



Physico-mechanical response of acrylic-viscose ring spun and Dref 2 friction spun yarns

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Abstract: The physical and mechanical response of Dref 2 Friction spun yarn differs from that of ring spun yarn due to dissimilarities in yarn structure. The influence of extension rate and blend ratio was examined for acrylic-viscose yarn spun on both systems. The results reveal that unevenness and hairiness are dependent on both blend ratio and spinning system. Tenacity shows to increase with increase of extension rate upto a certain level and then decreases. For ring spun yarns tenacity continues to increase. Increase in acrylic content in the blend results in increase in yarn tenacity and extension for both yarn spinning systems. The present finding corroborates the postulation of blended yarn tenacity by Hamburger's model.

Keywords: DREF 2 Friction spinning, packing coefficient, mass evenness, extension rate

I. Introduction

Since the inception of non-conventional spinning systems, Dref 2 Friction Spinning technology characterised by low yarn tension and bundled yarn structure emerged successfully in the coarser yarn sector. This novel method is able to produce yarn with fairly soft handle, desirable mass uniformity and high bulk. A number of researchers have investigated into the tensile behaviour of ring and rotor spun yarns but not much been explored for friction spun yarns. Midgley and Pierce¹ stated that the breaking load of cotton ring yarn is inversely proportional to the logarithm of time to break the specimen. Kaushik et al² showed that yarns spun on a viscose majority blend are stronger but show low breaking extension than acrylic majority yarns at all twist levels. Singh and Sengupta³ observed an increase in yarn tenacity with an extension rate ranging between 0.1-100 cm/min. Balasubramanian and Salhotra⁴ observed that a very high extension rate results in lowering the tenacity of cotton yarns and maximum tenacity occurs at an optimum extension rate. Padmanabhan⁵ found that friction spun yarn shows better yarn mass evenness and higher hairiness than equivalent ring spun polyester blended yarn.

II. Materials and Methods

DREF 2 Friction spun yarns were produced from finisher drawn slivers of 5.2 ktex using 1.5 denier, 51 mm acrylic and viscose staple fibres with four different blend ratios of 0/100, 35/65, 65/35 and 100/0 by weight to a linear density of 90 tex on a Dref II spinning machine. Outlet speed, spinning drum speed and its diameter were 116 mpm, 3440 rpm and 81 mm respectively. The similarly processed finisher drawn sliver was used to produce ring yarn of same linear density processed through speed frame and then spun on a G5/1 ring frame using standard process parameters. The properties of fibres used are shown in Table I.

Table 1: Specifications of acrylic and viscose fibres

Fibre used	Fibre length, mm	Fibre denier	Tenacity, cN/tex	Breaking extension%
Acrylic	51	1.5	27.46	25.64
Viscose	51	1.5	18.33	15.72

Evenness, imperfections and hairiness were assessed simultaneously using UT3 Evenness Tester at a speed of 200 m/min. Average yarn diameter was measured on Projectina microscope using a magnification of 30 times from 50 readings. Yarn specific volume was found out from measured yarn diameter and yarn linear density. All the Dref 2 friction spun yarns were tested at four extension rates of 50, 200, 300 and 500 mm/min and specimen lengths of 100, 200 and 500 mm on an electronic tensile tester (Instron Model 4301) while ring spun yarns were evaluated at 200 mm./min except testing A/V (65/35) blend at four extension rates. The yarn diameter was measured by Wild Leitz optical microscope. Forty readings were taken to determine the average yarn diameter. Assuming circular yarn cross section the specific volume of yarn was calculated by using the formula

Specific volume of yarn (V_y) = $\frac{\pi d^2}{4} X \frac{10^5}{T_{\text{tex}}} \text{ cm}^3/\text{g}$
 Specific volume of fibre (V_f) = 1/ fibre density
 Packing co-efficient = V_f/V_y

III. Results and Discussions

Table 2: Effect of blend Ratio on packing coefficient, mass evenness and hairiness

Yarn Properties	Ring spun yarn				DREF 2 spun yarn			
	Blend ratio (A:V)				Blend ratio (A:V)			
	0:100	35:65	65:35	100:0	0:100	35:65	65:35	100:0
Linear density, tex	94.5	90.7	90.8	90.6	93.7	91.0	90.8	93.6
Diameter, mm	0.39	0.50	0.61	0.70	0.58	0.66	0.73	0.89
Packing coefficient	0.50	0.33	0.24	0.20	0.23	0.19	0.17	0.13
Mass CV (%)	13.7	14.3	15.7	17.3	13.7	13.3	11.0	12.0
Thin places (-50%)/km	02	56	48	308	88	24	02	48
Thick places(+50%)/km	56	120	184	312	16	48	02	24
Neps (+200%)/km	48	16	64	24	128	46	64	128
Total imperfections/ km	106	192	296	644	232	118	68	200
Hairiness Index	10.2	11.4	10.9	11.9	12.6	12.8	11.3	13.2

A:V = Acrylic:Viscose

Table 3: Effect of blend Ratio, extension rate and specimen length on tenacity and extension of ring spun yarn

Yarn Tensile Properties	Extension rate, mm/min	Blend Ratio (Acrylic : Viscose)					
		A =0/100	B =35/65	C = (65/35)			D = (100/0)
		Specimen length, mm		Specimen length, mm			Specimen length, mm
		200	200	100	200	500	200
Tenacity (cN/tex)	50				9.6		
	200				9.9		
	350				9.9		
	500				10.0		
Breaking Extension (%)	50				14.5		
	200				14.4		
	350				14.4		
	500				14.2		

A Properties of Ring Spun Yarn

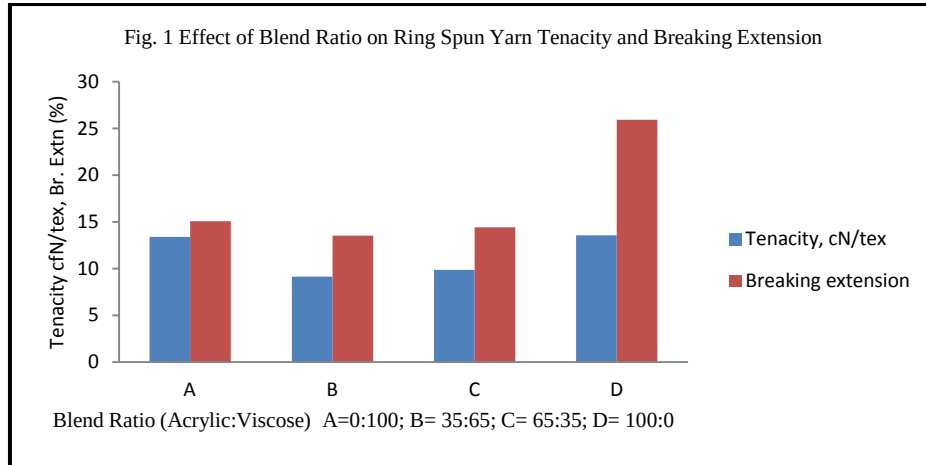
While comparing ring yarns with friction spun yarns, it is observed from Table 2 that the latter exhibit better uniformity and increased hairiness for all blend compositions. This is in agreement with the findings of Padmanabhan⁵ who found similar trend with polyester viscose yarn.

However in all, A:V (35:65) blend friction yarn shows best results in terms of evenness and hairiness. Hence this blend composition is considered the most ideal blend on friction Dref 2 spinning system. This may be ascribed to more uniform and controlled fibre movement and fibre collection on the perforated drums during the course of spinning process.

In ring spinning, viscose majority (0:100) blend shows minimum unevenness and hairiness under identical process conditions. In all it may be stated that ring yarns spun from a viscose majority blend are more uniform than acrylic majority blended yarns while in friction spinning system acrylic majority yarns exhibit more uniformity than viscose majority blended yarns. While proportion of acrylic regulates the said attribute in friction spinning system, manner of fibre flow in the friction field becomes an important determinant in controlling evenness of the produced ring yarn. It may therefore be surmised that increase in the acrylic content in the blend leads to uncontrolled fibre movement in the friction field of the ring spinning drafting zone.

It may be observed from Table 3 and Table 4 that viscose majority ring yarn exhibit higher tenacity at a particular extension rate of 200 mm/min than the ring yarns of acrylic: viscose (35:65 and 65:35) varieties. Tenacity first drops with the increase in proportion of acrylic in the blend and then rises at a steady rate for the same extension rate. Further increase in acrylic content continues to show increase in tenacity. However the tenacity for acrylic majority yarn does not appreciably increase. This may be clear from tables 2 and 3 where acrylic majority ring spun yarns show higher variability than equivalent viscose majority blend and this gives rise to inclusion of potential weak places and thus non-uniform stress concentration during yarn straining. In addition, the fibres in acrylic majority ring spun yarn are less closely packed (Table 2) than the fibres in viscose majority yarn. This in consequence develops lesser frictional forces and transverse pressure during tensile loading producing lower tenacity. Breaking extension first drops with increase in acrylic content and then rises for 65:35 blend and reaches maximum for acrylic majority yarn at an extension rate of 200 mm/min which may be ascribed to inherent higher elongation of acrylic fibres. The less compact characteristic of acrylic oriented

blends permits relative movement of constituent fibres in the yarn during straining and enhances possibility of fibre slippage and orientation of fibres along the axis.



B. Properties of Friction Spun Yarn

Similar trend exists for Dref 2 yarns at all blend ratios. Initially a small inclusion of acrylic results in a decrease in tenacity at 200 mm/min extension rate and then increases showing maximum for acrylic majority yarn. Major contribution to tenacity is now achieved from stronger acrylic although there is a drop in packing coefficient with the addition of bulkier acrylic fibre.

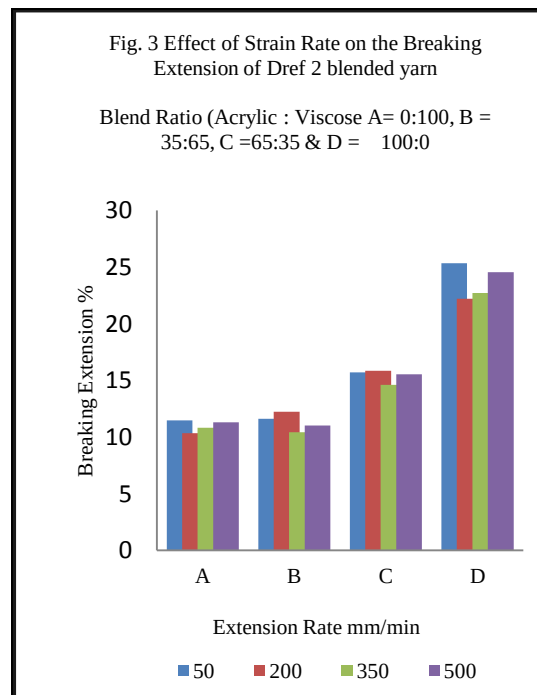
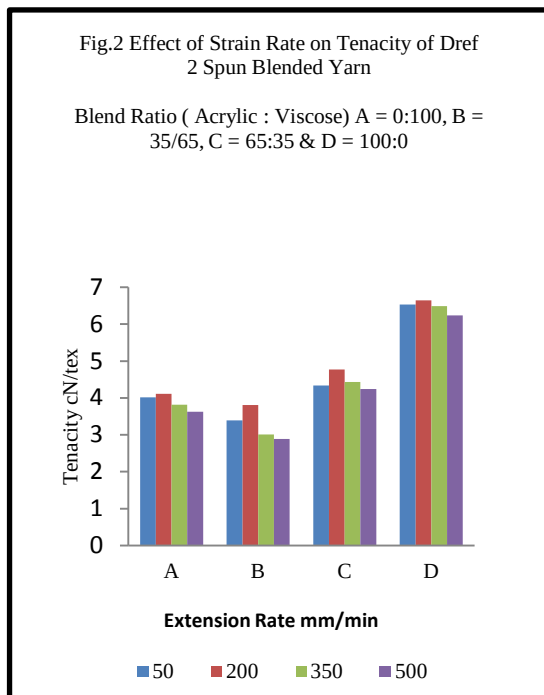
It is well known that rapid straining of yarn results in higher breaking load and in turn a higher a tenacity. The test results for tenacity and breaking elongation values are depicted in Tables 3 & 4 and Figures 1 to 4.

Maximum tenacity for friction yarn is obtained at 200 mm/min for all blend compositions with 500 mm/min showing less tenacity. For ring yarns with blend ratio of 65:35, tenacity increases with initial increase in strain rate and beyond 200 mm/min also, tenacity begins to increase. The inter-fibre friction experiences an increase due to generation of transverse forces that leads to a build up of frictional resistance in the structure. Fibres also have an opportunity to align them to a certain degree depending on packing and position of individual fibres.

The net result of this partial alignment of fibres enables maximisation of the contribution to the breaking load arising from individual fibres. Increase in strain rate increases the percentage of ruptured fibres and so results in higher tenacity. Our findings corroborate the findings of Kaushik *et al.*². For Dref 2 yarns the reason behind such fall in tenacity beyond 200 mm/min is the short time available for the fibre alignment and less contribution of individual fibres to yarn tenacity. The fibre alignment is further restricted by the less tightly packed structure of Dref 2 friction yarn (Table 2). For ring yarns at a strain rate of 500 mm/min fibre alignment is still continues owing to their closely packed structure. The overall result is that a very high strain rate yields in a low tenacity for DREF 2 yarns. Initial increase in tenacity with increase in strain rate may be attributed to increasing incidence of fibre rupture and partial fibre alignment.

Table 4: Effect of blend ratio, extension rate and specimen length on tensile properties of Dref 2 Friction Spun Yarn

Yarn Tensile Properties	Yarn Type		Dref 2 Friction Yarn					
	Blend	Extension rate, mm/min	A:V (0:100)			A:V (35:65)		
			Specimen length, mm			Specimen length, mm		
			100	200	500	100	200	500
Tenacity, cN/tex	50			4.0			3.4	
	200	4.2		4.1	3.0	3.9	3.8	2.6
	350			3.8			3.0	
	500			3.6			2.9	
Breaking extension %	50			11.5			11.6	
	200	12.8		10.3	10.1	13.5	12.2	10.2
	350			10.8			10.4	
	500			11.3			11.0	
	Blend		A:V (65:35)			A:V (100:0)		
	Extension rate, mm/min		Specimen length, mm			Specimen length, mm		
			100	200	500	100	200	500
			100	200	500	100	200	500
Tenacity, cN/tex	50			3.3			6.4	
	200	4.9		4.8	2.9	6.8	6.6	2.6
	350			4.4			6.5	
	500			4.2			6.2	
Breaking extension %	50			15.7			11.6	
	200	17.1		15.9	13.9	29.1	12.2	21.9
	350			14.6			10.4	
	500			15.5			11.0	

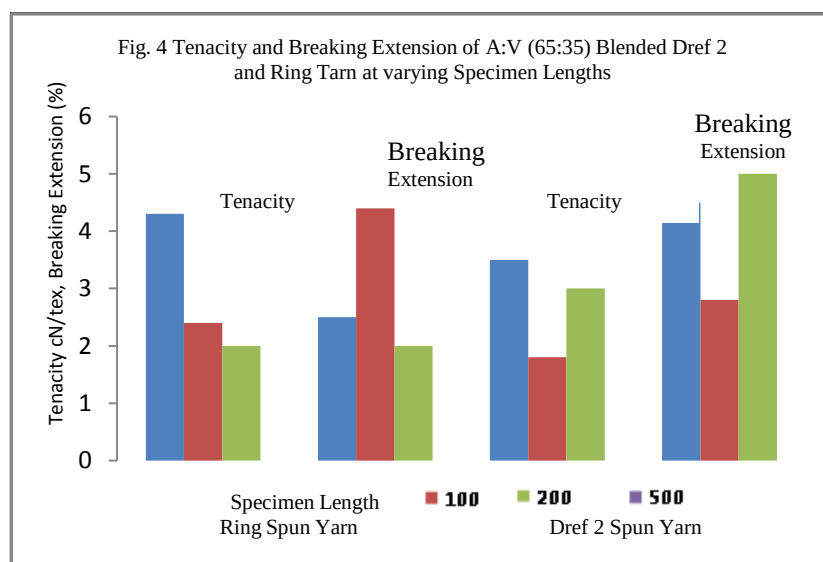


In general it may be inferred that at very low strain rates more time is available for stress relaxation and this results in more decay of stress eventually accounting for lower tenacity.

Breaking extension increases with increase in strain rate for ring yarn for a selected blend ratio. For Dref 2 yarns, it is also influenced by the strain rate. The trend is such that the breaking extension first decreases for viscose majority and acrylic majority Dref 2 yarns and then increases but not beyond the value obtained with lower strain rate. This differential behaviour for breaking extension may be ascribed to somewhat different structural response of Dref 2 friction yarns.

C Effect of Specimen Length

It may be depicted from Table 3 and Figure 4 that increase in specimen length from 100 to 500 mm during tensile loading reduces both tenacity and breaking extension for both ring and Dref 2 friction yarns. This occurrence may be attributed to classical weak link effect described by Peirce⁷. Longer specimen length in a tensile test is associated with higher yarn mass unevenness, which is responsible for lowering of tenacity⁸. Similarly breaking extension is low in yarns tested at longer length, which is again ascribed to increased possibility of weak spots in yarn. The weak spot in a longer specimen is statically more probable to occur. This is in agreement with the findings of Kaushik *et al.*².



IV. Conclusions

1. Friction spun yarns exhibit improved mass evenness but appear to be more hairy. The blend ratio of A:V (65:35) is considered to be most ideal under present perspective for producing yarn on Dref 2 friction spinning system on account of its improved mass evenness and least hairiness. For knitwear and winter garments, evenness and imperfections are the determinants of yarn quality in comparison to tenacity.
2. Maximum tenacity for Dref 2 friction yarn is observed at an extension rate of 200 mm/min for 100 mm long specimen for all blend ratios. The general finding with respect to tenacity of Dref 2 yarn is that its tenacity increases up to a certain value with strain rate and then decreases. In contrast, tenacity of ring spun continues to increase with increase in strain rate. It may decrease or follow similar trend with further increase in strain rate beyond 500 mm/min.
3. In general ring yarns spun at all blend ratios possess higher tenacity than equivalent Dref 2 yarns at any particular extension rate and specimen length. Breaking extension increases with increase in specimen length for ring yarn but no specific trend is noticed for Dref 2 yarns.

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