SAWTRI TECHNICAL REPORT

No. 347

Some Preliminary Observations on the Open-End Spinning of Wool

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SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

P. O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 0988 4

SOME PRELIMINARY OBSERVATIONS ON THE OPEN-END SPINNING OF WOOL

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ABSTRACT

The effect of various parameters on the rotor spinning of a 60 tex all-wool yarn was investigted. With metallic wire opening rollers, a speed of 6 000 r/min and a rotor speed of 35 000 r/min were found beneficial towards resultant yarn properties.

INTRODUCTION

In 1967 the Czechoslovakian BD 200 rotor spinning machine made its début. At that stage it was not fully realised that a new era for spinning had been introduced. Currently, rotor spinning is going from strength to strength. It is necessary, however, to look at certain limitations and various fields of application of this technique which many users of this relatively new technology have not taken into consideration. One of the first things to appreciate is that rotor spinning has its limitations in terms of yarn linear density. For linear densities in cotton yarn finer than about 20 tex, rotor spinning is uneconomical in most countries because of labour and power costs and ring spinning then becomes the more economical process.

There are a number of advantages and disadvantages associated with rotor spinning. The advantages are:

(a) Less floor space and operatives required.
(b) Production rates three to six times greater.
(c) A wide range of staple lengths can be used and variation in staple length has very little effect on spinnability.
(d) Very short and also relatively *weak* cotton fibres can be spun as hardly any tension is imposed on the fibre during actual yarn formation process.
(e) Power consumption is less, something which is becoming increasingly important on account of the energy crisis[1].
(f) Rotor yarns tend to have fewer neps.

The following disadvantages are to be considered:

(a) Initially, a high capital cost is involved.
(b) Yarn strength is 10 to 30 *per cent* lower. Normally, rotor yarns also require about 25 *per cent* more twist than their equivalent ringspun

yarns[2].

(c) End-uses of rotor yarns are restricted. At the present moment the bulk of rotor yarns goes into denims, towelling, sheeting and fabrics for printing and coating. There is, however, some further scope for rotor yarns.

(d) Rotor spinning would appear to be more sensitive to impurities such as trash and dust. Effective removal of such impurities will be of great advantage to better spinning performance. Extra cleaning points in the blowroom, especially with a trashy cotton, can only lead to more effective removal of impurities. Double carding also was shown to be effective especially when combined with two drawing processes. One has, of course, to look very closely at the economics of such a procedure. Tandem carding has also proved to be very effective in removing trash and possibly some of the micro-dust.

(e) Pilling of rotor yarns, especially polyester/cotton yarns, would appear to be worse than that of ring-spun yarns.

In many respects, rotor yarns differ inherently from ring-spun yarns. One important feature of rotor yarns is that there is a large twist gradient between the core of the yarn (having the higher twist) and its surface[1]. The stiffer and coarser fibres tend to be on the periphery of the yarn. There is, therefore, some evidence of preferential fibre migration in the case of rotor yarns[3]. Rotor yarns also tend to give a harsher handle in the end commodity. Furthermore, they are duller but give clearer prints in fabrics. Dyed fabrics from rotor yarns also tend to appear deeper in shade for the same dye uptake[4]. Rotor yarns are also not as sensitive to twist as ring-spun. A large increase in twist factor may only increase the strength very slightly. Another point to remember is that the sliver mass should vary with the linear density required. A 20 tex yarn requires about a 2,7 ktex sliver whereas a 98 tex yarn requires a 7,2 ktex sliver[5].

The construction of the opening rollers on the rotor spinner is also of vital importance and they would appear to be more effective when covered with saw-toothed metallic wire[6]. The shape of the trash box around the opening roller also plays an important role. Automatic emptying of the trash box underneath the opening rollers and cleaning of the rotors has been improved considerably by using a ®Clean Cat system developed by Suessen. In fact, the ®Spin Cat and ®Clean Cat processes can be considered as remarkable achievements in the field of automation.

Yarn tensions in rotor spinning have been measured by Krause and Soliman[7] and from their observations it would appear that for a particular linear density the spinning tension (cN/tex) and yarn tenacity *increase* as the rotor speeds increase, up to a rotor speed of about 35 000. Furthermore, at a particular rotor speed, the yarn tension and yarn tenacity *decrease* for increases in linear density. Twist factor increases also effect higher yarn tenacities. Finally, yarn irregularity, yarn tenacity and spinning tension could be correlated, i.e. as yarn tension increases irregularity increases.

Rotor spinning is a very interesting and challenging new spinning technique. There are, however, still many anomalies in existence. For example, the question as to whether the *abrasion resistance* of fabrics from rotor yarns, when compared with those from ring yarns is higher, is still a debatable point. Fabric cover is another matter of dispute and so is the resultant hairiness and elongation of the spun yarns.

The rotor spinning of all-wool, although not a new venture, has been relatively unsuccessful when compared with cotton. Furthermore, very little has been published about research findings on the various factors which could affect spinnability. Recently, the ITG 300 (SACM) rotor machine made its début and it is claimed that this machine represents a major advance in the rotor spinning of medium and long fibres, such as wool. The manufacturer[8] quotes examples of 21 μm wool spun to a 37 tex yarn at an English cotton twist factor of 3,2 and rotor speeds of 24 000 r/min. The resultant yarns had an irregularity (CV) of about 17,2 *per cent*.

Artz[9] claims that fibre-to-fibre and fibre-to-metal friction are of great importance in the spinnability of wool. To reduce these values to a minimum (and thereby facilitate fibre separation during yarn formation in the rotor) suitable lubricants should be used on the wool having a fatty matter content of 0,7 to 0,8 *per cent*. No particular lubricant has been recommended in this paper. It is interesting to note that Artz was also using cotton twist factors of the order of 3,7.

The purpose of the present report is to establish the importance of some of the parameters in the rotor spinning of an all-wool yarn.

EXPERIMENTAL

Raw Materials:

Combed wool top : This particular top comprised a short lambs wool type having the following characteristics:

mean fibre length	=	38 mm (CV % = 43,3)
mean fibre diameter	=	19,0 μm (CV % = 23)
Grease content (dichloromethane)	=	0,4 *per cent*

After scouring the wool was carded and combed on the worsted system.

Drawing and Rotor Spinning:

The wool top was attenuated on a Schlumberger N4 Drawframe to a sliver mass of either 6,6 ktex or 4 ktex. This sliver was then presented directly to the rotor machine.

The rovings were rotor spun on a Schubert & Salzer RU II rotor spinner. This machine has metallic wire clothing on its opening rollers. Cleaning of the opening rollers was automatic. Fifty-six mm diameter rotors (with V-grooves) were used. The resultant yarns were conditioned at standard atmosphere and tested for tenacity, irregularity, thick and thin places, neps and hairiness.

Spinning Trials:

Two series of trials were carried out. In the first series the twist was 704 t/m (i.e. a tex twist factor of 54,53 or a cotton twist factor of 5,6 was used) and the yarn linear density was 60 tex. The speed of the opening rollers was 4 000 r/min or 6 000 r/min and rotor speeds of 35 000 r/min or 40 000 r/min were used. These results are depicted in Table I.

Addition of Lubricants:

In the second series the effect of a few specific lubricants were employed at add-on levels of 0,3 and 0,6 *per cent.*

These lubricants were ®Bevaloid Lubricant 4 012, an oil-less anti-static ®Bevaloid Lubricant 4 018, having high lubricative properties and ®Duranol 60 designed to impart lower fibre-to-fibre and fibre-to-metal friction.

All lubricant additions were made in the form of an aqueous emulsion at the preparer gilling stage (i.e. before worsted combing). Conditions on the rotor spinning machine were similar except that a twist of 806 t/min (i.e. a 63,43 tex twist factor) was used.

Accumulation in Rotors:

The deposit which accumulated in the rotors was collected and analysed for composition by extraction of the grease with dichloromethane. The residual solids were qualitatively assessed on a microscope.

RESULTS AND DISCUSSION

From Table I the following points are worth mentioning:

(a) A change in sliver linear density, with a concomitant change in draft to arrive at a 60 tex yarn, had little or no effect on yarn properties.
(b) An increase in opening roller speed from 4 000 r/min to 6 000 r/min had a beneficial effect on yarn properties — yarn tenacity increased, yarn

TABLE I

EFFECT OF VARIOUS PARAMETERS ON 60 TEX ROTOR YARN PROPERTIES

Sliver Density (ktex)	Draft	Opening Roller Speed r/min	Rotor Speed r/min	Yarn Tenacity in cN/tex (and % Extn.)		Hairiness/ Metre	% Yarn Irregularity	Thick and Thin Places, (per 1 000 Metres)	Neps
4	66,7	4 000	35 000	5,46	(23,9)	6,81	16,7	48	64
4	66,7	6 000	35 000	5,75	(25,3)	6,44	16,1	32	54
4	66,7	4 000	40 000	5,02	(22,1)	6,63	17,4	124	128
4	66,7	6 000	40 000	5,11	(22,6)	6,06	16,7	52	62
6,6	110	4 000	35 000	5,49	(23,9)	9,49	16,3	50	110
6,6	110	6 000	35 000	5,54	(24,9)	7,72	15,9	18	36
6,6	110	4 000	40 000	5,12	(22,4)	6,66	17,2	148	222
6,6	110	6 000	40 000	5,31	(22,8)	6,66	15,7	24	56

Note: Twist 704 t/m (i.e. English cotton twist factor = 5,6)

irregularity improved, thick and thin places and neps were reduced.

(c) An increase in rotor speed from 35 000 to 40 000 r/min had a detrimental effect on yarn properties. Yarn tenacity decreased, thick and thin places and neps tended to increase.

From the results it can be concluded that, for the limited range of speeds studied, an opening roller speed of 6 000 r/min were beneficial towards better yarn properties. Tensile properties of a 60 tex yarn produced under these conditions were, as to be expected, only 25 *per cent* lower when compared with those obtained on the worsted system. The irregularity values were, however, of inferior quality by IWTO standards.

As regards the effect of lubricants, by consulting Tables II and III it should be clear that these specific lubricants hardly had any effect. In fact, in most cases the presence of a lubricant had a detrimental effect on yarn properties and twist had to be increased even further in order to get the yarn to spin.

An analysis of the composition of the deposit collected in the rotors in the

TABLE II

THE EFFECT OF LUBRICANTS ON THE YARN PROPERTIES OF A 60 TEX ROTOR WOOL YARN AT A ROTOR SPEED OF 35 000 r/min

Lubricant	Opening Roller Speed r/min	Yarn Tenacity (cN/tex)	% Extension	% Irregularity CV %	Thick and Thin Places, (per 1 000 metres)	Neps
None	4 000	5,54	25,5	16,6	44	38
None	6 000	5,3	24,9	15,2	14	28
0,3% Bevaloid Lub. 4012	4 000	5,05	23,2	18,5	202	250
0,3% Bevaloid Lub. 4012	6 000	5,2	25,8	16,7	46	74
0,6% Bevaloid Lub. 4012	4 000	5,16	25.0	17,3	100	102
0,6% Bevaloid Lub. 4012	6 000	5,23	23,9	16,6	46	50
0,3% Bevaloid Lub. 4018	4 000	5,08	24,2	18,1	106	88
0,3% Bevaloid Lub. 4018	6 000	4,83	22,6	15,9	36	62
0,6% Bevaloid Lub. 4018	4 000	5,21	24,9	16,5	78	50
0,6% Bevaloid Lub. 4018	6 000	5,12	23,9	16,7	40	44
0,3% Duranol 60	4 000	5,10	25,0	18,3	66	88
0,3% Duranol 60	6 000	5,04	24,0	17,3	54	72
0,6% Duranol 60	4 000	5,35	23,2	17,2	28	24
0,6% Duranol 60	6 000	5,03	24,1	16,8	32	52

Notes:

1. Sliver linear density: 4 ktex
2. Twist inserted 806 t/m (i.e. English cotton twist factor = 6,4)

case of the unlubricated wool gave the following results:

Wool grease	:	50 *per cent*
Wool bits (scales?)	:	40 *per cent*
Micro-dust	:	7,5 *per cent*
Foreign fibres	:	2,5 *per cent*

The influence of rotor deposits upon yarn properties was not studied in detail during this preliminary investigation and will be the subject of a further report.

TABLE III

THE EFFECT OF LUBRICANTS ON THE YARN PROPERTIES OF A 60 TEX ROTOR WOOL YARN AT A ROTOR SPEED OF 40 000 r/min.

Lubricant	Opening Roller Speed r/min	C.S.P.	Yarn Tenacity (cN/tex)	% Extension	% Irregu-larity CV %	Thick and Thin Places, (per 1 000 metres)	Neps
None	4 000	842	5,47	25,7	17,3	104	68
None	6 000	819	5,13	23,1	16,4	50	48
0,3% Bevaloid Lub. 4012	4 000	683	4,72	21,5	19,0	86	76
0,3% Bevaloid Lub. 4012	6 000	803	5,16	24,0	16,7	40	74
0,6% Bevaloid Lub. 4012	4 000	775	4,92	22,0	17,8	40	22
0,6% Bevaloid Lub. 4012	6 000	751	5,12		17,6	68	18
0,3% Bevaloid Lub. 4018	4 000	764	5,03	23,2	17,8	98	120
0,3% Bevaloid Lub. 4018	6 000	749	5,15	21,7	17,0	74	98
0,6% Bevaloid Lub. 4018	4 000	748	5,17	23,7	17,9	108	116
0,6% Bevaloid Lub. 4018	6 000	733	5,14	23,4	17,6	62	120
0,3% Duranol 60	4 000	757	4,96	22,5	17,7	148	146
0,3% Duranol 60	6 000	734	4,83	22,6	18,2	88	98
0,6% Duranol 60	4 000	Would not spin					
0,6% Duranol 60	6 000						

Notes:

1. Sliver linear density: 4 ktex
2. Twist: 806 t/m

SUMMARY AND CONCLUSIONS

A lambswool type having a mean fibre length of 38 mm and residual grease content of 0,4 *per cent* was spun successfully on a Schubert & Salzer RU-II rotor spinner at an opening roller speed of 6 000 r/min and a rotor speed of 35 000 r/min. Tenacities of the resultant 60 tex yarn were lower when compared to those of worsted spun yarns and irregularity values were low by IWTO standards.

ACKNOWLEDGEMENTS

The authors are indebted to Dr D.W.F. Turpie for supplying the wool roving and to the Textile Physics Division for testing the yarns. Permission by the S.A. Wool Board to publish this report is gratefully acknowledged.

THE USE OF PROPRIETARY NAMES

®Bevaloid Lubricant 4012 and ®Bevaloid Lubricant 4018 are proprietary names of lubricants manufactured by Messrs Bevaloid and ®Duranol 60 is made by Messrs Hansawerke. ®Spin Cat and ®Clean Cat are trade marks of Messrs Suessen.

The fact that chemicals with proprietary names have been used in this paper in no way implies that there are not others as good or even better.

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ISBN 0 7988 0988 4

Published by
The South African Wool and Textile Research Institute
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by P.U.D. Repro (Pty) Ltd., P.O. Box 44, Despatch