STUDY ON RING & AIR-JET YARNS AND ITS' MECHANICAL PERFORMANCES IN FABRICS

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1. Introduction

Yarn engineering plays an important role in producing fabrics for particular use. It is a common practice that yarn properties are predicted from constituent fibre properties. A large number of scientists have worked on the predictability of yarn properties based on fibre characteristics such as length, strength, inter-fibre friction, etc. All the works reported good correlation between fibre properties and yarn properties. The main aim of the study was to investigate the change in fabric mechanical behavior during tearing strength, abrasion resistance, pilling, and tensile strength of 100% polyester fabrics made out of both ring and air-jet yarns.

The tearing strength of the fabric is directly proportional to the single thread strength of the yarn used. The yarn with high extensibility and smoothness are likely to give greater tearing strength. Since the smoothness will facilitate the slippage of yarn [Paul P. *et al* 2011].

Abrasion is an ability of the fibre to withstand rubbing in use and care [Joseph Marjori L. 1977]. Pilling can be considered to be the first sign of wear by light abrasion in a fabric, made from staple fibre yarns [Angappan et al 1997]. It has been observed that a higher roughness of yarn surface due to presence of wrapper fibres in air-jet and rotor yarns causes higher friction force between warp and weft yarns. This enhances the radial pressure between the fibres of longitudinal yarns, increasing their frictional potential and in the process a better utilization of fibres in the yarn contributing to fabric strength [Rengasamy R. S. *et al* 2008]. The study was carried out to investigate the change in mechanical performance behavior of fabrics made out of ring & air-jet spun polyester yarn using as filler yarns where the same air-jet polyester yarn (warp) has been used for both type of fabrics. Four polyester yarns of different linear densities spun on ring & air-jet spinning systems, both having the same count, were used. Fabrics were woven with 2/30s air-jet polyester warp in all eight fabric samples with different weft count (1/20s, 1/24s, 1/30s and 2/30s).

2. Material and method

The material of this study consisted of 100% polyester made eight 2/1 twill weave fabrics. These fabrics were made from 2/30 air-jet warp in all the eight fabric samples. Whereas, four fabric samples were produced by using ring polyester weft yarns and four fabrics were produced by using air-jet polyester weft yarns by keeping the same weft count in both types of fabrics. The tenacity and abrasion of yarns were measured by using ASTM D-2256 and Mag Sitra Abra Test. The data of the yarns are given in Table- 1.

The fabric tearing, abrasion resistance, pilling resistance and tensile strength of the fabrics, were measured according to relevant

Standards: ASTM D1424-09, ASTM D4966-98, ASTM D3512-82 and ASTM D5035-95, respectively.

The abrasion resistance was determined by the mass loss as the difference between the masses before and after abrasion cycles of 15000, 30,000 and 45,000. These values were then expressed as a percentage of the initial mass. Finding no change regarding the pill formation after 4000, 8000 and 12000 cycles, number of cycles was kept at 15,000 cycles. The specifications of the eight woven fabrics tested in this experimental study are given in table- 2.

The fabrics were produced at 51 ends/inch for single weft yarn & 48 ends/inch for plied weft yarn and 54 picks/inch for single weft yarn & 34 picks/inch for plied weft yarn all samples.

In order to understand the statistical importance of above mentioned fabric properties, T-test had been performed. All test results were assessed at significance level of $\alpha \leq 0.05$

Table 1: Specifications of the Yarns Used

	Ring Yarn	Ring Yarn	Ring Yarn	Ring Yarn	Air-jet Yarn	Air-Jet Yarn	Air-jet Yarn	Air-jet Yarn
Count	1/20 Ne	1/24 Ne	1/30 Ne	2/30 Ne	1/20 Ne	1/24 Ne	1/30 Ne	2/30 Ne
T.M	2.72	2.82	2.92	2.20	-	-	-	-
T.P.I	12.16	13.81	15.99	8.52	-	-	-	-

Table 2: Specifications of the Fabrics Used

Sr. no	Specification	Fabric-1	Fabric-2	Fabric-3	Fabric-4	Fabric-5	Fabric-6	Fabric-7	Fabric-8
1	Warp Count	2/30 AJ	2/30 AJ	2/30 AJ	2/30 AJ	2/30 AJ	2/30 AJ	2/30 AJ	2/30 AJ
2	Weft Count	1/20 R	1/24 R	1/30 R	2/30 R	1/20 AJ	1/24 AJ	1/30 AJ	2/30 AJ
3	EPI	51	51	51	48	51	51	51	48
4	PPI	54	54	54	34	54	54	54	34
5	Weave	2/1 Twill	2/1 Twill	2/1 Twill	2/1 Twill	2/1 Twill	2/1 Twill	2/1 Twill	2/1 Twill
6	Gsm	156	145	134	132	155	146	133	133

AJ- Air-jet Yarn and R- Ring Yarn

3. Result and discussion

3.1 Tenacity and elongation of ring & air-jet yarns

Table- 3 showed the tenacity of both ring & air-jet yarn produced with the count from 1/20s to 1/30s except the count 2/30s. Overall, the tenacity values of Air-jet yarns were less than that of Ring yarns for all yarn counts ranging from 1/20s to 2/30s.

Table 3: Yarn Properties

Yarn Type	Count	Yarn Tenacity		Abrasion Resitance
		Tenacity (cN/tex) (T.M)	Elongation (%)	RRI
Ring Yarn	1/20s	24.52 (2.72)	9.5	7962
	1/24s	16.87 (2.82)	8.5	7733
	1/30s	14.94 (2.92)	8.28	5603
	2/30s	25.89 (2.2)	12.74	10468
Air-jet Yarn	1/20s	16.74	8.13	1364
	1/24s	13.44	8.41	1173
	1/30s	10.1	7.18	659
	2/30s	11.27	11.27	9272

*RRI = Relative Resistance Index *T.M = Twist Multiplier

Tenacity of ring spun yarns were found to be more than that of air-jet spun yarn. It is due to better orientation of the individual fibres, a high level of migration and reasonably high packing of fibres into the yarn structure, of the ring spinning process.

While, on the other hand, air jet spun yarn was weaker than ring spun yarn. The tenacity is about 65-80% for polyester yarn as compared to ring spun yarn. In air-jet yarn, the weakness originates from the non-uniform wrapping of surface fibres on the yarn core and the existence of loose wrapper fibres. The portions of the yarn that are not wrapped and in which the wrappings are not tight enough are a source of weak places in the yarn. The elongation of the air-jet yarn was 2- 16% lower than that of ring spun yarn. It is due to twist less, straight and parallel arrangement of core fibres which is wrapped by tight wrapper fibres, hindering the change of the twist angle. Ring spun yarns are spun under highest level of spinning tension and it is more of less free of hooked and disoriented fibres. Moreover helically twisted arrangements of fibres give higher extensibility than air jet yarns which are spun at much lower level of tension.

The statistical analysis by the use of t- test between the ring and air-jet yarns are showing significant difference between them for all the count range from 1/20s to 1/30s except the 2/30s. In case of ring ply yarns, when a tensile load is applied on yarn, the transverse pressure between the yarn increases. It improves the cohesion between the ply yarns which enhanced the strength of ply yarn. On the other hand, in case of air-jet ply yarn, when a tensile load is applied on such yarn, the transverse force also acts on this yarn. The core consists of parallel bundle of fibres which increases the cohesion between the core fibres of individual yarn, and further improves the strength of air-jet ply yarn. This is the reason that statistical analysis between ring & air-jet ply yarns were showing in-significant difference.

3.2 Tenacity and elongation of fabrics woven with ring & air-jet weft yarns

From Table-D, it had been observed that the tensile strength of the fabrics made out of air-jet spun polyester yarn used as weft were found to be inferior to that of ring spun polyester yarn fabrics by 6 to 19% in almost all the count for its weft direction. When the same in warp direction observed no change as expected.
The tenacity of fabrics woven with ring spun polyester yarns used as weft was found higher than that of fabrics woven with air-jet spun polyester yarns. It may be due to more compact structure of ring spun yarn to air-jet spun yarn. While air-jet spun yarn provides lower strength to fabrics due to its unique structure of yarns, which consists of core of parallel bundle of fibres, tightly wrapped by means of wrapper fibres. Due to non uniform wrapping of yarn structure may be the reason of creation of weak spots. Thus, fabrics woven with air-jet weft yarns showed lower strength.

Table 4: Fabric Properties

Type of yarn	Count	Fabric Tenacity		Abrasion Resistance as Percentage of weight loss			Pilling Resistance as Pilling Grade at			Tearing Strength (N)
		Tenacity (N) weft wise	Elongation (%) weft wise	after 15,000 rubbing cycle (%)	after 30,000 rubbing cycle (%)	after 45,000 rubbing cycle (%)	30 Min	60 Min	90 Min	
Ring Yarn Fabric	1/20s	829.1	22.9	13.05	17.4	20.1	2	2	1	78.81
	1/24s	624.6	22.3	17.23	22.43	24.54	2	2	1	70.40
	1/30s	511.1	20.3	11	14.08	18.22	2	2	2	67.52
	2/30s	786	25.4	9	11.12	16.66	4	4	4	C.T
Air-jet Yarn Fabric	1/20s	714.4	21.2	20.84	25	27.22	4	4	4	74.79
	1/24s	573	20.5	23.81	28.14	31	4	4	4	62.42
	1/30s	417.7	20.1	20	25	28.36	4	4	4	55.14
	2/30s	743.3	22.2	19.05	27.58	29	4	4	4	C.T

*C.T= Cross Tear

From the above result, it was observed that the tenacity properties of fabrics made out of ring & air-jet single polyester filler yarns, are behaving similarly as that of yarns behavior.

The statistical analysis by the use of t- test were showing significant difference between fabrics made out of ring & air-jet polyester weft yarns for all the count range from 1/20s to 2/30s.

3.3 Abrasion resistance of ring & air-jet spun yarns

Table-C showed that the abrasion resistance of polyester air-jet yarn is about 11-18% of ring spun yarn for count varying from 1/20 Ne to 1/30 Ne except the count 2/30 Ne. Which showed abrasion resistance of about 88% as compared to ring spun yarns.

The abrasion resistances of polyester ring yarns are better than that of Air-jet yarns due to helical arrangement of fibres in association with tight packing of fibres.

While, the abrasion resistances of the polyester air-jet spun yarns are lower as compare to ring spun yarns because yarn structure is bound by outer wrapper fibers only and have no internal twist. The core portion gets immediately exposed once the binding wrappers are broken and thus, yarn disintegrates immediately. The statistical analysis by the use of t- test between the ring and air-jet yarns were showing significant difference between them except the 2/30s. The abrasion resistance of ring ply yarn was high. At the cross-over points of the junction line between the single yarns, some portion of peripheral fibres got escaped from abrasive action. Which became responsible for plied yarn withstanding the higher abrasion cycles compared to ring single yarn. On the other hand, parallel bundle of core fibres of single yarn were helically bound with the other air-jet single yarn by means of twist. It helped to improve the cohesion even after the wrappers breakage.

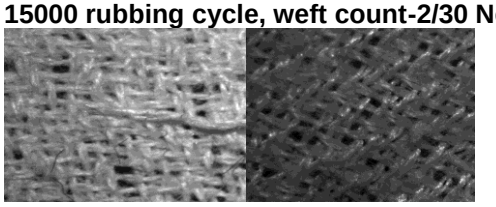
3.4 Abrasion resistance of fabrics woven with ring & air-jet weft yarns

Abrasion resistances of the woven fabric samples were evaluated at 15,000, 30,000 and 45,000 number of rubbing cycles. From the Table-4, it was observed that the abrasion resistances of fabrics woven with ring polyester yarns as weft were better than that of fabrics woven with air-jet polyester yarns as weft. It may be due to difference in yarn structure. Helical arrangement of fibres in association with tight packing, the ring yarns made the fabric good abrasive resistance.

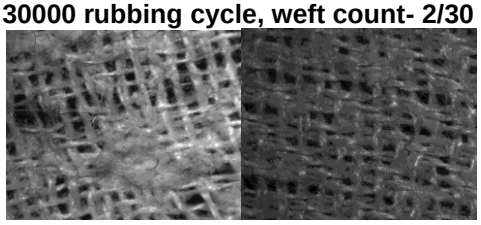
The tension used during abrasion testing, appeared to result in quick rupture of fewer wrapper fibres. Which in turn, caused an early exposure of core fibres to the abrading surface leading to poor abrasive resistance.

Air-jet Ring

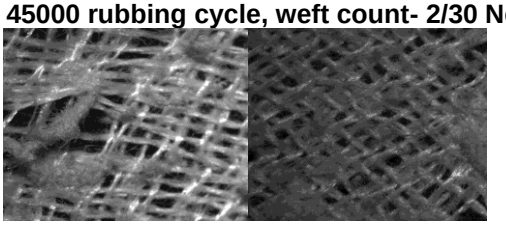
At 15000 rubbing cycle, weft count-2/30 Ne



At 30000 rubbing cycle, weft count- 2/30 Ne



At 45000 rubbing cycle, weft count- 2/30 Ne



Fabrics woven with ply ring yarn as weft provided better abrasion resistance than air-jet ply yarn fabrics. When two single yarns were twisted together, surface fibres were trapped between the two single yarns. This improved the abrasion resistance of ply yarn and hence of fabrics. From the table- 4, it is also observed that % of weight loss of fabric sample made with air-jet weft yarn was more than that of ring weft yarn due to loss of more fibres from the fabric surface during the abrasion.

3.5 Pilling resistance of fabrics woven with ring & air-jet weft yarns

It has been observed from Table- D that the pilling tendencies of fabrics woven with ring spun polyester yarns used as weft were found to be more than fabrics woven with air-jet polyester weft yarn. Fabrics woven with ring spun polyester yarns, got pronounced pilling effect as compare to air-jet woven fabrics due to the more hairiness of the yarn surface, twist displacement of the yarn structure.

On the contrary, fabrics woven with air-jet spun polyester yarns used as weft show less pilling tendency due to tight traverse strips of wrap fibres in the structure of yarn resist axial disposition with friction and high stress. Thus provide less pronounced pilling to air-jet woven fabrics compared with ring woven fabrics.

3.6 Tearing Strength of fabrics woven with ring and air-jet weft yarns

From the table- D shown above, it has been observed that the tearing strength of the fabrics woven with ring spun polyester yarns used as weft are more than that of fabrics woven with air-jet spun polyester yarns in weft, , while cross tear has been observed warp wise for both the ring and air-jet woven fabrics.

This difference in tear behavior of both fabrics woven with ring & air-jet polyester weft yarns may be due to difference in yarn structure. In case of air-jet woven fabrics, with a higher roughness of yarn surface, the presence of wrapper fibres cause higher frictional force between warp and weft yarns. While in case of ring woven fabrics, lowest friction level of ring spun yarn is due to the fact that it is characterized by an assembly of helically arranged, well by an assembly of helically arranged, well aligned fibres. This provides relatively smooth surface to yarn allowing more yarns to group together and bear the load. Being in weft, the greater strength and extensibility of these yarns contribute further to enhance the weft way tearing strength of ring woven fabrics than air-jet woven fabrics.

It has been observed that by using ply yarns (2/30s) of both types, leads to cross-tear in weft direction. It is due to higher friction level between warp and weft yarns, which does not allow the yarns to group together to bear the load which is valid for both type of fabrics. So it was concluded that fabrics woven with polyester ply yarns in both warp & weft direction will tear easily as compare to ply yarn in warp direction and single yarn in weft direction. Due to which, statistical analysis by the use of t- test between the fabrics woven with ring and air-jet polyester yarns used as weft, are showing significant difference between them for all the count range from 1/20s to 1/30s.

4. Conclusion

From the result obtained, it was concluded that

1) Tenacity of fabrics woven with ring spun polyester yarns as weft was found higher than that of fabrics woven with air-jet spun polyester yarns as weft.
2) Abrasion resistance of fabrics woven with ring spun polyester yarn used as weft was more than that of fabrics woven with air-jet spun polyester yarns as weft. But the similar tendency had not been observed in the fabrics woven with 2/30s ring and air-jet weft yarns.
3) Pilling resistance of fabrics woven with air-jet spun polyester yarns used as weft found better than that of fabrics woven with ring spun polyester as weft . Fabrics woven with both air-jet warp & weft yarns provided better pilling resistance to fabrics as compare to fabrics woven with air-jet warp & ring weft excepting the fabrics made of 2/30 ring & air-jet weft yarns. In these cases, the pilling resistances are observed to be same.
4) Tearing strength of fabrics woven with ring spun polyester yarn as weft were more than that of air-jet spun yarn as weft. Fabrics woven with polyester ply yarns in both warp & weft direction will cross tear easily as compare to polyester ply yarn in warp direction and polyester single yarn in weft direction.

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