A novel method of hairiness reduction by modified lappet design and separator in conventional ring frame

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ABSTRACT

For many years, during the spinning process the protruding fibers are formed in ring yarn structure. The protruding fibers are known as "Yarn hairiness". This yarn hairiness reduces the quality of yarn and fabric and also it decreases the selling price of the yarn, because of the presence of yarn hairiness make uneven dyeing. Yarn hairiness is an important factor that affects the textile appearance, feel and usability, which is also very crucial to the quality assessment of the yarns. Now-a-days compact spinning is used to reduce the yarn hairiness. Hairiness in yarn is caused by raw material fault or by machine fault. The high percentage of short fibres in the cotton, lack of floating fibre control in the drafting zone are the main causes of producing hairiness in ring spun yarn. In this research work an attempt is made to reduce the hairiness level in the yarn by modified lappet design and providing suction pressure in the lappet zone. Also an attempt is made to alter the separator design to find the impact of reduction in hairiness of the yarn. The yarn is tested for its imperfection and hairiness index values using Uster tester. The results shows a positive node and we conclude that by the use of modified lappet and separator yarn can be produced with less imperfection and hairiness in the conventional type of ring frame.

Key Words: *Hairiness, Imperfection, Lappet, Seperator, Suction pressure*

1.Introduction:

The yarn produced by ring spinning has hairiness. Lot of research work has been done to reduce the hairiness level in ring spun yarn. The introduction of compact spinning system is one of the best methods in controlling the hairiness in yarn. The main advantages of reducing the hairiness in yarn makes all the fibres to contribute the strength factor of yarn and also make the spinner to produce the yarn with lesser twist multiplier than the conventional process. This enables the spinner in making the yarn with higher strength with less imperfection level and also increases the production per spindle by increasing the spindle speed. The compact spinning system needs initial investment in existing ring frame. Yarn hairiness assumes a significance which should not be underestimated. This refers to the length and frequency of fiber ends that are not integrated in the yarn and therefore protrude from the yarn bundle.

High yarn hairiness (primarily of hairs longer than 3 mm) can have a negative impact, both due to a diffuse fabric appearance lacking in clear structure and also in downstream processing due to a tendency to cling and fiber deposits on the machines. If these deposits reach the final fabric they are usually rated as disturbing defects. However, high yarn hairiness (hairs shorter than 3 mm) is positive where it contributes to soft fabric hand. Soft, flexible fabric hand is preferred in knitted fabrics for underwear, T-shirts and leisurewear.

An automatic measurement method of measuring hairiness by using image processing techniques has been attempted [1]. A new method developed by obtaining the yarn image using digital camera, then extracts the yarn skeleton by image processing technology, calculates the yarn length by the minimum enclosing rectangle (MER) and calculates the hairiness length by pixel search method, finally gets the Hairiness Index by the proportional relationship between the actual length and pixel length of the reference object [2]. The method of finding yarn hairiness using image processing techniques with a low-cost USB Web Camera in association with a yarn moving arrangement also been attempted [3]. Development of algorithm to edge detection of yarn image by computer programming is done to measure hairiness [4]. Reducing hairiness in ring spinning made possible by introducing contact surface was also done [5]. Effect of different gauge of pin carding plate and saw-tooth carding plate respectively installed under the licker-in of carding machine on polyester yarn hairiness was also studied [6]. Influence of the opening-roller speed on the hairiness of cotton open-end-spun yams for various values of the applied twist multiplier has been studied [7]. The influence of the hairiness of open-end-spun yarns on the opening-roller speed, the linear density of the feed sliver, and the cleaning device that in some instances is coupled to spinning heads was studied[8]. JetRing and JetWind techniques, which use air-jet nozzles to reduce yarn hairiness has been studied[9]. The various causes which determine yarn hairiness are studied with particular reference to the influence of twist[10]. Dynamic process of hairiness formation in worsted ring spinning has been studied. A special CCD camera was used to observe the fibre behavior in the spinning triangle. The formation mechanisms of leading, trailing, looped, and wild hairs are demonstrated with a series of photos[11]. A report on computational fluid dynamics (CFD) simulation of airflow inside the nozzles used in Nozzle-Ring spinning. Using the CFD, air velocities at different locations of the nozzle were obtained and then drag forces acting on hair and yarn were computed. At very high impact angle, curving of protruding hair was bound to occur during its folding, signifying the difficulty in wrapping the hair over the yarn and, hence, a lower reduction in hairiness[12]. Theoretical analysis of the influences by protruding fiber ends on the change in hairiness during the winding process has been studied [13]. An investigation on the effects of yarn hairiness on air drag in ring spinning was conducted. The results show that hairiness increases the air drag by about one-quarter and one-third for the rotating cotton and wool yarn packages, respectively. In addition, yarn hairiness increases the air drag by about one-tenth on a ballooning cotton yarn. [14]. Design and development of an air nozzle that can be easily attached on to the sirospun spinning system to reduce hairiness has been done. Various nozzles having different injector angles, main hole diameters, injector diameters, number of injectors, nozzle shapes and injector positions were used and siro-jet yarns were produced at different air pressure levels. At the end of the experiments, it was determined that there is an optimum value for each nozzle parameter, and that the number of injectors and injector position play the most important roles in reducing yarn hairiness, whereas nozzle shape shows the weakest effect. On the other hand, the findings showed that it is possible to get lower hairiness values by different modifications on the same nozzle design. Considering the hairiness results, a constant was defined indicating the relationship between nozzle structural parameters and hairiness of the yarns to ease the nozzle design efforts. Depending on nozzle type, the siro-jet spinning system truly improves the yarn hairiness by 40–75% [15]. The influence of modified yarn path on spinning tri angle and, in turn, on yarn hairiness has been studied using 100% cotton yarns of the counts 25s, 40s, 60s, 70s & 100s, and polyester/cotton blended (70/30) yarns of the counts 30s, 45s & 64s with various left diagonal path offsets in ring spinning. It is observed that there is upto 40% reduction in hairiness at 60 mm offset left diagonal path with slight increase in the strength for all the counts produced except 100s[16]. An attempt has been made to produce condensed yarn using mingling chamber fitted in the front drafting zone in the conventional ring spinning machine. Three combed cotton yarns of 60s, 80s and 100s Ne have been spun on the existing and modified ring spinning systems. he proposed method of yarn condensing has great potentiality to be used as an alternative method of compact spinning as it is capable of producing optimum quality yarns at lower cost [17]. Reducing yarn hairiness during yarn winding by the use of air jets has been studied as an innovative method on lowering the level of hairiness of ring spun yarns. This can be achieved by shooting compressed air to the yarn, through a swirl nozzle comprising a yarn duct and an airjet nozzle attached to a traditional ring spin frame. When compressed air is applied from the air-jet nozzle to the yarn duct, the swirling air flow tucks surface fibers of the ring spun yarns into its body. Four controllable variable parameters for the process, supplied pressure, nozzle position, twist factor and spindle speed, and their effects on the lowering of yarn hairiness will be clarified. Their impact on the quality of the yarn is statistically analyzed, and the optimum outcome of the combination of parameters for the process, will thus be determined [19]. A new method for the reduction of yarn hairiness is presented by attaching a simple effective air suction system to the web detaching zone of a conventional carding machine immediately behind crushing rollers. The slivers produced were almost free from dust or short loose fibers. The ring-spun yarn that was produced was called Vacuum Cleaned Carded yarn or VCC yarn, due to the removal of the short fibers by air suction. The properties of VCC yarns were compared with those of conventionally produced reference yarn sample. Comparison of the results showed that the hairiness of optimum VCC yarn decreases by approximately 20%, while its tenacity, elongation at break and evenness were significantly improved. It was also found that the VCC yarn exhibited better spinning stability and was more environmentally friendly than the reference yarn[20]. Balloon control rings are used to contain the yarn-loop, by reducing the yarn tension and decreasing the balloon flutter instability. Flutter instability here refers to the uncontrolled changes in a ballooning yarn under dynamic forces, including the air drag. This study investigates the variation in the radius of a free balloon and examines the effect of balloon control rings of various diameters at different locations on yarn tension and balloon flutter stability. The results indicate that the maximum radius of a free balloon and its corresponding position depend not only on the yarn-length to balloon-height ratio, but also on yarn type and count. This study suggest that theoretically, a balloon control ring that always remains approximately half way between the yarn-guide and the ring rail during spinning can lead to significant reduction in yarn tension[21].

2. Materials and Methods

The following table will give an outline of the preparatory process used for carrying out this research work.**(Table 1)**

S.No	Parameters	Details
1	Cotton used	Sankar4
	Mean staple length	28mm
2	**Carding**	**LC 300 A V3**
	a) Delivery Hank	0.120
	b) Delivery Speed in mpm	120
	c) Production Rate (Kg/hr)	35.4
3	**Pre Comber Draw Frame**	**LD-2**
	a) No of Doubling	5
	b) Delivery Hank	0.120
	c) Delivery Speed in mpm	600
4	**Uni Lap**	**E-5**
	a) No of Doubling	22
	b) Lap Weight	75gms/mt
5	**Comber**	**E-65**
	a) Delivery Hank	0.120
	b) Comber Speed (npm)	450
	c) Noil %	18
6	**Finisher Draw Frame**	**D-40**
	a) Delivery Hank	0.120
	b) No of Doublings	8
	c) Delivery Speed in mpm	400
7	**Simplex**	**LFS 1660 V**
	a) Delivery Hank	1.1

	b) Spindle Speed (rpm)	980
	c) TPI / TM	1.1

The spinning machine details are given below (Table 2)

Particulars	Details
Name of machine	Jenn Tex, Cbe
Number of Spindles	48 (24 per side)
Type of drafting	WST UT 620 (3over 3)
Drafting roller setting	55mm/45mm
Break draft	1.2
Main draft	28.33
Feed Hank	1.1
Count of Yarn	34;sN_e
TPI	24.3
Spacer used	4mm
Traveler	6/o sapphire elliptical
Spindle speed	9500 rpm

Methodology

The following chart (Figure 1) gives the details of sample production using the ring frame

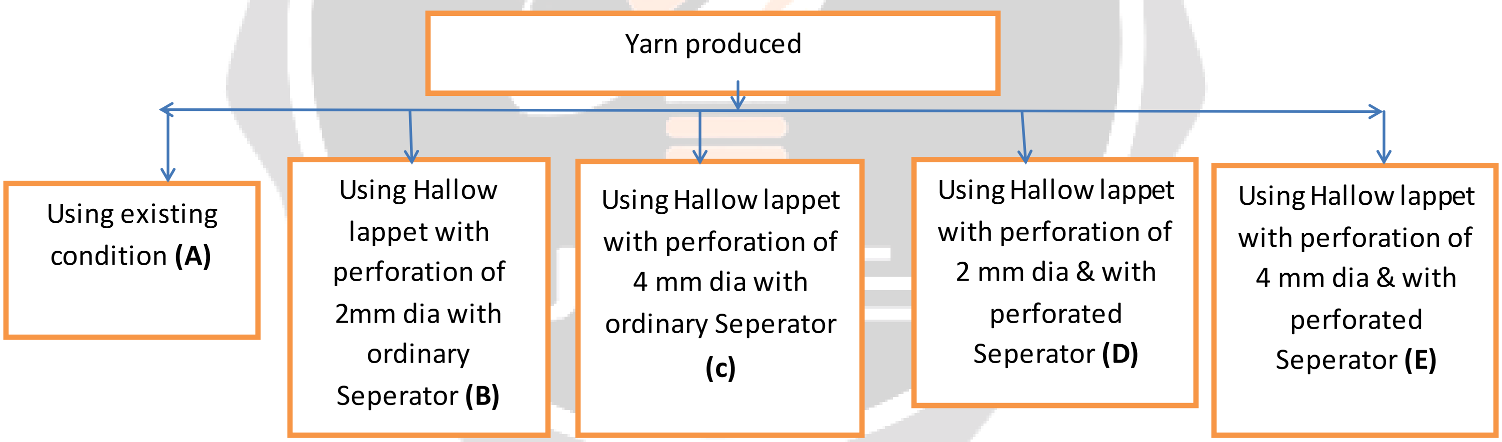


Figure 1

The yarn was produced using the above said particulars. 5 samples of yarn were produced. Yarns were produced with the existing condition, with modified lappet design and using modified lappet with perforated Seperator. The hallow lappet is connected to a suction equipment which will provide suction pressure of 2 millibar. The suction pressure, break draft, main draft, TPI and Spindle speed were kept constant throughout the study. During the production of every sample ,traveler has been changed. The hollow lappet was made by using 4mm hollow copper tube which was suitable bend in to a lappet shape and the rear end of the tube is blocked by welding so that the suction pressure is maintained. The hollow lappet is made perforation without any burr using drilling tool with subsequent interval in the inner side of the lappet. The front end of the hallow lappet is suitably connected to a suction instrument by means of a suction tube. The suction instrument is connected to a separate power source so that constant suction pressure will be maintained throughout the experiment. The lappet and Seperator design is illustrated in (Figure 2)

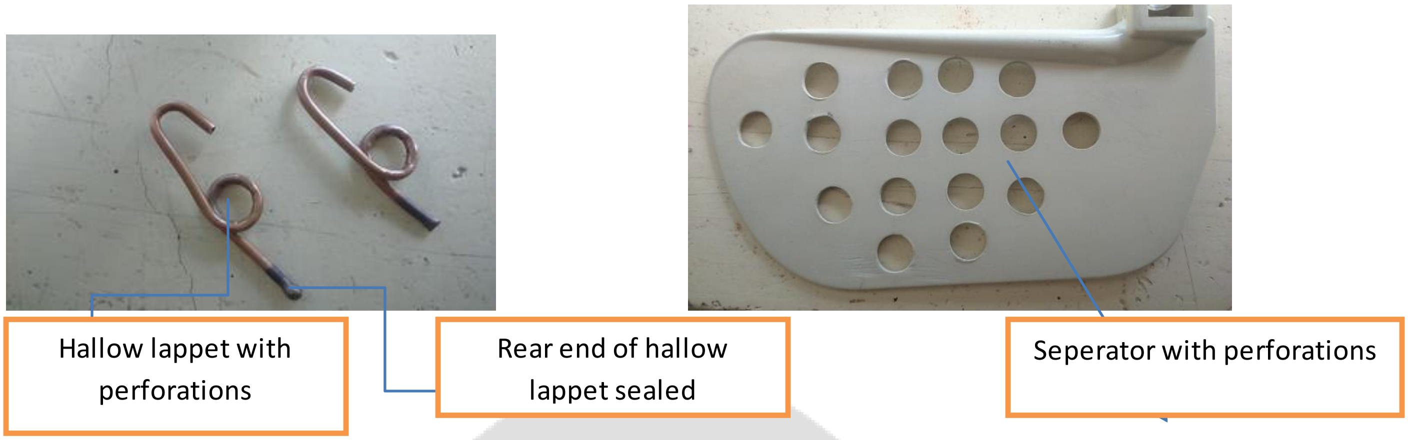


Figure 2 : Hallow lappet and perforated Seperator

3. Results and Discussion

The yarn produced from the above experimental set up were tested for count and its variation , strength and its variation, Imperfection level , hairiness index and classimat faults.

Figure 3- Experimental set up

Line diagram illustrating the experimental setup

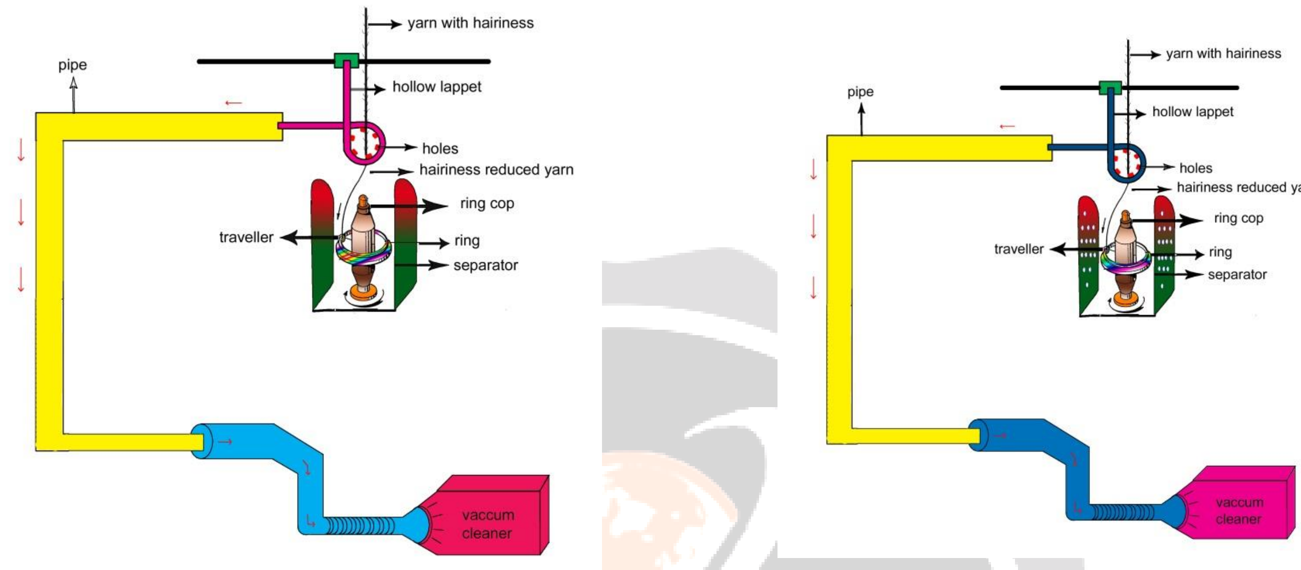


Figure-4

The experimental set up and line diagram were shown in figure 2,3,4. The yarn produced using the experimental plan were coded as follows

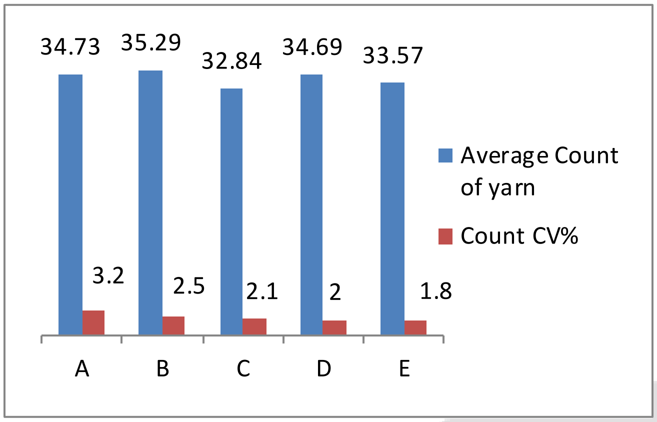
Table 4

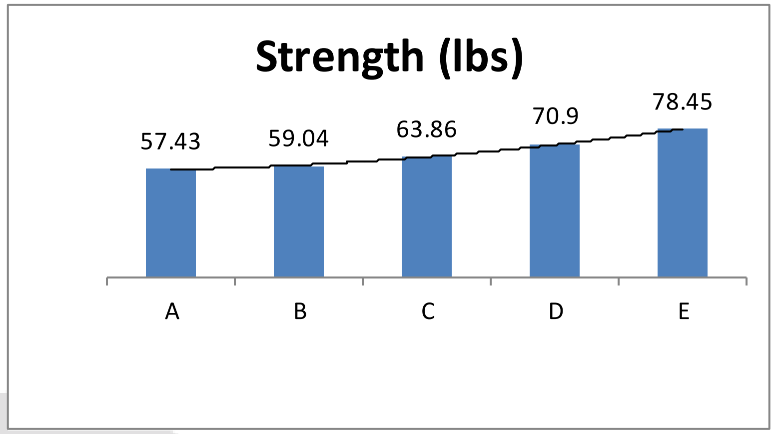
Sample code	**Particulars**
A	Yarn produced with existing set up
B	Yarn produced with hallow lappet having 2mm perforation and with ordinary Seperator
C	Yarn produced with hallow lappet having 4 mm perforation and with ordinary Seperator
D	Yarn produced with hallow lappet having 2 mm perforation and with perforated Seperator
E	Yarn produced with hallow lappet having 4 mm perforation and with perforated Seperator

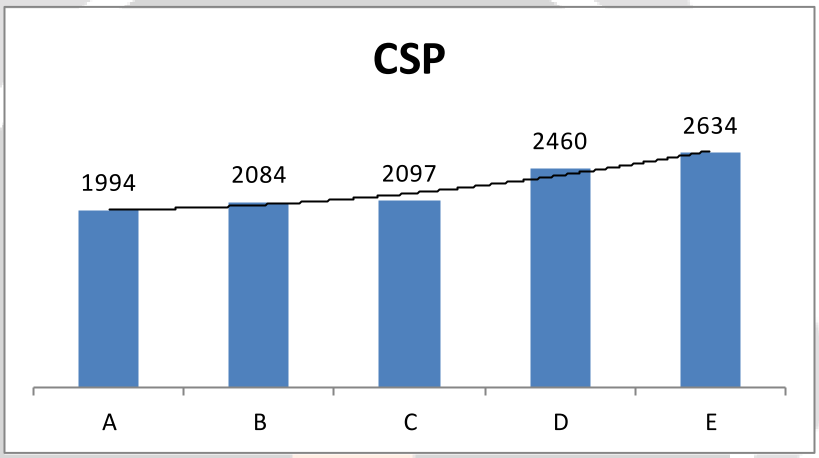
The following table gives the results of the count of yarn and its variation

Table 5

Sample code	Count of yarn	Count CV%	Strength (lbs)	Strength CV%	CSP
A	34.73	3.2	57.43	4.0	2601.31
B	35.29	2.5	59.04	3.75	2700.90
C	32.84	2.1	63.86	3.2	2670.66
D	34.69	2.0	70.90	2.9	3066.00
E	33.57	1.8	78.45	2.6	3220.15





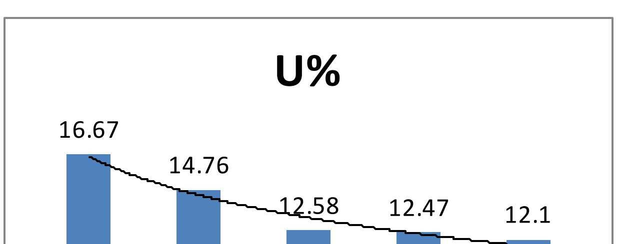


From the above findings we can find that the count CV of the yarn produced with hallow lappet having 4mm perforation and with perforator Seperator gives a better result compared to other 4 samples. Similarly the strength and CSP of the sample produced with hallow lappet having 4mm perforation and with perforator Seperator gives a better result. The CSP and strength of the sample E is 24% higher compared to sample A.

The following table gives the imperfection and hairiness index of the samples produced.

Table 6

Sample code	U%	Thin(-50%)	Thick(+50%)	Neps (+200%)	Total Imperfection	Hairiness Index
A	16.67	611.3	1478	118.8	2224.77	4.38
B	14.76	230	606	95	850.76	4.21
C	12.58	40	241	81.3	374.88	4.18
D	12.47	22.5	243.8	78	356.77	4.07
E	12.10	21	220	70	323.1	4.02



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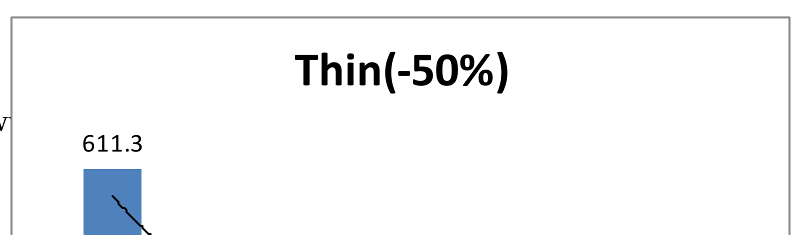
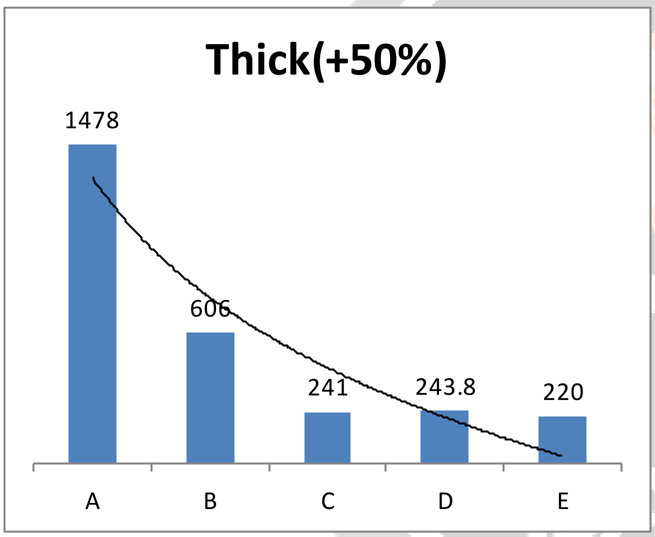
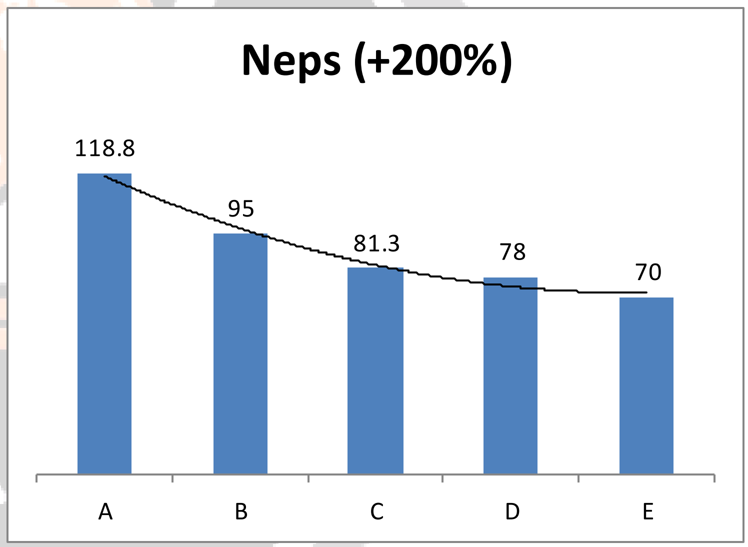



Thick(+50%)
1478
606
241
243.8
220
A
B
C
D
E


Neps (+200%)
118.8
95
81.3
78
70
A
B
C
D
E

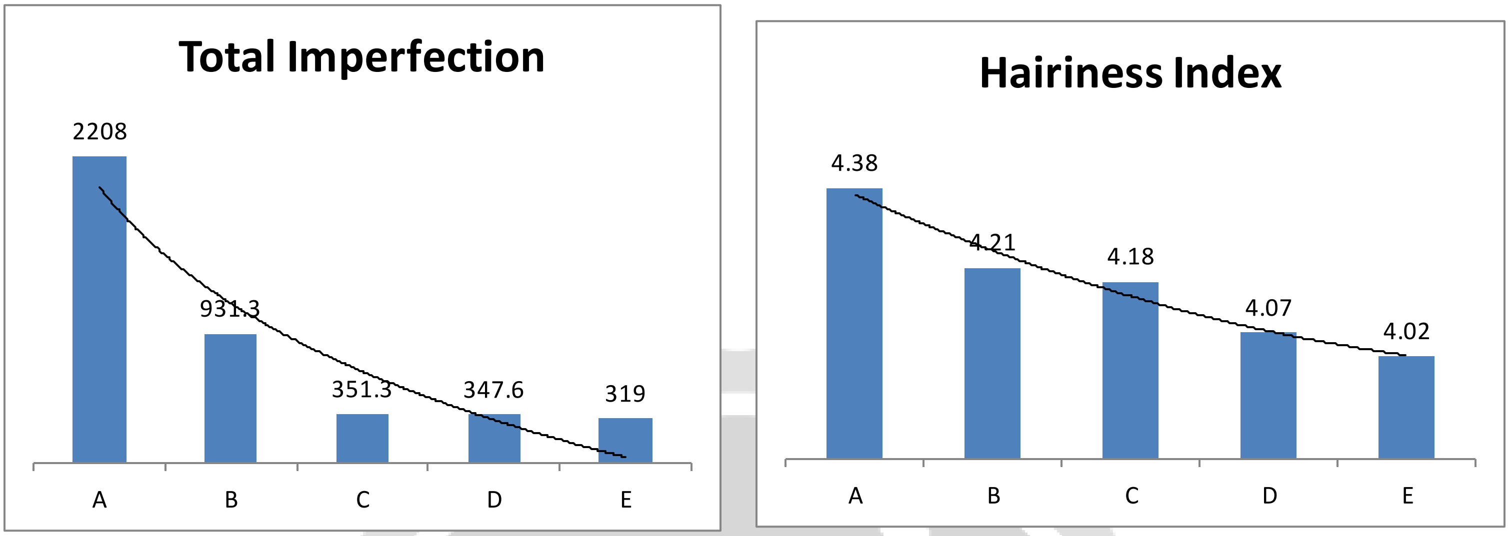


Figure 6

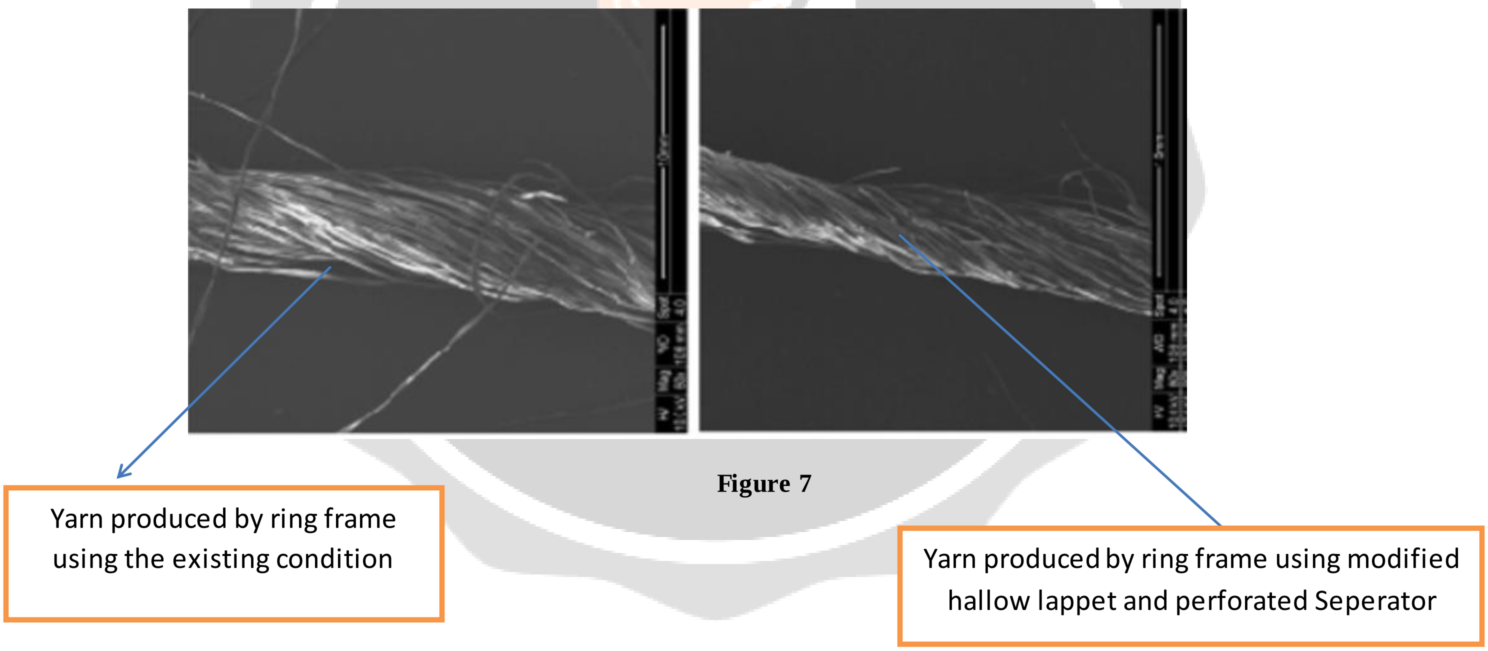


Figure 7

From the interpretation of the graph (Figure 6) it can be found that the imperfection level (NEPS Thick and Thin Total imperfection) is very much reduced in the samples which are made from the hollow lappet with suction and with perforated Seperator. It can be concluded that the sample “E” (Yarn produced with hallow lappet having 4 mm perforation and with perforated Seperator) is having very low imperfection level and hairiness index level. (85% reduction in total imperfection level compared to other sample, 8.25% reduction in hairiness index).

Conclusion

From the study it can be concluded that the modified lappet design with suction pressure and with perforated Seperator has got an impact on reducing the imperfection level of yarn and the hairiness index. Due to the suction provided in hollow lappet the short fibre in the yarn was sucked and it makes the yarn more compact. The perforation in Seperator gives way for the escape of air turbulence created by the balloon of the yarn, during yarn formation which adds a valuable intact in reducing the hairiness further.

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