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ABSTRACT

The performances of three different types of knots (dog, fisherman's and weaver's) during the knitting of different single jersey and double jersey structures have been compared. It was found that the number of yarn breakages (holes) during knitting, attributable to knots, depended upon the fabric structure and, in the case of the Punto-di-Roma structure, also on the particular feeder at which the knot occurred, with far more of the knots causing holes at the dial only feeders than at the cylinder only or dial and cylinder (i.e. interlock) feeders. The different types of knots did not differ much in their performance during knitting, although, on average, the weaver's knot caused the least yarn breakages and the dog knot the most. None of the some 750 knots knitted into the interlock structure caused holes whereas for the Punto-di-Roma structure more than 5% of the knots resulted in holes. For the Punto-di-Roma structure, about 50% of all the holes which occurred during knitting were due to knots, the corresponding figure for the plain single jersey structure being approximately 6% while for the interlock and satin stitch structures it was zero. The other yarn breakages during knitting were due to thin places in the yarn, the total number of breakages being decreased by waxing and by decreasing fabric tightness.

INTRODUCTION

It is generally accepted that knots can play an important rôle in determining the performance of staple fibre yarns in both knitting[1–13] and weaving[12–20], even though the actual number of knots causing faults may represent only a small percentage of the total number of knots present in the yarn. In weaving, for example, knots can be responsible for anything between 20% and 60% of the warp stops[10–12,14,16–18]. It is interesting to note that attention is increasingly being turned towards splicing yarns rather than knotting them because of the disadvantages associated with knots[13].

The extent to which knots cause problems during knitting depends upon various factors, such as the yarn friction[1,2], tail length[20], yarn input tension[2], knitting machine type[3] and speed[20], fabric tightness[8,20] and yarn linear density (relative to machine gauge)[6]. Generally, the higher the yarn linear density, friction and tension, the greater the incidence of faults due to knots.

Studies[3,5,9,20] have been undertaken on certain knitted structures (1 x 1 rib, Swiss double pique, interlock) and knitting machines to determine which knots perform best during knitting, and from these it appears as though the differences between the commonly used knots are generally small with, if anything, the weaver's knot possibly superior to the fisherman's knot, probably because of its smaller dimensions[9,21]. Garnsworthy and Plate[14], however, have drawn attention to the fact that there are three distinctly different types of fisherman's knots used in the industry and not only do they perform differently in unbalanced weaving yarns but their relative performance could also depend upon whether they are used in S or Z twist yarns.

Because no information appears to be available on the relative performance of different types of knots for popular structures such as Punto-di-Roma, interlock and plain single jersey when knitting wool yarns on modern high speed circular knitting machines, a project was carried out at SAWTRI in which the performances of three types of knots were compared using different knitted structures, fabric tightnesses and yarn linear densities.

EXPERIMENTAL

YARNS

Wool worsted yarns of linear density 18, 20 and 24 tex (the 18 and 20 tex yarns being in both waxed and unwaxed states) were used in one experiment and the 20 tex waxed yarn was used in two other experiments. Three different types of knots, viz. *dog* (also called bunch or thumb knot), *fisherman's* (SZ)[14] and *single weaver's* knots were tied approximately 50 m apart in separate lengths of yarn, using hand knotters.

KNITTING DETAILS

In all the experiments about to be described, only four knitting feeders were used, with yarn at three of the feeders containing no knots (except for the isolated knot and that at the fourth containing the knots intentionally inserted for purposes of the experiment. Each trial involved the knitting of a length of yarn containing about 50 knots, about 50 m of yarn separating successive knots. After knitting, the holes (yarn breakages) which occurred in the fabric were counted, with those occurring in the yarn within the proximity of a knot being recorded separately.

Experiment 1

In the first experiment, 18, 20 and 24 tex yarns were knitted into interlock and plain single jersey structures on a 22 gauge double jersey machine and a 28 gauge single jersey machine, respectively. Knitting details were as follows:

Plain Single Jersey

Machine	: Bentley JSJ 28 gauge (30″)
MTF	: 14
Yarn input tension	: 2,5 cN
No. of feeders	: 4
No. of machine revolutions	: 400
Machine speed	: 18 rev/min

Interlock

Machine	: Albi Combirib 22 gauge (20″)
MTF	: 14
Yarn input tension	: 2,5 cN
Machine speed	: 31 rev/min
No. of feeders	: 4
No. of machine revolutions	: 600
Timing	: 6 needle delay

The results obtained in this experiment are given in Table I.

Experiment 2

In the second series of experiments, the effect of fabric tightness was investigated by knitting the 20 tex waxed yarns into interlock, plain single jersey and satin stitch structures at various tightness factors. All the knitting conditions were as in *Experiment 1* except that MTF was changed (see Table II). The satin stitch structure was knitted on the Bentley machine, 700 machine revolutions being knitted in each case.

Experiment 3

In the third series of experiments the effect of run-in-ratio and fabric tightness (MTF) on the performance of the knots was investigated for the waxed 20 tex yarn knitted into a Punto-di-Roma structure. In addition, the performance of the knots at the different feeders viz. i.e. cylinder only, dial only or cylinder/dial (interlock) was studied. Knitting conditions were as follows:

Machine	: Albi Combirib 22 gauge (20")
Yarn input tension	: 2,5 cN
No. of feeders	: 4
No. of machine revolutions	: 600

The results of the tests are given in Table III.

RESULTS AND DISCUSSION

EFFECT OF YARN LINEAR DENSITY AND WAXING (Experiment 1)

In Table I the results are given for the plain single jersey and interlock structures when keeping MTF (fabric tightness) constant and varying yarn linear density. From these results it is apparent that, for the interlock structure, all the three different types of knots presented no problems during knitting, virtually all the yarn breakages being due to thin places in the yarn. No differences between the different knots could therefore be detected.

For the plain single jersey structure on the other hand, the knots contributed significantly towards the number of yarn breakages, particularly for the 20 tex yarns, with if anything, the dog knot performing worst and the weaver's knot best. What is apparent from Table I is that the unwaxed yarns generally performed far worse than the waxed yarns, confirming numerous earlier studies, both at SAWTRI and elsewhere, and the yarn breakages also decreased significantly as the yarn linear density increased. The latter is not difficult to explain in view of the fact that the majority of yarn breakages were due to thin places in the yarn and the fact that the stitch length had to be decreased as the yarn linear density decreased so as to keep the MTF constant.

EFFECT OF FABRIC TIGHTNESS (Experiment 2)

The results obtained when knitting the waxed 20 tex yarn into interlock, plain single jersey and satin stitch structures of varying tightness factors, are given in Table II. As in the previous experiment involving the 20 tex waxed yarn, the contribution of knots to the number of yarn breakages during knitting was negligible except for the plain single jersey structure. Once again, the yarn breakages occurred predominantly as a result of thin places in the yarn rather than as a result of knots or thick places. More than 1 500 knots were contained in the yarn knitted in this experiment of which only 11 were responsible for yarn breaks, and all these occurred in the single jersey structure. Once again it appears that the dog knot performed worst with, if anything, the weaver's knot producing marginally fewer yarn breakages than the fisherman's knot. As could be expected, the yarn breakages increased with increasing fabric tightness, i.e. with decreasing stitch length.

EFFECT OF RUN-IN-RATIO AND FABRIC TIGHTNESS (Experiment 3)

In Table III the results are given for the experiment in which the waxed 20 tex yarns containing different types of knots were knitted into a Punto-di-Roma structure at different run-in-ratios, tightnesses and at different feeders. The feeder at which the knot occurred played an important rôle in determining whether or not the yarn broke, with the knots being associated with yarn breaks far more frequently at the dial only feeder than at either the cylinder only or the interlock (dial/cylinder) feeders. It is apparent too, that the weaver's knot performed best, the other two types of knots performing very similarly. If the results for an MTF of 16 and a run-in-ratio of 1,8:1 are ignored, since these conditions led to excessive yarn breakages (all thin places), the results in Table III show that, when the values were averaged over the different feeders, 60% of the yarn breakages during knitting were due to knots in the case of the dog knots, while for the fisherman's knot the value was 57% and for the weaver's knot it was 43%. Considering the total number of knots in the yarn knitted, it appears that 8,7% of the 1 350 dog knots caused yarn breakages, while the corresponding values for the fisherman's knots was 7,6% and for the weaver's knots it was 4,9%. This is considerably higher than was the case for the other structures knitted in the other experiments and is due mainly to the high breakages associated with knots at the dial only feeder. In fact, taking an overall view of the results, (i.e. combining the results obtained for the different types of knots) it appears that, of the knots which were in the yarn knitted at the interlock (dial and cylinder needles knitting) feeder, only 1,3% were associated with yarn breaks and of those in the yarn knitted at the cylinder only feeder, only 2,4% were associated with a yarn break. On the other hand, 17,5% of the knots in the yarn knitted at the dial only feeder were associated with yarn breaks. What is also apparent from Table III is that the total number of yarn breakages increased with increasing MTF and run-in-ratio. These trends are in line with those observed in previous studies.

TABLE I

A COMPARISON OF THE PERFORMANCES OF DIFFERENT KNOTS FOR DIFFERENT YARN LINEAR DENSITIES AND KNITTED STRUCTURES

Structure	YARN LINEAR DENSITY		MTF	YARN BREAKAGES (HOLES) DURING KNITTING							
				Control Yarn		Dog Knot		Fisherman's Knot		Weaver's Knot	
	Tex	Waxed/ Unwaxed		Thin Places	Knots	Thin Places	Knots	Thin Places	Knots	Thin Places	Knots
Interlock	18	Waxed	14	103	0	129	0	66	0	76	0
	18	Unwaxed	14	128	0	200	0	179	0	163	0
	20	Waxed	14	15	0	10	0	12	0	8	0
	20	Unwaxed	14	48	0	99	0	120	0	113	0
	24	Waxed	14	0	0	2	0	0	0	0	0
Plain Single Jersey	18	Waxed	14	44	1	84	1	57	3	29	2
	18	Unwaxed	14	133	2	126	6	165	3	117	3
	20	Waxed	14	2	4	1	4	2	4	0	0
	20	Unwaxed	14	2	8	7	11	4	5	1	2
	24	Waxed	14	—	—	6	0	6	0	1	0

TABLE II

A COMPARISON OF THE PERFORMANCES OF DIFFERENT KNOTS AT VARIOUS MACHINE TIGHTNESS FACTORS (MTF'S)*

Structure	MTF	Yarn Breakages (Holes) During Knitting							
		Control Yarn		Dog Knot		Fisherman's Knot		Weaver's Knot	
		Thin Places	Knots	Thin Places	Knots	Thin Places	Knots	Thin Places	Knots
Interlock	14	1	0	3	0	0	0	3	0
"	15	2	0	1	0	4	0	2	0
"	16	4	0	6	0	12	0	8	0
"	17	30	0	26	0	23	0	31	0
Plain Single Jersey	14,5	9	0	1	1	9	1	0	0
"	15,0	19	—	5	2	5	1	3	1
"	16,0	68	—	72	3	53	1	64	1
Satin Stitch	13,0	20	0	10	0	13	0	15	0
"	14	51	0	150	0	45	0	81	0
"	15	537	0	490	0	467	0	520	0

*Waxed 20 tex yarn

TABLE III

A COMPARISON OF THE PERFORMANCES OF THE DIFFERENT KNOTS FOR THE PUNTO-DI-ROMA STRUCTURE (20 TEX WAXED YARN).

MTF	Run-in-Ratio	Feeder at which Knots were Knitted	YARN BREAKAGES (HOLES) DURING KNITTING							
			Control Yarn		Dog Knot		Fisherman's Knot		Weaver's Knot	
			Thin Places	Knots	Thin Places	Knots	Thin Places	Knots	Thin Places	Knots
14	1,2:1	Control Yarn	0	4	—	—	—	—	—	—
14	1,2:1	Interlock	—	—	0	0	0	2	0	0
14	1,2:1	Dial	—	—	0	19	—	19	1	12
14	1,2:1	Cylinder	—	—	0	3	1	2	1	2
14	1,5:1	Control Yarn	1	3	—	—	—	—	—	—
14	1,5:1	Interlock	—	—	0	0	1	2	0	3
14	1,5:1	Dial	—	—	0	7	1	3	1	2
14	1,5:1	Cylinder	—	—	0	0	0	3	1	0
14	1,8:1	Control Yarn	1	1	—	—	—	—	—	—
14	1,8:1	Interlock	—	—	1	0	2	1	1	3
14	1,8:1	Dial	—	—	1	6	1	5	1	1
14	1,8:1	Cylinder	—	—	1	0	1	1	0	0
15	1,2:1	Control Yarn	2	0	—	—	—	—	—	—
15	1,2:1	Interlock	—	—	0	1	1	1	0	0
15	1,2:1	Dial	—	—	1	13	1	15	1	9
15	1,2:1	Cylinder	—	—	0	1	2	1	1	0
15	1,5:1	Control Yarn	4	0	—	—	—	—	—	—
15	1,5:1	Interlock	—	—	0	0	2	0	3	0
15	1,5:1	Dial	—	—	2	5	1	8	2	0
15	1,5:1	Cylinder	—	—	1	0	2	0	3	0
15	1,8:1	Control Yarn	7	0	—	—	—	—	—	—
15	1,8:1	Interlock	—	—	15	1	4	1	13	0
15	1,8:1	Dial	—	—	9	12	6	8	13	3
15	1,8:1	Cylinder	—	—	11	1	22	3	19	0
16	1,2:1	Control Yarn	2	1	—	—	—	—	—	—
16	1,2:1	Interlock	—	—	1	1	1	0	2	1
16	1,2:1	Dial	—	—	1	27	2	7	2	13
16	1,2:1	Cylinder	—	—	2	3	1	2	1	2
16	1,5:1	Control Yarn	13	0	—	—	—	—	—	—
16	1,5:1	Interlock	—	—	16	0	11	0	10	0
16	1,5:1	Dial	—	—	4	17	5	16	6	9
16	1,5:1	Cylinder	—	—	11	0	11	3	5	6
16	1,8:1	Control Yarns	135	0	—	—	—	—	—	—
16	1,8:1	Interlock	—	—	276	0	226	0	200	0
16	1,8:1	Dial	—	—	300	0	211	0	275	0
16	1,8:1	Cylinder	—	—	248	0	251	0	229	0

SUMMARY AND CONCLUSIONS

The performances of three different types of knots (dog, fisherman's and weaver's) were compared when knitting singles wool yarns of different linear densities into different single jersey and double jersey structures.

The single jersey structures (plain and satin stitch) were knitted on a 28 gauge circular machine, while the double jersey structures (interlock and Punto-di-Roma) were knitted on a 22 gauge circular machine. Positive feed was employed on both machines. The effect of yarn linear density (18 to 24 tex), yarn waxing, fabric tightness (MTF), run-in-ratio (Punto-di-Roma only) and feeder (Punto-di-Roma only) on the performance of the knots during knitting was studied. The performance of the knots was assessed by counting the yarn breakages which occurred during knitting, with those occurring within the proximity of a knot attributed to the knot and counted separately.

It was found that the different types of knots did not differ much in their performances, although generally, the weaver's knot was best followed by the fisherman's knot, with the dog knot performing slightly worse than the latter. Although the *relative performance* of the different types of knots was not affected by factors such as yarn linear density, yarn waxing, fabric tightness and fabric structure, the actual number of yarn breakages attributed to knots in the yarn was dependent upon certain of the parameters investigated.

For the *interlock* structure, none of the more than 750 knots in the yarn appeared to have been responsible for holes (i.e. yarn breakages) during knitting irrespective of whether the yarn had been waxed or not and irrespective of the yarn linear density (between 18 and 24 tex) and fabric tightness. For the interlock structure, virtually all the yarn breaks during knitting were associated with thin places in the yarn.

For the *Punto-di-Roma* structure, the number of holes caused by knots depended upon the feeder (i.e. dial only, cylinder only or dial and cylinder), at which the yarn containing the knots was knitted, and to some extent on run-in-ratio. Of the 1 350 knots (dog + fisherman's + weaver's) in the yarn knitted at the interlock (dial and cylinder) feeders, only 1,3% caused yarn breaks, while the corresponding value for the cylinder only feeder was 2,4%. In contrast to this, some 17,5% of the approximately 1 350 knots in the yarn knitted at the dial only feeder caused yarn breaks during knitting. If the one set of results (obtained at a run-in-ratio of 1,8:1 and MTF of 16) is ignored, because of the high incidence of yarn breaks due to thin places, then it appears that, for the yarn containing the dog knots, some 60% of the total number of yarn breaks (holes) during knitting were due to knots, the corresponding value for the yarn containing the fisherman's knots being 57% and for the weaver's knots 43%. In all, 8,7% of the some 1 350 dog knots caused yarn breaks, 7,6% of the fisherman's knots caused yarn breaks and 4,9% of the weaver's knots caused yarn breaks when knitting the

Punto-di-Roma structure.

In the case of the *plain single jersey* structures, it was found that the number of yarn breaks associated with knots was higher for the unwaxed than for the waxed yarns as was the case for the total number of yarn breaks. Apparently the number of holes caused by knots was not affected by the fabric tightness. The actual percentage contribution of knots to the total number of yarn breakages observed for the plain single jersey structure depended upon the yarn linear density as well as on whether or not the yarn had been waxed, being lowest for the weaver's knots and highest for the fisherman's knots. For the waxed yarns, approximately 3,3% of the 750 knots caused holes, with knots responsible for 5,3% of the holes on average, although as already mentioned, the percentage was marginally lower for the weaver's knots and decreased as fabric tightness increased. For the unwaxed yarns, some 6,6% of the holes were due to knots.

For the *satin stitch* structure, which was knitted to different tightness factors using only 20 tex waxed yarn, none of the more than 450 knots resulted in yarn breakages (i.e. holes) during knitting, virtually all the holes being due to thin places in the yarn.

In general, it was found that most of the yarn breakages during knitting were due to thin places in the yarn, with the total number of yarn breakages being much higher for the unwaxed than for the waxed yarns, and the number of yarn breakages increased with increasing fabric tightness, i.e. decreasing stitch length.

The trends observed in this study should be valid for those cases where the yarn linear density is suitable for knitting machine but could change when this is not the case.

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