

PREDICTING FABRIC PROPERTIES AND CONSTRUCTIONAL DETAILS IN THE LABORATORY BEFORE WEAVING

التنبؤ بالتفاصيل الإنشائية للقماش في المعمل قبل نسجه

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خلاصة:

يقدم البحث طريقة معملية مبنية على أساس علمي وفي نفس الوقت سهلة وبسيطة وقليلة التكلفة سواء من حيث رأس المال أو التشغيل أو الخامات وذلك للتنبؤ بالخواص الهندسية والتفاصيل الإنشائية للقماش المنسوج قبل نسجه. فبمعلومية قطر الخيط المستخدم ونمر الخيوط والتركيب النسجي ونوعه يمكن التنبؤ بأقصى كثافة ممكنة للخيوط أو قابلية الخيوط للنسيج، أقصى نسبة تشريب للخيوط، أقصى نسب تغطية للخيوط والقماش، سمك القماش، أقصى وزن للمتر المربع من القماش، وأقصى كثافة حجمية للقماش. وبإضافة كثافة الخيوط في القماش المطلوب نسجه إلى المدخلات السابقة يمكن التنبؤ بالكثافة النسبية للخيوط، نسبة تشريب الخيوط، نسب تغطية الخيوط والقماش، سمك القماش، وزن المتر المربع من القماش، والكثافة الحجمية للقماش. ويمكن هذا البحث من الاستغناء عن كثير من الأجهزة مثل جهاز قياس نسبة تشريب الخيوط وجهاز قياس سمك القماش، كما يقلل من الفاقد في الخيوط إذ يمكن حساب كمية الخيوط اللازمة لإنتاج كمية معينة من القماش بدقة عالية، ويقلل من تكاليف الإنتاج باختيار الماكينة المناسبة حسب أقصى كثافة للخيوط، ويقلل من تكاليف اختبارات الخيوط والأقمشة.

1-ABSTRACT:

This research work presents a laboratorial method based on a scientific basis and, in the same time, easy, simple, and not costly with respect to capital, labour, or raw materials, to predict the geometrical properties and constructional details of the fabric before it is woven. Yarn diameter, yarn count, and weave structure each for warp and weft are used to predict maximum density of yarns in the fabric i.e. yarn weavability. Limit, maximum yarn crimp ratio, maximum yarn cover ratio, maximum fabric cover ratio, fabric thickness, maximum fabric weight per square meter, and maximum fabric volumetric density. By adding yarn density in the fabric required to be woven to the previously mentioned input data, the relative weaving density (the ratio between actual yarn density and maximum yarn density), yarn crimp ratio, yarn cover ratio, fabric cover ratio, fabric thickness, fabric weight per square meter, and fabric volumetric density can also be predicted.

This methodology is suggested to be used instead of many instruments used in testing fabrics such as fabric thickness meter, yarn diameter ordinary meter, and yarn crimp tester and helps reduce yarn waste as the amount of consumed yarn can be accurately calculated. It helps also reduce costs of weaving by choosing the suitable weaving machine according to relative weaving density of yarns, and costs of testing yarns and fabrics.

2- INTRODUCTION:

Till recently there are only geometrical models that have been suggested to relate fabric parameters to each other [1]. In order to relate crimp altitude to yarn spacing and crimp ratio, Peirce [2] assumed that weave angle is small, but this is not true except in very open structures which is a very special case [3]. Yarn diameter is not easy to be measured accurately with normal methods, and the trials which were carried out to calculate it were based on approximate formulae. The first pure

mathematical trial to investigate fabric structure and to describe it through perfect accurate relations was in 1994 [4]. That study dealt with plain square fabric. In terms of yarn count, yarn volumetric density and yarn set, many geometrical parameters could be expressed, such as yarn cover ratio, weave angle, yarn crimp ratio, fabric weight, fabric volumetric density, and packing density of yarn into the fabric. It could be concluded that maximum yarn cover ratio is $1/\sqrt{3}$ or 0.577. This means that maximum cover factor is 16.1658. Based on the assumption that fabric thickness is equal to the sum of yarn diameters and yarn crimp altitude of warp or weft whichever is more [5], weave angle could be expressed as a function of yarn diameters, yarn spacing, and crimp altitude as a ratio of the sum of warp and weft diameters. Crimp interchange has been analyzed and the state of zero-crimp yarns has been specified. Assuming the sum of yarn diameter and yarn crimp altitude is the same for warp and weft, as this is the case during weaving limp yarns, weave angle and yarn crimp ratio could be expressed in terms of yarn diameters and yarn spacing.

Non-classical methods were introduced [6] to calculate and measure yarn crimp ratio. Woven fabrics could be classified into two types: Floated Weaves and Extended Weaves. In a floated weave, yarn spacing is uniform and equal to yarn spacing at the point of intersection. In an extended weave, yarns are separated only at points of intersection. Simple mathematical models in dimensionless forms were introduced [7]. Yarn crimp ratios in 20 different styles of woven fabrics were measured [11]. Fabric weight was also measured for the same styles. Fabric weight was calculated using yarn counts, yarn densities, and these measured crimp ratios. Thereafter, fabric weight based on measured yarn crimp ratios was compared with measured fabric weight. There was an error in calculated fabric weight, i.e. fabric weight calculated from measured yarn crimp ratio. This error ranges from -4.792 % to 45.067 %. Ten styles out of the twenty styles gave a percentage of error more than 5. This means that the method used for measuring yarn crimp ratio is not accurate and that the degree of inaccuracy differs from one style to another. Accurate measurements or accurate calculations for crimp ratio are required because calculations of yarn consumption and yarn waste are based on it. Not only these calculations, but also the adjustments of let-off, take-up, and picking mechanisms depend on crimp ratios. Weinsdoerfer [8] studied the effect of yarn average float in woven fabric on the value of warp tension on the weaving machine. Yarn average float affects yarn crimp ratio. Yarn crimp ratio affects fabric abrasion resistance, fabric shrinkage, fabric extensibility, crimp interchange between warp and weft after finishing processes, fabric cost, and yarn demand [9].

Because of the importance of maximum set of yarn in the woven fabric, empirical and theoretical relationships relating maximum warp and weft cover factors have been derived, and theoretical relationships have been provided in graphic forms for only simple weaves [10]. Kienbaum [13] defined the relative weaving density as the ratio between actual yarn density and maximum yarn density in the woven fabric. He stated that warp sizing degree, yarn tension during weaving, weave structure, kinetics of beating-up, shed geometry and timing and denting affect yarn density. Weavability limit could be expressed as a function of weave design and yarn diameters [12].

New experimental methods were introduced for measuring fabric thickness under zero pressure [15, 16] and fabric volumetric density [14, 15].

3- EXPERIMENTAL WORK:

3-1- AN OUTLINE:

Experimental work is outlined in measuring diameter of each of warp and weft yarns depending on their counts and data obtained from a forming device [Fig. (1)]

which is like a loom but doesn't need heald shafts and doesn't produce a real woven fabric. It is used to *corrugate* a yarn sheet by inserting *straight light circular cylinders* through it. Yarns represent warp and cylinders represent weft [Fig. (2)]. There is no need to a beat-up mechanism as cylinders are put by hand one after the other on the warp sheet in such a manner that one cylinder is put in one side of the sheet and the next is put in the other side. Cylinders are laid in one plane. Cylinders are chosen light and when their diameter is relatively great they may be made hollow in order to be as light as possible. This test is carried out on a sheet of warp yarn and a sheet of weft yarn to determine warp and weft diameters, respectively. Yarn sheet is made by unwinding yarn from its package and winding it onto a hand or a motorized reel equipped with a helical traversing shaft to distribute yarn layers uniformly across the sheet. The length of creel circumference is chosen to suit the length of yarn sheet required for the test.

3-2- ESTIMATING LENGTH OF YARN SHEET:

Length of the part of yarn sheet which is corrugated using cylinders is estimated using the following derived relation:

$$L = \frac{\pi}{2} N_2 (d + D) \quad (1)$$

L: length of yarn sheet corrugated around cylinders.

d: yarn diameter (which is required to be measured).

D: cylinder diameter (which is known).

N₂: number of cylinders used for yarn sheet corrugating.

The yarn sheet length required to carry out the test is taken more than the length L to permit clamping and corrugating process.

3-3- CUTTING YARN SHEET:

Yarn sheet is cut, using a sharp knife, in two corresponding places on the sheet in order to have complete repeats of corrugated yarn: just under the first cylinder and just after the last one.

3-4- WEIGHING:

The yarn sheet between the two cutting locations is withdrawn or separated from cylinders and is then weighed. This weight is denoted as W and number of ends in the sheet is denoted as N₁.

4- DETERMINING YARN DIAMETER:

The yarn diameter d is determined from the following proven relation:

$$d = \frac{2000W N_m}{\pi N_1 N_2} - D \quad (2)$$

d: yarn diameter (mm)

D: cylinder diameter (mm)

N₁: number of ends in yarn sheet

N₂: number of cylinders used for yarn corrugating

N_m: metric count of yarn (m/g)

W: weight of corrugated yarn sheet (g)

If yarn number T is given in tex (mg/m), the relation will be

$$d = \frac{2 \cdot 10^5 W}{\pi N_1 N_2 T} - D \quad (2^*)$$

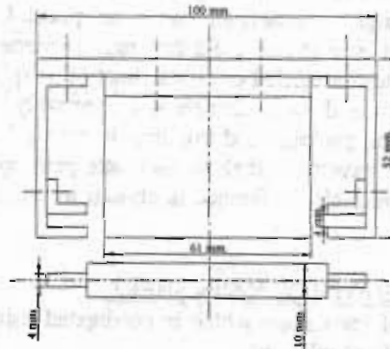
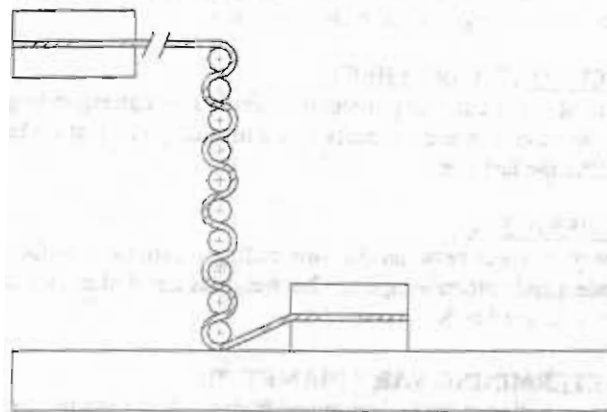


Fig. (1): A sketch of the forming device (a plan view) indicating the two vertical 4-mm slots, the 61-mm wide base plate, and one 10-mm diameter cylinder drawn separately

Fig. (2): Shape of yarn sheet (a side view) formed by inserting cylinders in one plane



5- NOTICE:

The same procedure of preparing yarn sheet, corrugating, cutting, weighing, and calculating is made for each of warp and weft yarns. It can be repeated for the same yarn to check the validity of results. Let:

F_1 : warp average float

F_2 : weft average float

N_{m1} : warp yarn count

N_{m2} : weft yarn count

d_1 : warp yarn diameter

d_2 : weft yarn diameter

(m/g)

(m/g)

(mm)

(mm)

6- CONSTRAINTS OF PLAIN AND FLOATED WOVEN FABRICS [11]:

Figs. (3 and 4) show the geometrical models of plain and floated woven fabrics, respectively.

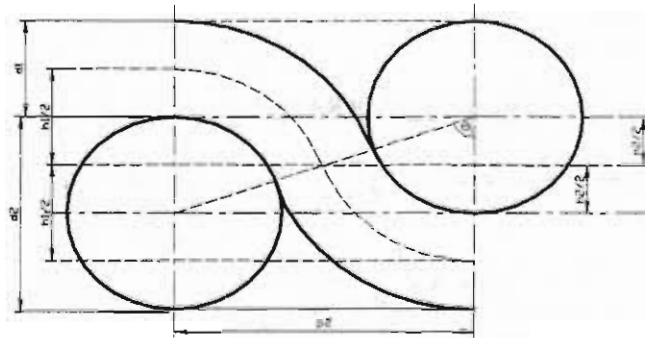


Fig. (3): Geometrical model of plain woven fabrics

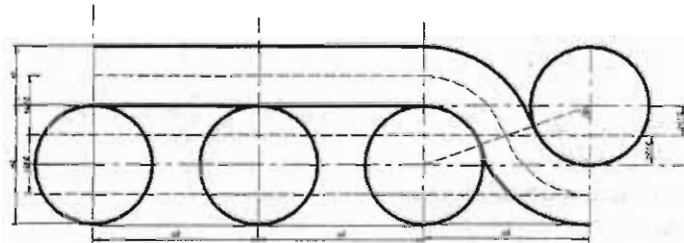


Fig. (4): Geometrical model of floated woven fabrics

6-1- MAXIMUM WEAVE ANGLE:

Maximum weave angle for warp and weft can be determined as follows:

$$\cos \theta_1 = \frac{d_1}{d_1 + d_2} \quad (3)$$

$$\cos \theta_2 = \frac{d_2}{d_1 + d_2} \quad (4)$$

θ_1 : maximum warp weave angle (degrees)

θ_2 : maximum weft weave angle (degrees)

It can be noticed that:

$$\cos \theta_1 + \cos \theta_2 = 1 \quad (5)$$

6-2- MAXIMUM YARN DENSITY (MAXIMUM YARN SET):

It can be expressed as follows:

$$n_1 = \frac{10}{\sqrt{d_1^2 + 2d_1d_2}} \quad (6)$$

$$n_2 = \frac{10}{\sqrt{d_2^2 + 2d_1d_2}} \quad (7)$$

n_1 : maximum warp set

(ends/cm)

n_2 : maximum weft set

(picks/cm)

6-3- MAXIMUM YARN CRIMP RATIO:

$$C_1 = \left[\frac{\pi(d_1 + d_2)}{180\sqrt{d_2^2 + 2d_1d_2}} \cos^{-1} \frac{d_1}{d_1 + d_2} - 1 \right] / F_1 \quad (8)$$

$$C_2 = \left[\frac{\pi(d_1 + d_2)}{180\sqrt{d_1^2 + 2d_1d_2}} \cos^{-1} \frac{d_2}{d_1 + d_2} - 1 \right] / F_2 \quad (9)$$

C_1 : maximum warp crimp ratio

F_1 : average warp float ($F_1=1$ in plain woven fabric)

C_2 : maximum weft crimp ratio

F_2 : average weft float ($F_2=1$ in plain woven fabric)

6-4- MAXIMUM YARN COVER RATIO:

$$K_1 = \frac{d_1}{\sqrt{d_1^2 + 2d_1d_2}} \quad (10)$$

$$K_2 = \frac{d_2}{\sqrt{d_2^2 + 2d_1d_2}} \quad (11)$$

K_1 : maximum warp cover ratio

K_2 : maximum weft cover ratio

6-5- MAXIMUM CLOTH COVER RATIO (K_c):

$$K_c = \frac{d_1}{\sqrt{d_1^2 + 2d_1d_2}} + \frac{d_2}{\sqrt{d_2^2 + 2d_1d_2}} - \frac{d_1d_2}{\sqrt{2d_1^3d_2 + 5d_1^2d_2^2 + 2d_1d_2^3}} \quad (12)$$

6-6- MAXIMUM FABRIC WEIGHT (W_f):

$$W_f = \frac{100n_1(1 + C_1)}{N_{m1}} + \frac{100n_2(1 + C_2)}{N_{m2}} \quad (13)$$

W_f : maximum fabric weight

(g/m^2)

6-7- FABRIC THICKNESS (T):

$$t = d_1 + d_2 \quad (14)$$

6-8- MAXIMUM FABRIC VOLUMETRIC DENSITY (g/cm^3):

$$\rho_f = \frac{n_1(1 + C_1)}{10N_{m1}(d_1 + d_2)} + \frac{n_2(1 + C_2)}{10N_{m2}(d_1 + d_2)} \quad (15)$$

7- CONSTRAINTS OF EXTENDED WOVEN FABRIC [12]:

Fig. (5) shows the geometrical model of extended woven fabric.

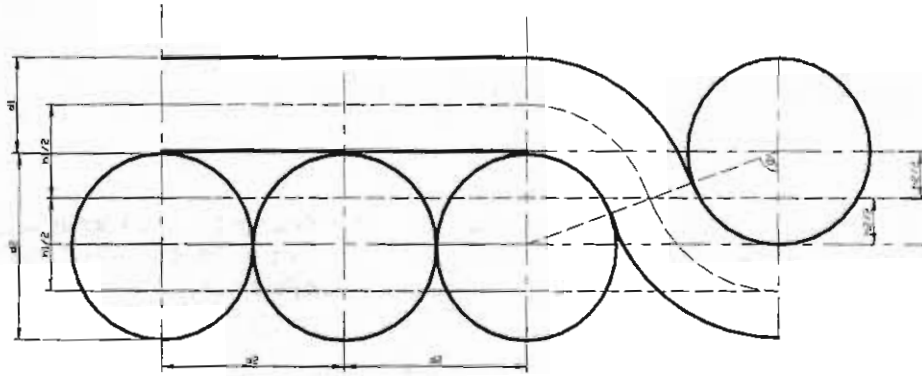


Fig. (5): Geometrical model of extended woven fabrics

7-1- MAXIMUM YARN DENSITY (MAXIMUM SET):

$$n_1 = \frac{10F_2}{\sqrt{d_1^2 + 2d_1d_2 + (F_2 - 1)d_1}} \quad (16)$$

$$n_2 = \frac{10F_1}{\sqrt{d_2^2 + 2d_1d_2 + (F_1 - 1)d_2}} \quad (17)$$

n_1 and n_2 are overall warp and weft maximum sets.

7-2- MAXIMUM YARN CRIMP RATIO:

$$C_1 = \frac{\frac{\pi}{180}(d_1 + d_2)\cos^{-1}\frac{d_1}{d_1 + d_2} + (F_1 - 1)d_2}{\sqrt{d_2^2 + 2d_1d_2 + (F_1 - 1)d_2}} - 1 \quad (18)$$

$$C_2 = \frac{\frac{\pi}{180}(d_1 + d_2)\cos^{-1}\frac{d_2}{d_1 + d_2} + (F_2 - 1)d_1}{\sqrt{d_1^2 + 2d_1d_2 + (F_2 - 1)d_1}} - 1 \quad (19)$$

7-3- MAXIMUM YARN COVER RATIO:

$$K_1 = \frac{F_2d_1}{\sqrt{d_1^2 + 2d_1d_2 + (F_2 - 1)d_1}} \quad (20)$$

$$K_2 = \frac{F_1d_2}{\sqrt{d_2^2 + 2d_1d_2 + (F_1 - 1)d_2}} \quad (21)$$

7-4- MAXIMUM CLOTH COVER RATIO (K_c):

$$K_c = K_1 + K_2 - K_1K_2 \quad (22)$$

K_1 and K_2 are obtained from equations (20) and (21), respectively.

7-5- MAXIMUM FABRIC WEIGHT (W_f):

It is calculated from equation (13).

7-6-FABRIC THICKNESS (t):

It is calculated from equation (14).

7-7- MAXIMUM FABRIC VOLUMETRIC DENSITY:

It is calculated from equation (15).

8- DETAILS OF ACTUAL WOVEN FABRIC:

If a warp with diameter d_1 and count N_{m1} is woven with a weft of diameter d_2 and count N_{m2} at n_1 ends/cm and n_2 picks per cm such that warp average float is F_1 and weft average float is F_2 , the following expressions [5 & 6] are used to specify fabric details:

8-1- WEAVE ANGLES :

$$\sin \theta_1 = \frac{10n_2(d_1 + d_2) - n_2d_1\sqrt{100 - n_2^2d_2(2d_1 + d_2)}}{100 + n_2^2d_1^2} \quad (23)$$

$$\sin \theta_2 = \frac{10n_1(d_1 + d_2) - n_1d_2\sqrt{100 - n_1^2d_1(2d_2 + d_1)}}{100 + n_1^2d_2^2} \quad (24)$$

8-2- CRIMP RATIO:8-2-1- FOR FLOATED WEAVES:

$$C_1 = \left[\sec \theta_1 - \frac{n_2(d_1 + d_2)}{10} \left(\tan \theta_1 - \frac{\pi \theta_1}{180} \right) - 1 \right] / F_1 \quad (25)$$

$$C_2 = \left[\sec \theta_2 - \frac{n_1(d_1 + d_2)}{10} \left(\tan \theta_2 - \frac{\pi \theta_2}{180} \right) - 1 \right] / F_2 \quad (26)$$

8-2-2- FOR EXTENDED WEAVES:

C_1 obtained from equation (25) must be multiplied by $\left[F_1 - \frac{n_2d_2}{10}(F_1 - 1) \right]$

and C_2 obtained from equation (26) must be multiplied by $\left[F_2 - \frac{n_1d_1}{10}(F_2 - 1) \right]$.

8-3- YARN COVER RATIO:

$$K_1 = \frac{n_1d_1}{10} \quad (27)$$

$$K_2 = \frac{n_2d_2}{10} \quad (28)$$

8-4- CLOTH COVER RATIO:

$$K_c = \frac{n_1d_1}{10} + \frac{n_2d_2}{10} - \frac{n_1n_2d_1d_2}{100} \quad (29)$$

8-5- FABRIC WEIGHT: [Equation (13)]8-6- FABRIC THICKNESS: [Equation (14)]8-7- FABRIC VOLUMETRIC DENSITY: [Equation (15)]

8-8- RELATIVE WEAVING DENSITY (the ratio between actual yarn density and maximum yarn density in the woven fabric):

8-8-1- PLAIN AND FLOATED WEAVES:

For warp

$$n_{r1} = \frac{n_1 \sqrt{d_1^2 + 2d_1 d_2}}{10} \quad (30)$$

and for weft

$$n_{r2} = \frac{n_2 \sqrt{d_2^2 + 2d_1 d_2}}{10} \quad (31)$$

8-8-2- EXTENDED WEAVES:

For warp

$$n_{r1} = \frac{n_1 \left[\sqrt{d_1^2 + 2d_1 d_2 + (F_2 - 1)d_1} \right]}{10F_2} \quad (32)$$

and for weft

$$n_{r2} = \frac{n_2 \left[\sqrt{d_2^2 + 2d_1 d_2 + (F_1 - 1)d_2} \right]}{10F_1} \quad (33)$$

9- EXAMPLES:

9- 1- FIRST EXAMPLE:

9- 1- 1- WEAVABILITY LIMIT OF YARNS:

Input Data:

Warp yarn diameter = 0.2 mm

Weft yarn diameter = 0.1 mm

Warp average float = 1.5

Weave class: Floated.

Warp yarn metric count = 50

Weft yarn metric count = 30

Weft average float = 1.5

Output Data:

Max. warp weave angle (degrees) = 48.214

Max. weft weave angle (degrees) = 70.564

Min. warp spacing = 0.2828 mm

Max. warp density = 35.355 ends/cm

Max. warp crimp ratio = 0.0856

Max. warp cover ratio = 0.7071

Max. cloth cover ratio = 0.8380

Max. warp weight / square meter = 76.76 g

Max. weft weight / square meter = 179.444 g

Max. fabric weight / square meter = 256.2 g

Max. fabric volumetric density = 0.854 g/cm³

Min. weft spacing = 0.2236 mm

Max. weft density = 44.721 picks/cm

Max. weft crimp ratio = 0.2037

Max. weft cover ratio = 0.4472

Fabric thickness = 0.3 mm

9- 1- 2- CONSTRUCTIONAL DETAILS OF ACTUAL FABRIC:

Additional Input Data:

Warp density = 20 ends/cm

Weft density = 15 picks/cm

Output Data:

Warp weave angle (degrees) = 8.837

Warp crimp ratio = 0.0076

Weft weave angle (degrees) = 24.742

Weft crimp ratio = 0.0556

Warp cover ratio = 0.4	Weft cover ratio = 0.15
Cloth cover ratio = 0.49	
Warp weight / square meter = 40.306 g	Weft weight / square meter = 52.784 g
Fabric weight / square meter = 93.08 g	Fabric thickness = 0.3 mm
Fabric volumetric density = 0.3102 g/cm ³	
Relative warp weaving density = 0.5656	Relative weft weaving density = 0.3354

9- 2- SECOND EXAMPLE:**9- 2- 1- WEAVABILITY LIMIT OF YARNS:****Input Data:**

Warp yarn diameter = 0.12 mm	Warp yarn metric count = 50
Weft yarn diameter = 0.2 mm	Weft yarn metric count = 25
Warp average float = 1.5	Weft average float = 1.5
Weave class: Floated.	

Output Data:

Max. warp weave angle (degrees) = 68.010	
Max. weft weave angle (degrees) = 51.343	
Min. warp spacing = 0.2498 mm	Min. weft spacing = 0.2966 mm
Max. warp density = 40.032 ends/cm	Max. weft density = 33.709 picks/cm
Max. warp crimp ratio = 0.1865	Max. weft crimp ratio = 0.0982
Max. warp cover ratio = 0.4803	Max. weft cover ratio = 0.6742
Max. cloth cover ratio = 0.8307	
Max. warp weight / square meter = 94.998 g	
Max. weft weight / square meter = 148.08 g	
Max. fabric weight / square meter = 243.085 g	Fabric thickness = 0.32 mm
Max. fabric volumetric density = 0.7596 g/cm ³	

9- 2- 2- CONSTRUCTIONAL DETAILS OF ACTUAL FABRIC:**Additional Input Data:**

Warp density = 20 ends/cm	Weft density = 15 picks/cm
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Output Data:

Warp weave angle (degrees) = 17.995	Weft weave angle (degrees) = 14.663
Warp crimp ratio = 0.03081	Weft crimp ratio = 0.01994
Warp cover ratio = 0.24	Weft cover ratio = 0.3
Cloth cover ratio = 0.468	
Warp weight / square meter = 41.232 g	Weft weight / square meter = 61.196 g
Fabric weight / square meter = 102.428 g	Fabric thickness = 0.32 mm
Fabric volumetric density = 0.32008 g/cm ³	
Relative warp weaving density = 0.4996	Relative weft weaving density = 0.4449

9- 3- THIRD EXAMPLE:**9- 3- 1- WEAVABILITY LIMIT OF YARNS:****Input Data:**

Warp yarn diameter = 0.18 mm	Warp yarn metric count = 50
Weft yarn diameter = 0.2 mm	Weft yarn metric count = 25
Warp average float = 1.5	Weft average float = 1.5
Weave class: Floated.	

Output Data:

Max. warp weave angle (degrees) = 61.7575

Max. weft weave angle (degrees) = 58.272	Min. weft spacing = 0.33466 mm
Min. warp spacing = 0.3231 mm	Max. weft density = 29.880 picks/cm
Max. warp density = 30.949 ends/cm	Max. weft crimp ratio = 0.1303
Max. warp crimp ratio = 0.1488	Max. weft cover ratio = 0.5976
Max. warp cover ratio = 0.557	
Max. cloth cover ratio = 0.8217	
Max. warp weight / square meter = 71.111 g	
Max. weft weight / square meter = 135.101 g	
Max. fabric weight / square meter = 206.213 g	Fabric thickness = 0.38 mm
Max. fabric volumetric density = 0.5426 g/cm ³	

9- 3- 2- CONSTRUCTIONAL DETAILS OF ACTUAL FABRIC:

Additional Input Data:

Warp density = 20 ends/cm Weft density = 15 picks/cm

Output Data:

Warp weave angle (degrees) = 18.286	Weft weave angle (degrees) = 23.091
Warp crimp ratio = 0.0311	Weft crimp ratio = 0.04614
Warp cover ratio = 0.36	Weft cover ratio = 0.3
Cloth cover ratio = 0.522	
Warp weight / square meter = 41.244 g	Weft weight / square meter = 62.768 g
Fabric weight / square meter = 104.012 g	Fabric thickness = 0.38 mm
Fabric volumetric density = 0.273 g/cm ³	
Relative warp weaving density = 0.6462	Relative weft weaving density = 0.5091

10- CONCLUSIONS:

From this work it is noticed that measuring yarn diameter by an accurate method is the most important step in predicting fabric parameters. Replacing thickness measuring by weight measuring interprets this accuracy. Moreover the measured value can be considered as an average of a number of locations on the yarn equal to number of cylinders multiplied by number of yarn ends in the prepared sheet. These locations are distributed regularly on the yarn sheet. Yarn diameter measured by this accurate method helps predict many constructional details in the woven fabrics. It helps predict the maximum angle of inclination yarn can make with fabric plane when it changes its position from one fabric side to the other i.e. maximum weave angle. It helps also predict the minimum yarn spacing, and the maximum yarn density in the woven fabric i.e. yarn weavability limit. As fabric is made to cover, yarn and fabric maximum covering powers must be known. This can be expressed in terms of yarn diameters. Weave structure (represented by yarn average float and weave class) is used with yarn diameters to determine maximum yarn crimp ratio. Maximum fabric weight can be predicted from yarn diameters, yarn average floats, and yarn counts. Only yarn diameters are needed to predict fabric thickness. Maximum fabric volumetric density can be predicted depending on yarn diameters, weave structure, and yarn counts.

These previously mentioned data are the boundaries of the fabric woven from certain yarns according to a certain weave structure. For the fabric to be woven and for which yarn densities are far enough from predicted maximum yarn densities according to yarn properties and weaving machine possibilities, many useful data can be presented. Fabric thickness can be simply estimated as the sum of warp and weft diameters. In terms of yarn diameters and densities, weave angles and yarn and fabric cover ratios can be calculated. Inputting weave structure to yarn diameters and densities enables estimating actual yarn crimp ratios. Fabric weight and volumetric

density can be predicted knowing the previous data. Relative weaving density can be determined from actual yarn density and maximum yarn density.

Predicting fabric properties and structural details in such a way saves effort and time.

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