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Study on Thermal Treatment of Hybrid Technical Yarns

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Abstract: The present paper reports the impact of thermal treatment on the characteristics of core-sheath type hybrid technical yarns. The core-sheath type hybrid yarns are prepared using DREF-III technology. Polyester and glass multifilaments are used as core components whereas the cotton and polyester staple fibers are the sheath components wrapped around the core filament with different proportions to form a hybrid structure. The thermal treatment is carried out both in dry and in wet state under relaxed condition and the thermal shrinkage, sheath-slipping resistance and tensile and bending properties of hybrid yarns have been studied. Thermal treatment markedly increases the thermal shrinkage and sheath-slipping resistance of hybrid yarns with polyester multifilament in core, but insignificant effect for yarns with glass multifilament in core. Breaking elongation of hybrid yarns with polyester multifilament in core increases with treatment temperature. The hybrid yarns with glass multifilament in core are least affected by thermal treatment.

Keywords: Core-sheath ratio, DREF-III, Hybrid yarn, Multifilament, Sheath-slipping resistance, Thermal shrinkage

Introduction

DREF-III technology works with friction spinning principle [1]. Among the modern high-production technologies, DREF technology has some advantages over others, especially for the production of technical hybrid yarns suitable for high performance uses like safety and protective textiles, automobiles, filter fabrics, geotextiles, etc. DREF-III friction spun core yarns have the advantage of complete covering the continuous filament core component by staple sheath fibers. The use of continuous filament in the core provides the required strength of the hybrid yarn and the staple fibers in the outer surface confers them a spun yarn look with desirable surface characteristics such as easy-care, soft handle and comfort. The main shortcoming of filament core and staple sheath type hybrid yarn is the undesirably low sheath-slipping resistance which causes outer sheath of staple fibres to slip, resulting disintegration of yarn structure. The sheath-slipping resistance is low due to improper gripping between staple sheath and smooth filament. During any technical applications the fabrics are subjected to rubbing action and hence the yarns also get similar rubbing treatment. During this rubbing action if the cohesion between the core filament and the staple fiber sheath is not good enough the outer sheath of staple fibers can slip and thus the yarn structure gets disintegrated. And thus the fabric structure is instable due to abrasion during their subsequent mechanical processing and end-use applications. In DREF-III friction spinning system, besides the continuous filament, staple fibers can also be introduced in the core by feeding sliver to the apron drafting system provided on the machine [1-6]. But in most of the technical applications the hybrid yarns are produced with filament as core. The effect of core-sheath ratio and several other process parameters on friction-spun yarn characteristics have also been investigated [7-11]. In some technical uses, like protective clothing for fire fighter, the textile materials, made of core-sheath type hybrid yarns, are exposed to high temperature. A number of studies have been reported on the impact of thermal treatment on different types of yarns and textile materials [12-17], but studies concerning the influence of thermal treatment on properties of friction-spun core-sheath type hybrid technical yarns are not available.

The objectives of the present study is to study the impact of thermal treatment on the characteristics of core-sheath type hybrid technical yarns made of glass and polyester multifilament as core and cotton and polyester staple fiber as sheath and also to investigate the effect of the proportion of sheath content and duration and temperature of the thermal treatment under relaxed conditions, on the properties of these yarns.

Experimental

Preparation of Hybrid Yarns

In the hybrid yarn glass and polyester multifilaments were chosen as core and the cotton and polyester staple fibers were used in sheath. The specifications of these multifilaments and staple fibers are given in Table 1. Four series of hybrid yarns with different combinations of multifilament core and staple sheath fibers were spun on DREF-III system. These are PC (polyester multifilament in core and cotton in sheath), PP (polyester multifilament in core and staple polyester fiber in sheath), GC (glass multifilament in core and cotton in sheath), and GP (glass multifilament in core and staple polyester in sheath). Keeping the same multifilament in the core the proportion of staple fibers in the sheath was adjusted to have the desired core-sheath ratio and thus the

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Table 1. Specifications of multifilaments and staple fibers

Material	Length (mm)	Fineness (dtex)/(μg/in)*	Breaking strength/bundle strength* (cN)/(cN/tex)*	Breaking extension (%)
Polyester multifilament	-	67.30	420.4	10.95
Glass multifilament	-	620	2305	1.30
Cotton	24.6	4.20	20.20	5.0
Polyester staple fiber	44	1.66	8.64	22.70

*For cotton.

Table 2. Spinning parameters of yarn samples

Sample code	Yarn linear density (tex)	Core-sheath ratio	Spinning drum speed (rpm)	Delivery rate (m/min)
PC$_1$	67.30	10:90	3500	160
PC$_2$	44.87	15:85	3500	160
PC$_3$	33.65	20:80	3500	160
PP$_1$	67.30	10:90	3500	160
PP$_2$	33.65	20:80	3500	160
PP$_3$	22.43	30:70	3500	160
GC$_1$	206.67	30:70	3500	160
GC$_2$	155.00	40:60	3500	160
GC$_3$	124.00	50:50	3500	160
GP$_1$	206.67	30:70	3500	160
GP$_2$	155.00	40:60	3500	160
GP$_3$	124.00	50:50	3500	160

resultant count of the yarn changes. Three different levels of core-sheath ratio were selected for each type of hybrid yarn. The details of these hybrid yarns along with process parameters used in DREF-III machine to produce these yarns are given in Table 2. The physical properties of core-sheath type of hybrid yarn are mainly dependent on the properties of multifilament in the core, so keeping the same core filament the proportion of sheath coverage was changed to study the effect of thermal treatment.

Thermal Treatment of Hybrid Yarns

The hybrid core-sheath yarns, both dry and wet state, were subjected to thermal treatment in a laboratory curing-setting chamber under relaxed condition. Skeins of yarns of 200-250 m were prepared on wrap reel and laced loosely at several points. The lacings were kept completely loose so as not to hinder the relaxation process in yarn during shrinkage. The skeins were then hung loosely in curing-setting chamber for thermal treatment. For wet treatment, the skeins were immersed loosely inside the distilled water for 24 hours and then squeezed the excess water in laboratory hydro extractor and immediately placed inside the curing-settling chamber for thermal treatment. The thermal treatment was done at three different time duration i.e. 5 min, 30 min and 60 min with a constant temperature at 150 °C. Again the treatment temperature was also varied i.e. 100 °C, 150 °C, and 200 °C keeping the duration of thermal treatment as constant for 30 min for all the yarn samples.

Measurement of Yarn Properties

All the hybrid yarns (before and after thermal treatment) were tested for thermal shrinkage, sheath-slipping resistance, bending rigidity and tensile properties.

Thermal Shrinkage

Thermal shrinkage was measured according to BSI method. The similar method was also adopted by earlier researchers [17]. The skeins were conditioned and hung from a hook at the top of a measuring scale so that the inside of the skein coincided with the zero of the measuring scale. Lengths of the skeins before (l_i) and after (l_f) thermal treatment were measured and yarn thermal shrinkage was calculated using the following expression:

$$\text{Thermal shrinkage (\%)} = [(l_i - l_f)/l_i] \times 100 \qquad (1)$$

Sheath-slipping Resistance

The sheath-slipping resistance is the peak resistance force generated during pulling out of multifilament core from 50 mm of hybrid yarn. Universal tensile testing machine manufactured by SDL was employed for measuring the sheath-slipping resistance. The sheath portion was removed carefully from about 40 to 50 mm from one end of the hybrid yarn keeping the opened out core filament intact. The core filament was then passed through the hole of a normal sewing needle. The other side of the needle (without hole) was then gripped vertically in the bottom jaw of the Universal tensile testing machine. The core filament, which was passed through the needle, was then gripped in the movable top jaw in such a way that only the entire opened-out core filament portion passed through the needle hole. The initial distance between the jaws was kept at 50 mm and the crosshead speed was 50 mm/min. The length of the intact hybrid yarn, on the other side of the needle hole, was kept exactly 50 mm. The hole of the needle was selected sufficiently large to allow smooth and uninterrupted passage of core-filament but did not allow the sheath portion to pass through. As the top jaw started moving, the load cell attached with the top jaw measured the pulling out force of core filament and the peak of the pulling out force was considered as sheath-slipping resistance. A minimum of twenty observations was made for each sample.

Tensile Properties

Universal tensile testing machine from SDL was also used for measuring single yarn strength and breaking elongation keeping a gauge length of 500 mm and cross-head speed of 100 mm/min. Mean single yarn strength and breaking elongation were averaged from twenty observations for each yarn sample.

Bending Rigidity

The bending rigidity of yarns was measured by the ring loop method. A ring of known circumference (L) was deflected under a constant load (M) and the position of each loop was observed before and after loading. The observations were termed as R_1 and R_2. The yarn deflection D_1, i.e. (R_1 R_2) was tabulated and respective values of Z i.e. (D_1/L) were read from the supplied table. These values were then used to calculate the corresponding values of bending rigidity (ML^2/Z).

Results and Discussion

Thermal Shrinkage

The shrinkage values of different thermally treated core-sheath type of hybrid yarns are given in Table 3. It is evident from the Table that in case of PC and PP series of yarns, for a particular core-sheath ratio, the thermal shrinkage value increases with the increase in treatment temperature. The reason for this is that the thermal shrinkage of polyester multifilament hybrid yarn is mainly due to shrinkage of thermoplastic polyester multifilament in the core. With the increase in treatment temperature, shrinkage in the core polyester filament causes due to disorientation and folding of molecular chain [18]. Table 3 also shows that in case of yarns of PC and PP series, the time duration of treatment does not have any significant effect on the shrinkage, particularly for dry treated yarns. But for wet treated yarn samples it increases very fast initially up to 30 min., but further increase of treatment time shows much slower increase in thermal shrinkage values. For dry yarns, due to very good heat transmission from surface to core the polyester multifilament present in the core gets shrunk within a small span of time say 5 min. But in case of wet yarn, due to presence of moisture mainly within sheath structure, the heat transmission is slow and it takes time to evaporate the moisture present in the yarn. The very slower increase in the thermal shrinkage at later stage may be due to presence of water vapour within the yarn structure after heating of 30 min. It is also evident from Table 3 that as the percentage of sheath fibers in the yarns of PC and PP series reduces, keeping the same polyester multifilament in the core, the thermal shrinkage value always increases, irrespective of time and temperature of treatment and is valid for both dry and wet conditions. Due to lower proportion of sheath fibers i.e. in the finer hybrid yarns, the restrictive force imparted by the sheath fibers on the core filament is low and also better heat transmission to the core filament. Both these two factors are responsible for higher thermal shrinkage when the proportion of sheath fibers is low and vice versa.

It can be seen from Table 3 that all the hybrid yarns with glass multifilament in the core, i.e. yarns of series GC and GP, do not show any thermal shrinkage and also do not have any impact of time and temperature of treatment within the present experimental range. This may be due to the fact that treatment temperature (maximum 200 °C) does not have any impact on shrinkage of the glass multifilament core, which is

Table 3. Effect of thermal treatment on shrinkage of hybrid yarns

Sample code	Thermal shrinkage of dry treated yarns (%)						Thermal shrinkage of wet treated yarns (%)					
	Time[1] (min)			Temperature[2] (°C)			Time[1] (min)			Temperature[2] (°C)		
	5	30	60	100	150	200	5	30	60	100	150	200
PC_1	6.16	6.47	6.50	1.76	6.47	14.04	2.92	7.60	8.19	2.92	7.60	14.62
PC_2	7.62	7.60	7.62	2.38	7.60	15.88	3.06	7.65	8.24	2.94	7.65	16.47
PC_3	9.46	9.52	10.00	3.51	9.52	20.24	5.95	9.52	10.32	2.98	9.52	20.24
PP_1	12.4	12.6	13.1	2.3	12.6	30.1	6.9	12.2	12.9	1.8	12.2	29.6
PP_2	14.7	14.7	15.3	2.8	14.7	29.9	6.6	13.8	13.8	2.2	13.8	30.4
PP_3	15.5	15.4	16.0	4.2	15.4	31.3	7.0	15.7	15.9	3.7	15.7	32.0
GC_1	0.05	–0.07	0.05	–0.06	–0.07	0.09	0.06	–0.05	0.00	0.05	–0.05	0.08
GC_2	–0.10	0.00	–0.04	0.12	0.00	0.00	0.10	0.00	–0.03	0.10	0.00	–0.10
GC_3	0.11	0.06	0.10	0.00	0.06	0.04	–0.07	0.00	–0.08	–0.06	0.00	0.05
GP_1	–0.08	0.04	–0.08	0.10	0.04	–0.08	–0.10	0.00	–0.08	–0.08	0.00	0.00
GP_2	0.00	–0.09	–0.04	–0.05	–0.09	0.00	0.09	0.06	0.00	–0.10	0.06	0.07
GP_3	0.10	0.05	0.09	0.06	0.05	–0.06	–0.08	0.00	0.00	0.05	0.00	0.00

[1] Temperature was kept constant at 150 °C, [2] Treatment time was fixed at 30 min.

Table 4. Effect of thermal treatment on sheath-slipping resistance of hybrid yarns

Sample code	Sheath-slipping resistance of parent yarn (cN)	Sheath-slipping resistance of dry treated yarns (cN)						Sheath-slipping resistance of wet treated yarns (cN)					
		Time[1] (min)			Temperature[2] (°C)			Time[1] (min)			Temperature[2] (°C)		
		5	30	60	100	150	200	5	30	60	100	150	200
PC$_1$	36.9	45.5	56.7	43.5	49.0	56.7	101.5	68.6	87.3	98.4	77.6	87.3	151.9
PC$_2$	33.1	18.4	32.3	27.3	27.5	32.3	57.1	45.5	58.0	66.5	42.4	58.0	150.0
PC$_3$	30.0	22.1	26.2	26.1	23.3	26.2	52.7	20.6	35.5	37.3	27.1	35.5	108.
PP$_1$	38.7	43.5	54.4	47.8	44.0	54.4	111.3	62.8	90.0	98.2	73.3	90.0	148.1
PP$_2$	33.8	27.8	34.3	28.7	26.7	34.3	62.5	40.4	56.7	69.4	43.0	56.7	140.5
PP$_3$	26.2	20.2	22.6	21.2	19.6	22.6	46.7	21.0	33.8	37.0	26.2	33.8	93.9
GC$_1$	29.1	29.3	28.8	28.6	29.1	28.8	28.9	29.2	29.0	28.7	29.2	29.0	29.4
GC$_2$	23.6	22.9	23.4	23.7	23.0	23.4	23.0	23.3	23.2	22.9	22.8	23.2	23.4
GC$_3$	18.5	18.8	18.6	18.0	18.2	18.6	17.9	17.9	18.4	18.0	17.9	18.4	17.3
GP$_1$	32.9	36.3	36.8	35.7	32.2	36.8	45.2	37.0	36.6	37.9	36.4	36.6	48.0
GP$_2$	26.6	32.4	31.9	32.2	28.1	31.9	39.6	33.4	33.8	33.0	34.1	33.8	42.1
GP$_3$	21.7	26.1	25.7	25.8	23.6	25.7	30.0	25.2	26.3	26.6	25.6	26.3	35.7

[1]Temperature was kept constant at 150 °C, [2]Treatment time was fixed at 30 min.

responsible for any thermal shrinkage of hybrid yarn.

Sheath-slipping Resistance

Table 4 shows the sheath-slipping resistances, expressed in terms of peak resistance force generated during pulling out of core multifilament from 50 mm of hybrid yarn. It is clear from the table that for all the hybrid yarns (PC, PP, GC, and GP series), the reduction in sheath content always reduces the sheath-slipping resistance, i.e. increases the sheath-slipping problem or the skinning tendency (term used by Standring and Westrop [19]); irrespective of type of thermal treatment. The reason for higher sheath-slipping resistance in case of higher sheath content is mainly due to better sheath-core binding [20].

It can also be seen from Table 4 that as the treatment temperature increases the sheath-slipping resistance also increases both during dry and wet treatment for yarns of series PC and PP. This may be due to the fact that at higher temperature the thermoplastic polyester multifilament core has undergone surface texturing effect, which might have changed the surface structure of the core multifilament resulting higher sheath-slipping resistance. It has also been observed that, for yarns of PC and PP series, sheath-slipping resistance for wet treatment is always higher than dry treated hybrid yarns. For yarns of PC and PP series, time thermal of treatment does not have any impact of sheath-slipping resistance of dry treated yarns, but in case of wet treated yarns the sheath-slipping resistance increases with time duration. The probable reason for this has already been explained earlier.

It is also evident from Table 4 that the time of thermal treatment does not have any impact on the sheath-slipping resistance of both GC and GP series of yarns. The sheath-slipping resistance does not affected by the increase in temperature in case of GC series yarns, but it increases with the increase of treatment temperature for GP series of yarn. In the hybrid yarns of GC series, both core and the sheath fibers (i.e. glass and cotton) are non-thermoplastic in nature. So, there is no thermal texturing within the fiber or multifilament structure takes place, which may be the reason for not increasing the sheath slipping resistance with the temperature. But in case of GP series of yarns the texturing effect might have taken place in the thermoplastic polyester staple sheath component, which may be responsible for increase in sheath slipping resistance with the increase in treatment temperature, as clear from Table 4.

Breaking Strength, Elongation, and Bending Rigidity

The breaking strength and percentage elongation values of parent and thermally treated yarns of all the series (PC, PP, GC, and GP) are given in Table 5. Although the core multifilament contributes directly to the breaking strength, but presence of sufficient wrap fibers i.e. sheath fibers maintain yarn integrity and enhance the breaking strength. In case of yarns of PC and PP series, the parent as well as thermally treated hybrid yarns show increase in breaking strength with the increase in sheath content, which is due to coarser yarn count and higher transverse pressure exerted by higher number of sheath fibres. It is also evident from Table 5 that, for PC and PP series yarns, there is no significant effect of treating time and temperature of on breaking strength of the yarns both for dry and wet treatment. Table 5 also shows that there is significant drop in breaking strength of hybrid yarns with glass multifilament in the core (GC and GP) as compared to the breaking strength of glass multifilament itself, as given in Table 1. This may be due to breakage of some glass filaments during hybrid yarn formation in DREF-III machine as glass multifilament is brittle in nature.

Also some inclination of individual filaments with the yarn axis resulted in reduction in breaking strength. No particular effect of core-sheath ratio, time and temperature of thermal treatment on breaking strength of yarns with GC and GP series have been found (Table 5).

Table 5 also shows that with the increase in treatment temperature the breaking elongation increases for all the yarn samples in PC and PP series. The increase in breaking elongation with treatment temperature up to 200 °C is also due to molecular disorientation and chain folding [18] of core filaments. The reduction in sheath proportion also increases the breaking elongation of both parent and thermally treated hybrid yarns of PC and PP series, which may be due to lesser restrictive force applied on the polyester multifilament.

Table 5. Effect of thermal treatment on tensile properties of hybrid yarns

Sample code	Breaking strength of parent yarn (cN)	Breaking strength of dry treated yarn (cN)						Breaking strength of wet treated yarn (cN)					
		Time[1] (min)			Temperature[2] (°C)			Time[1] (min)			Temperature[2] (°C)		
		5	30	60	100	150	200	5	30	60	100	150	200
PC$_1$	600	589	607	596	574	607	603	600	603	564	619	603	596
	(10.14)	(11.11)	(11.25)	(10.36)	(10.62)	(11.25)	(13.07)	(10.43)	(10.72)	(10.85)	(9.95)	(10.72)	(11.26)
PC$_2$	517	506	494	521	508	494	498	510	499	512	505	499	496
	(10.48)	(11.15)	(10.82)	(10.47)	(10.62)	(10.82)	(12.15)	(10.58)	(10.92)	(11.04)	(10.54)	(10.92)	(11.32)
PC$_3$	484	498	503	503	484	503	508	512	501	505	494	501	504
	(10.78)	(12.06)	(12.65)	(12.35)	(10.93)	(12.65)	(14.44)	(12.02)	(12.11)	(12.52)	(10.85)	(12.11)	(14.33)
PP$_1$	748	773	780	801	788	780	776	784	802	783	796	802	802
	(10.26)	(11.24)	(11.19)	(11.22)	(10.62)	(11.19)	(13.77)	(10.79)	(11.05)	(10.88)	(10.55)	(11.05)	(13.25)
PP$_2$	597	621	613	632	604	613	641	637	642	589	619	642	627
	(10.44)	(11.40)	(11.51)	(11.46)	(11.14)	(11.51)	14.13)	(11.01)	(11.13)	(10.96)	(10.62)	(11.13)	(13.86)
PP$_3$	533	549	537	528	555	537	530	521	549	551	559	549	538
	(10.79)	(11.97)	(12.05)	(11.89)	(11.68)	(12.05)	(15.41)	(11.42)	(11.40)	(11.56)	(11.02)	(11.40)	(14.98)
GC$_1$	1842	1826	1799	1837	1838	1799	1811	1802	1848	1892	1806	1848	1814
GC$_2$	1860	1919	1872	1889	1879	1872	1858	1796	1906	1866	1789	1906	1827
GC$_3$	1829	1904	1855	1866	1890	1855	1828	1859	1881	1920	1852	1881	1871
GP$_1$	1802	1852	1848	1866	1810	1848	1887	1855	1790	1844	1826	1790	1849
GP$_2$	1818	1888	1912	1872	1798	1912	1828	1827	1878	1829	1822	1878	1840
GP$_3$	1843	1863	1886	1850	1885	1886	1802	1868	1827	1880	1869	1827	1871

[1]Temperature was kept constant at 150 °C, [2]Treatment time was fixed at 30 min.
The figures in the parenthesis indicate breaking elongation (%).

Table 6. Effect of thermal treatment on bending rigidity of hybrid yarns

Sample code	Bending rigidity of patent yarn, (gm·cm^2)x 10^{-3}	Bending rigidity of dry treated yarns (gm·cm^2)x 10^{-3}						Bending rigidity of wet treated yarn (gm·cm^2)x 10^{-3}					
		Time[1] (min)			Temperature[2] (°C)			Time[1] (min)			Temperature[2] (°C)		
		5	30	60	100	150	200	5	30	60	100	150	200
PC$_1$	10.22	10.20	10.12	10.10	10.19	10.12	10.16	10.24	10.18	10.06	10.09	10.18	10.11
PC$_2$	9.70	9.71	9.66	9.64	9.70	9.66	9.68	9.68	9.72	9.66	9.64	9.72	9.60
PC$_3$	7.95	7.93	8.00	7.89	7.96	8.00	7.89	7.99	7.95	7.98	8.01	7.95	7.90
PP$_1$	14.2	14.4	13.9	14.1	14.3	13.9	14.4	14.0	13.9	14.5	14.1	13.9	13.8
PP$_2$	12.8	13.4	12.6	12.8	11.3	12.6	11.9	11.4	13.0	12.3	12.8	13.0	12.7
PP$_3$	9.6	9.9	10.0	8.9	9.2	10.0	9.1	8.7	9.4	9.9	8.9	8.9	9.1
GC$_1$	1038	1126	1073	1056	1112	1073	1082	1091	1103	1099	1091	1103	1055
GC$_2$	993	966	956	1006	991	956	974	1012	984	1021	1004	984	978
GC$_3$	940	931	922	945	892	922	910	929	904	890	924	904	911
GP$_1$	1150	1168	1204	1188	1197	1204	1169	1221	1218	1182	1190	1218	1182
GP$_2$	1061	1032	1082	1075	1058	1082	1045	1066	1102	1067	1055	1102	1106
GP$_3$	971	980	982	1004	1016	982	948	1012	1021	977	972	1021	978

[1]Temperature was kept constant at 150 °C, [2]Treatment time was fixed at 30 min.

The breaking elongation of both parent and thermally treated hybrid yarns with glass multifilament in the core (GC and GP series) are almost similar to the breaking elongation of glass multifilament. No significant impact of core-sheath ratio, duration and temperature of thermal treatment on breaking elongation of these yarns (GC and GP series) have been found.

It is evident from Table 6 that the bending rigidity of all the hybrid yarns (series PC, PP, GC, and GP) does not affected by the time and temperature of thermal treatment. The increase in sheath fiber content for a particular core multifilament increases the bending rigidity. This may be due to more restriction to bending fibrous assembly when the proportion of sheath fiber is high and also due to coarser yarn count when the proportion of sheath fibre increases.

Conclusions

The core-sheath type hybrid yarns are most suitable for various technical applications. The main problem with these yarns is poor sheath-slipping resistance, which results in disintegration of the yarn structure during end use. This problem can be reduced to a great extent by thermal treatment of hybrid yarns, particularly when both or any one of the component fibres is thermoplastic in nature.

The thermal shrinkage of core-sheath type hybrid yarn with polyester multifilament core increases with the increase in treatment temperature, but the treatment time shows no significant effect on thermal shrinkage these yarns. Also the decrease in proportion of sheath fiber results in increase in thermal shrinkage of these yarns. No impact of thermal treatment on shrinkage has been observed in the yarns with glass multifilament in the core. Increase in proportion of sheath fiber shows increase in sheath-slipping resistance for parent yarn as well as for thermally treated yarns. For hybrid yarns with polyester multifilament in core, as the treatment temperature increases the sheath-sipping resistance also increases significantly and it is higher in case of wet treatment than dry treatment. The increase in proportion of sheath fibers, in case of hybrid yarns with polyester multifilament in core, results an increase in breaking strength and this trend is valid for parent as well as thermally treated yarns. With the increase in treatment temperature, for the hybrid yarns with polyester multifilament in core, the breaking elongation increases but the breaking strength reflects no specific trend with regard to treatment temperature. There is no significant effect of core-sheath ratio, time and temperature of thermal treatment on breaking strength of hybrid yarns with glass multifilament in core. Thermal treatment does not have any significant effect of bending rigidity, but increase in proportion of sheath fibers increases the bending rigidity.

References

1. Brochure for *DREF 3 Friction Spinning Machine* (Textilmaschinenfabrik, Dr. Ernst Fehrer A G).
2. H. Fuchs, *Textile Horizons*, **2**, 20 (1982).
3. K. J. Brockmanns and J. Lunenschloss, *ITB International Textile Bulletin*, **30**, 5 (1984).
4. M. Gsteu, *Textile Horizons*, **6**, 36 (1986).
5. M. Gsteu, *ITB International Textile Bulletin*, **32**, 65 (1986).
6. E. Fehrer, *Textile Month*, 115 (1987).
7. W. Thierron and L. Hunter, *Melliand Textilber (English Edition)*, **13**, 226 (1984).
8. L. B. Kimmel and A. P. S. Sawhney, *Textile Res. J.*, **60**, 714 (1990).
9. G. K. Tyagi, K. R. Salhotra, and S. Gupta, *Indian J. Fibre Textile Res.*, **20**, 136 (1995).
10. A. K. Sengupta, R. Chattopadhyay, G. S. Venkatachelapathi, and A. R. Padmanabhan, *Melliand Textilber*, **73**, 224 (1992).
11. A. R. Padmanabhan and N. Ramakrishnan, *Indian J. Fibre Textile Res.*, **18**, 14 (1993).
12. G. K. Tyagi, A. P. Malik, and A. Lal, *Indian J. Textile Res.*, **12**, 40 (1987).
13. X. T. S. Sukigara, R. Postle, and R. C. Dhingra, *Textile Res. J.*, **57**, 601 (1987).
14. D. Daspal, M. Tech. Dissertation, Indian Institute of Technology, New Delhi, 1991.
15. G. K. Tyagi, R. C. D. Kaushik, and K. R. Salhotra, *Indian J. Fibre Textile Res.*, **23**, 105 (1998).
16. A. K. Sengupta, R. Chattopadhyay, and D. Daspal, *Indian J. Fibre Textile Res.*, **17**, 215 (1992).
17. G. K. Tyagi, S. Dhamija, and K. R. Salhotra, *Indian J. Fibre Textile Res.*, **24**, 215 (1999).
18. A. K. Sengupta in "Manufactured Fiber Technology", 1st ed. (V. B. Gupta and V. K. Kothari Eds.), p.188, Chapman and Hall, London, 1997.
19. P. T. Standring and K. J. Westrop, *J. Textile Institute*, **49**, 453 (1958).
20. R. Chattopadhyay, K. R. Salhotra, S. Dhamija, and R. C. D. Kaushik, *Indian J. Fibre Textile Res.*, **25**, 256 (2000).