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Structural Performance of DRF And Conventional Yarns

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ABSTRACT Constituent Wool Fibers Structure in DRF and Conventional yarns were elicited in Co-relation to Processing Parameters Wool Fiber Length, Twist Multiplier and Strand Spacing by using Box and Behnken's Design. The Straight fiber % increases as strand spacing increases at 65 and 70 mm fiber length and decreases at 75 mm fiber length. In all strands spacing, Straight fiber % increases up to 70 mm fiber length than decreases in further increase in fiber length, and Spinning-in-Coefficient % is increases as fiber length increases. In all 3 levels of fiber length, Spinning-in-Coefficient % increases up to 14 mm strand spacing than decreases in further increase. The straight Fiber %, Mean Fiber Extent and Spinning-in-Coefficient of Wool Fiber at optimum levels of variables DRF yarns are improved in comparison to Conventional yarns. The role of TM is not visible. In DRF yarns, straight fiber % was 71 to 61, mean fibers extent was 44.10 to 53.90, spinning in coefficient (%) was 64.75 to 74.90, trailing hooks was 9 to 15, leading hooks was 0 to 10, both leading and trialing hooked was 0 to 5, looped was 1 to 4 and entangled was 0 to 4 respectively.

KEY WORDS: DRF Yarn, Configuration of Wool Fiber, Straight Hooked (Trailing), Hooked (Leading), Hooked (Both), Looped and Entangled, Mean Fiber Extent and Spinning-in-Coefficient (%),

1. INTRODUCTION

Double Roving Feed (DRF) yarn production technique is relatively new and well accepted commercially for the long staple fiber spinning. It also yields better physical and mechanical properties in comparison to conventional yarns. Double yarns are normally used for the production of fabrics[1]. They are superior due to better binding of surface fibers into the yarn structure during twisting. Ordinarily made by twisting (spun) two strands together and then two folding (plying) them. Considerable efforts have been made to produce superior yarns in conventional ring frame for production of fabric without resorting to either two-plying or sizing[2].The invention of DRF technique is one of them. Literature reveals that the amount of twist required for DRF yarn is 60-65% and 85-90% for staple fibers and cotton mixing respectively of the twist inserted in single yarn for producing double yarns. Since in DRF technique there is eliminating of winding, parallel winding and doubling process and increased production of at ring frame by 2.5 to 3.5 depending on the type of yarn spun. The cost of conversion of DRF yarns is hardly 40-55% of the conventional double yarns. It is also observed that DRF yarn diameter is lower and packing density is 10 to 20% more than single yarn. DRF yarns are manufactured by feeding two–roving ends separately at the back of the ring frame drafting zone, combining and converge them as they emerge from the front roller nip. The yarns properties are depend on the yarn structure characterized by the geometrical arrangement of fibers in yarns as well as fiber movement at the point of the yarn formation and the resultant position of the fibers in the yarn structure[3]. The longitudinal and transverse distribution of fiber in yarn body dominantly impact on its characteristics.

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To elicit yarn geometry, twist and tension in the single strands in the convergence system was observed as with increasing strand spacing, twist and tension also increases sharply initially and then levels of with further increase in spacing. The twist in the single strands is hardly 3-5% of the twist in the plied yarn where as the tension in the single strand is slightly more than 50% than plied yarn, the increase in twist in single strand is likely to trap surface fibers in the yarn periphery, the increase in tension in the single strand with increase in spacing is likely to improve migration of fibers and packing density in yarn[4]. The present work is to elicit DRF and Conventional yarns Structural Performance, and discussed on the following headings.

1. Configuration of Wool Fibers in DRF and Conventional yarns.
2. Mean Fiber Extent and Spinning-in-Coefficient (%) of Wool Fiber in DRF and Conventional yarns.

2. MATERIAL AND METHODS

2.1. Materials

The Polyester Long Staple (Varying Cut Length) length longest (mm) 150, average (mm) 89, shortest (mm) 35, Fineness (denier) 2.50, Bundle Strength (gram/tex) 14.4 blended with merino wool fiber staple length longest (mm) ranging from 160 to 170, average (mm) 65 to 75, shortest (mm) 15, micron (μ) 2.5, Moisture Regain (%) 16.3, Bundle Strength (gram/tex) 12, Residual Grease (%) 0.5, Alkali Solubility 10.5 in 70: 30 ratio to produce 40^S Tex yarns in Ring Frame (NMM (WS 436) by DRF and Conventional methods.

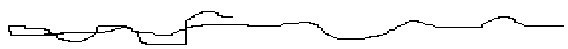
2.2. Experimental Plan

The DRF yarns are produced according to a compound centrally rotate-able scheme proposed by Box and Behnken's of 3 variables[8] i.e. Fiber Length(Length), Twist Multiplier(TM), and Strand Spacing (Spacing) and Conventional yarns are produced by different fiber length of constituent wool at fix TM level. The constituent polyester performance is presumed similar in all samples.

2.3. Configuration of Wool Fibers and Mean Fiber Extent and Spinning-in-Coefficient of Wool Fiber in DRF and Conventional yarns.

The optical tracer fiber technique established by Mortren and Yen[9] was used. The uncolored fibers in the yarn were dissolved in Methyl Salicylate to observe color tracer fibers through a projection microscope. A small amount of different colors dyed tracer fibers (approx 0.2%) were mixed uniformly before second gilling to discriminate 65, 70 and 75 mm wool fibers in yarn under microscopic observations. The configurations of each tracer fiber was grouped according to the classification illustrated in Table No: 2.3.1

Table No: 2.3.1 Fiber Configurations

No.	Tracer Fiber Configuration	Class Of Fiber
1.		Straight
2.		Hooked (Trailing)
3.		Hooked (Leading)
4.		Hooked (Both)
5.		Looped
6.		Entangled

Spinning–in-coefficient is an important characteristic of internal structure of staple fibers yarns. Large number of researches[5,6,7] measured the fabric configuration in terms of various parameters like fiber extent, migration parameters, helix angle, spinning-in-coefficient etc., as it is well known that the fibers in yarn follow helical path, to the direction of the yarn axis. Moreover, Constituent fiber of a spun yarn, being-in and a twisted assembly, can not cover a distance equal to the fiber length in the direction of yarn axis. The distance covered by a fiber in the direction of the yarn axis is known as fiber extent and average for all fibers is mean fiber extent. The Mean Fiber Extent and Spinning-in-Coefficient (%) was calculated by formula illustrated by Chaattopadhyay[9] as follows;

$$K_p = \frac{\sum L_n}{N}$$

Where ;

L_n = overall yarn length between the beginning and end of the spinning in fiber

n = number of observations

The spinning–in-coefficient was calculated by using formula;

$$K_f = \frac{(L_n - \sum X_1^n)}{l}$$

Where ;

L_n = overall yarn length between the beginning and end of the spinning in fiber.

X_1 = Length of yarn from which the fiber protrudes.

l = Overall length of the fiber.

If the whole fiber is straight and taken in by spinning the value of K_f is 1, on the contrary, if the fiber is fully wrapped on the yarn i.e. not spun–in, K_f become 0.

3. RESULT AND DISCUSSIONS

The observations of Tracer Fiber Configuration (Straight, Hooked (Trailing), Hooked (Leading), Hooked (Both), Looped and Entangled) and Mean Fiber Extent and Spinning-in-Coefficient (%) of DRF and Conventional yarns are given in Table: 3.1.

3.1. Configuration of Wool Fibers in DRF and Conventional yarns

The response surface equation of Straight Wool Fibers (%) is

$$Y_{(Straight)} = 70.33 + 2.50x_1 - 3.92x_1^2 - 2.25x_1x_3$$

The coefficient of correlation (R^2) between the observed and predicted values of Straight Fibers (%) obtained from the response surface equation was found 0.66 shows substantial influence of variables. The equation reveals that length is directly proportional to the Straight Fibers %. Only Length and spacing contributes in prediction of Straight Fibers %. The impact of TM is not visible. The contours were constructed as in Fig: 3.1.1.(b) and c) for length and Fig: 3.1.2.(a), (b) and (c) for spacing by surface equation. Fig. 3.1.1: (a), depicts, as spacing increases the straight fibers % increases at 65 and 70 mm of length. However at 75 mm length straight fiber % decreases as spacing decreases. Fig. 3.1.1: (b), depicts, that straight fiber % increases up to f length 70 mm and then decreases. The highest straight fiber % was found 71 at coded level 0 of all variables. The lowest straight fiber % was 61 at 65 mm fiber length, 2.00 TM and 14 mm spacing. The trailing hooks were in the range of 9 to 15. The leading hooks were in the range 0 to 10. The both leading and trialing hooked fiber present were in the range of 0 to 5. The looped fibers were present in the range of 1 to 4. The entangled fibers were 0 to 4 in DRF yarns. The conventional yarn made up of 65, 70 and 75 mm length at TM 2.25, the % fiber of straight were 59, 61 and 61, trailing hooked were 15, 13 and 13, leading hook were 12, 11 and 11, both hooked were 4, 2 and 4, looped were 2, 1 and 1 and entangled were 1, 1 and 1 respectively.

3.2. Mean Fiber Extent and Spinning-in-Coefficient (%) of Wool Fiber in DRF and Conventional yarns

The response surface equation of Spinning-in-Coefficient (%) of wool fibers present in polyester wool blended yarns is as follows.

$$Y_{(spg\text{-}in\text{-}co)} = 73.22 + 1.89x_1 - 3.64x_3^2$$

The (R^2) between observed and predicted values of Spinning-in-Coefficient (%) obtained from the response surface equation was found 0.66 shows substantial influence of variables. The equation shows that fiber length and strand spacing has impact on Spinning-in-Coefficient (%) however TM role is not visible. The contour for Spinning-in-coefficient are given in Fig. 3.2.1: (a), (b) and (c) for length and Fig. 3.2.2. (a), (b), (c) for spacing developed by response surface equations. The Fig. 3.2.1: (a), (b) and (c) depicts, at 14 mm spacing in all 3 cases of length the highest value of Spinning-in-coefficient is noted. The Fig. 3.2.2: (a), (b) and (c) reveals that, as length increases in all spacing the spinning in coefficient increases. The Mean Fiber Extent (mm) was in the range of 40.20 to 53.90 and the spinning in coefficient was in the range of 74.90 to 64.75. The minimum mean fiber extent was noted at 65 mm wool fiber length, 2.25 TM and 10 mm strand spacing. The maximum was at 75 mm wool fiber length, 2.25 TM and 18 mm strand spacing. The highest spinning in coefficient was noted at 65 mm wool fiber length, 2.00 TM and 14 mm strand spacing. The lowest spinning in coefficient was evaluated at 65 mm wool fiber length, 2.25 TM and 18 mm strand spacing in DRF yarns samples. In conventional yarns prepared by 65, 70 and 75 mm fiber length at TM 2.25, the mean fiber extend was 42.62, 47.60 and 49.60 and spinning in coefficient was 68.47, 70.90 and 69.11 respectively. It can be concluded as strand spacing increases from -1 wool fiber length, the straight fiber % increases and at +1 level of wool fiber length the reverse trend is observed. At all wool fiber length as the strand spacing increases from -1 to 0 levels, the increasing trends were observed and from 0 to +1 level, the reverse trend in spinning-in-coefficient is found. The TM impact on straight fiber % and spinning-in-coefficient is not visible. The straight fiber % have is significant role however other types of fibers present in the yarn could not develop correlation within or with other yarns. At all spacing as length increases from -1 to 0 levels the increasing trends and 0 to 1 level, the reverse trend in straight fiber % are observed The both straight fiber % and spinning-in-coefficient % of all wool fiber lengths are better in DRF yarns in comparison to conventional yarns. Overall in DRF yarns impact of constituent fiber length and roving spacing is significant however TM role is not visible. The roving spacing as increases, the convergence point depth also increases, therefore the convergence angle between roving's also increases. Ultimately the tension on the spun DRF yarn also changes in proportion to the convergence angle. This trend is observed for all three cases of Wool Fiber Lengths. In the increase in tension on emerging fiber strands, fibers are first straighten and after optimum tension they start slippage. Also increase in roving spacing the length of strand between roller nip and convergence point ultimately increases, more the length more the free fiber ends which results more fiber slippage. These free fiber ends have tendency to come under minimum energy state condition and may result to form loops and hooks etc. The free fiber ends ultimately reduces the fiber extent as roving spacing increases. It reveals that as in yarns fiber length increases the number of free ends in individual strand reduces which ultimately reduces fiber slippage and shows improve spinning-in coefficient of DRF yarn and in conventional yarn free ends are more shows lower spinning-in. The similar hypothesis concluded by various researchers for other than wool blended DRF and conventional yarns[10, 11, 12]. Ishtiaque et al[13,14,15] also concluded as, straight fibres % is more in DRF yarn in corresponding to single yarn, leading hooks % in DRF yarns is more than other type of hooks. Mean fiber position reaches an optimum value at certain roving spacing. The better yarn characteristics of DRF yarn at optimum roving spacing is mainly due to better spinning in coefficient and mean fiber position.

4. SUMMARY AND CONCLUSIONS

This can be summarize and concluded as follows.

1. The as strand spacing increases Straight fiber %, increases at 65 and 70 mm fiber length and decreases at 75 mm fiber length.
2. In all 3 levels of strands spacing, Straight fiber % increases up to 70 mm fiber length than decreases in further increase in fiber length and Spinning-in-Coefficient % is increases as fiber length increases.
3. In all 3 levels of fiber length, Spinning-in-Coefficient % increases up to 14 mm strand spacing than decreases in further increase.
4. The straight Fiber %, Mean Fiber Extent and Spinning-in-Coefficient of constituent Wool Fiber at optimum levels of variables DRF yarns are improved in comparison to Conventional yarns.
5. The role of TM is not visible.
6. In DRF yarns, the straight fiber % was highest 71 in sample prepared at 75 mm fiber length, 2.25 TM and 14 mm spacing and lowest 61 at 65 mm fiber length, 2.00 TM and 14 mm spacing the mean fiber extent was maximum 53.90 at 75 mm wool fiber length, 2.25 TM and 18 mm strand spacing and minimum 40.20 was noted at 65 mm wool fiber length, 2.25 TM and 10 mm strand spacing, the spinning in coefficient (%) was highest 74.90 at 65 mm wool fiber length, 2.00 TM and 14 mm strand spacing and lowest 64.75 were evaluated at 65 mm wool fiber length, 2.25 TM and 18 mm strand spacing. The range of trailing hooks was 9 to 15, leading hooks was 0 to 10, both leading and trialing hooked was 0 to 5 looped was 1 to 4 and entangled was 0 to 4 respectively.
7. The conventional yarn made up of 65, 70 and 75 mm length at TM 2.25, % fiber of straight were 59, 61 and 61, trailing hooked were 15, 13 and 13, leading hook were 12, 11 and 11, both hooked were 4, 2 and 4, looped were 2, 1 and 1 and entangled were 1, 1 and 1, mean fiber extend was

42.62, 47.60 and 49.60 and spinning in coefficient (%) was 68.47, 70.90 and 69.11 respectively.

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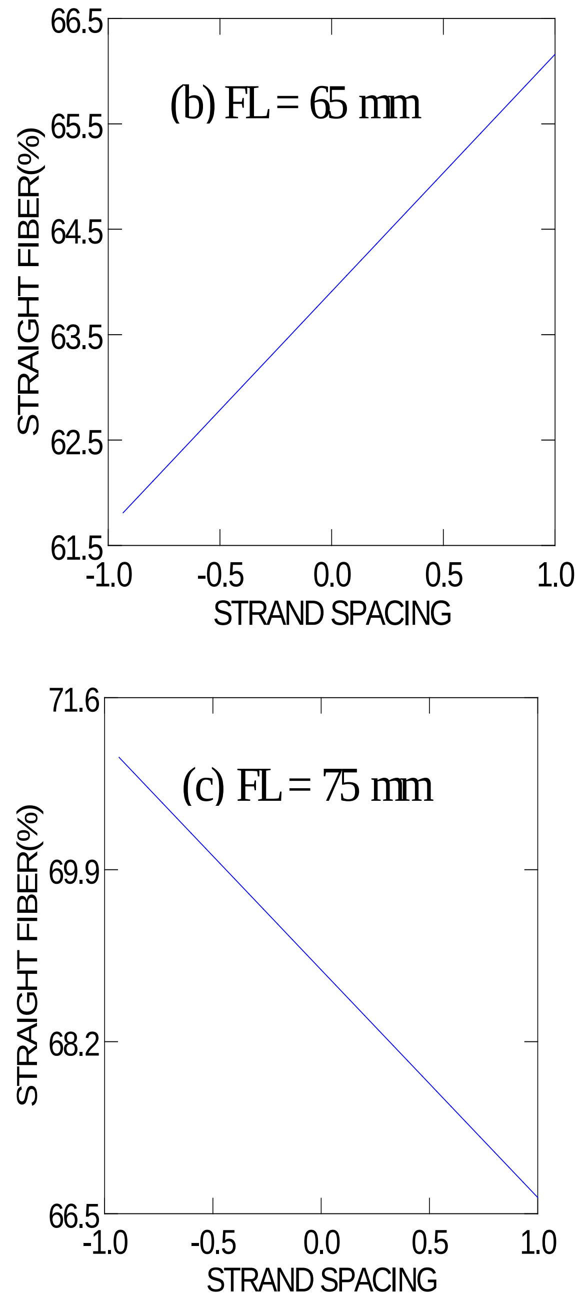


Fig. 3.1.1: Fiber Length Effect (b) 65 (c) 75 on Straight Fiber (%)

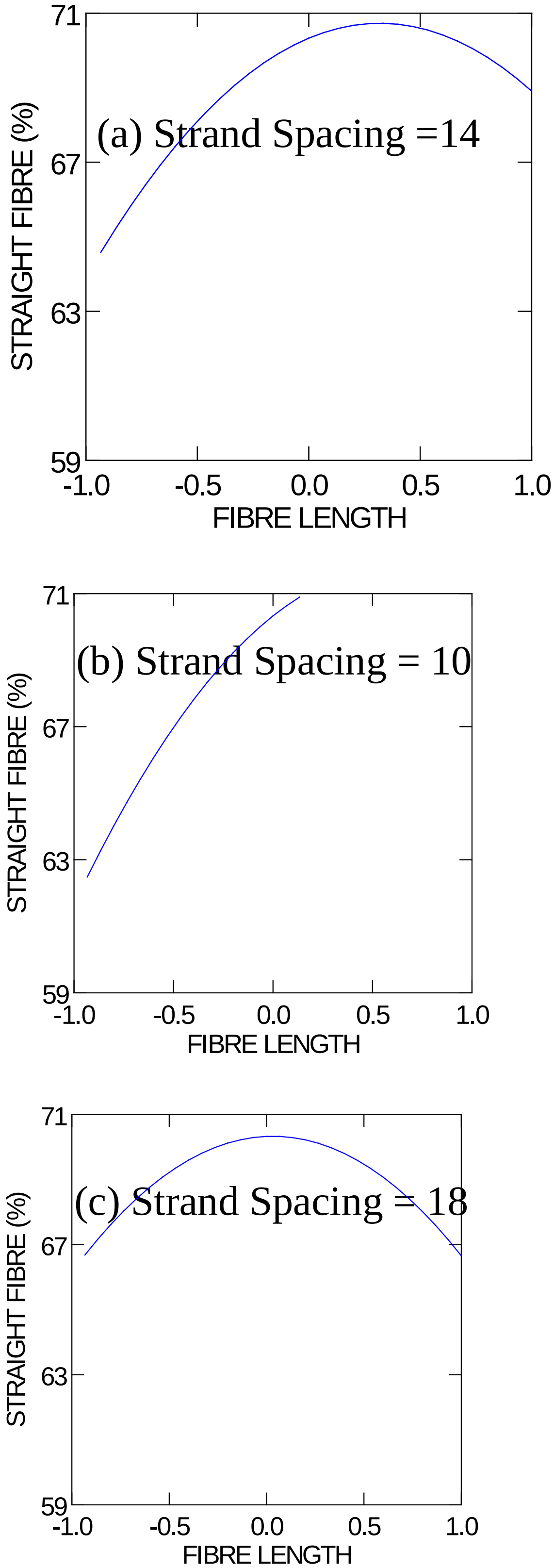


Fig. 3.1.2: Strand Spacing Effect (a) 10 (b) 14 (c) 18 on Straight Fiber (%)

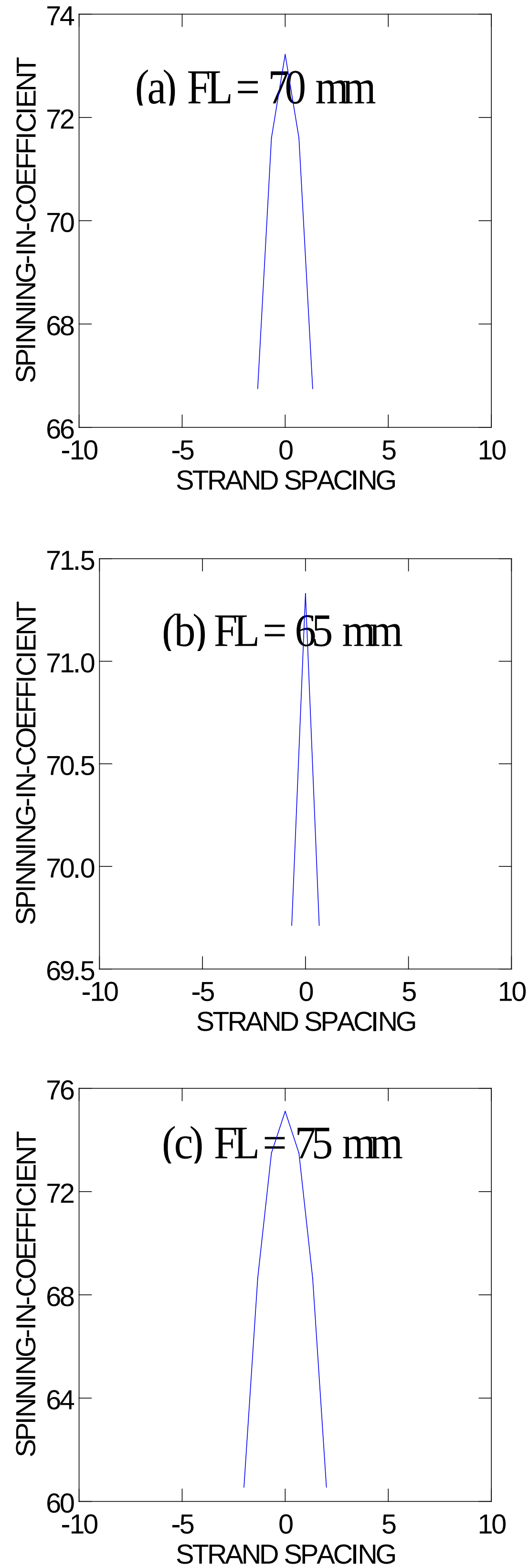
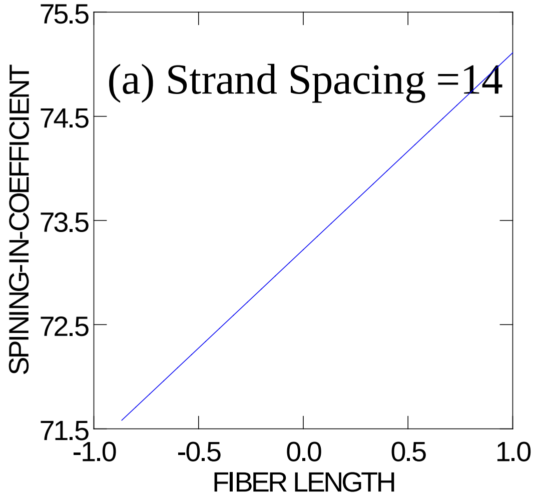
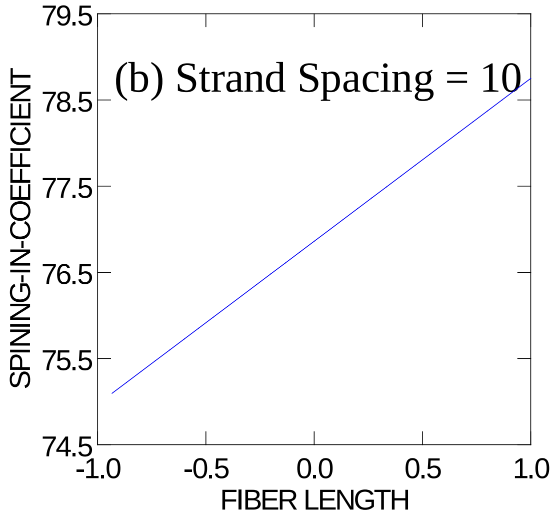


Fig. 3.2.1: Fiber Length Effect (a) 70 (b) 65 (c) 75 on Spinning-in-coefficient





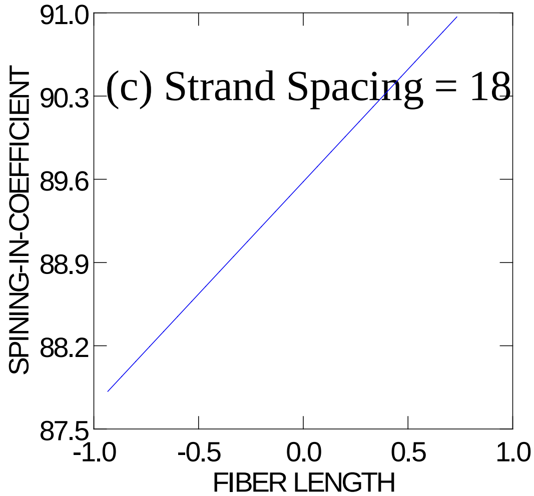


Fig. 3.2.2 Strand Spacing Effect (a) 10 (b) 14 (c) 18 on Spinning-in-coefficient

Table: 3.1. **Configuration and Spinning-in-Coefficient (%) of Constituent Wool Fiber in DRF and Conventional Yarns Blended with Polyester**

No	Level of Variables			Fiber Type						Mean Ext(mm)	Spg-In-C.
	x_1	x_2	x_3	Straight	Hooked			Looped	Entangled		
					Trailing	Leading	Both				
DRF Yarn											
1.	-1	-1	0	61	12	10	4	2	1	46.80	74.90
2.	+1	-1	0	68	11	8	2	2	3	53.60	74.37
3.	-1	+1	0	62	13	8	2	3	1	44.20	71.10
4.	+1	+1	0	70	10	8	2	3	1	53.30	74.17
5.	0	0	0	70	10	9	2	1	0	48.30	72.10
6.	-1	0	-1	63	12	10	5	2	1	40.20	64.75
7.	+1	0	-1	70	12	8	1	1	0	52.60	73.24
8.	-1	0	+1	65	13	9	1	1	1	44.10	70.85
9.	+1	0	+1	63	15	10	5	4	2	53.90	74.97
10.	0	0	0	71	11	9	2	1	1	50.20	74.81
11.	0	-1	-1	68	9	12	4	2	1	45.90	68.47
12.	0	+1	-1	69	12	8	0	3	4	45.60	68.12
13.	0	-1	+1	68	12	10	1	1	0	46.00	68.71
14.	0	+1	+1	67	12	8	1	1	1	46.40	69.18
15.	0	0	0	70	10	8	2	2	3	48.90	72.76
Conventional Yarn											
16.	**65 Wool Length**			59	15	12	4	2	1	42.62	68.47
17.	**70 Wool Length**			61	13	11	2	1	1	47.60	70.92
18.	**75 Wool Length**			63	13	11	4	1	1	49.60	69.11

x_1=Wool Fiber mean length (65, 70 and 75 mm)
x_2=Twist Multiplier (2.00, 2.25 and 2.50)
x_3= Strand Spacing (10, 14 and 18 mm