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THEORETICAL AND EXPERIMENTAL STUDIES FOR THREAD FLOATING IN THE FABRIC

دراسة نظرية وعملية لتشييف الخيوط في القماش

by
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الخلاصة ـ هذا البحث يشمل أولا دراسة للعلاقات الرياضية للتأثير المشترك للعوامل الانشائية (اللاأبعادية) وهي القطر ،الحيز ، الازاحة عن محور المنسوج ودرجة التفرطح لكل من خيوط السداء واللحمه بالاضافة الى درجة التشييف على نسب التجعد المتبادلة بينهما . حيث أمكن تحديد هذه النسب بدقة من خلال الدراسة السابقة لأى تركيب انشائي مفترض . كما تم الربط الرياضي بين زوايا الالتفاف لكل من خيوط السداء واللحمه نتيجة لاختلاف درجة التشييف النسبية بالاستعانة باتزان القوى الداخلية للمنسوج ومن هذه العلاقة أمكن الحصول على الشكل الرياضي لتأثير درجة التشييف على مقدار الشد في كل من خيوط السداء واللحمه داخل المنسوج منسوبة الى شد خيوط السداء واللحمه للتركيب النسجي السادة والتى بدورها تؤثر على مقدار تجعد خيوط السداء واللحمه .وقد شمل البحث ثانيا قياسات عملية لشد خيوط السداء للمنسوج السادة ١/١ ومنسوج السادة الممتد من اللحمه تم نسجها في آن واحد على ماكينات نسيج ذات مقذوف ذو ماسك جنبا الى جنب بنفس نسبة تغذية خيوط السداء مع اختلاف درجة التشييف في اللحمه وقد أظهرت النتائج توافقا جيدا ومشجعا بين الدراسات النظرية والعملية كما شملت القياسات العملية قياس الاختلاف في شد خيوط السداء بين الدرقات الأمامية والخلفية وبين الخيوط في الدرقة الواحدة .

ABSTRACT

This paper includes firstly a theoretical study of the combined effect of dimensionless fabric construction factors such as thread diameter,thread spacing, thread displacement from fabric centre,degree of thread flattening and float ratio on crimp interchange between warp and weft threads.

The obtained relations determines accurately the crimp percent for both warp and weft under any presumed construction,the mathematical relations between warp and weft wrap angles due to change of float ratio were also determined through the corrospondant change of the relative thread displacement from fabric centre based on fabric force analysis.

This previous relation paved the way to correlate mathematically the relation between the float ratio and crimp percent in both arp and weft under different thread spacing which showed that the nge in thread spacing has insignificant effect on the relation ween float ratio and relative thread displacement.

The study included secondly an experimental measurement of warp ion for simple plain weave and weft rib weave woven taneously on the same projectile weaving machine side by side was possible to change the weft float and mentain the same feeding rate.

he results showed a very good encouraging agreement between mental and theoretical results, the experimental measurement ncluded the warp tension variation within and between heald during the normal weaving process.

INTRODUCTION

The final crimp values of warp and weft threads in the fabric depend on the following three main factors:
i- The characteristic of the dimensional construction of fabric such as thread diameter, thread spacing, degree of flattening of threads, degree of thread displacement from fabric axis and fabric structure.
ii- The mechanical characteristics of warp and weft threads specially the behaviour of warp and weft threads under the effect of bending stress.
iii- Adjustment of weaving machine during weaving process such as warp- and weft-tension, timing of beating-up process and symmetry of shed.

The final value of crimp percentage together with the structural parameters affect the dimensional characteristic of fabric such as fabric thickness, fabric weight, volum density of fabric and maximum value of cover factor. These dimenstional characteristics affect the mechanical and physical properties of the fabric such as fabric strength, fabric extension, air- and water- permiability of fabric and thermal conductivity.

The value of crimp interchange for warp and weft threads in the fabric varies according to fabric position on the weaving machine beginning from cloth fell up to cloth beam /1/. The elastic variation in crimp interchange could be changed to a plastic deformation due to the mechanical stresses during the end uses of the balanced fabric /2/.

The simple empirical mathematical models /6/ demand more modifications to determine the effect of the combined parameters specially by using the electronical computing systems /1/. In this work the simple mathematical models were improved and modified in form of dimensionless relations to determine the effect of these combined parameters on the values of crimp interchange using the modern coputing systems.

By measuring the value of warp tension during weaving process it was found that the mean value of warp tension decreases with increasing the float ratio /7/, the value of warp tension by weaving a twill fabric is lower than the warp tension value by weaving a simple plain weave fabric. The positioning of warp threads in the heald shafts affect the value of warp tension, due to the large displacement of the last heald shaft than the first heald shaft (to form a clear shed) the warp threads in the last heald shaft have a high value of warp tension than the warp threads in the first heald shaft /8/ and /10/.

Some times to produce fabrics with certien characteristics weaving process must be occured at unsymmetrical shedding (displacement of the lower shed is higher than the displacement the upper shed), the value of warp tension was varied accordin the difference in the displacement between sheds /9/.

In this work the value of warp tension (static and dynamic measured on a projectile weaving machine under the effect of following parameters:
i- Type of fabric structure, plain weave and weft rib weave by side on prijectile weaving machine.
ii- Positioning of warp threads in heald shafts, firs last heald shaft.
iii- Positioning of warp threads in heald shaft, left-middel-r

THEORETICAL STUDIES

1- Effect of relative thread diameter, relative thread displacement and degree of flattening on crimp interchange between warp and weft threads

1-a) Nomenclature:

2a thickness of flattened thread
at =half warp thickness (a1) + half weft thickness (a2)
A = a/at relative thickness of flattened thread
2b width of flattened thread
C% crimp percent
e = a/b degree of flattening
h thread displacement from fabric axis
H = h/r relative displacement
K = Ls/at relative spacing of flattened thread
2Ls thread spacing
n = Number of threads per float
r radius of thread
rt= r1 + r2, total radius of warp and weft thread
R = r/rt relative radius of thread
S = Ls/rt relative thread spacing
T = thread tension
θ half wrap angle between warp and weft thread
suffix 1 for warp thread
suffix 2 for weft thread

1-b) Effect of relative thread diameter on crimp interchange at different thread spacing

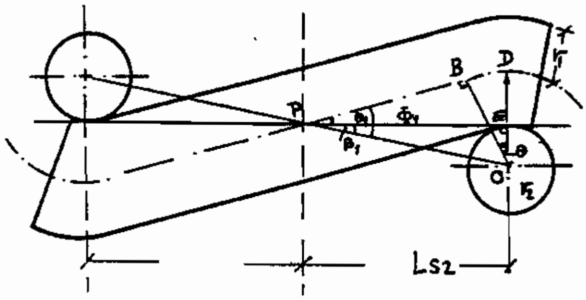


Fig.1 Cross section of half repeat for balanced plain weave

Fig.1 shows a weft cross section for a half repeat of balanced plain weave structure, the balanced structure means that the cross section of threads in a square fabric is symmetrical around fabric axis, the crimp percent could be calculated as follows: considering the triangles OEP and OBP to calculate the straight- and round-part of the warp thread axis PBD.

$$C1\ \% = ((rt.\theta_1 + \sqrt{r_2\hat{}2 + (Ls2)\hat{}2 - rt\hat{}2}) / Ls2 - 1)\ .\ 100$$

where,

$$\theta 1 = \Phi_1 - B_1 = \arctan(rt/\sqrt{r2\hat{}2 + (Ls2)\hat{}2) - rt\hat{}2}) - \arctan(r2/Ls2)$$

and the equation of crimp in dimentionless form is:

$$C1\ \% = ((\theta 1 + \sqrt{R2\hat{}2 + S2\hat{}2 - 1}) / S2\hat{}2) - 1)\ .\ 100 \ ....(1)$$

where,

$$\theta 1 = \arctan(1 / \sqrt{R2\hat{}2 + S2\hat{}2 - 1}) - \arctan(R2 / S2)$$

and analogous the crimp percent for weft thread is,

$$C2\ \% = ((\theta 2 + \sqrt{R1^2 + S1^2 - 1}) / S1^2) - 1) \cdot 100 \quad \ldots\ldots\ldots \quad (2)$$

where,

$$\theta 2 = \Phi_2 - \beta_2 = \arctan(1 / \sqrt{R1^2 + S1^2 - 1}) - \arctan(R1 / S1)$$

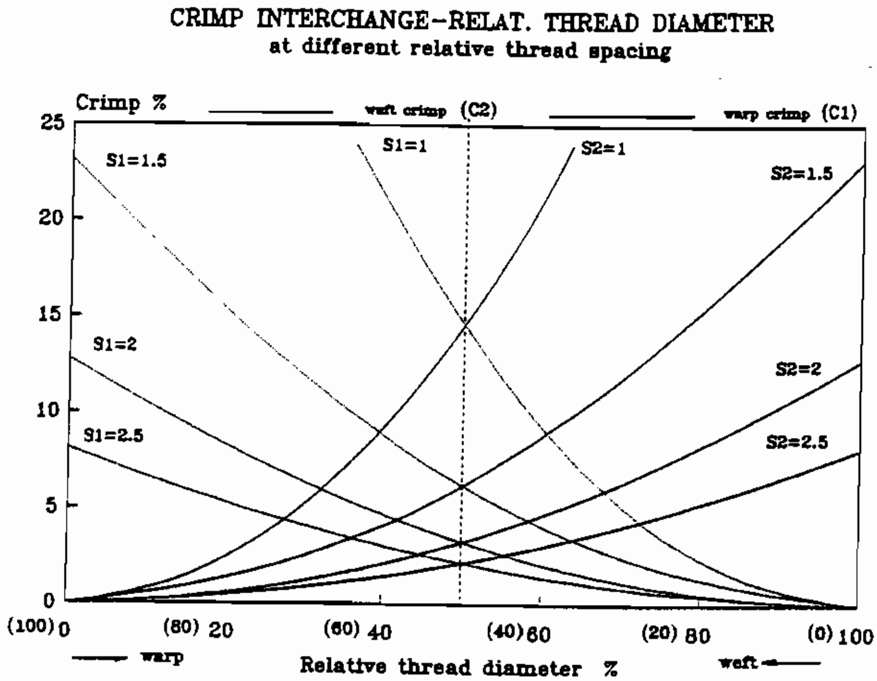


Fig.2 Crimp percent versus relative thread diameter

Fig.2 shows the behaviour of warp and weft crimp as a function from relative thread diameter at a different thread spacing, the value of thread crimp increases with increasing its relative thread diameter. At a constant relative thread diameter the value of thread crimp increases with decreasing thread spacing, the warp and weft crimp have the same value at a relative thread diameter equal to 50 % (r1=r2=rt/2).

1-c) Effect of relative displacement on crimp interchange at different values for relative thread diameter and relative thread spacing

In the latter model it was assumed that the cross section of thread diameters are tangential to fabric axis, in many cases the tangential to thread cross section is displaced from fabric axis due to the following factors:

- The characteristics of warp and weft threads (such as bending rigidity) are different.
- The type of fabric structure affects the wrapping angle between warp and weft thread.
- The variation in the values of warp and weft tension during weaving process.

In this model it was assumed that the tangential for thread cross sections was displaced a distance from fabric axis

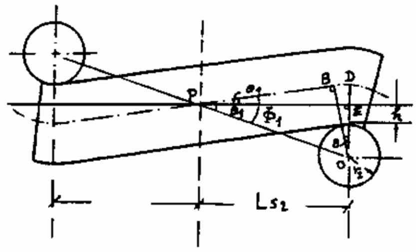


Fig.3-A Weft cross section

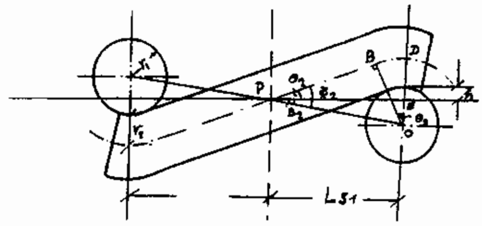


Fig.3-B Warp cross section

Fig.3-A represents a weft cross section with a tangential displacement (h) for thread cross sections from fabric axis, Fig.3-B shows the warp cross section at the same displacement.
The value of warp crimp could be calculated from Fig.3-A as follows:

$$C1\ \% = ((\text{length of centerline PBD} - Ls2) / Ls2) \cdot 100$$

$$C1\ \% = ((rt.\theta 1 + \sqrt{(h + r2)^2 + (Ls2)^2 - rt^2}) / Ls2 - 1).100$$

where,

$$\theta 1 = \Phi_1 - \beta_1 = \arctan\left(rt / \sqrt{(h + r2)^2 + (Ls2)^2 - rt^2}\right) - \arctan((h + r2) / Ls2)$$

and the equation of warp crimp in dimensionless form is,

$$C1\ \% = ((\theta 1 + \sqrt{(R2 + H1.(1-R2))^2 + S2^2 - 1}) / S2 - 1).100 \quad \ldots(3)$$

where,

$$\theta 1 = \Phi_1 - \beta_1 = \arctan\left(1 / \sqrt{(R2 + H1 \cdot (1-R2))^2 + S2^2 - 1}\right) - \arctan((R2 + H1 \cdot (1 - R2)) / S2)$$

and analogous from Fig.3-B the crimp percent for weft thread could be calculated as followes:

$$C2\ \% = ((rt.\theta 2 + \sqrt{(r1-h)^2 + (Ls1)^2 - rt^2}) / Ls1 - 1).100$$

where,

$$\theta 2 = \Phi_2 - \beta_2 = \arctan\left(rt / \sqrt{(r1-h)^2 + (Ls1)^2 - rt^2}\right) - \arctan((r1-h)/Ls1)$$

and the equation of weft crimp in dimensionless form is,

$$C2\ \% = ((\theta 2 + \sqrt{(R1 - H2.(1-R1))^2 + S1^2 - 1}) / S1 - 1).100 \quad \ldots.(4)$$

where,

$$\theta 2 = \Phi_2 - \beta_2 = \arctan\left(1 / \sqrt{(R1 - H2 \cdot (1 - R1))^2 + S1^2 - 1}\right) - \arctan((R1 - H2 \cdot (1 - R1)) / S1)$$

Figs.4 and 5 show the relation between crimp percent and relative thread displacement ,the crimp percent of the displacing thread (warp thread) decreases with increasing the relative displacement (H1) but the crimp value of the displaced thread (weft thread) increases with increasing the relative displacement (H2).

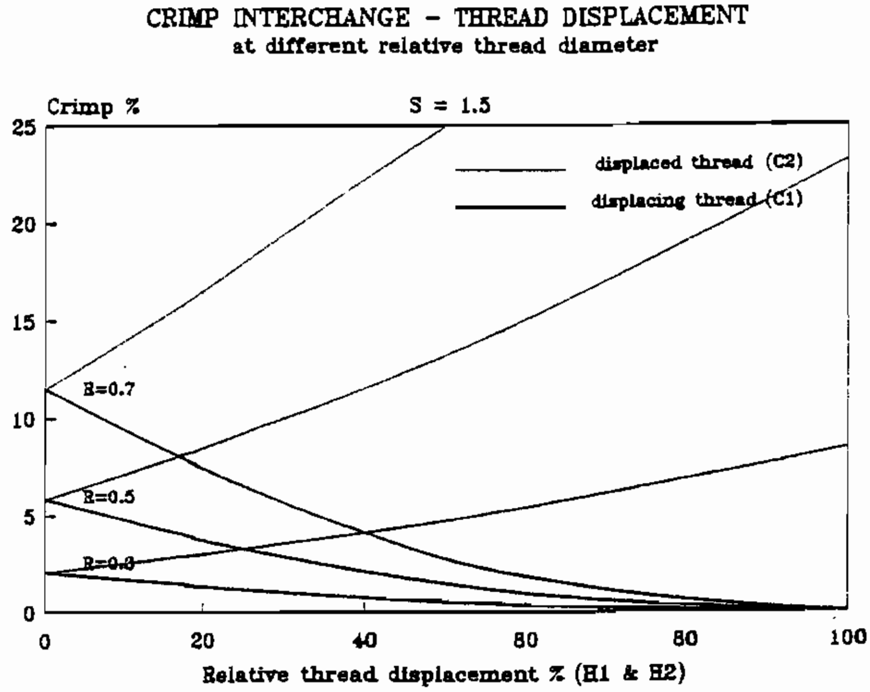


Fig.4 Crimp % versus relative displacement

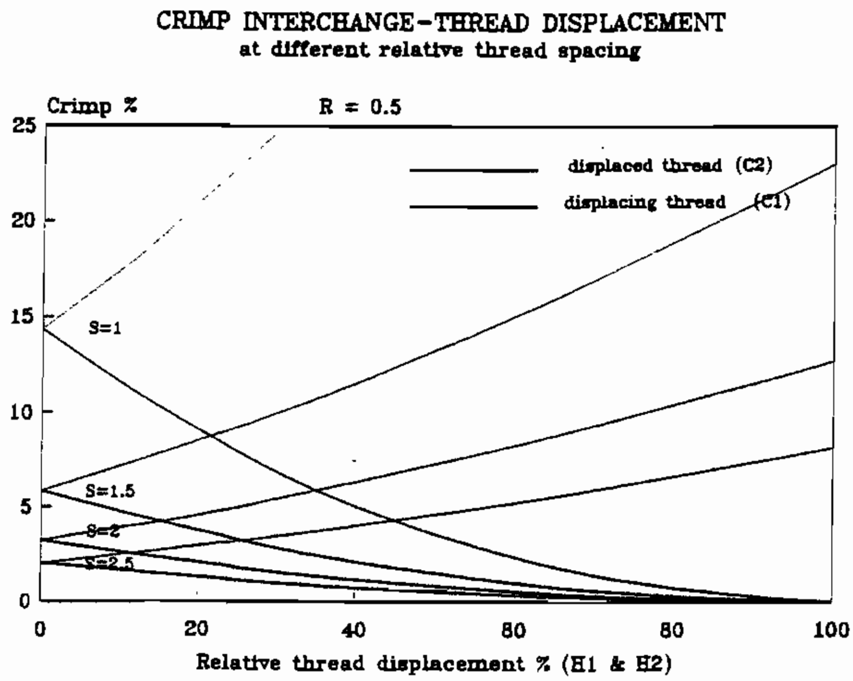


Fig.5 Crimp % versus relative displacement

1-d) Effect of relative thread displacement on crimp interchange at different values of flattened thread

In the latter two theoretical models it was assumed that the cross sections of the threads are circular, but due to the compressibility of the fibres in thread cross section the interchange force between warp and weft threads in the fabric act to deform the thread cross section to a flattened shape.

It was assumed in this theoretical model that the thread cross section has a race trac shape. Fig.6-A shows a half repeat of flattened weft section for a simple plain weave structure with a displacement h from fabric axis and Fig.6-B shows the warp section for the same repeat.

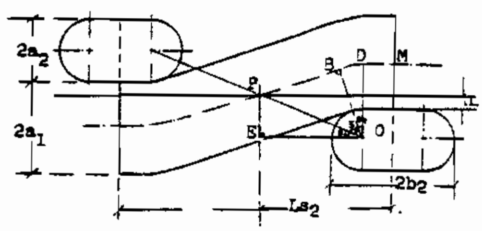


Fig.6-A Weft section

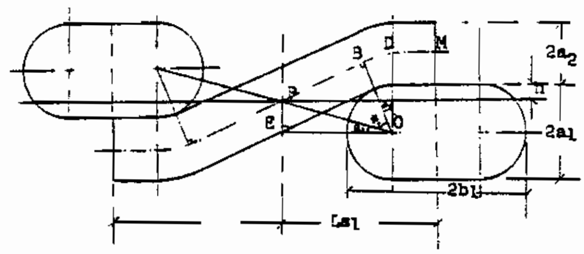


Fig.6-B Warp section

From Fig.6-A the value of warp crimp could be calculated as follows:

$$C1\,\% = ((\text{length of centerline PBDM} - Ls2) / Ls2) \,.\, 100$$

by using the triangles OEP and OBP to calculate the straight part PB then,

$$C1\,\% = ((b2-a2+at.\theta1+\sqrt{(a2+h)^2+(Ls2-b2+a2)^2-(at)^2}) / Ls2 -1).100$$

where

$$\theta1 = \pi/2 - \beta1 - \Phi1 = \pi/2 - \arctan((a2 + h) / (Ls2 - b2 + a2)) - \arctan(\sqrt{(a2+h)^2 + (Ls2-b2+a2)^2 - at^2} / at)$$

and the equation of crimp in dimensionless form is,

$$C1\% = ((A2/e-A2+\theta1+\sqrt{(A2+H1(1-A2))^2+(K2-A2/e+A2)^2-1}) / K2 -1).100 \quad \ldots\ldots\ldots\ldots\ldots(5)$$

and

$$\theta1 = \pi/2 - \arctan((A2 + H1(1-A2) / (K2 - A2/e + A2)) - \arctan\sqrt{(A2 + H1(1-A2))^2 + (K2 - A2/e + A2)^2 - 1}$$

and analogous the crimp percent for weft thread is,

$$C2\% = ((A1/e-A1+\theta2+\sqrt{(A1-H2(1-A1))^2+(K1-A1/e+A1)^2-1}) / K1 -1).100 \quad \ldots\ldots\ldots\ldots\ldots(6)$$

and

$$\theta2 = \pi/2 - \arctan((A1 - H2(1-A1) / (K1 - A1/e + A1)) - \arctan\sqrt{(A1 - H2(1-A1))^2 + (K1 - A1/e + A1)^2 - 1}$$

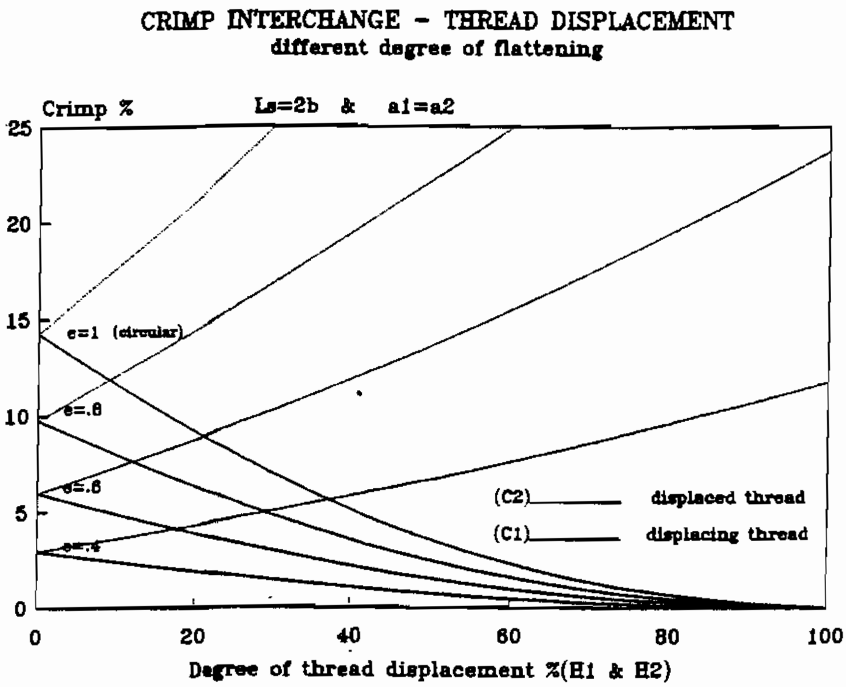


Fig.7 Warp and weft crimp versus relative displacement

Considering for example the thread spacing 2Ls=4b and thread hight=at/2 then Fig.7 shows the relation between crimp percent and relative thread displacement at different degrees of flattening, the crimp percent for the displacing thread (warp thread) decreases with increasing the relative displacement (H1)and for the displaced thread (weft thread) the crimp percent increases with increasing the relative displacement (H2). The level of warp and weft crimp decreases with increasing the degree of flattening (1-e). In general the threads with a flattened cross sections have a low value of crimp than the threads with circular cross sections.

1-e) Effect of thread float on the interchange force between warp and weft threads

The interchange force between warp and weft thread affected by the float of the threads in the fabric, Fig. 8-A shows the thread interlacing for a simple plain weave structure and its warp cross section, Fig. 8-B shows the thread interlacing in a weft rib structure and its warp cross-section.
The interchange force between warp and weft threads could be calculated as follows:
for plain weave is,

$$2.T1(pl.).\sin\theta 1(pl.) = 2.T2(pl.).\sin\theta 2(pl.)$$

$$T1(pl.) = T2(pl.).\sin\theta 2(pl.) / \sin\theta 1(pl.) \quad \ldots\ldots\ldots\ldots(7)$$

and for weft rib is,

$$(No.of\ ends).2.T1(rib).\sin\theta 1(rib) = 2.T2(rib).\sin 2.\theta 2(rib)$$

$$T1(rib) = T2(rib).\sin 2.\theta 2(rib) / \sin\theta 1(rib) \quad \ldots\ldots\ldots(8)$$

from eqs. 7 and 8 considering the following conditions:
- weft rib and plain weave was woven side by side with the same weft thread
- warp threads has the same float in plain weave and weft rib
- thread spacing for both fabric structure is the same

then,

$$T1(rib)/T1(pl.) = \sin 2.\theta 2(rib) \; / \; n \, . \, \sin \theta 2(pl.)$$

Fig.9 shows the relation between thread float and the reduction in thread tension, the ratio of T1(rib) / T1(pl.) decreases with increasing the weft float.

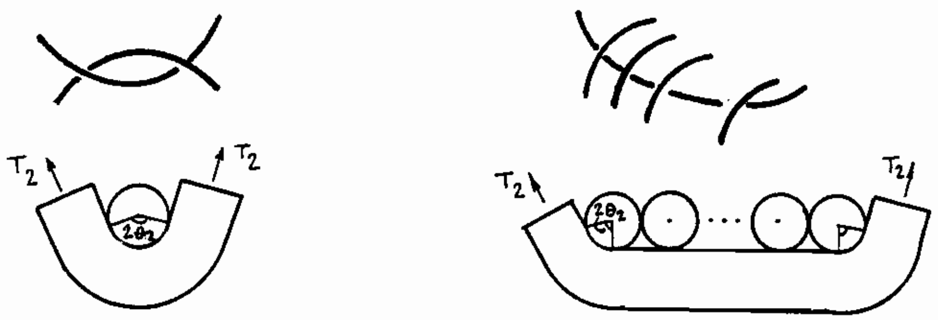


Fig.8-A Threads interlacing and warp section for plain weave

Fig.8-B Thread interlacing and warp section for weft rib

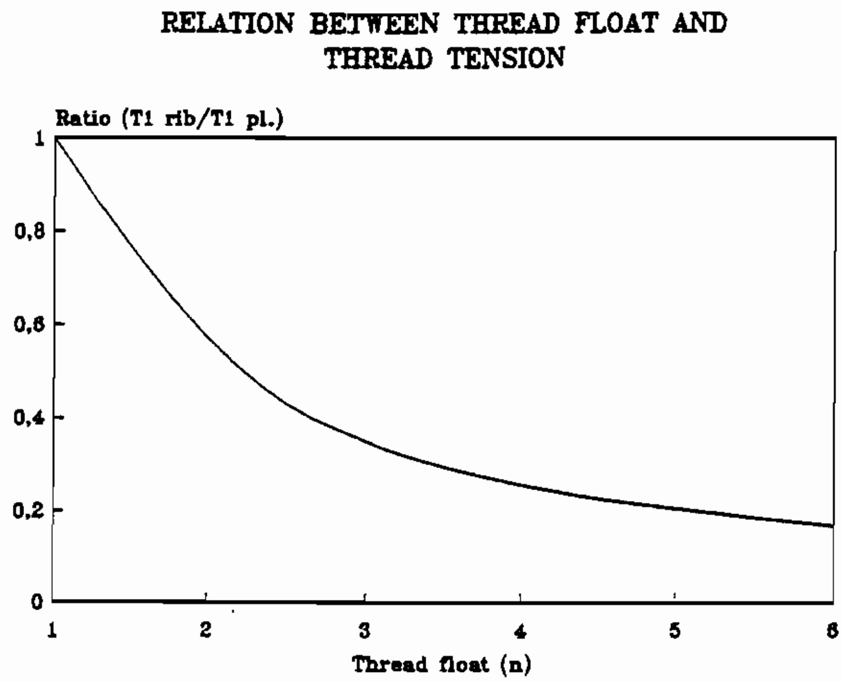


Fig.9 Float of weft thread versus ratio of warp tension

EXPERIMENTAL STUDIES

1- Specification of weaving machine and material used

Type of weaving machine ....Sulzer PU Projectile
Weaving machine speed ....330 picks/min
Maximum reed space ....2 m
Warp width in reed ....1.8 m
Ends/cm ....26, 2x16tex, cotton
Picks/cm ....12, 95 tex, cotton
Number of heald shafts 16
Fabric structure ....plain weave and weft rib

2- Instrumentation of warp tension measurements

The RES measuring head of tension measurement was used by intiating resistant strain gauges electronically connected to a measuring circut of 31 KHZ, the signal is then fed to an aplifier of 500 KHZ and finally demonstrated by a cathod ray oscilliscope with a recording facilities the signal could be later plotted graphically with the suitable speed using a chart recorder.

3- Experimental procedure

- Twenty seven single warp threads distributed across warp sheet width (seventeen warp threads across plain weave width and tweleve warp threads across weft rib width) marked provided that they pass through the last heald shaft and the last dropper bar, also ten successive warp threads were choosen in the left hand side (plain weave), middle (plain weave) and the right hand side (weft rib) of the first and last heald shaft at a distance 2 cm from selvedge.
- The measuring head of the RES were introduced through the specified warp threads in the region between the oscillating back rail and the last dropper bar to record their tensions consequantly.
- The recorded tension cycles were obtained by running the weaving machine first until stable weaving condition was reached then twenty successive signals will be recorded and stored, these twenty signal will then be transfered into chart recorded at appropriate speed, the weaving machine then brought to stop with the heald shaft level and the static warp tension then could be recorded at the end of the twenty cycles.

4- Evaluation of experimental results

- Fig.10 shows a typical recorded signals of warp tension, the average value of ten readings for each of the four described parameters could be then obtained per warp thread, the same procedure could be then repeated for the twenty-seven marked warp thread to form the distribution across warp sheet width. The same procedure could be repeated for every ten successive warp threads and the average value per ten warp threads was calculated.

(1) Warp tension at beating up by lower shed

(2) Maximum warp tension at lower shed

(3) Warp tension at beating up by upper shed

(4) Maximum warp tension at upper shed

(5) Static warp tension at closed shed

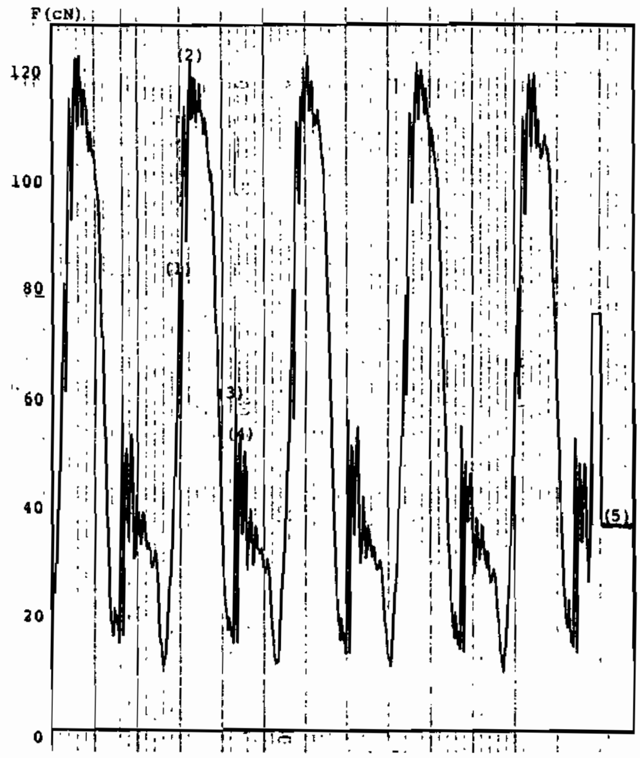


Fig.10 Typical tension signal for warp threads in the last shaft

DISCUSSION AND CONCLUSION

- It could be theoretically relating between crimp interchange (between warp and weft threads) and fabric characteristic such as thread diameter, thread spacing, shape of thread cross-section and type of fabric structure.
- As shown in Fig.2 it was found theoretically that the threads with large diameters have a high value of crimp percent but actually these threads have a high resistance to bending in the fabric, therefor the threads with large diameters act to displace the threads with small diameters against fabric axis as shown in Fig.3-A and 3-B.
- Figs. 4 and 5 show the effect of the value of relative displacement on the variation in crimp percent, the value of crimp for displacing thread equal to zero when its centre line become straight and has the displaced thread in this case its maximum value.
- Practically the cross section of threads in the fabric was flattened, the crimp percent for threads with circular cross-section is higher than for threads with flattened cross-section (when both threads under the same conditions). Fig.7 shows the effect of relative displacement, the behaviour of crimp percent for warp and weft threads is the same as mentioned latter in the case of circular thread cross section. The level of crimp percent decreases with increasing the degree of flattening (1-e).

- By analysing the interchange forces between warp and weft threads in the fabric, it was found that the tension in warp threads decreases with increasing the float of weft thread, (see Fig. 9). The crimp value affected by the interchange force between warp and weft threads, the value of crimp increases with increasing the interchange force.

- By measuring the warp tension during weaving process (Fig.10) shows a typical signal for the variation in warp tension due to shedding. The warp tension by forming the lower shed is higher than the tension by forming the upper shed, this is due to the unsymmetry of the shed (upper shed has a smaller displacement than the lower shed)

- The warp tension due to beating up process at the lower shed has a smaller value than the maximum tension due to lower shedding but the warp tension due to beating up process at the upper shed has a higher value than the maximum tension due to forming the upper shedding.

- Fig.11 shows the distribution of one static and four dynamic warp tensions in twenty seven warp threads across the warp sheet, the level of static and all dynamic warp tension in the weft rib section is lower than the level in plain weave section, this is due to the variation in crimp percent between weft rib weave and plain weave which the plain weave has a higher value of crimp than the weft rib weave.

- The maximum value of dynamic warp tension is due to forming the lower shedding and the minimum value at the upper shedding. The behaviour of four dynamic tensions is a function from static warp tension, the value of dynamic tension increases with increasing the value of static tension.

- The results showed a good agreement between theoretical and experimental values of warp tension , from the theoretical calculation it was found that at weft float n = 2,

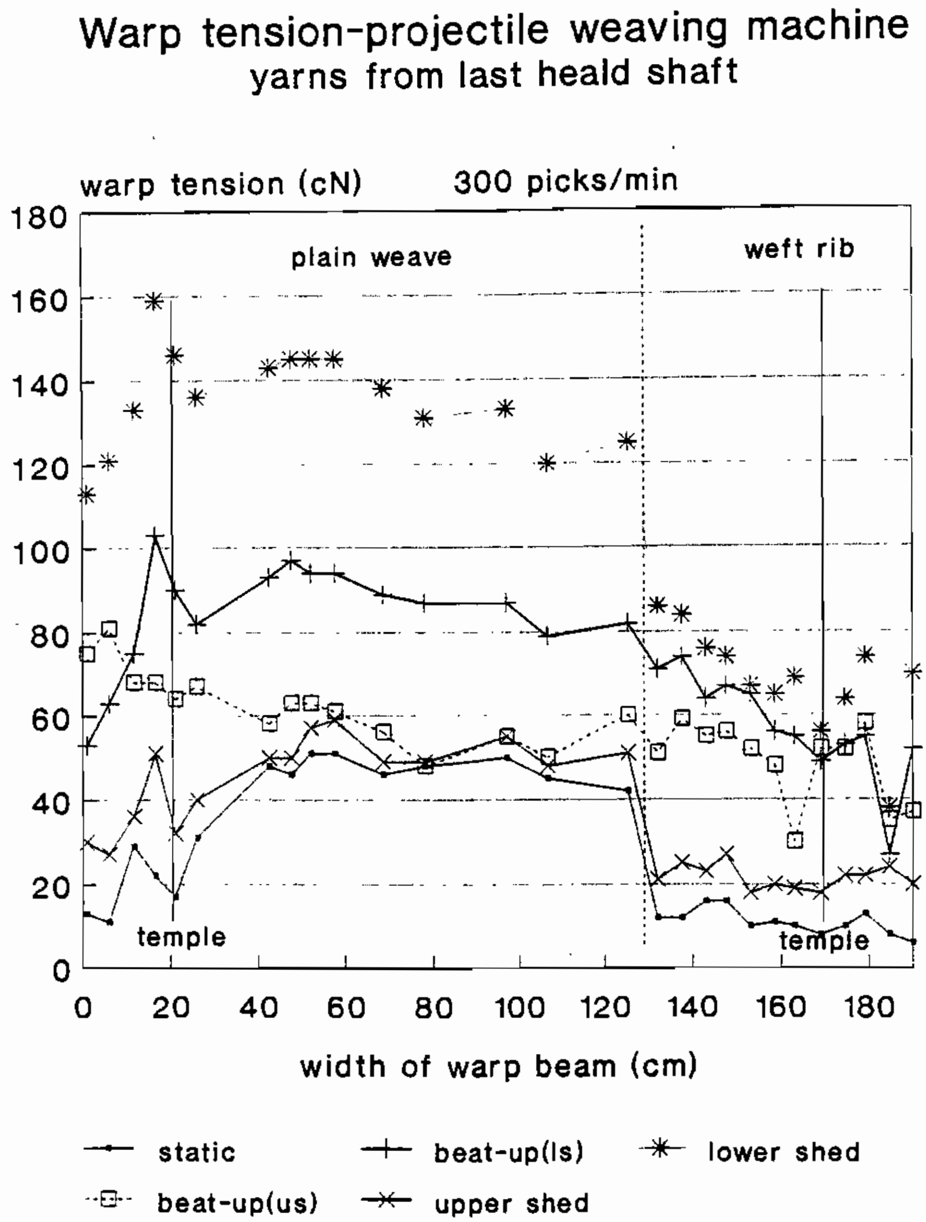
$$\frac{\text{warp thread tension for weft rib weave}}{\text{warp thread tension for plain weave}} = 0.5$$

and from the measurements (between temples) it was found that,

$$\frac{\text{mean value of the max. dynamic warp tension in weft rib}}{\text{mean value of the max. dynamic warp tension in pl.weave}} = 0.52$$

- Fig. 12 and 13 show the values of the calculated warp tension (calculated from ten successive warp threads) due to lower and upper shedding in the first and last heald shaft, the level of warp tension in the last heald shaft is higher than the values in the first heald shaft. The value of warp tension in weft rib weave section has a small value in both first and last heald shaft especially by forming the lower shed.

- Figs. 14 and 15 show the values of warp tension during beating up in the lower and upper shed, the difference in the tension due to beating up between first and last heald shaft is small. In weft rib weave section the warp tension due to beating up is smaller than the tension in plain weave section.



cotton Ne 37/2

Fig.11 Static and dynamic warp tension across warp sheet

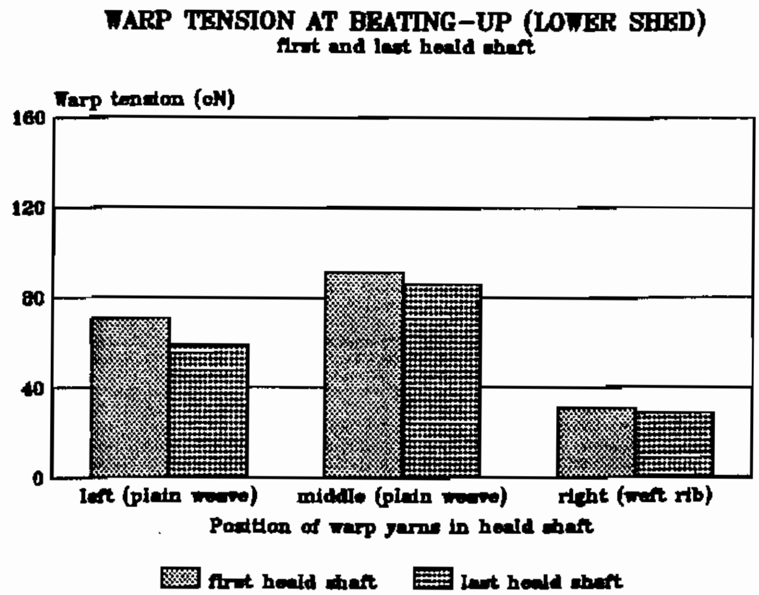


Fig.14 Mean value of tension at beating up (lower shed)

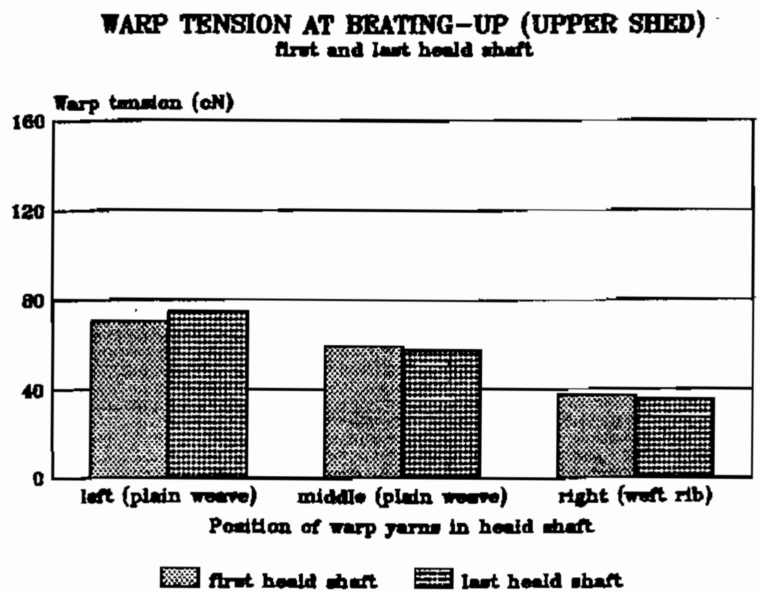


Fig.15 Mean value of tension at beating up (upper shed)

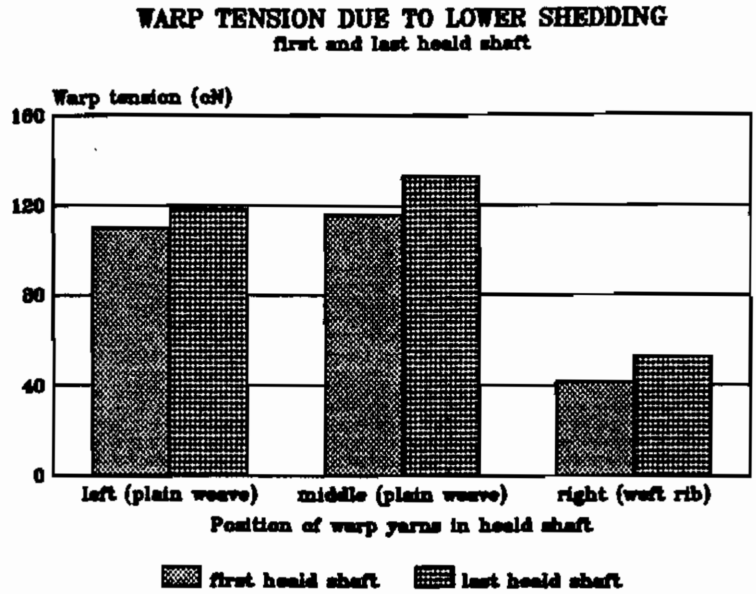


Fig.12 Mean value of tension for ten warp threads at lover shed

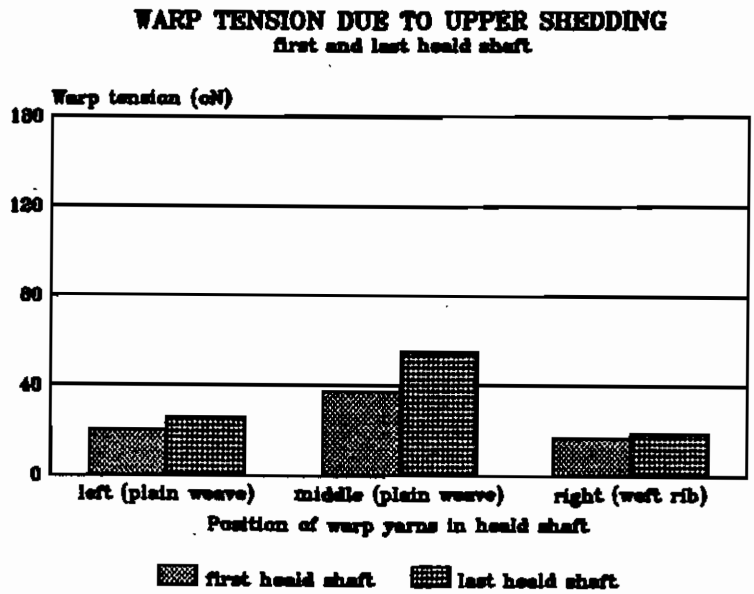


Fig.13 Mean value of tension for ten warp threads at upper shed

- To obtain on a homogenous distribution of crimp values across fabric width the following parameters must be considered:

a) the variation in thread float due to the different produced fabric structure must be within a certain limits.
b) the variation in the value of warp tension due to effect of the used temple should be small.
c) continuity in the feeding of warp threads from warp beam during weaving process
d) high quality of warping process for warp beam

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