A STUDY ON DIMENSIONAL STABILITY OF LYCRA CORE SPUN SINGLE JERSEY KNITTED FABRICS

A PROJECT REPORT

Submitted by

C.C.MATHUMITHA

M.PRADEEPA

In partial fulfillment for the award of the degree

Of

BACHELOR OF TECHNOLOGY

In

TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE

ANNA UNIVERSITY:: CHENNAI 600 025

APRIL 2005

ANNA UNIVERSITY: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report **"A STUDY ON DIMENSIONAL STABILITY OF LYCRA CORE SPUN SINGLE JERSEY KNITTED FABRICS"** is the bonafide work of **C.C.MATHUMITHA, M.PRADEEPA**, who carried out the project work under my supervision.

SIGNATURE

Dr. V. Natarajan
HEAD OF THE DEPARTMENT
Department of Textile Technology
Kumaraguru College of Technology
Coimbatore-641 006.

SIGNATURE

Prof. K. Thangamani
SUPERVISOR
Asst. Professor
Department of TextileTechnology
Kumaraguru College of Technology
Coimbatore-641 006.

A STUDY ON DIMENSIONAL STABILITY OF LYCRA CORE SPUN SINGLE JERSEY KNITTED FABRICS

This project work has been submitted by

Name :

Registered NO :

For Viva-Voice Examination held on : 20.04.05

Internal Examiner

External Examiner

We convey our deepest sense of gratitude to the correspondent Dr.K.Arumugam and the principal Dr.K.K.Padmanaban, under whose blessings this project has achieved its final shape.

Our wholehearted thanks to Dr.V.Natarajan, Head of the department of Textile Technology for his optimal encouragement and guidance.

We would like to show our gratitude to Prof.K.Thangamani, Department of Textile Technology, who has guided us throughout the project work. We would like to record our sincere thanks to all our staff members of Textile Department.

We are thankful to Shri.Palaniswamy, Managing Director, US Fabrics pvt ltd (Knitmac), Tiruppur, for helping us to heat set our samples.

We are thankful To Shri.Mani, Managing Director, Deepthy Finishers, Tiruppur, for their help in Washing and Tumble Drying of our samples.

One of the main objectives of knitted garments is to provide required stretch and comfort properties to the human body. But the stretch recovery in normal knitted fabrics is not sufficient for certain applications. In order to overcome this problem, lycra the most elastomeric filament with 95% of stretch recovery is used along with cotton as core spun. The purpose of blending cotton with lycra as core spun yarn is to improve the fabric elongation and to provide comfort feel to the wearer. Due to the presence of cotton fibers, which wraps around the core lycra, the itching effect to the body surface by bare lycra is eliminated.

The dimensional changes occur when a fabric is wet out and exposed to steam or when the moisture content of the fiber is altered. This can be determined from the percentage change in wales/inch, courses/inch, loop length and grams per square inch. A direct method of finding the dimensional stability is from the Shape Factor (Kc/Kw).

The fabric samples were produced from polyester lycra and cotton lycra core spun yarn, with 30s & 40s count of cotton lycra, and 170 & 97 denier of polyester lycra respectively. Each sample was run with three different loop lengths for the further analysis of change in fabric parameters with change in loop length.

The fabric is first left for dry relaxation at atmospheric condition, after which the samples are tested for wales/inch, courses/inch, loop length and dimensional stability parameters. Then the fabric was given wet

From the experiments, it is found that when loop length increases, the parameters such as CPI, WPI and Ns varies following a linear equation and the corresponding slopes got from the equations indicates knitted fabric dimensional constants such as Kc, Kw, Ks.

The samples that are fully relaxed are then subjected to shrinkage tests, which is carried out with normal washing and drying, and further analysis on the treated samples reveals that there is zero percentage shrinkage for both the cotton lycra and polyester lycra samples.

Objective:

To study the change of fabric parameters such as WPI, CPI and Ns with loop length and to find an equation relating them, from which dimensional constants such as Kc, Kw and Ks are obtained.

செயற்திட்ட சுருக்கம்

பின்னலாடைகளின் முக்கியத்துவம் அதனது விரிவுத் தன்மையிலும் உடுத்துபவர்களுக்கு இதமான பண்புகள் தரும் தன்மையிலும் அடங்கியுள்ளது. ஆனால் சில உபயோகங்களுக்கு அதனது விரிவு உள்வாங்குதல் தன்மை போதுமானதாக இருப்பதில்லை. இதற்கு விடிவாக லைக்ரா (Lycra) எனப்படும் 95% விரிவு உள்வாங்குதல் தன்மை கொண்ட மீள்சியுடைய இழை, பருத்தியுடன் மையநூற்பு நூலாக பயன்படுத்தப் படுகிறது. இவ்வாறு செய்வதன் மூலம் துணியின் இழுவை தன்மையும், உடுத்துபவர்களுக்கு இதம் தரும் பண்பும் உயர்த்தப்படுகிறது.

பின்னலாடைகள் ஈரப்படுத்துவதன் மூலமோ, அல்லது அதை நீராவியில் காட்டுவதன் மூலமோ அல்லது அதனது இழைகளின் ஈரத்தன்மை வேறுபடுவதன் மூலமோ பரிமாண மாற்றங்கள் ஏற்படுகிறது.இந்த பரிமாண மாற்றத்தை ஒரு அங்குலத்தில் உள்ள நெட்டிழை, குறுக்கிழைகளிலிருந்தும், ஒரு நூல் வளையத்தின் நீளம் மற்றும் கன அங்குலத்தின் எடையின் சதவிகித மாற்றத்தில் இருந்தும் கணக்கிடலாம்.

முதலில் துணிகளின் மாதிரிகள் உளர் தளர்த்துதல் முறைக்கு உள்ளாக்கப்படுகிறது. அதன்பிறகு அவைகளின் ஒரு அங்குலத்தில் உள்ள நெட்டிழை, குறுக்கிழை, ஒரு நூல் வளைய நீளம் மற்றும் பரிமாண உறுதி சமநிலை வழியலகு முதலியவை ஆராயப்படுகிறது. இதே முறையில் துணி மாதிரிகள் ஈரம் கொண்டு தளர்த்தப்பட்டு மேற்கண்ட வழியலகுகள் கண்டுபிடிக்கப்படுகிறது.

எங்களது ஆராய்ச்சியின் முடிவாக துணி வழியலகுகள் ஒரு அங்குலத்தின் நெட்டிழை, குறுக்கிழை மற்றம் தையல் அடர்த்தி ஆகியவற்றை நூல் வளைய நீளத்துடன் இணைத்து காண்கையில் ஒரு படிச் சமன்பாட்டை தொடர்ந்து வருவதாக காணப்படுகிறது.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CPI - Courses per inch

WPI - Wales per inch

Ns - Stitch density

Kc - Dimensional constant of courses per inc

Kw - Dimensional constant of wales per inch

Ks - Dimensional constant of stitch density

CL - Cotton lycra

PL - Polyester lycra

In olden days nylon was the prime material used for manufacturing materials such as gent's socks and ladies stalking. But it faced a big disadvantage of being inelastic and had very low stretch recovery, which failed it to provide required comfort properties to the human body. In order to overcome this problem lycra, the most elastomeric filament with 95% of stretch recovery was discovered.

Lycra was introduced in the year 1962. Nowadays it is utilized widely in textile industry. It's become a fashion to wear lycra-blended fabrics. From sports wear, swimming suits to children wear, it is used. Nearly 2% of men's wear and 40% of women's wear of readymade garments are produced with the help of lycra yarn.

Lycra has semi dull lusture and is supplied with zero twist in fused multifilament form. Lycra, known as spandex fiber is a long chain block copolymer comprising of 85% segmented polyurethane. Mass polymer comprising of alternate soft (amorphous) and hard (crystalline) segments. The highly resilient elongation is the result of the combination of these two segments.

The hard segment consists of polyurethane, which is cross-linked crystalline and polar. These hard segments provide mechanical stability and flexibility. The soft segment consists of polyol (polyester or polyether). These segments are easily deformed producing high extensions under low stress, which determines the high elongation. Few properties of lycra are high resilient elongation, high modulus, good elastic recovery, mechanical stability and flexibility.

and rib knitted structure. In that machine latch type needle is present. Tension in the running yarn is measured and corrected by the use of tension meter. The loop length is altered by turning the loop length set knob.

Elastomeric fibers will stretch to several times their original loop length, and on release will snap back quickly to recover their original length almost completely. Spandex fibers are produced as monofilaments e.g. round cross section, or as partially fused multifilament. Monofilaments made by cutting thin sheets of polymer may also be produced.

Spandex 'lycra' shows the following data:

Tenacity - 8.0 cN/tex

Elongation – 550%

Modulus of elasticity – 0.4 cN/tex

Recovery from 100% stretch – 95%

The large relaxation shrinkage and changes in shape absorbed for knitted fabrics emphasize the intrinsic problem of trying to produce a dimensional stability for garments produced from yarns containing fibers that exhibit poor elastic recovery after deformation. Hence, 'lycra' having high resilient elongation is blended with cotton as core spun is used.

2.1 DIMENSIONAL STABILITY OF PLAIN KNITTED FABRICS

D.L. MUNDEN (1) states that knitted fabrics are so notorious for its tendency to change size and shape, wear and washing, that to many people the phrase 'the dimensional stability of knitted fabrics' will be a contradiction in terms. And yet this paper will emphasize, there is in fact, a precise and unique shape and size for every piece of knitted fabrics. The shrinkage of knitted fabrics observed in wear and washing conditions is caused by the fabric recovering to this state from the dimensional distortions imparted to it during the processing stages.

The shrinkage is a serious problem was clearly shown in a recent analysis of the customers' complaints by a national newspaper, which revealed that it accounted for 20% of all textile complaints.

DIMENSIONAL SHRINKAGE AT VARIOUS STAGES OF MANUFACTURE OF PLAIN KNITED FROM 1/26S WORSTED YARN:

	L (in)	Stitch length Shrinkage (%)	Fabric length shrinkage (%)	Fabric width shrinkage (%)
After knitting	0.168	_	_	_
After wet relaxing	0.167	0.5	5	3
After finishing	0.165	2	5	12
Wet-relaxed after finishing	0.165	2	12	22
After finishing	0.165	2	18	16

His study reveals that there are three categories of shrinkage which are explained in the following way,

2.1.1. WET RELAXATION SHRINKAGE:

This shrinkage is obtained when fabrics are immersed statically in water. The strains imparted to the fabric by boarding, pressing, calendaring, and other distortions imparted to the fabric in the dry state, are normally released and measured by this treatment. For ecru fabrics (i.e., fabric not given a wet treatment during finishing) knitted from hydrophilic yarns, the relaxation shrinkage will include the 12-15% of fabric shrinkage, which all such fabrics exhibit when first, wetted out caused by change in yarn characteristics.

WET-RELAXATION SHRINKAGE OF PLAIN KNIT FABRICS KNITTED ON CIRCULAR KNITTING MACHINE UNDER MINIMUM STRAIN CONDITION:

YARN TYPE	STITCH LENGTH	Sample dimensions after 24 hr dry-relaxation		Sample dimensions after wet-relaxation		Relaxation Shrinkage		
		Length (in)	Width (in)	Length (in)	Width (in)	Length (%)	Width (%)	Area (%)
2/48s Worsted	0.19 0.15	13 ½ 10	25 21	11 2/5 9 ½	23 ½ 187/5	9 5	6 10	15 15
1/32s cotton	0.19 0.15	11 2/5 8	24 23	10 ½ 8	23 ¼ 19 ½	10 0	4 15	14 15
2/32s fibro	0.19 0.15	13 8 2/3	24 23	11 ½ 8 ½	22 ¾ 19 ½	12 1	7 14	19 15
1/38s acetate	0.19 0.15	13 ¼ 10	23 22	11 ¾ 9 2/5	22 ¾ 19 ½	11 6	3 11	14 17

This is more pronounced on fabrics wet-finished in rope forms. In wool fabrics consolidation and felting shrinkage often occur simultaneously during washing. Consolidation shrinkage is caused by gradual return of fabrics to their stable wet-relaxed shape from a loop shape temporarily set in to the fabrics by the wet finishing Treatments, ecru cotton and rayon fabrics may show consolidation shrinkage owing to their inability to attain there stable shape during static wet-relaxation.

ECRU COTTON FABRIC CAUSED BY SEVERE LENGTH STRAINS:

	SAMPLE 1			SAMPLE 2		
Knitting Machine size (m)	18			20		
	Length	Width	Area	Length	Width	Area
Predicted Shrinkage as received (%)	19	14	31	32	0	32
Relaxation Shrinkage (%)	15	14	27	16	1	19
Shrinkage after Washing (%)	19	14	31	30	0	30
Consolidation Shrinkage (%)	4	0	4	12	7	11

This is unique to wool fabrics and may produce considerable area shrinkage without change in yarn length. It results from matting of fabrics. Which causes the knitted loops to be bent out of fabric plane. This is the only shrinkage affected by a shrink-resist treatment. It is normally measured by dimensional changes in the fabric during a standard washing treatment, but the figure obtained in this way is the sum of felting and consolidated shrinkages. True felting shrinkages can be obtained by measuring the k_l value of the fabric after a standard washing treatment (k_l). Measurements permits felting shrinkage to be assessed independently of consolidated shrinkages. This value of k_l may be described as the 'felting factor'.

It will be seen from this account that the study of the stable configuration of knitted fabrics in the dry- and wet-relaxed conditions has revealed a logical explanation of all aspects of shrinkage of knitted fabrics. In addition the stable dimensions may be determined with accuracy from knowledge of the length of yarn knitted into the stitch. With this knowledge shrinkage becomes a predictable parameter and fabrics may be accurately designed to produce garments of the required finished size.

IN ROPE FORM:

	Length Of Sample (in)	Fabric Width (double) (in)	Length Shrinkage (%)	Width Shrinkage (%)	Area Shrinkage (%)
After Finishing	20	43	_	_	_
After Wet-Relaxing	18	38	7	12	19
Dimensions After Washing	17	41	_	_	_
Shrinkage During Washing	_	_	7	-7	0
Shrinkage after Washing based on original finished dimensions	_	_	14	5	19

PROPERTIES OF PLAIN KNIT

According to the article presented by the author D.L.MUNDEN (2), the natural shape of the knitted loop is determined by the minimum energy conditions, that the loop tends to this state on relaxation and that this shape is independent of the properties of the yarn or length of the stitch. It is shown that with these assumptions, the dimensional and the length of yarn in the stitch determines weight properties of the knitted fabric in the relaxed state.

The relationships derived geometrically are confirmed experimentally by measurements after dry and wet relaxation on wool and cotton fabrics. The summary of yarn/fabric relationships derived from the various loop models is given below,

- The present geometrical model suggests that a specific relationship between stitch density and stitch length which is independent of fabric openness, also, that the course and wale spacing are directly proportional to the stitch length.
- From the particular case examined by Shinn and Chamberlain, relationships between stitch lengths and fabric dimensions are obtained similar in form to the present model.
- From the extension of this model suggested by pierce, a relationship between stitch length and stitch density is obtained which varies with the

- The leaf and Glaskin model, which rectifies the defects of the pierce model, suggests a relationship between stitch density and stitch length, which is also affected by the fabric openness. No relationship between stitch length and course and wale spacing can readily be drawn from this model.

The geometrical model suggests the relationship of the form,

$$N=Ks/L^2$$

Where,

N is the stitch density

L is the stitch length

Ks is a numerical constant given by the geometry of the loop configuration.

Given below are some Ks values after dry and wet relaxation for plain knitted fabrics knitted from different yarn materials,

Table: 2.5.

		Wet
Wool	19.0	21.6
Cotton	19.0	22.6
Regular Orlon	18.5	18.5
Staple Nylon	18.5	18.5

- The Ks values for fabric in the dry state are approximately the same for the fabrics knitted from all the yarns.
- The spread of Ks values for cotton fabrics in the dry state is much greater than for the wool fabrics, since the cotton fabrics do not recover completely from fabric distortion in this state.
- For wool and cotton, the experimental spread for Ks values in the dry state is much greater than in the wet relaxed state, thus confirming that the wet relaxation treatment is the more reliable method of obtaining the fabric in undistorted state.
- For the hydrophilic yarns, the Ks value of the fabric after wet relaxation is approximately 15% greater than the Ks value after dry relaxation; no such changes in Ks is observed on fabrics knitted from hydrophobic yarns.

As a conclusion it has been suggested in this paper that the natural configuration of the knitted loop is determined by conditions of minimum energy and, that in the relaxed state when released from mechanical strains, the loop will tend to take up this shape. It is also suggested that this configuration may be expected to be independent of the yarn properties or stitch length.

With these basic assumptions, geometrical analysis of knitted loop indicates that the dimensions of the knitted fabric in its relaxed state are uniquely determined by the length of the yarn knitted into the stitch; all other

This concept of stitch length as the unique variable affecting knitting quality offers new methods of controlling the quality of the fabric at the knitting point and also of ensuring the knitted fabric is constructed to the required dimensions and weight.

The basic relationship between fabric properties and the yarn and knitting variables are thus established, and have been confirmed experimentally. The knitting operation can now be based on standard engineering principles, both from the point of the view from the machine builder in the construction of knitting machine, and of the machine manufacturer in controlling the quality of the fabric.

2.3. GEOMETRY OF KNIT FABRIS MADE OF STAPLE RAYON AND NYLON AND ITS RELATIONSHIP TO SHRINKAGE IN LAUNDERING:

It has been shown by Hazd M.Fletcher (3) and S.Helon Roberts CS that data on both gray and finished fabrics for stitch length diameter of yarn and wale and course spacing were used in evaluating the equation for length of yarn in one stitch and for weight per unit area. Weight of the fabrics calculated by Pierce's equation showed good agreement with that obtained by weighing a known area.

spacing of both the laundered gray and laundered finished fabrics followed parabolic curves. Curves relating the wale and course spacing of the laundered materials conformed to no orderly pattern. Those unlaundered materials in which wale and course spacing approximated the parabolic relationship of the laundered fabrics changed the least in the length and width dimensions. Shrinkage in area increased with knitting stiffness for all of the gray fabrics and for the finished viscose but for the finished ace late viscose and nylon, shrinkage in area usually decreases as the knitting stiffness increased.

2.3.1. EFFECT OF LAUNDERING:

STITCH LENGTH:

Measurement of yarns raveled from the fabrics before and after Laundering reveled that the shrinkage of the different kinds of yarns was small. Stitch length of plain, rib and interlock gray fabrics decreased as much as 4% in 5launderings for the viscose and nylon, and as much as 25% for the ace late viscose.

In the finished goods the viscose and yarn in the plain and rib knit fabrics stretched between 2%and 3%laundeing, but in the interlock fabrics it neither shrank nor stretched. The nylon yarn in the finished fabrics showed only slight changes in laundering less than 1% stretch or shrinkage. The ace late viscose yarn shrank less that 2%.

The relationship of wale spacing to course spacing of the unlaundered fabrics, both gray and finished was quite different from that of the laundered fabrics. In the laundered fabrics, who were floated in water before drying in order to eliminate the stresses and strains, data for the wale and course spacing followed parabolic curves. These data were fitted to the quadratic equation,

$$P^2 \quad a\,(w+b)$$

Of the unlaundered finished plain and rib knit fabrics. Nylon was the only one for which the data approximated the parabolic curve of the laundered fabrics. The nylon fabric changed the least in length and width in laundering.

2.3.3. DIMENSIONAL CHANGE IN LENGTH AND BREADTH:

All of the gray fabrics shrank more than 10% in length in 5 launderings. All of the loosely knit gray materials except the plain knit nylon stretched excessively width. The excessive stretching in width was usually greatly reduced by the finishing.

Only the loosely knit viscose rib fabrics stretch more than 15%. Length wise shrinkage of the plain and the rib knit materials in laundering was about the same in the gray as in the finished fabrics. However finishing greatly reduced the length shrinkage of the interlock fabrics.

The trend in the relationship of "cover factor" l/d, the change in area in laundering was the same for all of the gray fabrics and for the finished viscose. The shrinkage in area increased with knitting stiffness.

On the other hand, the finished acetate viscose and nylon behaved quite differently. After finishing, the shrinkage of these materials usually decreased as the knitting stiffness increased.

2.4 THE GEOMETRY OF A PLAIN KNITTED LOOP

This paper by K.G.A.V.(4) Leaf presents geometrical model of a plain knitted loop as a basis for a mathematical description of the dimensional properties of a plain knitted fabric.

The theory set out in this paper has been developed with two objectives. First, it is an attempt to generalize, as far as possible, observed data and empirical relationships obtained from experimental work on fabrics. Secondly it was felt that an extension of the theory might indicate profitable lines of experimental investigation, not previously apparent, with possible consequences of practical value in the design and control of knitted fabrics.

Chamberlain has given a model of plain knitted fabric. Doyle describes this in the discussion following a paper and its limitations are pointed out. Another model was suggested by Pierce, who derived from it model is considered further in this paper, and it's shown that certain of its consequences make it unsatisfactory. A new model is proposed and the geometry of the fabric is worked out from it.

2.5 THE STRESSES IN A PLAIN KNITTED LOOP:

G.A.V.Leaf (5) further shows that there are some possible stress-distribution in a model of a dry relaxed plain-knitted loop are investigated, the fabric being assumed to lied in a horizontal plane. In particular, the forces and couples applied by its one loop by its neighbour at the points where they interlock are discussed, and estimates of their magnitude are As a conclusion, it was emphasized that the results we have obtained do not necessarily represent what actually happens in a knitted loop, because of the somewhat arbitrary procedures adopted to derive the boundary conditions. What we have found are system of forces and couples, which could hold a yarn in the shape suggested in leaf's model. Any conclusions that are drawn from the analysis must therefore be interpreted in the light of these remarks.

It seems reasonable, however, to suppose that even if the values of the stresses given by the analysis are not exactly correct, they are atleast of the right order of the magnitude. If this statement is correct, the main conclusion to be drawn from the analysis is that the couples applied to the loop at the crossover points are large compared with the weight and the dimensions of the loop. The yarn is held in the shape of loop primarily by

2.6.THE DIMENSIONAL PROPERTIES OF KNITTED WOOL FABRICS

Part I: The Plain Knitted Structure

J.F. KNAPTON (6) explains plain knitted structures to be a rationally determine structure only in the fully relaxed state, in any other state, the nature of the knitted loop is dependent on the yarn's physical properties, mechanical processing, and knitting variables. The fully relaxed state is only found after the fabrics have been thoroughly wetted out, briefly hydro extracted, and tumble-dried. In this state, the $k_{(1-4)}$ values are constant and predictable and independent of yarn or machine variables. In any other fabric state, values of $k_{(1-4)}$ may vary considerably and have little commercial value. Fabric thickness is shown to be independent of loop length and dependent only on yarn diameter in the fully relaxed state only.

Felting shrinkage protection can nowadays be assured by a number of proven chemical oxidative and resin additive processes, and machine wash ability of wool knitted fabrics may soon become a general reality, leading to higher consumer satisfaction with wool fabrics. The problem of relaxation shrinkage remains, however, and, until the fabric can be brought to its natural strain free and stable state, it will be possible to label any knitted wool garment a washable commodity.

practical condition, specified by a set of dimensional parameters that are different from those envisaged by Munden, but similar to those predicted by postle. Postle's model, although predicting a dependence of the dimensional parameter on L/d found in practice, also has certain inherent limitations. Consequently, it may be argued that the knitted loop does take up a position in space somewhat similar to those4 analyzed by these authors, but it is a more complex shape than they supposed. From a practical viewpoint, we suggested that this present empirical analysis demonstrates more adequately the nature of the plain knitted loop. The major conclusions are summarized below.

The fully relaxed state for plain knitted fabrics is arrived at after a thorough wetting out for 24 hr brief hydro extracted, and tumbles drying for a period of 1 hr at 70.c.

Little effect of wool fiber quality, twist level, yarn friction, and level of WURLAN treatment is observed on the fabric dimensional properties, which suggests that the natural loop configuration is a purely geometrically specified shape as originally suggested by munden.

Loop density is proportional to $1/L^2$ and independent of yarn diameter only in the fully relaxed state. A dependence on count is seen for any other relaxed state.

Knitting variables influence the area dimensions in all relaxed state other than the fully relaxed condition. For the fully relaxed condition, loop length.

k_2 and k_3 are dependent on L, d and L/d for all fabric conditions, although this dependence is smallest in the fully relaxed state.

k_4 in independent of CF in the fully relaxed state only and constant at 1.30+-0.05.

For fully relaxed fabrics, thickness is constant and dependent on yarn diameter .It can be concluded that in the plane perpendicular to the fabric plane, the loop shape corresponds to that of a semicircle. A new parameter k_5 is suggested as a dimensional parameter specifying fabric thickness.

Fabric bulk is proportional to loop length as predicted, and the ratio t/k1 is a constant for all conditions of fabric relaxation. These relationships now form a nucleus of a generalized system for accurately determining the fabric dimensional properties before knitting. But what is important is that this system can now be extended to encompass other knitted structures, as will be demonstrated in continuing papers of this series.

Part II: 1x1, 2x2 Rib, and Half-Cardigan Structures

J.J.F. KNAPTON (7) further explain that, the 1x1 rib and half-cardigan structures, like the plain-knitted structure, are shown to be rationally determinate structures only in the fully relaxed state; in any other state, their dimensional behavior is dependent on the yarn's physical properties and previous knitting and wet-finishing history.

The fully-relaxed state is reached only after the fabrics only after the fabrics have been thoroughly wetted-out, hydro extracted, and tumble-dried for 1 hr at 70degree Celsius, the courses and ribs per in of the1x1 structure are directly proportional to 1/L as predicted by Munden's original theory for plain-knitted structure, but this theory does not account for the complete dimensional behavior of this Structure, as k1 is not strictly a constant. However, k_4 is a constant at 1.76+-0.15 and independent of both loop length and yarn count. For the 2x2 rib, no true dimensional stable state is found with wet relaxation and tumble-drying.

Just as he outlined in part 1, today's major problem of machine washable knitted wool fabric acceptance is that of determining the dimensionally stable fabric state. Felting shrinkage need no longer be considered a major part of this problem as many adequate shrink- resist processes are available to inhibit this type of shrinkage, but relaxation this paper, it is now possible to specify the fully relaxed dimensional parameters of the rib knitted structures analyzed, and the relaxation procedures required bringing about the fully relaxed state of these structures.

In certain respects, the rib structures analyzed here have been shown to be more readily definable by Munden's plan knitted theory than the plain-knitted structure itself. This conclusion is reached from reference to appendices; where, except for the 2x2 rib structure, the calculated K values in any relaxed or semi relaxed state tend to be less variable with L than the equivalent values found for the plain-knitted structure. If the plain-knitted structural unit is studied carefully, the forces maintaining its configuration are likely to be high due to the complex torsion and bending involved in forming in this essentially two-dimensional fabric.

In the rib-structure, these forces will be lower, as the link yarn from one loop moves out the fabric plane instead of having to drastically bend back into this plane, as is the case for the plain knitted structure to form the adjacent loop in a different plane, but one parallel to the original. This arrangement forms a balanced knit structure in the 1x1 rib, which accounts for the lack of edge curling, very apparent in the plain-knitted fabric type is cut for making-up purposes.

Thus the natural loop configuration of the rib structure is likely to be Closer to the three-dimensional elastica envisaged by Mundan, because thetorsional effects are less responsible for the final loop shape in space. The fabric.

Along these same lines, the results we have obtained for these rib structures in their fully relaxed state, which agree closely with Munden's work, are contrary to the results found by Smirfit. However, as we have emphasized in the discussion, it is difficult to see how smirfitf's hypothesis of a modified plain knitted theory can apply, unless his relaxed states at all. This seems the most likely explanation, but once the fully relaxed state is achieved, her is no doubt that the dimensional behavior of the rib fabrics.

The technique necessary to arrive at a fully relaxed state for the 1x1 rib and half cardigan fabrics are the same, viz, wetting out and 1 hr tumble drying at 70.c. This technique incidentally was also found applicable in achieving the fully relaxed state in the plain knitted structure.

In conclusion, the relaxation problem of the rib structure is now more clearly understood and, by the use of the constants derived empirically, the stable, fully relaxed state of the 1x1 rib and half cardigan fabric structures may now be accurately specified before knitting.

2.6 THE GEOMETRY, DIMENSIONAL STABILIZATION OF COTTON PLAIN –JERSEY STRUCTURE:

It has been shown by J.J.F. Knapton at all (8) that dimensional stability of cotton plain-jersey fabrics can be attained by either mechanical relaxation techniques (consecutive laundering and tumble drying cycles) or chemical treatments (fabric mercerization without tension) both treatments causes large linear dimensional leading to the same final stable condition that is to a fixed loop configuration categorized by unique values of k_c and k_w.

Although for all practical purposes, the ultimate k values are close enough to constants, they are not entirely independent for fabric tightness (k) and some yarn variables. They are substantially the same as the values found for completely relaxed wool fabrics that have been treated to prevent felting. Geometrical fabric thickness and bulk density are significantly dependent on fabric tightness. The fixed loop configuration occurs when bulking leads to completely 'jammed' structure.

Evidences show that fixed loop configuration exists for weft knitted wool fabrics. Dimensional stability can therefore be guaranteed within normal tolerances, but it is to achieve this complete relaxation of the fabric is essential and felting must be restricted.

parameters governing stable fragment dimensions. Loop length is the fundamental parameter determining the stable linear dimensions hence the well-known relations k_c = CL and k_w =WL where C nad W are the courses in cm and whales in cm respectively can be used to predict stable fabric dimensions.

For wool k_c is significantly dependent on the fiber quality, but k_w is not. No significant effect of yarn twist, linear density or ply on the k values for the completely relaxed fabric were noted, which lead to the suggestion that fiber properties, not yarn properties are the sources of secondary effects on the stable dimensions of the fabric. The work described in the present allows direct comparisons of the dimensional properties of wool with those of cotton plain-jersey fabric.

Table: 2.6.

PERCENTAGE CHANGES IN L WITH RESPECT TO LINEAR DENSITY:

Linear Density / Treatment	Average percentage change in L				Overall average percentage change in L
	18.5	18.5x2	29.5	29.5x2	
Mechanical relaxation	1.73	2.68	2.32	3.16	2.47
Chemical relaxation	2.22	2.97	3.02	3.98	3.05

JERSEY FABRIC:

The area parameters (k_s=k_c x k_w) of cotton plain jersey fabric changes during relaxation. Initial wet relaxation causes considerable area shrinkage. This is not a stable state, since further shrinkage occurs after the fabric has again been wetted -out and tumble-dried. This is defined as the fully relaxed state (FR) for wool. This is not a dimensionally stable state for cotton fabrics because further cycles of Laundering and tumble-drying cause further small shrinkages in area. The dimensionally stable state will be defined as the fabric condition after the tenth Laundering cycle.

2.8.2 GEOMETRY OF THE COMPLETELY RELAXED FABRIC:

After the tenth Laundering cycle, the linear parameters (k) for cotton plain jersey fabric are relatively constant. The values of kc for the completely relaxed fabrics are not quite constant, as they are for wool.

Kw is independent of all the variables, namely fiber quality, yarn linear density, twist and ply, and fabric tightness but there be a slight dependence on yarn linear density. On the other hand, kc is dependent on fabric tightness (k), yarn linear density and fiber quality.

Although kc is not entirely independent of fabric tightness, it changes very little over a wide range of k values. Because the fixed loop the completely relaxed fabric must be largely independent of the fiber at least for Hydrophilic fibers.

Table: 2.7.

MEAN K PARAMETERS IN VARIOUS FABRIC CONDITIONS:

Fabric Treatment	KC		KW	
	Mean	CV%	Mean	CV%
Mechanical	5.73	3.85	4.10	2.40
Chemical	5.63	4.55	4.02	3.00
Mechanical followed by chemical	5.78	4.05	4.19	2.49
Chemical followed by mechanical	5.76	4.63	4.10	3.21

Knitted fabrics are defined as an ensemble of loops bonded together in an elastic mode. Because of their elastic structure, there is a migration possibility of some amount of yarn between structural elements so that knitted structures can be deformed in both directions.

It has been shown by Monica szabo (9) that knitted fabrics have good dimensional stability when dimensional change after domestic laundering is below + (or) – 2%. Structural parameters such as the length of the loop and number of stitches in both directions give some information about knitted fabrics, dimensional stability. These parameters are modified during finishing processes and relaxation periods after knitting, finishing and domestic laundering process.

All knitted samples were relaxed in standard conditions for 24 hours, and then the dimensional stability was determined. Specimens (500 x 500 mm), were marked at 50 mm from the edge in three places on every side. The specimens were conditioned for atleast 24 hours in the standard atmosphere before testing. They were washed with a washing machine with 3 g/l of non-ionic agent at 95^{0} c for 15 minutes at a liquor ratio of 1:30, and then rinsed with water of 40^{0} c for 3 minutes and with water at 20^{0} c for 3 minutes at the same liquor ratio.

min

then dried on a plane surface at 20^0 c. The distance between marks was measured and the shrinkage was calculated by formula,

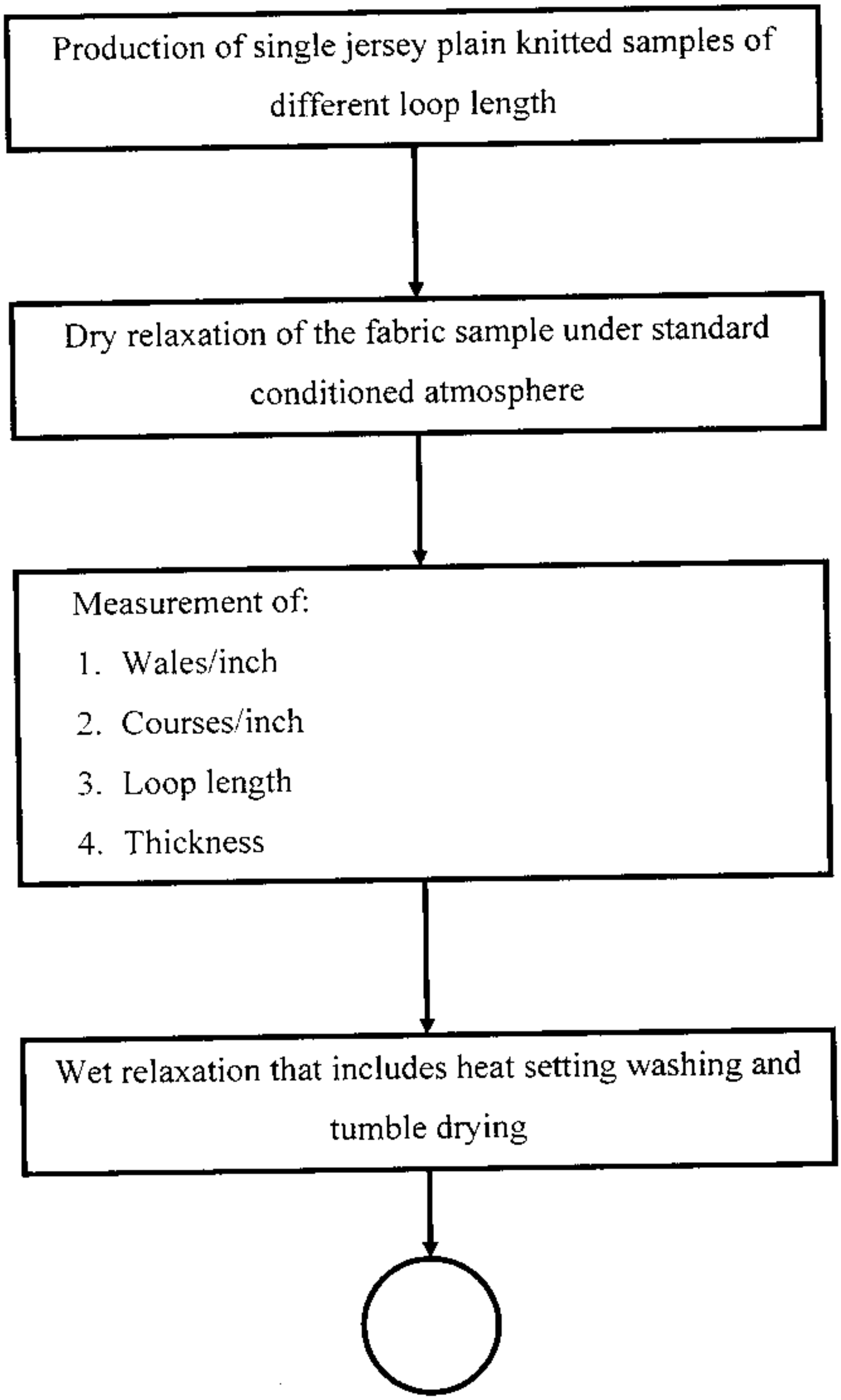
$$DL(\%) = \frac{(l_1 - l_0) \times 100}{l_0}$$

l_0 = Distance between marks before washing.

l_1 = Distance between marks after washing.

Elongation above a certain density is due to the change of contact surface between yarns and to the loop shape. A too high value of density does not allow the recovery of knitted fabrics through relaxation to minimal energy state. The shrinkage of jersey knitted fabric decreases with increase of vertical density.

The correlation between data related to relaxation shrinkage, finishing shrinkage and domestic laundering shrinkage allows the designing of jersey knitted fabrics with very high dimensional stability.


Production of single jersey plain knitted samples of different loop length
Dry relaxation of the fabric sample under standard conditioned atmosphere
Measurement of:
1. Wales/inch
2. Courses/inch
3. Loop length
4. Thickness
Wet relaxation that includes heat setting washing and tumble drying

Measurement of:

1. Wales/inch
2. Course/inch
3. Loop length
4. Thickness

The fabric is then fully relaxed followed by washing and flat drying, and then the above said parameters are again measured

In order to study the dimensional stability of cotton lycra and polyester lycra core spun yarn knitted fabric the following tasks were performed.

4.1. YARN DETAILS:

30sNe, 40sNe cotton lycra and 170, 97 denier polyester lycra core spun yarn is used to knit single jersey fabrics.

4.2. MACHINE DETAILS:

<u>Cotton Lycra Samples:</u>

Make: Falmac

Type: FSB 3XSK

Year: 2000

Diameter: 18"

Gauge: 24

Feeder: 54

<u>Polyester Lycra 97 denier sample:</u>

Make: Meyer cie

Type: 3.2

Diameter: 30"

Feeder: 96

Gauge: 28

Year: Nov 1998

Model: SH4BFA

Diameter: 18

Gauge: 24

Feeder: 54

Heat setting Machine parameters:

Make: Mersan

Year: 1999

Machine speed: 8sec/3m

Chamber length: 3 meters

Washing Machine parameters:

Make: Ramsons

Water Level: 500 liters

Tumble drier Machine parameters:

Make: Ramsons

4.3. FABRIC SAMPLES:

Three samples of varying loop length were produced for each count of cotton lycra and polyester lycra.

Loop length set:

Cotton Samples: 2.6,2.9,3.2mm

Polyester Samples: 2.7.2.9.3.1

4.4. DRY RELAXATION:

The fabric is conditioned in the standard test atmosphere at 65 (+or-) 2% RH and 27 °c (+or-) 2°c, in a fully relaxed state.

4.5. WET RELAXATION:

The wet relaxing includes heat setting, washing, tumble-drying and then relaxing the fabric at atmospheric condition.

<u>Heat Setting Process Parameters</u>:

Temperature: 180 degrees

Stretch percentage:

Cotton: 15%

Polyester: 5%

<u>Washing process parameters:</u>

Temperature set:

Cotton – Room temperature (cold wash)

Polyester – 55 degrees (hot wash)

Time taken: 20 mins

Wetting agent: 50 ml

<u>Tumble drying process parameters:</u>

Time taken: 75 mins

Temperature: 95 degrees

measured after wet processing.

1. Wales per inch
2. Courses per inch
3. Thickness
4. Loop length.

4.7. MEASUREMENT OF WALES AND COURSE PER INCH:

Take the fabric sample and lay it flat on the table. Remove all creases wrinkles without distorting it. On one side of the specimen, wales and courses per inch are measured with the help of pick or magnifying glass. Five such readings are taken and the average is accounted.

4.8. MEASUREMENT OF THICKNESS:

Using thickness meter, the fabric sample is tested for its thickness in mm at various places. Five readings are taken and the average is noted.

4.9. MEASUREMENT OF LOOP LENGTH:

It's the length of yarn in mm to one loop,

$$\text{Loop length} = \frac{\text{Length of yarn in mm}}{\text{Known number of wales}}$$

The loop length is measured by taking 50 wales. 50 wales are marked on the fabric surface. Then unraveling of yarn for that particular length is taken and measured in mm. By substituting the measured values in the above formula, the loop length is measured.

Samples of one meter are taken and are marked in three places with 25X25 mm measurements. It is then washed under normal washing for one hour and is then flat dried. After all these procedures the samples are again measured, and the shrinkage percentage is found using the formula,

$$\frac{\text{Initial readings} - \text{final readings}}{\text{Initial readings}} \quad X\ 100$$

4.11. DETERMINATION OF MATHEMATICAL RELATIONSHIP:

Graph is plotted between variable loop length and wales per inch, course per inch, thickness. The plot is then extended to cut its corresponding Y axis (C) and respective slopes are found. Hence the equation $Y = mX + C$ is determined for all the above parameters.

4.12. SAMPLE IMAGES:

The microscopic images of cotton lycra and polyester lycra are taken after wet relaxation, using an instrument called image analyzer with the magnification of 40.

5.RESULTS AND DISCUSSION

We carried out our observation on two different samples of cotton lycra and polyester lycra with 3 different loop length.We chose 30s and 40s samples of cotton lycra and in polyester lycra we chose 170DN and 97DN.All these samples were set on to observation in their dry relaxed,wet relaxed and fully relaxed fabric.

The datas obtained for dry relaxed fabrics are given below:

<u>CL 30s:</u>

Table: 5.1.1:

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.30.1	2.6	72	39	2808
CL.30.2	2.9	63	38	2409
CL.30.3	3.2	58	36	2111

Fig: 5.1.1(a)

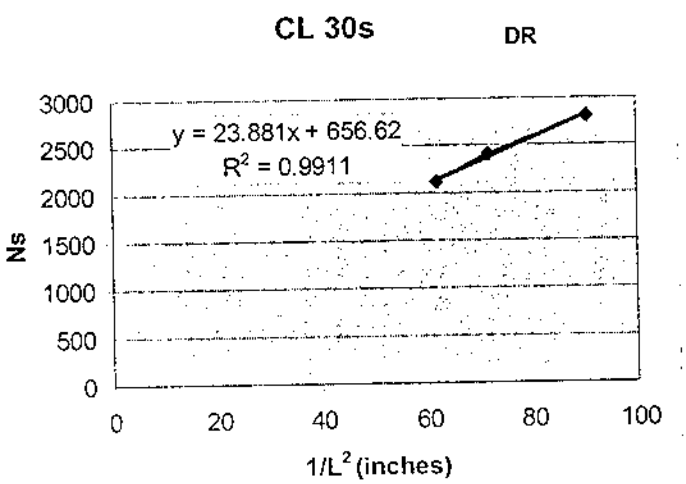
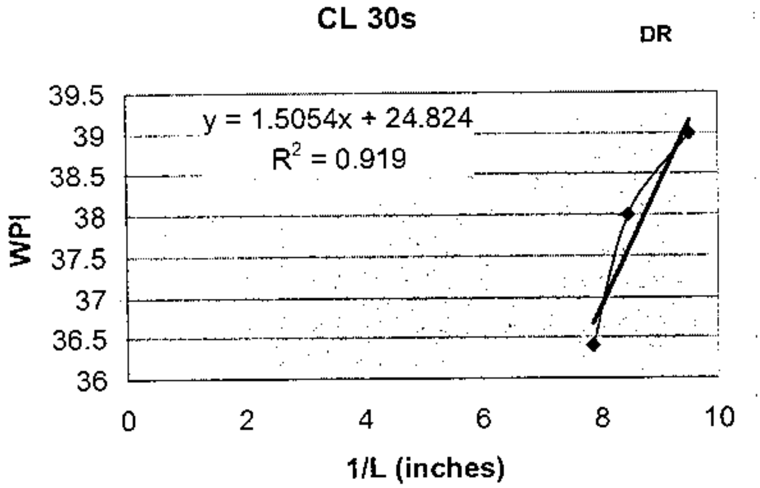


Fig: 5.1.1(b)



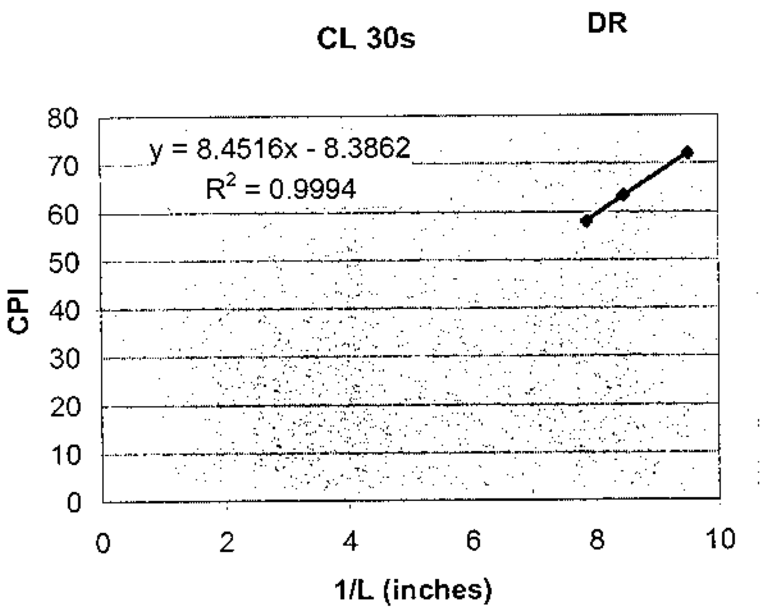


Fig: 5.1.1(c)

From the above information we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=8.4516, Kw=1.5054

Table: 5.1.2

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.40.1	2.6	81	41	3321
CL.40.2	2.9	66	41	2706
CL.40.3	3.2	61	40	2440

Fig: 5.1.2(a)

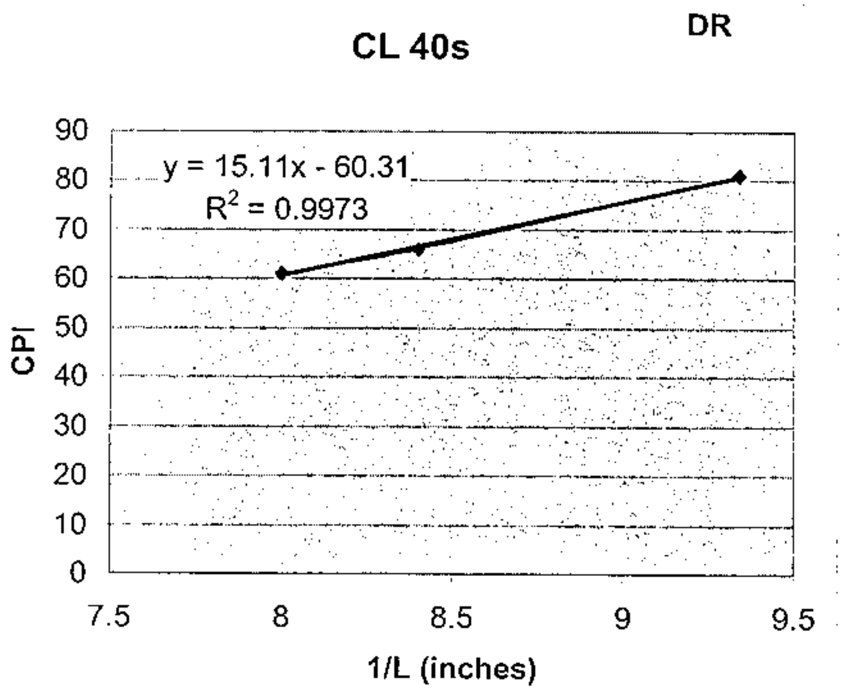
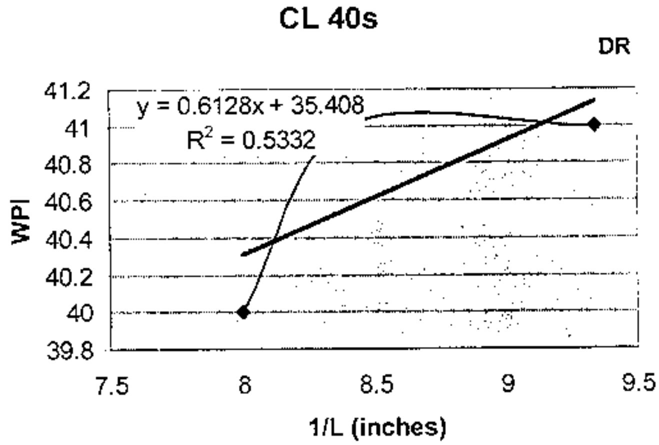


Fig: 5.1.2(b)



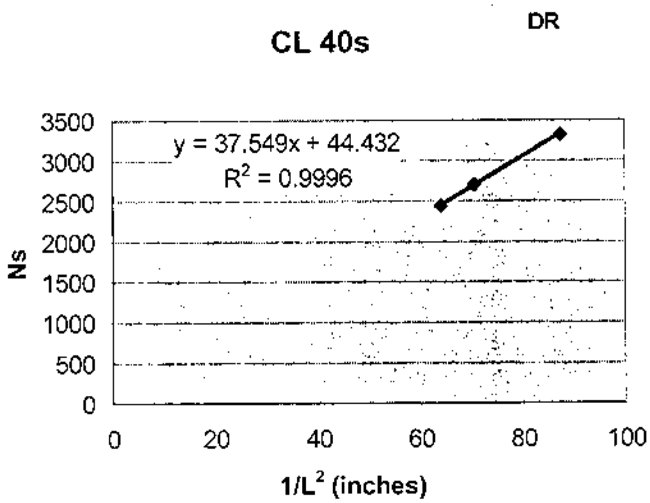


Fig: 5.1.2(c)

From the above information CPI and WPI varies l[illegible] with the loop length.

The obtained constant values are,

Kc=15.11

Kw=0.6128

Table: 5.1.3

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.170.1	2.7	75.4	41.6	3136.64
PL.170.2	2.9	66.2	41	2714.2
PL.170.3	3.1	59.8	39.8	2380.04

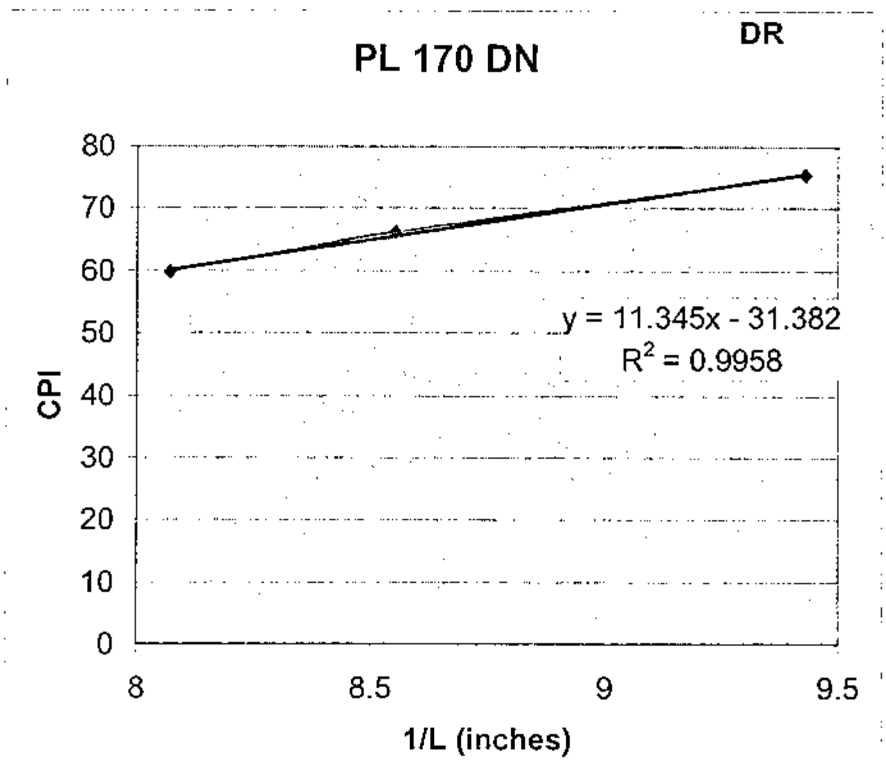
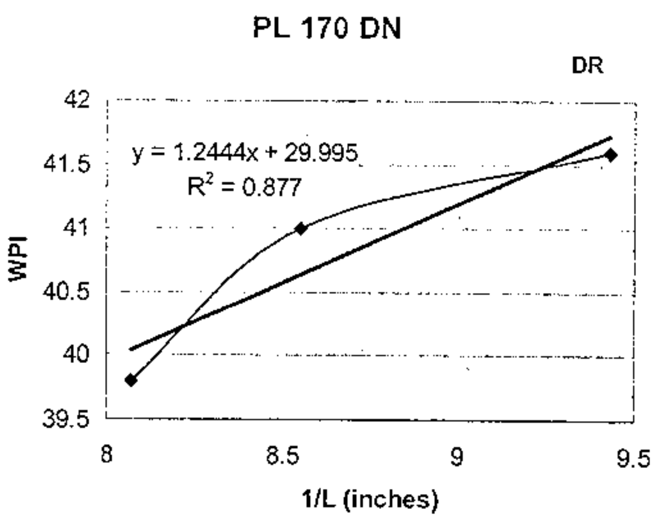


Fig: 5.1.3(a)

Fig: 5.1.3(b)



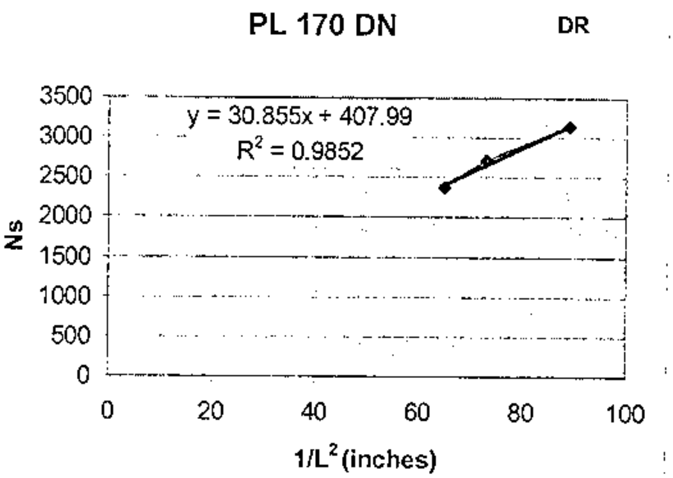


Fig: 1.1.3(c)

From the above information we know that CPI and WPI varies linearly with the loop length.

The obtained constants are ,

Kc=11.345,Kw=1.2444

Table : 5.1.4

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.97.1	2.5	110	62.6	6886
PL.97.2	2.7	103.6	62	6216
PL.97.3	2.9	91	60	5642
PL.97.4	3.1	82	59.5	4879

Fig: 5.1.4(a)

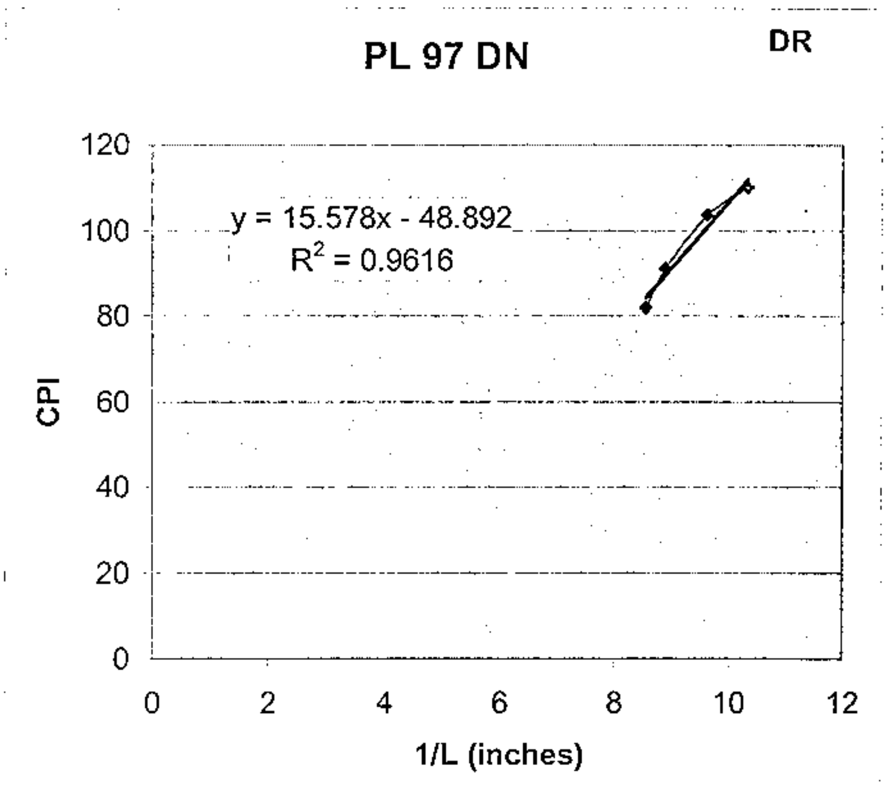
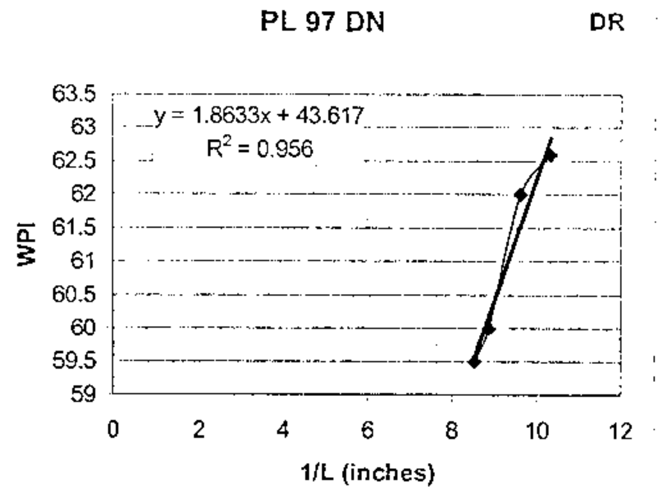


Fig: 5.1.4(b)



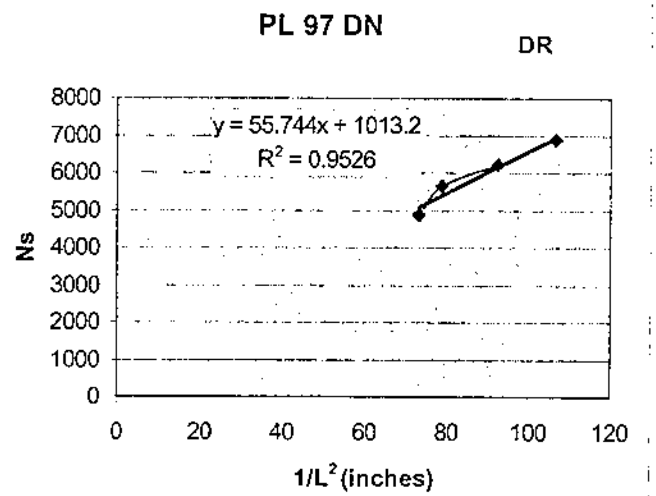


Fig : 5.1.4(c)

From the above information we know that CPI and WPI linearly varies with the loop length.

The obtained constant values are,

Kc=15.578

Kw=1.8633

CL 30s:

Table:5.2.1

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.30.1	2.6	72	40	2880
CL.30.2	2.9	64.8	38.6	2619
CL.30.3	3.2	60	36.8	2208

Fig: 5.2.1(a)

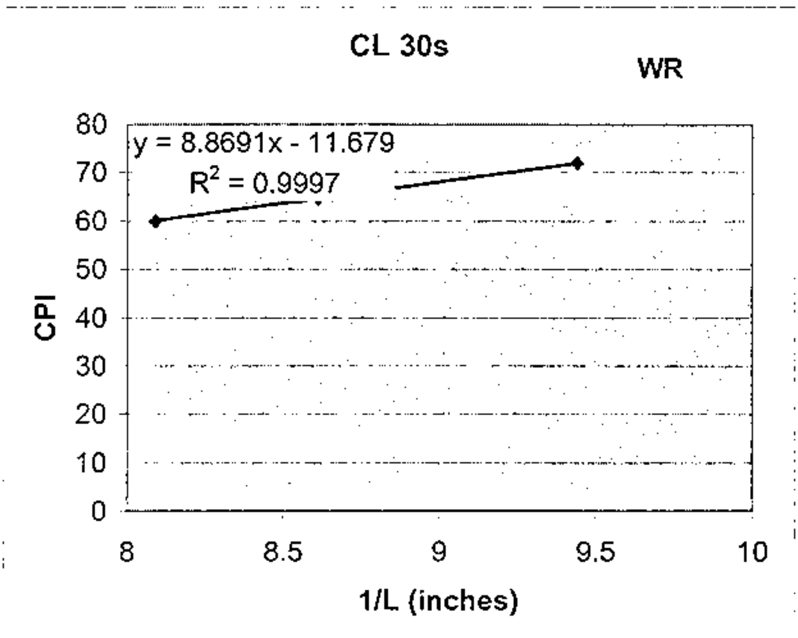
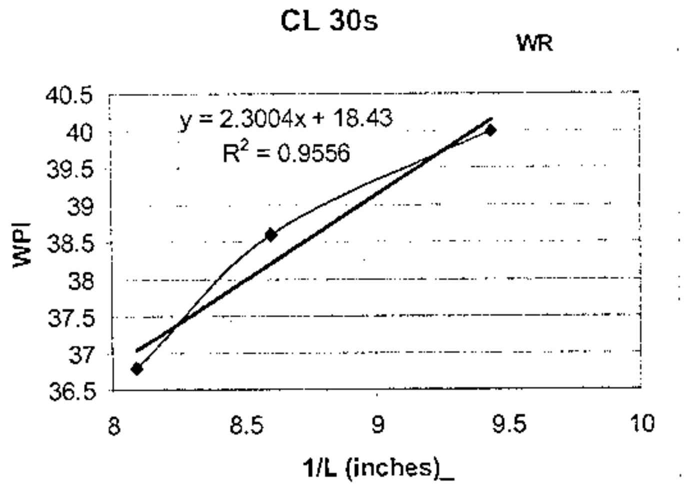


Fig.5.2.1(b)



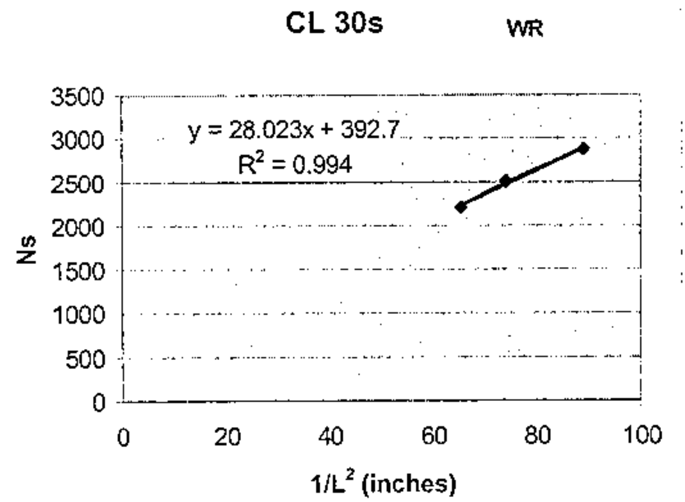


Fig: 5.2.1(c)

From the above results we know that CPI and WPI varies linearly with the loop length.

The obtained constants are,

Kc=8.8691

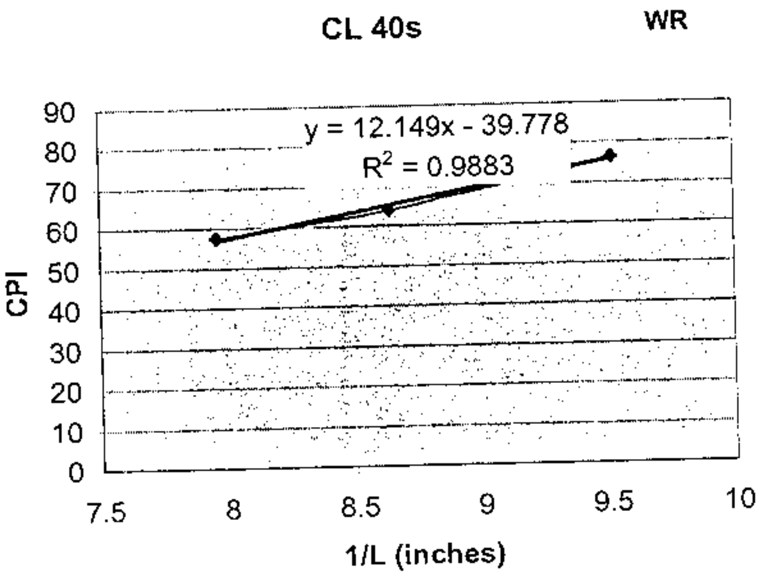
Kw=2.3004

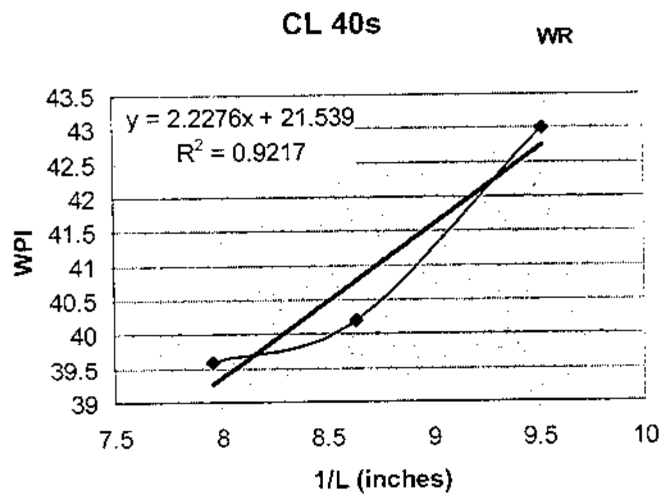
CL 40s:

Table: 5.2.2

SAMPLES NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.40.2	2.6	76.4	43	3285.2
	2.9	64	40.2	2572.8
CL.40.3	3.2	57.6	39.6	2280.9

Fig: 5.2.2(a)





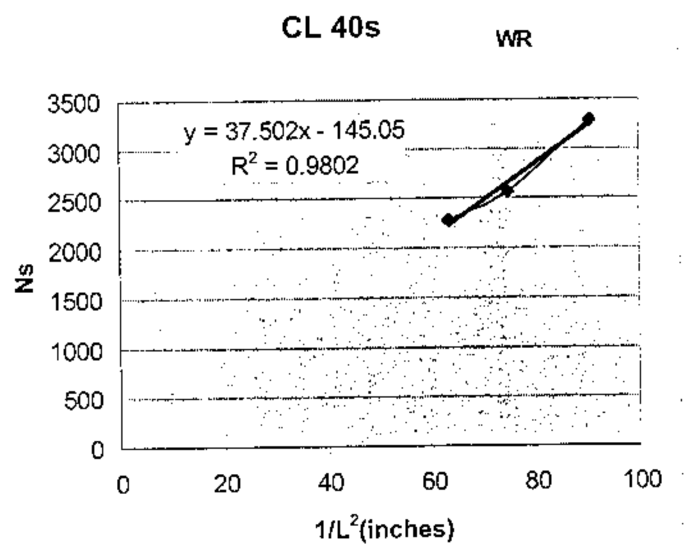


Fig: 5.2.2(c)

From the above results we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=12.149

Kw=2.2278

Table:5.2.3

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.170.1	2.7	72	38.75	2618
PL.170.2	2.9	63	39	2457
PL.170.3	3.1	57	39	2223

Fig: 5.2.3(a)

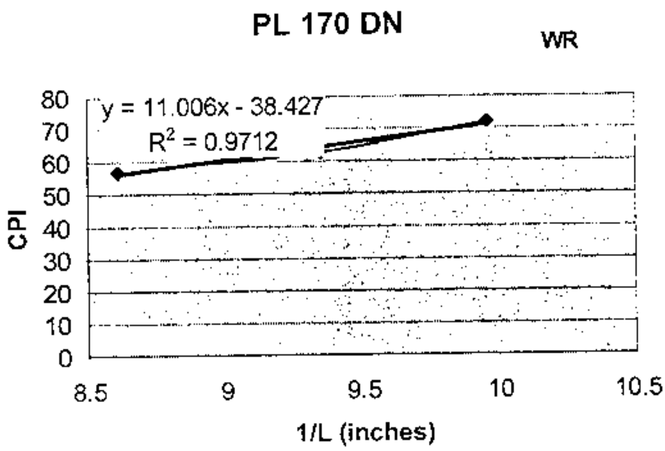
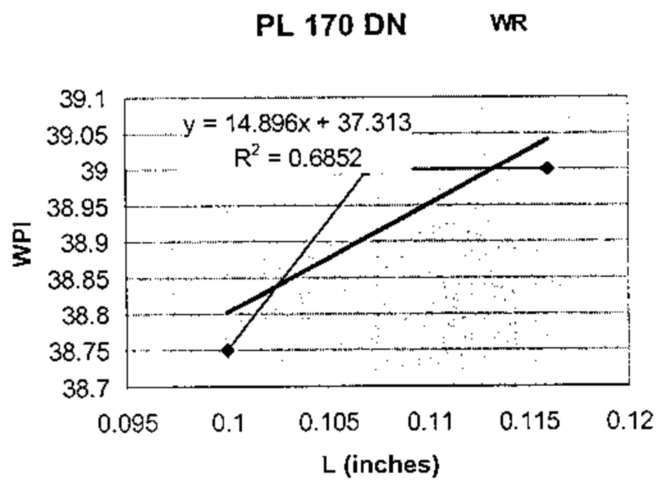


Fig:2.2.3(b)



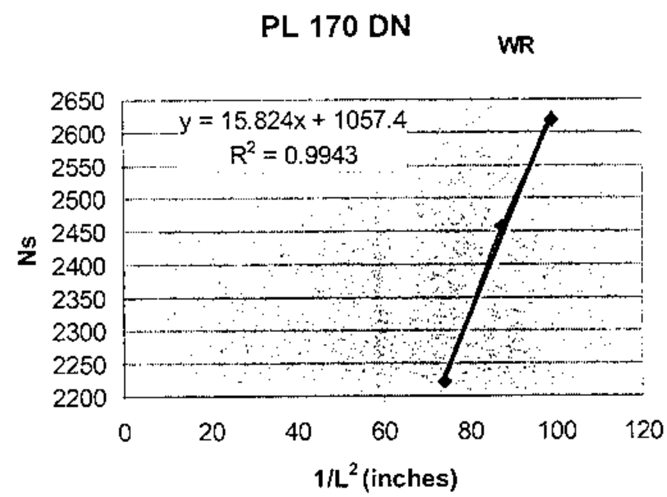


Fig: 5.2.3(c)

From the above results we know that CPI and WPI varies linearly with the loop length.

The obtained constants are,

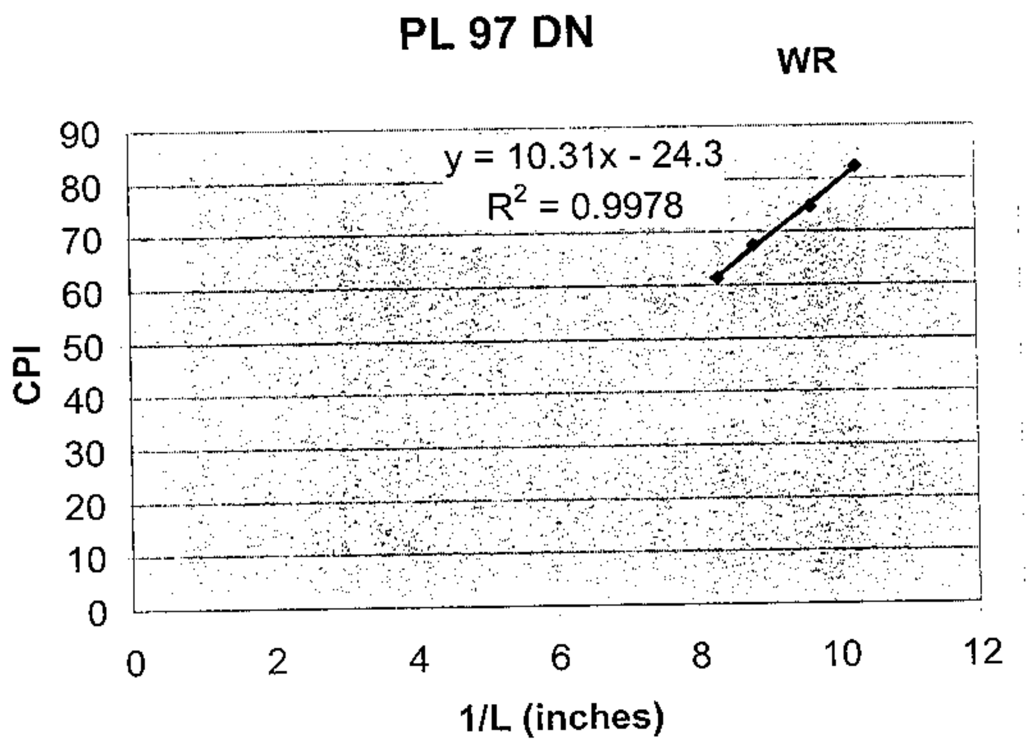
Kc=11.006

Kw=14.896

Table: 5.2.4

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.97.1	2.5	82.2	51	4159.32
PL.97.2	2.7	74.8	50.8	3754.96
PL.97.3	2.9	67.4	50.6	3437.4
PL.97.4	3.1	61.4	50.2	3119.12

Fig: 5.2.4(a)



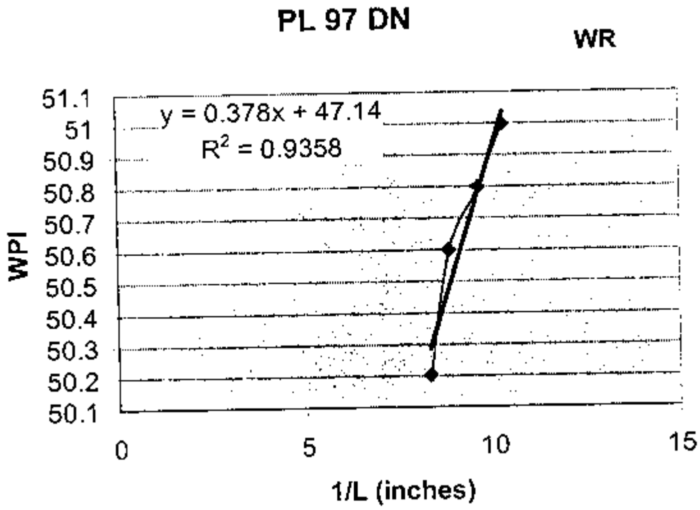
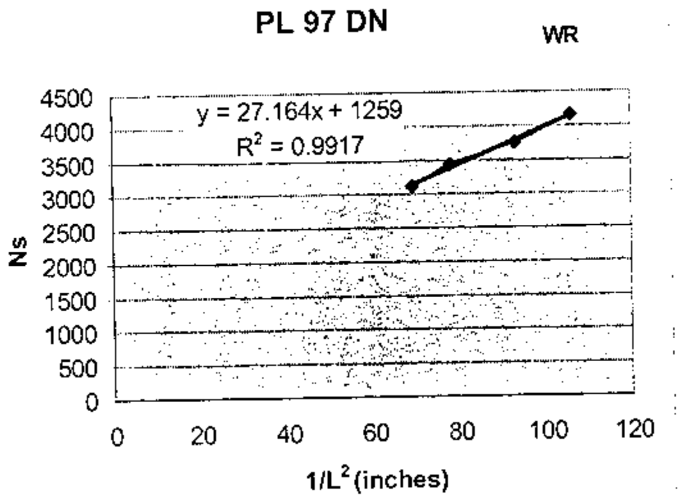


Fig: 5.2.4(c)



From the above results we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=10.31

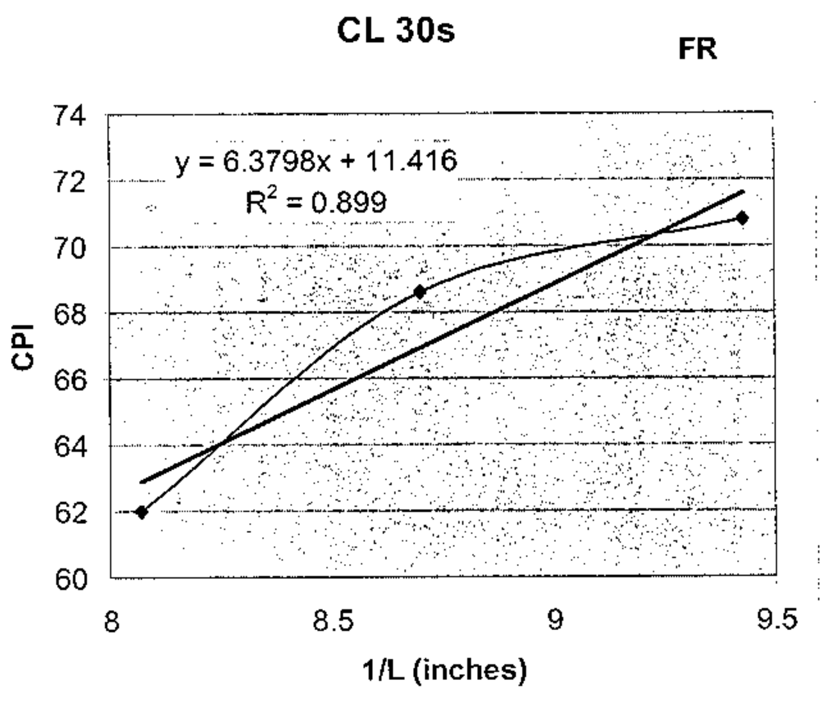
Kw=0.378

below:

CL 30s:
Table: 5.3.1

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.30.1	2.6	70.8	40.6	2874.48
CL.30.2	2.9	68.6	39.8	2730.28
CL.30.3	3.2	62	37.8	2343.6

Fig: 5.3.1(a)



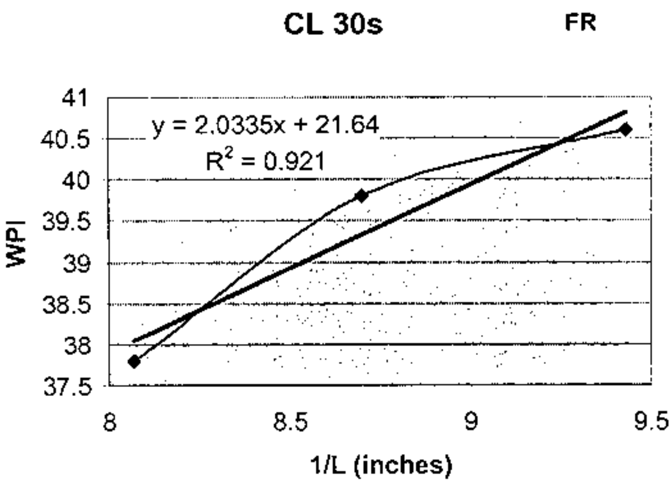
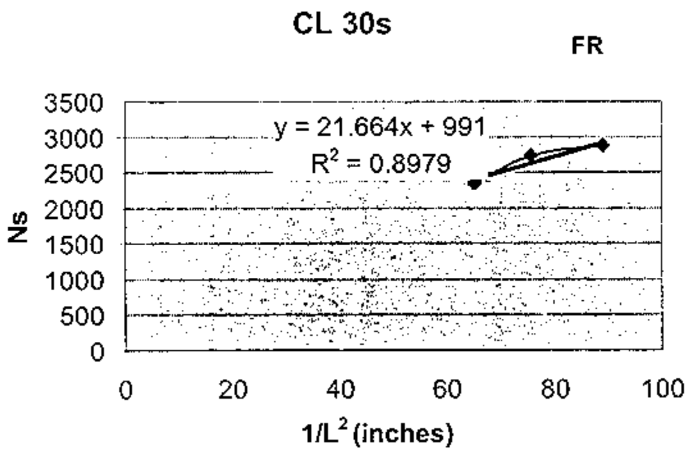


Fig: 5.3.1(c)



From the above information we know that CPI and WPI varies linearly with the loop length.

The obtained constants are,

Kc=6.3798

Kw=2.0335

Table: 5.3.2

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
CL.40.1	2.6	76.2	45.6	3474.72
CL.40.2	2.9	66.4	40.4	2682.56
CL.40.3	3.2	58.4	39.4	2300.96

Fig: 5.3.2(a)

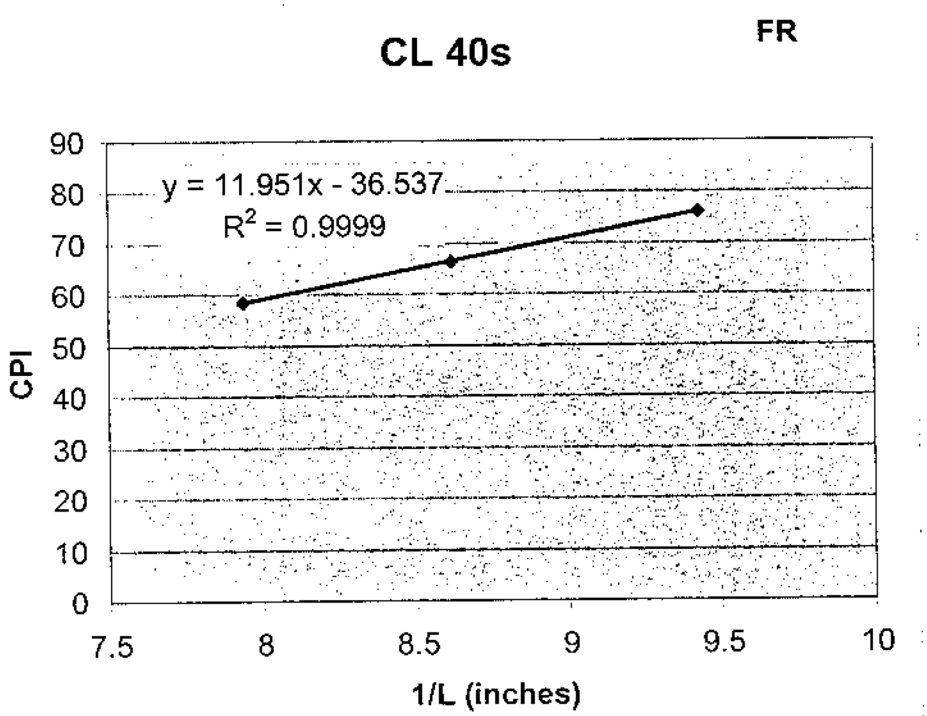
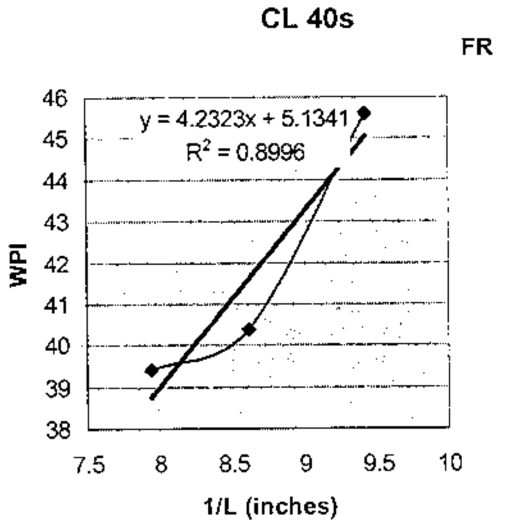


Fig: 5.3.2(b)



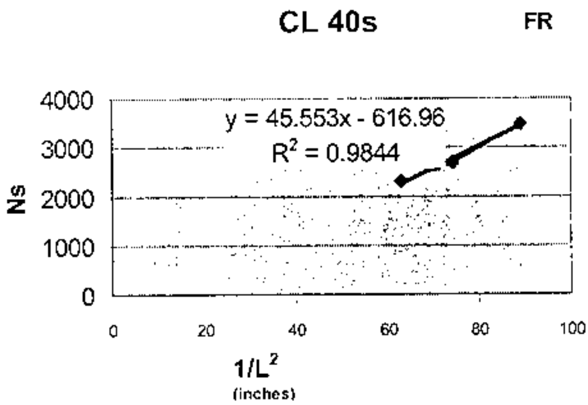


Fig:5.3.2(c)

From the above information we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=11.951

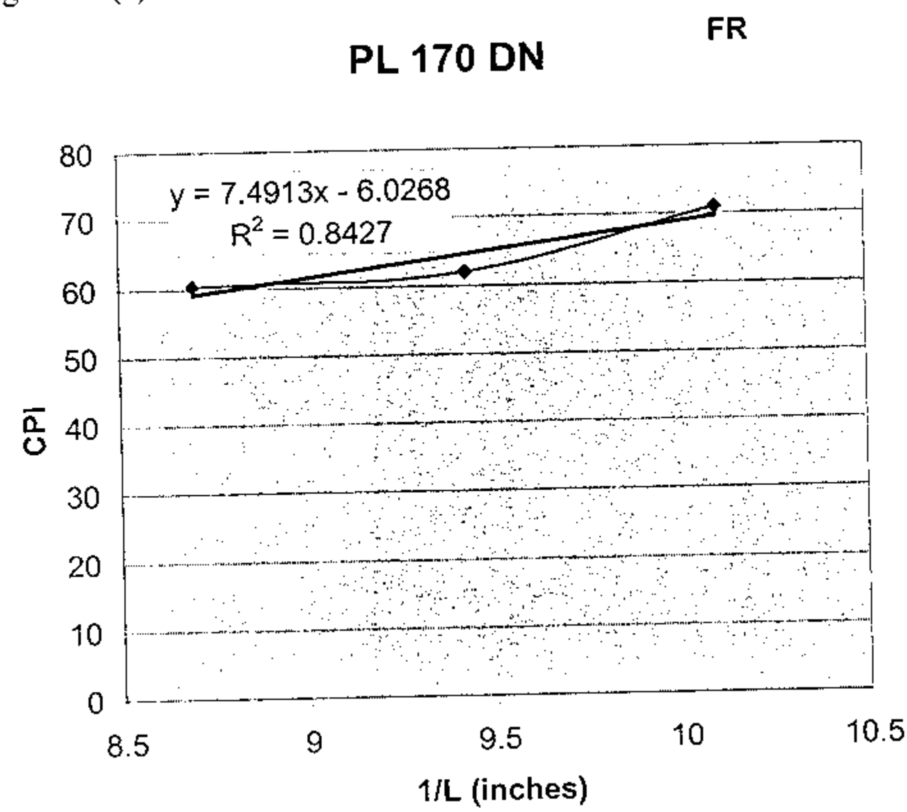
Kw=4.2323

PL 170 DN:

Table: 5.3.3

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.170.1	2.7	71	41	2911
PL.170.2	2.9	62	40	2480
PL.170.3	3.1	60.4	38.6	2331.44

Fig: 5.3.3(a)



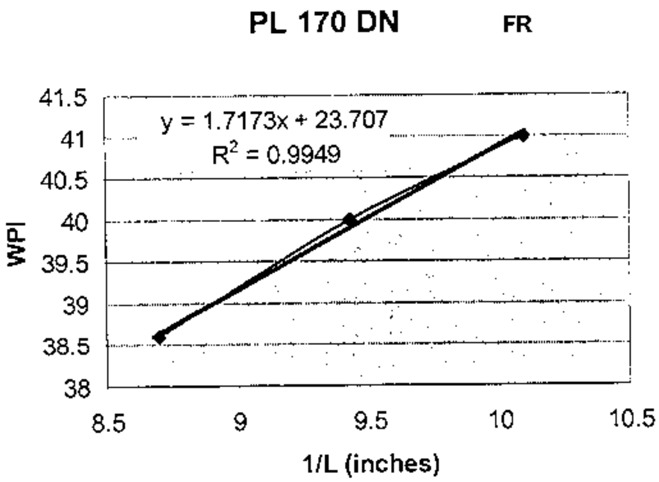
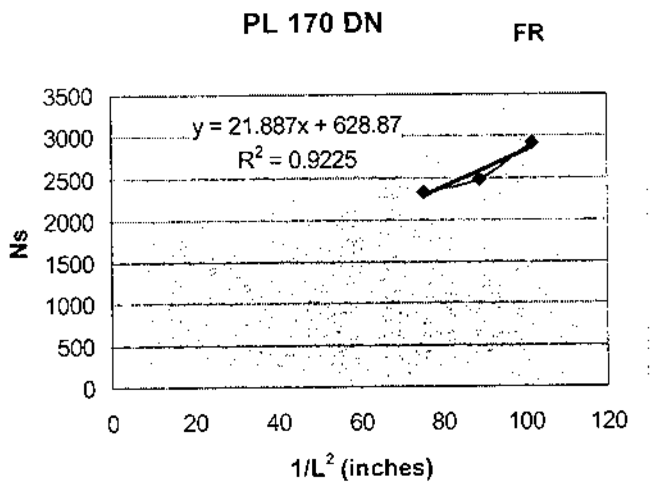


Fig: 5.3.3(c)



From the above results we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=7.4913

Kw=1.7173

Table: 5.3.4

SAMPLE NO	LOOP LENGTH (mm)	CPI	WPI	Ns
PL.97.1	2.5	84	52	4368
PL.97.2	2.7	81	50.6	4098.6
PL.97.3	2.9	79	49.6	3918.4
PL.97.4	3.1	63.6	49.6	3154.6

Fig: 5.3.4(a)

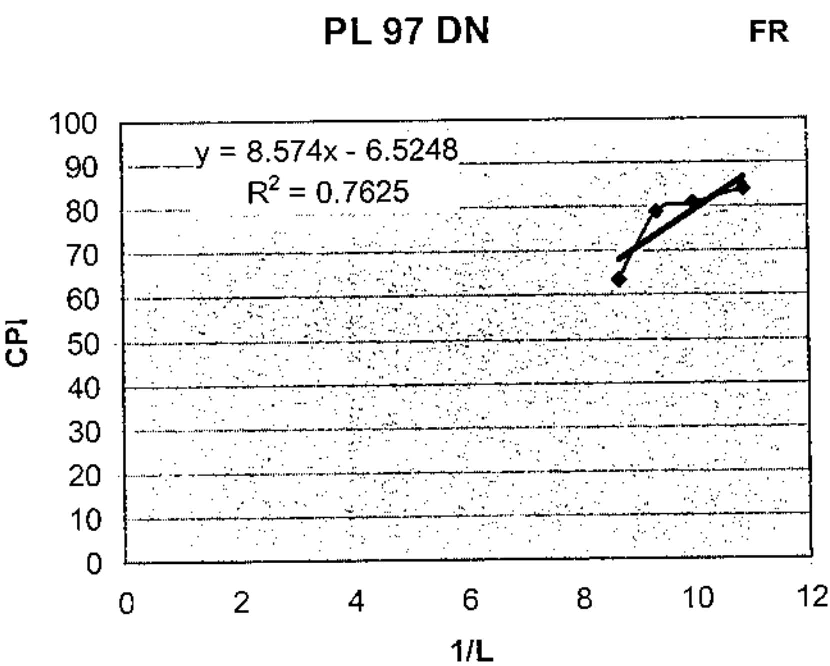
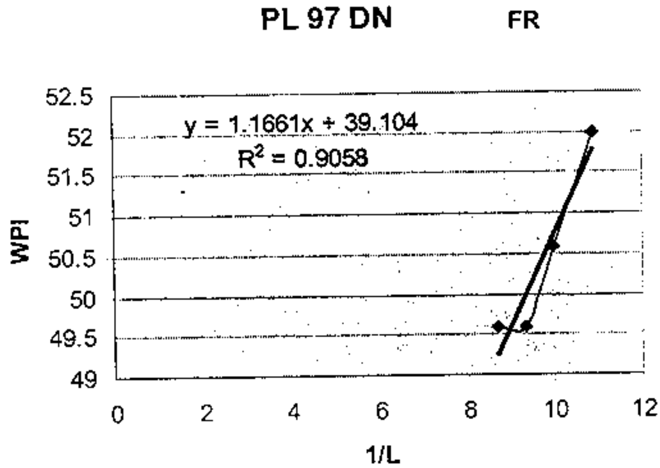


Fig: 5.3.4(b)



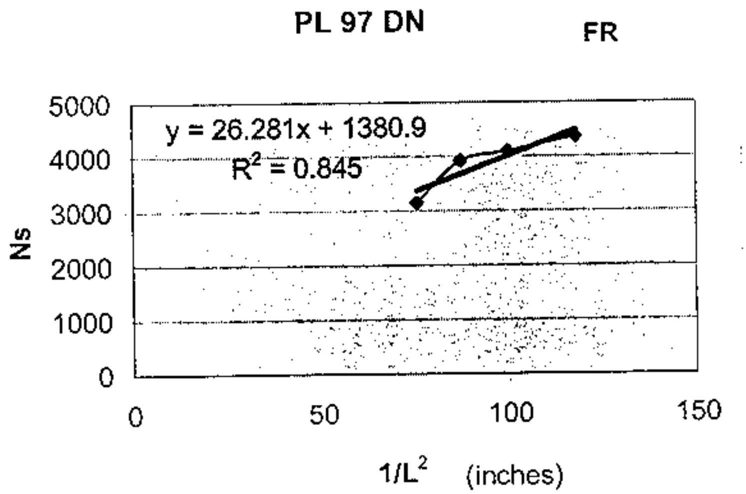


Fig: 5.3.4(c)

From the above information we know that CPI and WPI varies linearly with the loop length.

The obtained constant values are,

Kc=8.574

Kw=1.1661

6.CONCLUSION

From the results observed, we come to the conclusion that, when lycra is blended with cotton and polyester, the knitted fabric parameters such as CPI, WPI, and stitch density Ns are found to vary, following a linear equation with change in loop length.

The experimental samples of cotton lycra 30s and 40s, after getting dry and wet relaxed comes up with the conclusion that as their loop length varies their CPI, WPI and Ns also varies and obviously follows a linear equation.

The polyester lycra samples are also found to follow the cotton lycra samples after wet and dry relaxation, with their loop length varying linearly with change in CPI , WPI and Ns.

The corresponding linear equations foolowed by the parameters of both the samples are given in Results and Discussions (Chapter 5).

One of the other conclusions is that shrinkage analysis on the fully relaxed samples shows zero percentage shrinkage in both the cotton lycra and polyester lycra samples.


SITRA

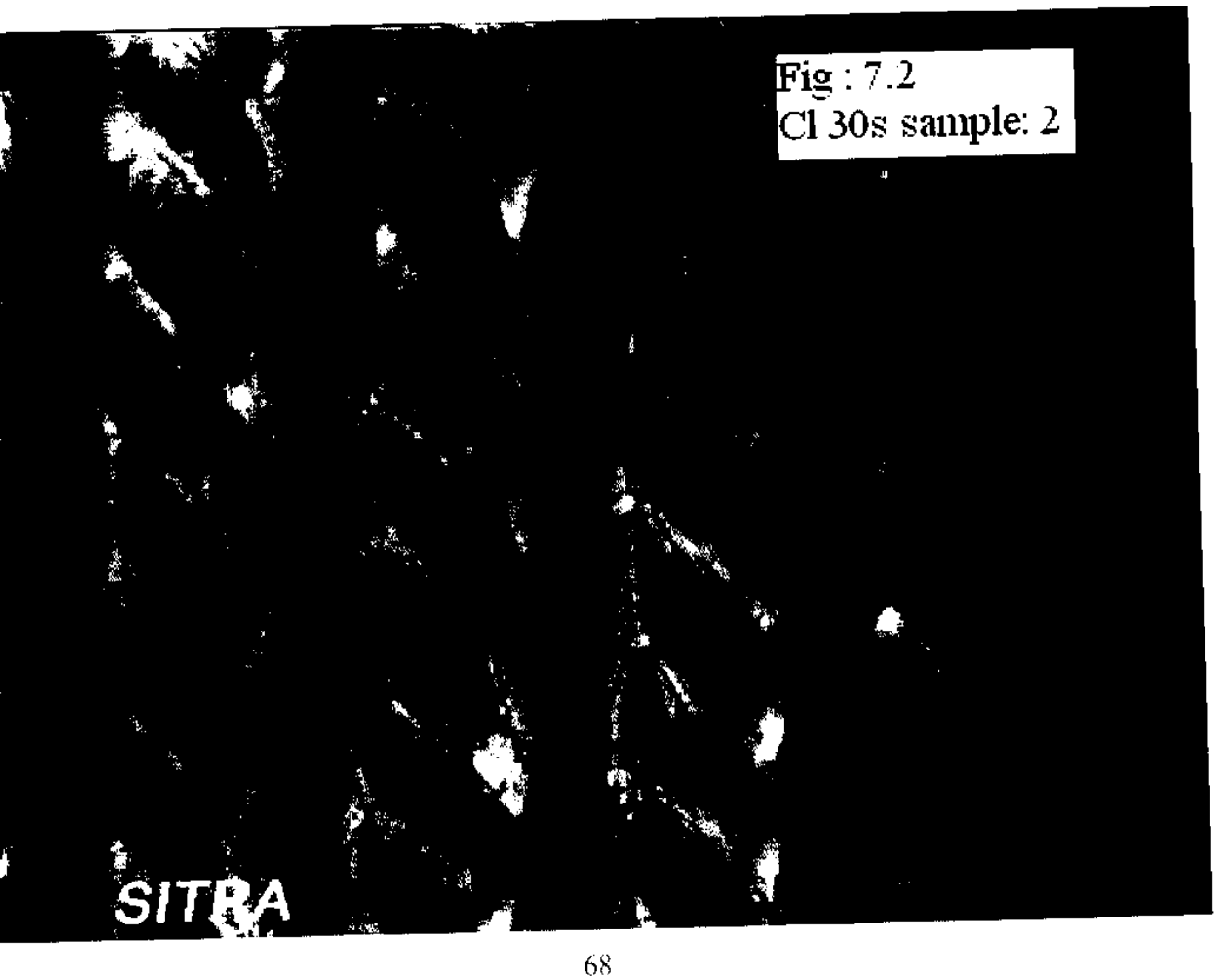
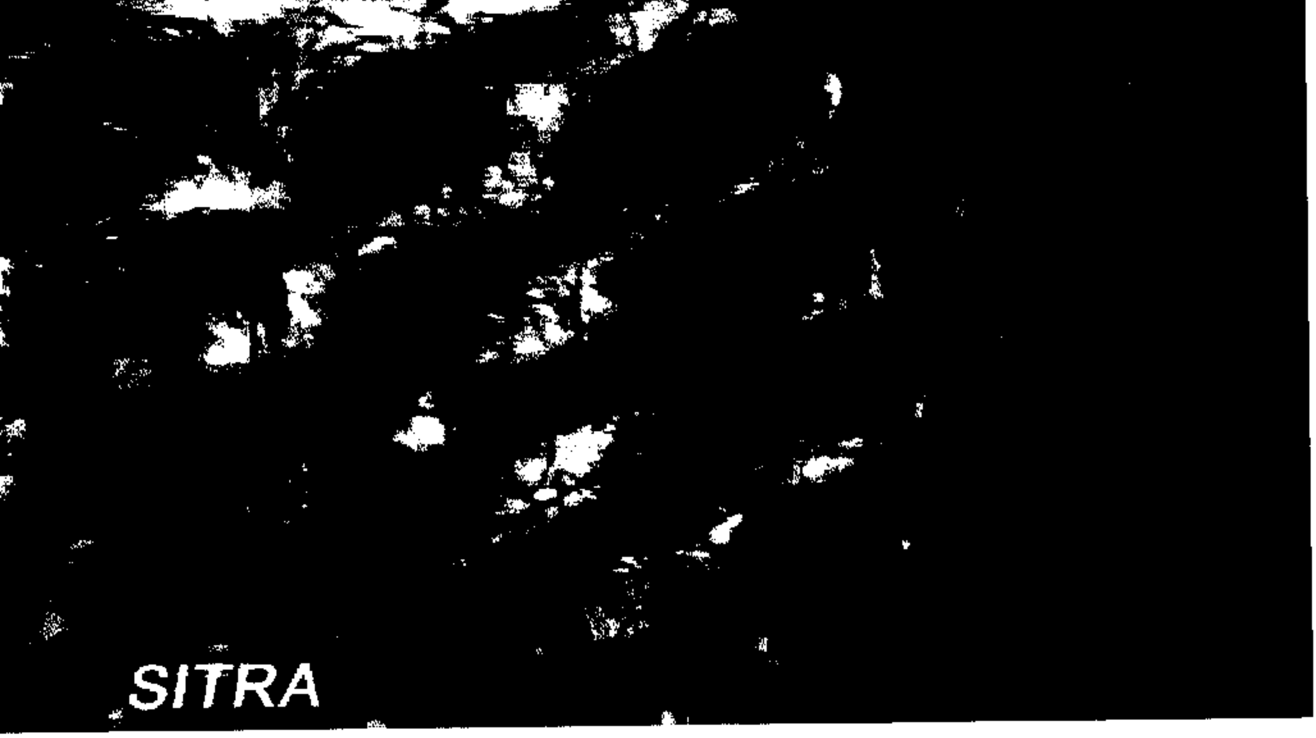


Fig : 7.2
Cl 30s sample: 2
SITRA



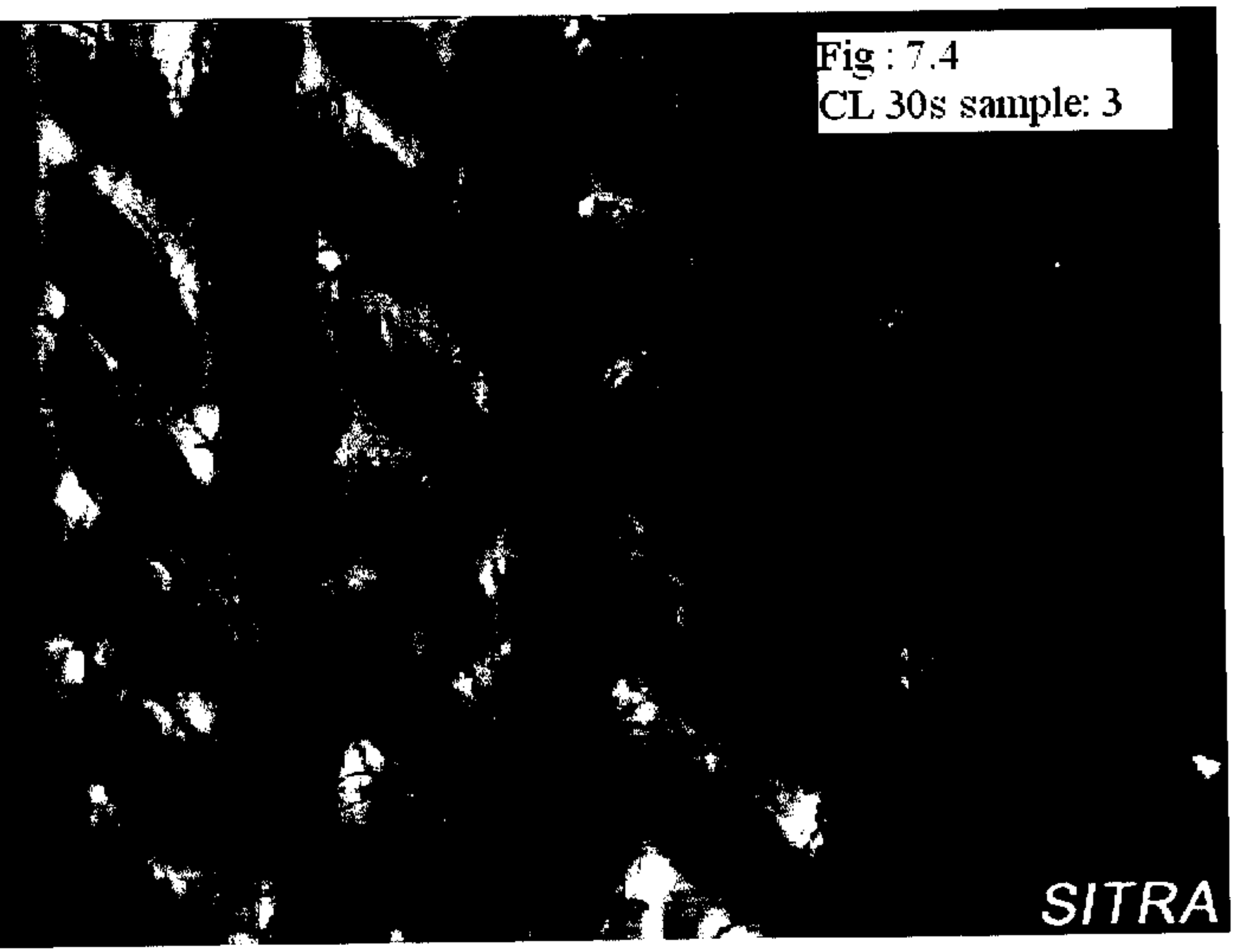
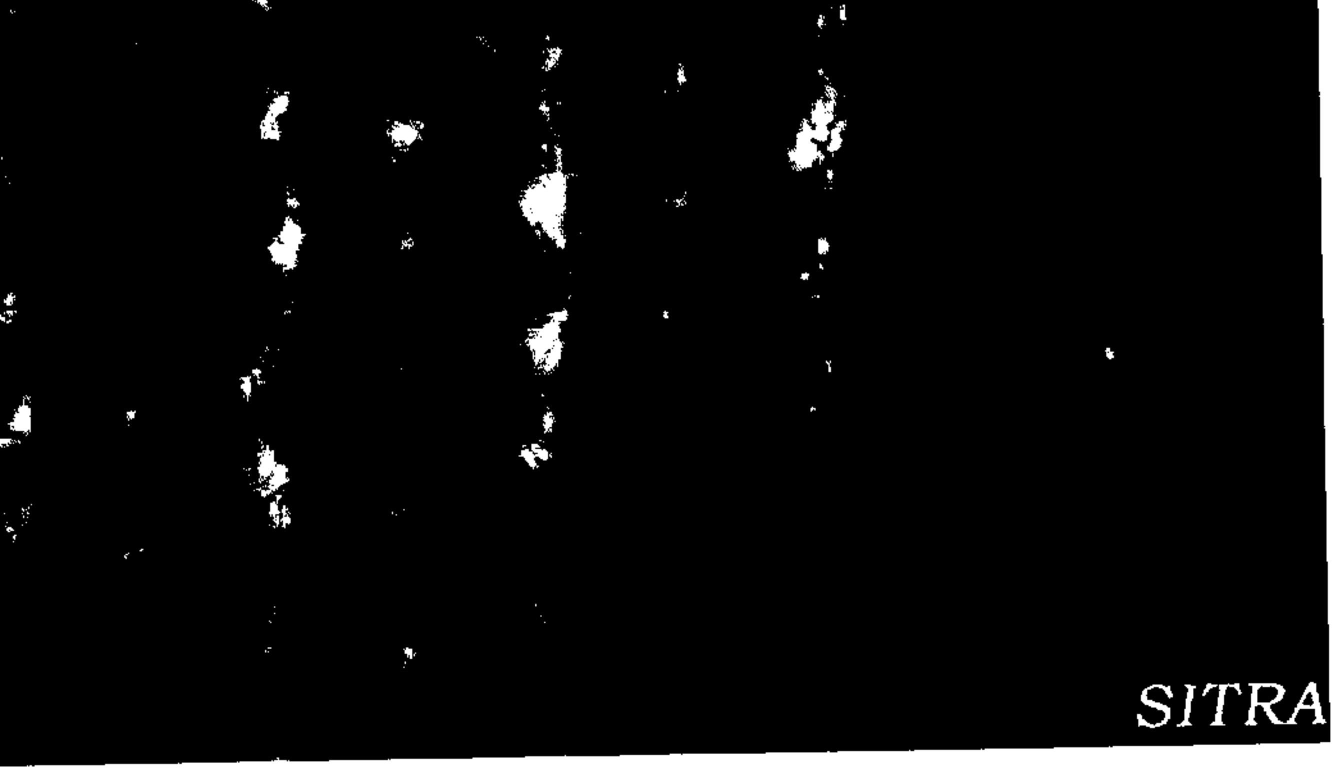


Fig : 7.4
CL 30s sample: 3



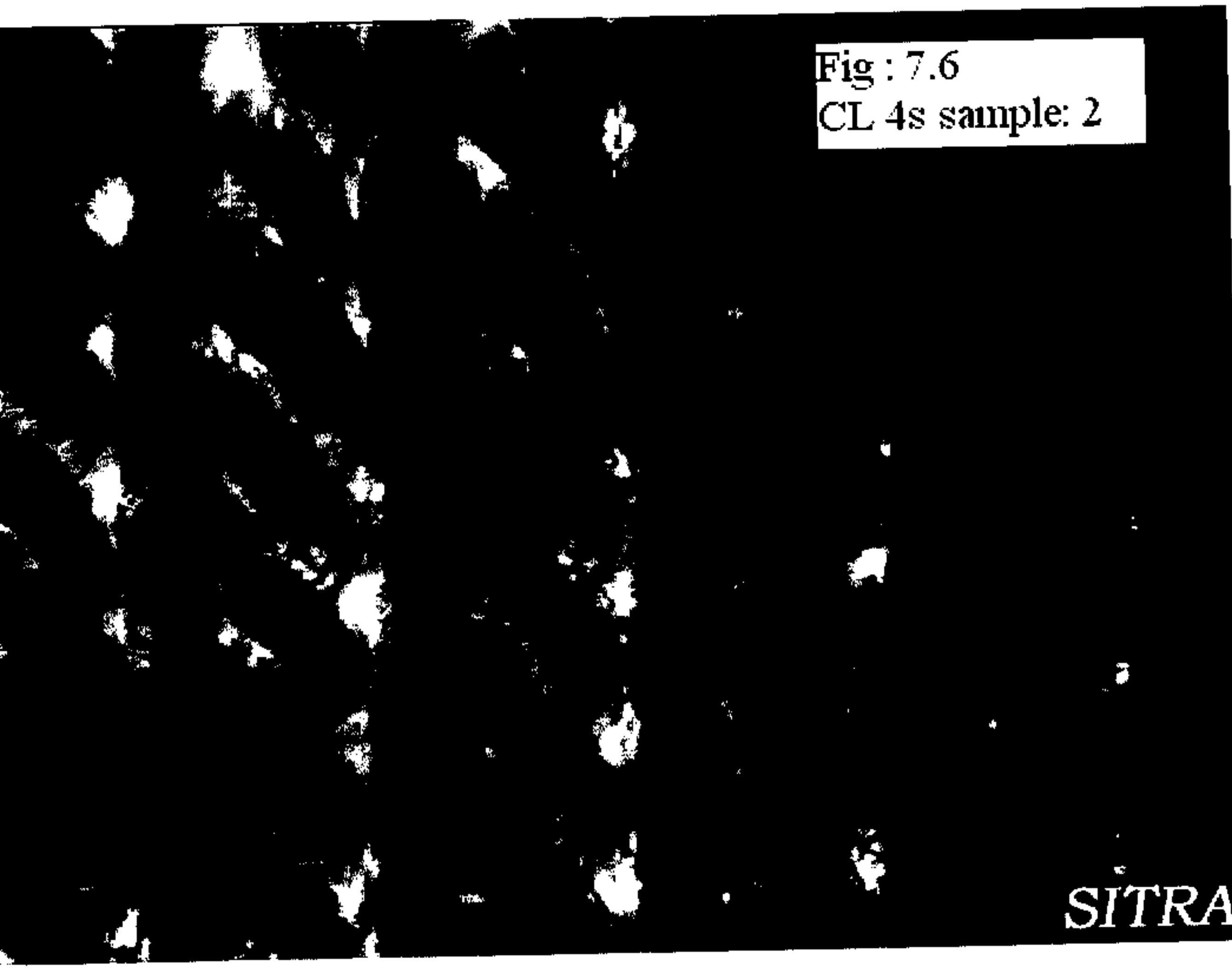


Fig : 7.6
CL 4s sample: 2

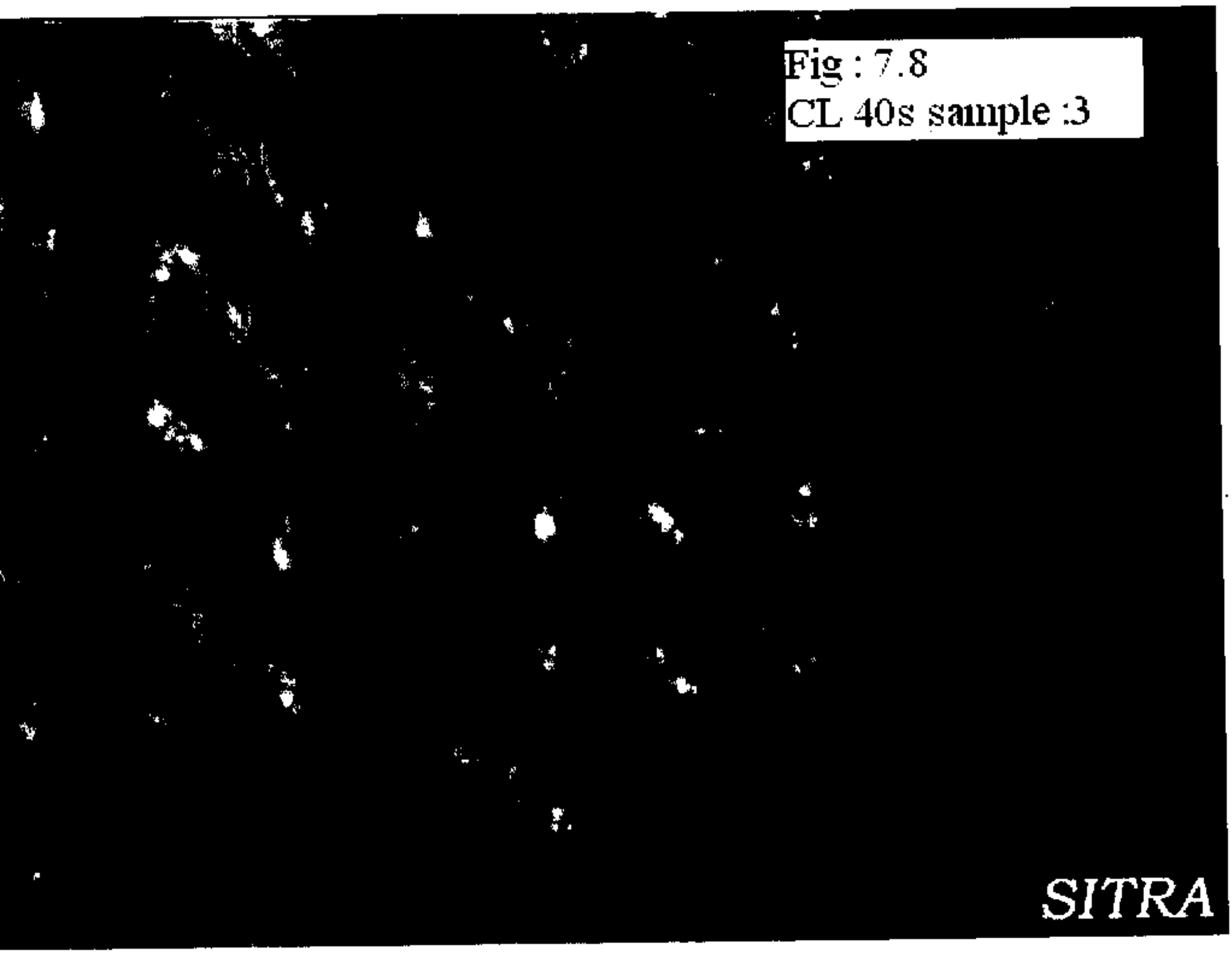
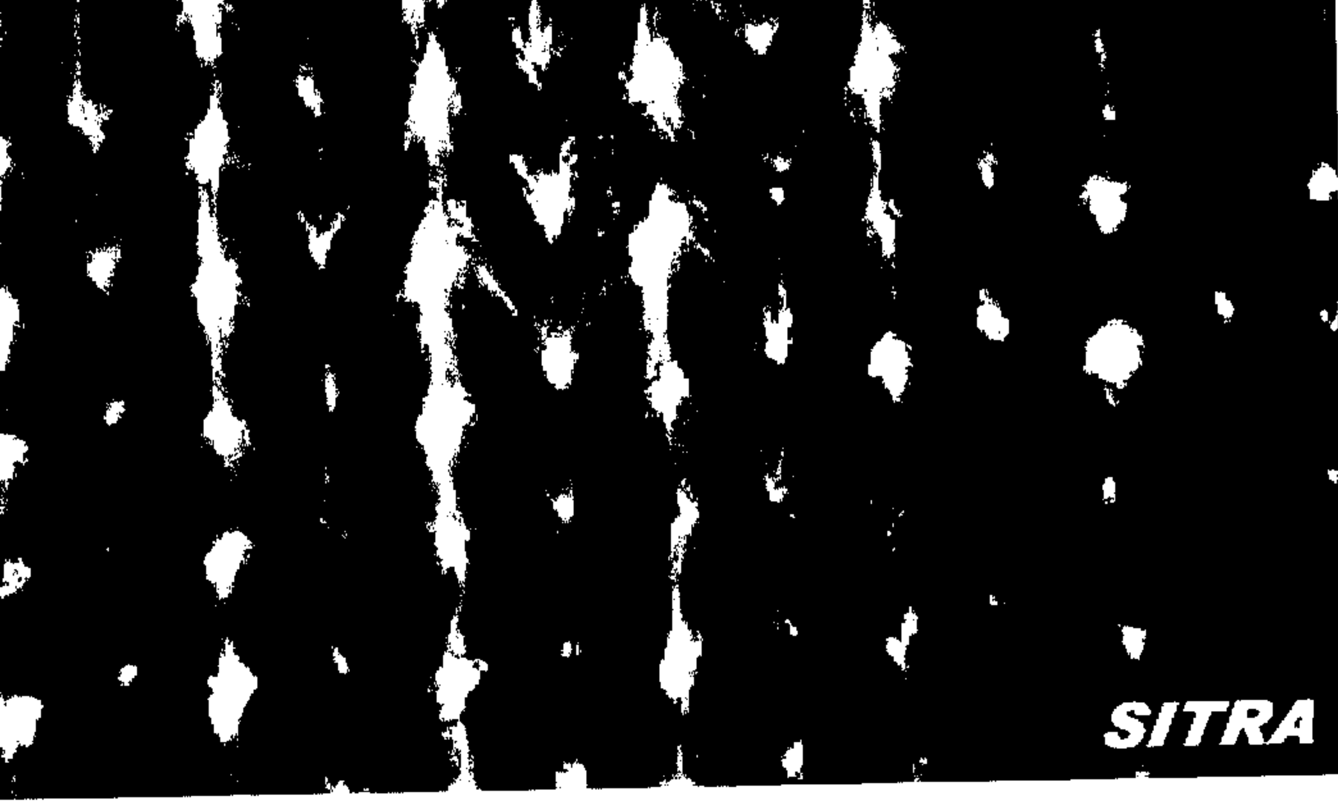


Fig : 7.8
CL 40s sample :3



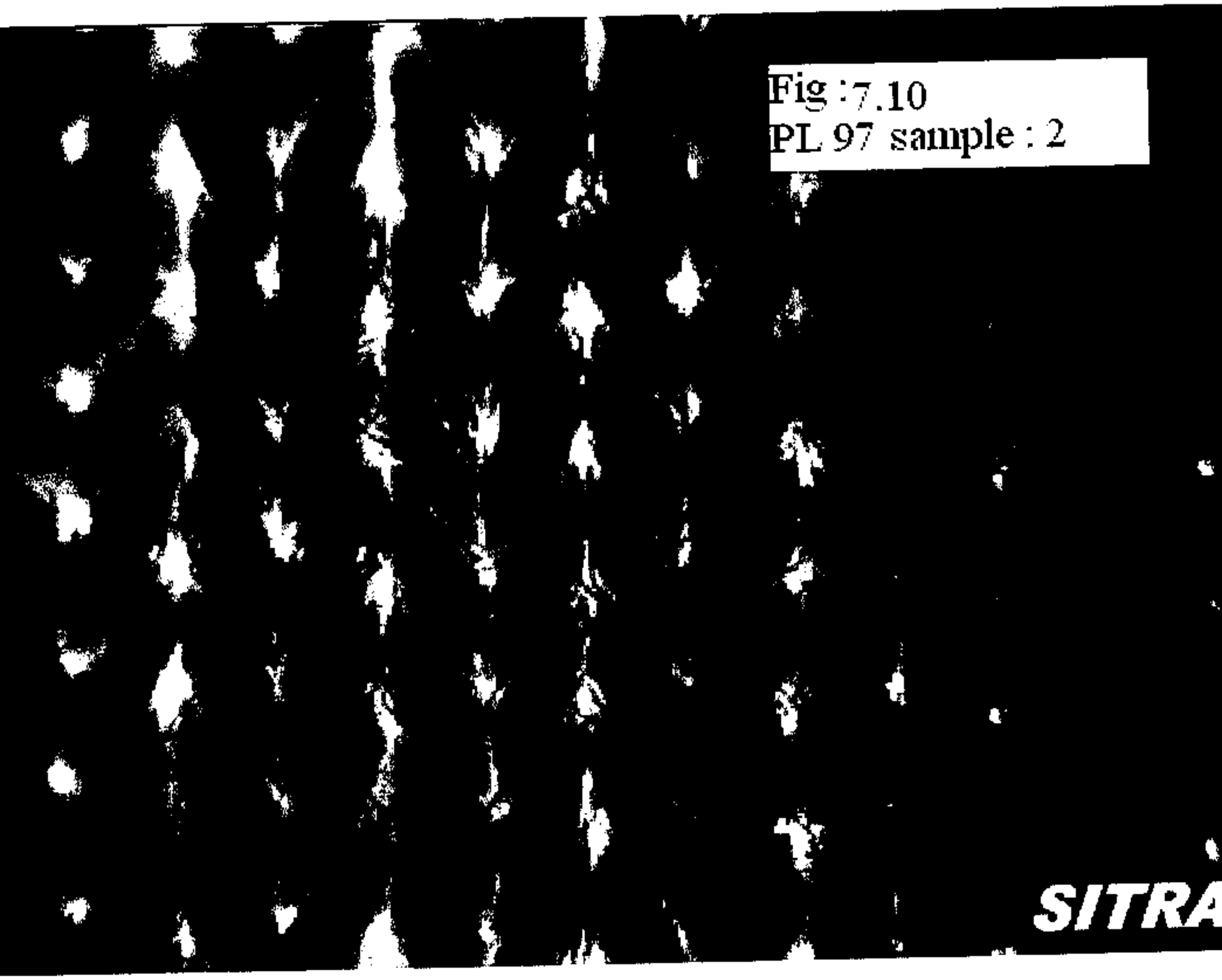


Fig :7.10
PL 97 sample : 2

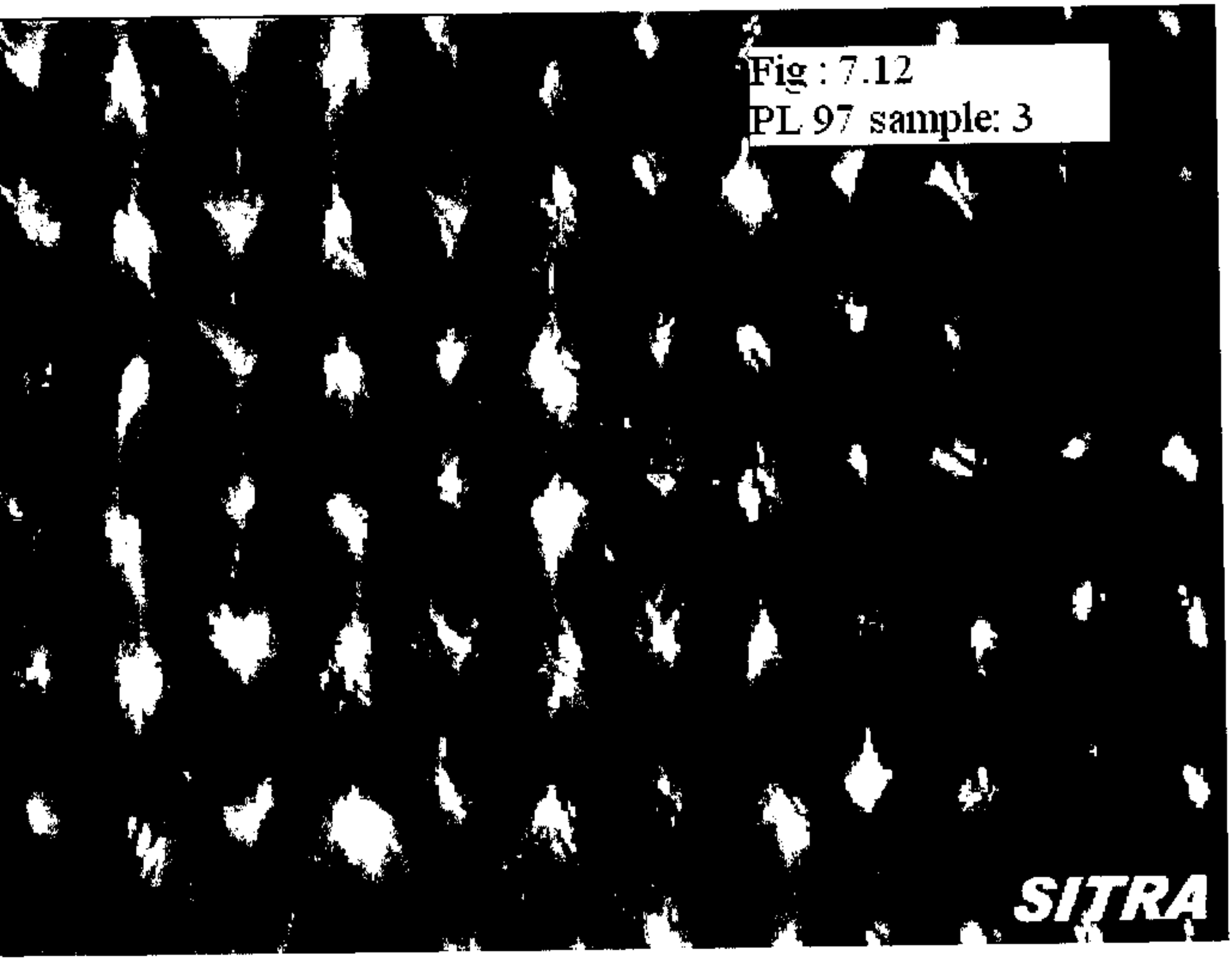
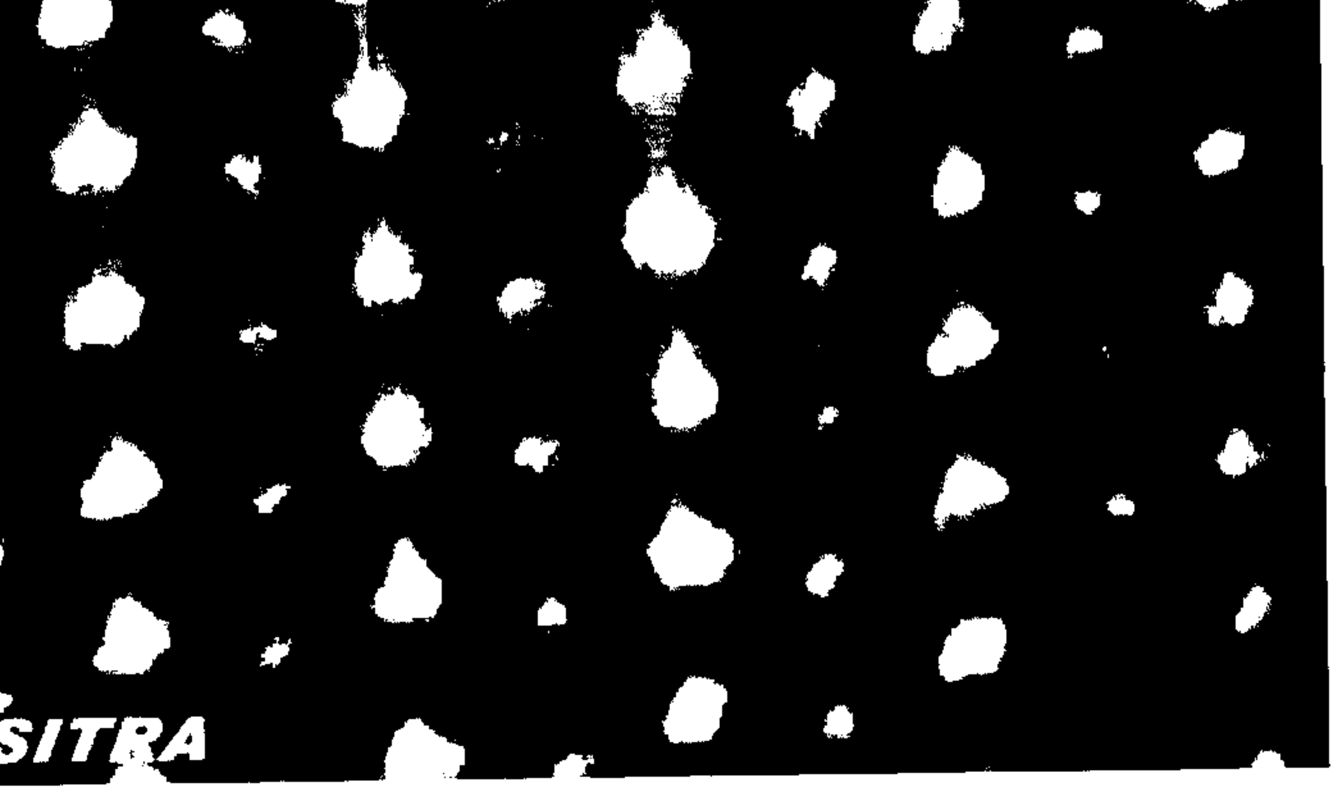


Fig : 7.12
PL 97 sample: 3



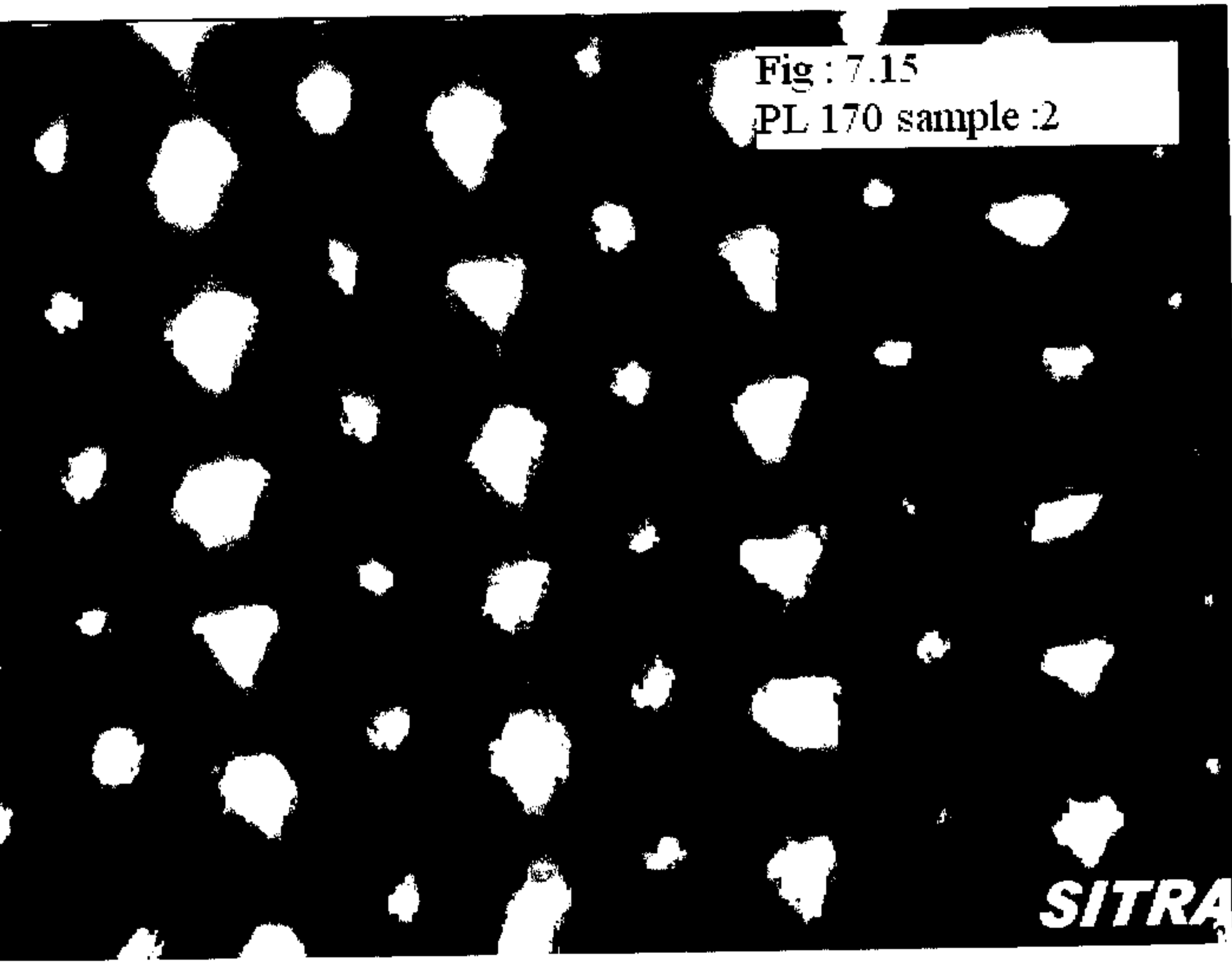
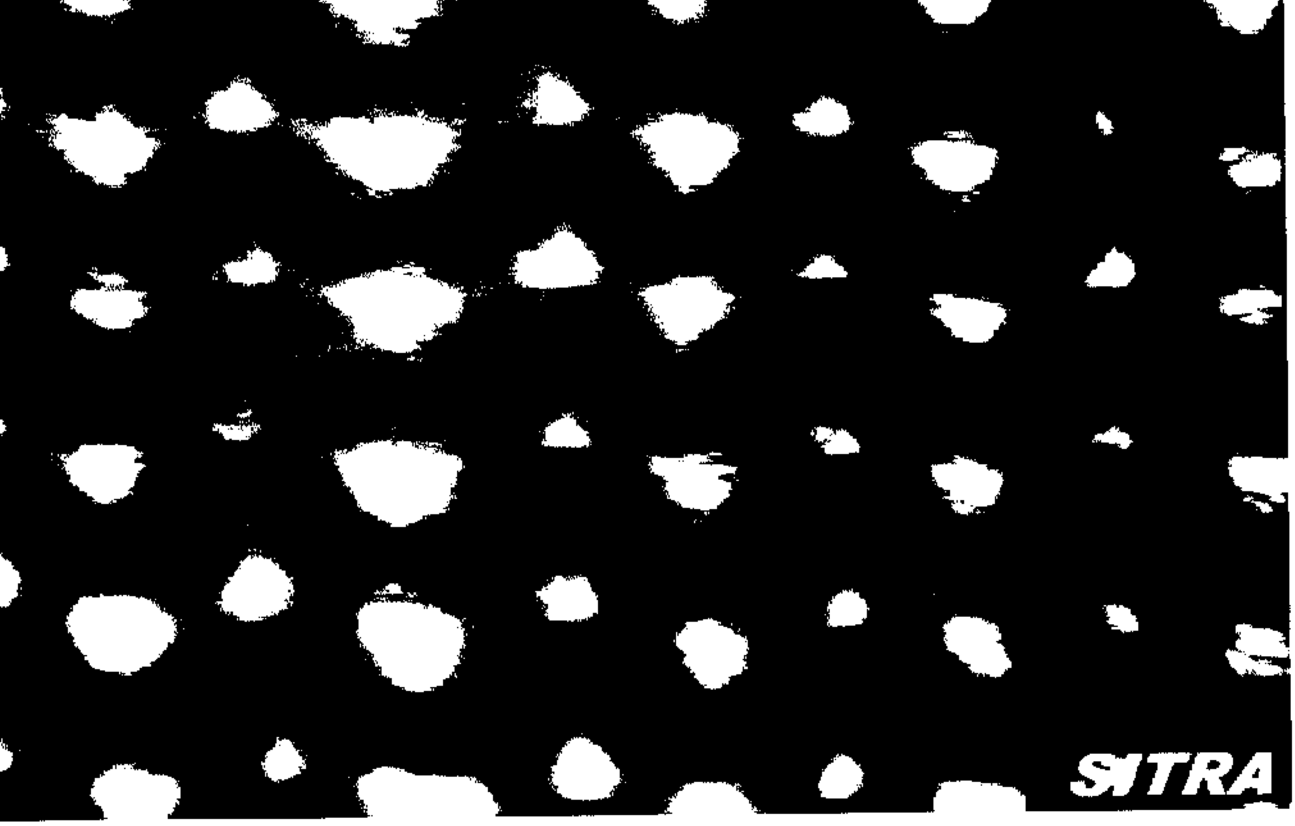


Fig : 7.15
PL 170 sample :2



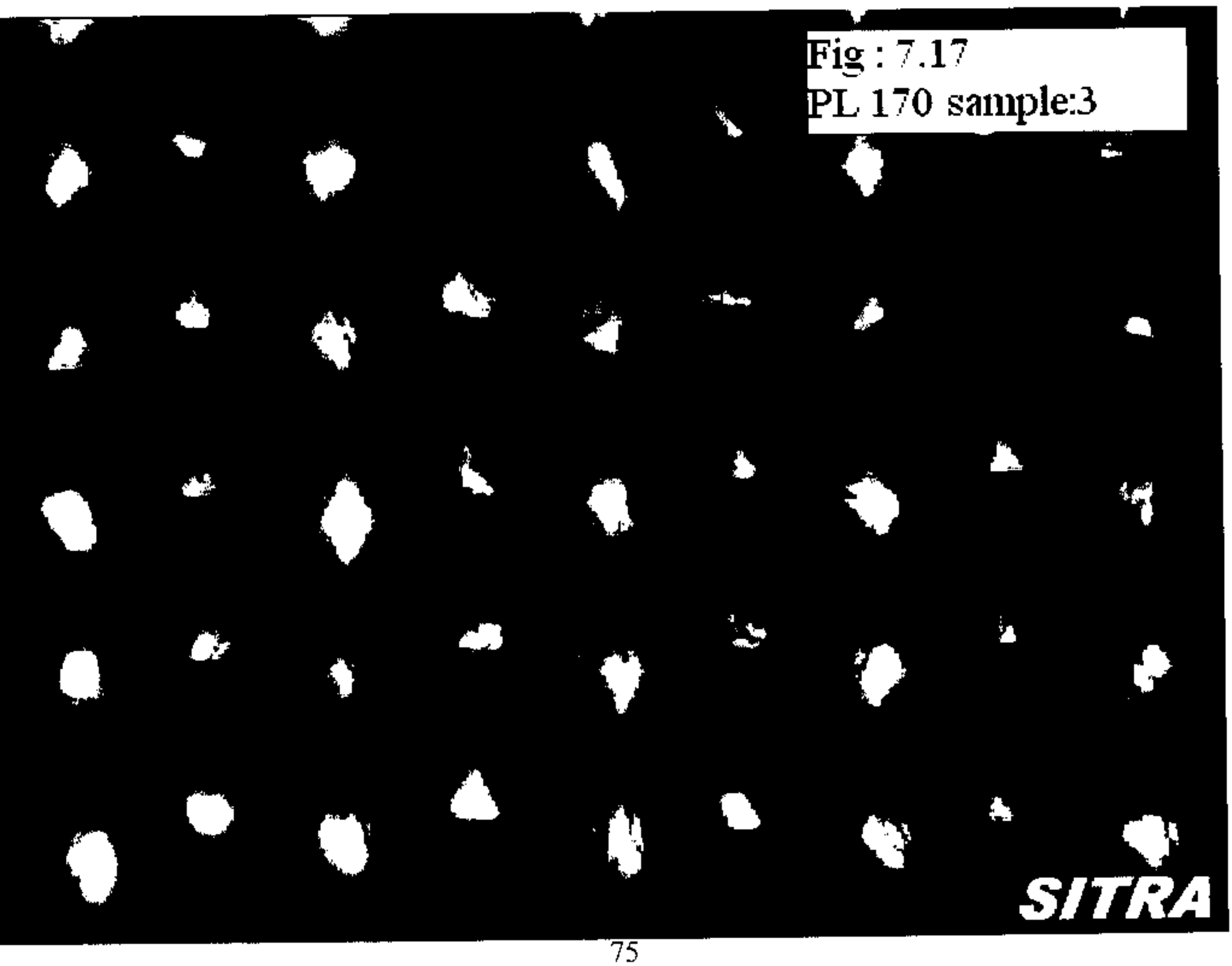
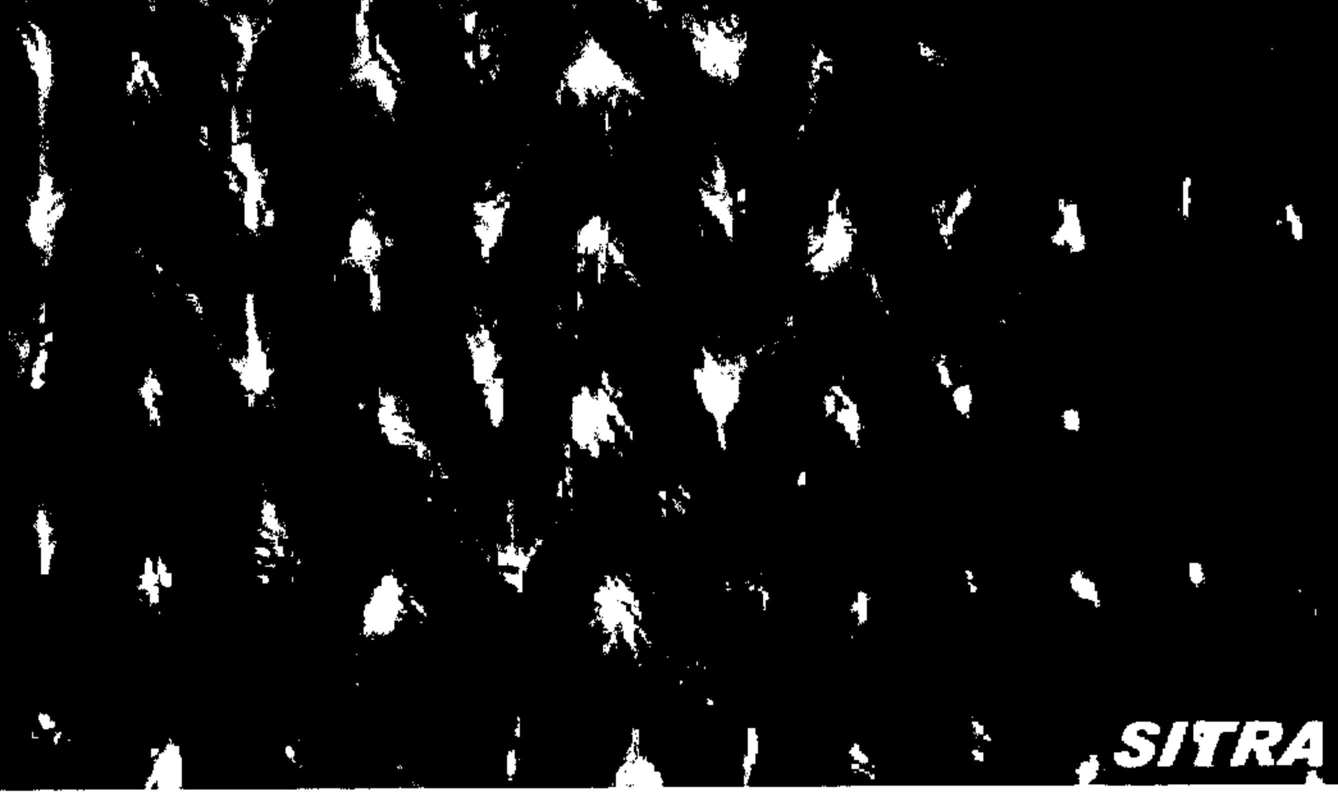


Fig : 7.17
PL 170 sample:3



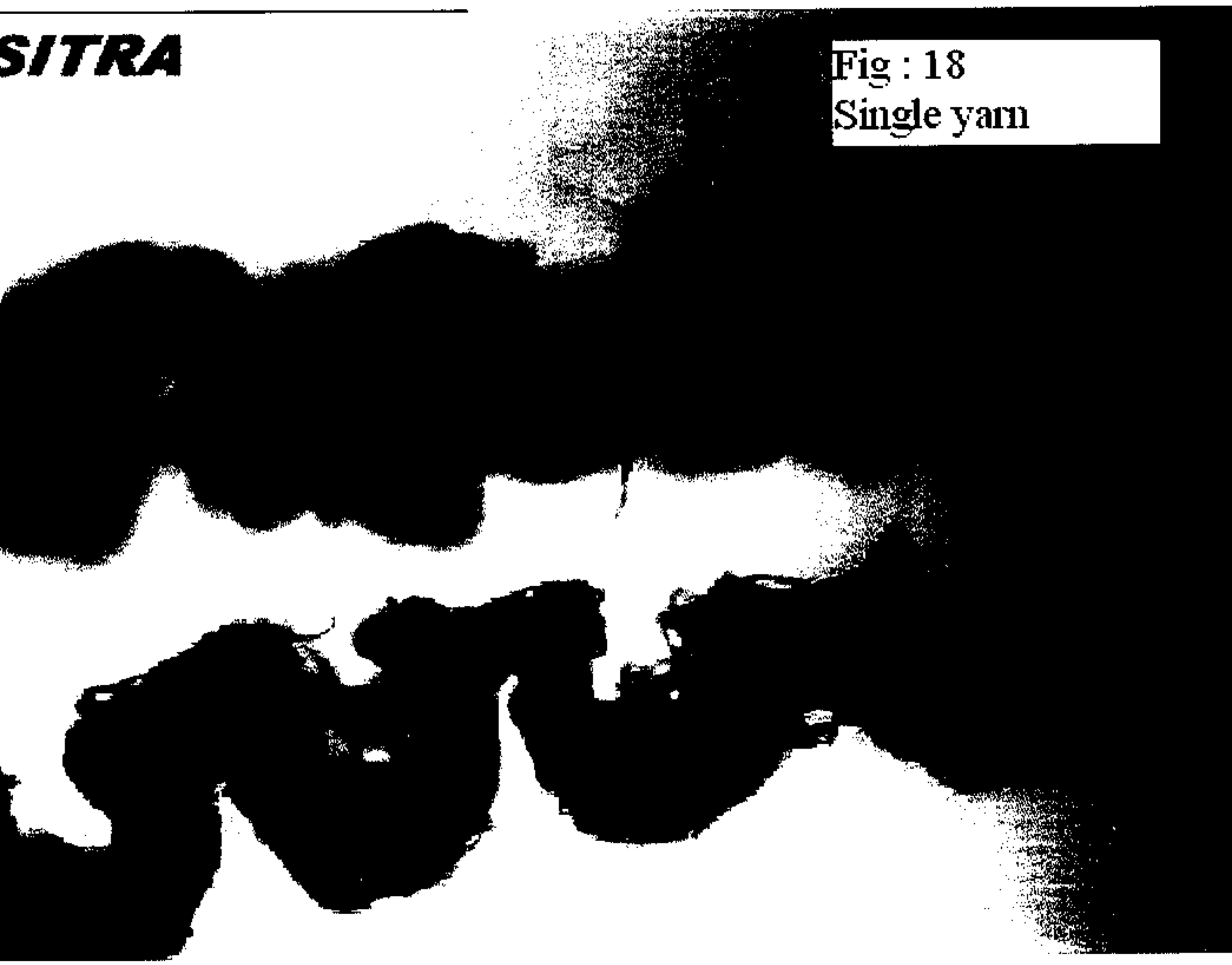


Fig : 18
Single yarn

REFERENCES

1. Munden D.L. 'Dimensional Stability of plain-knit fabrics'. Journal of textile institute. P: 200

2. Munden D.L. 'The Geometry and Dimensional Properties of Plain-knit fabrics. Journal of textile institute. P: 448

3. Hazel M. Fletcher, and Helen Roberts S.(July 1952) 'The Geometry of knit Fabrics made of staple rayon and nylon And its relationship to Shrinkage in laundering'. Textile Research Journal. P: 466.

4. Leaf G.A.V, and Glaskin A. 'The geometry of plain knitted loop'.

5. Leaf G.A.V.(Aug 1961) ' The stresses in a plain knitted loop'. Journal of the Textile Institute. Vol 52 No 8. P: T352

6. Knapton J.J.F, (oct 1968) Ahrens F.J, Ingenthron W.W, and Fong W. 'The Dimensional properties of knitted wool fabrics'. Part 1: The plain knitted structure. Textile Research Journal. P: 999.

7. Knapton J.J.F, (oct 1968) Ahrens F.J, Ingenthron W.W, and Fong W. 'The Dimensional properties of knitted wool fabrics'. Part 2: 1x1, 2x2 Rib, and Half-Cardigan Structures. Textile Research Journal.

8. Knapton J.J.F, and Truter E.V (1975), and Aziz A.K.M.A. The Geometry, Dimensional properties and stabilization of the cotton-plain jersey structure'. Journal of Textile Institute Vol No 12, P: 413.

9. Monica szabo and Mircea Bucur (May 2003) 'Dimensional Stability of Jersey Cotton knitted Structures'. Textile Asia. P: 26.