DESIGN AND DEVELOPMENT OF IMPROVED WET SELF COMPACTING SYSTEM

A PROJECT REPORT

Submitted by

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ABSTRACT

The technology development that has taken place in Weaving and Knitting processes during the past few decades to achieve higher productivity demanded high tenacity and less hairy high performance yarn. These have necessitated the invention of Compact yarn. In this project an attempt is made to design and develop an improved system of Wet Self Compacting (WSC) for producing compact yarn.

In WSC System wetting of fibers are carried out using additional pair of delivery roller in front of existing front roller. To ensure uniform application of water in WSC System dripping control arrangement is used.

The study reveals that there is a phenomenal reduction of more than 94 - 95% in the Zweigle S3 value and 35 - 41% in Uster Hairiness Index in WSC System. Also the Single Yarn Strength is increased by 16 - 18% and the Overall Packing Density is increased by 28 - 43% . From the above results one can conclude that, WSC System yarn has high potential to be used in the emerging technical textile field. But the system needs fine tuning towards achieving further reduction in imperfections alongwith provision of roving stop motion to make it commercially successful.

குறு இழைகளுக்கான "மேம்படுத்தப்பட்ட ஈரப்படுத்தி, தாமதமாகவே நெருக்கப்பட்ட நூல் நூற்கும் முறை"

இன்றைய உயர் உற்பத்தி நெசவு மற்றும் பின்னலாடை தொழில் நுட்பங்களுக்கு உயர்ந்த செயல் திறன் பொருந்திய நெருக்கப்பட்ட நூல் தேவைப்படுகிறது. இந்த நெருக்கப்பட்ட நூலின் உயர் பண்புகளாகிய அதிக வலிமை மற்றும் குறைந்த மயிர்த்தன்மையானது துணியில் அதிக உற்பத்தி மற்றும் தரத்தை ஈட்ட உதவுகிறது. எனவே இந்த திட்ட நோக்கத்தில், நெருக்கப்பட்ட நூலின் பண்புகளை மேலும் அதிகரிக்க "ஈரப்படுத்தி தாமாகவே நெருக்கப்பட்ட நூல் நூற்கும் முறை" (Wet Self Compacting-WSC) புதிய வழிமுறையில் வடிவமைக்கப்பட்டுள்ளது.

இந்த புதிய முறையில் நூற்கும் பொறியிலுள்ள இழுவை உருளைகளில் கூடுதலாக மேலும் ஒரு ஜோடி உருளைகள் வடிவமைக்கப்பட்டு இணைக்கப்பட்டுள்ளது. மேலும் ஈரப்படுத்துதல் சீராக இருப்பதற்கு நீர் விழுதலில் கட்டுப்பாடு அமைப்புகள் நிறுவப்பட்டுள்ளன.

இத்திட்ட ஆராய்வின் முடிவுகளின்படி நூலின் முக்கியப் பண்பான மயிர்த்தன்மையானது கணிசமான விழுக்காடு குறைந்திருப்பது கண்டறிப்பட்டுள்ளது. இது நூலின் மயிர்த்தன்மையைக் கண்டறியப்பட்டுள்ளது. இது நூலின் மயிர்த்தனமையைக் கண்டறியும் கருவிகளான ஜுவிகல் S3 மதிப்பின்படி 94-95% மற்றும் உஸ்ட்டர் மதிப்பீட்டுக்கருவியின் மூலம் 35-41% குறைந்துள்ளது என்பதை அறியலாம். மேலும் தனி நூலின் வலிமை 16.5-18% வரை உயர்ந்துள்ளதும் நூலிலுள்ள இழைகளின் மொத்த அடர்திறன் 28-35% அதிகரித்துள்ளதும் தெரிய வந்துள்ளது.

மேற்கூறிய முடிவுகளின்படி இந்த புதிய " மேம்படுத்தப்பட்ட ஈரப்படுத்தி தானாகவே நெருக்கப்பட்ட நூல் நூற்கும் முறை எதிர்காலத்தில் நூலின் மிக உயர்ந்த பண்புகளான நூலின் மயிர்த்தன்மை மற்றும் வலிமையை மேம்படுத்த உதவியாக இருக்கும் என்பதில் ஐயமில்லை.

ஆனால் இந்த புதிய முறையில் நூலின் சீரின்மைத்தன்மையை மேம்படுத்தவும் ரோலிங் எனப்படும் முழுமையாக முறுக்கப்படாத தொடர் இழைகளின் தொகுப்பானதை நிறுத்தும் அமைப்புகளை ஏற்படுத்தவும் முயற்சிகள் எடுத்தால் இப்புதிய முறை மேலும் மெருகூட்டப்பட்டு நூற்பு இயந்திரச் சந்தையில் பெரிய வெற்றியைத் தேடித் தரும் என்பதில் சந்தேகமில்லை.

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WSC – Wet Self Compacting system.

K – Carded cotton English count(Ne).

C – Combed cotton English count(Ne).

REG – Regular Ring.

CHAPTER 1

1.0 INTRODUCTION:

1.1 GENERAL:

Spinning system to produce compact yarn has come into existence to meet the high performance requirements of super speed downstream process machines and to enhance the aesthetic appearance of fabrics made from spun yarn.

The structure of regular ring spun yarn is not ideal due to poor integration of fibre that emerges from the front roller in the twisting mechanism that is propagated by the revolution of spindle .

Due to the above reason the realization of fibre strength into yarn strength is not high and protruding hairs having length more than 3mm creates process problem in the downstream and also poor appearance in the fabric. An extra zone has been created and the drafted fibre strand are first condensed before getting twisted in the compact spinning system that have come into existence with the pneumatic and mechanical compacting principle.

1.2 NECESSITY FOR AN ALTERNATE SYSTEM FOR THE COMPACT YARN PRODUCTION:

The Pneumatic/Mechanical Compacting System that are commercially available today are costing exorbitantly and it is not viable to Indian mills to venture on it. Further, certain systems are only retrofittable. All these have made us to take up a research project to develop a simple suitable cost effective and retrofittable alternate system, so as to obtain a gain in quality in respect of hairiness and strength.

Addition of coherent such as water facilitate self compacting of drafted strand. But the addition couldn't be carried out in the main drafting zone as it affects the drafting field and yarn uniformity

This necessitated to design & develop an alternate system of application of water by shifting the addition of water subsequently to main drafting.

The addition of water changes, the suppleness of fibre and reduce flexural rigidity to a greater extent, thereby producing a yarn with minimum hairiness and improved strength.

In this work, an attempt has been made to design and develop an improved retrofit able wet self compacting system.

CHAPTER 2

LITERATURE REVIEW

2.1 CONVENTIONAL RING SPINNING:

2.1.1 Reason for Yarn Hairiness and Deterioration in Strength:

Chattopadhyay (2002) observed that when a roving strand is drafted for a given count, high draft has to be set at the ring frame. As the result of it the width of fibre flow becomes too large at the front roller creating a wider spinning triangle. During twisting process all the fibres are not integrated properly into yarn, there by increasing the yarn hairiness and deterioration in strength.

2.1.2 Spinning Triangle:

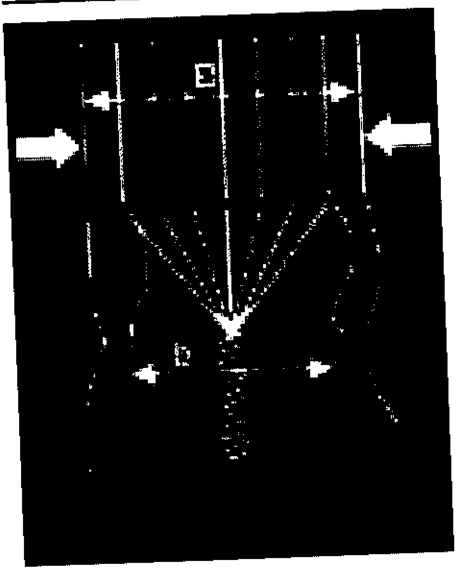
The turns of twist in a yarn are generated at the traveller and it travel against the direction of movement to the drafting arrangement. Klein (1987) observations are that the twist must run back as close as possible to the nip line the rollers, but it never penetrates completely to the nip because the drafted fibre strand is wide strand, after leaving the rollers, the fibres first have to move inwards and wrapped around each other. Accordingly at the exist point of front roller there is always a bundle of fibres in triangular shape without twist, which is called spinning triangle.

The size of the spinning triangle depends upon the roving hank, draft, spinning tension spinning tension and the twist level in the yarn.

Spinning triangle cannot catch all the incoming fibres. Hence some edge fibres are lost while others get attached to the already twisted yarn core in disorderly manner. Thus poor strength & evenness of yarn results.

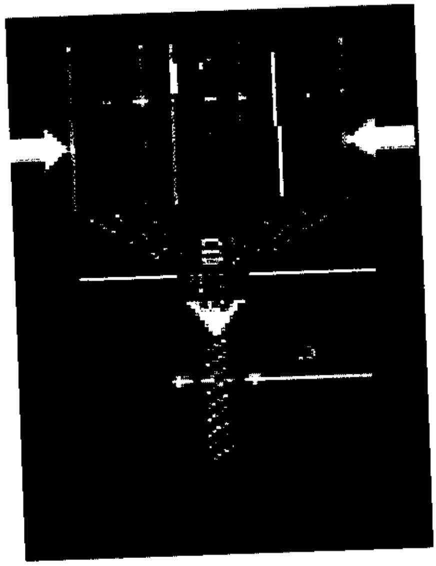
Fig.1. spinning triangle

Ring Spinning:



$\Delta = B - b > 0$

Compact spinning:



$\Delta = B - b = 0$

Spinning triangle is reduced to near zero by using compact spinning principle.

2.2 EXISTING COMPACT SPINNING SYSTEM:

Commercially available compact spinning systems are as follows:

- Aerodynamic Condensation
  - Suessen – EliTe
  - Rieter – Com4
  - Zinser – AirComTex700
- Mechanical condenser
  - RoCoS

Chellamani et al (2002) and Ishtiaque et al (2003) in their papers critically reviewed the advantages and disadvantages of the above systems apart from

2.2.1 Suessen –Elite Spinning:

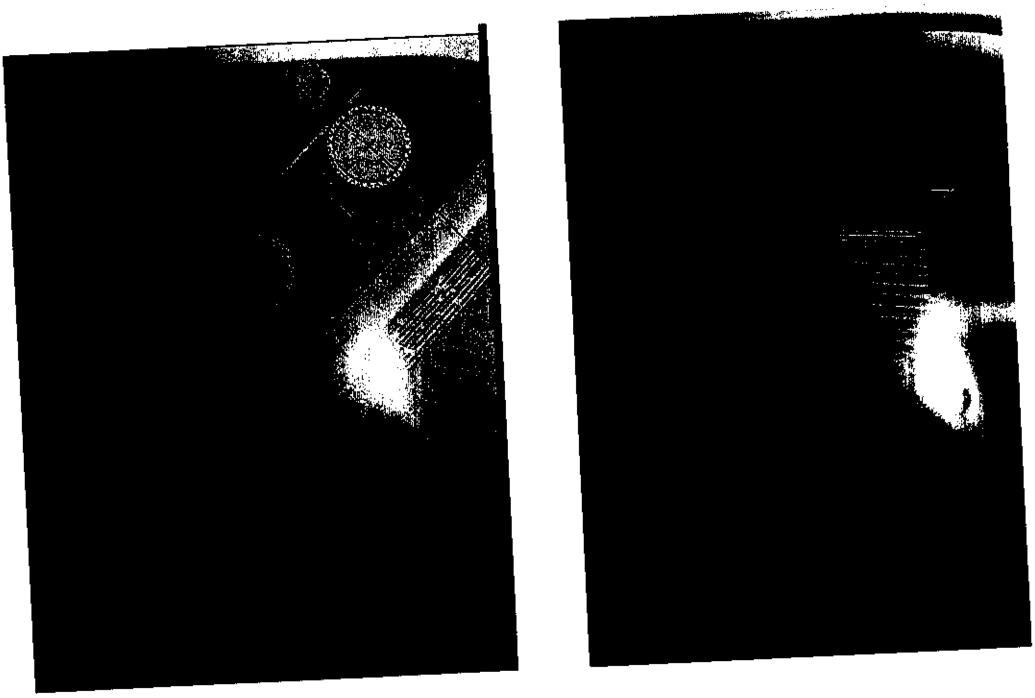


Fig. 2. Suessen –Elite spinning

2.2.1.1 Design Concept and System of Functioning:

Suessen Elite spinning catalog spinnovation (5/1999) explain the functioning of Elite spinning system.

- In the EliTe process top roller is driven by the front bottom roller of the drafting system and transfers the speed to the delivery top roller by a gear transmission.
- A tubular profile subjected to negative pressure is closely embraced by a perforated lattice apron.
- The delivery top roller fitted with rubber cots presses the lattice apron against the hollow profile and drives the apron, at the same time forming the delivery nipping line.
- The tubular profile has a small slot in the direction of fibre flow, which commences at the immediate vicinity of the front roller, nipping line and ends in the region of delivery nipping line as shown in fig.2

- This creates an air current through the lattice apron namely the slot towards the inside of the profile tube. These air current seizes the fibres after they leave the front roller nipping line and condenses the fibre strand, which is conveyed by the lattice apron over a curved path and transported to the delivery line
- As the slot being under negative pressure reaches right upon to delivery nipping line, the fibre Assembly remains totally compacted.

2.2.1.2 Features:

- The diameter of the delivery top roller is slightly bigger than the diameter of front top roller, which creates a tension in longitudinal distance during the condensing process.
- The consequence of this tension causes the curved fibre to straighten end, therefore support the condensing effect of the negative pressure acting on the fibre band in the slot area of the profile tube.

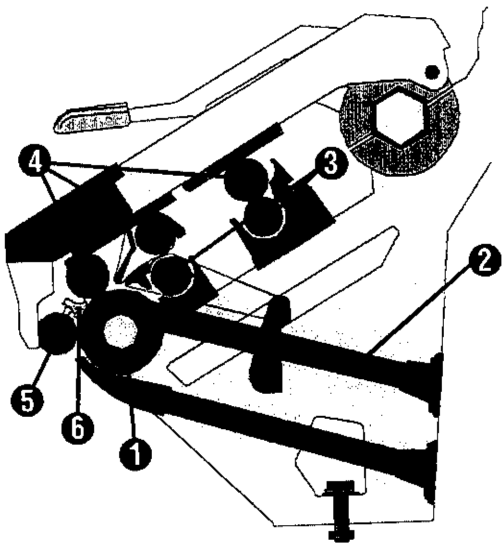
2.2.1.3 Advantages of Elite spinning:

- Carded Elite yarn match with conventional combed yarn in strength.
- It needs less twist and therefore produces an excellent fabric handles.

2.2.1.4 Disadvantages of Elite spinning:

- Maintenance cost per spindle is very high.
- As time passes the lattice apron tends to smoothen so that co-efficient of friction may change, leads to breakages.
- Roving traverse is restricted to 3-5 mm which reduces the life of cots.

2.2.2 Rieter - Comfor Spinning:



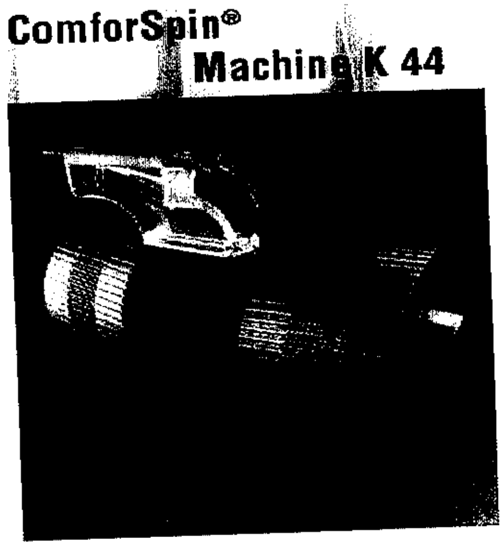


Fig.3. Rieter-Comfor Spinning

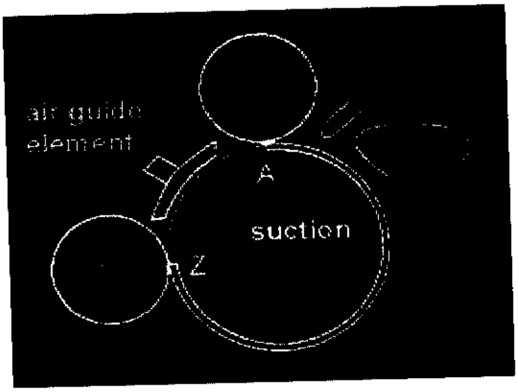
Stalder (2000) states that the Comfor Spin technology allows aerodynamic parallelization and condensation of the fibres after the main draft. The spinning triangle is thus reduced to a minimum. The heart of the Comfor Spin machine is the compacting zone, consisting of the following elements:

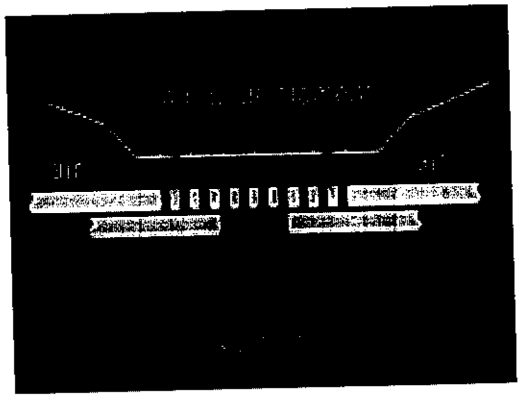
- Perforated drum
- Suction inserts
- Air guide element

The directly driven perforated drum is hard wearing and resistant to fibre clinging. Inside each drum is an exchangeable stationary suction insert with a specially shaped lot. It is connected to the machine's suction system. The air current created by the vacuum generated in the perforated drum condenses the fibres after the main draft. The fibres are fully controlled all the way from the nipping line after the drafting zone to the spinning triangle. An additional nip roller prevents the twist from being propagated into the condensing zone.

The compacting efficiency in the condensing zone is enhanced by a ... air guide element. Optimal interaction of the

Fig.4. Rieter-comfor-AirGuideElement





2.2.2.1 Features:

- The fibre condensing zone immediately follows a 3 roller drafting system with double aprons.
- The delivery roller of drafting system is replaced by a perforated drum.
- The fibres supplied from the delivery nip line of the drafting system and thus hold firmly on the surface of the perforated drum and move with the circumferential of the drum.

2.2.2.2 Advantages of Comfor Spinning:

- Frequent cleaning is not required due to big hole size.
- Consistency of condensing, no clogging.
- Short zone without fibre guidance in the main draft.
- Immediately after the main draft (A) the fibres are captured by the suction slot and guided ideally to the nipping roller (Z).
- The shape of the suction slot permits accurate fibre guidance, even during traversing.
- Fibre condensing is further intensified by the air guide element.

2.2.2.3 Disadvantages of Comfor Spinning:

- Power consumption and cost is high.
- Restriction of roving frame.
- Diameter of bottom perforated roller is very large, this restricts short fibre processing.
- There is no tension draft between front top roller and delivery top roller, this causes disturbance in fibre orientation & straightening
- The absence of flutes on the perforated bottom roller leads to roller slip
- The diameter of perforation is 80 times greater than that of the fibre, hence there is great loss of valuable raw material during suction.
- It cannot be retrofitted and the cost per spindle is Rs.10,000
- Fibre loss in suction due to big holes.

2.2.3 ZINSER AIR COM-TEX 700:

On Zinser Compact Spinning machine the fibre bundling produced in the conventional 3 roller drafting system run from compact nip line directly on to the perforated rubber apron under suction the fibres are united by the means of air steam applied by the three dimensionally air laterally and compacted to the diameter determined by yarn count and number of fibres per cross section. Only tiny spinning triangle results for this. All the fibre are optimally align and twist insertion takes place very homogeneously with out any great difference between peripheral fibres and core.

Fig.5.Zinser air com-tex 700

Fig.6. Fibre guide and air flow

The compacting zone is the CompACT3 spinning procedure is sub divided into

1. Compact element
2. Perforated apron
3. Pneumatic system

Pneumatic system is to provide the sub pressure .the compact element is used in addition to the conventional spinning element. Due to it geometry and shape this element is resistance to fly accumulation. The essential component is the compact apron.

On the compact apron compaction of yarn in corporation of vertical transport and air stream applied lateral to the perforation the fibres end which are to be strike out and or not use in subsequent process.

2.2.3.1 Advantages of Air Com Tex:

- Due to the favourable geometry and flexibility of the apron, a self cleaning is affected with each turn of the apron.
- The condenser apron used is absolutely maintenance free and has a long life.
- Apron has favourable geometry & flexibility, so
    i. It has self cleaning property
    ii. Maintenance free
    iii. Long life of apron.

2.2.3.2 Disadvantages of Air Com Tex:

- Condensing is effective only for small widths.
- Hence roving traverse is restricted to minimum level.
- It cannot be easily retrofitted.

2.2.4 Lakshmi RoCoS:

2.2.4.1 The Principle:

Hans Stahlecker of Rotor Craft (www.oe-rotocraft.com) has developed a Mechanical Compact Spinning System using magnetic condensor and Lakshmi Machine Works in collaboration with them has started manufacturing and marketing it.

Compact Yarn is produced by compacting the strand of fibre in a condensing zone - arranged after the drafting system - to such a degree so as not to allow the formation of a spinning triangle while twisting the strand of fibres into yarn. The undesirable yarn hairiness and the reduction of yarn strength resulting there from are thus avoided.

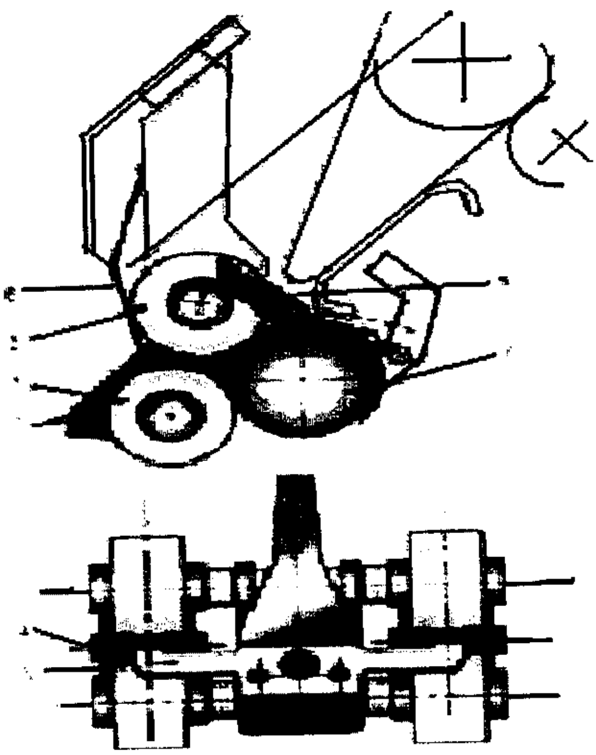


Fig.7. Lakshmi Rocos

Until now, the condensing of the strand of fibres is brought about by air suction. The power required to produce this suction is substantial, the pneumatic compacting devices are expensive, and may require elaborate maintenance.

RoCoS, the Rotorcraft Compact Spinning System, works without air suction and uses magnetic mechanical principles only. The bottom roller 1 supports the front roller 2 and delivery roller 3. The condensing zone extends from clamping line A to clamping line B.

The very precise magnetic compactor 4 is pressed by permanent magnets without clearance against cylinder 1. It forms together with the bottom roller an overall enclosed compression chamber whose bottom contour, the generated surface of cylinder 1, moves synchronously with the strand of fibres and transports this safely through the compactor.

RoCoS 1 is suitable for cotton, pure and as blends with synthetic fibres, as well as for pure synthetics with a maximum staple length of 60 mm (2 1/2 ").

On the other hand RoCoS 2 is suitable for wool, pure and as blends with synthetic fibres as well as for pure synthetics, having a minimum staple length of 50 mm (2").

In respect of yarn fineness and yarn twist, the standards usual in the industry are applicable. Compactors for coarse, medium and fine count yarns ensure ideal compacting.

The RoCoS device consists of cylinder 1, front roller 2, and delivery roller 3, the precision-ground and with Supra-Magnets equipped ceramic compactors 4, the supporting bridge 5, the yarn guides 6 and the top roller holders 7 with the weighting spring 8.

2.2.4.2 The Design:

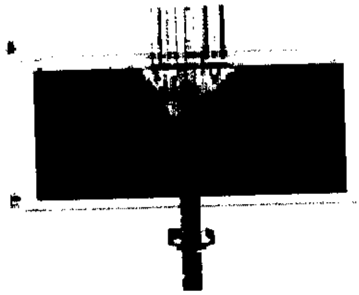


Fig.8.Rocos – Drafting Zone

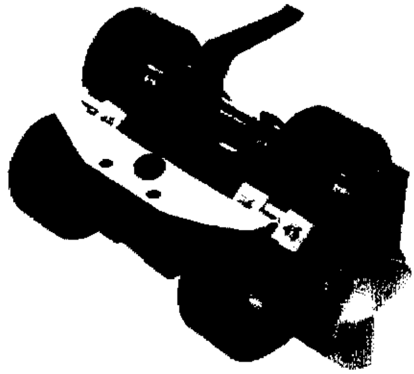


Fig.9.Magnetic compactor

Maintenance and operating instructions for high-drafting systems as common in the industry today is equally applicable for RoCoS. RoCoS does not require an investment in new spinning machines. The newly developed Compact Drafting System is available as a draft zone retrofit to most of today's ring spinning equipment.

2.2.4.3 Advantages of RoCoS Spinning:

- No air required
- No perforated aprons or drums required
- No new machine required and retrofitting is easy. Low operating cost.
- No additional power required, hence saving money (Rs.1.35 to Rs.5 per kg of yarn)
- Higher productivity by optimizing twist insertion and low ends down
- Low pneumafil waste (by 0.3 to 0.6%)
- For fine counts, strength can be increased in the order of 10%

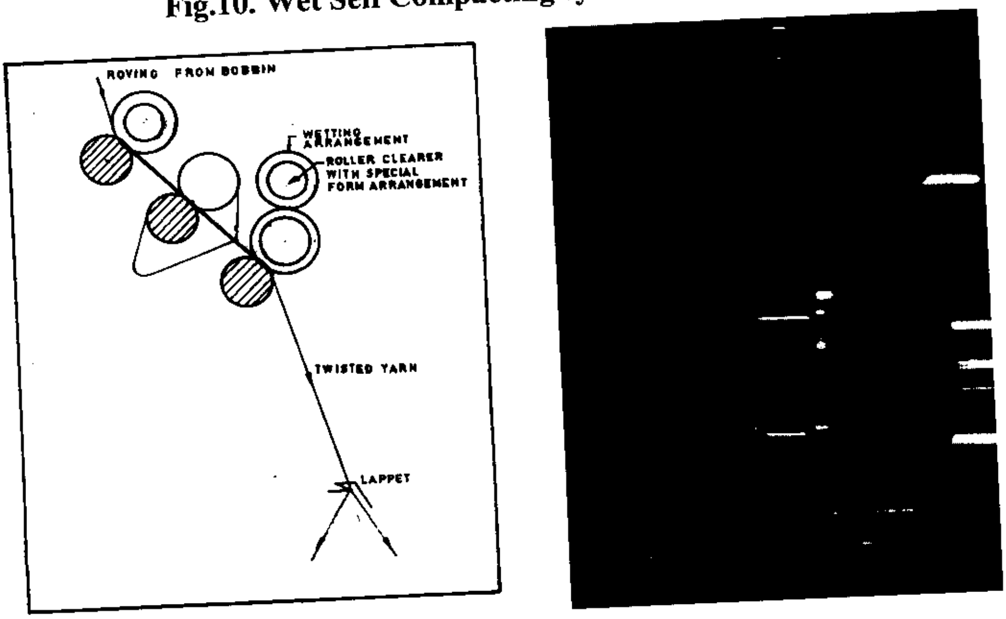
2.2.4.4 Disadvantages of RoCoS Spinning :

- In coarse count 15-18 % and in fine count 10% increase in strength and elongation.
- No roving traverse motion attached causing reduction in cot's life.

2.2.5 Functioning of Wet Self Compacting System Developed Earlier:

Aravindhan et al has designed and developed a Wet Self Compacting System in their under graduate project as shown in Fig.10.

Fig.10. Wet Self Compacting system developed earlier



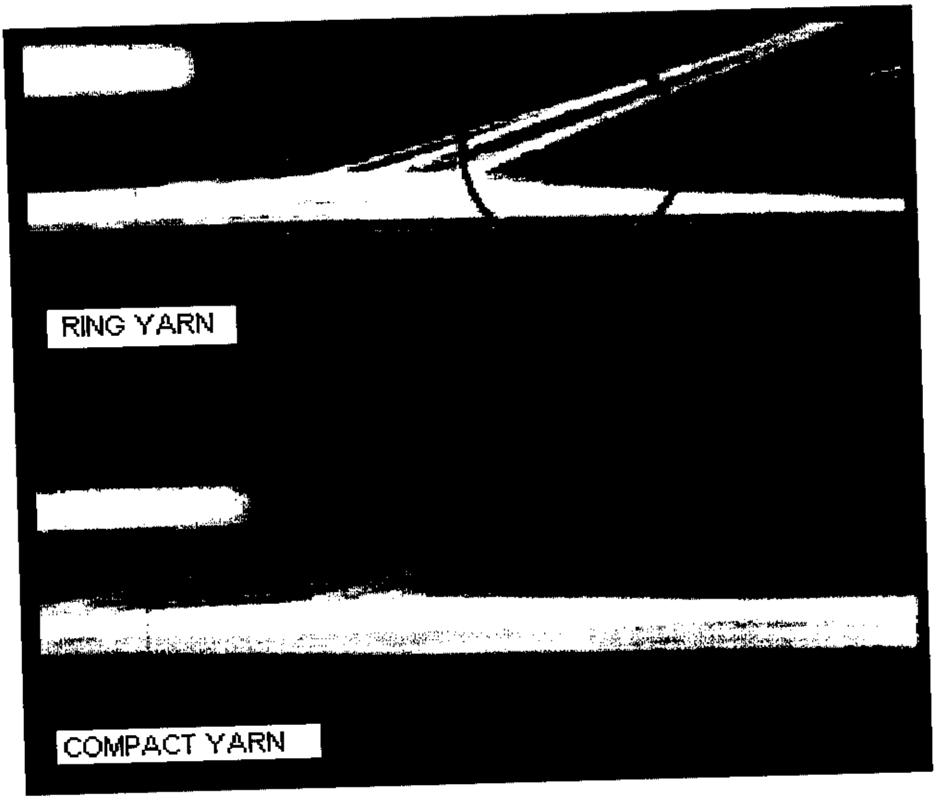
- In this system wetting of drafted fibre strand, that is emerging out of front roller, is carried out through a water dripping flow control system on to the front top roller as given in the figure.
- This experiment revealed that, there is significant reduction (90 -94%) in long and short fibres along with increase in strength (2 -5%) and density (18 - 27%).
- However, there is high increase in imperfections (more than 100%) due to the disturbances created in the drafting field in the process of wetting.
- This has necessitated us to take up design modification project so as to overcome the above deficiency.

2.3 Advantages of compact yarn:

Ishtiaque et al has summarized the following advantages of compact yarn. The special yarn structure of compact yarns enables both economic and qualitative benefits and these are as follows:

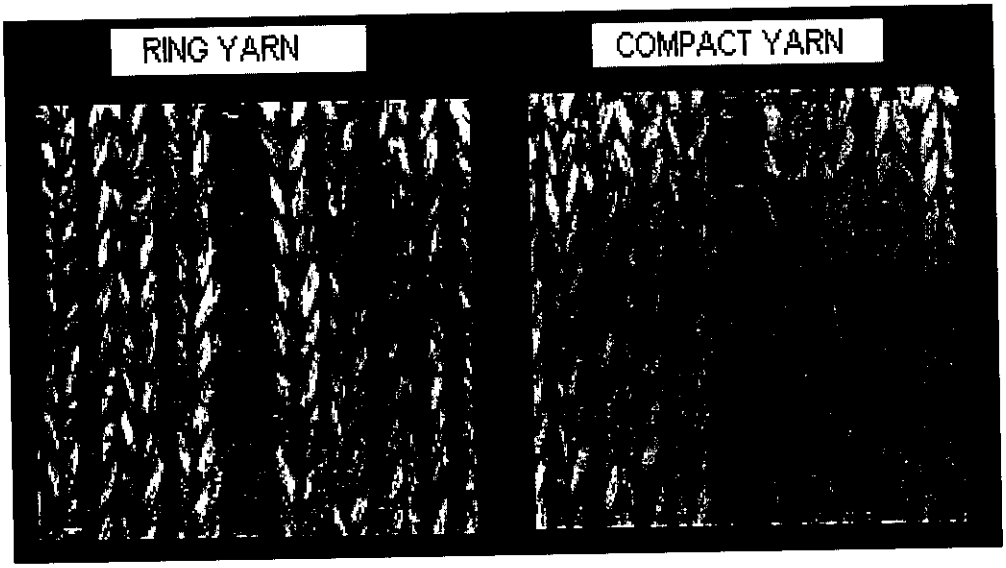
- Higher efficiency in weaving preparation and on the weaving .

Fig.11.End use of Compact yarn in Weaving



- Reduced clinging of warp threads (Fig.11)
- Reduced application of size
- Fewer ends down
- Less abrasion
- More attractive final fabric appearance (Fig.12)
- Higher tenacity with same twist factor, or same tenacity with reduced twist factor for higher production
- Lowest hairiness (highest reduction in hairs longer than 3 mm)
- Fewer weak points.
- Higher abrasion resistance
- Intensive dye penetration.

Fig.12.End use of Compact yarn in Knitting



2.4 Inferences from Literature Review:

The commercially above available systems are complex, costlier and only few are retrofittable (Elite and RoCos). Hence the Indian mills cannot afford for such system. Towards finding an alternative, cost effective system, a WSC System was developed through a earlier batch under graduate project. But there is a draw back in the performance of yarn produced from that system in respect of yarn imperfections and breaking elongation. As the gain in respect of hairiness and strength being very good, it was felt that positive potential could be exploited if the negative aspects are all rectified through modifications in the system design. This has driven us to take up the project on 'Design and Development of improved WSC System'.

CHAPTER 3

AIM AND SCOPE

The following are the aim and scope of this project work:

- To design and develop an improved Wet Self Compacting system as retrofit in the lab model Ring Frame.
- To study its performance in the production of 100% cotton compact yarn of coarse carded (20s & 30s) and medium combed count (40s).
- To assess the performance in terms of changes in the following yarn characteristics:
    - ➢ Evenness
    - ➢ Imperfections
    - ➢ Uster hairiness index
    - ➢ Zweigle hairiness frequency
    - ➢ Zweigle hairiness index
    - ➢ Single thread tenacity
    - ➢ Breaking elongation
    - ➢ Overall yarn packing density.

CHAPTER 4

MATERIALS AND METHODS

4.1 DESIGN AND DEVELOPMENT OF WET SELF COMPACTING (WSC) SYSTEM :

- In this, wetting of drafted strand through suitable mechanism is done to create coherence among the fiber resulting in self compacting.
- Wetting reduces flexural rigidity of fibers (by 5 times), improve its suppleness and well binding of it in twisting actions.
- This results in hair free super compact yarn.

4.1.1 Design concepts:

- In this design, the problem of increased imperfection in the earlier design is overcome by deciding to shift the wetting subsequent to the main drafting.
- This is done by locating additional pair of delivery roller (15 mm Φ bottom flutted roller, 20 mm Φ top rubber roller) in front of existing front roller at a distance slightly more than span length (32 mm) and arranging the wetting of newly introduced delivery roller through controlled water dripping arrangement as shown in the Fig.13 (a) and (b).

4.1.2 Method adopted for assessment of performance:

- This attachment developed is fitted into the lab model computerized ring spinning machine.

Fig.13.(a). Improved Wet Self Compacting system

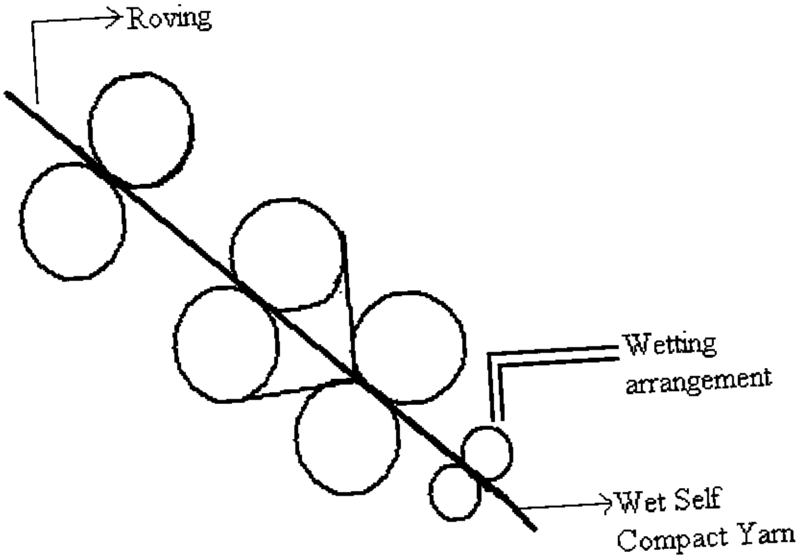
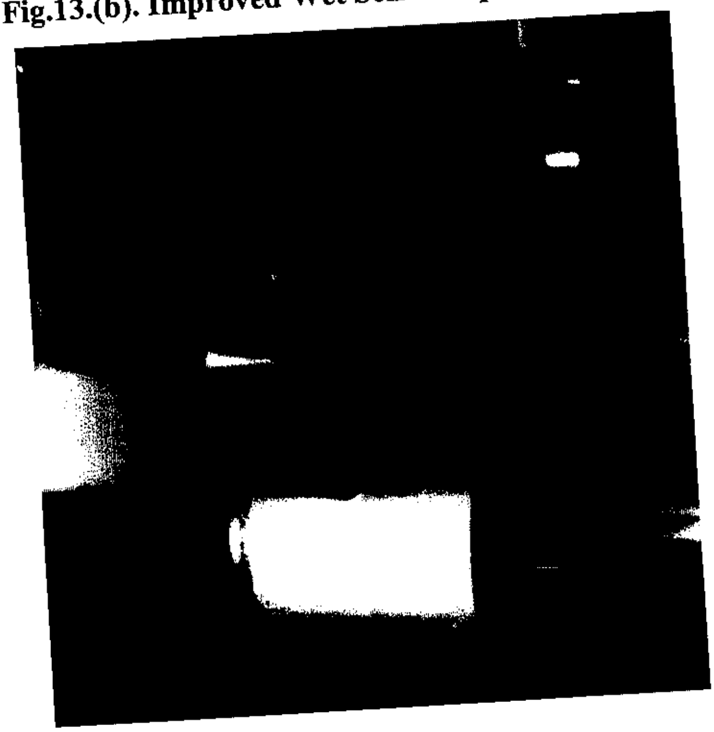


Fig.13.(b). Improved Wet Self Compacting system



- The system performance is assessed through spinning trials carried out on [illegible]d/combed 100% cotton counts.

4.2 MATERIALS USED:

For assessing the performance of this system, 100% cotton counts namely, 20s carded warp, 30s carded warp and 40s combed warp were selected. Rovings are procured from standard mills.

4.2.1 Properties of Materials (Cotton Mixing) Used for 20s, 30s Carded and 40s Combed Count:

The properties of cotton mixing used to produce 20s, 30s Carded and 40s Combed Count are given in table 1, 2, 3 respectively.

Table.1 Materials used for Ne 20 Carded

Varieties	% Of Mixing	2.5% Span Length (mm)	50% Span Length (mm)	Bundle Strength (g/tex)	Mic. Value	U %
Sankar-6	100	28.98	13.93	21.76	3.86	48.06

Table.2 Materials used for Ne 30 Carded

Varieties	% Of Mixing	2.5% Span Length (mm)	50% Span Length (mm)	Bundle Strength (g/tex)	Mic. Value	U %
NHH44	100	26.3	13.5	18.5	4.1	51.3

Table.3 Materials used for Ne 40 Combed

Varieties	% Of Mixing	2.5% Span Length (mm)	50% Span Length (mm)	Bundle Strength (g/tex)	Mic. Value	U %
Sankar4	32	27.6	13.9	20	3.8	50.36
Sankar6	17	29.5	14.8	21.5	3.9	50.16
Brama Ponni	33	30.2	15.4	21.9	3.8	50.99
Brama Ponni (Premier)	13	30.5	15.6	22.2	4.3	51.1
H4	5	28.5	14.3	20.7	3.5	50.17
Average		**29.2**	**14.8**	**21.2**	**3.86**	**50.6**

4.3 PROCESS SPECIFICATIONS:

The WSC System designed and developed are fitted in the lab model computerized ring frame and its performance is assessed in the production of 100% cotton counts namely, 20s carded, 30s carded and 40s combed. The details of ring frame process parameters are given in Table.4. Identical spindle and process parameters are maintained for the production of normal ring and compact yarn.

Table.4 Process specifications

Parameters	100% Cotton Yarn Counts		
	Ne 20 K	Ne 30 K	Ne 40 C
Spindle Speed (rpm)	13500	15000	16000
Twist Multiplier TM	4.7	4.4	4.2
Hank Feed	1.3	1.2	1.4
Ring Traveler No	2/0	5/0	7/0
Break Draft	1.14	1.15	1.15

4.4 YARN TESTING:

This section deals with testing methods and sample size used in this research work

4.4.1Yarn Characteristic Test:

The characteristic of yarn studied are Evenness, Imperfection, Uster hairiness index and Zweigle hairiness frequency and its index, Tenacity, Breaking elongation and Overall yarn density systems was investigated by using the image analysis method. Table 5 furnishes the details on yarn characteristic test carried out, test method followed along with instrument tested sample size and number of test carried out.

4.4.2 Hairiness Testing of Yarn:

The two leading manufacturer of yarn testing equipment namely, Uster and Zweigle provides data on hairiness of yarn. The Uster gives the total length of protruding fibers in cm per cm of yarn. The Zweigle provides length wise frequency of hairs and overall Index. As the long hairs are only creating problems in the downstream process, there is a need to measure frequency of hair having 3mm or more length, which is designated as S3 values by Zweigle. The hairiness tester of Zweigle, measure and provide lengthwise distribution of hairs and overall hairiness Index. Suessen through their information bulletin explained the importance of having complete distribution of the different lengths of hairs.

4.4.3 Uster Hairiness Index – H:

It is defined as total length of all the hairs (measured in centimeters) within one centimeter of yarn. The hairiness value given by the tester at the end of the test is the average and standard deviation of all these values measured, that is, if 400m yarn is tested, it is the average and standard deviation of 40,000 individual values.

4.4.4 Zweigle Hairiness Tester- G566:

Zweigle Hairiness Tester gives separately the number of hairs of different length, starting from 1 to 25mm and the total number of long hairs having length 3mm or more and also the overall hairiness index for the measured length, generally of 100 meters. It also provides SD and C.V. % of the above for the measured readings.

Table 5 - Details on Yarn Characteristic Test					
Sr. No	**Yarn characteristic tested**	**Instrument used**	**Test Method /Procedure**	**Sample Size**	**Number of Test carried out**
1	Yarn Evenness, Imperfection and Hairiness Index – H(cm/cm)	Uster- UT3	ASTM D 1425-96 (at 400m/min for 1min)	10 Cops	1test/cop Total Test = 10
2	Single Thread Tenacity & breaking elongation	Uster-Tenso-rapid 3	Uster Standard Method – CRE- at 5m/min	10 Cops	20 test/cop, Total Test =200
3	Hairiness Frequency and Index (Zweigle)	Zweigle - G566	ASTM D 5647-01 (at 100 m/min 1min)	10 Cops	1test/cop Total Test = 10
4	Yarn Diameter & Overall Density	Uster- UT4-OM Module	Uster Std Method (at 400m/min for 1min)	10 cops	1Test/Cop Total= 10 Cops

(Note:- All the yarn testing were done at standard atmospheric conditions - 27° C± 2 and 65 % RH ± 2)

4.4.5 Uster Tester UT4- OM Module

The yarn diameter and yarn densities are measured using Uster Tester UT4-OM Module. This OM Module of Uster UT4 equipment is working on the photo cell principle measures yarn diameter at two different angles with 90° difference and provide the mean for the yarn's entire test length.

CHAPTER5

RESULTS AND DISCUSSIONS

The WSC System yarn characteristics test results of 20s K, 30s K and 40s C are given alongwith the regular ring spun yarn in the following tables 6 to 14. The results are discussed characteristicwise in the following section using charts.

Table 6-Yarn Evenness Test Results-Ne 20 Carded

S.No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Irregularity C.V.m%**			
	Mean (#)	16.85	17.95*	+6.5
	CV_b%	2.5	2.59	+3.6
	T_{Act}(table $T_{95\%}$=2.101)	7.45		
2	**Thin (-50%)/km**			
	Mean (#)	18.5	22.2	+20
	CV_b%	63.4	64.8	+2.21
	T_{Act} (table $T_{95\%}$=2. 101)	0.63		
3	**Thick (+50%)/km**			
	Mean (#)	370.3	444	+19.9
	CV_b%	19	19.5	+2.63
	T_{Act} (table $T_{95\%}$=2. 101)	2.08		
4	**Neps (+200%)/km**			
	Mean (#)	452.3	542*	+19.83
	CV_b%	17.3	18.2	+5.2
	T_{Act} (table $T_{95\%}$=2. 101)	6.72		
5	**Total Imperfections/km**	841.1	1008.2	+19.87

Code Used:- Reg.Ring= Regular Ring ; WSC – Wet self Compacting.

Note:-T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates

Table 7 -Yarn Evenness Test Results-Ne 30 Carded

S.No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Irregularity C.V.m%**			
	Mean (#)	16.53	16.61	+0.48
	CV_b%	3.1	3.2	+3.23
	T_{Act}(table $T_{95\%}$=2.101)	0.34		
2	**Thin (-50%)/km**			
	Mean (#)	29	34.8	+20
	CV_b%	50.3	50.5	+0.4
	T_{Act} (table $T_{95\%}$=2. 101)	0.8		
3	**Thick (+50%)/km**			
	Mean (#)	385	462.2*	+20.36
	CV_b%	18.9	19.2	+15.9
	T_{Act} (table $T_{95\%}$=2. 101)	2.114		
4	**Neps (+200%)/km**			
	Mean (#)	388	465.6*	+20
	CV_b%	11	12	+9.09
	T_{Act} (table $T_{95\%}$=2. 101)	3.469		
5	**Total Imperfections/km**	802	962.6	+20.02

Code Used:- Reg.Ring= Regular Ring ; WSC – Wet self Compacting.

Note:-T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates statistical significant difference at 95% confidence level when TAct >T95%

Table.8 -Yarn Evenness Test Results-Ne 40 Combed

S.No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Irregularity C.V.m%**			
	Mean (#)	13.98	14.05	+0.5
	CV_b%	2.7	2.8	+3.7
	T_{Act}(table $T_{95\%}$=2.101)	0.398		
2	**Thin (-50%)/km**			
	Mean (#)	6.5	6.8	+4.62
	CV_b%	65.9	66.2	+0.46
	T_{Act} (table $T_{95\%}$=2. 101)	0.15		
3	**Thick (+50%)/km**			
	Mean (#)	73.8	82.1	+11.25
	CV_b%	24.6	25.2	+2.44
	T_{Act} (table $T_{95\%}$=2. 101)	0.95		
4	**Neps (+200%)/km**			
	Mean (#)	75.8	89.4*	+17.94
	CV_b%	24.1	24.8	+2.9
	T_{Act} (table $T_{95\%}$=2. 101)	1.49		
5	**Total Imperfections/km**	156.1	178.3	+14.22

Code Used:- Reg.Ring= Regular Ring ; WSC – Wet self Compacting.

Note:-T Act=Calculated ‘t’ value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates statistical significant difference at 95% confidence level when TAct >T95%

Table 9-Uster & Zweigle Hairiness Test Results-Ne 20 Carded

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
	Zweigle Hairiness Test			
1	**Hairiness Frequency 1mm(per100m)**			
	Mean (#)	20870.3	5156*	-75.29
	CV_b%	15.44	56.4	+265.28
	T_{Act} (table $T_{95\%}$=2. 101)	11.38		
2	**HairinessFrequency2mm(per100m)**			
	Mean (#)	1153.7	368*	-68.1
	CV_b%	11.9	66.3	+457.14
	T_{Act} (table $T_{95\%}$=2. 101)	8.82		
3	**Hairiness Frequency-S3(per 100m)**			
	Mean (#)	3815.7	223*	-94.16
	CV_b%	28.05	78.4	+179.5
	T_{Act} (table $T_{95\%}$=2. 101)	10.41		
4	**Zweigle Hairiness Index**			
	Mean (#)	264.5	9.8*	-96.29
	CV_b%	14.47	87	+501.24
	T_{Act} (table $T_{95\%}$=2. 101)	20.91		
5	**Hairiness Index(H) cm/cm**			
	Mean (#)	6.99	4.09*	-41.49
	CV_b%	4.9	16.1	+228.57
	T_{Act} (table $T_{95\%}$=2. 101)	12.39		
Code Used:- Reg.Ring= Regular Ring; roller; WSC-Wet Self Compacting system				
Note:- T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates [illegible]				

Table 10-Uster & Zweigle Hairiness Test Results-Ne 30 Carded

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
	Zweigle Hairiness Test			
1	**Hairiness Frequency 1mm(per100m)**			
	Mean (#)	15105.1	5472*	-63.77
	CV_b%	7.4	42.3	+471.62
	T_{Act} (table $T_{95\%}$=2. 101)		11.78	
2	**HairinessFrequency2mm(per100m)**			
	Mean (#)	1086.8	414*	-61.91
	CV_b%	5.22	63.1	+1108.81
	T_{Act} (table $T_{95\%}$=2. 101)		7.91	
3	**Hairiness Frequency-S3(per 100m)**			
	Mean (#)	3343.6	226*	-93.24
	CV_b%	17.15	141.6	+725.66
	T_{Act} (table $T_{95\%}$=2. 101)		14.92	
4	**Zweigle Hairiness Index**			
	Mean (#)	374.1	10.8*	-97.11
	CV_b%	11.64	189.5	+1528.01
	T_{Act} (table $T_{95\%}$=2. 101)		23.72	
5	**Hairiness Index(H) cm/cm**			
	Mean (#)	6.11	3.86*	-36.82
	CV_b%	3.5	11.3	+222.86
	T_{Act} (table $T_{95\%}$=2. 101)		14.71	

Code Used:- Reg.Ring= Regular Ring; roller; WSC-Wet Self Compacting system

Note:- T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates

Table 11 -Uster & Zweigle Hairiness Test Results-Ne 40 Combed

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
	Zweigle Hairiness Test			
1	**Hairiness Frequency 1mm(per100m)**			
	Mean (#)	8093	2723*	-66.35
	CV_b%	11.26	33.2	+194.85
	T_{Act} (table $T_{95\%}$=2. 101)	13.15		
2	**HairinessFrequency2mm(per100m)**			
	Mean (#)	731	197*	-73.05
	CV_b%	10.64	58.33	+448.21
	T_{Act} (table $T_{95\%}$=2. 101)	12.09		
3	**Hairiness Frequency-S3(per 100m)**			
	Mean (#)	954.6	53*	-94.45
	CV_b%	35.86	121.1	+237.7
	T_{Act} (table $T_{95\%}$=2. 101)	8.14		
4	**Zweigle Hairiness Index**			
	Mean (#)	81.6	0*	-100
	CV_b%	53.24	0	-100
	T_{Act} (table $T_{95\%}$=2. 101)	5.9		
5	**Hairiness Index(H) cm/cm**			
	Mean (#)	4.52	2.92*	-35.39
	CV_b%	1.7	16	+841.18
	T_{Act} (table $T_{95\%}$=2. 101)	10.46		

Code Used:- Reg.Ring =Regular Ring; roller; WSC-Wet Self Compacting system

Note:- T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates

Table 12 -Yarn Tensile and Yarn Density Results-Ne 20 carded

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Single Thread Tenacity-Rkm(gf/tex)**			
	Mean (#)	16.48	19.03*	+15.47
	CV_b%	9.93	12.2	+22.86
	T_{Act} (table $T_{95\%}$=1.96)	12.75		
2	**Breaking Elongation %**			
	Mean (#)	6.51	4.13*	-36.56
	CV_b%	6.27	11.7	+86.6
	T_{Act} (table $T_{95\%}$=1.96)	59.50		
3	**Yarn Diameter-(UT4-OM) mm**			
	Mean (#)	0.304	0.253	-16.78
4	**Overall Yarn Density-(g/cm3)**			
	Mean (#)	0.41	0.59*	+43.9
	CV_b%	4	5.8	+45
	T_{Act} (table $T_{95\%}$=2.101)	13.33		

Code Used:- Reg.Ring= Regular Ring; WSC-Wet Self Compacting system

Note:-T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates statistical significant difference at 95% confidence level when TAct >T95%

Table 13 -Yarn Tensile and Yarn Density Results -Ne 30 Carded

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Single Thread Tenacity-Rkm(gf/tex)**			
	Mean (#)	14.63	17.38*	+18.79
	CV_b%	9.51	15.7	+65.05
	T_{Act} (table $T_{95\%}$=1.96)		13.1	
2	**Breaking Elongation %**			
	Mean (#)	5.29	2.86*	-49.94
	CV_b%	6.5	13.9	+113.85
	T_{Act} (table $T_{95\%}$=1.96)		60.75	
3	**Yarn Diameter-(UT4-OM) mm**			
	Mean (#)	0.231	0.199	-13.85
4	**Overall Yarn Density-(g/cm3)**			
	Mean (#)	0.47	0.63*	+34.04
	CV_b%	1.6	8.9	+456.25
	T_{Act} (table $T_{95\%}$=2.101)		8.89	

Code Used:- Reg.Ring= Regular Ring; WSC-Wet Self Compacting system

Note:-T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates statistical significant difference at 95% confidence level when TAct >T95%

Table 14-Yarn Tensile and Yarn Density Results -Ne 40 Combed

S. No.	Characteristics	Reg. Ring	Improved WSC	% Difference (+/-)
1	**Single Thread Tenacity-Rkm(gf/tex)**			
	Mean (#)	16.95	20.14*	+18.82
	CV_b%	9	13.5	+50
	T_{Act} (table $T_{95\%}$=1.96)		14.5	
2	**Breaking Elongation %**			
	Mean (#)	5.12	3.23*	-36.91
	CV_b%	8.6	13.8	+60.47
	T_{Act} (table $T_{95\%}$=1.96)		47.25	
3	**Yarn Diameter-(UT4-OM) mm**			
	Mean (#)	0.194	0.171	-11.86
4	**Overall Yarn Density-(g/cm3)**			
	Mean (#)	0.5	0.64*	+28
	CV_b%	1.5	3.5	+133.33
	T_{Act} (table $T_{95\%}$=2.101)		15.56	
Code Used:- Reg.Ring= Regular Ring; WSC-Wet Self Compacting system				
Note:-T Act=Calculated 't' value for the actual values of Mean and S.D found from the study; T 95%=t- table value at 95% confidence level; *-indicates statistical significant difference at 95% confidence level when TAct >T95%				

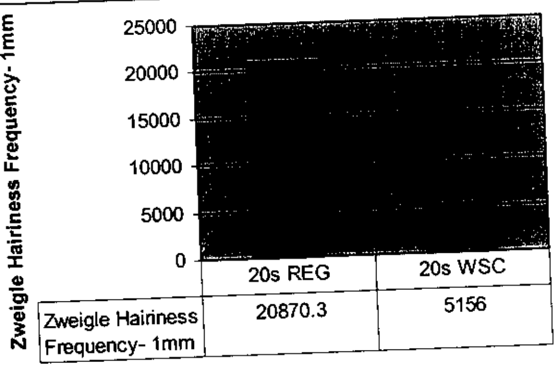
5.1 Effect of WSC System on Zweigle hairiness frequency(1mm,2mm & S3 value) :

The fig. 14 to 16 shows the comparative value of Zweigle hairiness frequency 1mm, 2mm, and S3 value(3mm) for 20s K , 30s K, 40s C from WSC System & Regular Ring System and their relative change in terms of percentage.

- The WSC system has shown 75.29% , 63.77%, and 66.35% reduction of 1mm compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively

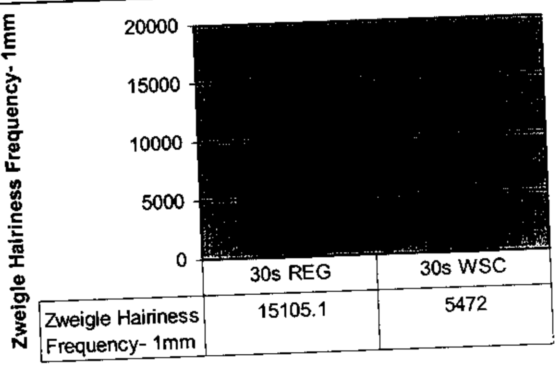
- The WSC system has shown 68.10%, 61.91% and 73.05% reduction of 2mm compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively

- The WSC system has shown 94.16%, 93.24% and 94.45% reduction of S3 value compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively



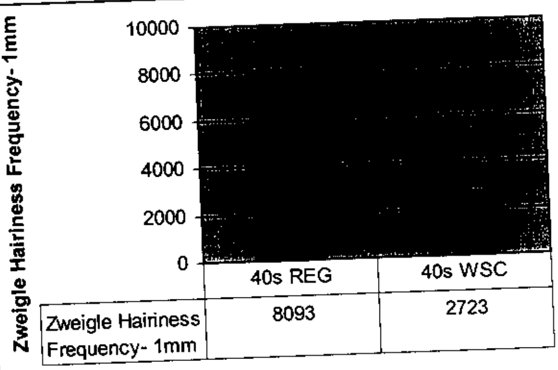
	20s REG	20s WSC
Zweigle Hairiness Frequency- 1mm	20870.3	5156

20s WSC < 20s REG 75.29%



	30s REG	30s WSC
Zweigle Hairiness Frequency- 1mm	15105.1	5472

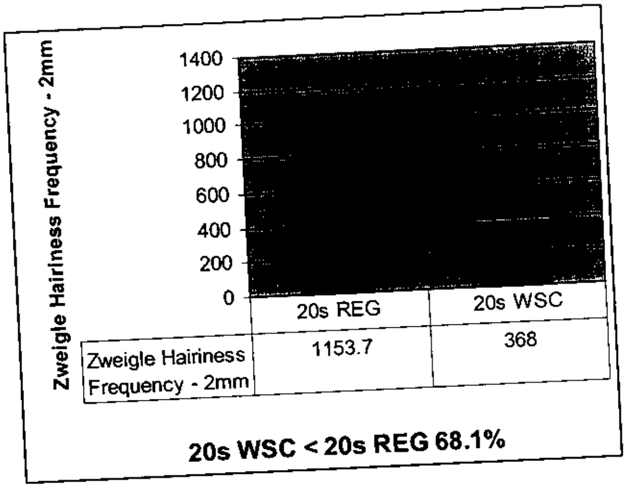
30s WSC < 30s REG 63.77%

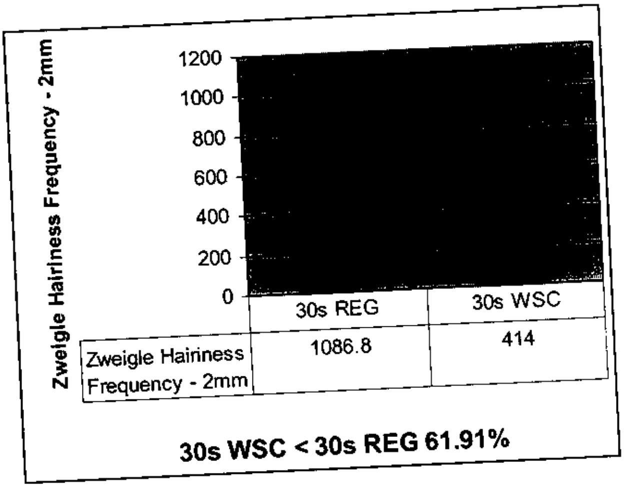


	40s REG	40s WSC
Zweigle Hairiness Frequency- 1mm	8093	2723

40s WSC < 40s REG 66.35%

Fig.14 Zweigle Hairiness frequency- 1mm of 20s K, 30s K, 40s C





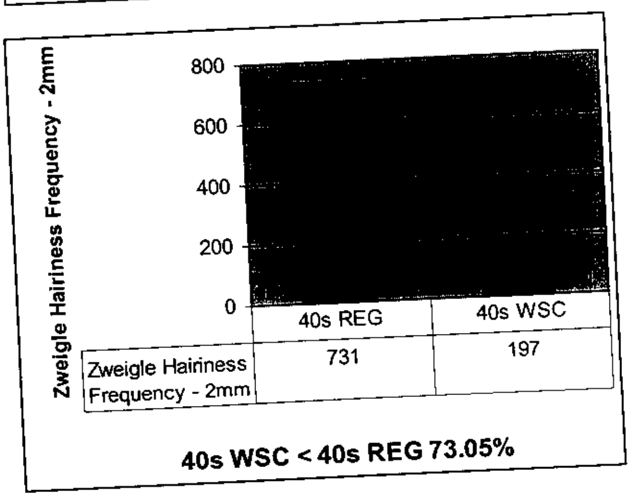
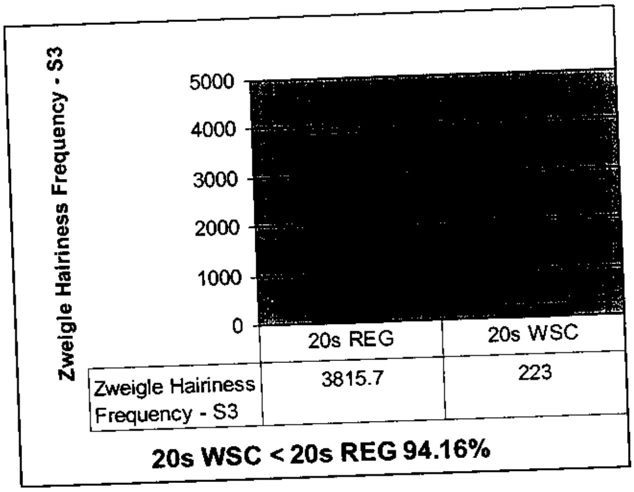
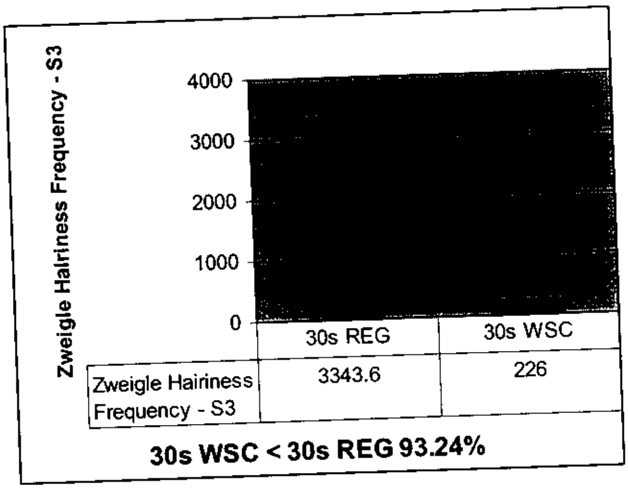


Fig.15 Zweigle Hairiness frequency- 2mm of 20s K, 30s K, 40s C





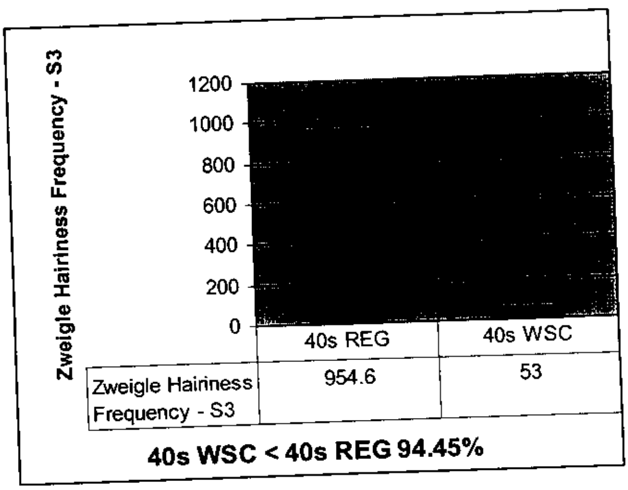


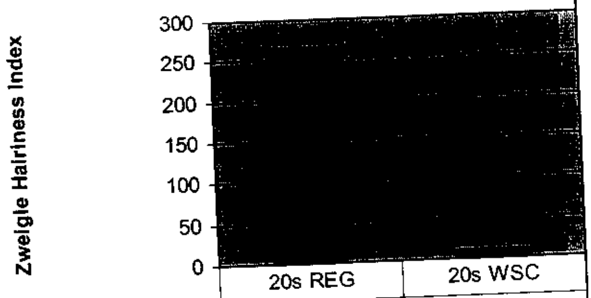
Fig.16 Zweigle Hairiness frequency- S3 of 20s K, 30s K, 40s C

5.2 Effect of WSC System on Zweigle & Uster Hairiness Index:

The fig. 17 & 18 shows the comparative value of Zweigle & Uster hairiness index for 20s K , 30s K, 40s C from WSC System & Regular Ring System and their relative change in terms of percentage.

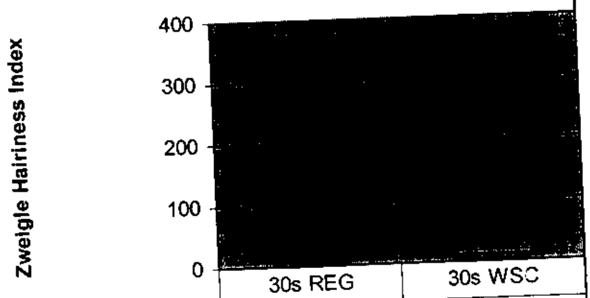
- The WSC system has shown 96.29%, 97.11% and 100% reduction in Zweigle Hairiness Index compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively

- The WSC system has shown 41.49%, 36.82% and 35.39% reduction in Uster Hairiness Index compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40sC respectively



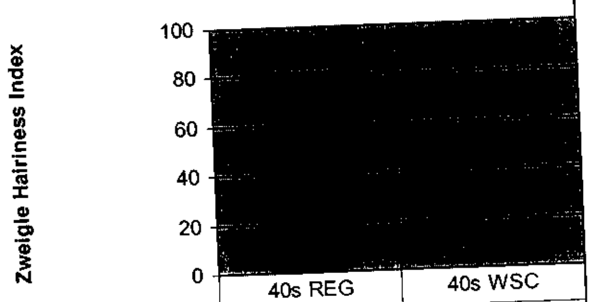
	20s REG	20s WSC
Zweigle Hairiness Index	264.5	9.8

20s WSC < 20s REG 96.29%



	30s REG	30s WSC
Zweigle Hairiness Index	374.1	10.8

30s WSC < 30s REG 97.11%



	40s REG	40s WSC
Zweigle Hairiness Index	81.6	0

40s WSC < 40s REG 100%

Fig.17 Zweigle Hairiness Index of 20s K, 30s K, 40s C

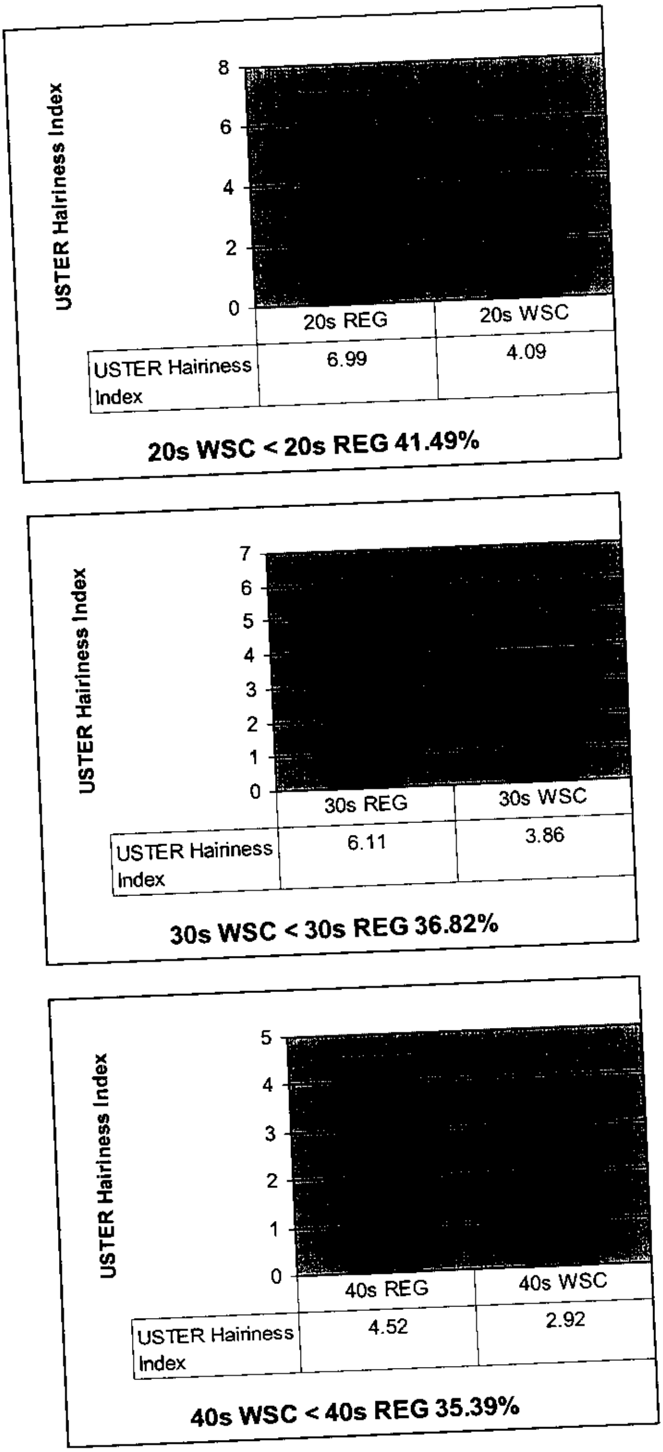


Fig.18 USTER Hairiness Index of 20s K, 30s K, 40s C

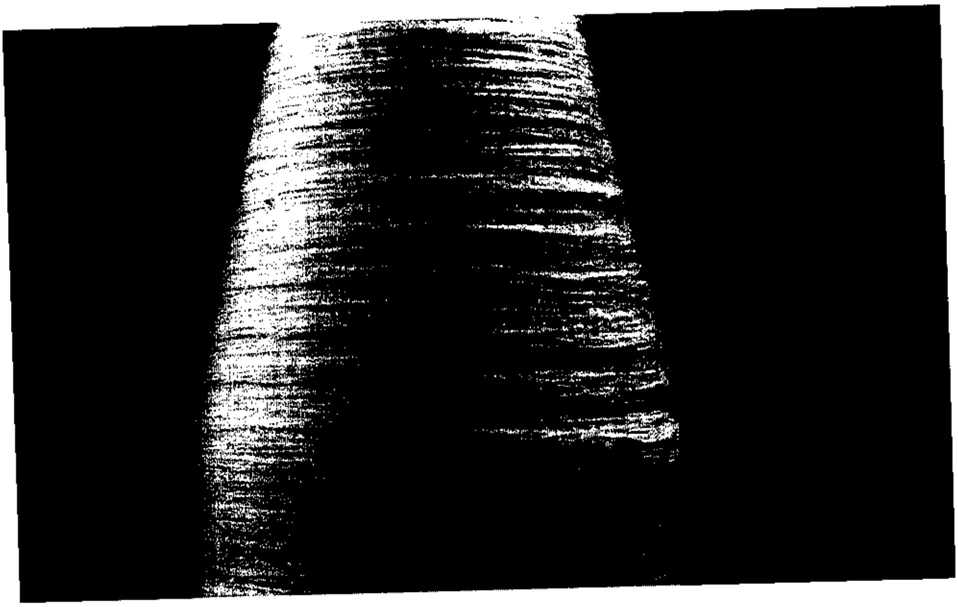


Fig.19 Regular Ring Yarn

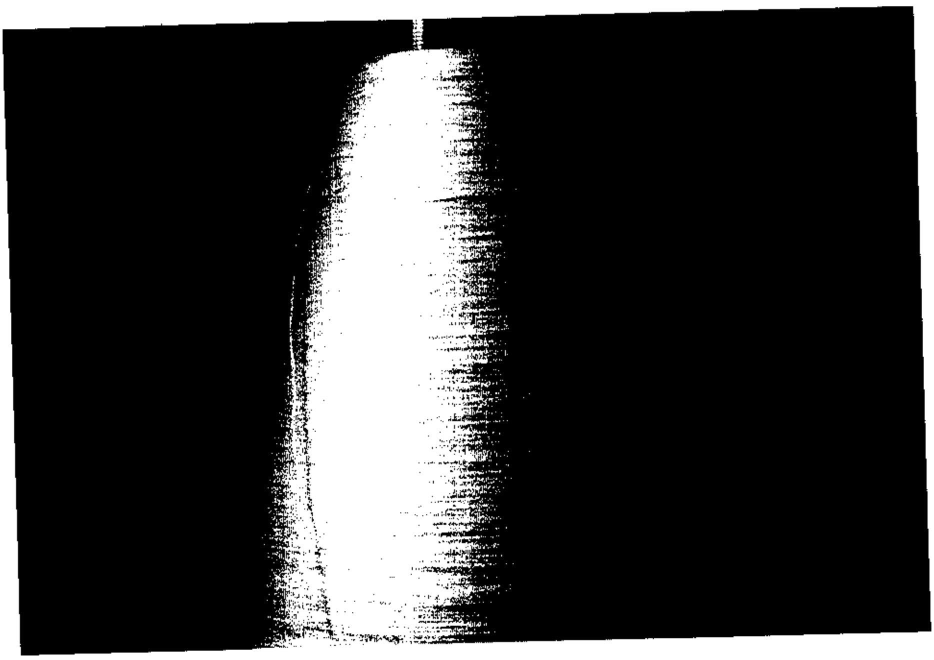


Fig.20 Improved WSC Yarn

The Fig. 19 and 20 shows the photograph of yarn of regular ring and WSC System indicating the significant reduction in hairiness for WSC yarn compared to regular yarn.

5.2.1 The reason for the reduction in hairiness is explained below:

All the above results show there is a phenominal reduction in Hairiness of all length in opting for WSC System of yarn production. The wetting of drafted fibre strand reduces the Flexural rigidity and increases suppleness of fibre so as to get easily integrated into the yarn body resulting in almost hairless yarn. In other words by changing the basic fibre flexural rigidity to significantly lower, facilitating easy binding of fibres into the yarn body. The result obtained is better to one of the first version of WSC System, where the wetting is done on the front roller.

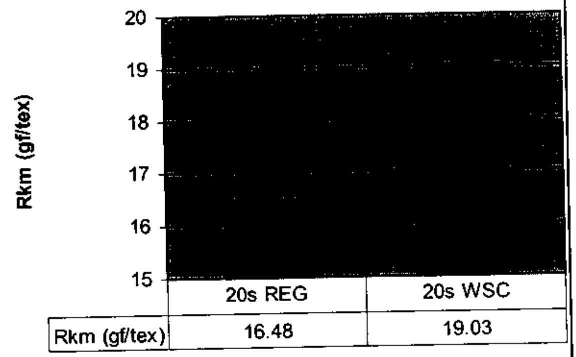
5.3 Effect of WSC System on Single Thread Tenacity, Breaking Elongation and Overall Yarn Density :

The fig. 21 to 23 shows the comparative value of Single thread tenacity, Breaking elongation and Overall yarn density for 20s K, 30s K and 40s C cotton yarn from WSC System & Regular ring system and their relative change interms of percentage.

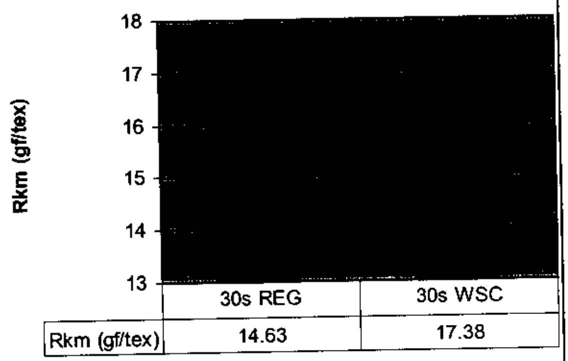
- The WSC system has shown 15.47%, 18.79% and 18.82% increase in Single thread tenacity compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively

- The WSC system has shown 43.9%, 34.04% and 28% increase in Overall yarn density compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively. This has contributed significantly to the increase in yarn strength.

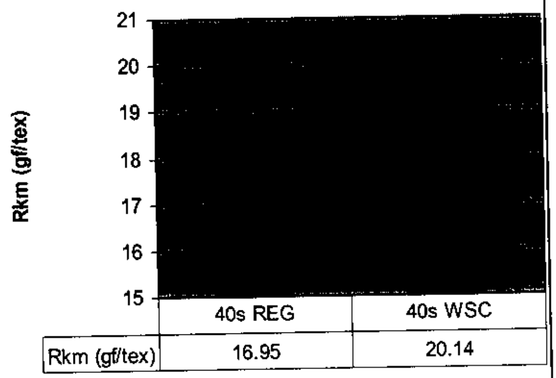
- The WSC system has shown 36.56%, 49.94% and 36.91% reduction in Breaking elongation compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively. But there is an improvement to the tune of 20.97% compared to the earlier WSC design. Through fine tuning in respect of wetting zone draft and setting further improvement could be obtained



20s WSC > 20s REG 15.47%

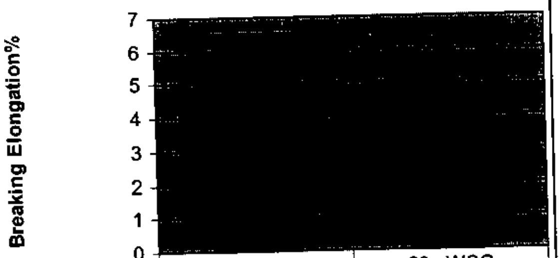


30s WSC > 30s REG 18.79%



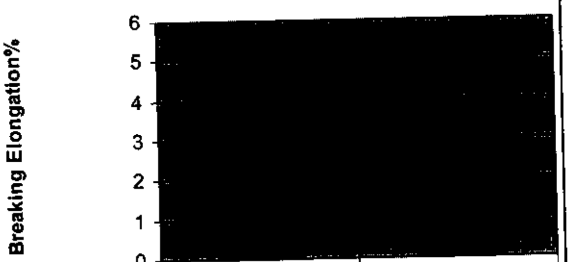
40s WSC > 40s REG 18.82%

Fig.21 Single Thread Tenacity of 20s K, 30s K, 40s C



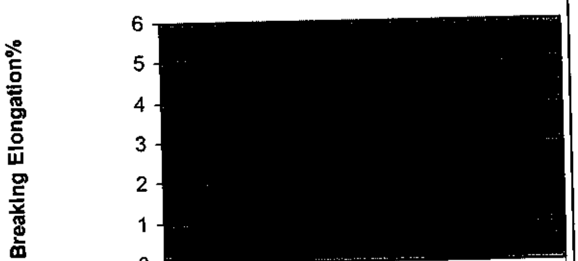
	20s REG	20s WSC
Breaking Elongation%	6.51	4.13

20s WSC < 20s REG 36.56%



	30s REG	30s WSC
Breaking Elongation%	5.29	2.86

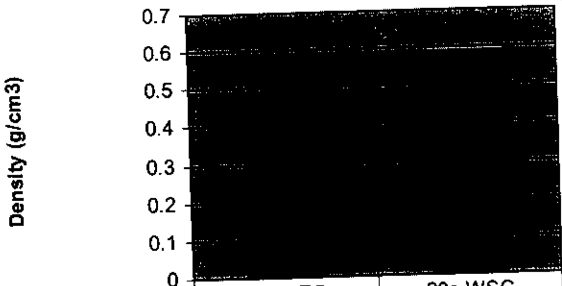
30s WSC < 30s REG 49.94%



	40s REG	40s WSC
Breaking Elongation%	5.12	3.23

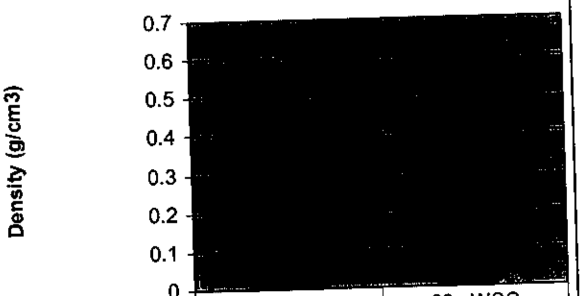
40s WSC < 40s REG 36.91%

Fig.22 Breaking Elongation% of 20s K, 30s K, 40s C



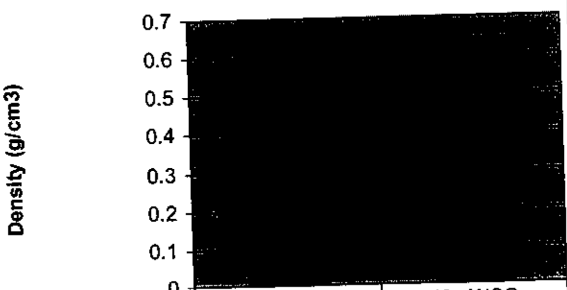
	20s REG	20s WSC
Density (g/cm3)	0.41	0.59

20s WSC > 20s REG 43.9%



	30s REG	30s WSC
Density (g/cm3)	0.47	0.63

30s WSC > 30s REG 34.04%



	40s REG	40s WSC
Density (g/cm3)	0.5	0.64

40s WSC > 40s REG 28%

Fig.23 Overall Yarn Density of 20s K, 30s K, 40s C

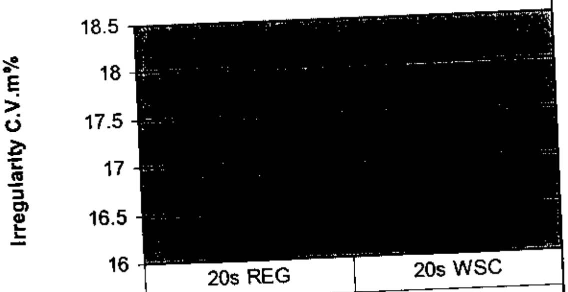
5.4 Effect of WSC System on Yarn Evenness and Total Imperfections :

The fig. 24 and 25 shows the comparative value of yarn evenness and total imperfections for 20s K, 30s K and 40s C cotton yarn from WSC System & Regular ring system and their relative change in terms of percentage.

- ❖ The WSC system has shown 6.5%, 0.48% and 0.5% increase in Yarn Evenness compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively .

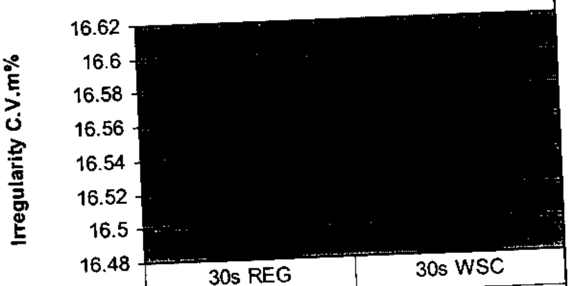
- ❖ The WSC system has shown 19.87%, 20.02% and 14.22% increase in Total Imperfections compared to the Regular Ring Yarn for the counts 20s K, 30s K and 40s C respectively .

- ❖ These results shows that there is a significant reduction in imperfection to the tune of 86.67% in this design of WSC system compared to earlier design. Through fine tuning in respect of wetting zone draft and setting further improvement could be obtained.



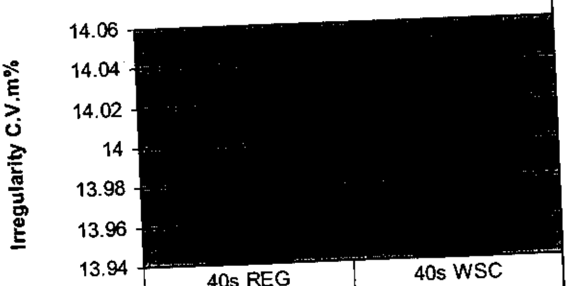
	20s REG	20s WSC
Irregularity C.V.m%	16.85	17.95

20s WSC > 20s REG 6.5%



	30s REG	30s WSC
Irregularity C.V.m%	16.53	16.61

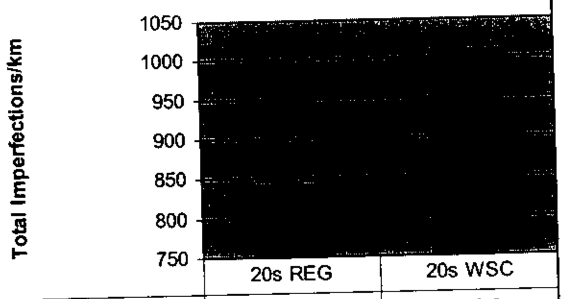
30s WSC > 30s REG 0.48%



	40s REG	40s WSC
Irregularity C.V.m%	13.98	14.05

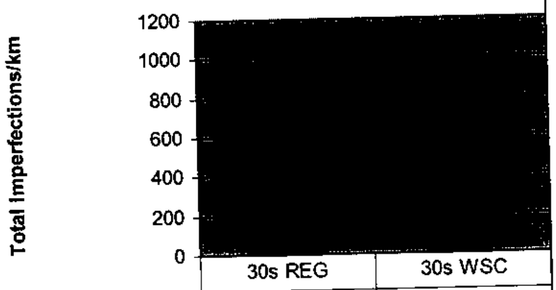
40s WSC > 40s REG 0.5%

Fig.24 Irregularity C.V.m% of 20s K, 30s K, 40s C



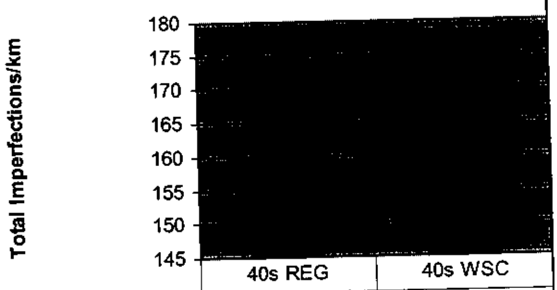
	20s REG	20s WSC
Total Imperfections/km	841.1	1008.2

20s WSC > 20s REG 19.87%



	30s REG	30s WSC
Total Imperfections/km	802	962.6

30s WSC > 30s REG 20.02%



	40s REG	40s WSC
Total Imperfections/km	156.1	178.3

40s WSC > 40s REG 14.22%

Fig.25 Total Imperfections/km of 20s K, 30s K, 40s C

5.4.1 The Reason for the Increase in Strength, Imperfections and Evenness is explained below :

There is a significant increase in packing density contributed to increase in strength and also reduction in elongation. Fine tuning in respect of setting between front roller & delivery roller and through variations in stretch of the floating fibre could be controlled, thereby reducing the increase in imperfections and improving further loss in elongation.

CHAPTER 6

CONCLUSION

The following are the conclusion drawn from the foregone results and discussions:

- There is a phenominal reduction in Zweigle 1mm & 2mm (61 - 75%) and Zweigle S3 value (93 - 95%), Zweigle hairiness index (96 - 100%) and Uster hairiness index (35 - 41%) and appreciable gain in strength (16 - 18%) and packing density (28 - 43%) of WSC yarn compared to Regular ring yarn.

- There is a significant improvement in the WSC design in respect of breaking elongation to the tune of 20.97% and in yarn imperfection to the tune of 86.67% compared to the earlier design of WSC System.

- These improvements shows that WSC system yarn has high potential to be used in the emerging technical textile field.

- To make it commercially successful the system needs fine tuning towards achieving further reduction in imperfection and gain in elongation alongwith provision for roving stop motion.

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