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Sizing of Singles Wool-Worsted Yarns
Part I: An Introductory Investigation

by

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SIZING OF SINGLES WOOL-WORSTED YARNS PART I: AN INTRODUCTORY INVESTIGATION

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ABSTRACT

An attempt to find a suitable size formulation for the weaving of all-wool singles yarns is described. The fabric woven was a $^2/_2$ twill trousering (250 g/m^2) made in three constructions and using three readily available sizes, (standard 7,5% mix). The method of sizing, using a modified Hergeth sample sizing machine is also described.

It was found that 44 tex and 37 tex yarns performed well but 27 tex yarns caused a significant difference in production efficiency. Yarn properties did not correlate with weaving efficiencies obtained and neither did the types of size used, with the exception, that warps sized with a mixture of polyvinyl alcohol and modified starch had lower abrasion resistance. This particular size mix gave higher wet pick-ups and generally higher weaving performance. It is concluded that sizing of all-wool worsted yarns can be effectively carried out, but it appears that yarn linear density is the dominant factor in respect to weaving performance rather than the type of size mix applied. Desizing of the fabrics in preparation for piece dyeing necessitated the use of an enzymatic designing agent.

INTRODUCTION

A vast amount of information exists on sizing and its application to textiles and it is beyond the scope of this report to attempt a review on the sizing of yarns. However some references to observations related to the sizing of singles wool yarns are included.

Hall[1] examined a large number of yarn properties that can affect either a yarn's ability to absorb the size solution or the adhesive properties of the resulting size film thus protecting the fibre bundles. He stated that by inserting more twist into a yarn the penetrability of the size solution is reduced, resulting in a less firmly anchored size with increased shedding and other problems in weaving. Chemical treatment of wool to reduce its felting propensity affects the surface of the fibre and thus, obviously, the sizing of wool yarns.

Tomiuk[2] explained that natural yarns contain waxes and oils which can cause problems with size adhesion. Sizing of spun yarns is different from the sizing of filament yarns. In the case of spun yarns the size should be a film-former, acting primarily as a coating agent and as an adhesive. It should coat and bind the staple fibres together so that they cannot slip and the fuzziness and hairiness of the yarn is reduced. He stated that the primary function of sizing warps is to increase the strength of individual fibres which could result in the yarn having the necessary stiffness, strength and elasticity, in order to enable it to withstand the mechanical operations of weaving. This statement is questionable and perhaps it would be more correct to say sizing increases the friction between individual fibres which results in an increase in strength etc etc.

The nature of a fibre or yarn determines the type of size to be used, while the construction of the yarn and the fabric required to be made determines how much size should be used. Therefore, yarn linear density, yarn twist, number of ends in warp, warp density and total width; fabric construction, pick density, weft linear density, type of filling, type of reed, speed of weaving machine, type of harnesses, drop wires, etc. are all factors that may influence the weavability of a warp yarn and to some degree determine the ultimate choice of size ingredients and concentration.

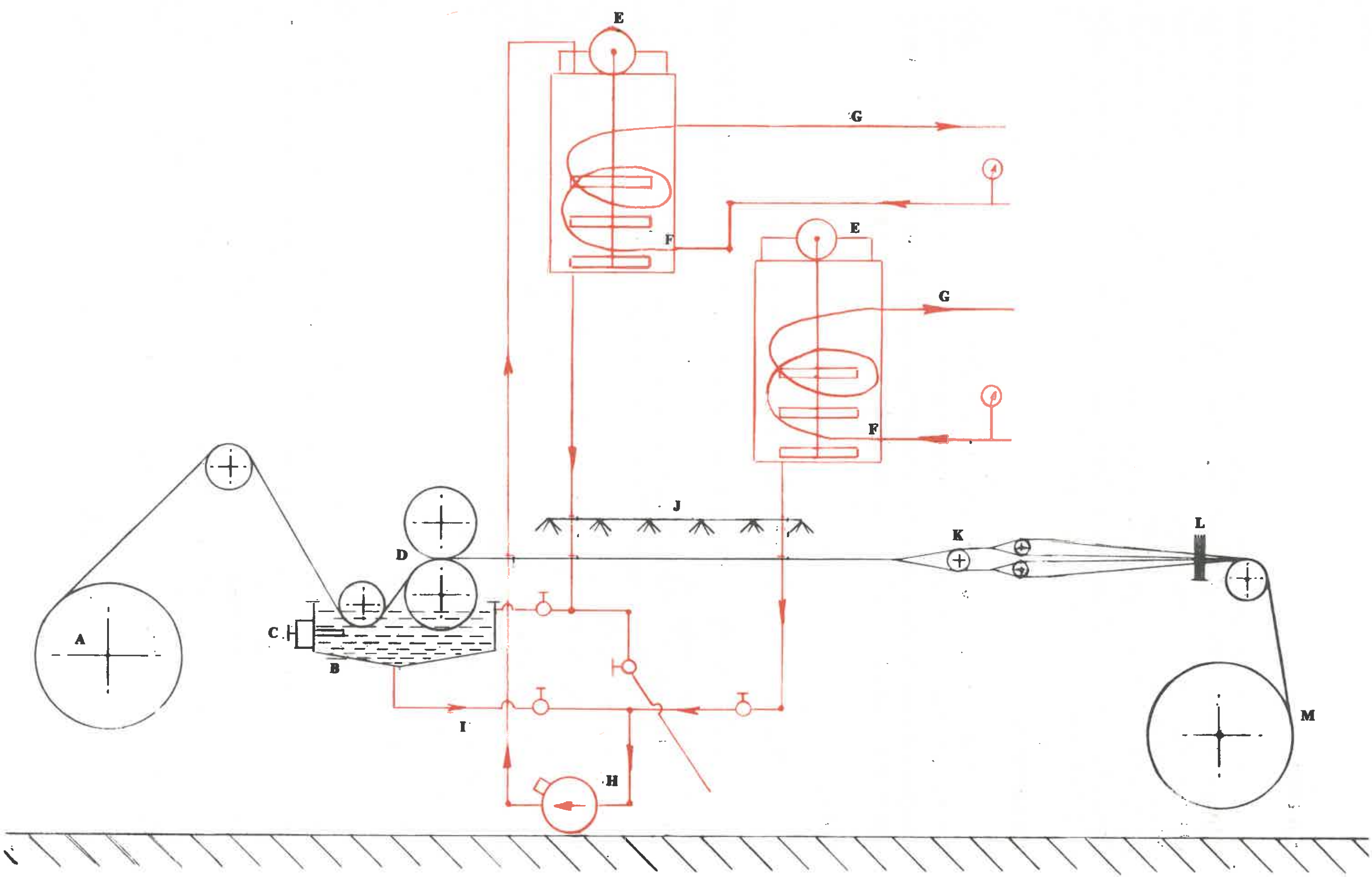
The use of synthetic sizes for spun yarns is increasing, both as additives to conventional recipes or as separate sizes. Chemical manufacturers can now tailor-make these materials to any properties required.

The cost of synthetic sizes is high compared with starch sizes or starch derivatives but the advantages in application, weaving and particularly in dyeing and finishing has persuaded more and more manufacturers to turn to synthetic products. This is perfectly true in the case of cotton and blend yarns but the sizing of singles wool yarns is still not carried out to any great extent although several patent size formulations exist for the sizing of wool.

Marsland[3] pointed out that with conventional sizing the adjacent yarns are sized together and that before a weavable warp can be made they must be separated. It is this separation or splitting stage that can cause damage, especially so in the sizing of filament yarns. An alternative method of sizing known as warper sizing, or *single-end-sizing* on a multiple basis, affords protection to the yarn at the earliest possible stage and does not require splitting during beaming. This method, however, is particularly appropriate for sizing continuous filament yarns.

Control in warp sizing is very important. Size feed, wet tensioning of the yarn to avoid stretch, size bath temperature, drying, moisture content and tensions during drying and beaming must all be carefully controlled. The end product of sizing is considered as giving optimum weaving results in quality with the highest possible machine utilisation factor. Today automatic controls on conventional sizing machines are available at the size box and drying cylinders, with draw roller control and beam tension control, dynamometers automatically measure tension of winding onto the weaver's beam and can incorporate a progressively reducing tension arrangement to eliminate crimping on the beam.

Sizing is a relatively expensive process and the control of uniform size application and consistent sizing results have been greatly assisted by the use of the Shirley size box[4], which controls the size pick-up regardless of the speed of



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Spinning

A lot of combed S.A. merino tops (m.f.d. 21 μm, m.f.l 54 mm) was lubricated with 0,3% ®Bevaloid 4027 (fibre lubricant) and gilled, followed by one operation of drawing on an NSC gill box type GNP. It was then gilled twice on an NSC GN4 intersecting gill box, followed by a final drawing operation on an NSC FM 1 high draft draw frame, producing a roving of around 500 tex. Spinning was carried out on a Rieter H6 spinning frame to produce three different worsted yarns the physical properties of which are given in Table II.

Preparation

The yarns were wound and cleared on a Schlafhorst IKN cone winder fitted with Uster electronic automatic yarn clearers and Classimat recorder. Warping was carried out on a Hergeth sample warping machine, and the warps transferred onto the swift of the Hergeth sample sizing machine.

Sizing

Three different size formulations were used as follows:

1. ®Solvitose XI (a modified potato starch ether) plus ®Bevaloid 6381 (a polyacrylate solution)
2. ®Corn products 5080 (a modified maize starch) plus Bevaloid 6381
3. ®Bevaloid 4032 (a blend of polyvinyl alcohols with modified starch plus other auxiliaries).

   All the above formulations were used for size mixes having a standard viscosity. The percentage total solids used was 7,5% which included in all cases 2,5% on mass of solids ®Bevaloid 581D (a fatty acid ester in a hydrocarbon which acts as a defoamer) and 10% on mass of solids anti static. Whenever Bevaloid 6381 was used a 2:1 mix was made, i.e. 2 parts Bevaloid 6381 to one part modified starch as is.

Method of Size Application

The method of size preparation was to run about one-third of the required volume of water into a storage kettle and then to sprinkle in the size ingredients whilst stirring. The solution was heated to 96°C and kept at this temperature for 30 minutes and then made-up to a volume of 45 ℓ. Sizing was carried out at a temperature between 80°C and 90°C.

The sheet of yarn was passed over a guide roller and underneath an immersion roller into the size liquor. The same size bath temperature and level were maintained throughout to ensure uniform size application. The yarn was then passed between the quetsch rollers, with the bottom roller revolving, partly immersed in the liquor.

The top roller load was 2,25 kN over a 200 cm width. The yarn was then drawn forward at the relatively low speed of 1 m/min under a 19,2 kW infra-red heater to dry. The temperature of drying was maintained between 75°C and 85°C, the sheet of yarns being split by means of lease rods and expanding comb and finally wound onto the weaver's beam.

Physical Properties of Yarns

The tensile properties of the yarns were measured on a Goodbrand single thread tester. The abrasion resistance of the sized yarns was determined on a Bevaloid abrasion tester[7] on which the number of rubbings (emery 400, ®Carborundum) which caused the yarn to break was recorded. A headweight of 25 cN provided the load tension. The unsized yarn (control) was also tested for comparison. All tests were carried out at 20°C and 70% RH.

Measurement of size pick-up on warp[8]

Approximately 10 g of sized yarn was dried at 102°C for two hours and then weighed. The same yarn was then scoured, filtered, dried and re-weighed and the percentage dry pick-up of size calculated.

An **unsized** sample of yarn was also subjected to the same desizing procedure to determine the soluble fractions and waxes on the fibre and the percentage dry pick-up of the sized yarn was then corrected accordingly. The results of tests carried out on the warp yarns are shown in Table III.

Weaving

The specifications of the three basic constructions are given in Table I.

TABLE I

SPECIFICATION OF FABRICS (250 g/m²) WOVEN FROM 64's ALL-WOOL

Yarn linear density	44 tex Z 560	37 tex Z 630	27 tex Z 733
Total ends	3672	4680	5980
End x picks (grey)	22,04 X 23,23	28,34 X 28,34	36,22 X 29,13
Ends x picks (finished)	24,41 X 23,62	33,07 X 31,40	40,15 X 30,70

The warps were woven on a 190 cm Saurer 100W automatic loom running at 180 picks/min using weft mixing. The weave construction was $^2/_2$ twill.

The fabrics were woven under ambient conditions of 20°C and 70% RH and for each formulation samples of the warp yarn before sizing (control) and after sizing were tested for size efficiency. During the weaving trials all weaving machine stoppages were recorded. All stoppages unrelated to warp breakages were eliminated and the warp weaving efficiency calculated as follows:-

$$\text{Warp weaving efficiency (\%)} = \left(1 - \frac{A}{B - C}\right) \times 100$$

where A = Total stopped time for all warp faults

B = Total running time

and C = All stopped time other than for warp faults.

The number of warp yarn breakages per 1 000 ends per 100 000 picks was then calculated. These results are shown in Table III.

Desizing of fabrics

All the size formulations used in these trials were claimed to be easily removable without the use of enzymes, but this claim, in some cases, was probably based on their use with 100% cotton and cotton/polyester blends rather than 100% wool worsted yarns. Normally the size is removed under strongly alkaline conditions. This, however, was untenable in this investigation as such conditions are detrimental to wool.

During trials on sizing with mixture sizes (modified starch plus synthetic sizes) and their removal from the fabric, it was found that, after crabbing, a 30 minute aqueous treatment at pH 9, adjusted with ammonia, plus 0,5 g/ℓ ®Nonidet P40 (a non-ionic detergent) at 45°C gave satisfactory removal of all four main size ingredients, although not necessarily a complete removal. In order to desize the fabrics completely for subsequent piece dyeing it was found that ®Rapidase, an enzymatic desizing agent designed for the removal of starch, gave satisfactory results.

Dyeing and Finishing

After desizing the fabrics were scoured, piece dyed on the winch, hydro-extracted, stentered, steamed and brushed, cropped and finally decatised.

RESULTS AND DISCUSSION

Table II gives the properties of the yarn prior to preparation.

TABLE II

PHYSICAL PROPERTIES OF ALL-WOOL YARNS PRIOR TO PREPARATION

Yarn Linear Density (tex)	Goodbrand single thread Breaking Strength (cN)	Tenacity (cN/tex)	Extension (%)	Irregularity CV (%)
44	306	7,3	23,9	15,3
37	241	6,9	24,4	16,5
27	170	6,6	19,7	18,2

Table III gives the properties of the unsized and sized warp yarn. The yarn in the singles unsized state was unweavable.

It can be seen that when comparing the single thread breaking strengths after warping with the results in Table II, that the strength of the yarns was reduced by about 15%. The warped yarn had obviously undergone some damage during winding, warping and beaming. The extension of the yarns had been considerably affected and it would appear that in the case of the 27 tex warp the deterioration in breaking strength and elongation was critical, as shown by the very low abrasion resistance of the yarn. The abrasion resistance of the unsized yarns indicated that the 44 and 37 tex yarns were satisfactory.

From Table III it can be seen that in general the 44 tex yarn performed extremely well irrespective of the size formulation used. The 37 tex yarns were very much weaker and higher end breakage rates were recorded although the weaving efficiencies were still relatively high. The 27 tex yarns, however, were very weak and a high number of yarn breakages were recorded and in general, the weaving efficiencies were low. The results were encouraging from the point of view of the satisfactory weaving of singles worsted yarns although they were somewhat disappointing in that trends were not significant. A regression analysis of the data shown in Table III was carried out and only in the case of abrasion resistance did the actual add-on of the size mixture have an effect. Solvitose X1 and Corn products 5080 combined with Bevaloid 6381 both gave

TABLE III

PROPERTIES OF WARP YARNS BEFORE AND AFTER SIZING WITH A 7,5% MIX

Yarn Linear Density Tex	Size Mix	Size* Add-on (%)	Goodbrand Single Thread Breaking Strength (cN)	Extension at Break (%)	Abrasion Resistance (cycles to Break)	End Breaks 1 000 Ends/ 100 000 Picks	Warp Weaving Efficiency (%)
	—	—	260	17,5	39	∞	Unweavable
44	Solvitose XI + Bevaloid 6381	4,4	296	18,5	57	0	99,7
	Corn Products 5080 + Bevaloid 6381	3,8	320	17,5	56	2,8	98,1
	Bevaloid 4032	6,9	324	23,0	48	0,7	99,6
	—	—	204	22,0	39	∞	Unweavable
	Solvitose XI + Bevaloid 6381	5,0	224	19,0	50	3,6	92,3
37	Corn Products 5080 + Bevaloid 6381	4,4	272	23,8	52	1,1	99,1
	Bevaloid 4032	5,8	264	18,4	38	7,3	93,9
	—	—	146	8,4	28	∞	Unweavable
	Solvitose XI + Bevaloid 6381	4,5	164	12,7	36	25,1	69,3
27	Corn Products 5080 + Bevaloid 6381	4,2	160	7,5	33	25,8	73,7
	Bevaloid 4032	4,5	168	10,9	34	13,0	89,9

* Corrected for residual foreign matter on yarn prior to sizing

better resistance to abrasion than did Bevaloid 4032 which was to be expected. The manufacturers' specification for Bevaloid 4032 indicated it was primarily for use with blends of natural fibres and polyester.

All the other dependent variables, breaking strength, extension at break, end breaks/1000 ends/100 000 picks and efficiencies appeared to be dominated by the effect of yarn linear density.

It can be seen from the results of actual size add-on, that Bevaloid 4032 gave the highest add-on, Solvitose XI + Bevaloid 6381 the second highest and Corn Products 5080 + Bevaloid 6381 the lowest add-on in all warp constructions. The average calculated wet pick-ups were 75%, 60% and 55% for the three sizes respectively. In every case the yarn breaking strength was improved by sizing.

The 27 tex yarn was very weak and exhibited excessive end breakages. Considering the relatively better weaving performance of the 44 and 37 tex yarns it was felt that the 27 tex yarns would show up any differences in the effect of the size mixtures. Whilst the differences in warp weaving efficiency of sized 27 tex warp yarns were significant, there was no evidence to support this from the physical properties of the yarns. The end breakages recorded in the case of 44 tex sized warps were very low (average 1,2/1 000 ends/100 000 picks) and extremely high warp weaving efficiencies were achieved (average 99,1%). In the case of the 37 tex yarns the average weaving efficiency was 95,1% with an average 4,0 end breaks/1 000 ends/1 000 000 picks).

SUMMARY AND CONCLUSION

An attempt was made to find a suitable size formulation for sizing all-wool singles yarns. A typical construction using 44 tex yarn formed the basis of the sizing trial and it was decided to size three different warps using two popular sizing formulations (mixtures of starch derivatives and a polyacrylate size) which are readily available on the local market. A third size formulation (a "one-shot" size) specially developed for blends of staple fibres with polyester was also evaluated.

Analysis of the pick-up of the size (7,5% mix) showed that only a low wet pick-up of approximately 60% were obtained on the worsted warps with this method of sizing, i.e.: on a modified Hergeth sample sizing machine.

In all cases the 44 tex yarn performed extremely well during the weaving trials with low end breakage rates being recorded.

A second structure using 37 tex yarn with a concommitant change in thread density was then woven and resulted in a slightly higher end breakage rate, but was still woven with little trouble and at fairly high efficiencies.

A significant decrease in yarn linear density to 27 tex caused significant differences in production (efficiency) for the three different sized warps. Yarn strength, extension and abrasion resistance, however, showed no correlation with weaving efficiencies and the only significant difference was a lower abrasion resistance for the warp sized with the Bevaloid 4032. It appears that this particular size gave higher wet pick-ups (on all three lots of yarn) than the other formulations, and the higher weaving performance obtained was in line with observations made in parallel investigations.

It can be concluded that sizing of all-wool worsted singles yarns can be effectively carried out using certain conventional size formulations available locally. It would appear that, in general, the application of a size increases yarn strength as a result of increased cohesion between the wool fibres which in turn makes all the difference in terms of warp weaving efficiency. Whilst sizing of the yarn resulted in a slight increase in the yarn breaking strength and the abrasion resistance of the yarns when subjected to simulated weaving conditions (abrasion and extension) the type of size did not effect the general results significantly with the possible exception that in the extreme case of the 27 tex warp, that a higher warp weaving efficiency was obtained using Bevaloid 4032.

It was found that in general that the size formulations used in this investigation could not be removed from the wool satisfactorily by normal alkaline scouring and caused unlevelness in the piece dyed fabrics. This, nevertheless was overcome by using an enzymatic desizing agent.

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THE USE OF PROPRIETARY NAMES

®Bevaloid 4027, 356, 581 D, 6381 and 4032 are products of Messrs Bevaloid S.A. (Pty) Ltd., ®Solvitose XI is manufactured by Messrs W.A. Scholten, Chemische Fabricken N.V., Nederland, and ®5080 is a product of Messrs Corn Products (S.A.) (Pty) Ltd. ®Nonidet P40 is a product of Shell (SA), ®Carborundum is manufactured by Messrs 3M (S.A.) and ®Rapidase is a product of Messrs Societie Rapidase.

The fact that chemicals with proprietary names have been mentioned in this report does not in any way imply that SAWTRI recommends them or that there are not substitutes which are of equal or better value.

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