Influence of Yarn Properties on the Characteristics of Weft Knitted Fabrics

Project Work

Submitted By

S.Sakthivel
N.Sandeep
D.Sathyamoorthy
S.Shyamchandkumar

Under the guidance of
Dr.J.Srinivasan M.Tech., Ph.D.,
Assistant Professor

CHARACTER IS LIFE

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Department of Textile Technology

Kumaraguru College Of Technology
Coimbatore – 641006.

Certificate

Department of Textile Technology
Kumaraguru College of Technology
Coimbatore – 641 006.

PROJECT WORK 2000-2001

University Register No...
Name.......................................Roll No.......................

Certified that this is Bonafide Record of the Project Work Done by

Mr...

In Partial Fulfillment for the Degree of Bachelor of Technology in Textile Technology Branch of the Bharathiyar University

....

Head of the Department **Faculty Guide**

Place :

Date :

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....

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Internal Examiner **External Examiner**

Synopsis

SYNOPSIS

This project is a methodical study about the influence ot the most prominent yarn properties on the characteristics of knitted fabrics. This project gives a clear idea about the varioations that occur in the performance characteristics of the knitted fabric due to the changes in the properties of the respective yarns from which the fabrics are knitted. This project was selected based on its importance in the present scenario and also the benefits it can provide to the fast growing knitting industry.

Three different counts of yarn were selected for study. The yarns were tested for their respective values of Count Strength Product, Uster unevenness% and Twist per inch. Twenty packages for each count were subjected to tests and the results were condensed. The tested yarn packages were used to knit two different types of fabrics i.e, Single jersey and interlock. As known we ended up with six fabric samples, two from each count.

The knitted fabric samples were made into two halves and one half of the samples was subjected to wet relaxation treatment and other half to dry relaxation treatment. The wet and dry relaxed fabrics

Dedicated

To

Our

Beloved

Parents

Acknowledgement

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Introduction

INTRODUCTION

The demand for knitted fabrics as outer wear is increasing rapidly in both domestic and export markets. The knitted made out of 100% cotton are most preferred by the consumers invariably because of its aesthetic properties and wearing comfort and also due to its superior qualities over the other man made and synthetic fibers.

Although the 100% cotton knitted fabrics show poor dimensional stability during washing they are preferred nowadays due to the fitness they provide and the comfort.

The properties of any fabric is attributed to the yarns from which they are made of. The knitted fabrics are no exemptions to this and they are more dependent on their constituent yarns and their properties.

The main yarn properties that are found to influence and effect a variation in the performance characteristics of the fabric and especially the knitted fabrics are the strength of the yarn, the amount of twist in the yarn, the unevenness in the yarn.

Small variations in these yarn properties are found to vary the various performance characteristics of the knitted fabrics in a noticable manner. Weft knitted fabrics are the most used ones in todays world. Although there are a few warp knitted fabrics also in use weft knitted ones find multifold usage and compared to the former.

The various fabric characteristics such as the abrasion resistance, bursting strength, drape, pilling resistance, stitch density, stretch, water retaining capability, thickness are found to be greatly influance by the yarn properties such as the count strength product, twist per inch, unevenness % etc.,

The project report is based on a detailed study conducted on the single jersey and interlock type of fabrics which are the most popularly used ones in the indian knitting industry and also have much difference in their constructions.

The special objective of the project is to provide the present knitters with statistical data which can help them to choose the yarns according to the fabric requirements in a selective manner.

In this study the yarn properties were tested using large number of samples and using the tested samples fabrics were knitted. The knitted fabrics were divided into two groups, One group of the fabrics were subjected to dry relaxation treatment. Ther other group of fabrics were subjected to wet relaxation treatment. Dry and Wet relaxed were tested seperatly for their individual characteristics. The variations that occured in the performance characteristics of both the dry and wet relaxed fabrics corresponding to the changes in the yarn properties were drawn out.

The dry and wet relaxed fabrics themselves have shown difference in their performance characteristics. This gives a rough idea about how the performance of these fabrics would be when they are new and when they are subjected to practical regular usage.

The results obtained show a regular trend between the variations in the yarn and the corresponding fabric characteristics.

Yarn Basics

2. YARN BASICS

The word yarn is derived from the Anglo-Saxon word gearn and resembles the word garn in the German and Scandinavian languages. The term is used to describe an assemblage of fibres or filaments, either natural or synthetic, that are twisted,plied, or otherwise laid together so as to form a continuos strand. Though the term yarn is applied to all fibrous threads, it is more commonly applied to a quantity of strands or threads. When a single thread or piece of yarn is considered, it is usually spoken of as a thread or an end.

A yarn composed of several ends twisted together to form a strand of considerable bulk, is termed cable or cord. Contrary to the custom in the spinning and weaving industry, where the word thread is synonymons with end, the clothing and sewing industry uses the word thread to describe the thin, twisted yarns used for sewing.

Common yarns may therefore be divided roughly into cotton spun yarn, woolen and worsted spun yarn, and thrown or filament yarn. There are certain yarns, made for special purposes, that cannot be grouped among common yarns.

Man-Made Fibres : Synthetic fibers were developed in recent times and are strictly a product of the twentieth century. Yarn spinning processess were originally developed to suit the raw material, such as cotton, wool, silk, and other natural fibers. Rayon an artificial product, was produced at first to imitate silk, the fiber being made to fit, as nearly as possible, the existing silk machinery. When rayon moved into cotton territory, cotton machinery waws used. Here it was a matter of compromise, with rayon being adapted to cotton machinery, and the machinery being adapted to rayon. Rayon staple with crimps, has been adapted to the woolen and worsted systems of spinning.

Spinning and Throwing : All cottona and woolen yarns are spun, the variation in the different kinds depending upon the extent to which the fibers have been straightened out and put parallel in the spinning process. Filament rayon and silk yarns are thrown; that is, the yarns consist of endless, consecutive filaments which are doubled, wound and twisted. Thrown rayon yarn must not be confused with spun rayon, which consisits of short lengths of rayon filament spun like cotton or wool.

In the manufacture of rayon fibers a liquid material is solidified into filaments. This chemical process may be called spinnin, in the same sense as the activity of a silk worm or a spider may be called spinning. However, only when the rayon has been converted into short fibers and then spun, it is called spun rayon.

Yarns for Knitting

3. YARNS FOR KNITTING

3.1 Fibres Used in Knitting

Yarns used for knitting belong to either of the two main groups of fibres viz., (i) Natural fibres and (ii) Man-made fibres. Natural fibres are obtained either from vegetable, animal or mineral source.

(1) Vegetable Source	(i) Cotton (ii) Flax (iii) Jute (iv) Manila (v) Coir, etc.
(2) Animal Source	(i) Silk (ii) Wool (iii) Camel Hair (iv) Mohair
(3) Mineral Source	(i) Asbestos (ii) Glass.

Man-made fibres may be divided into two categories :

1. Regenarated cellulosic fibres.

   Regenerated cellulosic fibres : (i) Viscose rayon (ii) Acetate rayon (iii) Cuprammonium rayon.

2. Synthetic man-made fibres

   Synthetic man-made fibres : (i) Polyamides like Nylon (ii) Polyester (iii) Acrylonitriles like Acrylic (iv) Polyurethane like Spandex (v) Polypropylene (vi) Polyethylene, etc.

Only a few of the above listed fibres are used in knitting. Others are not even suitable for knitting them into fabrics. It is therefore, intended to discuss in brief the physical and functional properties of those fibres only which are most commonly used in the knitting indsutry.

3.2 Major Types of Yarns

3.2.1 Cotton :

Till the innovations and recent developments of man-made fibres, the most common yarns used in weft knitting were made either from wool or cotton, though silk was also used to a very small extent in stockings. 'King Cotton' is still used in weft knitting as a major fibre and its main field of application is in hosiery and intimate apparel fabrics. To some extent it is used in knitted sports shirts and blouses but now the knitters prefer a blend of cotton-polyster to pure cotton yarns and the proportion of the use of cotton in knitting is declining.

Cotton is soft and comfortable next to the skin. It readily abosorbs perspiraton and carries it away from the body. It is also a good conductor of heat. It can be used in tropical as well as in cold climate countries, if fabrics are properly constructed. Its peculiar characteristic is that its strength increase by about 25 percent when wet. This is significant for apparel fabrics, as garments are subjected to very severe strains when wet during laundering. Cotton fabrics are easy to sew and the seams hold tight. It is by far the least expensive though not necessarily the cheapest. Cotton has very little natural elasticity and has a tendency to wrinkle. It lacks appreciable resilencee. Though it absorbs water well, it does not dry very quickly. It shrinks considerably when wet. It has a good affinity for almost all types of dyes and retains dyes better if mercertised cotton is used. Cotton yarns for knitting are either carded or combed but preferably combed cotton yarns are used. Combed yarns are obtained by removing the short fibres ane foreign matter from the fibres and fibres are straightened to a large extent in combing process. Therefore, the combed yarns are stronger, less hairy and more uniform and more lustrous in appearance which are the desired properties of yarns in knitting. Usually long staple cotton (staple length = 45 to 55 mm) are combed. As hoisery yarns are required for soft-surfaced garments, worn next to the skin less amount of twist than that required for weaving yarns is given to yarns for knitting. They are called soft-twisted yarns. Cotton yarns are generally waxed for weft knitting so that needles will not break frequently and yarn will not become hairy due to friction.

3.2.2. Wool :

Wool was the foremost natural fibre used in knitting industry. Even today sweaters and other outer garments including men's suitings are knitted with woollen or worsted yarns. Woollen yarns are commonly used in hand-knitting all over the world.

Wool is a very coarse fibre and breeding of the sheep and the production of the wool fibre into fabric is more costly process than cultivation of plant fibre. Long-continued selective breeding is required to develop into soft and fleecy wool of good variety; but wool provides warmth and physical comforts that cotton fabric cannot give. As sufficient supply of new or virgin wool to take care of increasing demand is not available, wool fibres have had to be recovered from old clothings, rags, smaple swatches. Such wool is known in the textile industry as 'shoddy' wool.

Wool fibre has a peculiar outer layer called epidermis which has scales or flattened plates ranging from 40 to 160 per mm. These scales are responsible for its cohesiveness quality. The wool fibre is wavy in structure unlike other natural fibres and the waviness is greater in finer varieties of wool. The natural crimp of the wool fibre enables the fibres to cling tenaciously to each other and it is therefore possible to make a relatively strong yarn from wool fibres without much twist. Pressure, heat and moisture can convert and woolen web into a 'felt' fabric. High absorptivity of water is another characteristic of the wool fibre. Wool is the weakest fibre as far as strength is concedrned but its elasticity compensates its relative weakness. The fibre may be stretched to 25 percent of its natural length before breaking. It has also a high degree of resilience which is responsible for its wrinkle-resistant property.

Just as from cotton fibres, carded and combed yarns are manufactured, woollen and worsted yarns are manufactured from wool fibres The difference between woollen and worsted yarns can be summarised as follows :

Woolen yarns are obtained from short staple fibres while worsteds are obtained from uniformly selected long fibres, and as such the sorsted yarns are stronger. Woollen yarns are only carded while worsted yarns are carded and combed. Low twist is given to the woollen yarns while high twist is given to the worsted yarns. Worsted yarns are therefore harder, finer and less hairy than woollen yarns.

Wool fibre canbe easily dyed and the dyeing process of wcool does not require expensive dye-stuffs or costly retarders or carrier and hence dyeing of wool yarn or knitted garments is economical. Wool can be handled with less difficulty than most synthetics in the knitting processes. Properly conditioned wool yarns run much more smoothly on a knitting machine than a comparable hydrophobic synthetic firbre-yarn. Knitted fabric from wool also presents a more uniform structure than many fabrics knitted with synthetic fibre-yanrs. Because of its natural hygroscopy, wool does not generate static as the synthetic fibre yarns and therfore woollen knitted garments do not attract lint or dirt as readily as some synthetic fibre yarns.

As wool fibre is highly resilent, the knitted fabrics from wool are unmatched as far as loftliness and wrinkle-resisting properties are compared with other man-made fibre yarns. Wool can be mixed with other natural or man-made fibre with more ease than is the case with any other fibre. The intimate blend of wool with other fibres will offer such properties as soft hand, reduction in pilling, reduction in static charges, better covering power and better resistance to snagging to knitted fabrics. (In the above discussion, a comparison is always made with the synthetic fibre yarns because the field of knitting which was mainly dominated by the wool fibre has been, so to say, encroached upon by the new synthetic man-made fibres)

Wool fibre has got some short-comings too. It is much vulnerable to felting and moth and mildew attacks. Shirnkage control of woollen knitted garments is also a major problem in tis use. In order to get shrink-proof fabric for knitting, resin-treated tops or resin-treated loose wool is used. Usually a wet-relaxation treatment followed by tumble drying gives dimensional stability to the knitted fabrics. With harder twist, the knittability of woollen yarn is improved and the resultant fabric possesses a crisp handle but, for single knit fabrics, a higher degree of twist gives a wale spirality and an unbalanced loop results.

3.2.3 Nylon :

It is chemically a polyamide wherein the element of carbon, oxygen, nitrogen and hydrogen are combined by chemical reactions into compounds which react to form a long-chain polymer from which nylon fibre is obtained. Bylon is a generic name and has not special meaning. It is, so to say, a family name and members of the family are known by various numbers. Du Pont's earlier polymer was known as Nylon, 6.6 which refers to nylon obtained from adipic acid and hexamethylene diamine. Other important commercial nylon is Nylon 6, which is obtained from polymide called 'caprolactum'. There are other nylons also such as Nylon 7, Nylon 11, Nylon 2, 3, 4, 9, 10, 12 etc. Chemically they are similar but they differ in molecular structure and therfore in their porperties in subtle ways.

In general, main properties of nylon fibre are its light weight, high strength, excellent drping quality, good abraison resisitance, quick drying property and dimensional stability in laundering. The most important property of nylon is its heat setting to the shape and size which would remain life-long, unless the fibre is exposed to a very high temperature. This thermoplasticity of nylon is put to good use in making nylon stokings. These are given a permanent leg-shape by stretching over a mould and then subjecting them to heat and pressure. Nylon was used for the first time in history in the USA in 1940. (Prior to that, nylon was used for making bristles of the tooth-brush, combs or gears). The members of nylon family viz. Nylon 6 and Nylon 6,6 are the most popular and commercially used nylons. The fundamental differnece in these two nylons are mainly in their affinity for dyes and in their melting points. Nylon 6 has better affinity for acid dyes than Nylon 6,6. However, Nylon 6,6 filament is more readily processable on texturinsing equipment and gives superior stretch and bulking property than Nylon 6.

Nylon may be obtained in four forms : (i) Monofilament (ii) Multifilament (iii) Strecth or textured yarn and (iv) Spun yarn. Monofilament yarns are usede for hosiery. Other types of yarns are used for both warp and weft knitting. A new bicomponent fibre known by trade name 'Cantrece' is obatained by extruding Nylon 6,6 and Nylon 6,10 solytions from a single spinneret. On emerging out, due to different effects of heat on the individual components, the resulting nylon develops a helical shape. Thus, it is a self-crimping yarn which provides a good resilence, fit retention and comfort. Multifilament nylon being stronger, is used for industrial purpose such as fishning nets, robes, gliders' tow, tyre cords etc. Nylon filaments are cut to about 2.5 cm to 12 cm in staple length and intimate blends are made with cotton or wool.

As mentioned earlier, nylon is used extensively in knitting indistry. For hosiery, 15 or 20 denier yarn is suitable while for circular knitted outerwear 70 to 120 denier yarn is used. The stable nylon denier runs fron 1.5 to 15 and is mainly used for knitted sweaters, outerwear fabrics and half-hose for men. For tricot knitting 40 denier to 70 denier nylon is commonly used.

3.2.4. Polyester :

Polyester is a manufactured synthetic fibre and contains at least 85 per cent by weight an ester of dihydric alcohol and terephthalic acid fibre forming substance is a long-chain polymer. Polyester fibre is manufacured under various trade names. In the USA alone, Du Pont polyester is known as Dacron, while Eastern Chemical Product Inc. manufacturers it as Kodel. Celeanese Corporation names its polyester as Fortrel while American Enka names it as Enka. In India also trade names of Terence, Jailence, Futura, Ilacron etc. are used for polyester fibres.

Polyester is a fibre with very high tensile strengh, high resistance to chemicals and abrasion, excellent durability, high degree of resilience, satisfactory drapability and least cbsorbancy. The characteristic property last mentioned may be considered as a disadvantage also because fabric from pure polyester would be clammy and uncomfortable in humid weather. Polyester provides a high degree of shape-rentention and wrinkle-resistance to knitted fabric than other man-made fibres. Polyester fibres are the most dimensionally stable of all man-made fibres. Polyester alone was used to a very small extent in the knitting sector because of processing difficulties till early '60s, when textured polyester yarn made its entry in the textile yarn field. Since then textured polyester has made its progress be leaps and bounds and today about 80 percent of the production of filament yarn in the world is 'textured'. However, intimate blends of polyester with other fibres are also used successfully in the industry. The blends are ideal for outerwear fabrics. Intimate blend of Polyester-cottin (65-35) provides wrinkle resistance and shape-retention properties from polyester and water absorbancy and comfort from cotton. This blend is suitable for permanent press finish also.

Other blends used in polyester-cotton are 55-45 or 50-50. In blend with wool, the proportion of 60 percent of polyester to 40 percent wool provides a greater abrasion resistance, outstanding crease-resistance and wrinkle-resistance, due to the presence of polyster, while wool provides good draping quality and elasticity. Polyester-wool suiting of proper blend can be comfortably used for the year-round wear. Other blends are polyester-viscose and polyester-nylon. Viscose contributes to the abosorbancy and acetate may be used for cross-dyeing purpose as acetate shows addinity for different dyes than the polyester. Nylon contributes stregth and abrasion resisitance. The main drawbacks of polyester fibres are its (i) low water absorbancy, (ii) propensity to pilling and (iii) porpensity to generation of static charges on the surface of the fabric in dry and cold atmosphere.

3.2.5 Textured Polyester

Polyester fibres are obtained in two forms; filament and staple, but in the knitting industry the main outlet for filament polyester is in the form of textured polyester filaments. It will not be wrong to say that textured polyester has rejuvenated the knitting industry in general and double-knit section of the industry in particular.

The most common deniers used for textrued polyester yarn for double-knit are 150, 130, 120, 100 and 70. Polyester staple fibre is used to a very small extent in the knitting industry because of its pilling propensity.

Acrylics : Acrylic is manufactured by synthesising basic elements like carbon, hydrogen and nitrogen with small amount of toher chemicals to form a large polymer combination, The fibre forming substance is a long chain polymer consisting of atleast 85 percent by weight of acrylonitrile units. Acrylonitirile may be obtained from acetylene or from acetylene or from ethylene which are petroleum derivatives. Yarn forming acrylic fibre has high bulk and fabrics woven or knitted from it give a warm, wool like handle. The high bulking process of acrylics is used to get raw material to be used in the ashion knitting. Outerwear knitted garments from acrylics have an extreme lightness, warmth and softness. Of all the man-made fibres, acrylics have the least propensity to pilling. Orlon, Acrilan, Creslan etc. are acrylic fibres. Orlon has a somewhat dog-bone cross section. It has a softer hand than one with a circular or bean-shaped cross section of AcrilanbutAcrylan possesses better resilience than Orlan Acrylic fibre is weaker than most of the natural fibres except wool The abrasion resisitance, though not as good as nylon or polyester, is favourably comparable to that of wool. The low stretchability of aCrylic makes it suitable for knitting. It has good resilience and therefore will not wrinkle easily. Acrylic does not conduct heat rapidly and hence Acrylic fabrics are warm. Staple Acrylic fabrics have approximately 20 percent greater insulating power per ounce of fibres than wool fibres. The warmth of the yarns can be increased by bulking and hence most of the high-bulk textured yarns are obtained from acrylics. Acrylic Sayelle is one such variant. Cotton-Acrylic combination gives strenght and absorbancy to the resultant yarn. A blend of 80 percent of Acrylic with cotton provides wash-and-wear property to the fabrics. Acrylic staple blend with wool gives a light weight yet warm fabric with soft hand. It will have good creasee - retention with wrinkle resisitance. Acrylic nylon with 70-30 blend provides wrinkle-resisitance with soft hand and wash-and-wear blend.

Acrilan is similar to Acrylic but its properties differ slightly with those of Acrylic. It is slightly stronger than Acylic, rayon and acetate. It has less stretchability and good resiliece. Like cotton, Acrylic can be blended with coton, wool, viscose, acetate and nylon to get the desired characteristic properties.

Acrylic is used in knitting maily in sweater manufacturing. However, in knitting any type of acrylic fibres, from high bulk staple or tow form, care should be taken to provide shrinkage allowance to the extent of 25-30 percent.

3.3 Minor Types of Yarns Used in Knitting :

The major types of fibres used in knitting have been discussed above. However, there are some other fibres which are used in small proportion in the knitting sector.

Viscose rayon : It is a regenerated cellulosic fibre. The raw material is cotton linters or wood pulp. Viscose rayon is obtained in monofilament, multifilament and spun staple yarn. In general viscose rayon is weaker than cotton, silk or linen but stronger than wool. (Modified rayons like polynosics or high wet-modulus rayons are comparable with cotton and other fibres as regards their wet strength). Though it is a weaker fibre, it produces fairly durable, economical and serviceable fabric. High tenacity viscose possesses lightness with strength. Viscose has greater elasticity than cotton but less than wool. It lacks resilience and creases readily. Viscose rayon is one of the most absorbent of all textile materials. The combination of heat conductivity and high absorbancy of viscose rayon makes it suitable for summer-wear fabrics. It is mainly used in blends and more for warp-knitted structures than for weft-knitted structures.

Acetate Rayon : It is also a regenerated cellulose obtained from a compound of cellulose and glacial acetic acid. It is manufactured in monofilament and multifilament form and can be cut to desired staple length and spun into yarn. Flat filament is mainly used for warp-knitting in ranges from 40 to 80 denier. For weft-knitted structure, the deniers used are 70, 120, and 180. In weft-knitting, however, the flat filament is not used but textured acetate yarn is used. Acetate is weaker than any rayon and it has also poor abraison resisitance. However, it has got good body and the fabric made from acetate has a good drape. It is neither a good conductor of heat nor a good absorbent of moisture. Its beld with other fibres reduces the price and sometimes it is purposely used for cross-dyeing in a blend. Acetate-viscose, and acetate-wool are the most common blends used.

Spandex : It is a manufactured fibre in which the fibre forming substance is a long chain synthetic polymer, composed of atleast 85 percent of segmented polyurethance. It is an elastomeric fibre having rubber-like properties. Spandex fibres can be stretched from fgive to seven times their original length and they can return to their relaxed state upon release of the tension. It is not made of rubber but is composed of soft stretchable segments of polyurethane linked together by hard segments. Fabrics are not entirely made from such an elastic material and Spandex yarns are frequently used in combination with other staple fibres. Usually 4 to 30 percent Spandex with other fibres possesses sufficient elasticity and holding power for knitted fabrics. Spandex does not reach the breaking point till the fibre is stretched to its maximum length. It has great flexibility and good resilience.

Yarn Dimensions

4. YARN DIMENSIONS

4.1 Linear Density Count or Yarn Number

The 'Count' of a yarn is a numerical expression which definres its fineness. 'The count of the yarn is the number of such yarns which are required to form one strand of a three-strand 3 in. circumference rope'. This is an unusal approach used for a particular job and is not met with in the normal run of things. A defninition of yarn count is given by the Textile Institute : 'Count. A number indicating the mass per unit length or the length per unit mass of yarn. Note : various counting systems using different units of mass and length are in use, so the system used must be stated.

4.1.1. Direct and Indirect Sytems of Yarn Numbering

a) Direct Systems. In a direct yarn counting system the yarn number or count is the weight of a unit length of yarn. The units of weight and length vary from trade to trade and district to district, a stateof affairs which results in a multiplicity of counting systems. This will be looked into shortly but for the moment we will consider a general formula which applies to all direct sytsems.

Let N = the yarn number or count

W = the weight of the sample at the official regain in the units of the system

L = the length of the sample, and

l = the unit of length of the system

Then

$$N = \frac{W \times l}{L}$$

b) Indirect sytem. In an indirect sytem the yarn number or count is the number of 'units of length' per 'unit of weight'. Here again there are various units of length and weight and numerous systems. Generalising :

Let N = the yarn number or count

W = the weight of the sample at the official regain in the units of the system

w = the unit of the weight of the system,

L = the length of the sample, and

l = the unit of length of the system

Then

$$N = \frac{L \times w}{l \times W}$$

4.2 Twist

In its wider connotation, the word 'spinning' embraces all the various processes which are necessary to transform fibrous raw materials into yarns. Even in the man-made continuous filament plants where extrusion processes produce the yarns, one still talks of spinning. A more particular meaning is given to the word when we consider the process in which a strand of fibres in a more or less parallel order is spun or twisted on its axis to form a yarn. The necessity for twist in yarn construction is reflected in most but not all definitions of the term 'twist'.

'Twist is the measure of the spiral turns given to a yarn in order to hold the constituent fibres or threads together' (Skinkel).

'When a strand is twisted the component fibres tend to take on a spiral formation, the geometric perfection of which depend on their original formation' (Morton)

'Twist may be defined as the rotation about the yarn axis of any line drawn on the ayrn which was originally, i.e. before twisting, parallele to the yarn axis' (wool Res.Vol.3).

'Twist : The spiral disposition of the components of a thread whifh is usually the result of relative rotation of the two ends' (J.Text.Inst.38, P626 (1947)).

4.2.1 Twist direction

The direction of twist at each stage of manufacture is indicated by the use of the lettters S or Z in accordance with the following convention :

A single yarn has S twist if , when it is held in the vertical positon, the fibres incline to the axis of the yarn conform in direction of slope to the central portion of the letter S. Similarly, the yarn has Z twist if the fibres inclined to the axis of the yarn conform in direction of slope to the central portion of the letter Z.

Figure 4.2.1 illustrates these difinitions. Other methods of describing the twist direction will be found in older textbooks on spinning, but since they lead to confusion it is considered wise to omit them here.

From the spinning point of view, it normally matters little which way the twist goes. However, when single yarns are plied or combined in the form of fabric, the dirction of twist becomes important because it influences the character and the appearance of the finished article.

4.2.2. Amount of Twist

It is stated that 'the amount of twist in a thread at each stage of manufacture is denoted by a figure giving the number of turns of twist per unit length in the twisted condition at that stage. Thus in Figure 4.2.1 we note the meaning of 20 t.p.i., twenty turns per inch.

For many practical purposes this method of expressing the amount of twist serves quite well, but the expression contains no reference to the count of the yarn. A coarse yarn with 20 t.p.i. has vastly different twist characteristics to a fine yarn with 20 t.p.i. By using an expression known as the 'twist factor' or 'twist multiplier' it is possible to appreciate the twist character of a yarn even without knowledge of the yarn count.

Figure 4.2.2 represents an idealised element of a yarn, showing one fibre on the yarn surface following a helical path and making one turn round the ayrn axis. The twist angle ø is the angle between a tangent tot he helix formed by the fibre and the yarn axis. By 'unrolling' the surface layer we see that the fibre becomes the hypotenuse of a right-angled triangle.

Let the yarn diameter be d inches and let l be the length of yarn occupied by one complete turn of twist. Then

tan - d

l

and 1 = turns per inch

The constant K is termed the 'twist factor' or 'twist multiplier' and is directly proportional tot he tangent of the twist angle.

A range of, say, cotton yarns spun to different counts, but with the same twist factor throughtout, will possess the same degree of hardness and twist character. The spinning frame overlooker can readily calculate the t.p.i. required to spin a given count with a specified twist factor and calculate the twist wheel required from the twist constant of the frame.

In addition to describing the amount of twist in the yarn, the twist factor also described to some extent the nature of the yarn. A cotton yarn with a twist factor of 3.0 will be soft in feel and comparatively docile, whereas a yarn possessing a twist factor of 6.0 will be hard and lively. The choice twist factor will therefore be realted to the use of which the yarn is to be put - weft, warp, knitting etc.

4.3 Yarn hairiness

One of the important differences betwen continuous filament yarns and yarns spun from staple fibres is that the latter are 'hairy' that is, fibre ends and loops of fibres stand out fromt he main body of the yarn. Barella (F.Text.Inst. 57, T461 (1966)) states that : 'The non-existence of a method sufficiently satisfactory from both a scientific and a practical point of view for the easy measurement of hairiness in routine industrial proceses has been noted. The scientific mehtods are slow and the quicker ones are open to criticism in that they re not soundly based. It would therefore be desirable to devise a new method that is superior to the existing ones. Furthermore, according to the nature of the fabrics and the characteristics they must possess, the yarn hairiness can either be a desirable or an undesirable property, so that is measurement and controlare important.

Tests for Yarns

5.1 Count Strength Product Determination

Yarn strength is far and by the most important property of any yarn. A person who ever buys a particular yarn for any purpose will always demand a certain amount of strength of the yarn.

The yarn when it is woven is subjected to heavy stresses whether it is in the warp way or the weft way directions. In the case of knitting also yarn strength is the important perameter which determines the reilability of the yarn. During knitting yarn has to pass through a number of guides and tensioners for which requires some amount of strength. Even during practical use the yarn strength is the one that determines the life of the particular fabric.

The count strength product is the most common method of expressing the yarn strength. The yarn is wound in the form of lea using the wrapreel. The lea is then mounted on the lea strength tester. The instrument is now switched on. The lea is now continiously extented at a constant rate. As soon as the pressure exceeds the limit the lea starts breaking.

As soon as the lea gives way the instrument switches off by itselfs. The dial that is mounted on the instrument gives the strength of the lea. From the lea strength values obtained the countstrength product is calculated and the values are recorded in the table. 20 samples are tested for each count of yarn.

5.2 Uster Unevenness

Yarn faults bring down the efficiency of knitting machine and the quality of the fabric, Slubs, spun-in fly, spinners doubles, crackers and thin ends down-grade the quality of the yarn. However, removal of every fault after spinning introduces another fault viz. a knot. Therefore a suitable relationship must be found between faults which can be left unremoved in the yarn and those faults which are considered as "objectionable" or "disturbing faults". In knitting, knots tend to limit the action of the sinker which can result in a missed stitch and thereby a hole in the fabric. In certain cases knots can be responsible for breaking needles. The problem of knots has recently been encountered by winding machine manufactures with the introduction of splicers which nearly achieve strength values in the yarn to those of knots and are less disturbing.

In order to determine which yarn faults require to be extracted and which faults can be allowed to remain in the yarn, after yarn clearing in winding USTER CLASSIMAT system is necessary.

The U% values for the 3 counts of yarn were obtained from the respective spinners itself.

5.3 Twist Per Inch

The amount of Twist in yarn determines the way in which the yarn is going to perform in future. The twist is also a factor that determines the strength of the yarn. There is a limit for insertion of twist in the yarn because if the amount of twist inserted exceeds a limit then the yarn starts curling. The twist inserted should therefore be optimum. The twist is expresed commonly as the twist per inch.

The twist per inch of single yarn can be determined acurately using the single yarn twist tester. Here the yarn is held tigthly at one end by a fixed jaw. And the other end the yarn is rotated in a direction opposite to the direction of thé twist in the yarn. There is a needle which moves in one direction as far as the yarn is being untwisted. As soon as yarn gets retwisted the needle shifts its movement to the opposite direction. At the point where the needle changes direction the untwisting procedure is stopped. The amount of twist that was present in the yarn can be directly read from the counter.

From the values obtained that twist per inch of the given yarn is calculated and the values are recorded in the table. The same procedure is repeated by taking 20 samples from the same count.

Tabulations

6.1.YARN - COUNT STRENGTH PRODUCT

Sample type	25 s	34 s	40 s
1	2070	2230	2380
2	2100	2200	2344
3	2070	2290	2390
4	2170	2190	2410
5	2050	2230	2355
6	2055	2222	2280
7	2070	2301	2422
8	1978	2330	2380
9	2077	2110	2386
10	2206	2290	2334
11	1960	2225	2401
12	1990	2080	2380
13	2070	2200	2375
14	2100	2275	2440
15	2041	2186	2380
16	1990	2288	2333
17	2070	2100	2375
18	2010	2276	2380
19	2110	2297	2395
20	2213	2280	2388
Average	2070	2230	2380

6.2. YARN - USTER UNEVENNESS (U%)

Serial number	Yarn count	U%
1	25 s	9.8
2	34 s	10.3
3	40 s	10.6

6.3. YARN - TWIST PER INCH

Sample type	25 s	34 s	40 s
1	17.0	19.8	21.5
2	16.8	19.7	21.4
3	17.5	19.3	22.0
4	17.1	20.5	20.8
5	17.4	20.4	20.3
6	17.4	19.8	20.9
7	16.2	19.8	21.5
8	16.9	19.6	22.5
9	17.2	19.8	22.0
10	17.0	19.7	21.7
11	17.1	20.0	21.8
12	17.2	19.5	22.1
13	17.0	19.8	21.0
14	16.9	19.6	21.0
15	17.0	20.1	21.0
16	16.9	19.5	20.5
17	17.0	20.0	21.5
18	16.9	19.8	21.8
19	17.1	19.9	22.0
20	16.8	19.8	22.1
Average	17.0	19.8	21.5

Knitting Basics

7. KNITTING BASICS

7.1 Definition of Knitting

Knitting is a process of manufacturing a fabric by the intermeshing of loops of yarns. When one loop is drawn through another loop, a 'stitch' is formed.

7.2 Comparision of Woven and Knitted Facbrics

i) Woven fabrics are rigid, in the sense, they are inextensible, having high elastic recovery. Weft knit fabrics are highly extensible with incomplete elastic recovery. This semi-permanent deformation left after the partial recovery can be almost removed by agitation, as in washing and tumble drying. The warp knit fabrics are not, however, as extensible as the weft knit ones. The standard warp knit tricot fabrics are similar to woven fabrics though they are a little more extensile than the woven fabrics. The qualitative relative behaviour of the wovens. the warp knits and the weft knits is shouwn in Fig (7.2.1)

The high extensibility of knitted fabric gives advantages as well as disadvantages. As the knitted fabric is not rigid, it is more comfortable when body movements are made. Its high elastic recovery gives a shape fitting property to the fabric. The knitted fabrics have found a prominent place in women's dresses because of this shape-fitting characteristic of the weft knitted structures. KNitted fabrics conform to the figure without constricting the wearer. The semi-permanent deformation of the knitted fabric gives comfort in wear. It permits greater freedom of body movements; but the extensibility of knitted fabrics is also responsible for creating problems in cutting and sewing the garments.

The semi-permanent deformation may give rise to 'bagging' at knees and elbows. The extensibility of knitted structures is because of the loop structure. When the fabric is extended, the lpps are distorted and stretched out. In woven fabrics, the extensibility would be to the extent of crimp in the woven yarn.

ii) Right-angled woven threads can easily be ripped by grabbing between the fingers. Knitted fabrics, being very extensibile, distribute the stress throughtout the entire fabric. It, therfore, becomes difficult to tear the knitted garment. The knitted fabric has another distinctive property. It is highly crease-resistant. When a woven fabric is bent, the yarns and fibres, constituting the fabric, also bend and deform beyond their elastic limit. This gives the creasing and wrinkling properties to the woven fabric.

In knitted structures, when a fabric is folded, the yarns or fibres are not deformed much. Bending occurs mainly by loops acting as hinges, when it is folded widthwise or it results in twisting and untwisting in the straight arms of the knitted loops when the fabric is folded lenghthwise. Since in both these cases the fibres are not permanently deformed, the knitted fabrics are not creased or wrinkled. The weft-knit fabrics are usually highly crease-resisitant. The woven goods are least crease-resisitant, while the warp knits are in between the woven and the weft-knits as far as crease-resistance is concerned.

The weft-knit fabrics are usually thicker than the woven fabric of equal weight. This is because of low twisted yarns of the knitted structures as well as due to the crease-resisitance of the knitted fabric. This thickness is also responsible in preventing the formation of a shartp bend in the knitted fabric. The advantage of the wrinkle-resisitance nature of the nitted structure is that the fabric 'hangs out' and no ironing. It gives a smart appearance to the wearer but the same property of crease-resistance is a disadvantage because of the difficulty in producing the desired creases required in the case of men's trousers. Knitted fabrics have, therfore not been found much suitable in men's apparel fabrics. About 99 percent of men's trousers are still woven.

iii) The woven fabrics are considerably stiffer than the knit fabrics of the same weight. Both the wrap and the weft knits have a low bending lenght which is reflected in their typically soft drape. Woven of the same weight has a much fuller drape. We know the 'flexural rigidity' of a fabric is greatly influenced by the bending length.

$$\text{Flexural Rigidity} = \text{Weight per unit area x (bending length)}^3$$

iv) The feel of the fabric is related to the flexural rigidity of the material. As the knits have lower flexural rigidity than the woven of the same weight, the knits feel 'soft' or limp while the wovens feel stiff.

v) The fullness or hand of the fabric depends on the bending modulus of the structure. The 'bending modulus' is related to the flexural rigidity and thickness of the fabric.

$$\text{Bending Modulus} = \frac{\text{Constant X Flexural Rigidity}}{(\text{Thickness})^3}$$

A fabric with high bending modulus is said to be full. The weft knit fabrics have low flexural rigidity and more thickness than the woven or the warp knits. The weft knits are, therefore, 'fuller' fabrics than either the woven or the warp knit.

Thus, while the weft knit fabrics are thicker than the woven fabrics of the same weight, warp knits are similar to woven, in this respect. The low twist of the yarn also contributes to softness, fullness and covering properties of the knitted fabrics.

vi) Knits are also several times more permeable to air than wovens of the same weight. This air-permeability of knits is useful quality for underwear whereby the garment next to skin can 'breathe'. This higher air-permeability of the knitted fabric gives a comfortable feeling in summer, as even low velocity draughts of air sweep away warm air from around the body but the same propery of air-permeability is undesirable in winter, particularly in cold countries, as it will cause a chilling effect. Knit suits, are therefore not popular in cold weather countries in winter.

vii) As far as strengh property is concerned, the wovens are generally stronger than knitted fabrics because yarns with higher twist levels are used in the wovens. However, strength properties of woven and knit fabrics cannot be compared as the methods and instruments for testing woven and knitted fabrics work on different principles. For example, most of the woven fabrics are tested by loading or extending fabrics in warp or weft direction, whereas knitted fabrics are tested by multi-directional fabric bursting strength test.

viii) In still other fields, very unusal end-uses have been developed for the knitted structures. For example, a nylon knitted tubing is produced which can serve as a substitue for the heart's principle artery - the aorta and the Y-shaped aortic arch. These knitted fabrics have been proved superior to plastic cloth because the interstices of the knitted tubing become permanently sealed off by coagulating blood.

This does not mean that the wovens have no future. Woven fabrics have an advantage in that they require less yarn for comparable fabric properties. The fact that wovens do require less yarns becomes very important because the cost of yarn much exceeds the cost of production, particularly in heavier fabrics. At present, knitted fabrics find scope in the apparel market while woven garments and fabrics have been found suitable both in apparel as well as in industrial fields. Some of the special problems related to knit fabrics are shrinkage, snagging and handling difficulties.

7.3. Terms and Definitions in Knitting

Here, some few terms used in knitting are defined as per international standards. All illustrations headed (i) refer to weft knitting and those headed (ii) refer to warp knitting.

Loop - The fundamental unit of a knitted structure that is formed by 'kinking' (bending) of the yarn and that at its base, intermeshed with similar units as shown at Fig (7.3.1).

Open Loop - A loop in which the same thread (h) enters and leaves the loop at opposite sides without crossing over itself Fig. (7.3.2)

Closed Loop - A loop which the same thread crosses over itself and the base (k), shown Fig (7.3.3)

Needle loop - The aggregate (e) of the top arc and of the two sides of the loop.

Note : The needle loop is identical to the 'overlap' in warp knitting. i.e. identical to the length of yarn placed over the needle during the loop formation. Fig (7.3.4)

Sinker loop - The yarn (f) that connect two adjacent needle loops.

Note : In warp knitting a sinker loop (f) is formed only when double needle overlaps are made. Fig (7.3.5)

Float (weft knitting) - A length of yarn (n) not received by a needle and connecting two loops of the same course that are not in adjacent wales. Fig (7.3.6)

Foat (warp knitting) - A length of yarn (p) not received by the needle and connecting two loops of non-consecutive courses that may (a) or may not be (b) and adjacent wales. fig(7.3.7) (someties wrongly termed as 'underlap')

Tuck loop- A lenghth (r) of yarn received by a needle and not pulled through the loop of the previous course. Fig (7.3.8) (It is not a tuck stitch which is defined in a different way)

Underlap - The yarn that connects two needle loops in consecutive courses in a warp knitted fabrics. Fig (7.3.9) (It should not be confused with sinker loop. Fig (7.3.4) or float Fig. (7.3.5)

Stitch Length - The length of yarn (t) knitted knot one stich. Fig (7.3.10)

Note : In warp knitted fabric, the stitch length is equal to the length of the overalp Fig (7.3.4) plus the length of underlap.Fig (7.3.9)

Face Stitch - (plain stitch) A stitch (V) that is so intemeshed towards the technical face-side of the fabric that its legs are visible and are situated above the top arc of the stich formed in the same wale in the previous course. Fig (7.3.11)

Back Stitch - (reverse stitch, purl stitch) A stitch that is so intermeshed towards the technical back (or reverse side) of the fabric that the top arc of the stitch together with bottom arc is visible and situated above the legs of the stitch formed in the previous course. Fig (7.3.12).

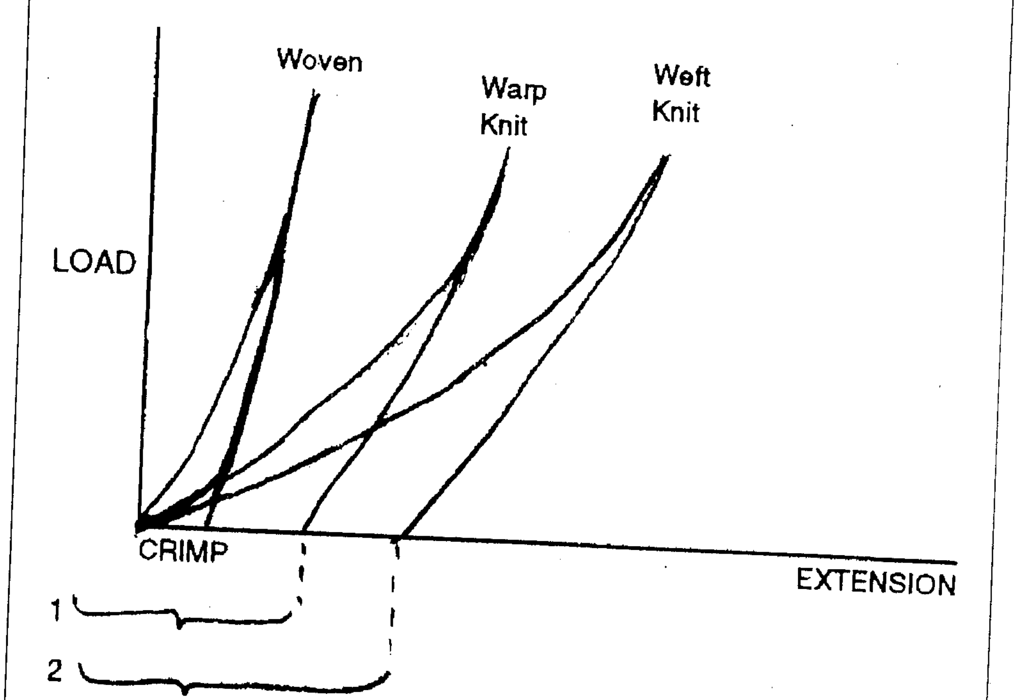


Fig-7.2.1

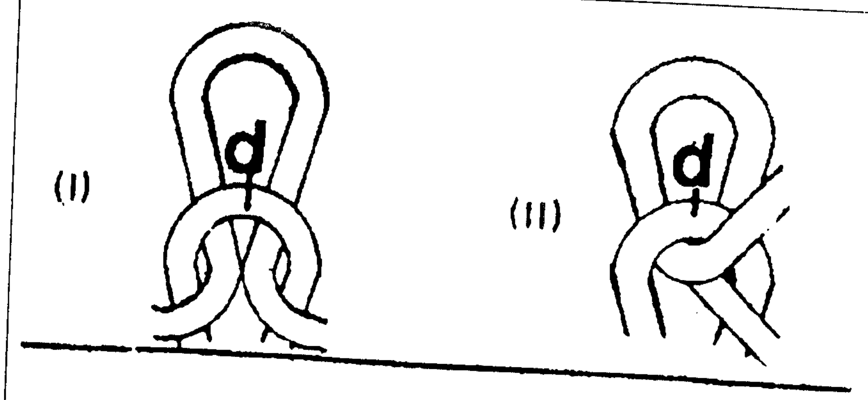


Fig-7.3.1

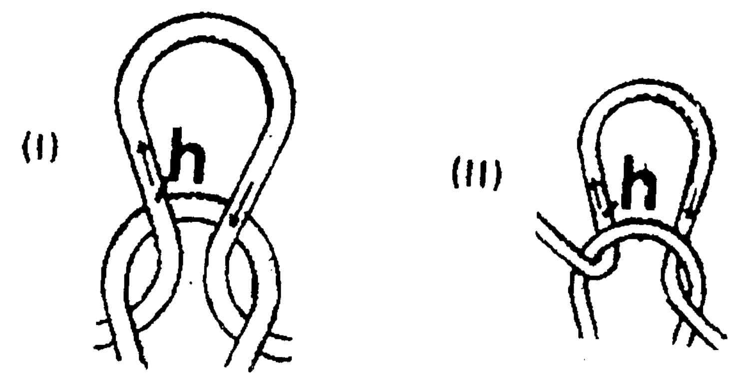


Fig-7.3.2

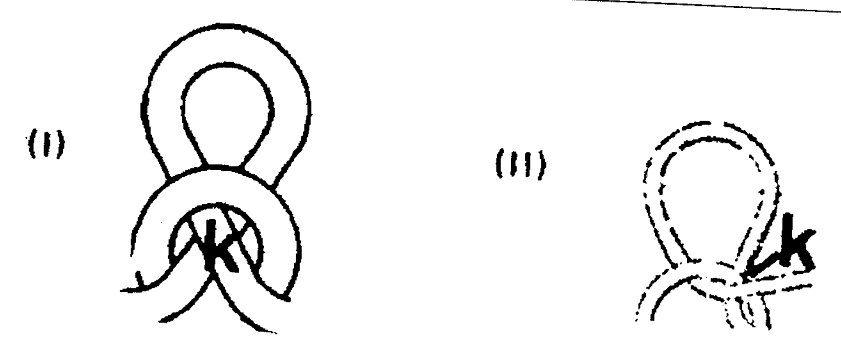


Fig-7.3.3

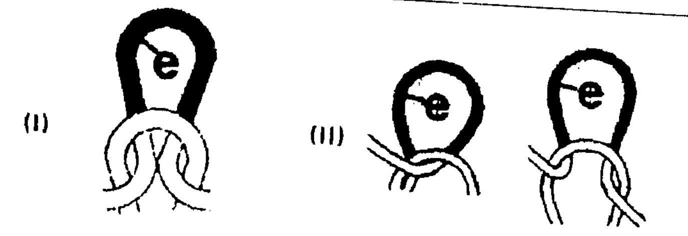


Fig-7.3.4

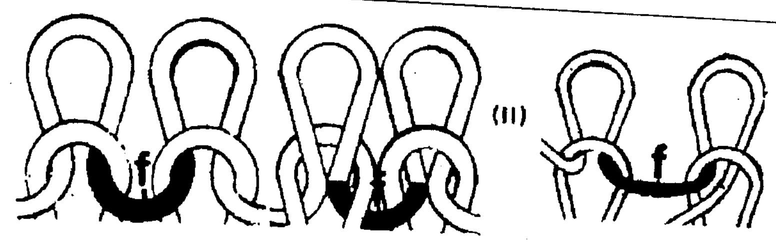


Fig-7.3.5

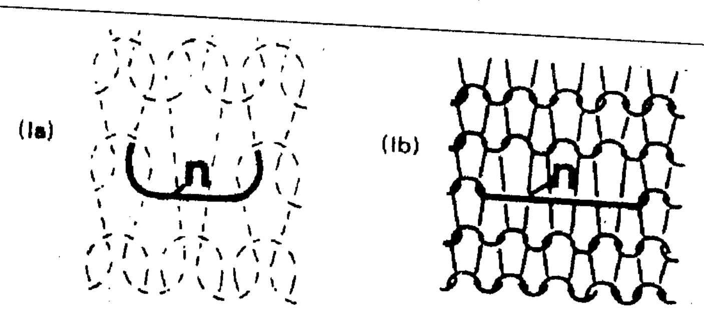


Fig-7.3.6

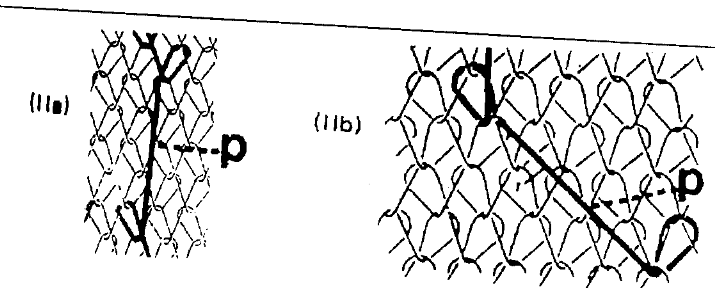


Fig-7.3.7

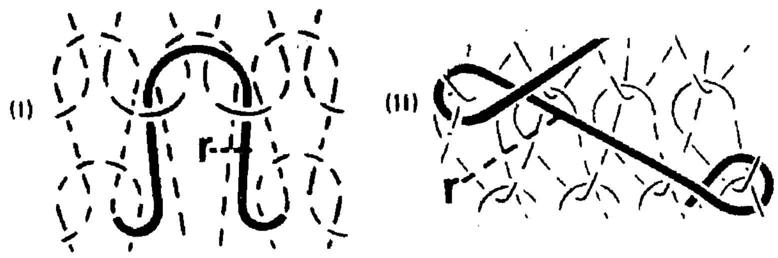


Fig-7.3.8

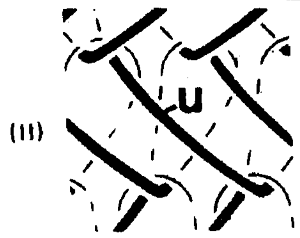


Fig-7.3.9

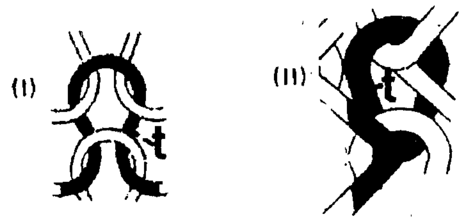


Fig-7.3.10

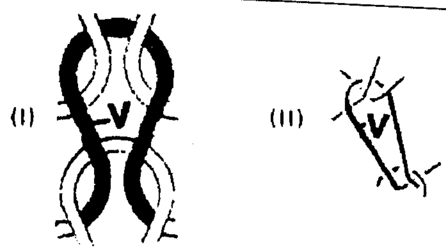


Fig-7.3.11

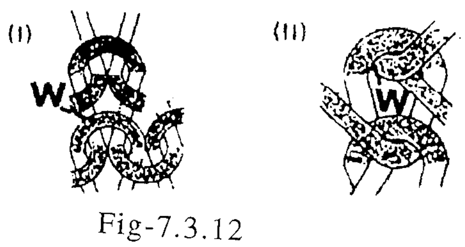


Fig-7.3.12

which exert a constant tension. Below the take-down is the cloth roll-up mechanism on the roller of which the knitted cloth is wound in a roll form.

Cylinder Diameter and Cut : The diameter of the cylinder varies from a few centimetres to 75 cm according to the types of goods to be manufactured. An approximate count of yarn to be worked can be decided by using the formula

$$\text{Count of Cotton Yarn} = \frac{\text{Square of the Cut of the machine}}{20}$$

$$\text{Count of the Worsted Yarn} = \frac{\text{Square of the cut of the machine}}{20}$$

Stitch Length : Though stitch length can be adjusted as required by the tightness or flimsiness of the fabric the general formula is :

Stitch Length in inches = 16.66d where d1 = Dia. of yarn which can be calculated by using d = 1/24 Ne where Ne is English Count

The ideal stitch length gives the ratio of courses to wales about 1.3 in the relaxed state of the nit goods.

8.3.Comparision of warp and weft knitting

The technical pecularities in warp and weft knitting machines and warp and weft knitted fabrics can be briefly summarised as follows :

i) In weft knitting, the yarns are fed course-wise. While in warp knitting the feed is walewise. It means that if there are, for example, 2,000 neeldes in a warp-knit machine, then upto 2,000 warp ends can knit simultaneously one row of course while, with the weft-knitting machine, even one thread from a cone/ cheese of yarn is sufficient to knit a 'course'.

ii) The needles knit sequentially in weft knitting while they knit concurrently in warp knitting, with the result that the yarn path with weft knitted fabric is horizontal while that in warp-knitted fabric is either vertical or diagonal.

iii) The yarn supply in weft knitting is usually in the form of a cone or a cheese, while in warp knitting the yarn is in one long beam or a number of small warp beams.

iv) Usually staple fibre yarns (cotton, wool, jute) as well as continuous filament yarns (silk, filament, viscose, nylon, polyester, polypropylene filaments) can be worked on weft knitting machines, while only filament yarns can be successfully worked on warp knitting machies, though claims are made by warp knitting machinery manufacturers that staple fibre yarns also could be knitted successfullyworked on warp knitting machines. However it is wellknown that staple fibres yarn require sizing to withstand the stresses and strains of a knitting cycle. This coating of the size material or fluff of staple fibres createes problems due to shedding off, of the size and fluff.

v) Usually latch needles are used on weft nitting machines while latch, beard or compound needles are used on warp knitting machines to obtain a fine warp-knit structues (beard needle) or to obtain higher prodnction (compound needle) on warp knitting machines.

vi) A variety of goods can be knitted on a warp knitting machine while only one class of goods, with very little modification, can be knitted on a weft knitting machine. It means versatility is less with weft knitting machines. Diameter and guage being fixed the dimensions and fabric quality cannot be changes on weft machines as can be done on the warp knitting machines.

vii) Change in patterning does not affect the speed of warp knitting machines. They do not require special attachments for pattern work. The scope for stitch variation and combination is unlimited in warp knitting. In weft knitting the production speed reduces with cams or with mechanical means of change in designs. With electronic neelde selection the patterning on weft knitting machine can be immensely improved but the capital cost of such machines is tremendously high.

viii) The quality of the fabric obtained on warp knitting machines is consistent and uniform due to the type of collective movement given to the needles. Warp-knit loops are very uniform.

ix) Warp-knit fabrics cannot be cheaper than weft-knits but they offer certain functional, aesthetic or novelty effects over the weft-knits. Tricot jersey has been accepted as a standard material for ladies underwears due to its superiority ot wovens or weft-knits, though the tricot material is more expensive. For men's wear, the desired properties are smooth surface, without much luster and with good resistance to pilling and snagging. Warp knit fabrics fulfil these requirements more than weft-knits. However warp knits do not retain creass which are required for men's pair of trousers.

x) Weft nit fabrics tend to have greater inherent resilence that warp knit fabrics, and hence are more suitable for ladies and children's outerwear fabrics.

xi) Warp knit fabrics usually stretch in widhtwise direction in contrast to weft-knit structures which possess extensibilty in both, widthwise and lenghwise.

xii) Invariably, the warp-knit fabrics are much more dimensionally stable than weft-knit fabrics. Warp knitted fabrics are also ladder resistant. (When a stitch is boken, then a wale will disintegrate, causing the stitch to 'run'. This fabric-fault has an apppearnace of 'Ladder')

xiii) Weft knit fabrics are cheaper to produce than warp-knit fabrics because of less preparatory processes involved. Only a cone or a cheese wound package is minimum requirement for weft knitting. In warp knitting, winding and warping processes are required to prepare the warp, on beam. Space required for weft knitting machines is very much less than that for warp knitting machines. Hence all costs related to space, such overheads for rents, taxes, insurance, air conditioning and supervison are more for a unit of warp knitting machines than that for weft knitting.

xiv) Semi-complete garments can be made on weft knitting machines. For example, a circular weft knitting machine can knit tubular weater lengths with welts, rib borders or neck-lines.

xv) Weft knitting machines, even with multifeed yarns require less capital cost and floor space. Less expensive yarns can be suitably used on weft knitting machines. For warp knitting, stronger yarn is required.

xvi) In tailoring, that is, in cutting and sewing, warp-knit fabrics have a greater advantage, because warp-knits are generally less extensible than weft-knits, though they possess good crease-resistance and recovery.

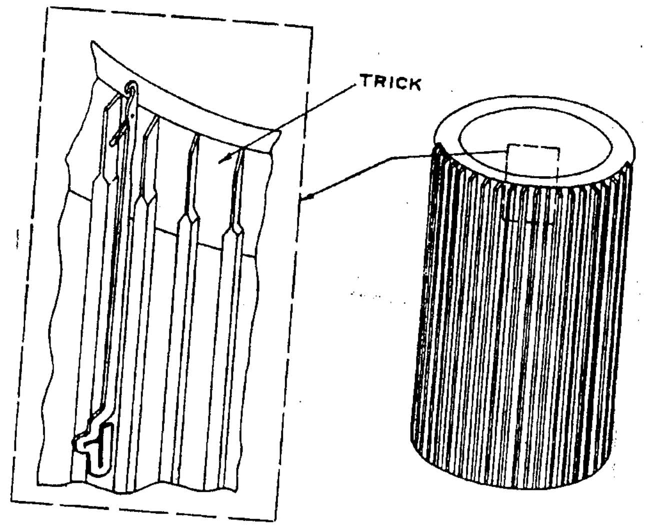


Fig-8.2.3a

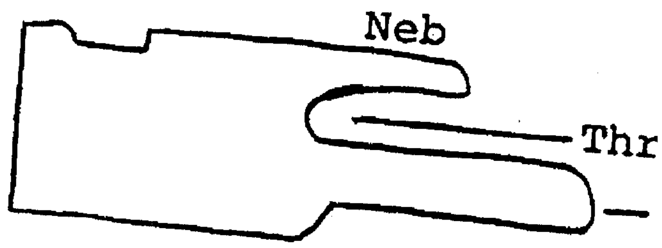


Fig-8.2.3b

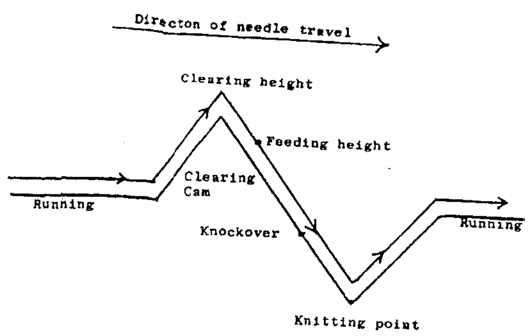


Fig-8.2.3e

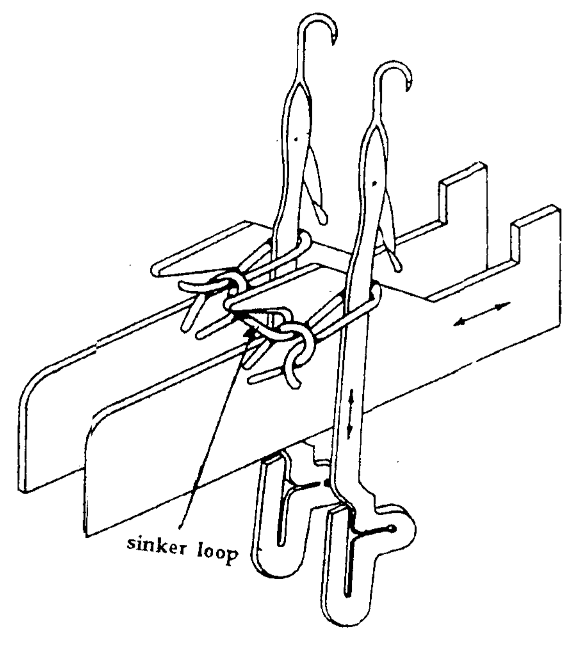


Fig-8.2.3c

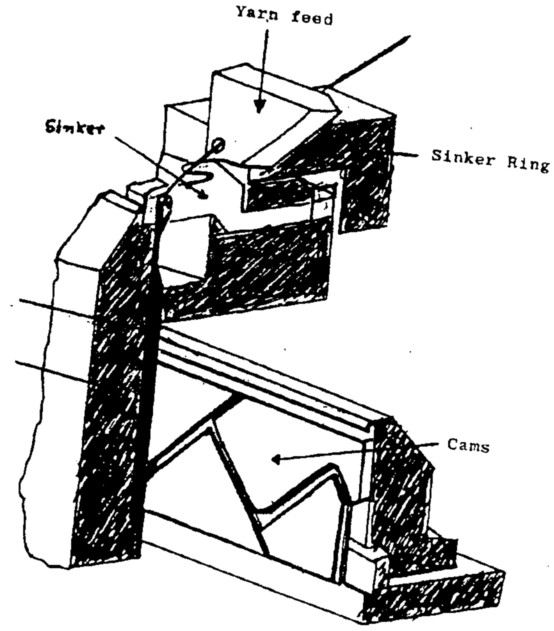


Fig-8.2.3d

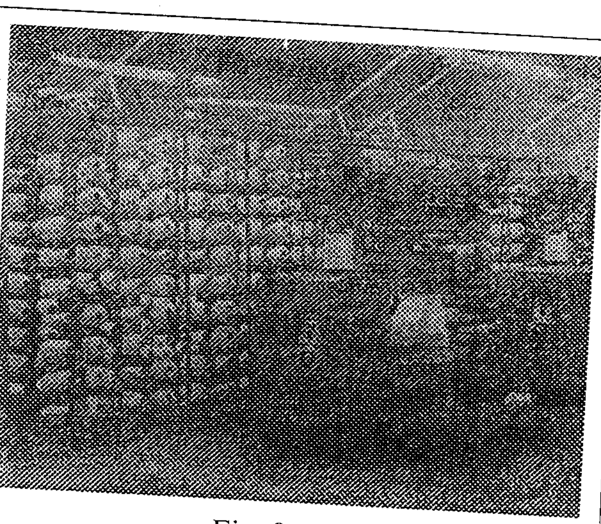


Fig-8.2.3f

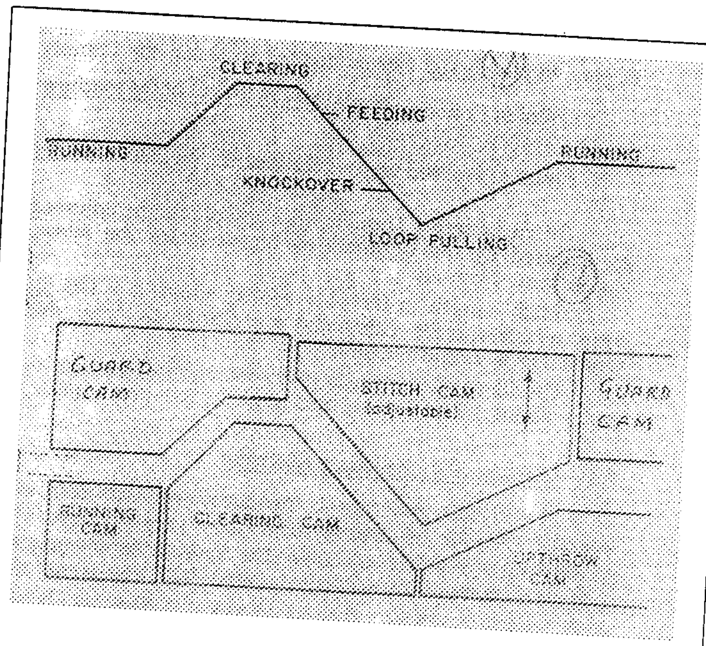


Fig-8.2.3g

Knitting Needles

9. KNITTING NEEDLES

9.1 Spring Bearded Needle

9.1.1.Construction

This is most commonly used on a tricto warp knitting Machine. Main parts of the spring beard needle are :-

1. The Head : The hooked portion of the stem of the nedle to draw the new yarn, form a loop and intermesh through old loop.
2. The Beard : The continuation of the hooked portion which has a good springiness and shape of a beard on a chin
3. The eye : A groove cut in the stem to receive the pointed tip of the beard when it is pressed in by the presser, so that the new loop is entrapped.
4. The stem : is the needle around which the loop is formed and fabric is held with the last loop on it.
5. The butt : (shank) is bent for location in the machine or is cast with other needles in a metal lead.

The beard needle was the needle used in the first knitting machine known as the 'stocking frame'. The invention of the beard needle in 1589 is attributed to Rev.William Lee, as has already been referred to Fig.(9.1.1a) shows the shape and parts of a beard needle. It is a single unit but external assistance is needed to close the beard. It does not require a latch and rivetting of the latch to the needle. It is therefore finer in its cross section and more needles in a unit space can, therefore, be accommodated. Hence a finer guage of the machine can be achieved. (The term 'guage' is the deisgnation of the 'number of needle per inch', in the case of weft knitting and tricot warp kniting and it is the designation of 'needles per two inches' of the needlebed in the case of Raschel warp kniting) Fig (9.1.1b) shows the knitting action by the spring beard needle, which has been described earlier.

In the case of beard needle machiens, 50 needles to an inch was a common gauge over 100 years ago but now gauges upto 60 needles to an inch are available. The beard needle are less expensive than the latch needles. However, they require additional help to close the beard, which is usually provided by a presser. To that extent, motion to the presser is an additional expense for the beard needle knitting machine. It is claimed that the beard needle produces superior knitted stitches when compared to those of a latch needle. Most of the warp knitting machines like tricot, simplex and Milanese machines use the beard needle.

9.1.2. Knitting Cycle

Fig (9.1.2a) shows main three stages by the beard needle N to form a single loop. At (a) the needle is raised to receive the yarn T, which has been taken by the hook. P is a presser which is a bit away from the needle. At (b), the needle has been lowered until the tip of the beard is just above the already knitted loop of the fabric 'F' on the stem. The presser 'P' is now brought into contact with the beard to close it. The tip of the beard is pressed into the groove of the needle. From this position it continues downward to position (c). carrying the yarn T through the last loop in the fabric. This cycle is repeated.

9.2 Latch Needle

9.2.1. Construction

The latch needle is shown in Fig (9.2.1a) it consists of a hooked portion at the top, with a latch or spoon rivetted at a certain distance from the head of the needle. Latch needle forms a stitch with a simple up and down movement, as shown in the Fig. (9.2.1b) latch needles are given individual movements, sliding in grooves, called the 'tricks' of the cylinder. The latch can swing freely. The stem or shank is a straight portion of the needle with a prtruding butt, some distance from the end of the needle. The reciprocating movement to the needle in the vertical direction is given through this butt part of the needle. Latch needles are mainly used in circular weft knitting machines for single knit, and doubel knit fabrics. They are also used for the purl fabrics and in V-bed and flat bed machines and on Raschel warp-knitting machines.

The latch needles are self-acting, in that, they require only previous loop on the stem and do not require any outside agency to close the hook. The swinging latch has a cup at the end to fit the hook in the groove, when a latch is closed. The latch is rivetted to the stem. Because of these facts, the total thickness or the space occupied by a latch needle cannot be reduced beyond the capacity of the mechanical means of manufacturing. Hence these needles,with the result that the machines with finer guages use spring beard needle. Tricot machines, whic usually produce finer varieties of knitted fabrics, use spring beard needles. The latch needle are expensive, because of the assembly of needle and latch.

Fig (9.2.1b) shows the knitting action of the latch needle.

9.2.2. Knitting Cycle

The latch needle is shown at 1 in a partly raised position. The last loop in the fabric is on the needle. At position 2, the needle has been raised so that the last loop of the fabric is on the stem and the new yarn T has been placed in the hook of the needle. At 3, the needle has been lowered. Its latch has been closed by the last loop of the fabric. When the needle is further lowered the last loop is thrown over the top of the hook and the thread T is drawn into the fabric as a new loop. The cylce is repeated.

9.3. Comparision of Spring Bearded and Latch Needle

Each type of needle has some advantages and some disadvantages. For example, as the latch needles are thick, they are rigid and needle deflection is difficult while the beard needles can be deflected, particularly during the long loops on a warp knitting machine. Beards also tend to wear and break easily. Latch needles, being storng, withstand this abuse to a certain extent. They do not require presser and are self-acting; but the latch itself imposes a certain strain on the yarn. There is also a possibility of fluff or lint accumultion on the latch due to rubbing action of the yarn on the needle. This may cause a deformation in loops.

As compared to beard needle, the altch needle makes a longer stroke in the cycyle of kniting operation. As the beard needles are usually mounted in finer guages than the latch needles, the stitches obtained with the beard nedle are tight and minimum loop robbing is achieved. Yarn strain in the case of beard neelde is also less because of the precise closing of the beard at the knock-over time. In general, the latch nedle takes a longer time to knit a loop and hence the speed of the latch needle knitting machine is generally found lower than that of the beard neelde knitting machine, though attempts are now made to reduce this margin of the spped difference.

9.4. Compound Needle

9.4.1. Construction

The spring beard needle and latch needle both were found to have limitations in their operating sppeds. The speed of the beard neelde operation was restricted because of an external element, presser, required to close the beard and the springy action desired of the beard for re-opening of the hook. Similarly, the extent of the movement required in loop formation, depended on the length of the beard i.e. the lenght from the head of the hook to the tip of the beard. These factors restricted the speed of knitting machines with the spring beard needle.

The latch needle is automatic for the opening and closing of the hook, in that, the yarn loop itself acts to open or close the latch; but if the knitting speed is increased, the swinging action of the latch gains inertia and it reaches the peak which may cause damage to the fine filament yarns. Latch needles are also expensive to manufacture.

To overcome these difficulties, in increasing the speed of knitting, many attempts were made to develop a compound needle. One such compound needle was introduced in 1938. Fig (9.4.1a) shows one of the cokpound needle that has been most popular in warp knitting. It consisits of a hollow steel tube of finer guage in which a hook-closing element, which is also a steel tube of fine gauge, is inserted. The upper end of this element covers the tip of the needle-hook when it is raised. Fig (9.4.1b) shows another type of a compound needle.

It is claimed that, theoretically, a compound neelde combines the advantages of both the latch and the beard needle. Strain is not put on the yarn, during the loop formation and the movement required to form a loop is about half to that of a latch or beard needle. Both members of a compound needle have a straight movement instead of a swinging movement. Thus the knitting speed can be increased and a great production rate is possible by the use of the compound needle. However the compound needles are very expensive to manufacture and hence have not become popular so far.

9.4.2. Knitting Cycle

The knitting action by a compound needle is shows in Fig. (9.4.2a) In the tongue is withdrawn into the hollowstem of the needle. The fabric loop is on the stem and the new yarn is fed into the hook of the compound needle.

At (2) the new yarn is kinked by the needle hook. The tongue is then raised closing the gap between the needle stem and the hook.

At (3) the needle is in the lowest position, when the new yarn has been through the old loop and the old loop slides off the needle hook. The tongue is subsequently withdrawn into the stem of the needle as shown at (1)

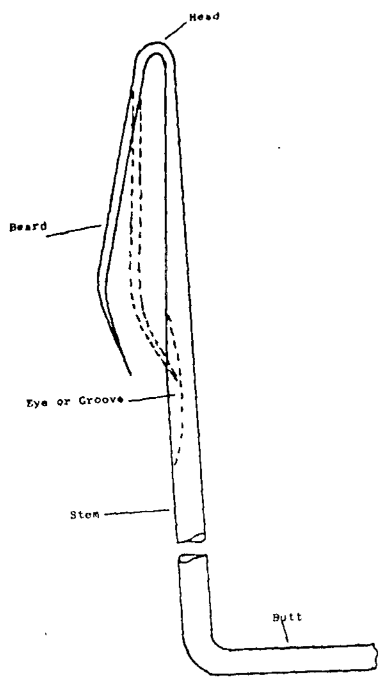


Fig-9.1.1a

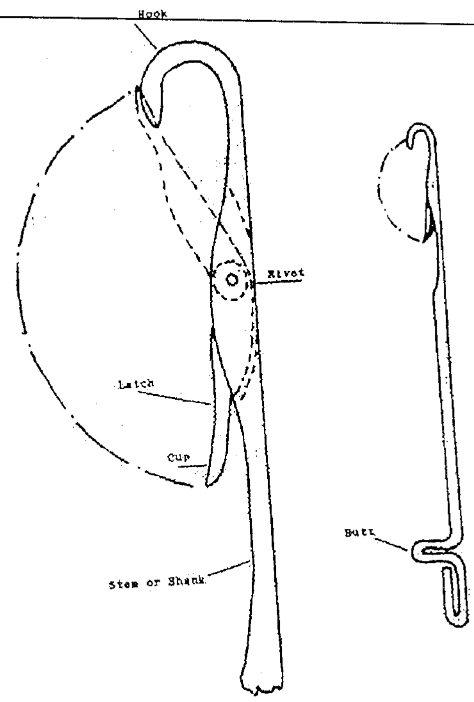


Fig-9.2.1a

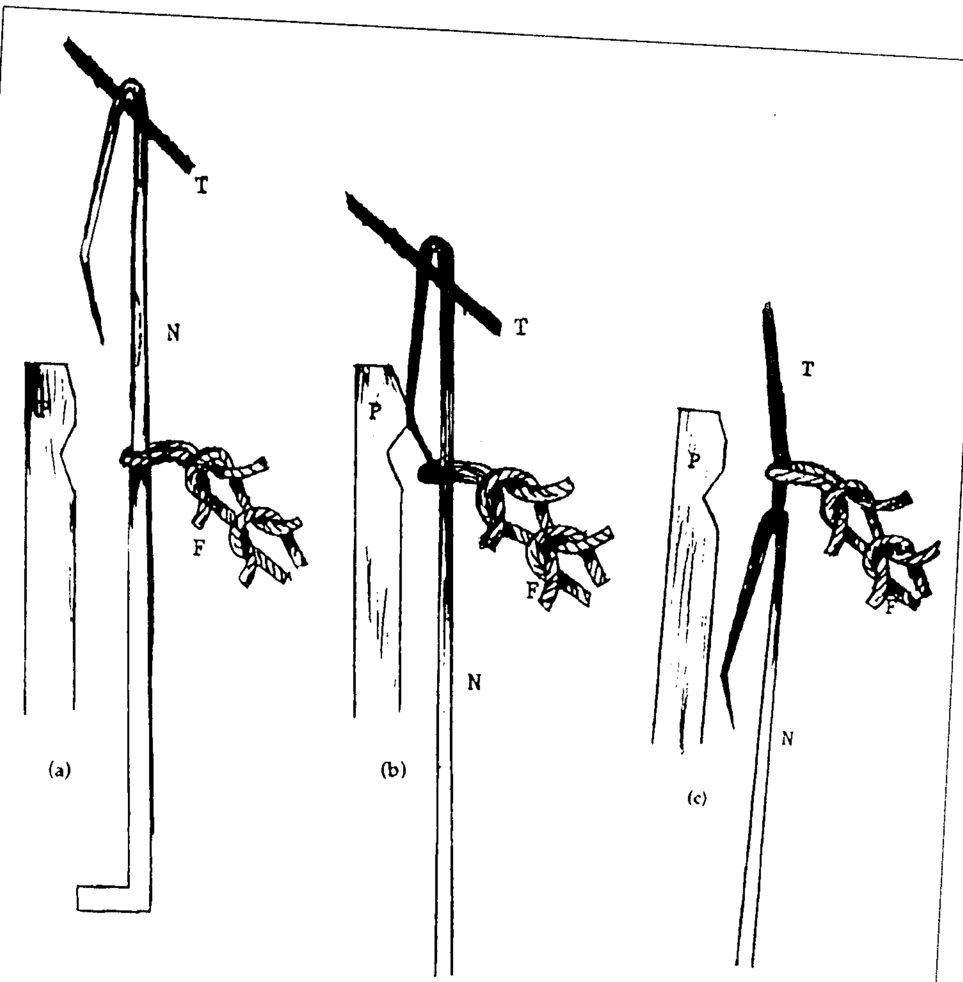


Fig-9.1.2a

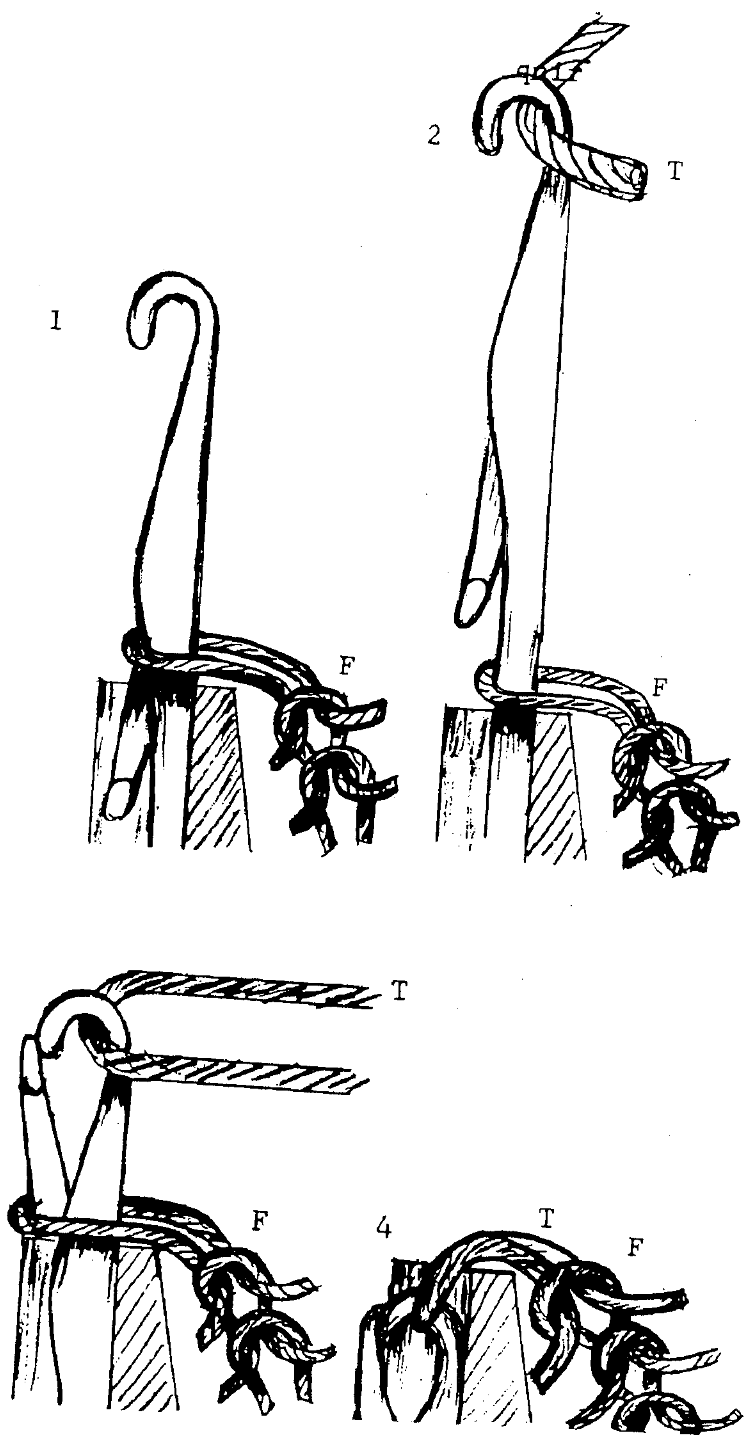


Fig-9.2.1b

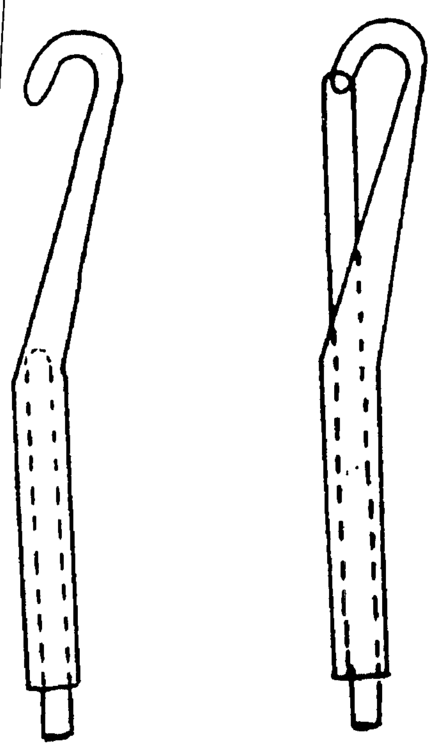


Fig-9.4.1a

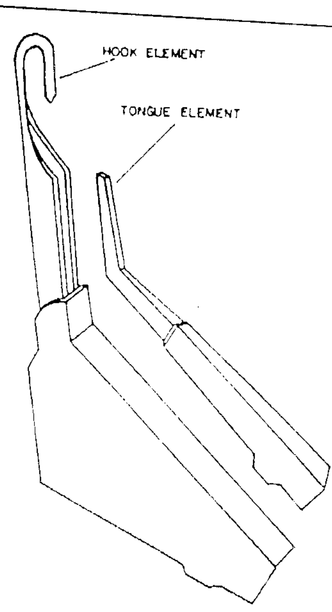


Fig-9.4.1b

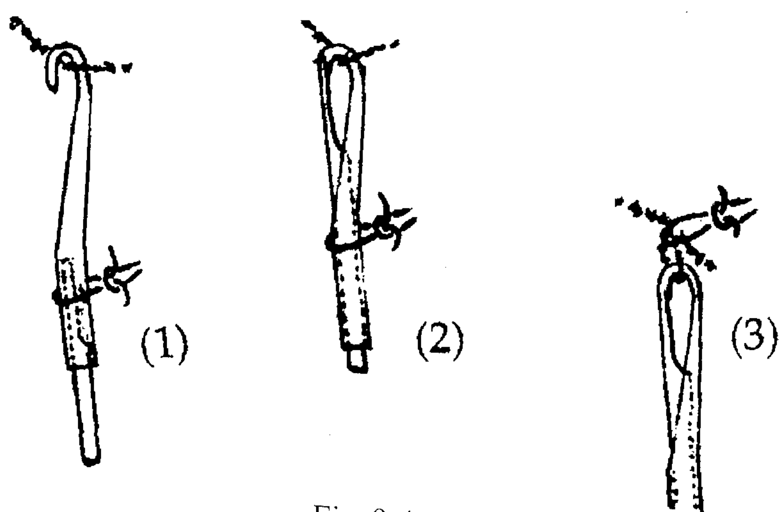


Fig-9.4.2a

Weft Knitted Fabrics

10. TYPES OF KNITTED FABRICS

10.1. Single Jersey

The simplest and the most widely used weft-knit fabric is 'jersy' or 'plain' knit fabric. It consists of face loop stitches only. The technical 'face' and 'back' sides of a jersy or a plain knit fabric are shown in Fig (10.1a) and Fig (10.1b) respectively. The main characteristic features and properties of this fabric are :

The loops have a V-shaped loop appearance on technical face side and show semi-circular loops on the technical back side.

Because of the side limbs of the loop on the face side, it feels smoother on face side than on the back side. It is thus not reversible,. from the feel and appearance point of view.

The interlocking semi-circles at the technical back can be used to produce interesting effects if alternate courses are knitted in different coloured yarns.

Knitted loops in plain-knit fabrics tend to distort easily under tension which help to give a 'form fitting' and 'comfort' due to property of elastic recovery.

It has potential recovery of about 40 per cent in width after stretching. Its width shortens if the length is extended by tensions while the lenght shortens if width is stretched. Normally widthway extensibility is approximately twice the length - way extensibility.

The structures can be unroved from the course knitted last by pulling the 'needle loops' through from technical back or from the course knitted first by pulling the 'sinker loops' through from the technical face side.

As explained earlier, if the unrelaxed plain knit fabric is kept flat on the surface, it curls upwards at the top and bottom and backwards at the sides.

Its production rate is very high because of stitch simplicity and its cost is low because of machine simplicity (capital cost also low) and rate of production is high.

The stitch length can be vaired with cam setting giving more courses per unit lenght with short stitch lenght and vice-versa. The properties such as rigidity, air permeability, weight per unit area, bursting strenght changes with the stitch length . The fabric may appear thick or flimsy if the stitch length is reduced or increased.

It is knitted on a sinlge cylinder machine with a single set of latch needles.

10.2. RIB

The simplest rib fabric is I X I rib shown in extended thread diagram in Fig (10.2a). A rib unit stitch is shown in black colour, from which it will be seen that a unit rib stitch consists of two loops - a face loop as shown in wale (b) and a reverse loop shown in the wale (c). If the structure is seen from the back side of the fabric then the same back loop (c) will be seen as 'a face loop' and the loop (b) will be seen as ' a reverse loop'. Hence there is no technical face and technical back side of the fabric. It is therefore a reversible structure. Note, also that the structure will not be, as shown in Fig (10.2a). The wales (a) (c) etc - the reverse loops - are almost behind wales (b) and (d) or between the face wales. The thread diagram shown in Fig (10.2a) is when the fabric is stretched a bit on both sides. Thus there are two planes of the rib structure - one showing 'face' loop stitches and the other showing the 'reverse' loop stitches. Therefore both side shown 'single jersy' or ' plain knit' structures when viewed from the either side; and should be theoretically twice as thick and half the width of an equivalent plain-knit fabric. (However in practice it does not contract widthay exactly to half the width) It has maximum (or nearly 100 per cent) extensibility in width way.

Symbolic Representation of 1x1 Rib Structure

Graph Paper Representation :-

Diagrammatic Representation :

Features and Properties of Rib Fabric :

It is a reversible structure, i.e., face and back side has the same appearance in 1x1, 2x2, 3x3 ribs etc. The appearance shows vertical cords and thin ridges, in between.

1x1, 2x2, 3x3 ribs etc. are balanced structures because of alternate number of face and reverse wales on each side.

It is heavier and thicker structure than the plain knit structure with similar guage used for plain-knit and rib structure.

It requires a knitting machine with cylinder and dial and two sets of needles- cylinder needles and dial needles (the mechanism of knitting rib structure with cylinder and dial needles is described in Chaper)

Rib structure cannot be unroved from the course knitted first because sinker loops are securely anchored by the cross-meshing between face and reverse loop wales. It can be unroved from the last course knitted.

As mentioned earlier, it has the maximum extensibility in widthway and hence rib trimmings are most suitable for neck bands, collars, arm bands, sleeve cuff bands and waist bands in sweater knitting and for tops of socks, as they fit tighter to the body than the plain knit and give a smart appearance.

Rib fabrics are extensively used in the production of outerwear garments in the Western world.

The fabric does not curl at the edges due to the balanced nature. This property of rib structure is particularly useful in cutting and sweing operations.

The structure is more opaque than a jersey and hence this structure s used for swimwears.

10.3 Interlock

Interlock is the interlocking of two 1x1 rib strucutres in such away that the face wale of one rib fabric 'A' Fig (10.3a) is directly in front of the 'reverse wale' of rib fabric 'B'. Then as the next wale the order is reversed. The interlocking is a result of crossing of the sinker loops in this interchange of sinker loops between the front and back wales. It would be difficult to make stitch illustration of the actual interlock structure which is somewhat similar to that shown in Fig (10.3b) Hence in the diagram Fig (10.3c) the reverse wales are slightly shown shifted to the right for clear understanding of the structure by the reader. The illustration is shown in two shades -,darker and lighter black colours -for clarification.

For complex structure like interlock, the graphical representaton is rather difficult to relate by symbols to fabric loops without some experience. Diagrammatic method shown below is therefore preferable for compiex structures.

The same 4 needles are representated in knit course, 1 and knit course, 2, but second modification (at right) needles are represented by short and long lines, instead of dots in the first. For knitting interlock structures short and long, cylinder and dial needles are used. These needles can be represented by lines of different lengths as shown at the right side.

Feature and Properties of Interlock Structure

The characteristic features and properties can be summarised as.follows :

As the face loops are directly in front of the reverse loops in each wale, if the fabric is viewed from one side and then from the other side, it would present the appearance of a plain knit (jersey) strucutre. Simple interlock structure is therefore reversible as the rib one.

The fabric is firm (i.e. less extensible than either single jersey or rib) due to the interlocking structure knitted in two seperate planes by the sinker structures knitted in two seperate planes by the sinker loops. It can be compared to a 'double cloth' in woven strucutres.

The strucutres do not curl at edges when cut and are more 'ladder resisitant' than either the single jersey or the rib structure.

The knitting of strucutre with cylinder and dial needles makes the strucuture thicker, stronger, less elastic and hence is nearer to the woven strucutre so that cutting and sewing operations are easier for garment making.

It unroves from the course knitted the last.

As two courses of knitting make one effective course in the knit-strucutre, the production rate is reduced to half for the same speed as that of rib or single jersey knitting machine.

Due to complicated machanisims cam tracks and short and long needles operating on the machine, the speed and number of feeds are reduced thus affecting the production.

The fabric becomes costlier per linear metre due to increase in thickness and less production.

The interlock machines are in finer guage (nedles per inch) than the other machines as alternate needles only knit.

10.4 Purl

The characteristic features and properties of purl knit strucutres are as follows :

In the simplest purl structures each wale consists of face and reverse loops. Hence semicircles of needle and sinker loops are seen on both-face and back-sides of the fabric due to reverse loops. This has led to the term 'links-links' being applied to the fabric and the machine.

It is reversible in appearance and has soft hand with full cover.

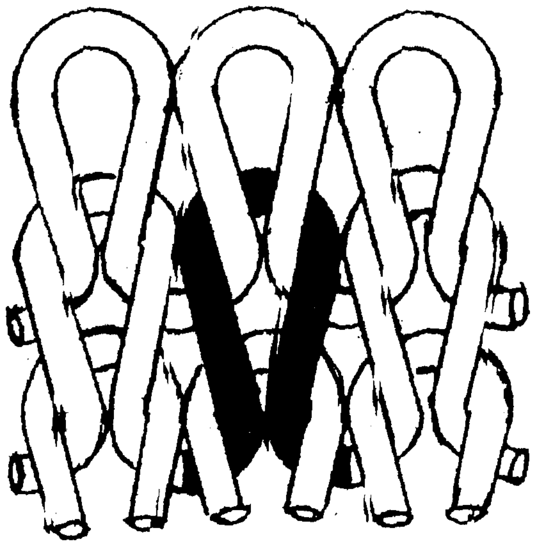
Its thickness is theoraticaly double to that of a plain knit of jersey fabric.

Like the jersey knit fabric, it can be unroved from either end.

As the link machine has a horizontal bed for the needles to reciprocate, the speed of the machine and the production is much less compared to other weft knit fabrics. However as it is knitted on a coarse gauge machine, the coarse yarn can result in higher production by weight.

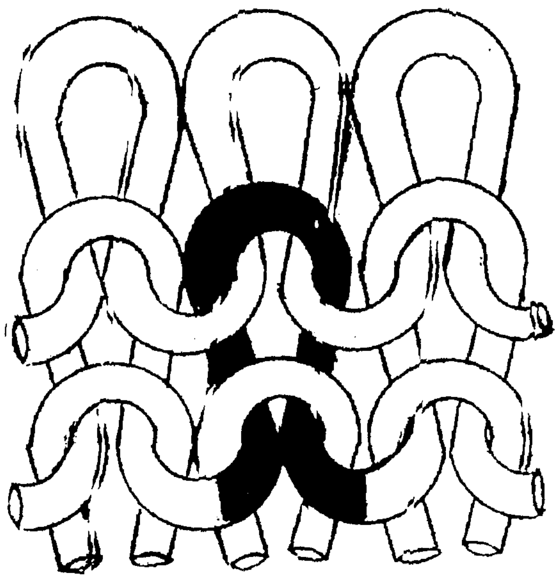
It does not curl at the edges and because of alternate face and reverse courses it is a balanced structure which property is useful in cutting and sewing.

In its circular version two small cylinders located one over the other to knit socks or half hose.



Technical face side

Fig-10.1a



Technical back side

Fig-10.1b

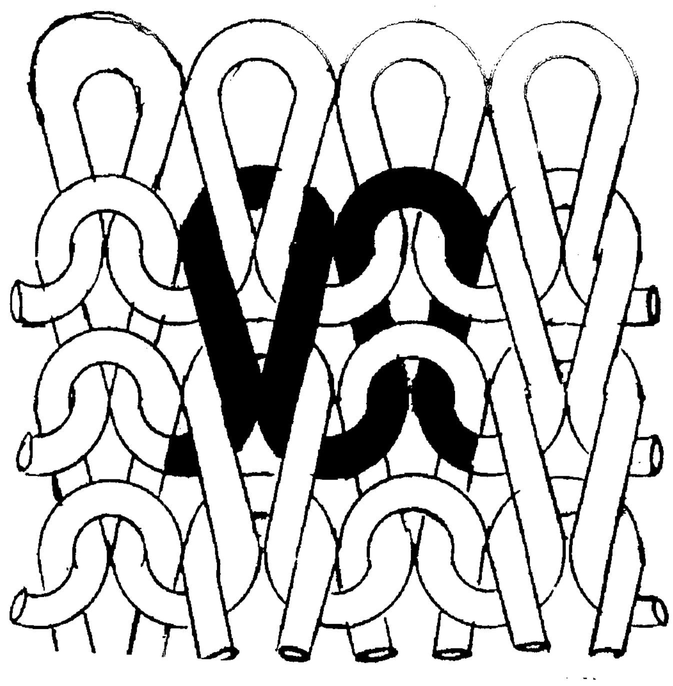


Fig-10.2a

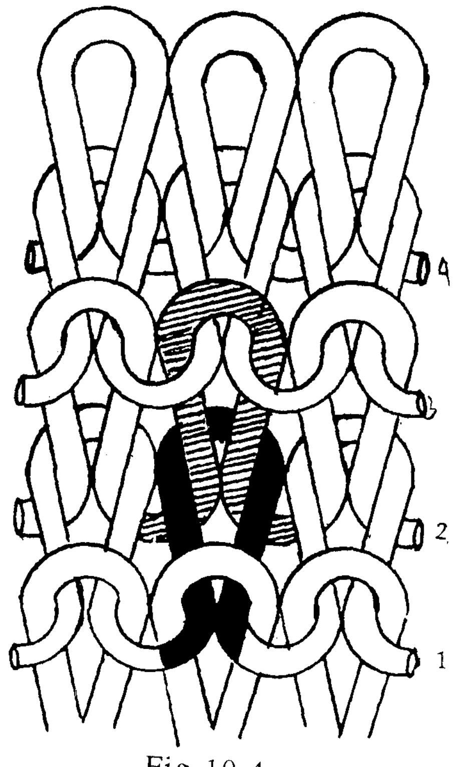


Fig-10.4

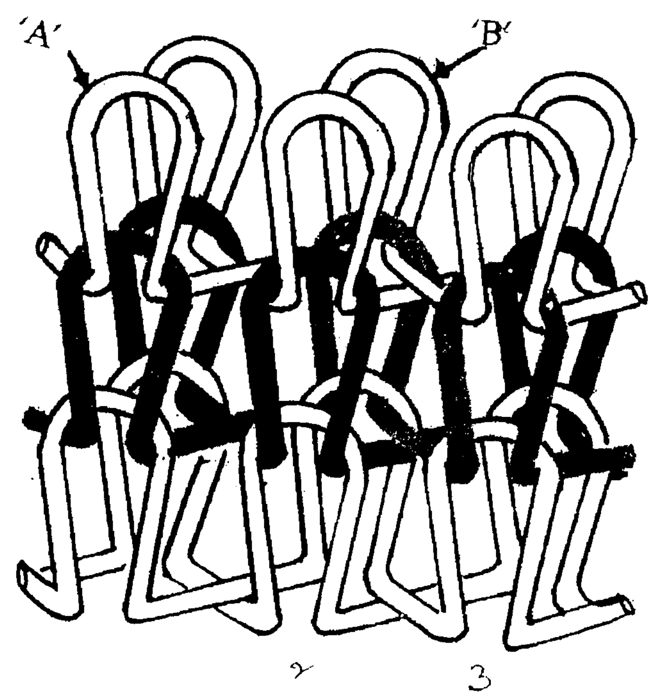


Fig-10.3a

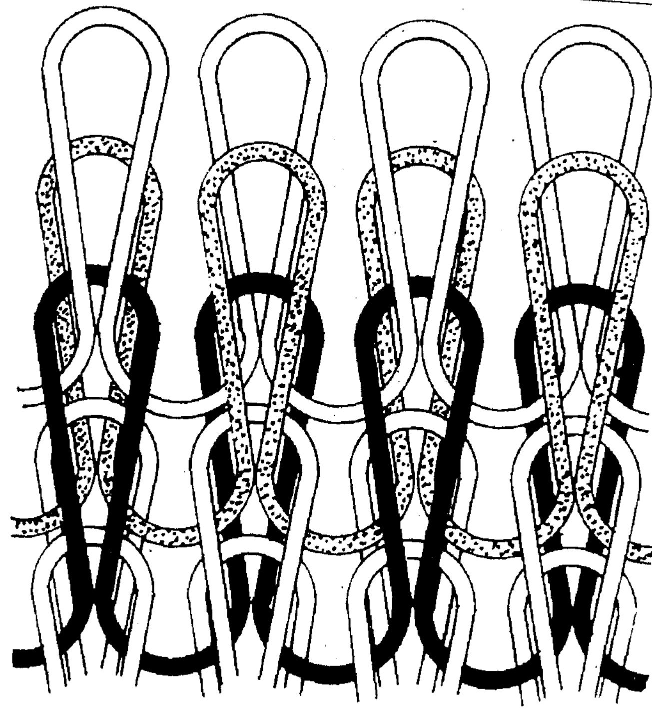


Fig-10.3b

Dimensional Properties

11. GEOMETRY OF PLAIN WEFT KNITTED FABRICS

The basic element in a fabric is a "stitch " or a "loop". A loop has got two faces namely face loop and back loop. The difference between the two can be seen from fig f11.1 & f11.2

In studying the theory of fabric geometry to its practical application, two fundamental factors must be appreciated.

a) Stitch length: - (i.e.)The length of yarn in knitted loop, is dominant factor for all structures.

b) These are several dimensionally stable states possible for a knitted structure.

Dry - Relaxed State :

The fabric has been taken off the knitting machine and in course of time attains a dimensionally stable condition called the dry –relaxed state.

Wedt - Relaxed State :

If the fabric is soaked in water and allowed to dry, flat the wet –relaxed state is attained, again a dimensionally stable condition.

Finished Relaxed State :

In order to reach this stable condition the fabric is subjected to agitation in water or steam and a denser fabric results.

Some of the terms used in the study of the weft knitted structure are given in the figure 11.1.The lines of loops across the fabric are known as "courses" and the lines down the fabric as wales one loop is referred to a stitch .Various symbols are used.

S = the number of stitches per square unit

C = the number of courses per unit length

W = the number of wales per unit width

L = the stitch or loop length.

11.1 : Relationship Between Stitch Density, Loop Length, Courses and Wales

The result recent research into knitted fabric geometry here enable some important relations to be derived.

1) The number of stitches or loops per unit area is inversely proportional to the stitch length squared .

S 1/l

Or

S = Ks/l

2) The number of courses per unit length is inversely proportional to the stitch length .

C =1/l

Or

C = Kw/l

3) The number of wales per unit width is inversely proportional to the stitch length

W = 1/l

Or

W = Kwl

4) From the relations (2) & (3),

Courses per unit length = C/W = KcC/Kw

Wales per unit width

Note the importance of stitch length ,"L", and the fact that the either yarn diameter or knitting machine gauge in appear in the equations.

The constants in table 11.1 were derived by using similar length units for courses per unit length wales per unit and stitch length. In imperial units , the inch is used ,and in the metric system the centimeter is used in SI units , the recommended length unit for courses and wales per unit length is the centimeter and that for the stitch length is the millimeter . This causes the values of Ks to be multiplied by 100 and those of Kc & Kw by 10 .

11.2 Arial Density of a Plain Knitted Fabric :

If we know number of 100ps/m2, the loop length, and the linear density of yarn, the Arial density of the knitted fabric can be calculated as,

100ps/m2 x stitch length cm x linear density (tex) x 10-6

(the factor of 10-6mm in km)

If the stitch density S, in stitches /cm2, then the number of stitches /m2 will be S x 104 and arial density becomes ,

$$\frac{S \times L \times \text{linear density (tex)} \times 10}{10} \quad \text{(Since L is in mm)}$$

$$= \frac{SI \times \text{Linear density (tex)}}{100}$$

We can further use the relation ,

$$S = Ks/l2$$

Substituting for S gives

$$\text{Arial density} = Ks/l2 \times 1/100 \times \text{linear density (tex)}$$

$$= \frac{Ks \times \text{linear density (tex)}}{100\ L} \quad g/m2$$

11.3 Courses / cm and Wales / cm:

It is noted that the ratio of courses/cm to wales is 1.29 for the wet-relaxed state . If we know the product of the courses/cm and wales/cm ,we can estimate both the number of courses/cm and the number of wales/cm.

11.4 Cover for Plain Knitted Fabrics :

Fractional Cover :

In fig.11.1,there is a simplified two dimensional representation of a plain knitted structure one assumption being that the structure lies perfectly flat which it does not, and another that the yarn has a circular cross-section, with diameter d. If the stitch length is 1 mm and the diameter d mm, the area covered by one stitch or loop is 1xd mm2 if the number of stitches/cm2 is the total area covered by the yarn is given by;

Sxlxd

Expressed in cm2, this becomes,

$$\frac{S \times l \times d}{100} \text{ cm2}$$

This expression is also, the fractional cover of the fabric, since it is the yarn area covering 1 cm2 of fabric

Applying the relation,

S=Ks/l2,

Gives the expression ,

$$\text{Fractional cover} = Ks \times l \times d/l2 \times 100$$
$$= Ks\ xd\ /\ 100\ L$$

In the knitted structure, four approximately square areas are covered twice, where the yarns cross, and m to be a little more accurate, a correction could be made. The area q each square is d mm2 or d/100cm2 .The correction is therefore 4d2/ 100 , and the fractional cover equation would now read,

$$\text{Fractional cover} = (Ks\ d - 0.04\ d2\ )/100L$$
$$= [Ks\ d\ (1\text{-}0.04d)]\ /\ 100L$$

An expression for the yarn diameter in terms of its linear density in tex is now required . Suppose we decide to use grosber's formula,

d = {4.44 x 10 v(linear density (tex)/fibre density } cm

We can now express the fractional cover as ;

Fractional cover ={ Ks x 4.44 x 10 v [linear density (tex)/fibre density]/100L

11.4.2 Cover factor or tightness factor

A number that indicates the extent to which the area of a knittes fabric is covered by the yarn .

Tightness factor = v[tex]/l

11.5 Width of Plain Knitted Fabric :

If there are 'n' needles knitting on the machine ,it following that

Fabric width = number of needles./ wales /cm

From earlier discussion , it is learnt that the number of wales/cm is goverened by the stitch length,

Wasserkopf = Kw/l

Hence, a general formula for fabric width is,

Fabric width = n /(Kw/l)

= nl/Kw cm.

The value of the constant low for fabric in three stable is given in Table 6.2

Furthermore, the fabric course length, L, is n x 1, and the fabric width can therefore be expressed as, L/Kw cm.

Note that the number of needles does not figure in this cast formula, which indicates that the fabric width is really dependant on the number of needles knitting.

11.6 Fabric Mass Per Running Meter

The total length in a running meter of fabric will be the number if courses in ale of 1m of fabric with n needles knitting and a stitch length of 1mm, the course length in kilometers is

nxlx10^-6 km

The number of courses/cm is given by,

Courses/cm = Kc / l

Courses /m =100 Kc/l and total length of yarn per running meter is,

(n x l 10^-6 x 100 Kc) / l = n x Kc x 10^-4 km.

Multiplying this total length by the linear density of the yarn in tex produces the mass per running metre Hence ,

Mass per running metre = n x Kc x10^-4 xtex.

11.7 Shapes and Dimension of Loop

It has been normal practice some yarns to express the dimensions of knitted loops in the form

$$C = Kc/L, \quad W = Kw/L,$$

Where C and W are the number of courses and wales per unit length, respectively, and Kc and Kw are dimensionless parameters. The value of Kc and Kw can be calculated and their variation with d / l is shown in diagram 11.2 , the values of Kc and Kw for values of d / l in the practical range are close to those that have been found experimentally

The thickness of the fabric is given by

$$T = Yb - Ya + d,$$

And the values of the ratio t /l are plotted against d / l in the fig. 11.3. These results imply that as mechanical loop length is increased the yarn count remaining constant the ratio of the loop length decrease.

The fig.11.4(a) and (b) shows the projection of central axes of loops on co-ordinate planes(a) d/l =0.03 : jamming does not take place between both wales and course respectively.

Testing of Knitted Fabrics

12.1 ABRASION RESISTANCE TEST

The knitted fabrics which are commonly used as sports wear are subjected to more amount of abrasion against soil and other factors making the resistance to abrasion provided by them an important requirement. The abrasion resistance of these fabrics is tested using the MAG obrasion resistance tester.

First the dry relaxed fabrics are taken. From each type of fabric 10 samples are cut using template. The samples are tem weighed on an electronic balance. Four samples can be tested at a time on the instrument there is a counter available on the instruments itself which indicates the number of revolutions completed by the instrument.

The fabric surface is abraded using emery sheet of specified roughness. The instrument is allowed to complete 100 revolutions. The fabric samples are then removed and weighed. The difference between the inital and the final weights of the fabric is calculated. The difference gives the wieght lost due to the abrasion of the fabric surface.

The same procedure is repeated for the wet relaxed samples also. The readings are tabulated in table 13.1

12.2 BURSTING STRENGTH TEST

The knitted fabrics are also subjected to extensive pressures during their usage. The bursting strength of the knitted fabric determines the life of the knitted fabric and to some extent its reliability.

The bursting strength of the knitted fabric is tested on the pressure type bursting strength tester. The heart of the bursting strength tester is the rubber diapragm which moves up and down according to the pressure applied beneath.

The fabric samples are divided into two groups. One part of the fabrics are the dry relaxed fabrics and the other part of the fabrics are the wet relaxed ones.

The dry and the wet relaxed samples are tested seperately.The rubber diapragm is initially brought to the lowermost position by making the pressure applied zero. The needle in the pressure gauge which shows the pressure applied in terms of lbs/sq.inch is also brought to zero.

The fabric sample is placed on the diapragm and the lid is screwed down. The motor is now switched on and the pressure applied on the diapragm gradually rises the diapragm.As soon as the pressure is well enough to tear the fabric the rubber diapragm pierces through the fabric surface.At this moment the motor switches off by itself. This arrangement is provided in order to avoid any damage to the diapragm.now the needle in the pressure gauge shows the pressure applied and the value gives the bursting strength of the fabric directly.

The same procedure is repeated for all the samples of individual fabrics and the readins are tabulated.

12.3 DRAPE TEST

The drape that any fabric offers is an important quality parameter of the corresponding fabric. The drape of the fabric is expressed in the form of the drape coefficient.

The drape co-effeciant can be found out using the drape meter. The tests were carried out on the Eureka drape meter. The samples are cut using the bigger disc as template. The disc is of 300mm diameter. The cut fabrics are placed on a smaller disc with two small pegs on its surface. The smaller disc is fixed. Above the fabric another disc is placed and screwed.

The lid of instrument is closed and the illumunating bulb is switched on. The thin sheet of paper is placed on the lid which is transparant and the out line of the fabric is sketched on the paper. Now the fabric is removed the same procedure is repeated for all the fabrics.

The fabric out line which is drawn on the paper is cut along. Another paper is marked with the disc size and both the papers are weighed. From the two values the drape co-efficient is calculated.

12.4 FABRIC STRETCH

The knitted fabrics which are most commonly used as sports wear should have the maximum amount of stretch in them. Fabric stretch is a very important quality parameter as far as any knitted fabric is concerned.

To test the fabric stretch samples of equal size are cut from each and every fabric. The samples are then held tightly at one end and are stretched at the other end. The maximum extent to which the fabric stretches is measured. The difference between the initial length and the final length gives the amount of stretch the fabric has undergone. The fabrics are stretched untill they start to tear.

The samples are stretched both in the course wise and wale wise directions seperately. About 5 to 10 samples are tested for each type of fabric and the results are tabulated. The same procedure is repeated for the wet relaxed fabric samples also.

12.5 FABRIC THICKNESS

The knitted fabrics are known for their bulkier look when compared to the woven fabrics. The reason being that the knitted fabrics are formed of loops that are raising from the surface.

The thickness of the knitted fabric is one that varies with the type of fabric and also with the type of yarn used to knit the fabric. Thus it is bound to show variations when the constitutent yarn parameters are varied.

The thickness of the knitted fabric is tested using a thickness guage. The thickness guage has a dial calibrated to show values acurate to the extent of 1/100 of an mm. There is a lever on the top of the guage which when lifted also lifts along a rod with a broader circular bottom which rests on a similar sized bottom half.

The fabric samples is placed by lifting the top lever and then it is again lowered so that the fabric sample is gently held between the upper and lower discs. Now the dial of the guage shows the thickness of the respective samples. The same sample is inserted in different positions and from different sides and readings are taken. The same procedure is repeated for all the samples and the readings are tabulated.

12.6 PILLING RESISTANCE

Pills are small ball like rounded structures that are formed on the surface of the fabric due to continous usage. The pills formed on the fabric surface are prone to spoil the aesthetic look of the fabric and also the wearing comfort. Thus resistance that a fabric can offer towards pilling also becoming an important requirement.

The Pilling resistance of the fabrics is tested using the MAG pilling resistance tester. The fabric samples are cut as per the size of the template provided. They are stiched at two ends to make them in a continious endless form. They now look like a hose. Eight fabric samples can be tested at the same time on the instrument.

The instrument consist of two hollow wooden boxes with cork linning on the innerside. There is a motor which continiously rotates the two boxes at the rate of 50 revolutions per minute. An led display indicates a number of revolutions completed. The required number of revolutions can be preset in the counter. As soon as the specified number of revolutions are completed the instrument stops by itself.

The stiched fabrics in the hose form are mounted over rubber tubes after inverting them. Four mounted samples are put in each box. After the completion of 18 thousand revolutions the machine is stoped. The fabric samples are removed from the boxes and are carefully stripped off from the rubber tubes. They ar ethen slowly reversed. The number of pills formed on surface of the fabric are noted down.

Depending upon the number of pills formed on the surface of individual fabrics they are given grades. The grades are recorded in the respective tables.

12.7 STITCH DENSITY

The stitch density is a factor which determines how close the fabric is knitted. The stitch density is calculated from the courses and wales that at present in one square inch of the fabric.

The courses and wales in a square inch of the fabric are manually counted using a pick glass. The ratio between the courses and the wales in the fabric give the stitch density of the respective fabric. The nominal stitch density value for any knitted fabric is said to be arround 1.29.

In Each fabric the courses and wales are counted at atleast five locations and the stitch density values are calculated and they are recorded in the respective tables.

12.8 WATER RETAINING CAPABILITY TEST

The knitted fabrics are known for their capacity to absorb water and retain it for considerably longer duration than the woven fabrics. This is the reason why knitted fabrics are preferred for sports weare and also as summer weare. Thus water retain capability of the knitted fabric is yet another quality perameter of itself.

The fabric samples are cut to a specified size and are weighed on electronic balance. The fabric samples are kept immersed in water for a duration of 30 minutes then the fabric samples are taken out and are dried under laboratory Conditions without squeezing them for about 15 minutes.

Then the half dried fabric samples are weighed on the electronic balance. The difference between the final wieght and initial weight of the fabric is calculated. It is expressed in means of percentage to its initial weight. The values are recorded in the table.

Tables & Values

13.1. ABRASION RESISTANCE

(Dry sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	0.00462	0.00476	0.00333	0.00410	0.00256	0.00360
2	0.00460	0.00477	0.00331	0.00411	0.00251	0.00361
3	0.00458	0.00475	0.00339	0.00415	0.00260	0.00351
4	0.00464	0.00459	0.00323	0.00410	0.00258	0.00369
5	0.00469	0.00467	0.00338	0.00405	0.00259	0.00358
6	0.00459	0.00476	0.00325	0.00416	0.00264	0.00362
7	0.00456	0.00457	0.00334	0.00404	0.00267	0.00354
8	0.00458	0.00469	0.00337	0.00412	0.00251	0.00357
9	0.00459	0.00486	0.00329	0.00408	0.00252	0.00359
10	0.00462	0.00466	0.00334	0.00410	0.00256	0.00368
Average	0.00462	0.00476	0.00333	0.00410	0.00256	0.00360

(Wet sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	0.00390	0.00535	0.00296	0.00449	0.00250	0.00389
2	0.00388	0.00548	0.00291	0.00449	0.00245	0.00387
3	0.00399	0.00538	0.00299	0.00445	0.00255	0.00396
4	0.00381	0.00528	0.00301	0.00456	0.00259	0.00384
5	0.00395	0.00521	0.00288	0.00440	0.00247	0.00396
6	0.00388	0.00536	0.00284	0.00459	0.00248	0.00381
7	0.00395	0.00534	0.00306	0.00456	0.00249	0.00381
8	0.00384	0.00527	0.00299	0.00438	0.00251	0.00387
9	0.00392	0.00529	0.00295	0.00448	0.00251	0.00399
10	0.00389	0.00539	0.00291	0.00459	0.00246	0.00384
Average	0.00390	0.00535	0.00296	0.00449	0.00250	0.00389

13.2. BURSTING STRENGTH

(Dry sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	10.4	12.0	8.8	10.8	8.0	9.2
2	10.0	11.6	8.8	10.4	8.0	9.6
3	10.0	12.0	8.4	10.4	8.0	9.2
4	10.4	12.4	8.8	11.2	7.6	9.2
5	10.8	12.0	9.0	11.2	8.0	9.6
6	10.0	12.0	9.0	10.4	8.4	8.8
7	10.8	11.8	8.4	10.8	8.0	8.8
8	10.4	12.2	8.8	10.8	8.0	9.2
9	10.4	12.0	9.2	11.2	8.0	8.8
10	10.4	12.0	8.8	10.8	8.0	9.6
Average	10.4	12	8.8	10.8	8.0	9.2

(Wet sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	10.0	11.2	8.4	10.0	7.2	8.8
2	10.4	11.6	8.8	10.0	7.2	8.4
3	10.0	11.6	8.0	9.6	7.2	8.4
4	9.6	11.2	8.4	10.0	7.6	8.8
5	9.6	11.0	8.4	10.4	7.6	9.2
6	10.0	11.0	8.4	10.4	7.0	9.2
7	10.4	11.2	8.8	10.0	7.0	8.8
8	10.0	11.2	8.4	9.6	7.0	8.4
9	10.4	11.6	8.0	10.0	6.8	8.4
10	9.6	11.0	8.4	10.0	7.2	9.2
Average	10.0	11.2	8.4	10.0	7.2	8.8

13.3. DRAPE COEFFICIENT

(Dry sample)

Serial number	Sample type	Drape coefficient
1	25s SJ	0.351
2	25s I	0.591
3	34s SJ	0.372
4	34s I	0.482
5	40s SJ	0.403
6	40s I	0.373

(Wet sample)

Serial number	Sample type	Drape coefficient
1	25s SJ	0.357
2	25s I	0.337
3	34s SJ	0.307
4	34s I	0.435
5	40s SJ	0.348
6	40s I	0.350

13.4. FABRIC STRETCH TEST

(Dry sample)-course wise.

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	105%	120%	82%	90%	70%	80%
2	105%	117%	80%	90%	68%	78%
3	105%	119%	84%	92%	72%	77%
4	106%	123%	81%	90%	69%	84%
5	104%	121%	83%	88%	71%	81%

(Dry sample)-Wale wise.

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	50%	44%	42%	36%	36%	28%
2	52%	44%	45%	36%	38%	30%
3	48%	43%	40%	36%	35%	31%
4	50%	45%	41%	38%	35%	25%
5	50%	44%	41%	34%	36%	27%

(Wet sample)-course wise.

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	92%	84%	76%	75%	55%	60%
2	90%	81%	74%	74%	54%	58%
3	86%	88%	75%	75%	55%	63%
4	96%	85%	77%	77%	56%	60%
5	96%	82%	76%	75%	55%	59%

(Wet sample)-Wale wise.

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	43%	38%	38%	31%	31%	22%
2	41%	40%	40%	31%	29%	21%
3	45%	36%	38%	31%	31%	22%
4	43%	37%	38%	33%	30%	23%
5	43%	39%	36%	29%	34%	21%

13.5. FABRIC THICKNESS

(Dry sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	0.55	0.92	0.51	0.86	0.40	0.81
2	0.54	0.92	0.51	0.85	0.41	0.81
3	0.54	0.91	0.53	0.85	0.41	0.82
4	0.55	0.92	0.52	0.86	0.40	0.81
5	0.53	0.93	0.51	0.87	0.39	0.81
6	0.54	0.93	0.50	0.87	0.39	0.82
7	0.52	0.92	0.51	0.85	0.38	0.80
8	0.55	0.92	0.52	0.84	0.42	0.78
9	0.55	0.92	0.51	0.86	0.42	0.81
10	0.55	0.91	0.49	0.88	0.41	0.80
Average	0.55	0.92	0.51	0.86	0.40	0.81

(Wet sample)

Sample type	25s SJ	25s I	34s SJ	34s I	40s SJ	40s I
1	0.59	0.96	0.54	0.92	0.51	0.89
2	0.58	0.96	0.54	0.93	0.50	0.89
3	0.59	0.96	0.53	0.91	0.51	0.89
4	0.59	0.97	0.52	0.92	0.52	0.91
5	0.60	0.95	0.51	0.91	0.53	0.91
6	0.60	0.96	0.55	0.92	0.49	0.86
7	0.58	0.97	0.54	0.91	0.49	0.87
8	0.59	0.95	0.55	0.93	0.850	0.87
9	0.59	0.96	0.56	0.93	0.51	0.89
10	0.59	0.96	0.54	0.92	0.51	0.89
Average	0.59	0.96	0.54	0.92	0.51	0.89

13.6. PILLING RESISTANCE

(Dry sample)

Serial number	Sample type	Grade
1	25s SJ	C
2	25s I	C+
3	34s SJ	B
4	34s I	B+
5	40s SJ	A
6	40s I	A+

(Wet sample)

Serial number	Sample type	Grade
1	25s SJ	C+
2	25s I	B
3	34s SJ	B+
4	34s I	A
5	40s SJ	A+
6	40s I	A++

13.7. STITCH DENSITY

(Dry sample)

SAMPLE TYPE	25s SJ	34s SJ	40s SJ
1	1170	2052	2400
2	1216	2052	2520
3	1170	2080	2400
4	1064	2024	2400
5	1080	2052	2280

(Wet sample)

SAMPLE TYPE	25s SJ	34s SJ	40s SJ
1	1786	2728	3102
2	1864	2698	3102
3	1708	2728	3046
4	1786	2742	3102
5	1786	2728	3158

13.8. WATER RETAINING CAPABILITY TEST

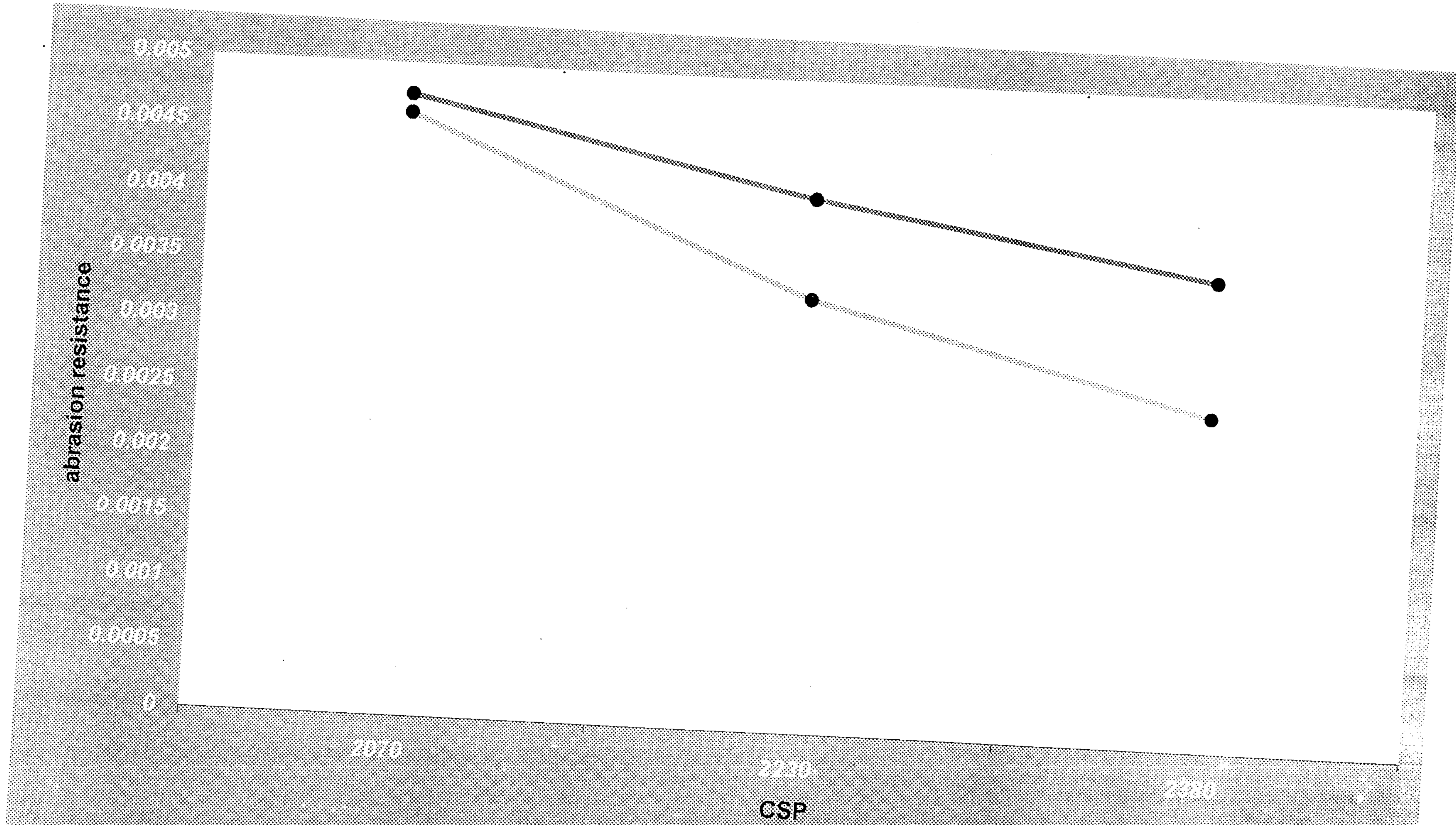
(Dry sample)

Serial number	Sample type	%Water retaining capability
1	25s SJ	265%
2	25s I	141%
3	34s SJ	274%
4	34s I	186%
5	40s SJ	314%
6	40s I	214%

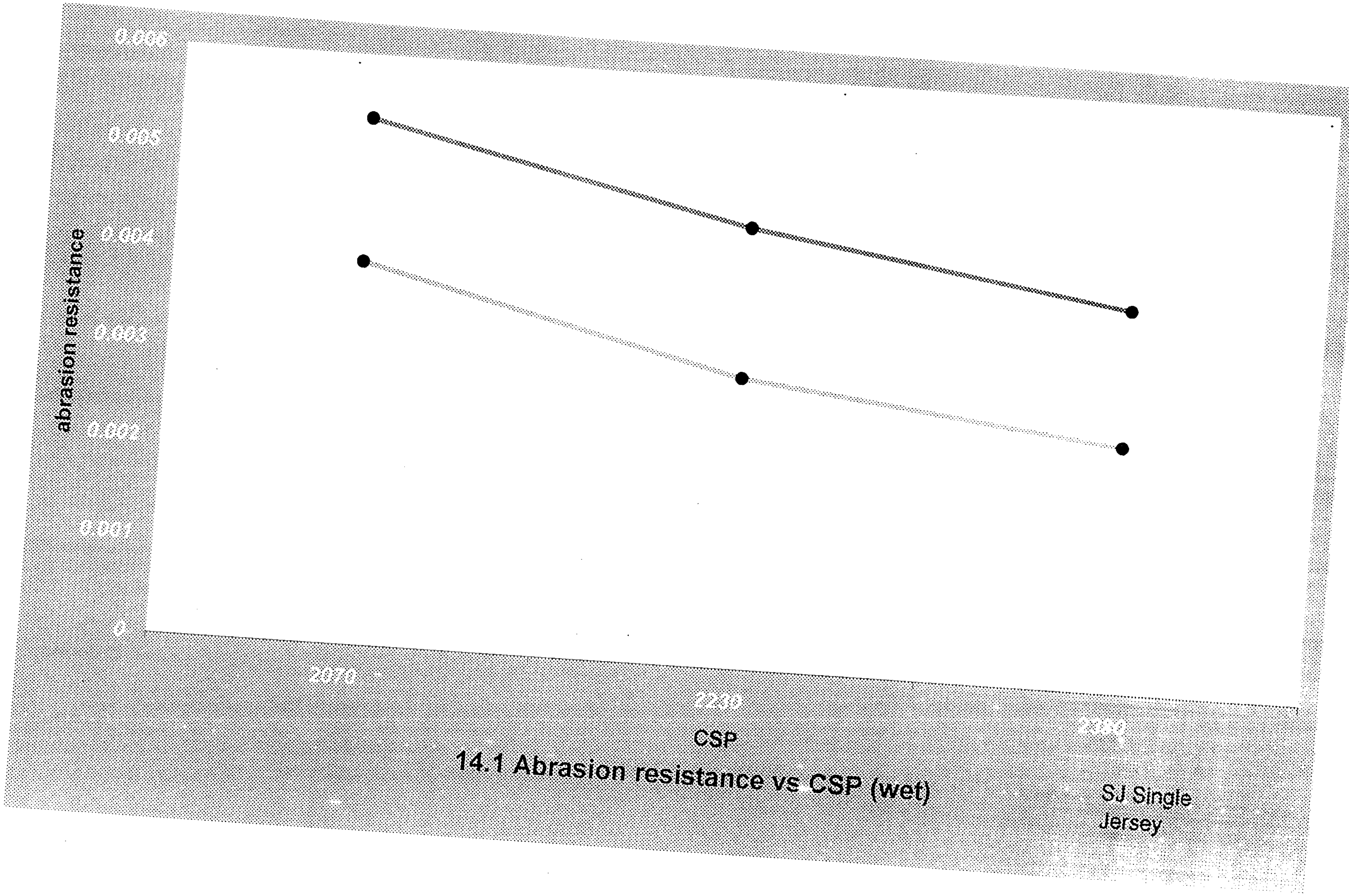
(Wet sample)

Serial number	Sample type	%Water retaining capability
1	25s SJ	260%
2	25s I	82%
3	34s SJ	274%
4	34s I	112%
5	40s SJ	330%
6	40s I	142%

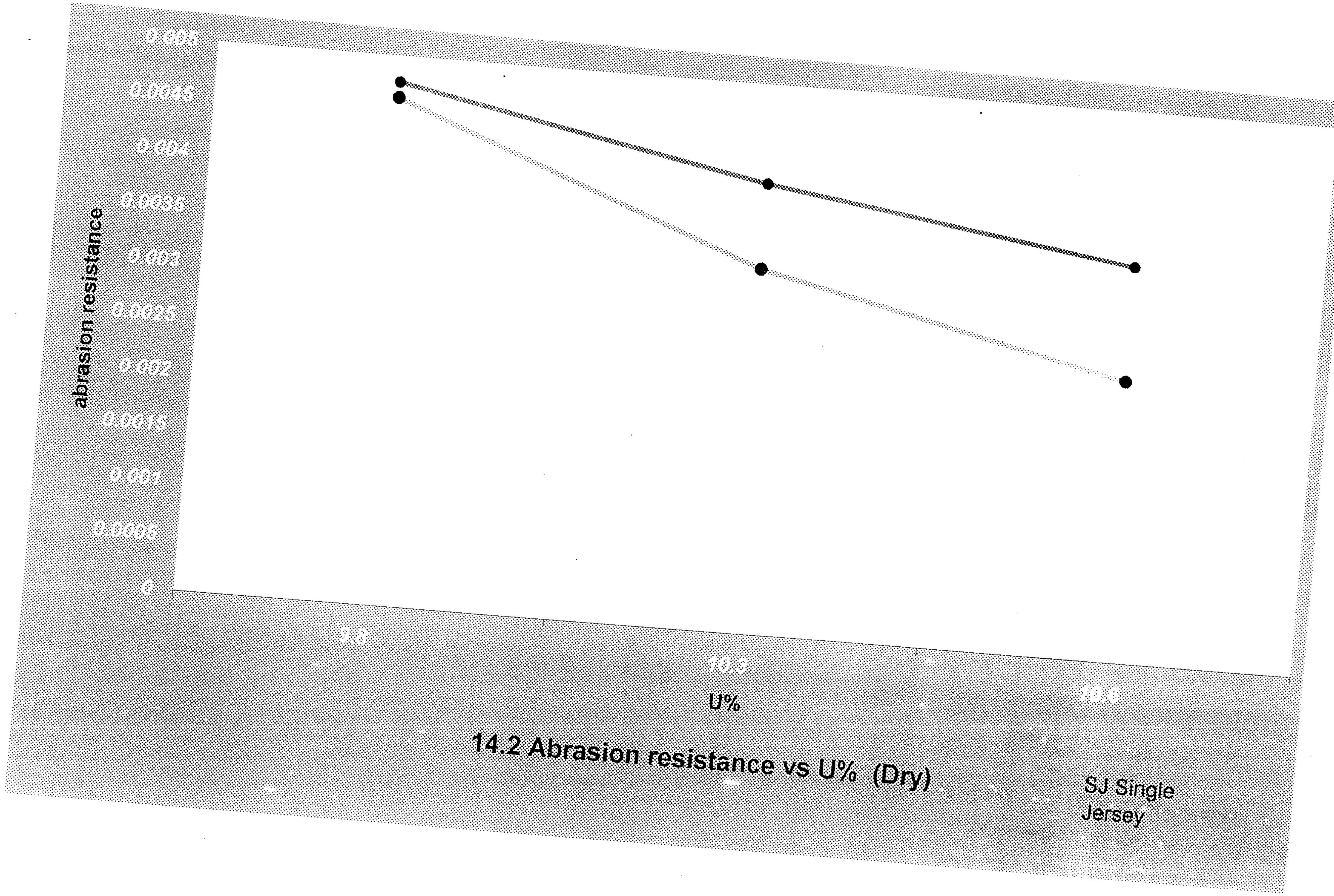
Plots



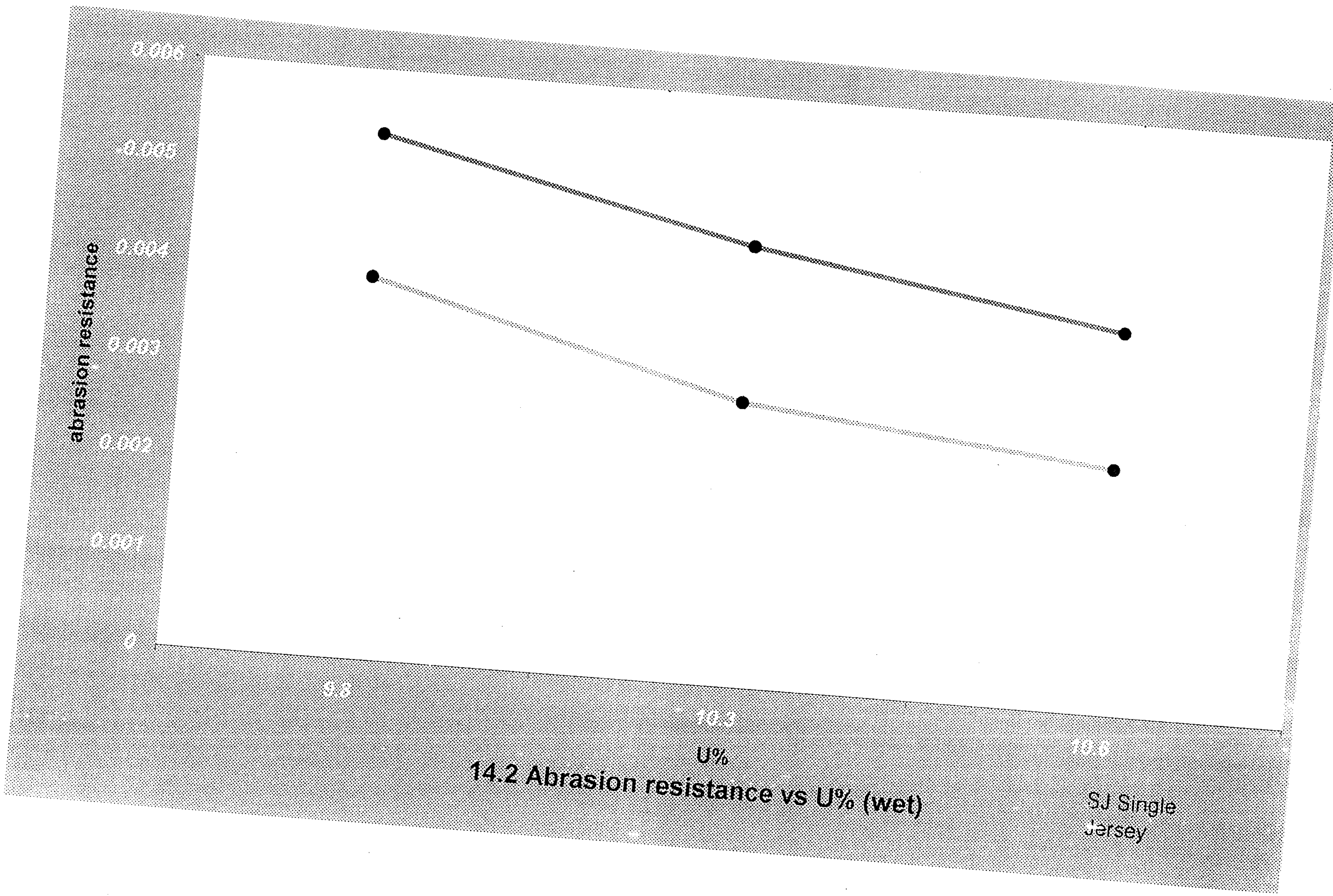
14.1 Abrasion resistance vs CSP (dry)



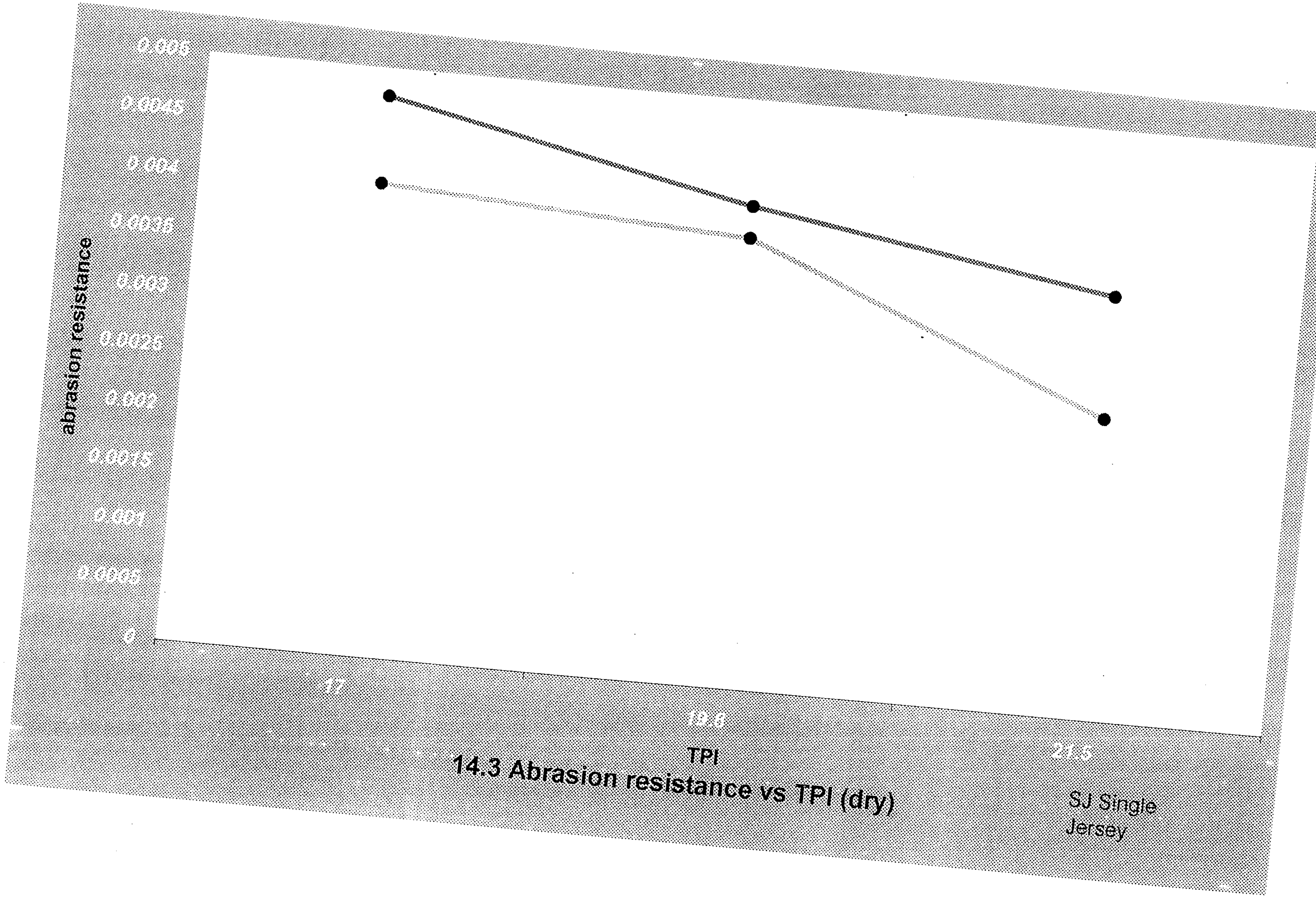
abrasion resistance
0.006
0.005
0.004
0.003
0.002
0.001
0
2070
2230
2380
CSP
14.1 Abrasion resistance vs CSP (wet)
SJ Single Jersey



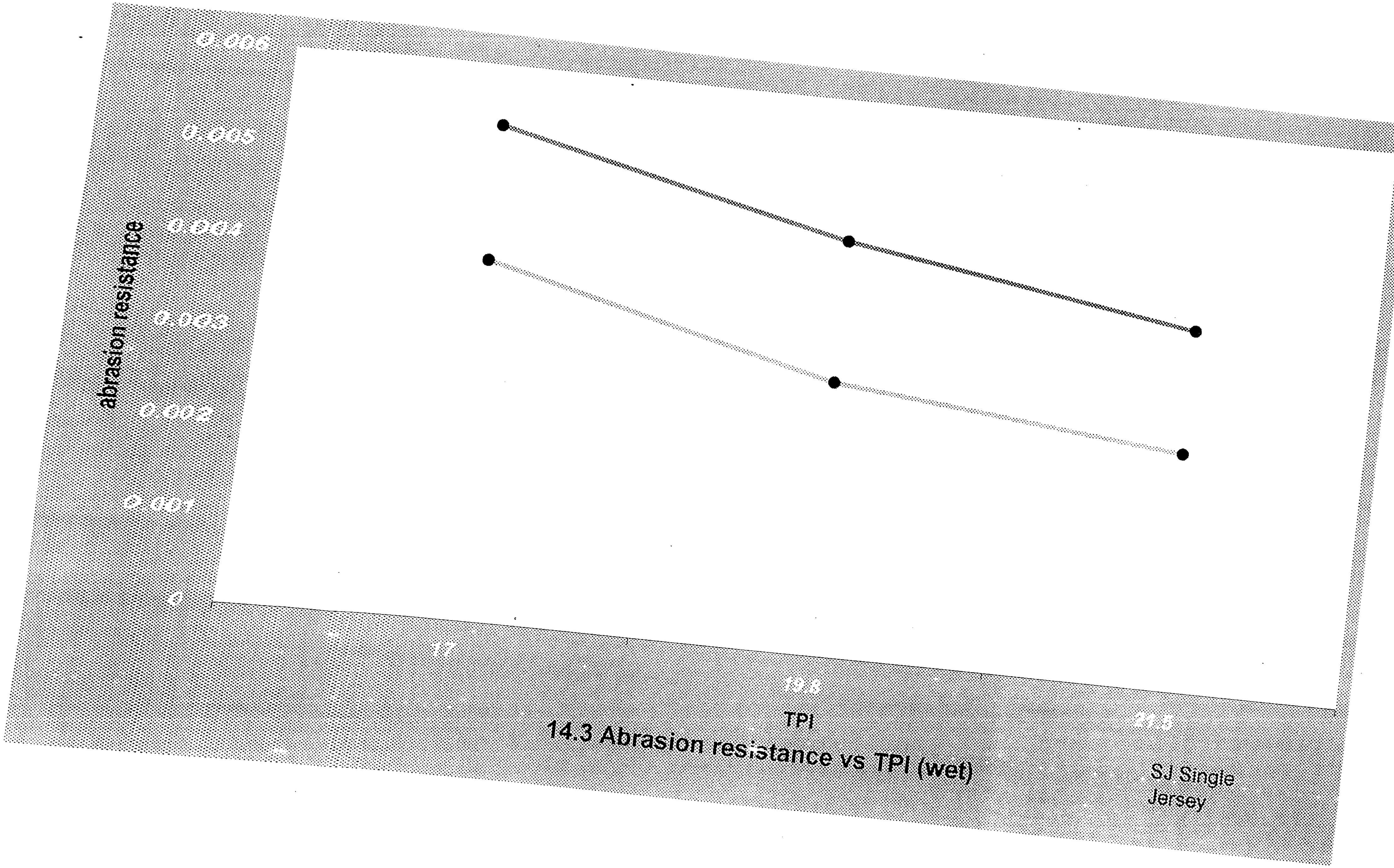
14.2 Abrasion resistance vs U% (Dry)



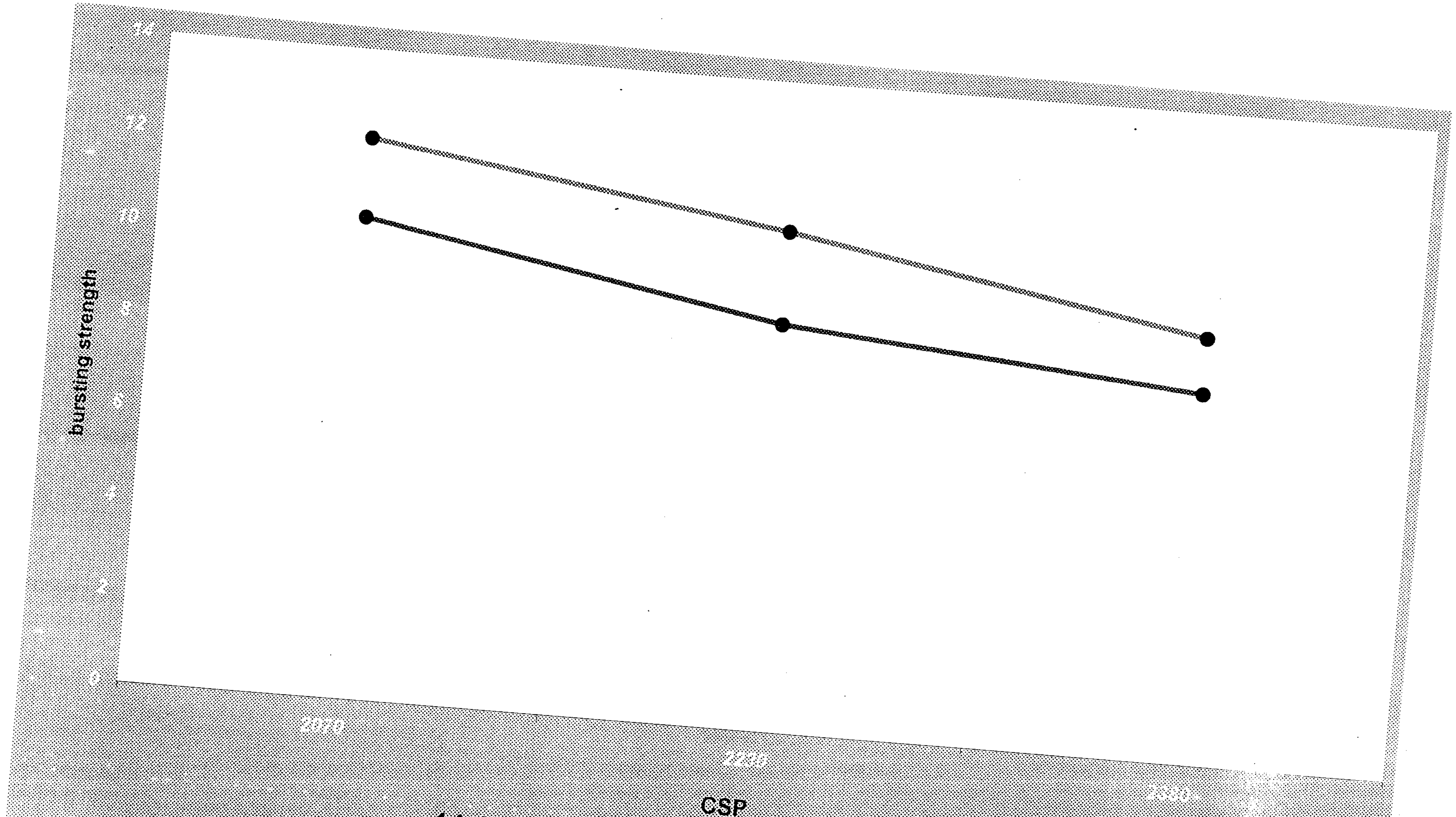
14.2 Abrasion resistance vs U% (wet)



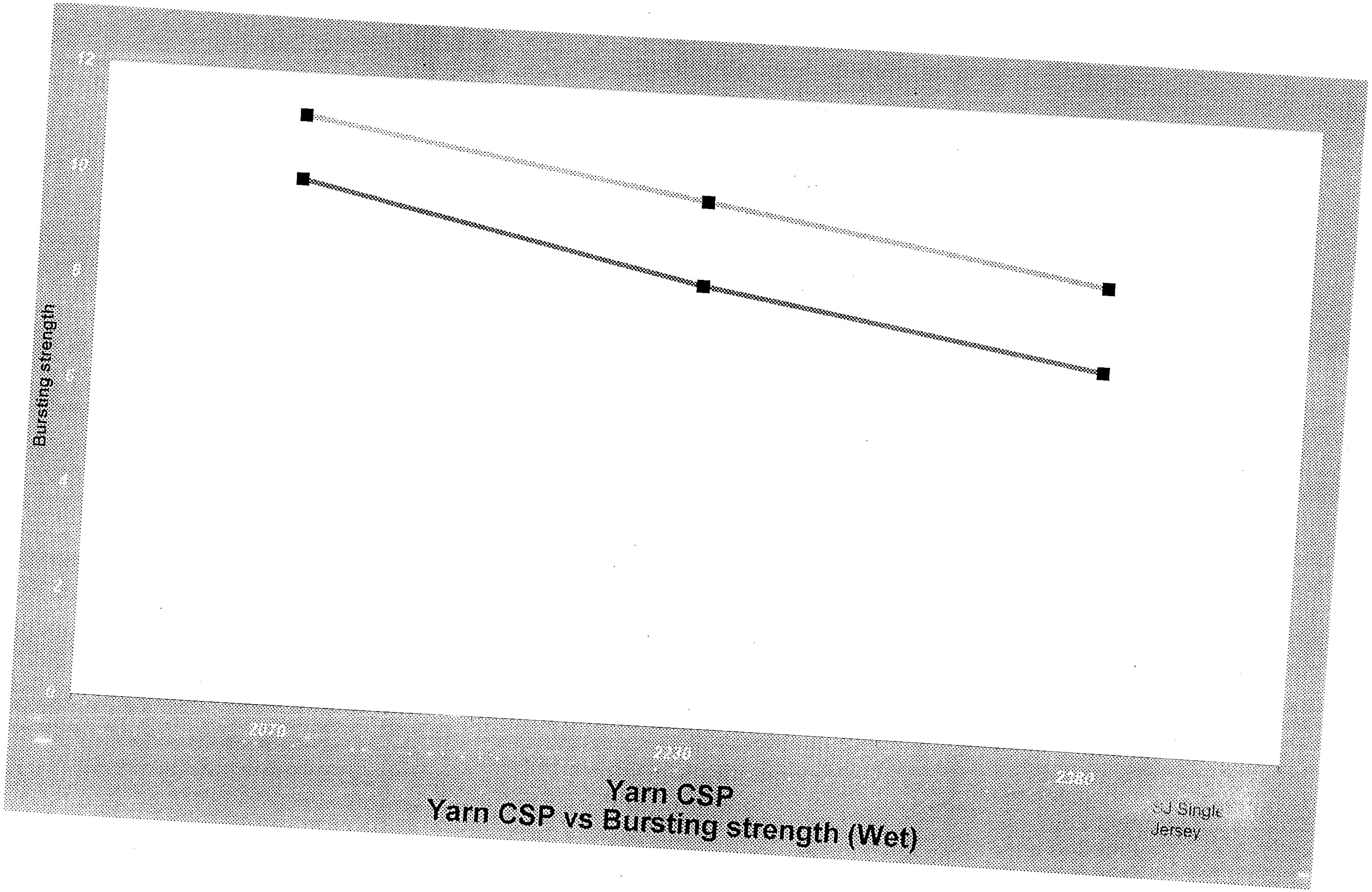
14.3 Abrasion resistance vs TPI (dry)

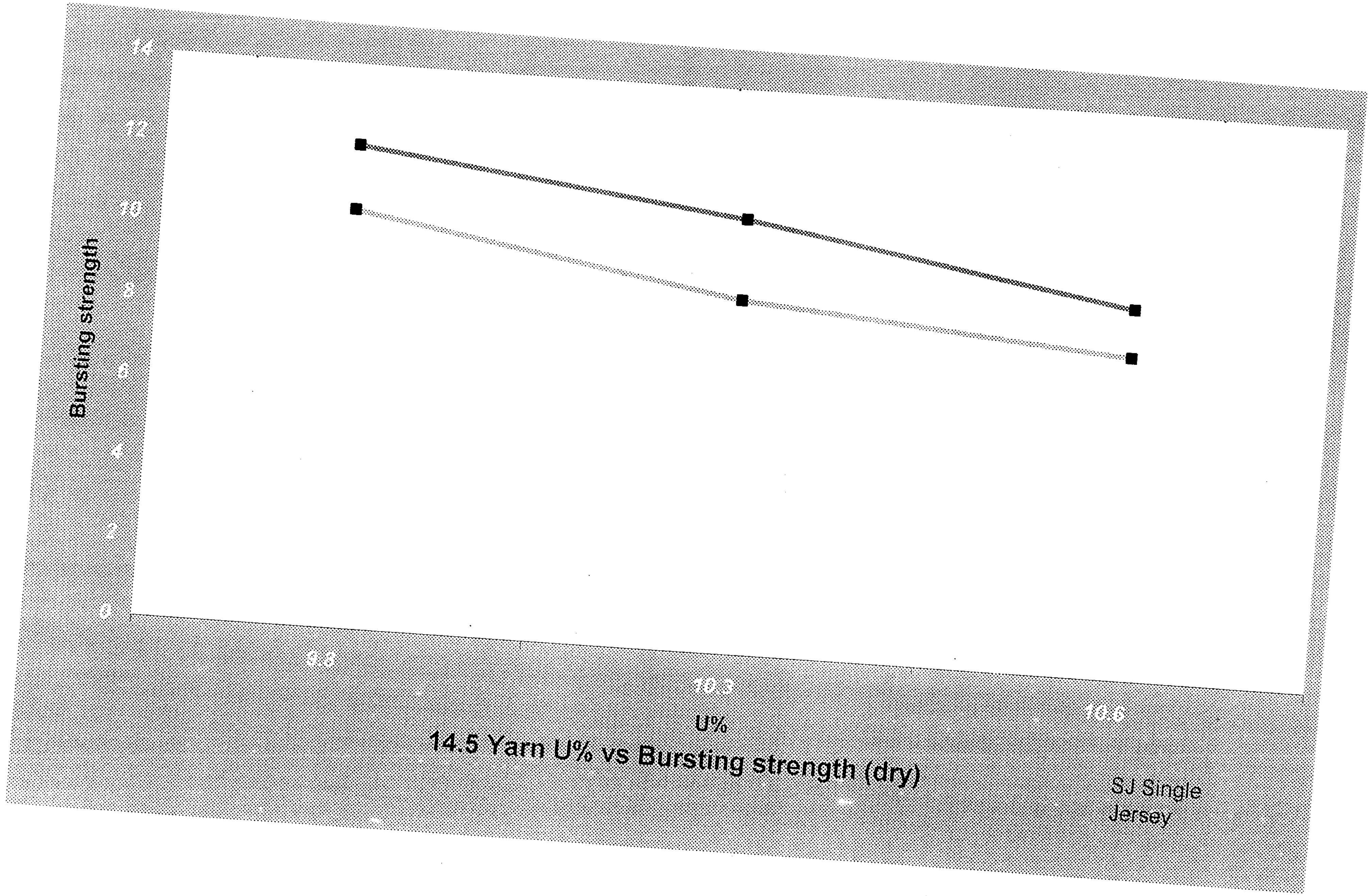


14.3 Abrasion resistance vs TPI (wet)

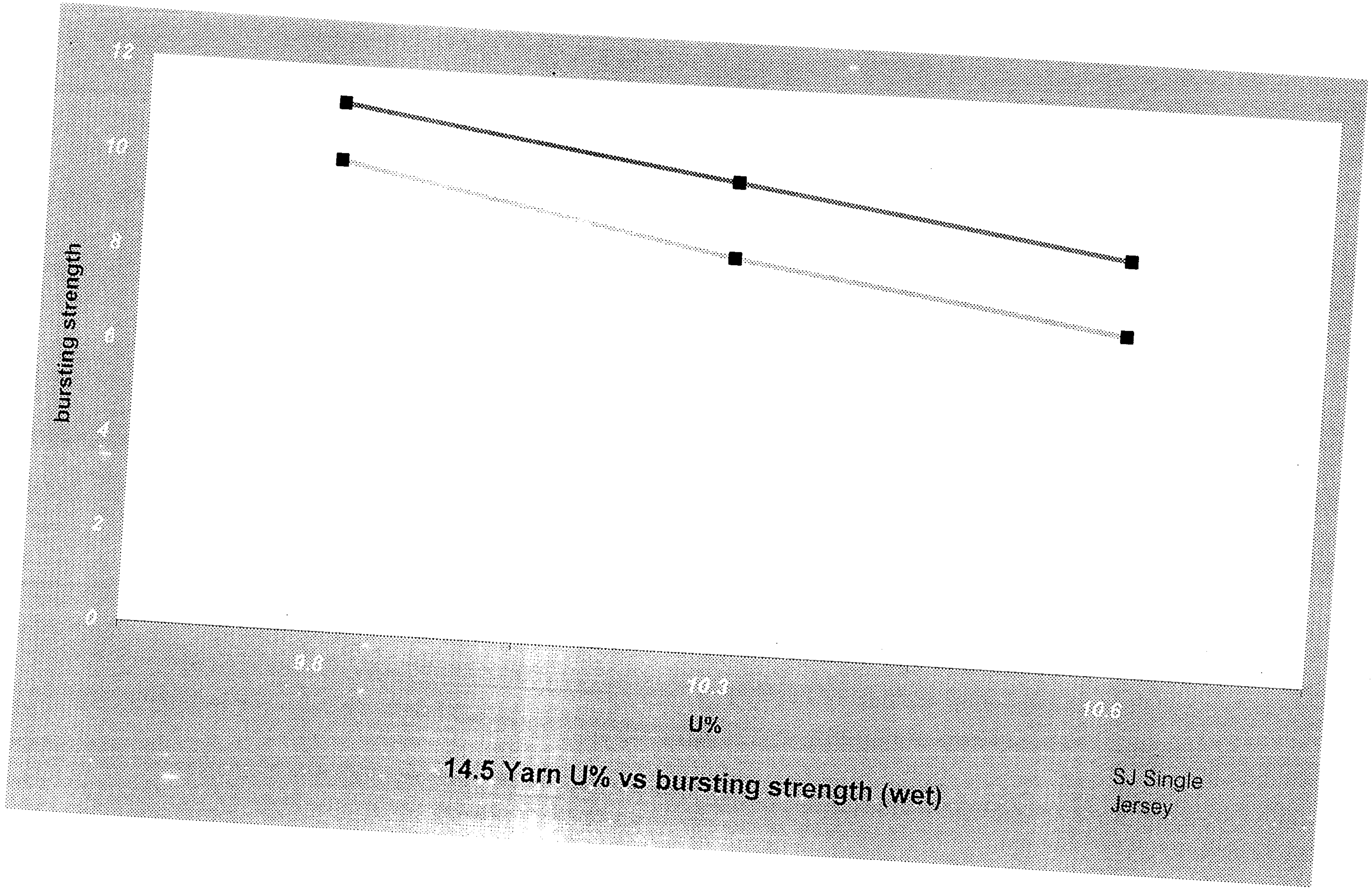


14.4 yarn CSP vs bursting strength (Dry)

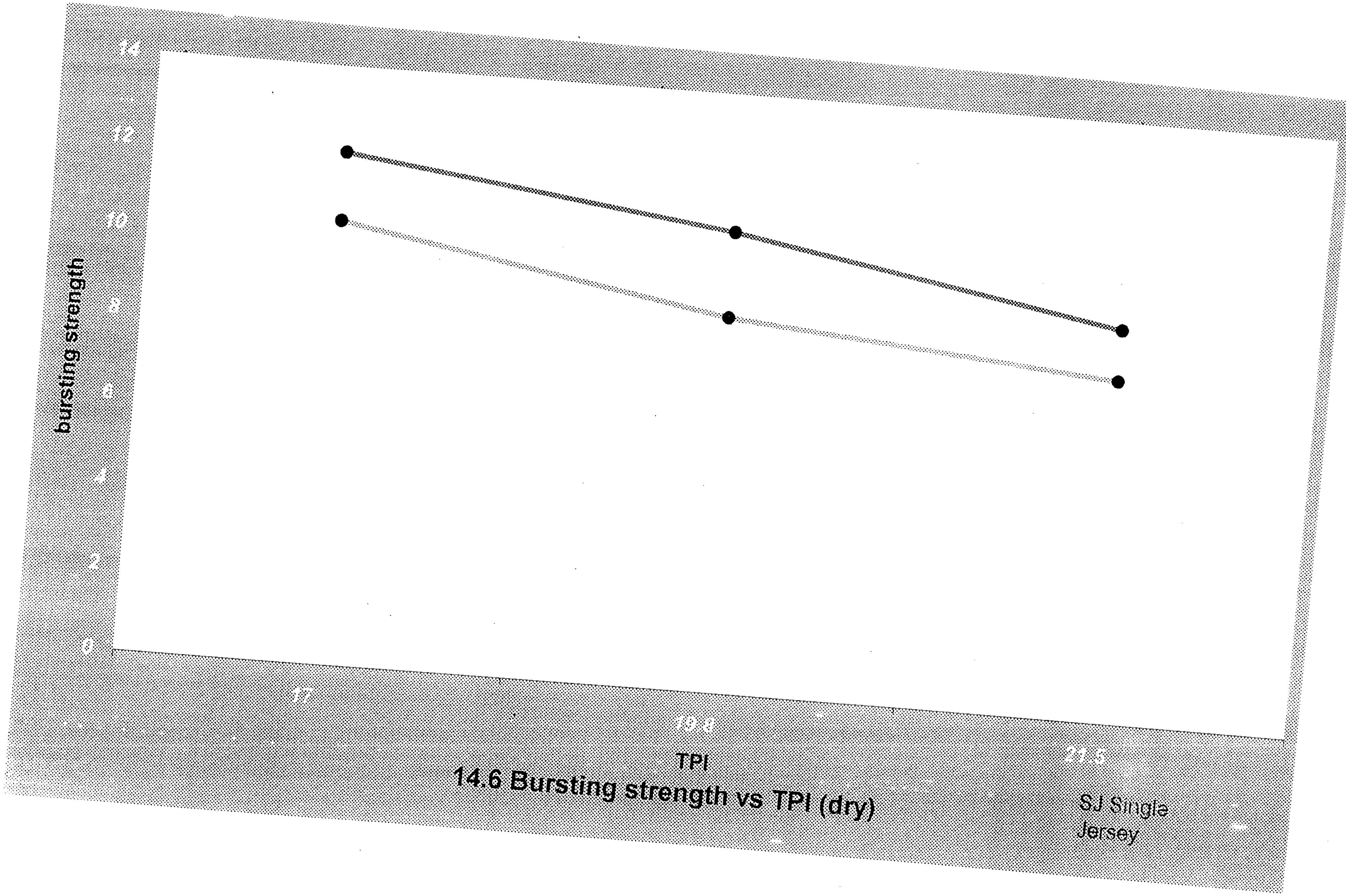

Bursting strength
12
10
8
6
4
2
0
2070
Yarn CSP
Yarn CSP vs Bursting strength (Wet)
Single
Jersey



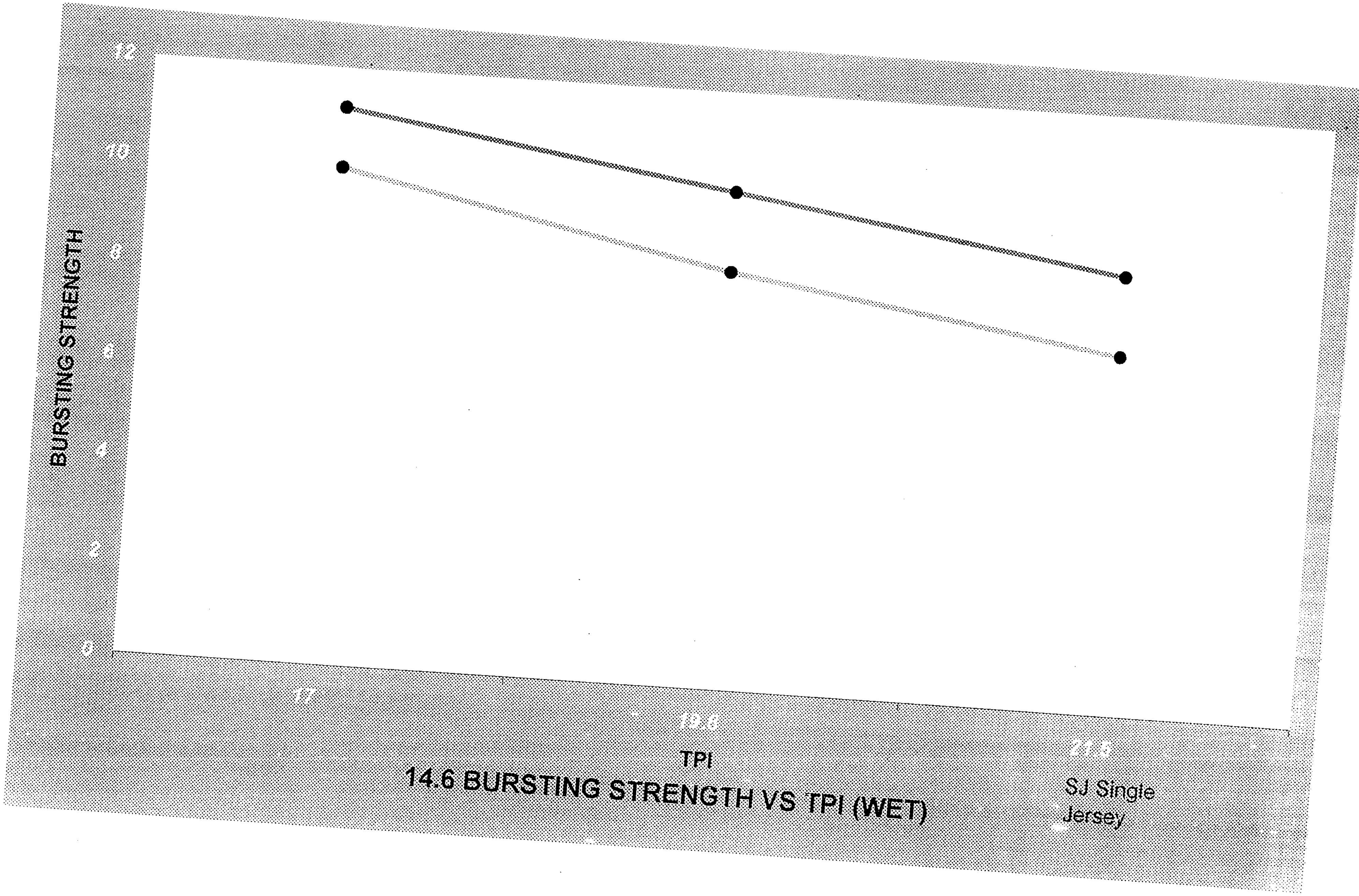
14.5 Yarn U% vs Bursting strength (dry)



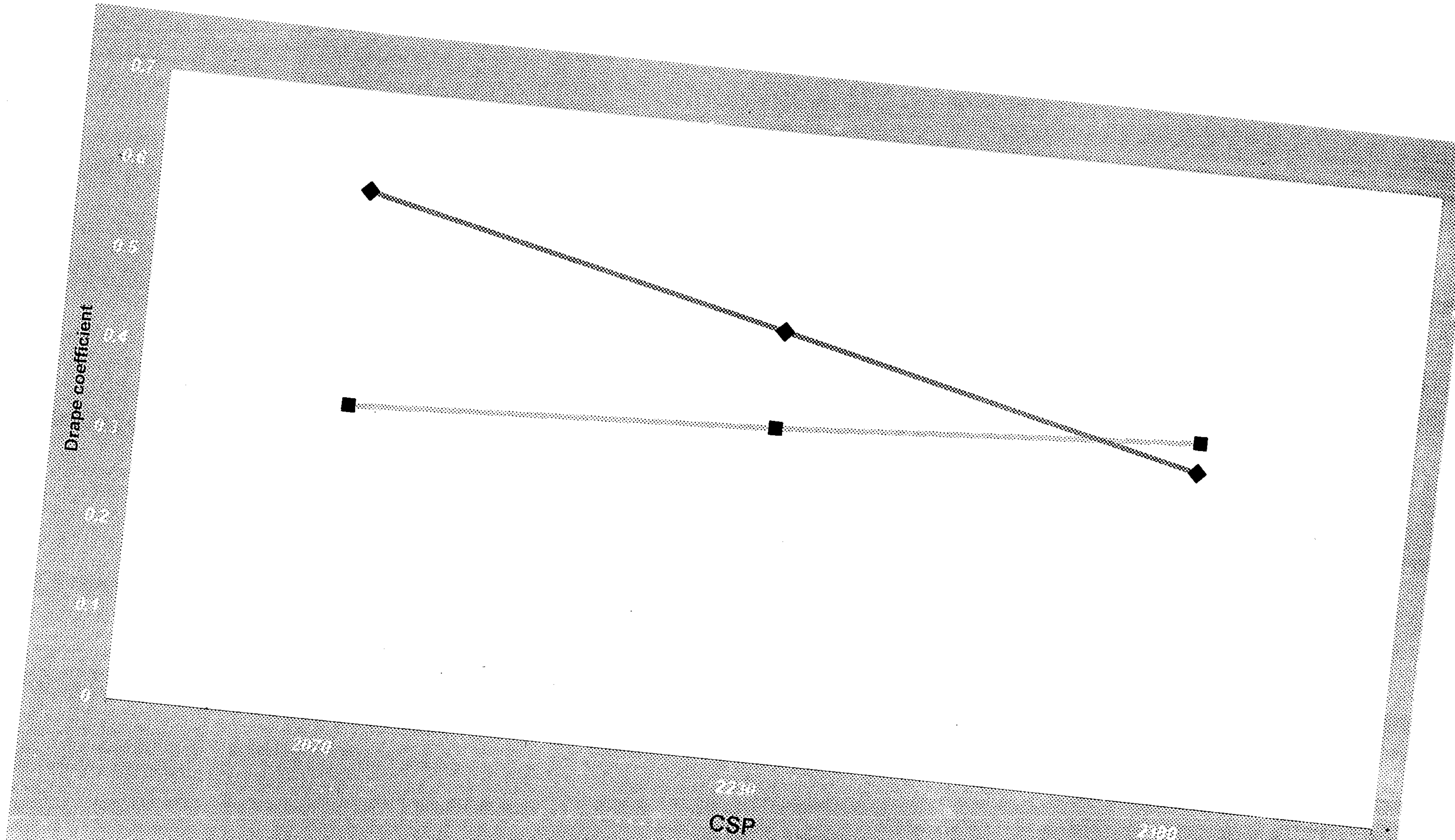
14.5 Yarn U% vs bursting strength (wet)



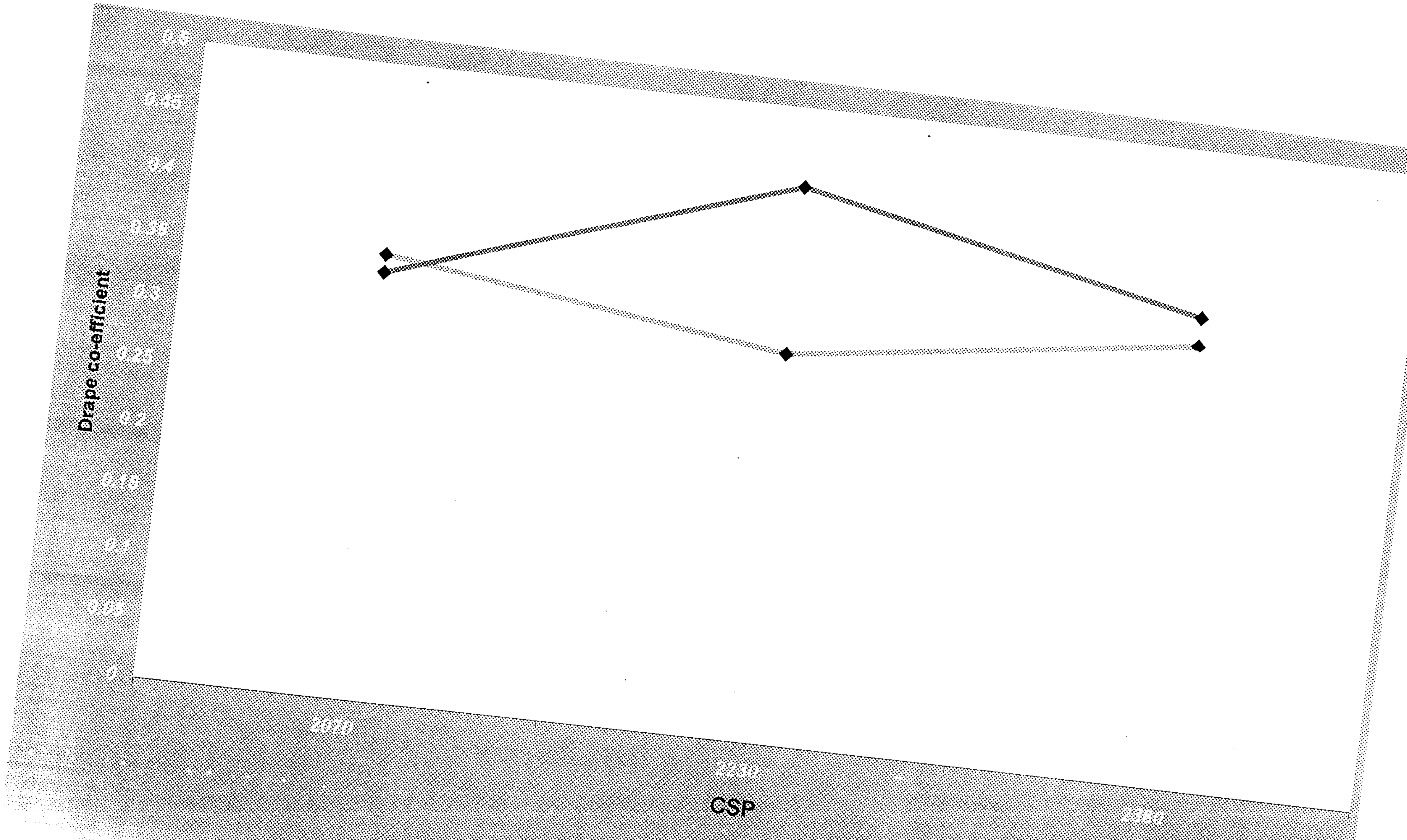
14.6 Bursting strength vs TPI (dry)



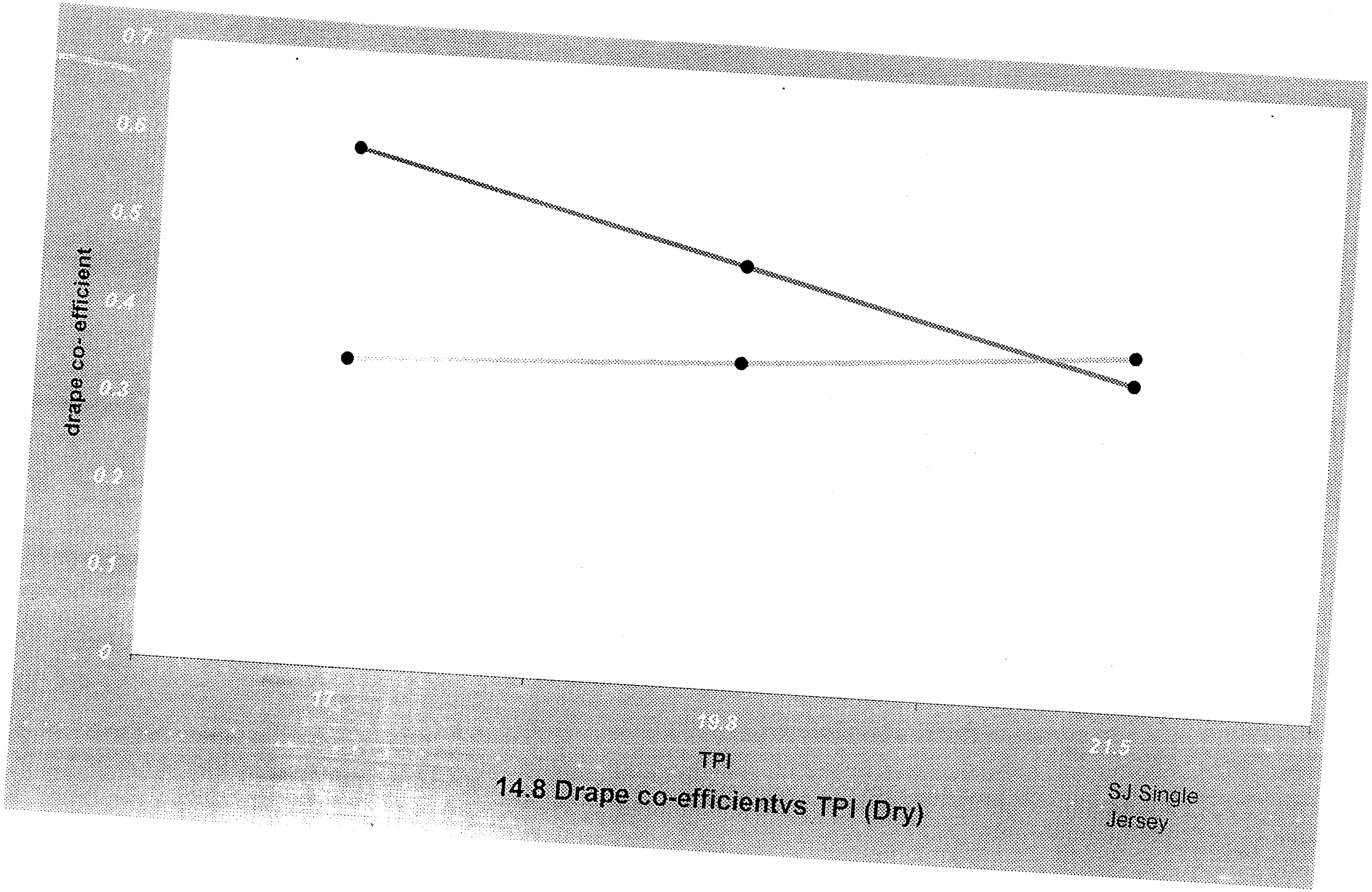
14.6 BURSTING STRENGTH VS TPI (WET)



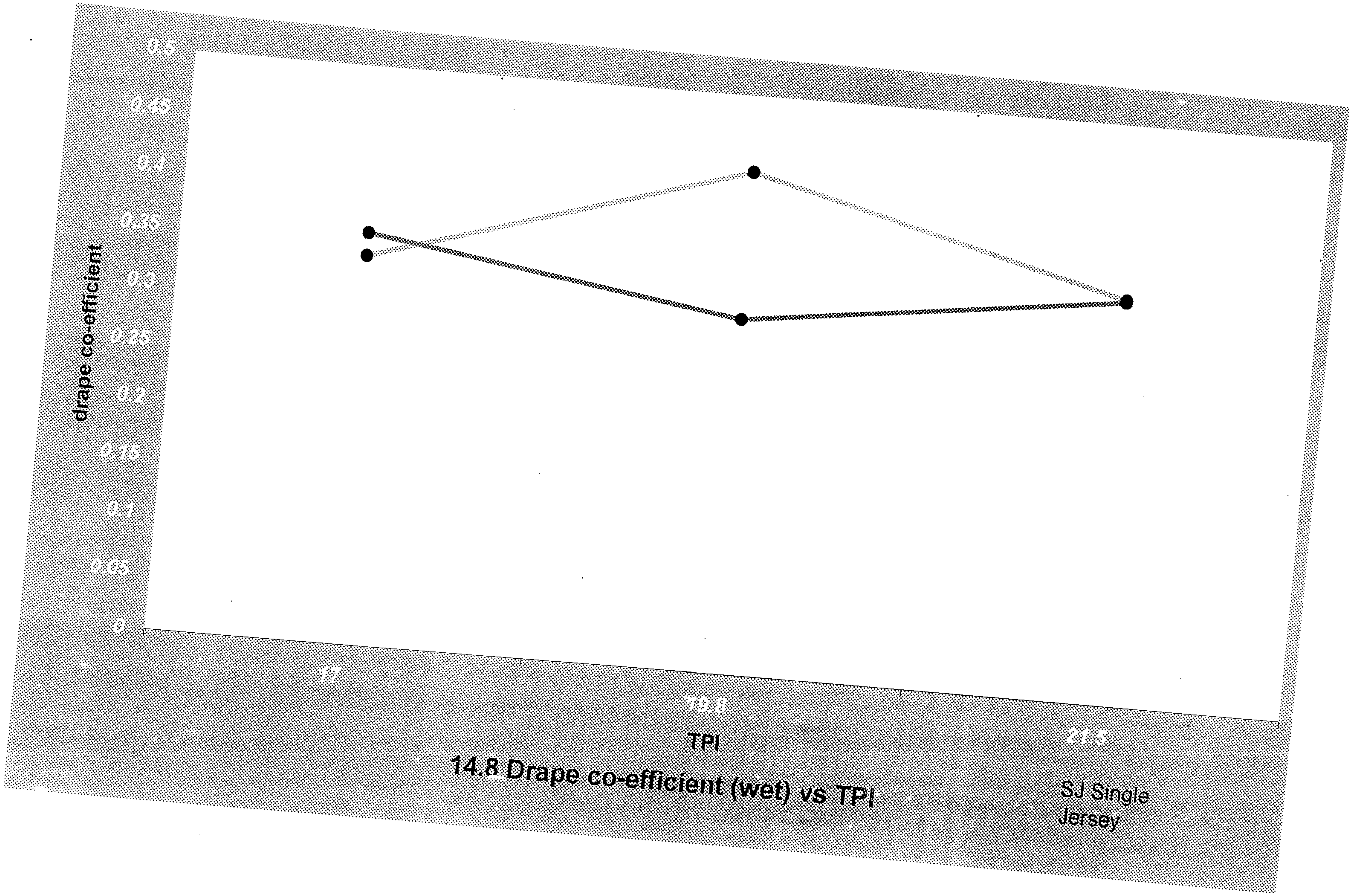
14.7 Drape coefficient vs CSP (Dry)



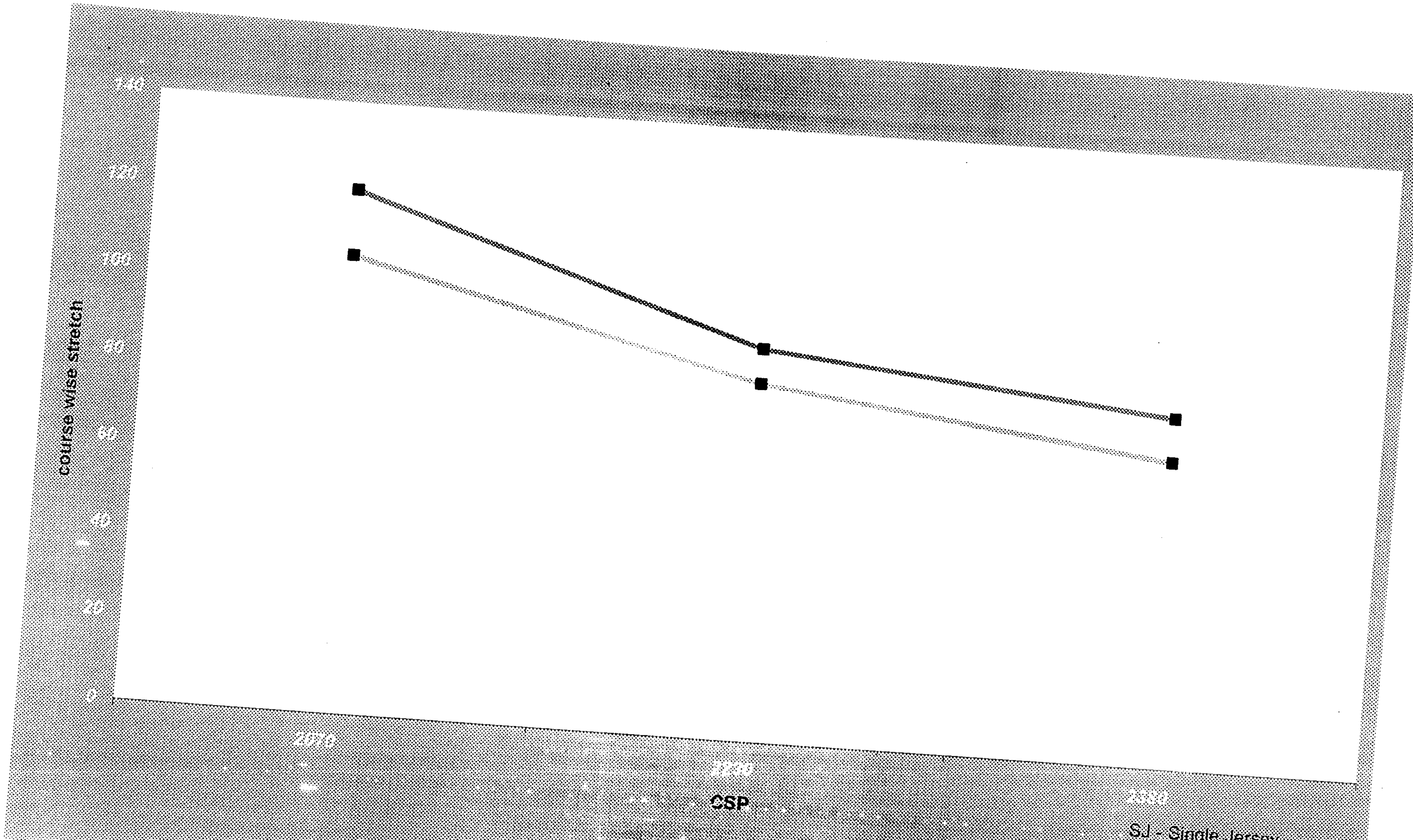
14.7 Drape co-efficient vs CSP (wet)



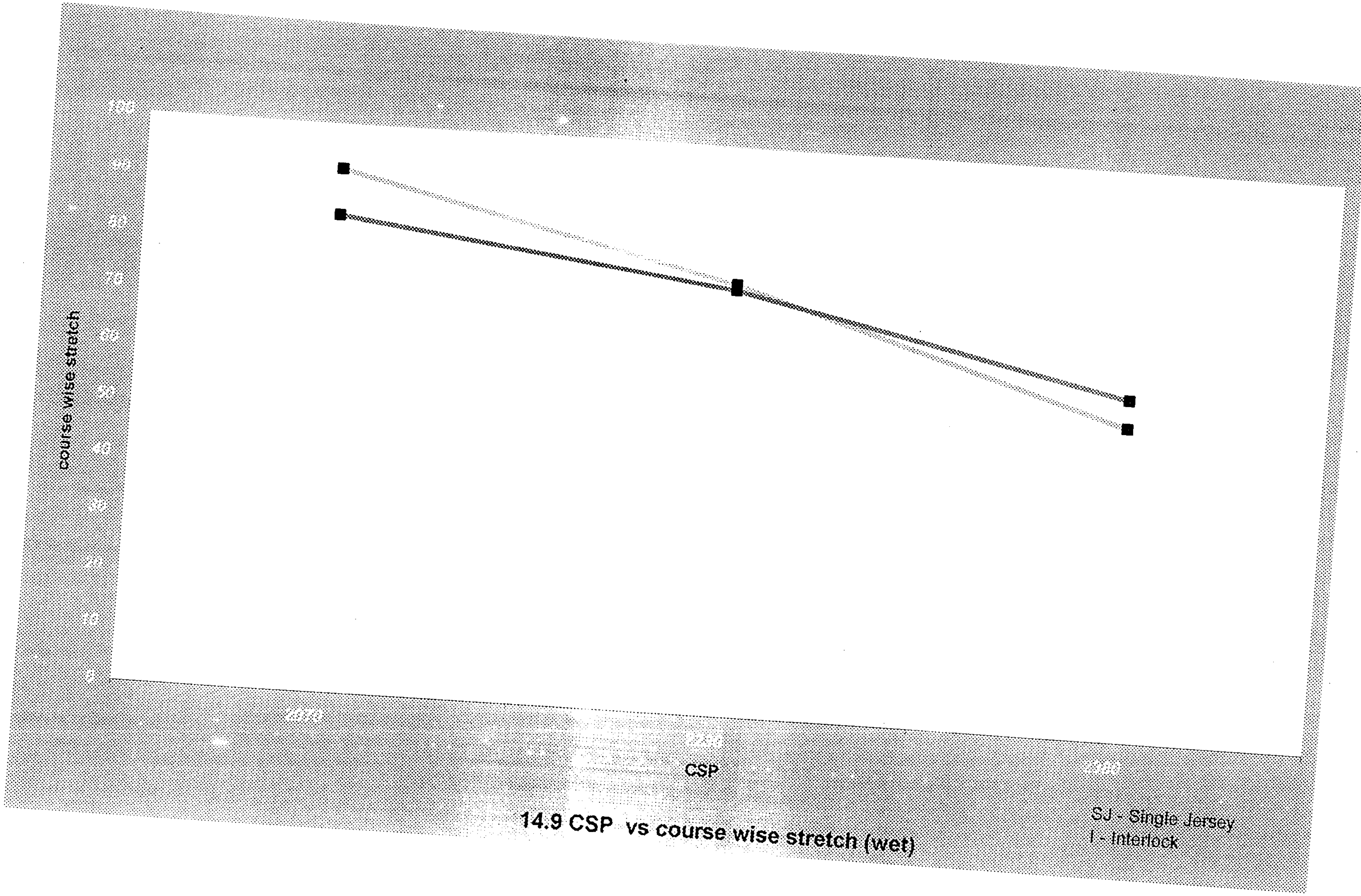
14.8 Drape co-efficientvs TPI (Dry)



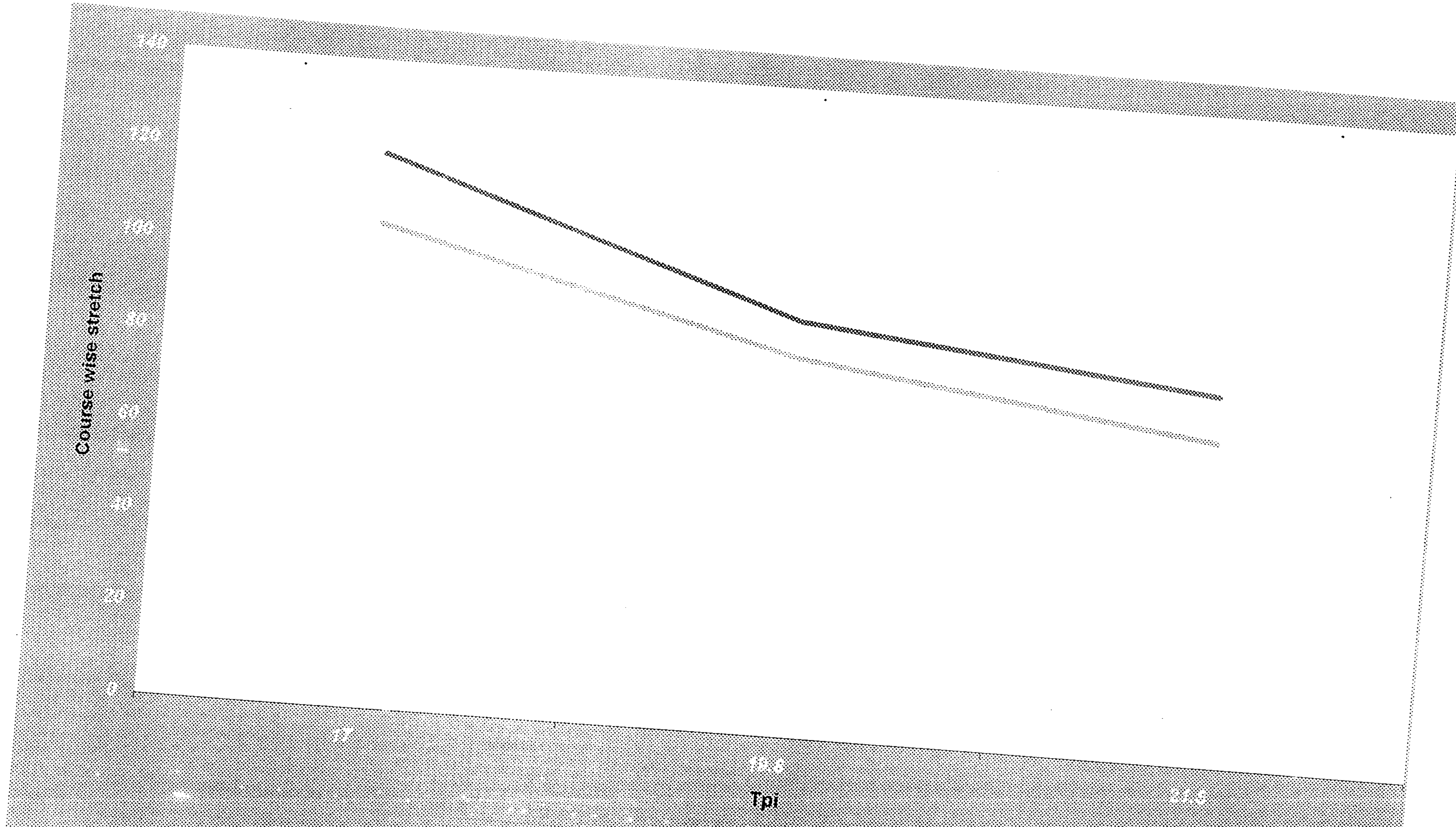
14.8 Drape co-efficient (wet) vs TPI



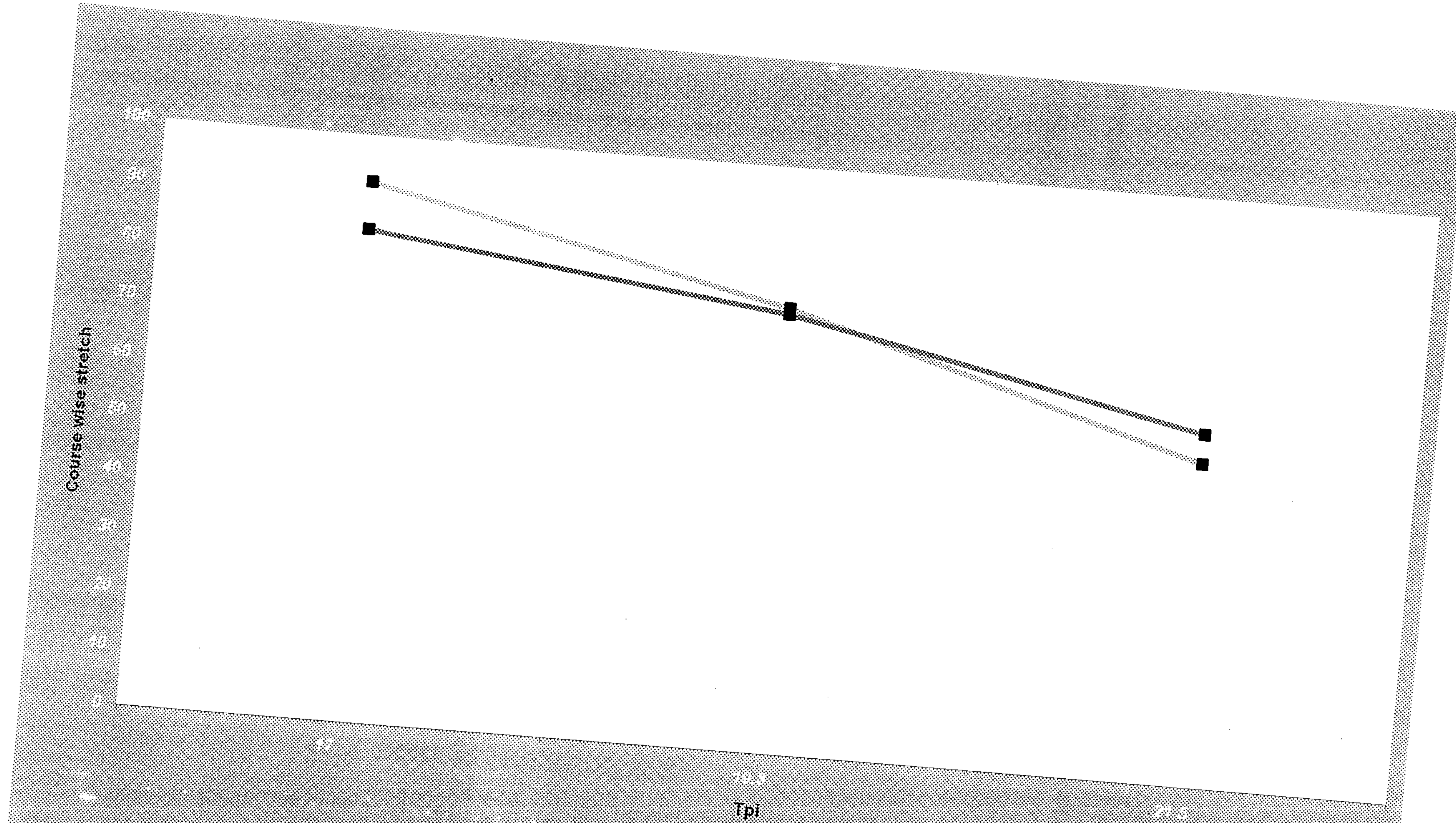
14.9 CSP vs course wise stretch(dry)



14.9 CSP vs course wise stretch (wet)

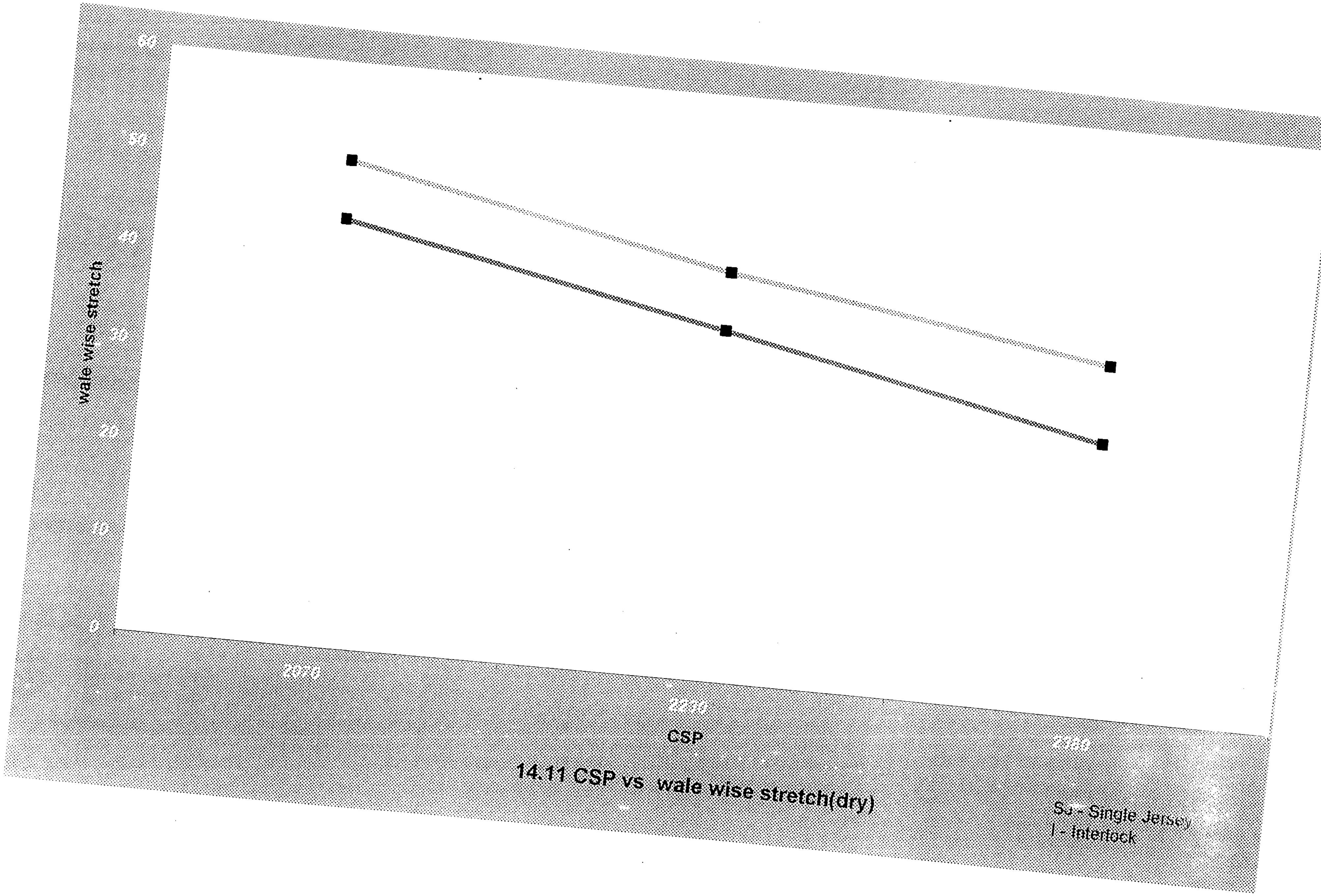


14.10 Tpi vs Course wise stretch (Dry)

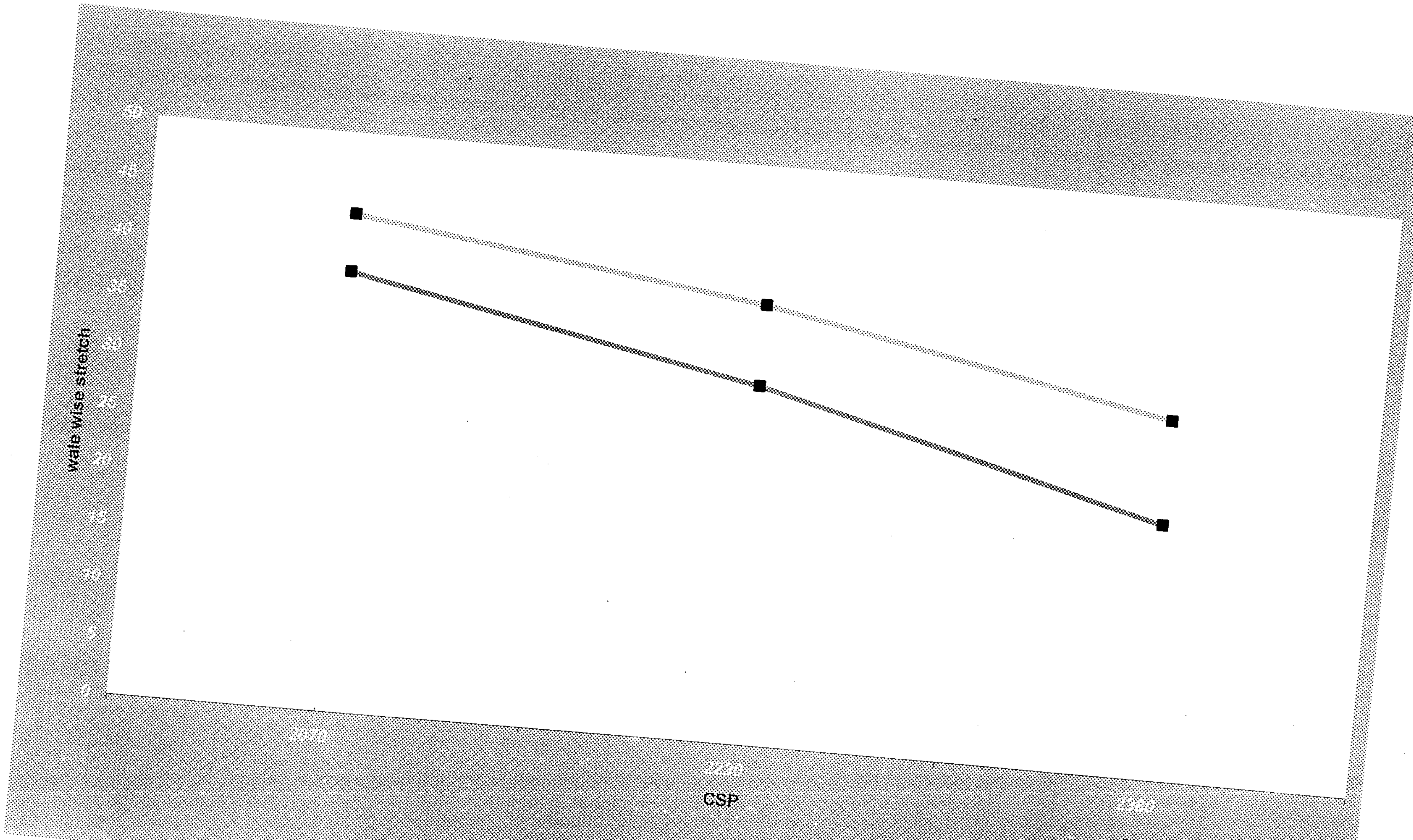


14.10 Tpi vs Course wise stretch (Wet)

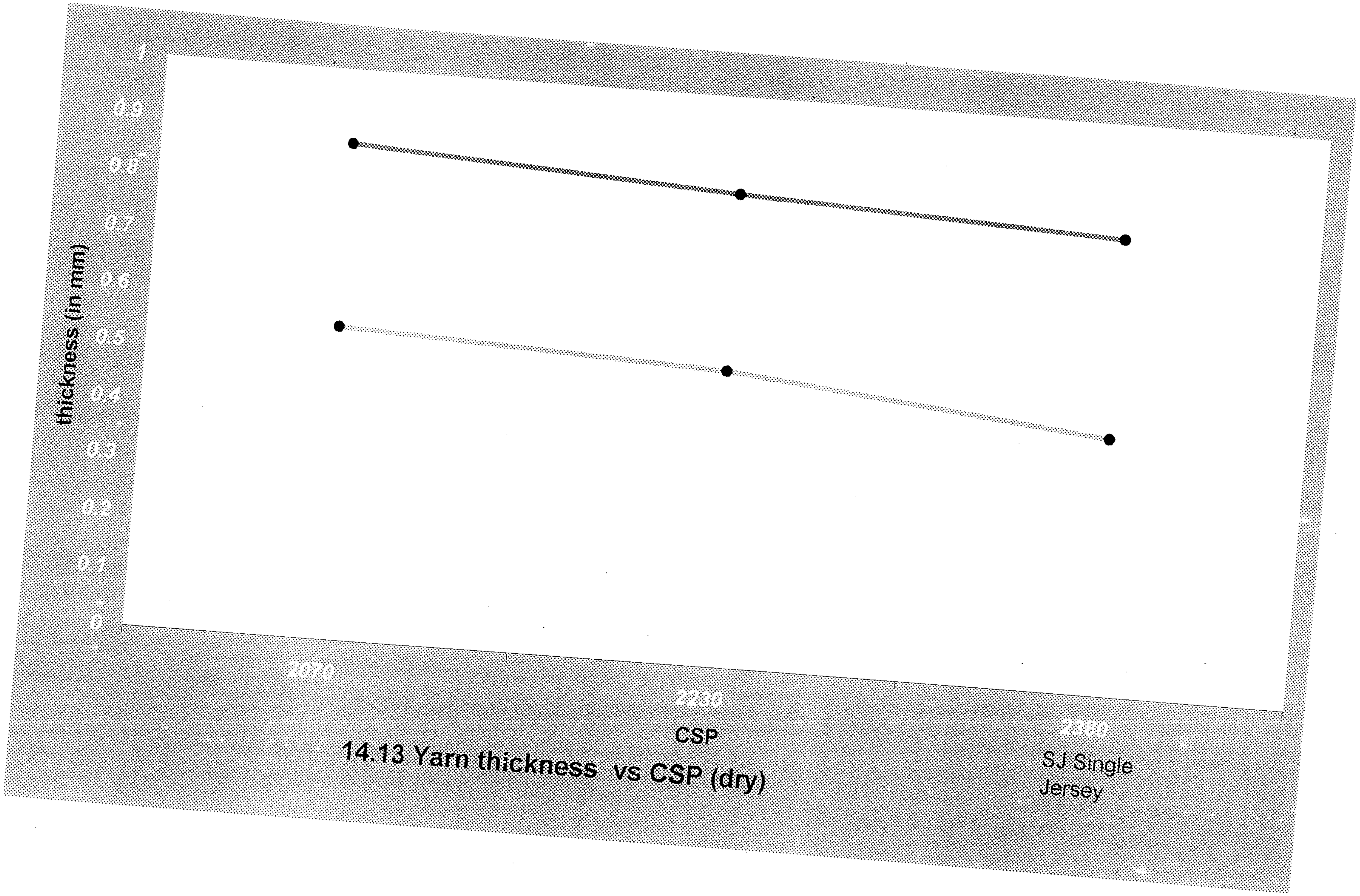
SJ - Single Jersey
I - Interlock



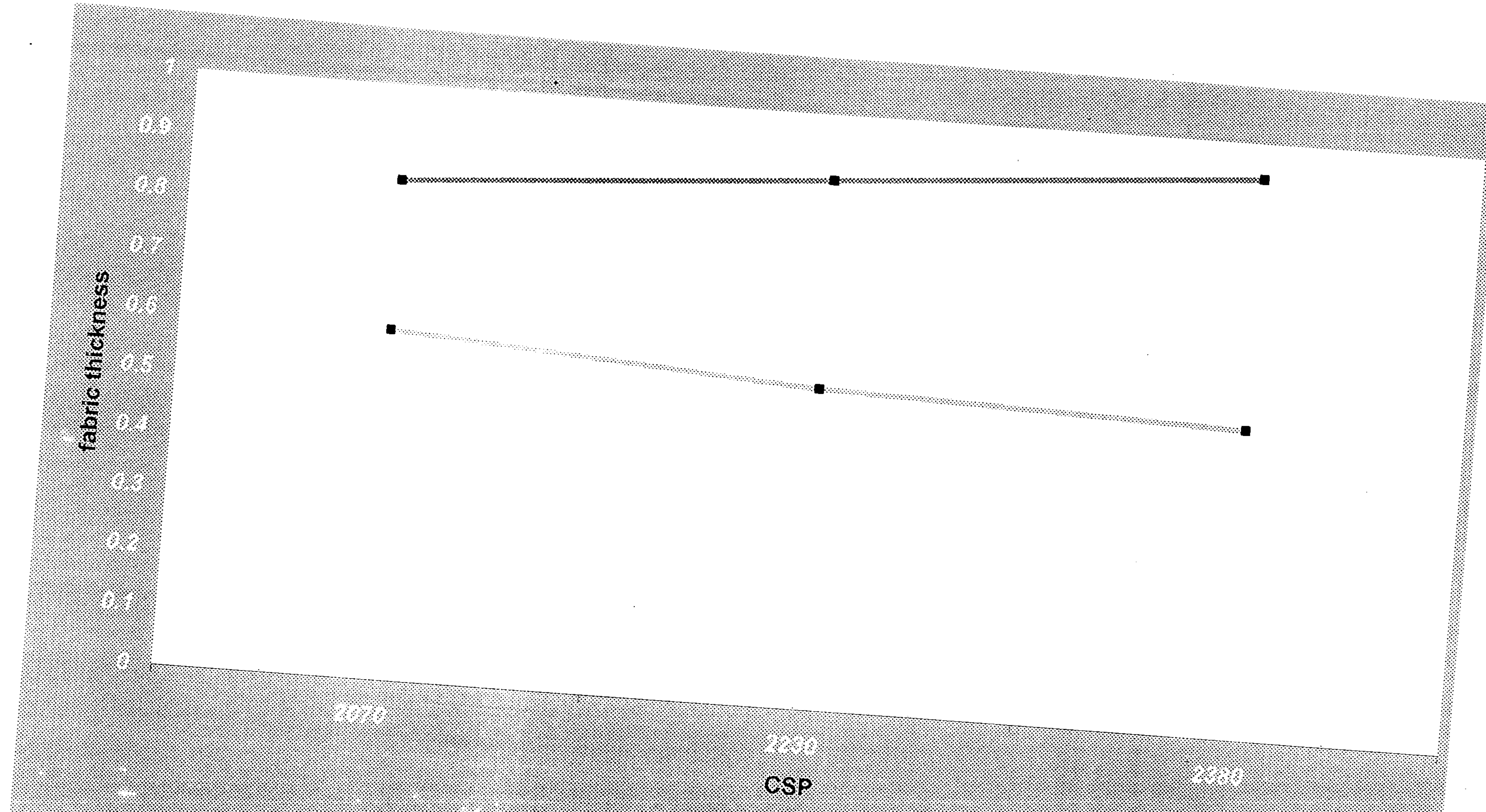
14.11 CSP vs wale wise stretch(dry)



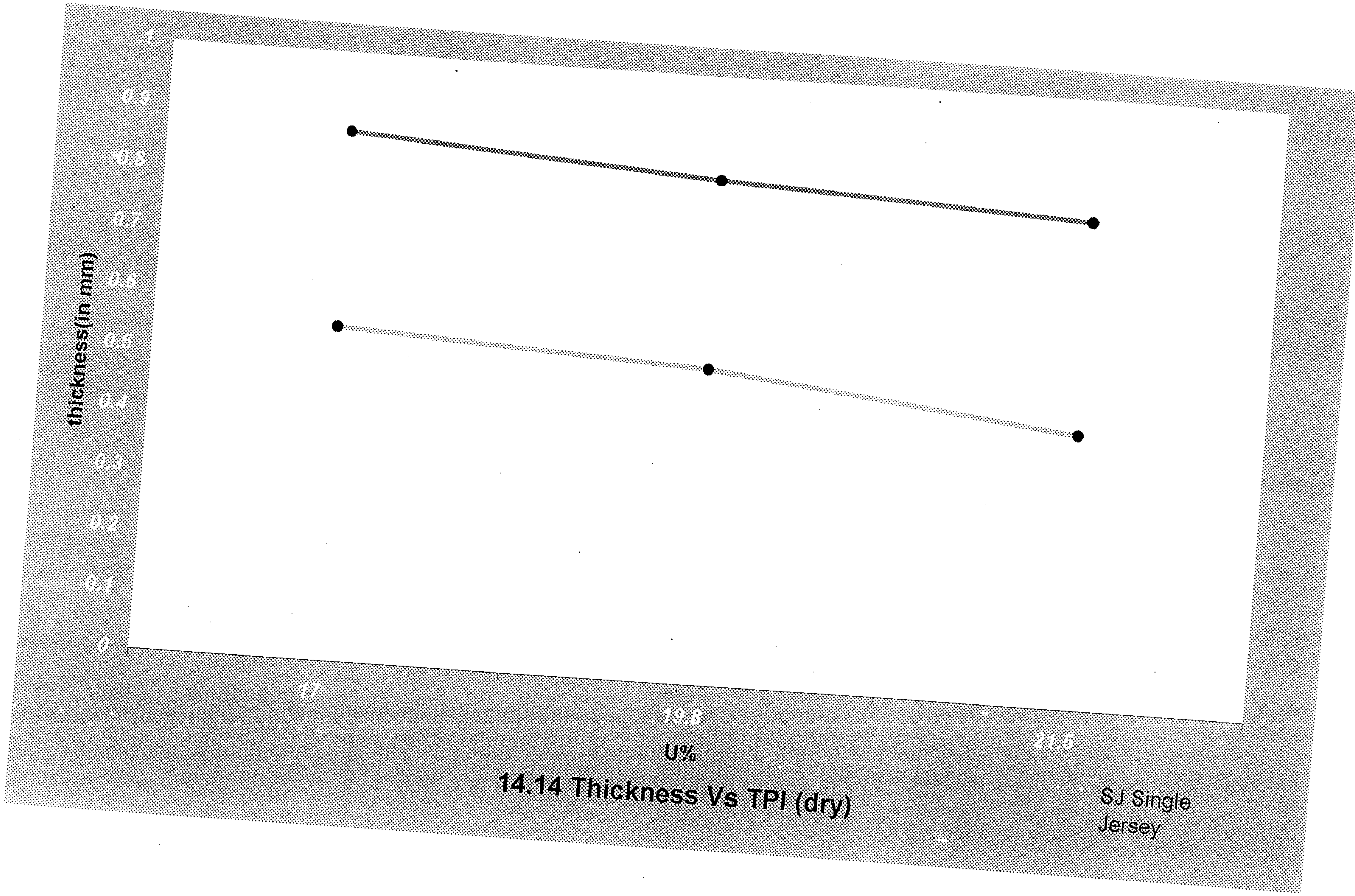
14.11 CSp vs wale wise stretch (wet)



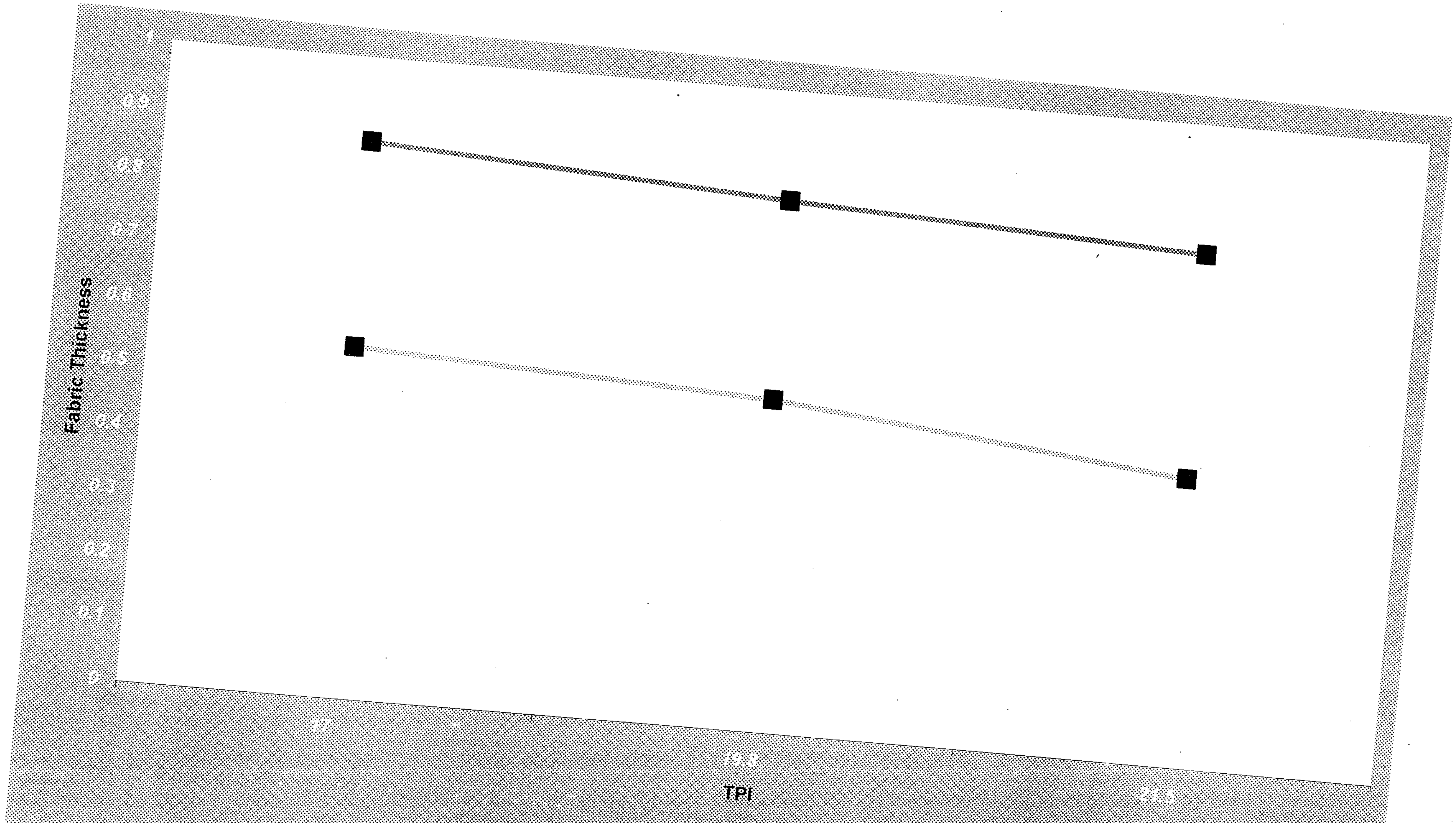
14.13 Yarn thickness vs CSP (dry)



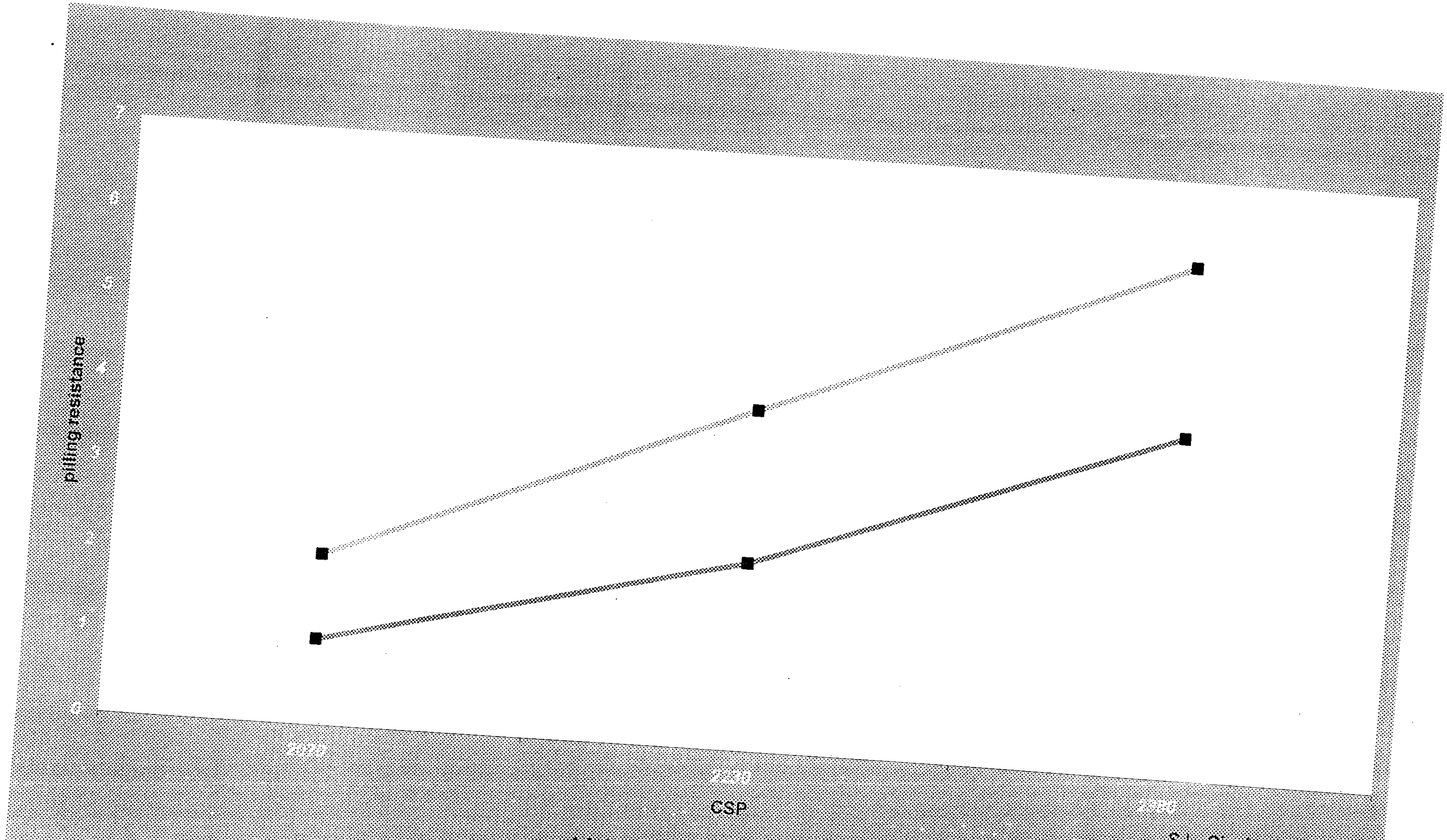
14.13 Fabric thickness vs CSP (wet)



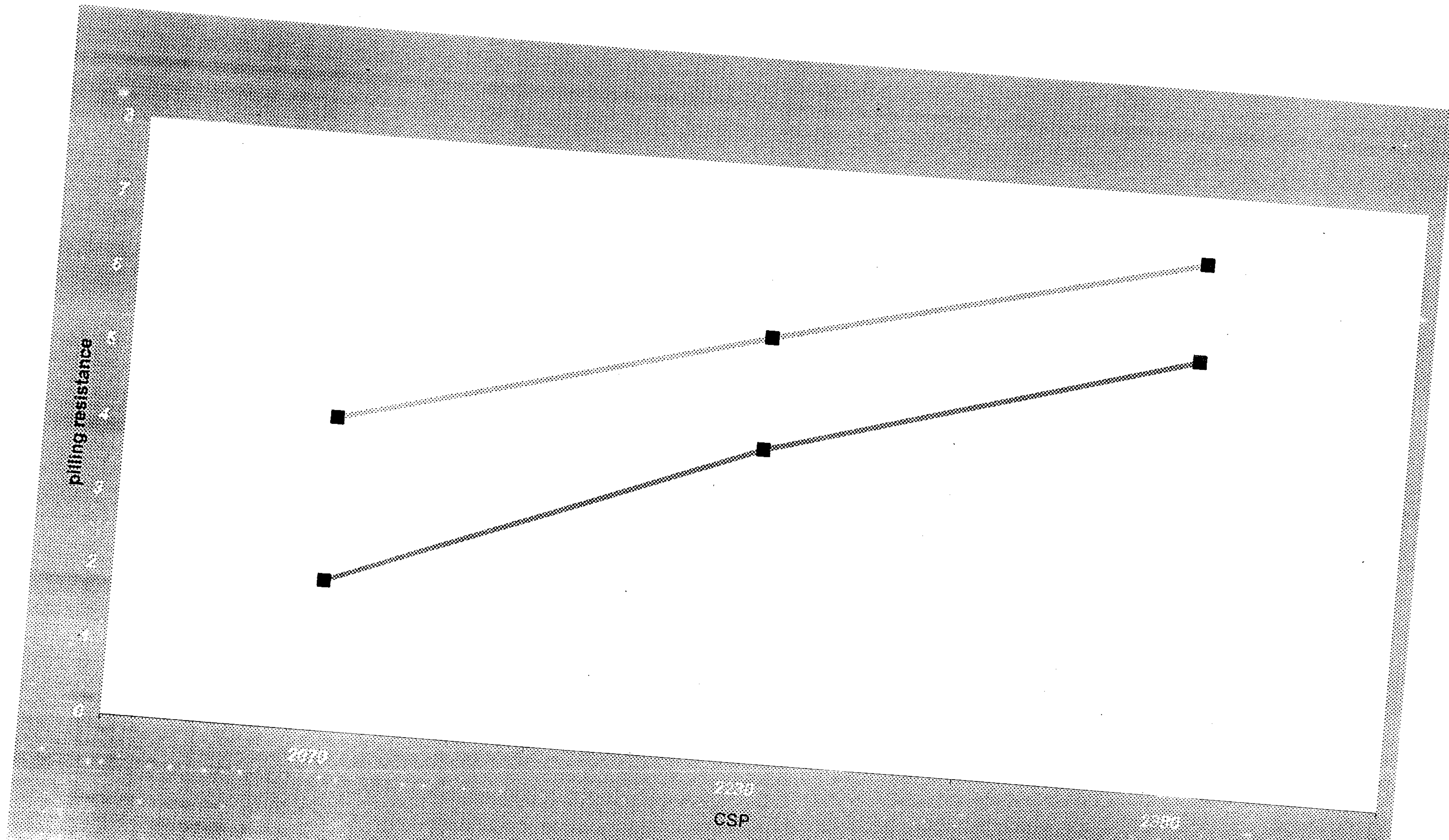
14.14 Thickness Vs TPI (dry)



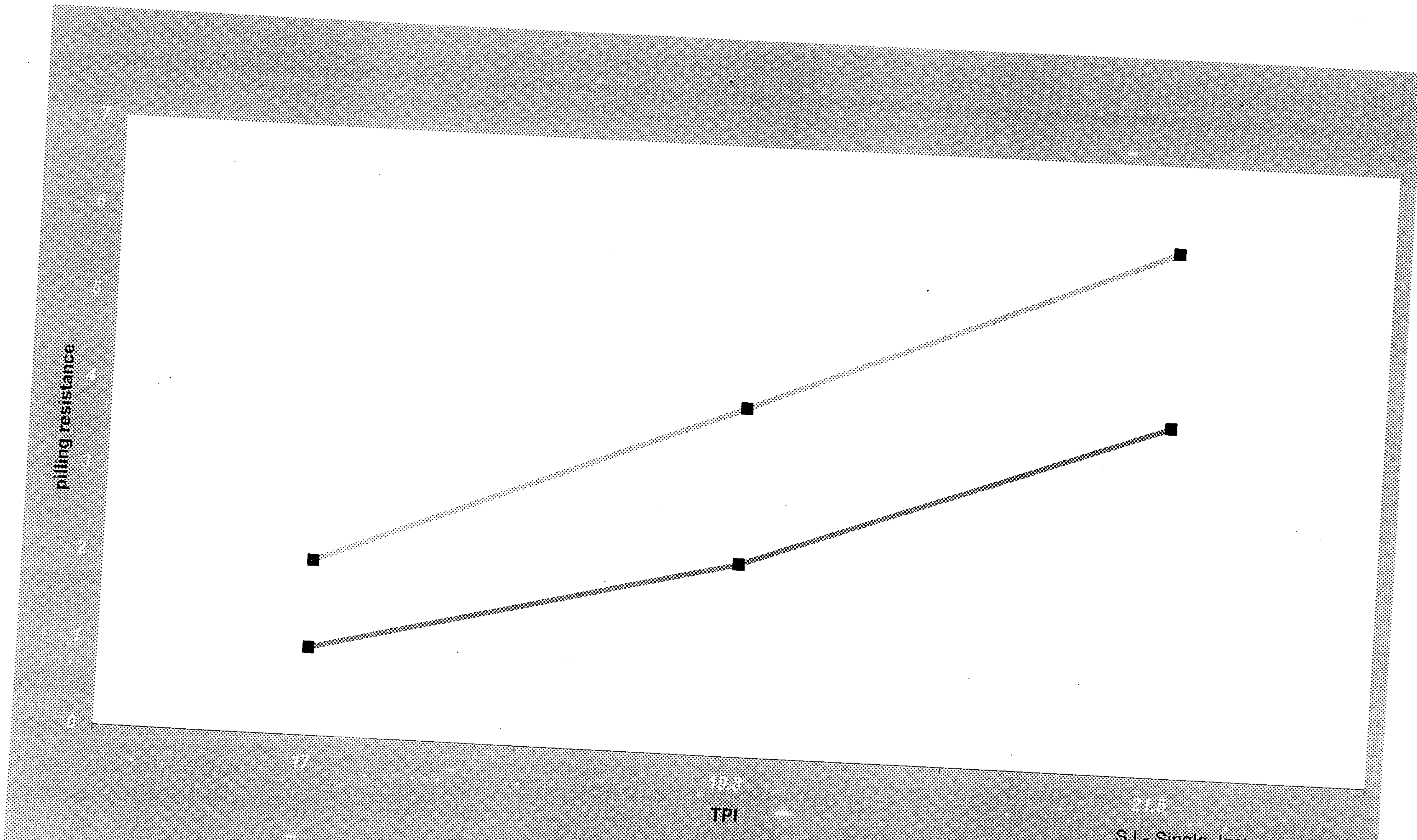
14.14 TPI Vs Fabric Thickness (Wet)



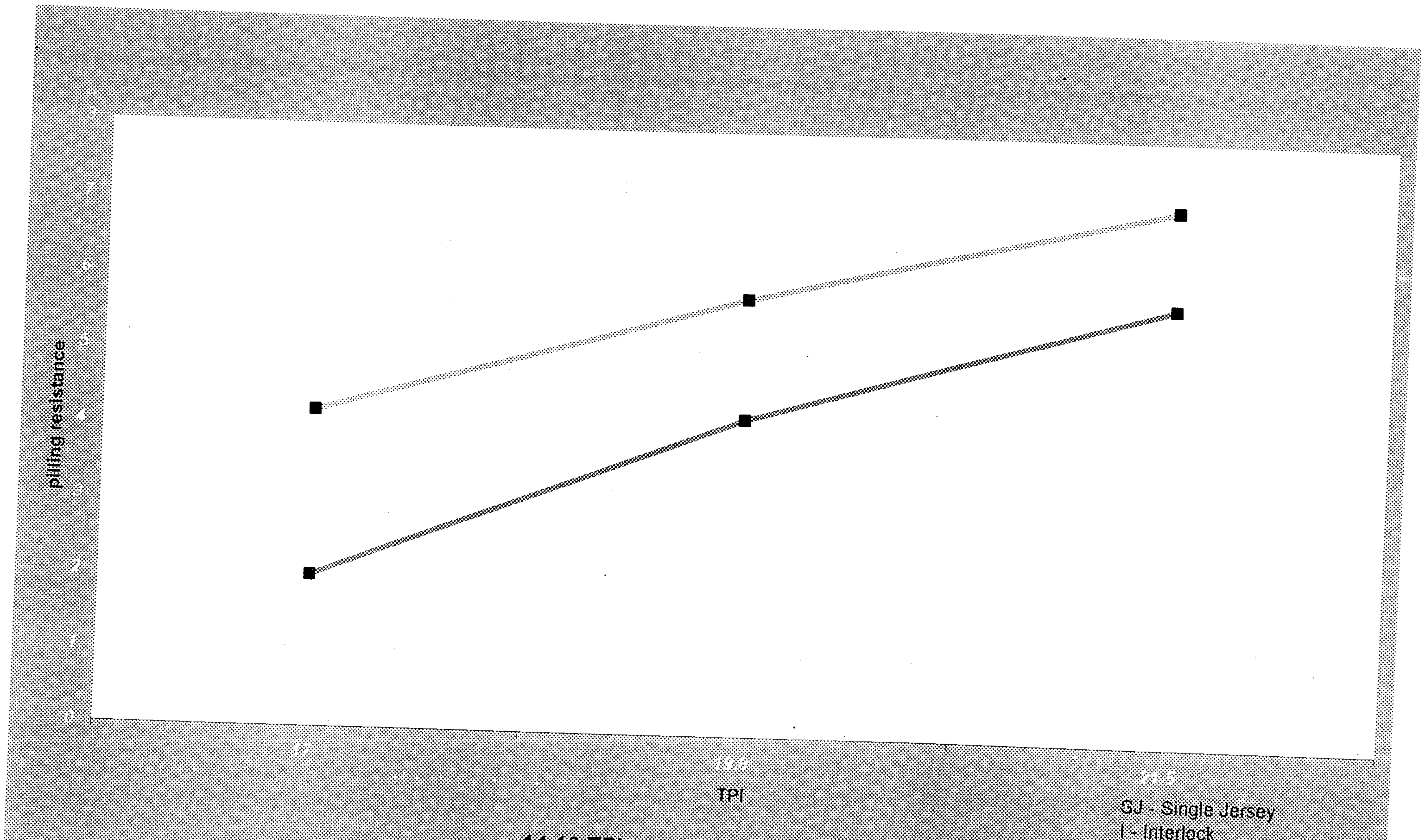
14.15 CSP vs pilling resistance



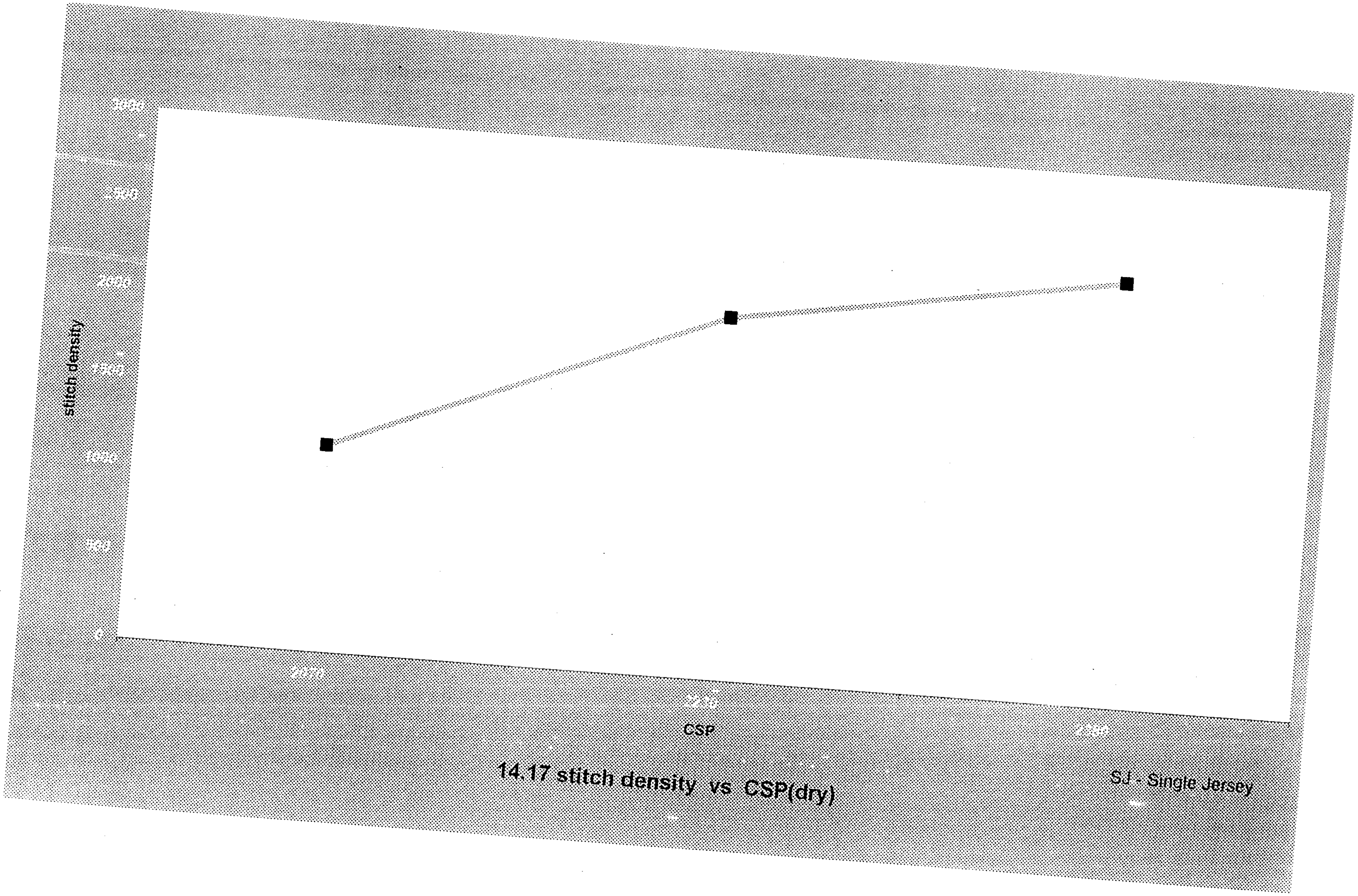
14.15 CSP vs pilling resistance



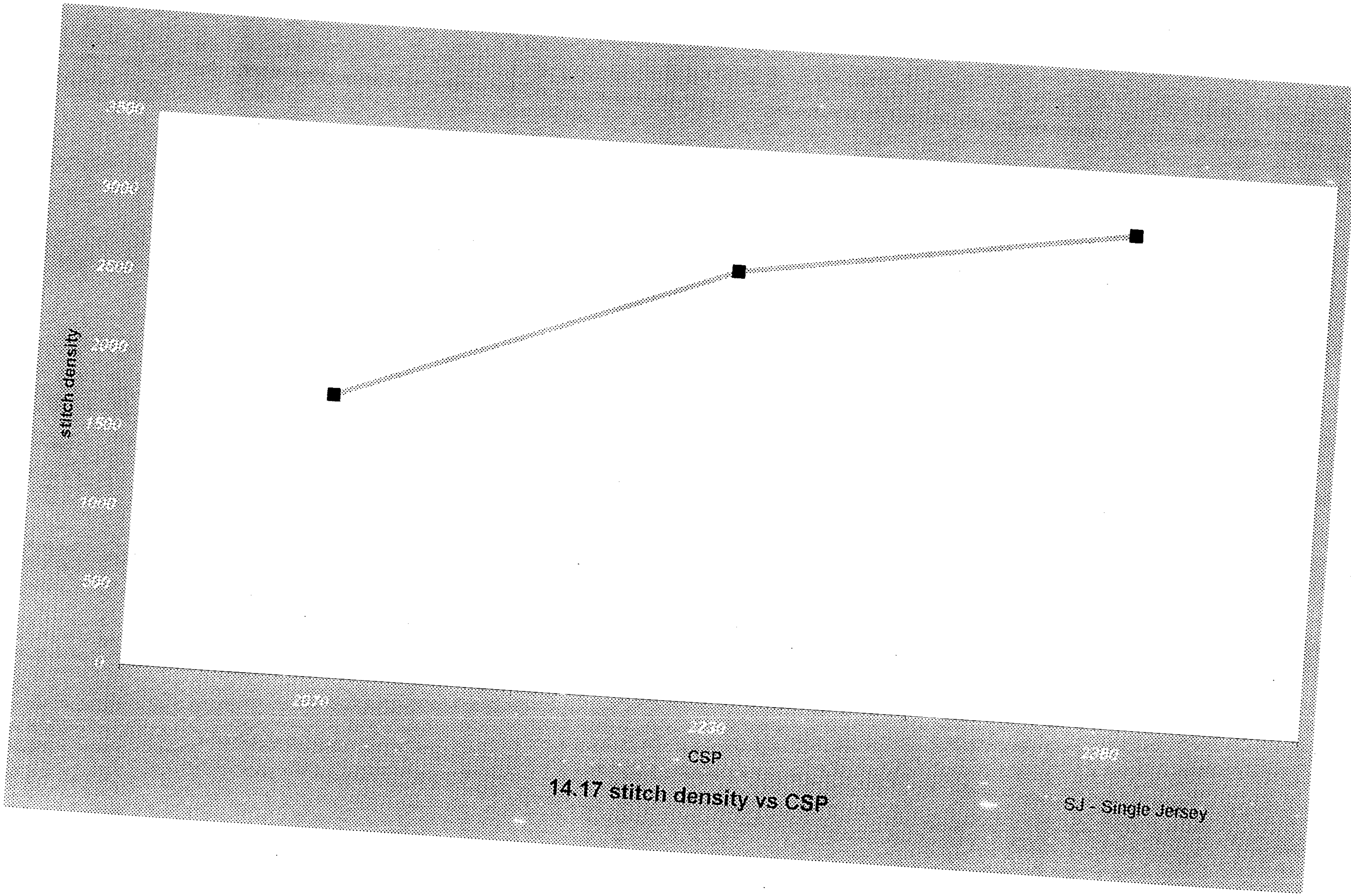
14.16 TPI vs pilling resistance(dry)



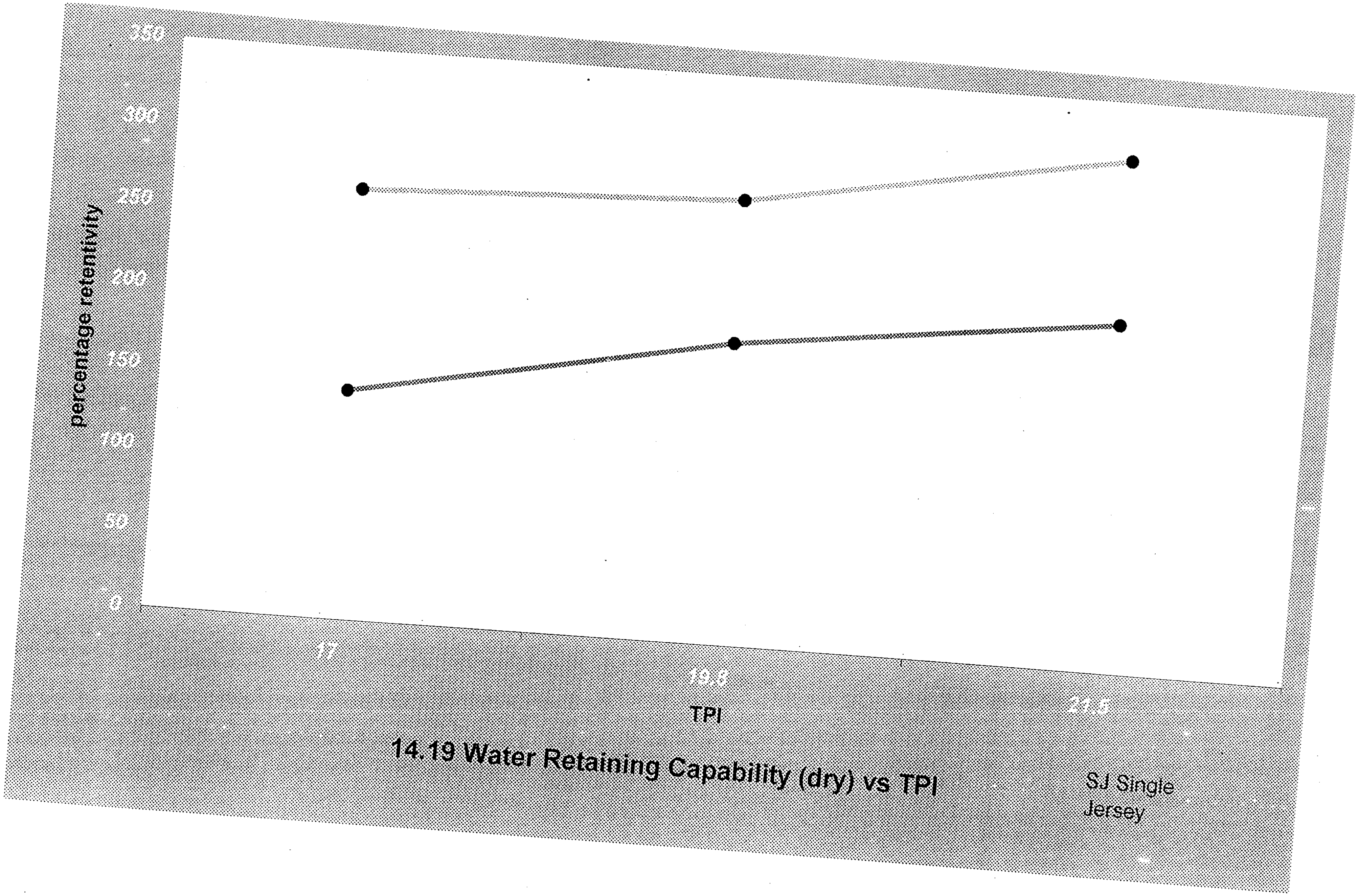
14.16 TPI vs pilling resistance (wet)



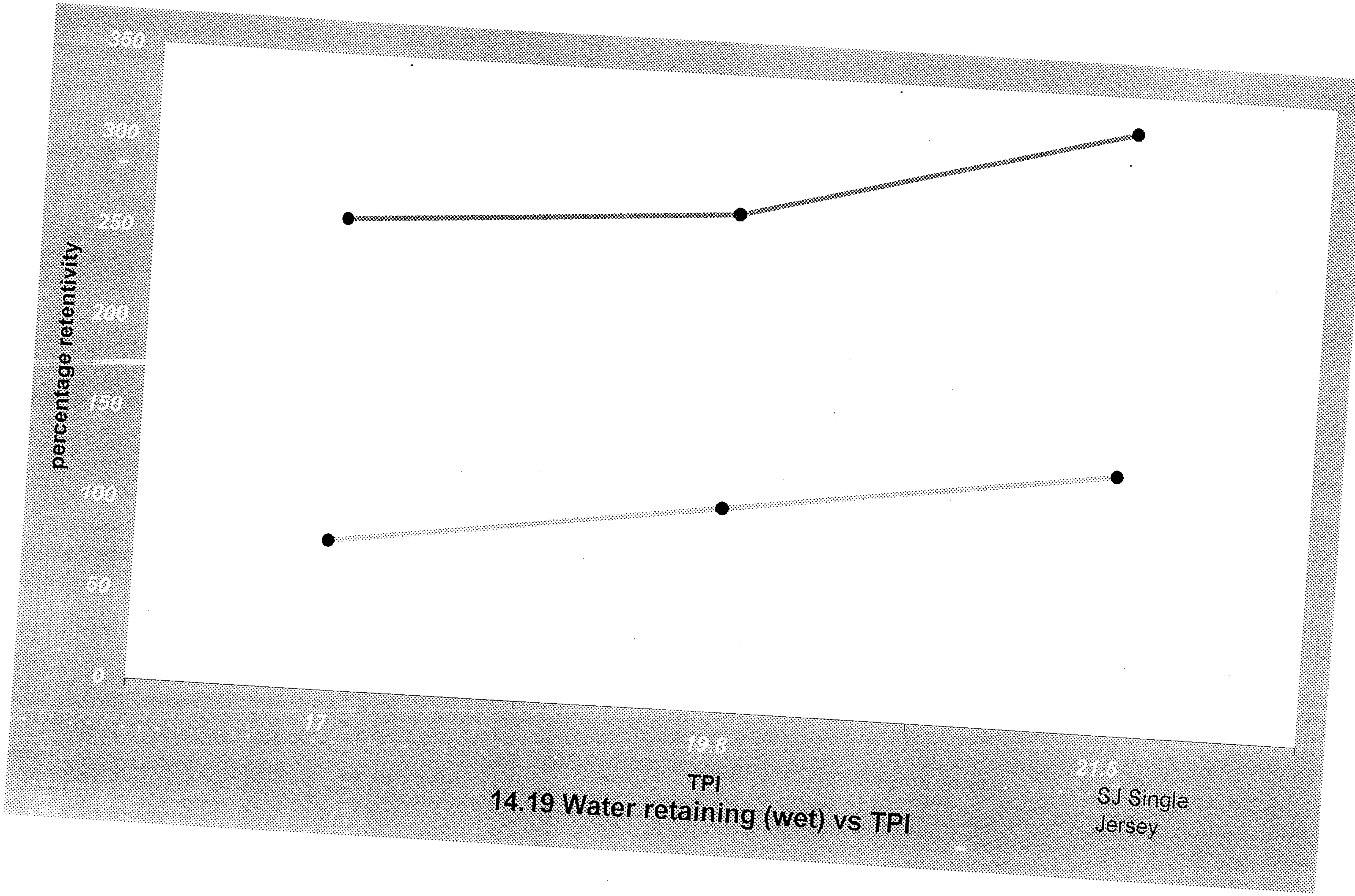
14.17 stitch density vs CSP(dry)



14.17 stitch density vs CSP



14.19 Water Retaining Capability (dry) vs TPI



14.19 Water retaining (wet) vs TPI

Results

RESULTS & DISCUSSIONS

Abrasion Resistance

- The Abrasion Resistance values of the dry relaxed single jersey fabrics are found to increase with the decrease in the CSP values of the respective yarns.

- The Abrasion Resistance values of the dry relaxed interlock fabrics are found to be a little bit more than the single jersey fabrics knitted from the same yarn and they also show a similar trend as that of the single jersey fabrics with respect to variation in CSP.

- The abrasion Resistance values of wet relaxed single jersey fabrics are found to decrease with increase in the CSP values of the respective yarns.

- The abrasion resistance values of wet relaxed interlock Structures are more compared to the single jersey fabrics knitted from the same yarn and they show a similar trend of decrease in resistance as the CSP increases like the single jersey structure.

- The abrasion resistance decreases as the TPI value increases in both dry relaxed and wet relaxed fabrics of single jersey and interlock structures, as the CSP increases.

- The increase in abrasion resistance of the interlock fabrics is little bit more compared to that of the single jersey fabrics.

- The abrasion resistance of the dry relaxed single jersey decreases as the U% increases, in both the dry and wet relaxed samples;

- The abrasion resistance of the interlock structures are more compared to that of the single jersey fabrics. They tend to decrease as the U% increases. This is true for both the cases of dry and wet relaxed structures.

Bursting strength

- The bursting strength of dry relaxed single jersey is found to decrease with the increase in the CSP values.

- The bursting strength of interlock fabrics are little bit more than that of the single jersey fabrics and they too decrease with the increase in the CSP values.

- The bursting strength of the wet relaxed single jersey and interlock seems to decrease with the increase in the CSP like that of the dry fabrics but with slightly lesser values.

- The bursting strength of the dry relaxed single jersey decreases with the increase in the TPI values of the respective yarns.

- The bursting strength of the dry relaxed interlock structures are slightly higher than the single jersey fabrics made from the same yarn. but they behave in the same way as that of the single jersey and decrease with the increase in the TPI values.

- The wet relaxed single jersey fabrics show that the increase in the TPI will result in the decrease of the bursting strength.

- The wet relaxed interlock fabrics have higher bursting strength compared to that of the single jersey fabrics and decrease with the increase in TPI. The bursting strength of the dry relaxed single jersey and the interlock are found to decrease with the increase in the U% of the yarn. But the interlock structures have higher bursting strength compared to that of the single jersey structures.

- The bursting strength of the wet relaxed single jersey and the interlock structures decrease with the increase in the U% values.

Drape co-efficient

- The drape co –efficient of the dry relaxed single jersey is found to increase with increase in the CSP values of the respective yarns.

- The drape co-efficient of the interlock structures increase with the increase in the CSP values. The interlock structures have higher drape co-efficient than the single jersey fabrics
- The drape co-efficient of the wet relaxed single jersey and interlock fabrics increase with the increase in the CSP values with the interlock having higher values.

- The drape co- efficient of both the dry and the wet relaxed increase with the increase in the TPI value, with the interlock structures having higher values.

Fabric stretch

- The course wise extention of the dry relaxed single jersey fabric is found to decrease with increase in CSP values.

- The course wise extention of the dry relaxed interlock fabrics of the same counts are found to be a little bit higher than the single jersey fabrics. The trend shown by them towards the increase in CSP is the same.

- The extension of wet relaxed samples of single jersey and interlock fabrics have decreased when compared to the dry relaxed fabrics. The trend shown by them towards increase in CSP is the same as the dry relaxed fabrics.

- The extension of dry relaxed samples of single jersey and interlock fabrics are found to decrease with increase in TPI.

- The extension of wet relaxed samples of single jersey and interlock fabrics are also found to decrease with increase in TPI and they also show a marginal reduction in their extensions.

- The wale wise extension of the dry relaxed samples of single jersey and interlock fabrics is much less than the course wise extension and the trend shown with respect to CSP and TPI is the same as in the course wise manner.

- The wale wise extension of the wet relaxed samples is considerably reduced due to the wet relaxation treatment but the trend with respect to CSP and TPI is the same.

Fabric thickness

- The thickness values of the dry relaxed single jersey fabrics are comparitively less than the interlock fabrics of the same count. The fabrics thickness is found to decrease with increase in CSP values.

- The dry relaxed interlock fabrics are found to be thicker and as the CSP values increase the thickness of the fabrics shows the reducing trend.

- The wet relaxed single jersey and interlock fabrics have little bit reduced thickness compare to the dry relaxed fabrics of the same type and they also show the same trend towards increasing CSP.

- The thickness values of the dry relaxed single jersey and interlock fabrics is found to decrease with increase in TPI.

- The thickness values of the wet relaxed single jersey and interlock fabrics also shows the same trend with TPI.

Pilling resistance

- The pilling resistance of dry relaxed single jersey and interlock is found to increase with the increase in the CSP , with the 40s count having the higher resistance than the other two counts namely 25s and 34s.

- The pilling resistance of wet relaxed seems to increase after wet relaxation treatment in both single jersey and interlock.

Stitch density

- The stitch density of the dry relaxed single jersey fabrics is found to increase with the increase in CSP values.

- The stitch density of the dry relaxed interlock fabrics are slightly higher compared to that of the single jersey fabrics but they also seem to increase with the increase in the CSP values.

- The stitch density of wet relaxed single jersey and the interlock structures increase with the increase in the CSP values of their respective yarns. But the increase in stitch density of interlock is more compared to that of the single jersey fabrics of same count.

Water retaining capability

- The water retaining capability of the dry relaxed single jersey and the interlock structures increases with the increase in the TPI values of their respective yarn values. The water retaining capability of the single jersey structures are more compared to the water retaining capability of interlock structures .

- The water retaining capability of the wet relaxed single jersey and interlock structures increase with the increase in the twist per inch of their respective yarns. The water retaining capability of single jersey has increased after the wet relaxation whereas the interlock structures show lesser retaining capacity after treatment.

Conclusion

CONCLUSION

This project was undertaken aiming at the support it can provide to the fast growing knitting industry, which are racing hard to achieve 100% efficiency.

The yarns which are the basic elements in fabric formation are the major contributors to the resultant fabric characteristics. Even though there are a few machinery parameters that can alter the characteristics of the fabric to some extent invariably the yarn properties stand atop all others in influencing the performance of the knitted fabrics.

At the end of the project, after completing various tests the results we obtained from the graphs are as follows :

The abrasion resistance tends to decrease with increase in various yarn parameters such as CSP, TPI & U%. The bursting strength decreases with the increase in all the three yarn parameters. The drape co-efficient graphs behave in opposite manner in the single jersey and interlock fabric which are made from yarns of same count. Pilling resistance of the single jersey and interlock structures increases with the increase in CSP & TPI due to the fact that finer yarns have less protruding fibres.

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