a result of the multiple twisting of two components with relatively slight overfeeds of one of them, or two components with the same or a slightly different linear density, and a different twist direction.

The spiral yarns produced for this study consist of two cores, white and black in colour, with a linear density 20 tex and twist direction Z. During the production process, the cores remained parallel before the twisting zone. From one to five effect yarns (20 tex each, twist

direction Z) were added, according to the roatal plan of the experiments. They had a different, contrasted colour (light yellow, dark yellow, orange, light blue and green) in order to identify them more easily when analysing the fancy yarns' structure. Both core and effect yarns were twisted in the S direction. The next important step was the binding process. A binding yarn (20 tex, in a violet colour) was twisted with the cores and effect yarns in the Z direction, each time with the same number of twists per metre, as in the process of twisting the cores with the effect yarns. In Table 1, the plan of the experiment for processing the spiral yarns is shown. The last input parameter from the table-

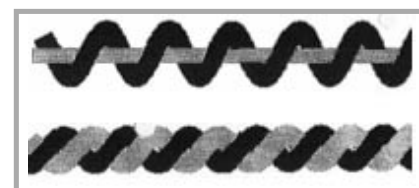


Figure 1. Schematic representation of a spiral yarn.

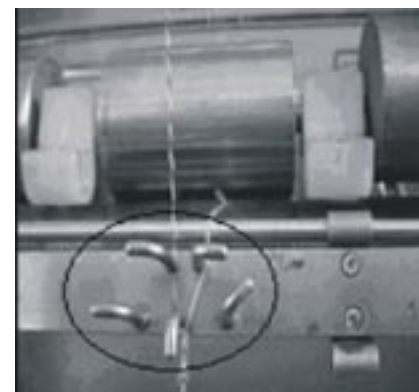


Figure 2. The ring-twisting frame PL 31C – a view of the slat with pegs.

Table 1. Plan of experiments for processing spiral, loop and bunch yarns.

Kind of yarn	Input Parameter	Value	Comments
Common parameters	Linear density of one component yarn, tex	20	The same for one core yarns; effect yarn; binding yarn; cotton
	Number of effect yarns introduced in the twisting zone	1-5	5 levels
	Number of components in the core	2	
SPIRAL YARNS	Number of twist, twists/m	285-521	5 different levels of twist: 200, 285, 400, 519, 600
	Linear density of one component yarn, tex	20-100	5 different levels of linear density: 20, 40, 60, 80, 100 tex
	Angle between cores and effect yarns in the twisting zone, degrees	90-120	5 different levels: 00, 30°, 90°, -90°, 120°
LOOP YARNS	Linear density of one component yarn, tex	20-100	5 different levels of linear density: 20, 40, 60, 80, 100 tex
	Number of twist, twists/m	285-521	5 different levels of twist: 200, 285, 400, 519, 600
	Overfeed, %	50-200	5 levels: 50, 82, 127, 172, 200
BUNCH YARNS	Linear density of one component yarn, tex	20-100	5 different levels of linear density: 20, 40, 60, 80, 100 tex
	Number of twist, twists/m	285-521	5 different levels of twist: 200, 285, 400, 519, 600
	Frequency of the rocker, actions/time unit	20 - 120	5 levels: 20, 40, 70, 100, 120
	Overfeed, %	50 - 200	5 levels: 50, 82, 127, 172, 200

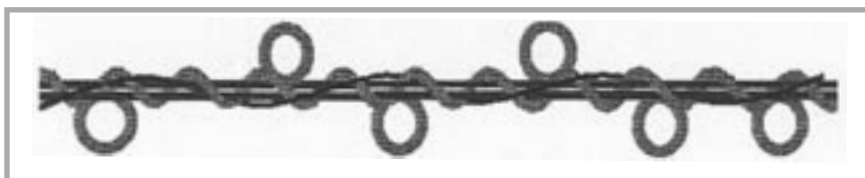


Figure 3. Schematic representation of a loop yarn.



Figure 4. Schematic representation of bunch yarn.

angle- represents the angle of lap of pegs by the yarn on the slat of the ring twisting frame; the pegs allow the components to be introduced into the twisting zone under the required angle (Figure 2).

Loop yan

Loop yarns have round, regular shape loops on their surface, of identical or different sizes. They are produced by the twisting process only with a big overfeed of one component yarn. Loop yarns consist of three component yarns: two core yarns and one effect yarn, twisted together with a binding yarn (Figure 3). Loop yarns were produced according to the plan of the experiments, having a linear density of one component (tex), twist (twist/m) and overfeed (%) as input parameters (Table 1). The production process was similar to that used in producing spiral yarns.

Bunch yarn

A bunch yarn (Figure 4) is made of two component yarns twisted together, one of them (the core) being introduced into the twisting zone with a locally higher tension. The effect yarn creates effect points, locally compacted, at regular or irregular distances. Such effect points may have different colours, shapes or sizes. The bunch yarns were produced, according to the plan of the experiments (Table 1) with the following input parameters: the linear density of the components (in tex), twist (in twist per metre), overfeed (in %) and rocker frequency actions per production cycle. The rocker decides the frequency of the effects points.

In Figure 5, the appearance of different variants of the produced spiral, bunch and loop yarns can be seen.

Methods for metrological analysis of the yarns

The following parameters were taken as output: the linear density of the fancy yarns, tensile properties, bending rigidity, air index, snarling abilities and the distribution of effects along the yarns and twist. The following apparatus and classical or innovative methods were used to assess the following metrological parameters:

- linear density of the fancy yarns: ITF maillemer was used, according to ISO 7211/5 (1984).
- elongation and breaking force of the yarn: Statimat M was used. 10 tests were performed for each yarn. The speed of the drawing frame head was 250 mm/min, and the length of the test specimen was 250 mm
- bending rigidity: the Kawabata system was used.
- air index: the Air Index Tester was used. This test checks the ability of the air jets to carry the yarns through the nozzle of an air-jet weaving machine. Specimens of 30 metres' length were passed through the nozzle with 5 windings for spiral and loop yarn, and specimens of 2000 metres' length were passed through the nozzle with 10 windings for the bunch yarn.
- snarling abilities: a snarling tester (no norms elaborated) was used. A specimen of 50 cm was fixed between 2 clamps. The moving clamp was drawn in the stationary clamp's direction until snarls appeared.

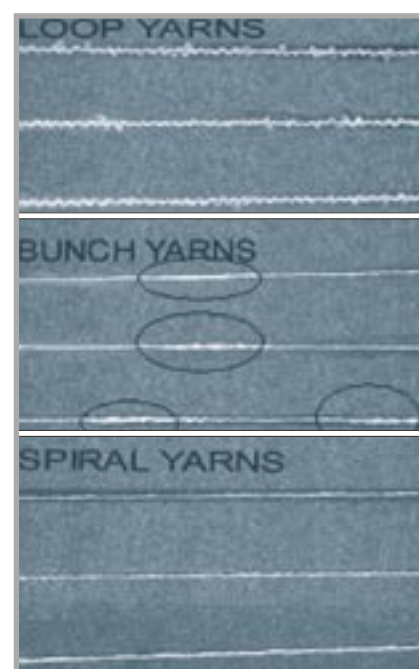


Figure 5. Appearance of investigated spiral, bunch and loop fancy yarns.

- distribution of effects along the yarns and real twist inserted: a microscope with System for Image Processing and Analysis, Lucia was used.

Statistical analysis of the results and discussion

All the metrological results of measurements obtained were analysed using the SPSS 12.0 for Windows program; multiple regression module statistical models were obtained. The following conclusions were found and discussed below for each type of yarn.

Spiral yarn

1) There is a linear dependence with determination coefficient $R^2 = 0.646$ on a level of significance of 0.01 between the thickness of the spiral yarn, measured at the point where the binding yarn covers the cores and effect yarns and collapses into them, and the twist measured in the place on the yarn where no collapse occurs. This dependence suggests that the twist applied before and during the binding process but in opposite directions has an influence on the final thickness measured at the point where the binding yarn collapses in cores and effect yarns. The higher the value of that twist, the lower the thickness value. Thus, one may ascertain that giving a twist, first to the effect yarns and then to the binding yarn, causes compression at the point of contact between the binding yarn and the effect yarn, which in turn causes the convexity of the fragment without the binding yarn collapsing.

2) There is a linear dependence with determination coefficient $R^2 = 0.650$ on level of significance 0.01 between the breaking force and the linear density of the spiral yarn. The higher the value of linear density, the higher the value of breaking force of the yarn.

3) There is a linear dependence with a determination coefficient of $R^2 = 0.650$ at a level of significance of 0.01 between the bending rigidity and the binding twist as well as the linear density. An increase in the linear density and the twist of the yarn causes an increase in bending rigidity. The dependence is linear. The linear density of the yarns has a higher influence on the bending rigidity than the twist, when the very restrictive level of significance of 0.01 is taken into account.

4) There is a statistical dependence between the linear density of the yarn and the width of hysteresis which appears in the bending rigidity test. Statistics show that the higher the linear density, the wider the hysteresis loop. The linear density is an excellent descriptor of the width of the hysteresis loop. The dependence is linear. This phenomenon is closely related to the bending rigidity, as mentioned above in point 3. The twist does not influence the widening of the hysteresis loop when the very restrictive level of significance of 0.01 is taken into account.

5) There is a linear dependence (determination coefficient $R^2 = 0.951$ at a level of significance of 0.01, standardised coefficient Beta = 0.981) between the standard deviation from the average distance between the clamps of the device used for the snarling test, at the moment of creation of the snarls, and the twist given to the yarn during the binding process. An increase in the value of linear density causes higher stiffness, which simultaneously decreases the ability of creating snarl on the yarn. This also suggests a high unevenness of the linear density.

6) There is a linear dependence ($R^2 = 0.962$ at a level of significance of 0.01) between the air index of the yarn and its linear density. The higher the linear density, the lower the ability of the air to carry the yarn through the nozzle of the air friendliness tester.

Loop yarn

1) The statistical analysis confirms that there is a statistical dependence between the angle of inclination of the binding yarn and the twist given to the yarn in the process of binding. The dependence is non-linear: the value of the angle increases (change of the angle from acute to straight) with the square value of the twist. This dependence demonstrates that the accumulation of braids on the length of the yarn causes a change in the direction of the angle. The determination coefficient $R^2 = 0.724$ at a level of significance of 0.01.

2) There is a statistical dependence between the standard deviation from the average value of the angle of inclination of the binding yarn and the twist given to the yarn in the process of binding. The dependence is non-linear: the standard deviation from average of the value of the angle of inclination of the binding yarn increases with the square value of

the twist. This dependence shows that the dispersion around the average value of the angle of the binding yarn inclination might be explained by an unevenness of the thickness of the core and effect components. For a low thickness of the components, the binding yarn covers them under a straight angle when the final twist is given. For a high thickness of the components, the angle of binding yarn inclination might be changed in the direction of the acute angle.

3) There is a statistical connection between the average value of the distance between loops and the twist given to the yarn in the final process. The dependence is linear, with the determination coefficient $R^2 = 0.936$ at a level of significance of 0.01.

4) There is a linear dependence (determination coefficient $R^2 = 0.983$ at a level of significance of 0.01) between the linear density and the length of the loop created at the end of the snarl effect. The higher the linear density of the yarn, the longer the loop at the end of the snarl. This might be explained by the increased stiffness of the yarn as a result of adding another effect component. In such a case, the ability of the yarn to create snarls with a small loop at the end decreases.

5) There is a statistical dependence between the elongation measured at the breaking moment and the twist given in the final process. The dependence is non-linear; the higher the square value of this twist, the higher the elongation value. The determination coefficient $R^2 = 0.589$ at a level of significance of 0.01.

6) There is a linear dependence ($R^2 = 0.801$ at a level of significance of 0.01) between the air friendliness and the linear density of the yarn. The higher the linear density value, the lower the ability of the air to carry the yarn through the nozzle of the air friendliness tester.

7) The square value of the number of effect components influences the standard deviation from the average value of the yarn carried through the nozzle of the air friendliness tester. This might be explained by the increased number of pores in the yarn with many components. Not only is the relief of the yarn changed by adding another component, which may give a higher resistance to the air, but also the air caught in the pores makes the yarn heavier. The dependence is linear, with a determination coefficient $R^2 = 0.801$ at a level of significance of 0.01.

Bunch yarn

1) There is a linear dependence with determination coefficient $R^2 = 0.801$ at a level of significance of 0.01 between the width of the hysteresis loop obtained in the bending rigidity test and the twist given to the yarn in the final process of binding.

2) There is a connection between the average value of bending rigidity and the twist given to the yarn in the binding process. The determination coefficient $R^2 = 0.903$ at a level of significance of 0.01.

3) There is a linear dependence ($R^2 = 0.825$ at a level of significance of 0.01) between the standard deviation from the average value of the bending rigidity and the square value of twist given to the yarn in the final process: the higher the square value of this twist, the higher the standard deviation from the average bending rigidity value.

4) There is a linear dependence (determination coefficient $R^2 = 0.869$ at a level of significance of 0.01) between the angle of inclination of the binding yarn between the bunches and the binding twist value: an increasing twist value causes a change of the angle of inclination from the acute to the straight direction.

5) The frequency of the rocker's action influences the distance between the bunches. The higher the frequency of the rocker's actions, the smaller is the distance between the bunches on the yarn. The determination coefficient $R^2 = 0.866$ at a level of significance of 0.01.

6) There is an influence ($R^2 = 0.866$ at a level of significance of 0.01) of the frequency of the rocker's action on the standard deviation from the average distance between bunches. The higher the frequency of the rocker's actions, the lower the standard deviation from the average distance between the bunches on the yarn.

7) There is an influence ($R^2 = 0.721$ at a level of significance of 0.01) of the twist given to the yarn in the final process on the standard deviation from the average length of the bunches. The higher the value of the twist, the lower the value of the standard deviation from the average length of the bunches.

8) The square value of the twist in the binding process influences the standard deviation from the average distance between the clamps of the snarling tester at the moment of obtaining the snarl. The increase in the twist causes the average distance between the mentioned clamps

to decrease. The determination coefficient $R^2 = 0.735$ at a level of significance of 0.01.

9) The effect yarn overfeed influences the number of twists on the snarl. It suggests that periodical effects on the yarn such as bunches reduce the ability of the yarns to create long snarls. Bunch yarns with a higher overfeed of effect yarns, which means a thicker bunch, have a lower ability to create snarls with many twists along them. The determination coefficient $R^2 = 0.500$ at a level of significance of 0.01.

10) The number of component yarns influences the air index value. This might be explained in a similar way to the case of the spiral yarn (point 6). The determination coefficient $R^2 = 0.613$ at a level of significance of 0.01.

Acknowledgments

This research has been carried out as part of a common project 'The architecture of new fine fancy yarns for a creative textile industry', funded by the Science and International Administration of the Ministry of Flanders and the Department of International Cooperation of the Polish Ministry of Scientific Research and Information Technology in Brussels, 2004-2006.

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Received 21.12.2005 Reviewed 15.02.2006



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