Production of Core Spun Yarn with Ring & Siro Spinning System

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Abstract

A common problem in production of core–spun yarns on the Ring spinning frame is the slippage of the staple fibers as sheath fibers relative to the core. This effect is known as 'strip-back' or barberpole. This problem may lead to an incomplete core coverage and results in end–breaks in subsequent processing.

In order to avoid this problem, in the present work, core spun yarns (acrylic sheath fiber / nylon flat core) on the Ring and Siro spinning have been produced and the effect of some factors were investigated. The factors studied were, filament pre-tensioning (i.e. 1, 7/5, 10, 15, 50 & 100 gram), spinning system (Ring and Siro), feeding arrangement of filament in to strand (6 types of feeding arrangements), in addition covering factor of core spun yarns was also determined by the image processing method.

The results show that quality of the core spun yarns produce by Siro spinning system is much better than Ring spun counterpart.

Keywords: Core spun yarn, ring, siro, core filament, sheath fiber.

1. Introduction

Core yarns have a structure in which one of the component, usually a synthetic filament either mono or multi, is covered by another component, a staple fiber sheath. The chief aim of using core yarn is to take advantage of the different properties of its both components. The filament improves yarn strength and also permits the use of lower twist level, while the sheath provides the staple fiber yarn appearance and surface physical properties. The technique for the preparation of core-spun yarn is very simple and the selection of core and cover materials can be made from a variety of fibers with predetermined end use. Nylon and Polyester continuous filaments are the common core materials. A common problem with core-spun yarns made on a ring-spinning frame is the slippage of the staple fibers relative to the filament, which gives a length of bare filament with a clump of fibers at one end. This effect is known as 'strip-back' or 'barberpole' [1]. This fault may lead to incomplete core coverage and results in end-breaks in subsequent processing. Thus, a rather high level of twist is normally needed to build up the necessary cohesion between the sheath and the core components. The high twist reduces the production speed and thereby increases the production costs. Further, the increased twist reduces the yarn strength. Several attempts have been made in recent years to minimize or eliminate the strip-back problem at low twist levels [1, 2].

Balasubramanian & bhatnagar recommended that pretension is necessary to obtain suitable yarn properties [3]. Khara and Jain, in a comparative study of core yarns prepared at ring and doublers, observed that moving away from the intimacy of component fibers and positioning one of the components at a certain preferential direction and position do not result in much deterioration in performance [4]. Shawney et al. revealed that double rove spinning is becoming more popular because of the tremendous cost saving. Double rove yarn strength increase with optimum twists level [5]. A new technique to produce a cotton/polyester blended yarn with improved strength has been reported by Sawhney et al. [6]. The siro spinning technique and the possibility of extension of this technology to cotton system have also been discussed and studied [7, 8]. N Tarafder & SM Chatterjee described the necessary modifications in the ring frame for the productions of core-spun yarns [9] also have reported the important physical and mechanical properties of nylon/cotton core-spun yarns [10, 11, and 12]. As well as they presented effect of strand spacing, filament disposition, break draft and core material on the physical properties of nylon/cotton core-spun yarns [13]. Nasir Mahmood et al. studied effect of multiple spinning variables on the spinability of cotton covered nylon filament core yarn [14]. Xue Yuan et al. studied effect of spinning conditions, such as, the tension ratio between filament and staple fibers, the position where the filaments were fed into the staple fibers and the twist factor and they analyzed the principles and the rules of their migrations [15].

2. Experimental:

At the present work, core yarns with ring, solo and siro spinning system produced on long staple ring spinning frame. Acrylic staple fiber (color red) with fineness of 3 Den and staple length of 90 mm was used as sheath fiber and tow multifilament nylon yarn with count of 60 Den and fiber fineness 3 Den, tenacity of 46.48 g/tex, elongation to break of 10.28% was used as core yarn.

But raw materials were conditioned and samples were produced in the temperature of 20±2°C and relative humidity of 65±2°% for 24 hours.

The Instrom testing machine model (M10-82701-1) was used to measure break tenacity and elongation at break of core yarn for 25 centimeters long yarn. For measure hairiness (number of hairs longer than or equal to 3 mm) the Shirley machine model SDL096/8 was used. Measuring was carried out on 25 meter of yarn with speed of 60 m/min. unevenness percent of yarns were determined by uster tester III on 25 meter of yarn at test speed of 25 m/min. Abrasion resistance of yarns were determined by the Shirley abrasion tester Y027.

30 tests have performed in other to determine all parameters including mechanical properties and physical properties. Statistical analysis using SPSS software and "ERROR BAR charts" in 95% of confidence level were performed too.

Table 1 shows some parameters of produced yarn and setting of ring frame.

Table 1

Nominal yarn Count (tex)	57
Roving count (hank)	0.66
Filament/Sheath %	23/77
Break draft	1/2
Total draft	20/2
Twist per meter	415
Core count (Den)	(60×2) 120

This work was carried out in two stages:

In stage1, six samples by codes R_1 to R_6 produced by the ring frame, according to table2.

Table 2

Code of Ring core yarn	Filament pre tension(gram)
R_1	1
R_2	7.5
R_3	10
R_4	15
R_5	50
R_6	100

In stage2: samples by codes Si_1 to Si_6 produced by siro spinning system, according to the condition in table3 and Fig 1.

Table 3

Code of Siro core yarns	Oriented feed of core filament
Si1	I
Si2	П
Si3	Ш
Si4	IV
Si5	V
Si6	VI

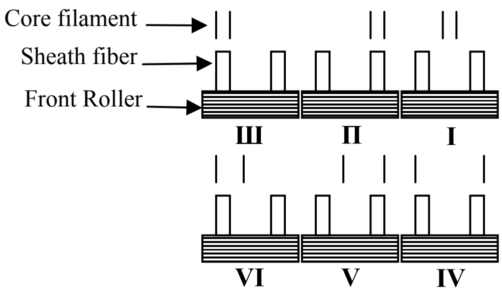

Fig1- different states of feed of core filament on siro core yarns

3- Discussions and Conclusion

3-1 The Effect of Pre-tension of Filament

For investigating the effect of pre-tension of filament on physical and mechanical properties of core spun yarns and also determined the optimum value of per-tension, various tensions were applied to core spun yarns according to table 2. The effect of pre-tension of filament on properties of produced yarns is given in table 4 and figures 2 to 7. According to they the highest strength and percent of elongation is for sample 6, the less hairiness is for sample 1 and the less unevenness percent is for sample 2.

According to Fig2, it is obvious that with increasing the tension, strength of core spun yarns will increase accordingly except a fall in sample R_5, although there is not a significant difference between sample R_6 and samples R_3 & R_4. The reason for this going up could be that: with increasing the tension, core attains a more likeliness to stand in center of yarn. So axial orientation of core filament will increase and they will pose a better contribution in linear strength of yarn. But with decreasing the pre-tension, core filament approaches the surface and their axial angle increases, so their contribution in linear strength decreases.

According to Fig3, sample's percent of elongation will decrease firstly with increasing the pre-tension of filament and then it will take a going upward. That could be explained like this: in low tensions yarn is likely to cohere in the surface of yarn so axial orientation would be low and yarn would pose a more elongation in linear loadings. But with increasing pre-tension however tendency of filaments to stand in the body of yarn increases but it is guessed that filaments will experience some elongation for settling in especially in 100g of tension.

According to Fig4 sample's hairiness increases with increasing the tension but in sample R_6 we note a severe fall, statistical analysis showed that sample R_1 & R_6 don't have any significant difference so these two samples have the less hairiness quantity. In tension of 1 g filament tends to approaches the surface so with laying the filaments in the surface free staple fiber's share of the yarn's surface will decrease and hairiness will decrease this way and in tension of 100 g filament will completely lay in the center and so attain a greater contact surface with staple fibers and a greater control on them so it has a smaller hairiness as it is expected.

Table4- effect of filament pre-tension on ring core yarn properties

	Ring core yarn					
	R_1	R_2	R_3	R_4	R_5	R_6
Filament pre-tension(gram)	1	7.5	10	15	50	100
Count of yarn (tex)	56.9	56.5	56.5	56.47	56.6	57.4
breaking tenacity (g/tex)	17.9	17.9	19.1	19.4	18.4	19.5
breaking elongation	18.96	18.02	17.67	18.14	18.87	20.07
Hairiness	146	153	155	161	166	150
CV%	13.36	13.12	13.74	13.78	15.33	15.63
abrasion resistance	139	139	129	143	147	144

According to Fig5: we can see a going linear at the beginning, then falling and a going upward at last for sample's abrasion resistance. Samples R_4, R_5 & R_6 don't have a significant difference. The reason of increasing of abrasion resistance in samples with a high pre-tension could be expressed as better lying of filaments in yarn's center and increasing cohesion of core with surface.

Fig6 shows the results of charts unevenness. As we can see with increasing the tension unevenness percent of samples will increase accordingly. Especially for samples R_5 & R_6 which have a significant difference with other samples. Since more the filaments lay in the center, more staple fibers will lay in the surface so a more hairiness will be expected.

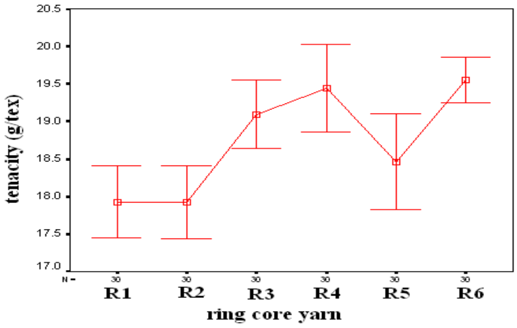

Fig 2- effect of filament pre-tension on tenacity of ring core yarns

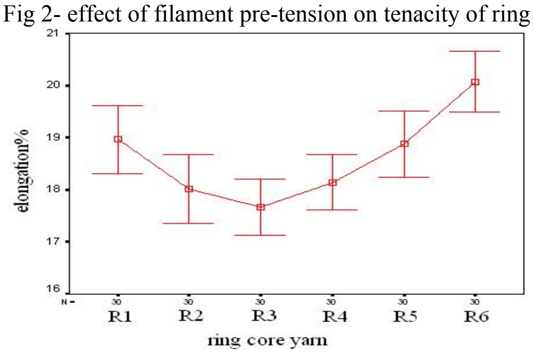

Fig 3- effect of filament pre-tension on percent of elongation of ring core yarns

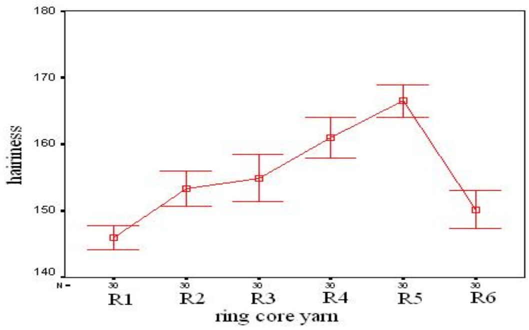

Fig4- effect of filament pre-tension on hairiness of ring core yarns

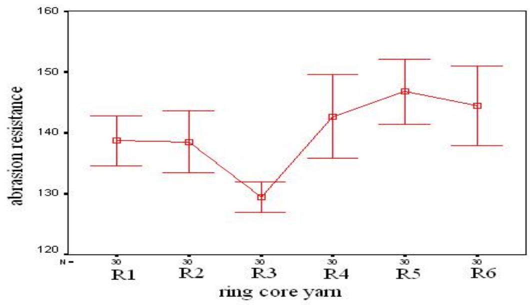

Fig5- effect of filament pre-tension on abrasion resistance of ring core yarns

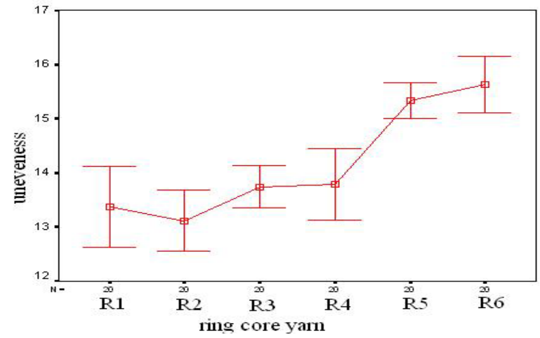

Fig6- effect of filament pre-tension on unevenness of ring core yarns

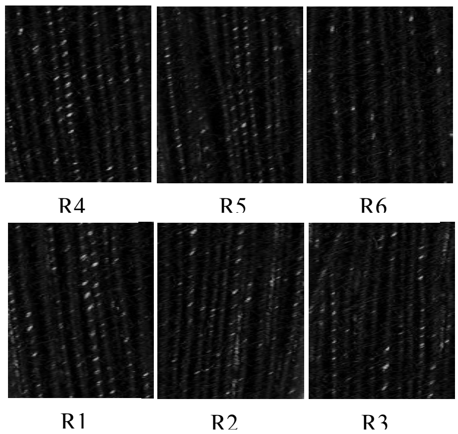

Fig7- pictures have been taken of ring core yarns surfaces

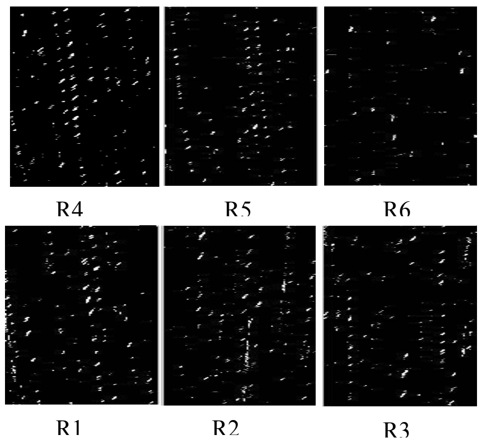

Fig8- pictures of modified of ring core yarns surfaces

$$\frac{\text{The whole number of taken pixels from the -surface of yarn in picture} - \text{The whole number of visible core's pixels in the surface of yarn}}{\text{The whole number of taken pixels of surface of yarn in picture}} = \text{Sheath covering index}$$

In next steps, two weaving reeds of 50 grooves in inch made completely smooth surface of lying said by said of core spun yarns. Then some pictures were taken of these surfaces (Fig7). Using this pictures and Image Processing Method cover of core spun yarns was obtained. So after modifying the taken pictures (Fig8) finally a relation has been concerned under the name of "Sheath covering index" based in this formula:

In table 5 we can see that with increasing the tension of filament, cover of core will increase because of lying filament in yarn's body, especially in sample R_6 with 100 g of tension, core has a cover of 95.09 % which could be interesting.

Table 5

Ring core yarn	Cover Factor of Core
R_1	85.31
R_2	86.86
R_3	88.01
R_4	90.45
R_5	90.67
R_6	95.09

Table 6- effect of feed position of core filament on siro core yarn properties

	Siro core yarn					
	Si1	Si2	Si3	Si4	Si5	Si6
state of feed of core filament	I	Π	Ш	IV	V	VI
Filament pre-tension(gram)	100	100	100	100	100	100
Count of yarn (tex)	58	58	58.2	57.4	57	57.5
breaking tenacity (g/tex)	19.9	20.6	20.3	20.5	20.9	19.8
breaking elongation	18.8	19.3	20.6	19.4	20.4	19.2
Hairiness	153	133	125	112	131	148
CV%	13.29	12.9	14.94	13.37	13.86	14.97
abrasion resistance	152	148	154	146	145	146

In an overall view, in contrary of Dr. Norbert's [16] opinion which has suggested a tension of 50 g for flat core spun yarns, we can consider a tension of 100 g as an optimum for flat core spun yarns, since with this tension core spun yarns obtain the best strength, abrasion resistance, percent of elongation and hairiness.

2-3 the Effect of Feed POSITION of CORE Filament

For investigating the effect of feed position of filament into the sheath fibers with two cores of multi filament, on physical and mechanical properties of cores pun yarn, and also finding the best position of feed according to table 3, six different position of feeding were applied to the Siro core spun yarns.

Table 6 is shown number of the effect of feed position of filament on properties of produced yarn. According to Fig9, sample Si_5 has the highest strength, although there is not a significant statistical difference between sample Si_5 and samples Si_2, Si_3 and Si_4. According to Fig10, sample Si_3 has the highest percent of elongation and it does not have a

significant difference with sample Si_5 either. According to Fig11 sample Si_4 has the least hairiness to the other samples. According to Fig12 sample Si_2 has the least percent of unevenness and doesn't have a sensible difference with samples Si_1 and Si_4, and from Fig13, there is no sensible variation in the limit of abrasion resistance of samples. According to the mentioned issues we can say that:

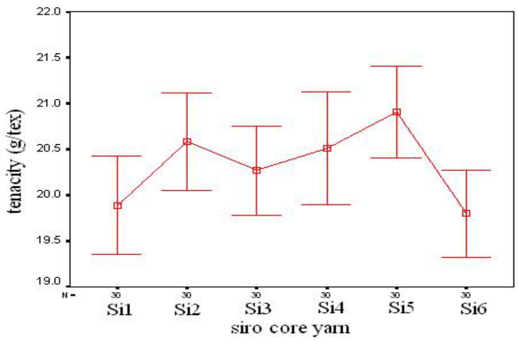

Fig 9- effect of feed position of core filament on tenacity of siro core yarn

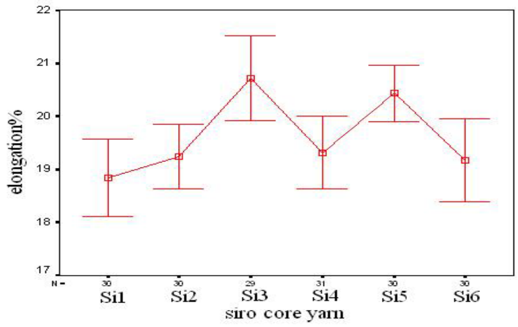

Fig 10- effect of feed position of core filament on percent of elongation of siro core yarn

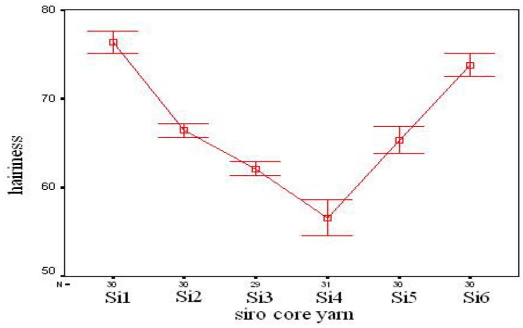

Fig 11- effect of feed position of core filament on hairiness of siro core yarn

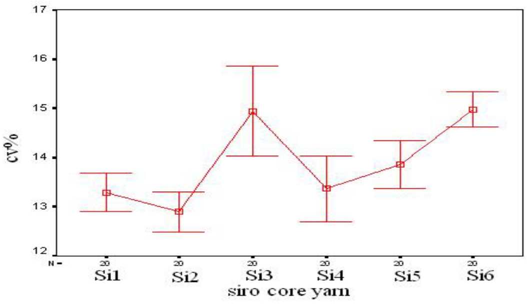

Fig 12- effect of feed position of core filament on percent of unevenness of siro core yarn

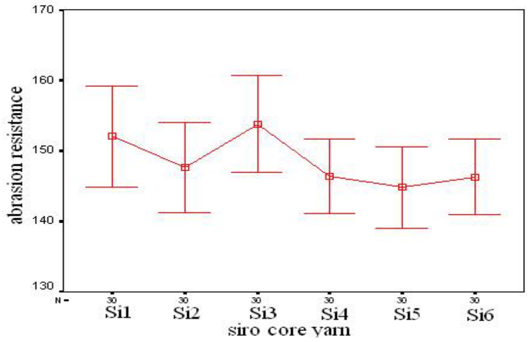

Fig 13- effect of feed position of core filament on abrasion resistance of siro core yarn

- Presence of filament in the left thread has a better result in hairiness of the core spun yarn. It is because of holding the left side fibers in the body of yarn however the filament itself could not obtain a suitable position in yarn's body. Just like samples Si_3, Si_4, Si_6
- Although the spinning triangle is assumed symmetrical in theory, but it is not like that in fact, for a ring yarn with a Z twist, fibers at the right corner of spinning triangle are under influence of a twisting force and are being surrounded in the yarn's body. While the left side fibers in spinning triangle are under a less control and force and are often being placed in yarn's body in a loose and undesired position [17]. So it is guessed that filaments are being fed in twist's direction are also under less control in yarn's body. Therefore they can't attain a good situation in yarn's body and will decrease the core's coverage.
- While the core is fed at the right side in comparison with when it is fed in center of yarn probably:

- A better control is being applied on filaments meanwhile of attaching to yarn's body.
- Core is controlling the surface fibers in a better way.
- A better quality is being obtained because of migration of filament fibers.

- Maybe because of the high tension (100 g) the extent of migration will decrease and they won't come so near to the surface. And this is why that the cover of yarn does not differ in tow situation (feeding in the middle and at the right side).

According to table 7 [18] can see that Si_2 has the best covering index and Si_3 has the worst covering Index. So sample Si_3 can not be a good position of feed. Within all samples produced in this section, samples Si_2, Si_4, Si_5 has a better properties in comparison with the other samples and sample Si_2 (position II) gives the best mechanical and qualitative properties and the coverage of core to the produced yarn.

- So, the best position for feeding the core filament is at the opposite direction of twist (right side)

Table 7- effect of feed position of core filament on covering Index of siro core filament[18]

Code of siro core yarns	covering index
Si_1	93/32
Si_2	95/23
Si_3	85/8
Si_4	92/4
Si_5	93/88
Si_6	88/23

3-3 Comparison of core spun yarns produced in two spinning systems of Ring and Siro

In this section, the best samples chosen of Siro and Ring core spun yarns in previous sections, are compared from the qualitative and mechanical point of view, Related quantities for each one of samples are given table 8. According to Fig 14 the highest strength is for Siro core spun yarn although there is a significant statistical difference between it and Ring core spun yarn. According to Fig 15 there is not a sensible difference between samples percent of elongation. Siro core spun yarn has the least hairiness and the samples are significantly different (Fig 16)

According to Fig 17 Ring core spun yarn has the least abrasion resistance and Ring and Siro yarns are almost similar. The least unevenness percent is for sample Si2 (Siro) and there is a significant statistical difference between it and Ring core spun yarn (Fig 18).

Table 8- Comparison of ring, & siro core spun yarns

	Core yarn	
	R6	Si2
state of feed of core filament	-	Π
Filament pre-tension(gram)	100	100
Count of yarn (tex)	57.4	58
breaking tenacity (g/tex)	19.5	20.6
breaking elongation	20.07	19.3
Hairiness	150	133
CV%	15.63	12.9
abrasion resistance	144	148

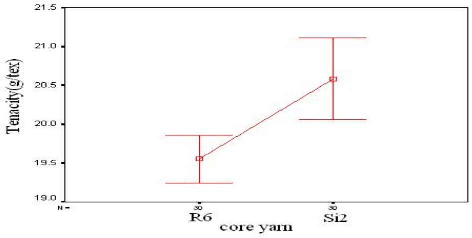

Fig 14- Comparison of tenacity of ring & siro core spun yarns

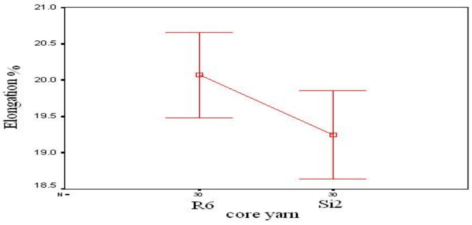

Fig 15- Comparison of elongation of ring & siro core spun yarns

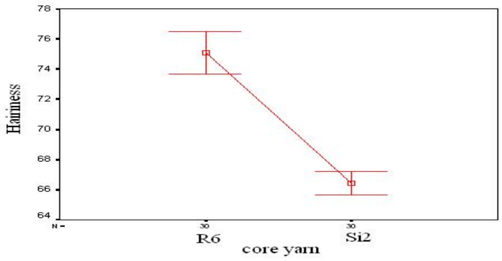

Fig16- Comparison of hairiness of ring, & siro core spun yarns

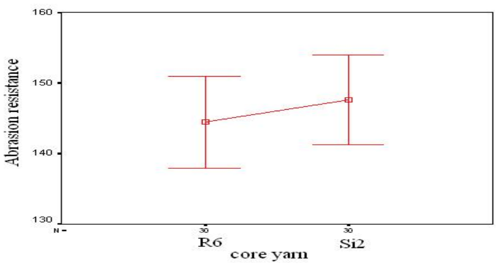

Fig 17- Comparison of abrasion resistance of ring & siro core spun yarns

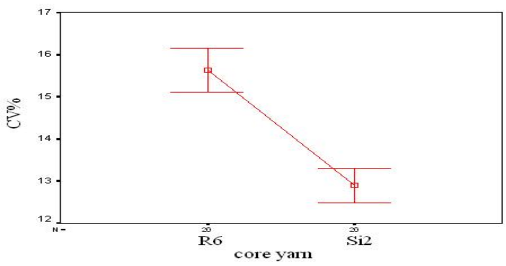

Fig 18- Comparison of unevenness percent of ring & siro core spun yarns

Considering performed comparisons we can say that:

- Siro core spun yarns are significantly better than Ring's ones in strength, unevenness percent and hairiness.
- There is no sensible difference in abrasion between Ring and Siro yarns.
- In totally, Siro Yarn has a better qualitative and mechanical property than the Ring yarns.

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4- Conclusion

In this research we investigated the effect of pre-tension of filament on Ring core spun yarn's properties and appointment the optimum tension for core filaments and afterward coverage factor were determined with the help of Image Processing Method. Then effect of feed position of filament in Siro was observed and the best position of filament was also determined. And in the Ring and Siro core spun yarns were compared. Overall conclusions are listed below:

- Pre-tension of filament could affect the core spun yarn's properties.
- Tension of 100 g result the best strength, percent of elongation, hairiness and abrasion resistance in core spun yarns.
- Tension of 100 g result the best coverage factor too.
- How to feed the core filament in Siro system affects produced yarn's properties.
- The best method of feeding in Siro with Z twist is to feed the filaments in right threads.
- Feeding the filament in an opposite direction of twist results better properties in yarn rather than feeding it in the same direction.
- Siro core spun yarns have better properties than Ring core spun yarns.

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