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Influence of Ring Traveller Weight and Coating on Hairiness of Acrylic Yarns

Abstract
This study involves the results of an investigation concerning the influence of ring travellers of different weights, types and coatings on the hairiness of acrylic yarns spun from microfibres. 30 tex yarn was produced using C-type travellers with a twist factor of α_{tex}=31.6. Travellers of 8 different weights and 4 different coatings were used working with two spindle speeds of 7000 rpm and 10,000 rpm. Yarn hairiness was evaluated with the use of a Shirley Yarn Hairiness Tester. The values of tension, breakage rate, count, twist, evenness, elongation and tensile strength of the yarn produced were measured. In addition the yarns were knitted into fabrics to observe and evaluate pilling. Some conclusions were drawn considering yarn hairiness.

Key words: *hairiness, acrylic yarn, spinning, traveller, pilling.*

Introduction

Hairiness significantly influences the properties of yarns and fabrics. Hairiness in warp yarns can cause considerable breakage and hence stoppage of weaving looms, thus reducing the efficiency of production. It causes pilling on fabrics, resulting in poor appearance. Yarn hairiness is very complex, but this parameter is now as routinely tested as the other parameters of yarns. Hairiness can be defined as the state of migrated fibre ends and fibre loops pushed to the surface of the yarn body. The factors causing yarn hairiness can be studied in three different ways; the physical properties of fibres, yarn parameters and machine parameters used.

Several investigations have been carried out on the influence of the ring traveller. In some studies, it was observed that yarn hairiness decreased as the weight of the traveller increased, whereas in some others it was stated that as the traveller weight is increased the hairiness gradually decreased to a certain point, then started to increase [1-5].

Experimental

Materials

The experiments were carried out using yarn of 30 tex with a twist factor of α_{tex}=31.6 which was produced from micro-acrylic fibres under laboratory conditions (20±2°C and 65±2% R.H.) Before spinning, the rovings were conditioned for 48 h. The fibre specification of the roving is shown in Table 1 and the parameters of ring spinning in Table 2.

Ring Travellers

Three different travellers of 8 different weights, 4 types of coating and 2 profiles were used designated by a 5-position code:

1 - type of traveller: C (standard type) and M (thick type of C)
2 - ring flange: type 2 (4.1mm)
3 - traveller profile: f (flat) and dr (half round)
4 - coating type: SP ('Superpolish') specially polished, B ('Blacknic') nickel coating, M ('Micronic') chrome coating, S ('Silvernic') silver coating
5 - spindle speed: 7000 and 10,000 rpm.

Methods

Eight different cops (roving 600 tex, yarn 30 tex) were produced with a twist factor of α_{tex}=31.6 using the C2f, M2f, and M2dr traveller types with SP, B, M, and S coating types with weights of 60, 71, 80, 85, 95, 106, 112, and 125 mg. Mean values of yarn count, twist, evenness, breakage rate, tensile strength and elongation were given according to the yarns produced, and are listed in Table 3.

Determination of yarn hairiness

All yarn samples produced were kept under standard laboratory conditions for 48 h before testing on a Shirley Yarn Hairiness Tester [6]. This instrument could test fibres at distances of every 5mm which protruded at an angle of 70° and were longer than 3 mm. Testing times could be set as 5, 10, 20, 30 and 40 seconds. A total of 250 m of yarn length were measured for their hairiness, and 30 tests were made on each sample of yarn with 8.33 m/10 seconds on the Uster Tester I during 50 m/min of test speed.

Position of fibres within yarn

Firstly, 9 different forms of fibres were determined within the yarn in a Projectina projection microscope, as in another work [7]. They were photographed by a Jeol JSM 5200 scanning electron microscope (SEM). Of these, 6 fibre forms which have substantial effect on yarn hairiness were selected. As can be seen in the photos (Figure 1), the fibres that caused hairiness are mainly those which appear on the yarn surface as: a - short fibres, b - long fibres, c - fibre bridges, d - fibre loops, e - loose fibres, f - vertical fibres. The fibre loops and bridges mentioned above were identified as fibre loops in [8], but as these two forms are completely different, we identified them separately.

The yarn samples were re-examined using a projection microscope considering the photos as in Figure 1. The yarns were magnified (x 50) and reflected on a screen scaled in cm. Two parallel lines of 2 mm (0.04 mm in actual yarn) apart were drawn on the yarn's appearance, as in [9,10]. The part between the parallel lines was assumed to be the yarn body. Two new parallel lines were drawn, 50 mm (1 mm on the actual yarn) away from the yarn axis. The fibres within this area were considered as short fibres, and those outside as long fibres (Figure 2). Yarn samples one metre in length were examined and evaluated as specified above. Since the variation in

Table 1. Fibre specification.

Fibre	Linear density	Staple length
Acrylic	0.9 dtex	38 mm

Table 2. Ring spinning parameters.

Parameters	Sizes, mm
Machine size	650x1960x1000
Drafting rollers	28
Top roller	28
Front drafting zone	45
Main drafting zone	42
Spindle length	210
Tube length	260
Ring diameter	50
Flange width	4

Table 3. Values of yarn properties.

Yarn properties	Unit	Traveller type	Weight of ring travellers, mg							
			60	71	80	85	95	106	112	125
Yarn count	tex	C2f07	29.2	28.5	28.5	28.4	29.0	29.2	29.7	28.7
		C2f10	28.7	29.0	28.5	28.3	28.7	28.7	28.8	29.5
		M2f07	29.5	29.0	29.2	28.3	28.0	29.1	29.3	29.5
		M2f10	28.9	29.1	28.9	29.4	29.5	29.3	28.9	29.8
		M2dr07	29.0	29.1	28.8	29.7	29.4	29.4	29.8	29.6
		M2dr10	28.9	28.8	29.0	29.1	29.0	29.2	29.3	29.6
Twist	tpm	C2f07	625	606.8	620.5	583.5	615.3	606	601.7	580.6
		C2f10	617.8	607.0	600.5	590.5	588.6	590.6	588.7	579.2
		M2f07	625.6	620.5	615.2	615.0	619.3	610.1	603.8	602.9
		M2f10	628.4	619.6	620.4	613.0	601.1	589.6	594.6	588.6
		M2dr07	617.7	638.7	628.4	624.3	610.0	614.3	616.3	617.0
		M2dr10	622.5	602.5	620.5	612.4	618.0	599.0	600.1	600.0
Evenness	U %	C2f07	10.3	11.1	10.2	10.5	10.4	10.2	11.5	10.0
		C2f10	11.0	11.2	11.0	9.9	10.8	10.2	11.2	11.7
		M2f07	10.1	10.3	10.6	10.2	10.1	10.5	10.3	10.5
		M2f10	10.4	10.3	10.2	10.3	10.9	10.6	10.5	10.7
		M2dr07	11.1	11.3	11.5	11.9	10.5	11.1	10.6	11.3
		M2dr10	10.3	10.2	10.8	10.3	10.3	10.0	10.3	10.1
Tensile strength	cN	C2f07	617.6	668.6	648.5	641.1	620.5	615.8	569.6	488.5
		C2f10	662.9	658.8	625.1	630.1	610.6	599.1	588.6	590.1
		M2f07	606.0	665.0	625.5	645.3	698.5	695.3	636.2	600.1
		M2f10	669.5	639.2	640.1	645.6	620.1	618.6	601.1	599.1
		M2dr07	660.6	661.1	667.5	648.5	615.3	600.2	614.5	593.1
		M2dr10	654.0	660.5	648.6	620.5	620.6	626.6	610.4	610.6
Elongation	%	C2f07	22.2	23.2	22.7	23.0	19.8	20.6	22.4	21.2
		C2f10	21.6	21.2	21.0	21.5	22.2	21.4	19.4	18.5
		M2f07	21.0	22.9	21.6	22.9	22.8	23.8	21.2	22.6
		M2f10	22.9	21.9	22.7	21.9	22.7	23.0	22.5	22.6
		M2dr07	21.8	23.1	23.1	22.3	23.2	22.4	23.1	21.6
		M2dr10	20.9	22.1	22.1	21.5	21.8	22.3	21.3	21.5
Breakage rate	spindle/1000 h	C2f07	333.4	333.4	500.1	166.7	166.7	333.4	500.1	833.5
		C2f10	500.1	500.1	333.4	333.4	333.4	500.1	833.5	833.5
		M2f07	333.4	166.7	166.7	333.4	166.7	166.7	333.4	666.8
		M2f10	333.4	500.1	333.4	500.1	500.1	333.4	500.1	833.5
		M2dr07	166.7	500.1	500.1	166.7	166.7	500.1	333.4	1000.2
		M2dr10	333.4	333.4	500.1	333.4	333.4	500.1	500.1	1000.2

measurements from the 4 coated types of travellers was insignificant, their average values were taken for 'coated' in general as tabulated in Table 4.

It is seen in the table that when using the C2f type ring travellers, yarn hairiness was caused (in order of importance) by fibre bridges, short fibres, long fibres, fibre loops, vertical fibres and loose fibres. With the M2f type ring travellers, the order was short fibres, fibre bridges, long fibres, vertical fibres, fibre loops and loose fibres. With the M2dr type ring travellers, the order becomes fibre bridges, short fibres, long fibres, loose fibres, vertical fibres and lastly fibre loops. According to these results, fibre bridges and short fibres are found as the major forms of fibres which cause hairiness in the acrylic yarns tested.

Pilling assessment on the fabric knitted
To determine the effect of hairiness on the pilling of fabrics, the yarns spun at 10,000 rpm were used for knitting a stocking fabric using a Bentley Comet machine of 4", E 14, 160 needles. The knitted fabric samples were stored in laboratory conditions for 48 h. The samples (4 samples related to each ring traveller type) were tested on a Nu-Martindale fabric abrasion and pilling tester. Testing circles were exposed to 1000 rubs, and the assessment made according to Empa Standards [11]. The results of the measurement were compared with the K2 Empa standard photographs in the order of 1-2, 2-3, 3-4 and 4-5 from worst to best. The results are presented in Table 5.

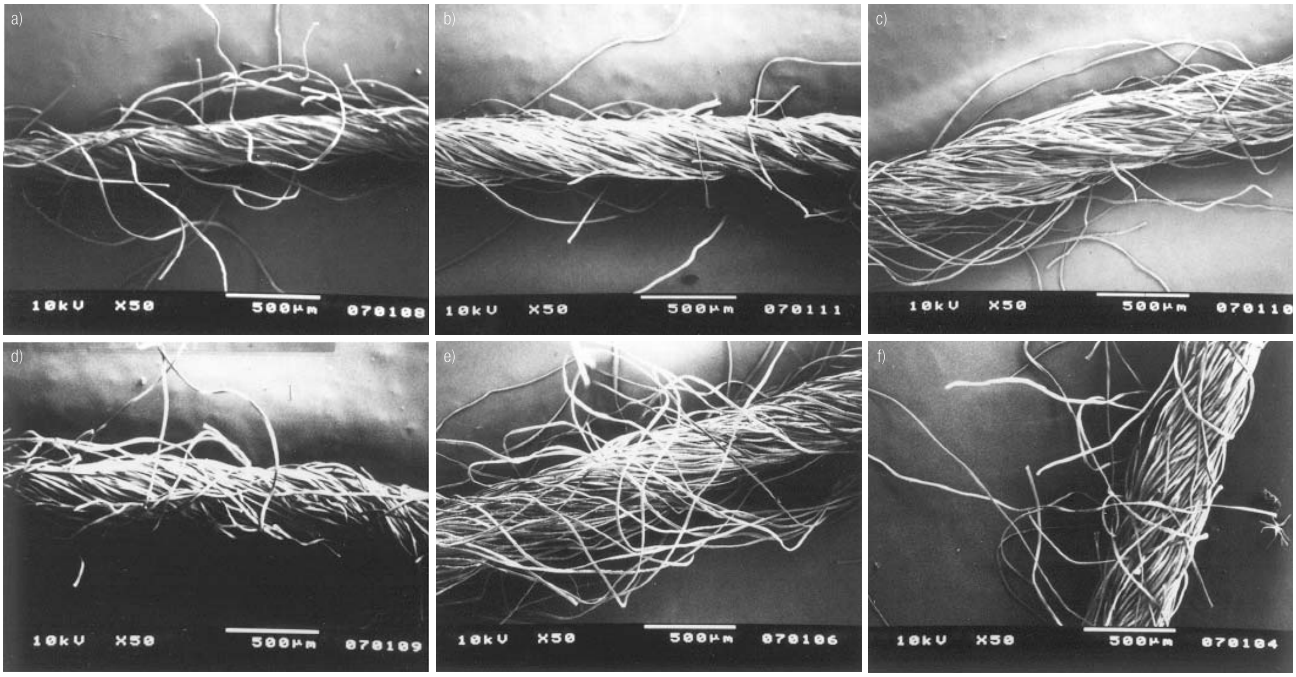

Figure 1. Photos taken by the SEM; a - short fibres; b - long fibres; c - fibre bridges; d - fibre loops; e - loose fibres; f - vertical fibres.

Determination of yarn tension

Yarn tensions determined during the spinning process were measured with the ring rail at the bottom position when the tension value was at maximum. A Schmid 2F2 tester was used for yarn testing between 10-100 cN. According to the well-known dependency, the yarn tension increased as the spindle speed and/or traveller weight increased (Table 6).

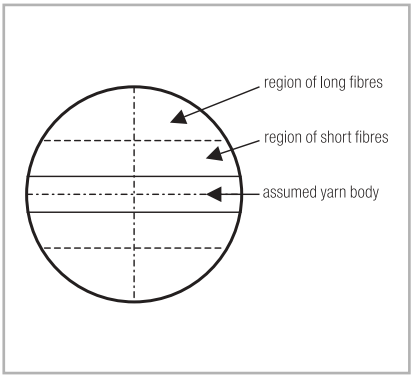

Figure 2. Areas of protruding fibres; a - region of long fibres; b - region of short fibres; c - assumed yarn body.

Results and Discussion

The results of the experiment clearly showed that the ring traveller weight had a significant influence on yarn hairiness, and that the character of this influence depends on the traveller type, coating and spindle speed. In general, for all experiments discussed the yarn hairiness decreased as the weight of the travellers increased. However, local maxima of the particular dependencies can be observed in Figure 3. Using C2f type travellers at 7000 rpm spindle speed, there were no significant changes in the results with respect to different coatings of the same type, but nevertheless it seemed that the best results were obtained from the Silvernic type travellers (Figure 3a).

With M2f type travellers at the same spindle speed of 7000 rpm, yarn hairiness became considerably lower (Figure 3b), especially with weights above 85 mg for the Silvernic coated traveller. With M2dr type travellers, the smallest hairiness was with the traveller of micronic type up to the weight of 95 mg. However above the weight of 95 mg, the Silvernic coated traveller produced lower hairiness than any other traveller type (Figure 3c). Running at 10,000 rpm spindle speed with C2f type travellers, the lowest values of hairiness were determined on yarns produced using C2fSP type ring travellers (Figure 3d). At a spindle speed of 10,000 rpm

Table 4. Numbers of fibres counted (No/m).

Weight of traveller, mg	Fibre bridges			Vertical fibres			Loose fibres			Long fibres			Short fibres			Fibre loops		
	C2f	M2f	M2dr	C2f	M2f	M2dr	C2f	M2f	M2dr	C2f	M2f	M2dr	C2f	M2f	M2dr	C2f	M2f	M2dr
60	168	182	192	22	65	62	48	28	160	72	85	112	178	202	136	51	45	52
71	183	158	159	41	48	70	33	33	127	63	82	148	162	210	148	72	32	48
80	178	120	128	71	81	48	28	20	140	66	77	121	170	187	156	50	51	21
85	151	145	133	42	75	60	38	15	131	68	62	98	151	174	121	41	50	42
95	145	132	136	33	38	58	32	19	59	45	68	92	148	175	132	45	28	38
106	170	146	130	28	36	25	20	15	62	36	48	86	136	159	111	22	18	18
112	171	72	136	51	32	25	30	18	22	28	36	75	124	133	98	32	40	33
125	120	70	122	32	48	32	30	16	28	25	32	62	96	119	92	25	26	30
Total	1286	1025	1136	320	423	380	259	164	729	403	490	794	1165	1359	994	338	290	282

Table 5. Pilling values of the fabrics knitted.

Weight of traveller, mg	Types of ring traveller											
	C2f				M2f				M2dr			
	SP	B	M	S	SP	B	M	S	SP	B	M	S
60	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	2-3	3-4	2-3	2-3
71	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	2-3	3-4	2-3	2-3
80	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	2-3	3-4	3-4	2-3
85	3-4	3-4	4-5	3-4	3-4	3-4	3-4	4-5	3-4	3-4	3-4	3-4
95	3-4	3-4	3-4	4-5	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4
106	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	3-4	3-4	3-4	3-4
112	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	3-4	3-4	3-4	3-4
125	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	3-4	3-4	3-4	3-4

using M2f type travellers, the Silvernic types give the lowest values (Figure 3e). At a speed of 10,000 rpm with M2dr type travellers (which were also of the Silvernic type), the yarn hairiness were the best, as they produced considerably less hairy yarns when compared with the others (Figure 3f).

Statistical Analysis

Two kinds of analysis were applied to the results of measuring the weight of the travellers, coating type and yarn tension to estimate their effect on yarn hairiness. The tests of significance were made at 95% and 99% confidence limits. The results are shown in Tables 7 and 8. Table 7 shows that the weight of travellers has a significant effect on yarn hairiness for all travellers analysed and at both spindle speeds. Regarding coatings, a significant effect can be observed only for M2dr at 7000 rpm and C2f at 10,000 rpm. Yarn tension also plays an important role in yarn hairiness, as can be seen from Table 8. The results in Table 8 shows the significant effect on yarn hairiness by spinning tension caused by traveller weight. The results with coated travellers were significant, except for C2f at both spindle speeds and M2f at 10,000 rpm.

Conclusions

- In all experiments, yarn hairiness generally decreased as the traveller weight was increased, regardless of type or coating.
- Yarn tension increased with increasing traveller weight. Hence the weight of the traveller had a signifi-

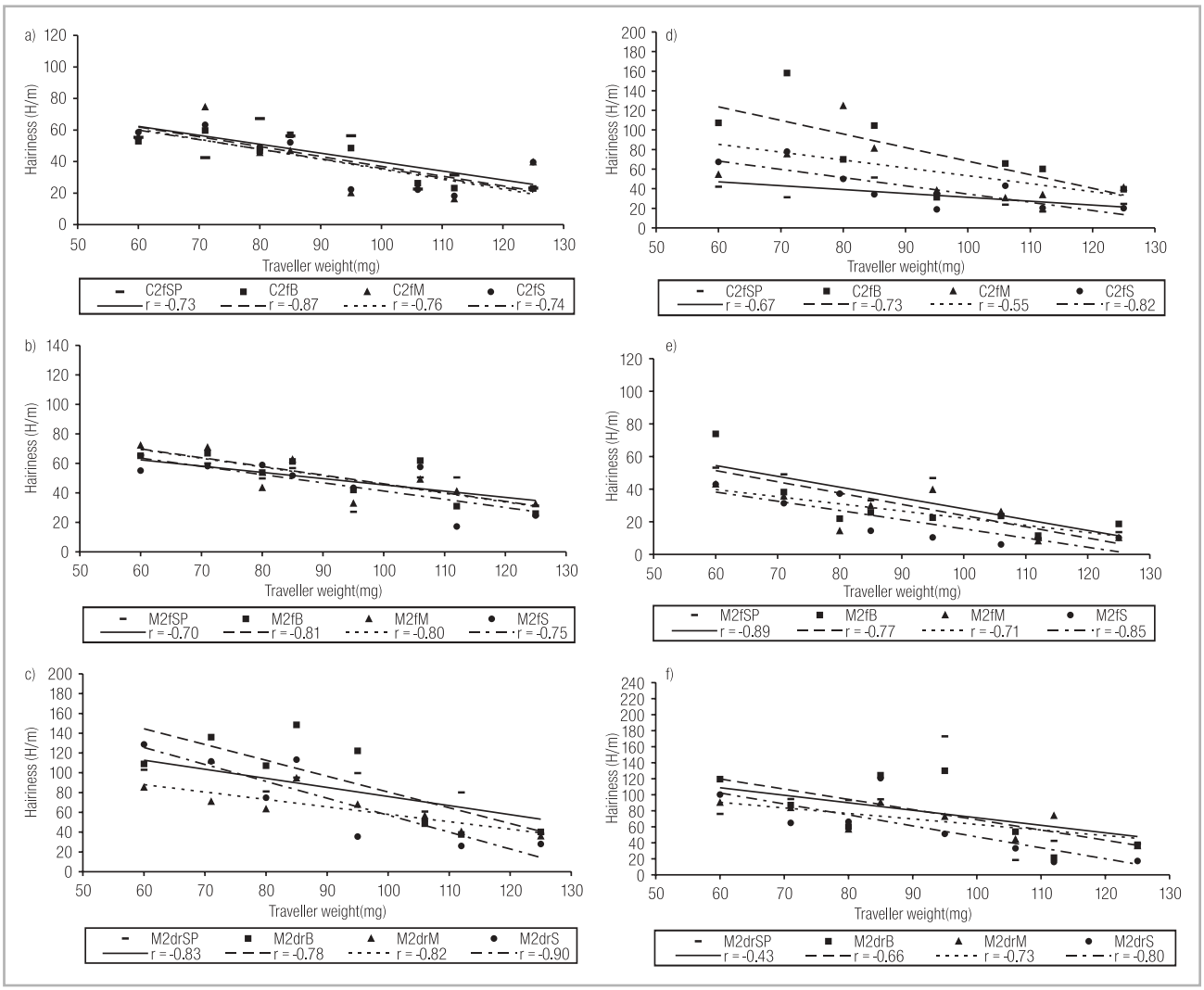

Figure 3. Yarn hairiness with different types of travellers and spindle speed: a - C2f, 7000 rpm; b - M2f, 7000 rpm; c - M2dr, 7000 rpm; d - C2f, 10,000 rpm; e - M2f, 10,000 rpm; f - M2dr, 10,000 rpm.

Table 6. Spinning tension of the acrylic yarns (cN).

Traveller type	Weight of ring travellers, mg							
	60	71	80	85	95	106	112	125
C2fSP07	15.5	16.0	18.0	19.0	20.0	20.5	20.0	21.0
C2fSP10	20.5	28.0	29.5	31.5	38.5	34.0	41.5	40.0
C2fB07	16.5	16.5	16.5	19.0	19.5	21.0	23.0	23.0
C2fB10	27.0	31.5	35.5	35.5	38.0	39.0	40.0	40.5
C2fM07	15.0	16.0	16.5	18.0	20.0	21.0	21.0	22.0
C2fM10	27.0	31.0	33.0	33.5	35.5	37.0	41.0	46.5
C2fS07	15.5	18.0	18.5	18.5	19.0	19.5	19.5	23.0
C2fS10	21.0	28.0	31.0	31.5	37.5	38.0	45.6	43.5
M2fSP07	15.0	17.5	18.5	16.5	18.0	18.5	18.5	19.5
M2fSP10	26.5	29.0	30.0	32.0	34.5	36.0	38.0	41.0
M2fB07	14.0	17.0	17.0	18.0	18.0	18.0	18.0	19.0
M2fB10	26.0	28.0	30.5	32.5	34.0	36.0	38.0	40.0
M2fM07	16.0	16.5	17.0	17.5	20.1	21.0	21.5	20.0
M2fM10	26.0	28.0	30.5	32.5	34.5	35.5	38.5	40.0
M2fS07	16.5	17.5	18.0	18.5	19.5	19.5	19.5	20.6
M2fS10	26.5	28.0	29.0	32.0	34.0	36.5	38.0	41.0
M2drSP07	16.5	18.0	18.0	18.5	22.5	23.0	23.5	24.5
M2drSP10	28.5	32.0	32.0	35.5	36.0	38.5	39.0	43.0
M2drB07	16.0	17.0	18.5	18.5	19.0	20.3	20.0	23.0
M2drB10	25.0	29.0	32.5	34.5	34.5	36.0	38.0	40.0
M2drM07	16.0	16.5	17.0	19.0	19.5	20.0	20.5	20.5
M2drM10	27.5	27.0	32.0	34.0	35.5	36.0	37.0	41.0
M2drS07	16.0	16.5	18.5	19.5	19.5	20.0	19.0	21.0
M2drS10	28.0	30.5	31.0	34.0	36.5	40.5	44.0	43.0

Table 7. Variance analysis of yarn hairiness using different weights and coatings of ring travellers (s - significant, n.s. - not significant).

Traveller		Spindle speed, rpm			
		7000		10,000	
		$\alpha_{0.05}$	$\alpha_{0.01}$	$\alpha_{0.05}$	$\alpha_{0.01}$
C2f	weight	s	s	s	s
	coating type	n.s.	n.s.	s	s
M2f	weight	s	s	s	s
	coating type	n.s.	n.s.	n.s.	n.s.
M2dr	weight	s	s	s	s
	coating type	s	s	n.s.	n.s.

Table 8. The results of the significance test on the dependence yarn tension-yarn hairiness, using travellers of weights & coatings and spindle speeds as in Table 7.

Traveller		Spindle speed, rpm			
		7000		10,000	
		$\alpha_{0.05}$	$\alpha_{0.01}$	$\alpha_{0.05}$	$\alpha_{0.01}$
C2f	weight	s	s	s	s
	coating type	n.s.	n.s.	n.s.	n.s.
M2f	weight	s	s	s	s
	coating type	s	s	n.s.	n.s.
M2dr	weight	s	s	s	s
	coating type	s	s	s	s

cant influence on reducing the yarn hairiness.

- Microscopic observations confirm the Shirley Yarn Hairiness test results.
- The flat types of M2f and C2f travellers caused less hairiness than the M2dr half-round type travellers.
- It is generally accepted that yarn hairiness increased as the spindle speed is increased [12]; however, this observation appeared as only partly true in our investigation. Spinning with light weight travellers, the yarn hairiness increased regularly as the spindle speed increased; but spinning with heavy travellers, the results became irregular, e.g. higher hairiness was measured at the spindle speed of 7000 rpm than when spinning at 10,000 rpm.
- Yarn hairiness is reflected in pilling of the fabric produced. Consequently, as traveller weight increases, pilling of the fabrics generally decreased. It should be stressed that the fabrics did not show any pilling when yarns had been spun with C2f and M2f travellers of 106, 112 and 125 mg weight.
- We propose that the travellers of two counts heavier than the manufacturers' specification must be utilised in spinning to produce less hairy yarns.
- In acrylic spinning, the use of M2f and C2f travellers can be preferred regarding the avoidance of hairiness in yarn, provided that they are not objectionable for other reasons.

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Acknowledgement

Grateful thanks are due to the Research Centre of the Marmara University, Yalova Fibre and Yarn Industries Co., and Temak Industrial and Commercial Co. of Textile Machine Auxiliaries, for the materials supplied.

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❑ **Received 02.12.2001 Reviewed: 12.07.2002**