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# Importance of the Cloth Fell Position and Its Specification Methods

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## 1. Introduction

The warp and weft densities are important parameters having significant effect on the visual, physical and mechanical properties of the fabrics. So, to have a fabric with desirable properties, these two parameters play the key role. Density has affected by many factors which appreciating them is crucial in controlling the evenness of fabric. Although, most of the warp regularity is the result of the appropriate weaving preparation, weft evenness is obtained by correct weaving process.

Therefore, pick density or pickspacing is one of the most important parameters that should be controlled continuously during weaving process to prevent any variations. pickspacing itself is influenced by different causes. Some studies have been done to investigate the effect of these factors on pickspacing.

According to previous studies, position of the cloth fell and the cloth fell distance (c.f.d.) are the effective elements on the pickspacing, the variations of which result in unevenness pickspacing.

As weaving is started, the cloth fell gradually finds its correct position by action of the take-up motion. When a low-pick density fabric is woven, the cloth fell lies on the front position of the reed; however in fabrics with more pick density, the cloth fell tends to move towards the warp direction and the distance of this position of the cloth fell from the front position of the reed is referred to as the cloth fell distance (c.f.d.). This position is maintained as long as the loom runs satisfactorily.

There are, however, many occasions when the correct cloth fell position is temporarily lost. The weft may break and the loom turn over for one or two revolutions without inserting weft; a fault may necessitate unweaving; more frequently still, the loom may be stopped for the night or for a meal break and the cloth fell may creep away from its correct position. In all these cases the weaver has to restore the cloth fell to its correct position. In addition, during weaving, the warp tension undergoes a cyclic change which is due to shedding and this, in turn, causes a cyclic variation in the position of the cloth fell (<sup>a</sup>Greenwood & Cowhig, 1956).

The importance of the cloth fell position is recognized and commented on by many researchers, especially from the point of view of the effecting parameters on it.

The preceding discussion in this chapter has mainly focused on the cloth fell position and the relations between different weaving parameters based on the theoretical methods and the mathematical models.

After identity the various effecting parameters on the cloth fell, designing a way to measure and control the variations of this parameter is critical.  
The proposed and presented methods for measuring the cloth fell movement and their advantageous and disadvantageous are discussed later in this chapter in detail.

**2. A review of the cloth fell position and the interaction between weaving factors**

It is necessary that a summary of the nomenclature used in this chapter be introduced. (Table 1)

Symbol	Definition	Units
a	Difference between actual and correct pickspacing	inches/pick
D	Minimum pickspacing (theoretical)	inches/pick
E <sub>1</sub>	Elastic modulus of warp	grammes/end
E <sub>2</sub>	Elastic modulus of fabric	grammes/end
k	Coefficient of weaving resistance	gramme inches
K	Cloth fell coefficient	square inches
l <sub>1</sub>	Free length of warp	inches
l <sub>2</sub>	Free length of fabric	inches
L	Cloth fell distance (c.f.d.)	inches
2m	Sweep of reed	inches
n	Number of picks woven	
P	Rate of take-up (correct pickspacing)	inches/pick
r	Distance between reed and cloth fell	inches
R	Weaving resistance	grammes/end
S	Pickspacing	inches/pick
t	Time	seconds
T <sub>0</sub>	Basic warp tension	grammes/end
T <sub>1</sub>	Instantaneous warp tension	grammes/end
T <sub>2</sub>	Instantaneous fabric tension	grammes/end
v	Angular velocity of main shaft	radians/second
X	Instantaneous distance of the reed from its front position	inches

Table 1. Definition of the nomenclatures

**2.1 The effect of take-up motion on cloth fell position**

In the conventional power loom the way to obtain a desired pickspacing, is to make the rate of cloth take-up per pick equal to pickspacing by suitable adjustment of the take-up motion. During normal weaving, the amount of fabric woven is increased by a length P at every beat-up, and the function of the take-up motion is to take up this length so as to ensure that the cloth fell stays in the same position (<sup>a</sup>Greenwood & Cowhig, 1956).  
In fact, during beat-up, the pickspacing is generally controlled by the action of the take-up mechanism (Zhonghuai & Mansour,1989).

The equilibrium between the amount of fabric woven and the amount taken up will be disturbed if the instantaneous pickspacing has a value which differs from the correct pickspacing. In this case there will be a net increase in the free length of fabric of  $S - P (= a)$  when the take-up has operated and the c.f.d. will have changed by an amount  $a$ . Thus

$$\frac{dL}{dn} = -a \quad (1)$$

Equation (1) will be referred to as the take-up equation and describes the function of the take-up motion in the most general way. When the pickspacing is correct,  $a=0$  and the c.f.d. remains constant, as is the case in normal weaving. Thus, the function of the take-up motion is to maintain the c.f.d. constant when pickspacing is correct. The direct effect of the take-up motion is therefore confined to the c.f.d. and it can affect pickspacing only to the extent that the latter affects pickspacing. The relation between the rate of take-up and the c.f.d. is given by the take-up equation. The c.f.d. in turn is related to pickspacing by a cloth fell equation. This shows that the c.f.d. is a vital link between the rate of take-up and pickspacing and also explains the importance of the relation between c.f.d. and pickspacing (a Greenwood & Cowhig, 1956).

## 2.2 The effect of the cloth fell position on pickspacing

The fact that pickspacing depends on the c.f.d. is due to a simple geometrical cause and to a more complex physical cause and is peculiar to the positive reed motion.

### 2.2.1 The geometrical aspect of the cloth fell equation

This aspect exists because the new pick is always carried to the front position of the reed. The previous pick is, by definition, at the position of the cloth fell and therefore pickspacing, which is the distance between the new and the previous pick, will depend on the position of the latter, i.e., on the c.f.d. The geometrical aspect would be the only one if no force were required to beat up the new pick and is, in fact, important where the applied beat-up force is small, i.e., in the weaving of low-pick fabrics or with other fabrics when the cloth fell is too near the weaver so that a bad thin place is created (a Greenwood & Cowhig, 1956).

### 2.2.2 The physical aspect of the cloth fell equation

This aspect exists because in beating up the new pick a resistance is encountered, which increases as the new pick approaches the cloth fell. A higher beat-up intensity will therefore cause a closer pickspacing and vice versa. The beat-up intensity, in turn, depends on the c.f.d. (a Greenwood & Cowhig, 1956).

## 2.3 The relation between the cloth fell position and the intensity of beat-up

Three distinct theories have been put forward to account for the variation of the intensity of beat-up with the cloth fell position. The first one (velocity theory) relates to the fact that the reed velocity decreases as the reed approaches its front position. This means that the kinetic energy of slay at the impact of the reed with the cloth fell, and hence the intensity of the beat-up, depends on the c.f.d.

The second theory (contact theory) suggests that the intensity of beat-up depends on the length of the period of contact between the reed and the cloth fell. This period in turn depends on the c.f.d., and hence the intensity of beat-up depends on the c.f.d.

The third theory (excess tension theory) relates to the fact that the force of beat-up has to be balanced by an excess of warp tension over fabric tension. This excess can be created only by a displacement of the cloth fell during beat-up and this displacement in turn will depend on the c.f.d. Therefore the intensity of beat-up depends on c.f.d.

Neither the velocity nor the contact theory has ever been formulated in precise mathematical form. This makes a direct comparison on the theories somewhat difficult. It must also be noted that the three theories interpret the intensity of beat-up in terms of three different physical quantities, namely, energy, time and force, respectively.

The excess tension theory has the advantage of being capable of extension to include the other two effects.

The relation between the c.f.d. and the force of beat-up on the basis of the excess tension can be established from equations (2) and (3) for non-bumping and bumping conditions, respectively (<sup>a</sup>Greenwood & Cowhig, 1956).

$$R_s = (S - L) \left( E_1 / l_1 + E_2 / l_2 \right) \quad (2)$$

$$R_s = (S - L) E_1 / l_1 + T_0 \quad (3)$$

#### 2.4 The relation between beat-up force and pickspacing

The beat-up force at any instant is equal to weaving resistance. The latter arises from many factors; the friction between warp and weft, the rigidity and tension of warp and weft, etc. The total weaving resistance,  $R$ , can be regarded as the sum of a frictional resistance and an elastic resistance, the difference between the two being as follows. The energy used in overcoming the frictional resistance is dissipated in heat and, to some extent, in the form of static electricity and, when the new pick has been forced to a point near the cloth fell, the frictional force will tend to keep it there. The energy used in overcoming the elastic resistance is stored in the form of potential energy and, when the new pick has been forced to a point near the cloth fell, the elastic resistance will tend to eject it from the fabric. In spite of these differences the elastic and frictional resistances have many common features. Both resistances increase as the new pick approaches the fell and tend to infinity for a finite value of the distance,  $r$ , of the new pick from the fell. Both increase with an increase in warp tension.

The distinction between elastic and frictional resistance is obviously of great importance in dealing fully with the phenomena which take place during beat-up, but this distinction becomes operative only after the beat-up is complete. During beat-up, the features common to both are dominant and, therefore, it was considered justifiable to simplify the treatment by dealing only with the total weaving resistance,  $R$ . The different and complex modes of action of the various components are also ignored, and it is assumed that the weaving resistance acts as a simple repulsive force between the cloth fell and the new pick.

For a mathematical treatment, it is necessary to express the weaving resistance,  $R$ , as a function of the distance,  $r$ , of the new pick from the cloth fell. Experimental technique on the running loom to determine this relationship is difficult and it would be unwise to expect too much from the results. On the other hand, it was also felt that to derive the relationship from theoretical considerations would lead to very complex mathematical expressions and be of little practical value. Therefore, to assume a simple relationship between  $R$  and  $r$  and to see how experimental results from more easily measured quantities would confirm this assumption. It is assumed that:

$$R = \frac{k}{r - D} \quad (4)$$

This equation takes account of the fact that  $R$  varies inversely with  $r$  and tends to infinity for a finite value of  $r$ .  $D$  and  $k$  are considered to be constants for a particular fabric.  $D$  can be considered the theoretical minimum pickspacing (the practical minimum will always be higher than  $D$ ) and should be of the order of the yarn diameter.  $k$  is termed the coefficient of weaving resistance and is a measure of the difficulty of weft insertion into a given warp. Although as a first approximation  $k$  is considered constant, there is a probability that it will vary with warp tension and, possibly, also with loom speed, some loom settings, or atmospheric conditions. The magnitude of all these effects will have to be investigated experimentally.

Equation (4) will be called to inverse distance equation. It applies at any instant during beat-up and when the reed reaches its front position it becomes:

$$R_s = \frac{k}{S - D} \quad (5)$$

This gives the required relationship between beat-up force and pickspacing (<sup>a</sup>Greenwood & Cowhig, 1956).

## 2.5 The relation between cloth fell position and pickspacing

By substituting for  $R_s$  in equations (2) and (3), the followings relations are obtained for non-bumping and bumping conditions, respectively:

$$L = -\frac{K}{S - D} + S \quad (6)$$

$$L = -\frac{k / (S - D) - T_0}{E_1 / l_1} + S \quad (7)$$

where

$$K = \frac{k}{\left( \frac{E_1}{l_1} + \frac{E_2}{l_2} \right)} \quad (8)$$

When conditions are stable, equations (6) and (7) take on the form

$$L_p = -\frac{K}{P - D} + P \quad (9)$$

$$L_p = -\frac{k / (P - D) - T_0}{E_1 / l_1} + P \quad (10)$$

and can be used to determine the correct c.f.d. for any rate of take-up (<sup>a</sup>Greenwood & Cowhig, 1956).



## 2.6 The effect of warp tension on cloth fell position and pickspacing

### 2.6.1 The warp tension cycle

Fig. 1 shows a typical warp tension curve. During the whole weaving cycle, with the exception of beat-up, the warp tension is the same as the fabric tension. During beat-up, the warp rises to a peak and the fabric tension falls to a minimum. The tension value at which beat-up begins is, by definition, the basic warp tension (<sup>a</sup>Greenwood & Cowhig, 1956).

The fluctuation of the tension curve is the result of shedding, beat-up, take-up, and let-off motions. The effects of these factors are not simultaneous and vary in duration and magnitude. Among these, the shedding and the beat-up processes bring into being considerable tension loads, and the effect of shedding is of the longest duration compared with the others (Gu, 1984).

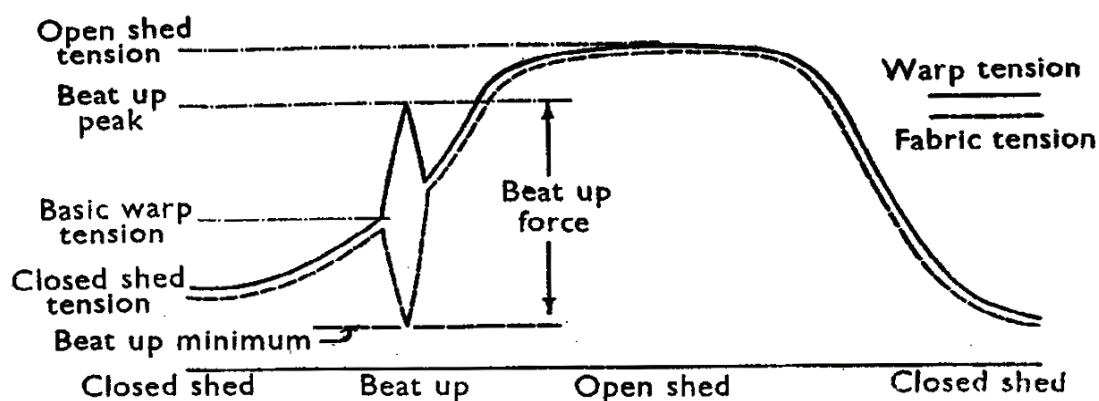


Fig. 1. Typical warp tension cycle

Outside the period of beat-up, the shape of the tension trace is determined by the shedding motion and reaches a peak at open shed and a minimum at closed shed. The whole tension cycle can thus be summed up in terms of five tension values, namely: open-shed tension, closed-shed tension, basic warp tension, beat-up peak and beat-up minimum (fabric).

The difference between the beat-up peak and the beat-up minimum represents the applied beat-up force (according to the excess tension theory). The applied beat-up force in turn determines pickspacing by the inverse distance equation (<sup>a</sup>Greenwood & Cowhig, 1956).

### 2.6.2 The effect of the warp tension cycle

The warp tension plays the contradictory effect during weaving. On the one hand, warp tension provides the only means of holding or supporting the cloth fell in position during beat-up. This is referred to as the supporting function. On the other hand, higher warp tension tends to increase the weaving resistance and can be said to oppose the entry of the new weft into the fabric. This is referred to as the opposing function. To introduce the opposing function it would be necessary to express the coefficient of weaving resistance as a function of warp tension. There is a great deal of evidence that the supporting function is by far the more important (<sup>a</sup>Greenwood & Cowhig, 1956).

### 2.6.3 The setting of the let-off motion

The relation between the let-off motion and warp tension is somewhat similar to the relation between the take-up motion and the cloth fell position. When a loom is gaited up and

weaving started, a certain amount of fabric has to be woven before the warp tension attains the value for which the let-off motion is set. This value is maintained as long as the loom runs satisfactorily, but when the loom is stopped, the instantaneous warp tension may deviate greatly from the normal value because of relaxation or unsatisfactory letting back (<sup>a</sup> Greenwood & Cowhig, 1956).

#### 2.6.4 The effect of the simultaneous variation in the cloth fell position and the warp tension on pickspacing

As mentioned in part 2.5, equations (6) and (7) show the instantaneous relation between c.f.d. and pickspacing under non-bumping and bumping conditions, respectively. Under normal weaving conditions, the pickspacing is always equal to the rate of take-up  $P$ , and to find the correct c.f.d.  $L_P$  for a given pickspacing, one need only to substitute  $P$  for  $S$  in equations (6) and (7) (equations (9) and (10)).

Equations (6) and (7) can be used to calculate the effect of a displacement of cloth fell from its correct position. Such a displacement is very often combined with a change in the basic warp tension from its normal value  $T_0$  to some other value  $T_0'$ .

If the changes are small, the effect on pickspacing can be calculated by differentiating equations (6) or (7). This gives

$$dP = \frac{1}{1 + \frac{K}{(P-D)^2}} dL \quad (11)$$

$$dP = \frac{\frac{dL}{l_1} \frac{E_1}{1} - dT_0}{\frac{k}{(P-D)^2} + \frac{E_1}{l_1}} \quad (12)$$

for non-bumping and bumping conditions, respectively.

The effect of large changes in the c.f.d. can be calculated as follows, for non-bumping and bumping conditions, respectively:

The correct cloth fell position  $L_P$  is given by equations (9) and (10).

$$L - L_P = -\frac{K}{(S-D)} + S + \frac{K}{(P-D)} - P \quad (13)$$

$$L - L_P = -\frac{\frac{k}{(S-D)} - T_0'}{\frac{E_1}{l_1}} + S + \frac{\frac{k}{(P-D)} - T_0}{\frac{E_1}{l_1}} - P \quad (14)$$

These equations determine the deviation from correct pickspacing in terms of the deviation from the correct c.f.d.

From these calculations, it will be seen that under non-bumping conditions, pickspacing depends on the c.f.d. alone and is independent of warp tension, whereas under bumping



conditions both the c.f.d. and the warp tension are important (<sup>b</sup> Greenwood & Cowhig, 1956).

### 2.6.5 The cloth fell displacement and the warp tension variation during loom stoppage

It is a well-known fact that, during a loom stoppage, the cloth fell tends to creep away from its correct position. To examine the effect of relaxation in the warp and the woven fabric on the position of the cloth fell and hence pickspacing, it was assumed that the cloth fell is fixed in its correct position during the stoppage and that, because of the difference in the properties of warp and fabric, the tension in the two materials falls from its original value  $T_0$  to a lower value  $T_1$  in the warp and  $T_2$  in the fabric, where in general  $T_1 \neq T_2$ . Immediately before starting the loom, the cloth fell is released to find its equilibrium position. Equilibrium exists when the warp and fabric tensions are again equal at a value  $T'_0$  and it is necessary to determine the displacement of the cloth fell which would bring  $T_1$  and  $T_2$  to the same value  $T'_0$ . The displacement of the cloth fell is calculated by equation (15) and the common warp and fabric tension resulting from this displacement is given by equation (16).

$$dL = \frac{T_2 - T_1}{\frac{E_1}{l_1} + \frac{E_2}{l_2}} \quad (15)$$

$$T'_0 = \frac{T_1 \frac{E_2}{l_2} + T_2 \frac{E_1}{l_1}}{\frac{E_1}{l_1} + \frac{E_2}{l_2}} \quad (16)$$

Equations (15) and (16) apply only when a brake-type of let-off motion is used. In this case it will be seen that, if  $T_2$  is smaller than  $T_1$ , i.e., if the fabric relaxes more than the warp, the cloth fell will move away from the weaver. This is the more usual case. Thus the direction of the movement is determined by the relative values of  $T_1$  and  $T_2$  alone.

The effect of the displacement of the cloth fell on pickspacing is calculated by substituting for  $dL$  from equation (15) in equation (11) and for  $K$  from equation (8). This leads to:

$$dP = \frac{T_2 - T_1}{\frac{k}{(P - D)^2} + \left( \frac{E_1}{l_1} + \frac{E_2}{l_2} \right)} \quad (17)$$

In comparing the brake-type with the dead-weight type of let-off, it is often held in favour of the latter that it keeps warp tension constant during a stoppage.

Using the same simplified assumption as before, it will be assumed that the cloth fell is fixed in its correct position during the stoppage. Owing to the action of the dead weight, the warp tension in the present case remains constant at  $T_0$ , whereas the fabric tension falls to a value  $T_2$  as before. Immediately before starting the loom, the cloth fell is released and the dead weight brings the fabric tension back to its original value  $T_0$  by stretching the fabric by an amount  $dL$  given by (<sup>b</sup> Greenwood & Cowhig, 1956):

$$dL = \frac{T_0 - T_2}{\frac{E_2}{l_2}}$$

(18)

2.6.6 The effect of the let-off motion type

It will be seen on comparing equation (18) with equation (15) that, when the fabric relaxes more than the warp ( $T_2 < T_1$ ), the displacement of the cloth fell will always be greater with a dead-weight than with a break-type let-off motion. It may be said that the constancy of the warp tension in the dead-weight let-off is obtained at the expense of a greater movement of the cloth fell. Whether this is an advantage or not depends on the type of fabric. With a lighter type of fabric, which will normally be woven under non-bumping conditions, the cloth fell position is probably more important and therefore the brake-type let-off preferable. With a heavier type of fabric, warp tension becomes more critical and the dead-weight type may give better results (Greenwood & Cowhig, 1956).

2.7 The effect of free length of warp and fabric on cloth fell position and pickspacing

Equations (15) and (17) indicate that a long free length of warp and fabric will tend to increase cloth fell displacement and changes in pickspacing due to relaxation, respectively, i.e., it will tend to make setting-on places worse but equation (18) points out that just free length of fabric will affect on cloth fell displacement (Greenwood & Cowhig, 1956). In addition, during weaving increasing in length of warp and fabric will affect on K and according to equation (11), will decrease the changes in pickspacing.

2.8 The effect of loom speed on cloth fell position

Three theories explained in section 2.3 differ in their prediction of the effect of loom speed on the cloth fell position. According to the contact theory, a reduction in loom speed would cause a movement of the cloth fell towards the weaver; according to the velocity theory, it would cause a movement of the cloth fell away from the weaver; according to the excess tension theory, it would not cause any change in the cloth fell position. To investigate these antonym effects, some experiments were carried out and their results are shown in Table 2. The weft used was 140/26 denier bright acetate and 56 picks per inch were inserted so that  $P = 0.0154$ .

Test Number	Loom Speed (Picks per Minute)	Cloth Fell Distance L (inches)
I	128	-0.151
	158	-0.139
		Difference 0.012
II	128	-0.162
	158	-0.141
		Difference 0.021

Table 2. The results of the investigation of loom speed effect

Table 2 shows that the cloth fell moves away from the weaver when the loom is running more slowly, as would be expected from the velocity theory; whereas the following argument shows that a much larger movement would be expected from the velocity theory. The results for the cloth fell position in the two tests agree well and for condition corresponding to a speed of 158 picks per minute, the position is taken as -0.140 inch. At the time of reed impact with the fell, the reed distance from the fell and the front position of the reed is  $P(=-0.154)$  and  $X_1(=-0.140-0.154=-0.155)$  (Greenwood & Cowhig, 1956). it is assumed that the motion of the reed near the cloth fell is single harmonic with an amplitude,  $m$ , so that:

$$X = m(\sin vt - 1) \quad (19)$$

So, the speed of the reed is given by:

$$\frac{dX}{dt} = mv \cos vt \quad (20)$$

$$\cos vt = \sqrt{\frac{2X}{m}} \quad (21)$$

Substituting for  $\cos vt$  from equation (21) in equation (20), the speed of the reed at impact moment is given by (Greenwood & Cowhig, 1956):

$$\frac{dX}{dt} = v\sqrt{2Xm} \quad (22)$$

From the velocity theory, one would expect that the cloth fell position would change with any alteration in loom speed, so that the velocity of the reed at the time of the impact with the fell should remain unaltered.

Thus

$$v_1(2X_1m)^{\frac{1}{2}} = v_2(2X_2m)^{\frac{1}{2}} \quad (23)$$

so that

$$X_2 = X_1 \left( \frac{v_1}{v_2} \right)^2 \quad (24)$$

Substituting numerical values,  $X_2 = -0.155 (158/128)^2 = -0.237$  inch. Subtracting from this the value of  $P$  (0.0154 inch), the new cloth fell position should, on this calculation, be -0.222 inch. Thus, from the velocity theory one would expect a movement of the cloth fell of -0.082 inch, which is much greater than that actually observed in the above experiments (0.012 in test I and 0.021 in test II).

It is obvious that, for this particular loom and fabric, the observed effect of changes in loom speed on the cloth fell position cannot be explained by any of the three theories alone (Greenwood & Cowhig, 1956).

### 3. Methods of measuring the cloth fell position

In general, proposed and presented methods for measuring the cloth fell movement are divided into two main categories:

1. Methods that measure the cloth fell movement during weaving.
2. Methods that measure the cloth fell movement during loom stoppage and try to prevent start-up marks. Such movements are due to difference in visco-elastic properties of warp threads and the cloth during loom stoppage.

These mentioned methods and their advantageous and disadvantageous are discussed later in this chapter in detail.

#### 3.1 The methods of measuring the cloth fell position during weaving

##### 3.1.1 Microscopic method

Early measurements of the cloth fell position were carried out by means of a microscope mounted on a rigid frame on the loom (© Greenwood & Cowhig, 1956). This method is difficult and time consuming.

##### 3.1.2 Optical method

A source of light was placed under the loom and focussed on the cloth fell by a 5-inch focal length lens, the illuminated area being approximately 0.5-inch in diameter. A 4-inch focal length projector lens was mounted about 5 inches above the cloth in line with the source and the first lens. The image of the fell formed by this lens was thrown horizontally on the wall by a mirror inclined at 45° mounted 20 inches above the cloth surface. A white screen fixed to the wall enabled the image to be clearly seen and its position measured. It is essential to avoid movement and vibration in the lens and mirror, and so both were mounted on a frame of 2-inch steel tubing bolted firmly to the floor. To specify the position of the cloth fell, the loom was stopped with fully open shed and cloth fell position was read off on the screen, in terms of its distance from an arbitrary zero line. A diagram of the arrangement of this method is shown in Fig. 2 (© Greenwood & Cowhig, 1956).

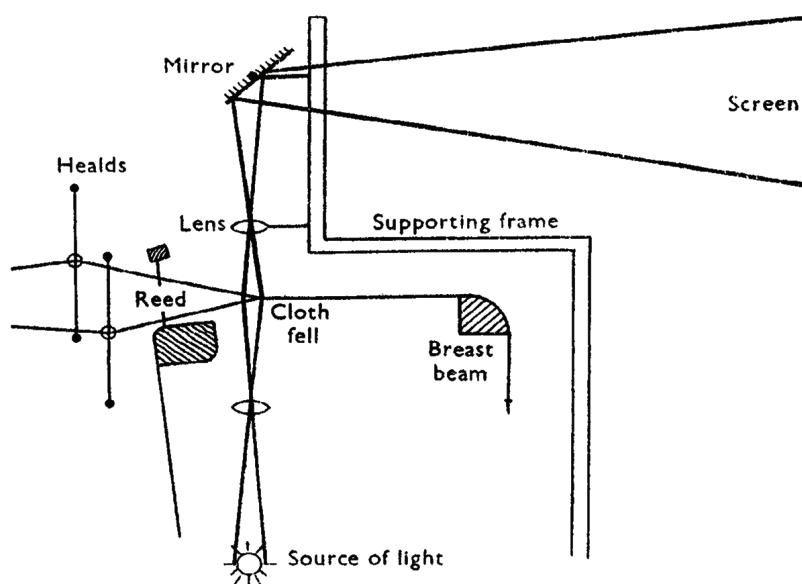


Fig. 2. Optical method for measuring the cloth fell position

The disadvantages of this method are as follows; there is no way to measure the cloth fell position dynamically during the loom running, so the loom has to be stopped to take the measurements (<sup>a</sup> Azzam & Büsgen, 2006). Moreover, it is impossible to measure the cloth fell position immediately before beat-up, since at this stage the race board of slay obstructs the path of the light from the source of the fell (<sup>c</sup> Greenwood & Cowhig, 1956; Azzam & Büsgen, 2006). In addition, the system is excessively complex, especially regarding the arrangement made to fix a reference point and adjustable pointer at the front position of the reed (<sup>a</sup> Azzam & Büsgen, 2006).

### 3.1.3 Improved optical method

From Fig. 2, it can be seen that it is impossible to measure the cloth fell position immediately before beat-up. It was, therefore, necessary to apply a correction. The loom was stopped with open shed, the slay was left stationary and the healds were brought to beat-up position by loosening and rotating the shedding tappets. The corresponding change in the cloth fell position was measured and used as shedding correction (<sup>c</sup> Greenwood & Cowhig, 1956).

### 3.1.4 Electronic needle wheel method

This method is a continuous measuring system for determining the movement of the cloth fell movement. The movement is measured in the immediate vicinity of the fell by a small wheel, placed on the fabric as close as possible to the fell, which follows the movement undergone by the cloth, as shown in Fig. 3, and is evaluated electronically (Kohlhass, 1981). The disadvantages of this method are the difficulty in fixation on the loom, the difference between the measuring point and the cloth fell is greater than 10 mm, and a great deal of electronics were used (<sup>a</sup> Azzam & Büsgen, 2006).

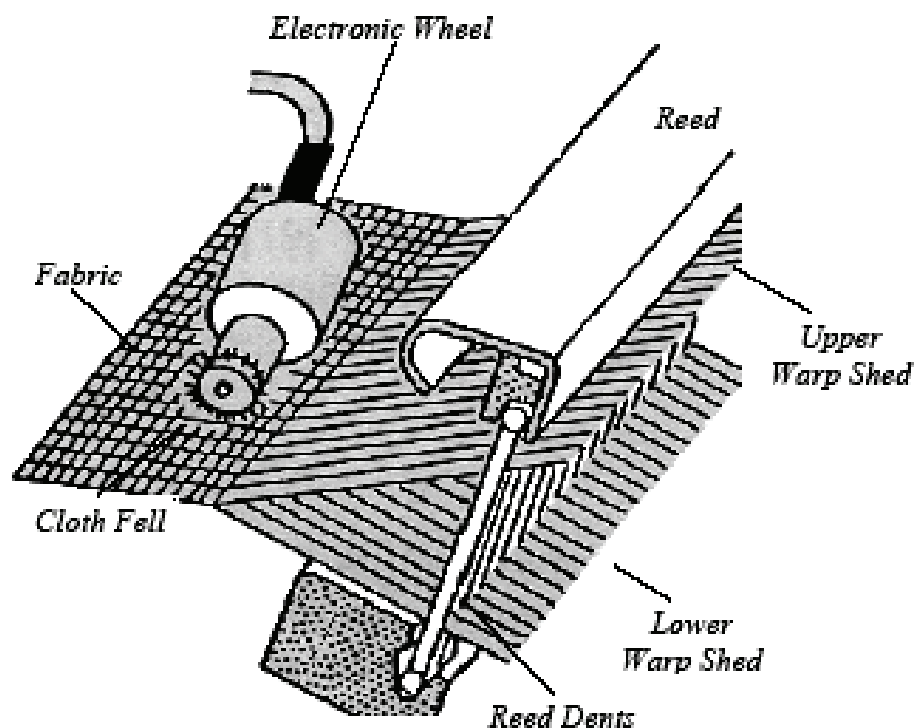


Fig. 3. Electronic needle wheel method for measuring the cloth fell movement

### 3.1.5 Using the high speed video system

The Kodak Ektapro High Speed Video System consists of a video camera, processor, controller, monitor, macro-objective, endoscope, personal computer, motion analysis package, and video recorder. The system provides a very sharp, clear depiction of the movement of the fell of the cloth during weaving (Weinsdörfer & Salama, 1992).

Also, a high speed camera at 1000 frames/sec has been used to record the cloth fell displacement during the beat-up. Fig. 4 shows the position of the cloth fell when the beat-up takes place. In this diagram the beat-up starts from 42° and ends around 58° (Mirjalili, 2003).

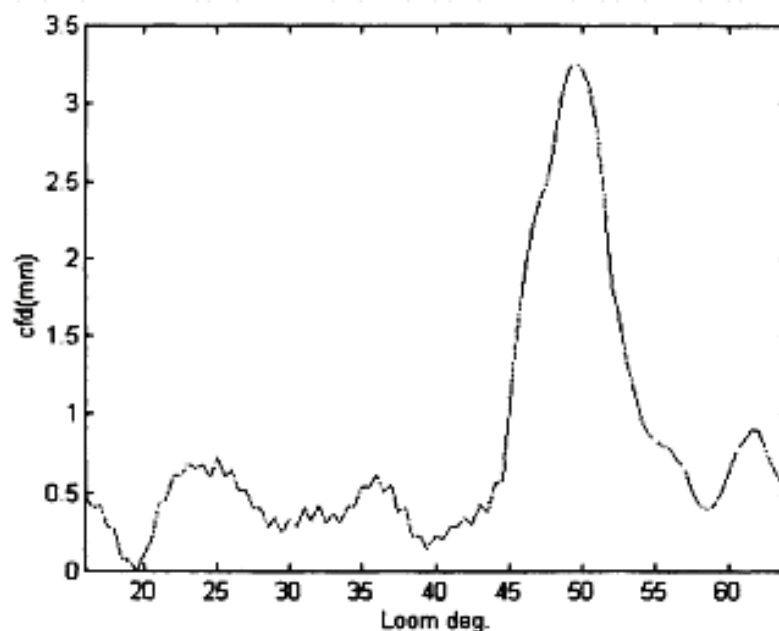


Fig. 4. Cloth fell displacement, c.f.d vs. loom degree

Uneconomical preparation and installation of this system on the loom are the great disadvantages of this method.

### 3.1.6 Using the lengths of cloth and warp thread

This method is based on the free lengths of warp and fabric. The desired lengths of cloth and warp thread are determined by averaging the actual values over a given number of weft insertions. The actual lengths of the cloth and warp are then continuously measured and compared with the desired values during weaving to compute warp and cloth offset values. A correction factor is determined based on the offset values and the elastic modulus of the warp thread and cloth. The cloth fell position is then corrected by adjusting the actual length of the cloth or the warp thread based on the correction factor (a Godert, 1996).

This method is also usable for measuring the cloth fell after loom stoppage and before loom restart and avoiding the start-up marks in fabrics.

### 3.1.7 Needle mechanical device

In this system, a simple and flexible needle mechanical device, fixed onto the loom frame and connected with the weave master to measure the cloth fell movement dynamically.

The measuring position for the needle was kept at 2-millimeter distance from the fabric support plate, as indicated in figure 5. This method is based on forced equilibrium. The



forces affecting the cloth fell will push the needle in the direction of force equilibrium; that means, if warp tension force is greater than the fabric tension force, the needle will be pushed towards the warp direction until beat-up takes place. In addition, if the fabric tension force is greater than the warp tension, then the needle will be pushed by the fell to move towards the fabric direction until shedding takes place. By using a special force-displacement calibration the cloth fell positions during shedding and beating could be calculated. In turn, the cloth fell movement could also be calculated. In fact, the difference between the cloth fell position due to beat-up and the cloth fell position due to open shed represents the cloth fell movement (Azzam & Büsgen, 2006). However, this method is a satisfactory way to measure the cloth fell movement, it can not calculate the cloth fell distance.

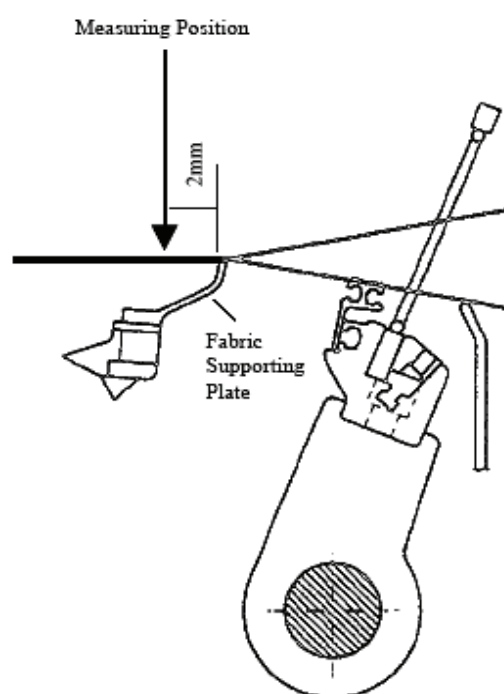


Fig. 5. Measuring position relative to the fabric support plate

### 3.2 The methods of measuring the cloth fell position during loom stoppage

The aim of this kind of studies is investigating the effect of cloth fell movement during loom stoppage on creating the start-up marks in fabrics woven after loom restart and controlling and preventing this fault.

Generally, the difference in relaxation between warp yarns and fabrics will cause a displacement of the cloth fell during loom stops. In addition to relaxation, cloth fell displacement is determined by the modulus of elasticity of warp yarn and fabric and by their relative lengths within the fabric warp yarn combination that exists on the loom (Vangheluwe & Kiekens, 1995).

#### 3.2.1 Using the sensor needle

In this method the position of the cloth fell is sensed with a sensor needle that can be moved into and out of the cloth at a location proximate the fell during interruption of the weaving

operation. Upon insertion of the sensor needle into the cloth, it moves with the cloth and therewith measures cloth displacement while the loom is at rest. The sensor needle is attached to an actuation device capable of reciprocating the needle into and out of the cloth. The sensor needle is inductively coupled to a distance sensor which measures the needle displacement and therewith the displacement of the fell. In this manner, fell displacement while the loom is at rest can be measured and, before weaving is restarted, the position of the cloth, and therewith of the fell can be corrected (Godert, 1996).

### 3.2.2 Using the photography system

This test method was presented for measuring the cloth fell displacement during relaxation of fabric yarn combination on a tensile tester. The equipment consists of a CCD-camera, a frame grabber, and appropriate software. This study has been carried out on the tensile tester rather than on the loom, where oscillations can hinder the efficient use of a camera.

Fig. 6 shows the arrangement of the equipment. The camera takes one image per second during relaxation measurements. This image is sent to the frame grabber in the PC controlling the tensile tester. In this way, the images are known as a grid (the grid points being called pixels), in which each pixel carries a light intensity value of the total image. In this digitized image, rows of pixels are in the direction of the weft yarns, and columns of pixels are in the direction of the warp yarns. At first, the sum of the pixel values is calculated over the horizontal lines (rows) of the digitized image. Next, values are filtered to eliminate noise. The results in a graph show the position of the weft yarns in the fabric clearly as peaks in the sum of intensity along the warp yarn direction (Fig. 7).

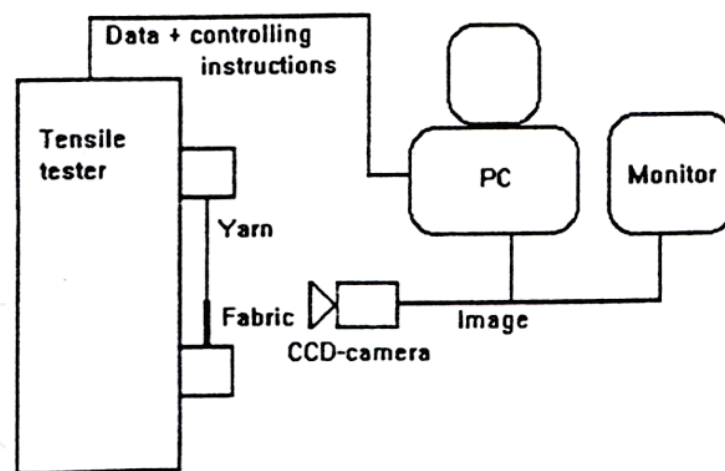


Fig. 6. Test equipment for measuring the cloth fell displacement

The position of the first weft yarn in the image determines the cloth fell. This position is compared with the cloth fell position of the first image that takes at the start of the relaxation. In fact, after calibration, cloth fell displacement is obtained in millimeters as a function of time during which relaxation is measured. This calibration is done by taking an image of a sheet of paper with lines on known distances, which is clamped in the tensile tester. A computer program converts the known distance between the lines to the number of pixels as measured between the lines. Therefore, the cloth fell displacement during relaxation will be measured (Vangheluwe & Kiekens, 1995).

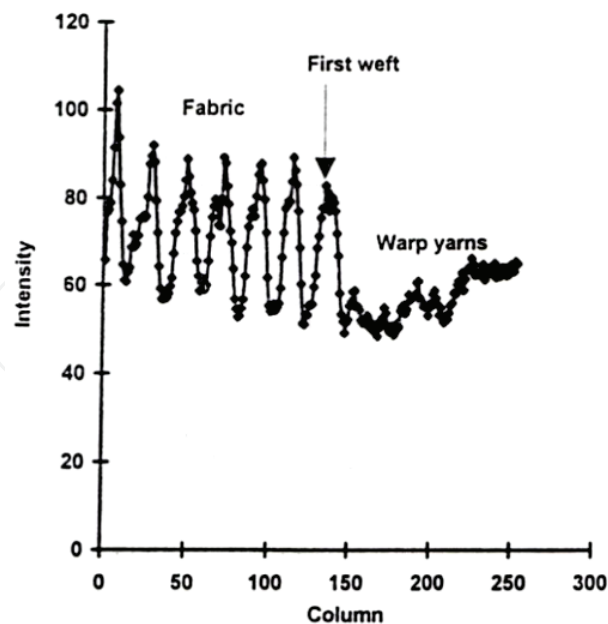


Fig. 7. Results obtained from image filtration

### 3.2.3 Using the laser analogue displacement sensor

A laser analogue displacement sensor was used, due to its comparatively small physical dimensions. This device, uses a fine laser beam to monitor the position of a target by detecting a spot of light falling on it. With a suitable amplifier, the device enables movements of the target position to be determined to an accuracy of  $1\text{ }\mu\text{m}$ . The working distance, which is the separation between the target and the front edge of the detector is,  $20\pm 2\text{ mm}$ . Within this range, the output signal of the sensor varies linearly with distance. Accordingly, a small lightweight target plate was made that could be placed very close to the cloth fell in such a way that it stayed stable during the loom stoppage period. As such, the movement of the target would be very nearly the same as that of the fell. The target had to be placed with precision on the fabric as soon as the loom stopped, and be removed immediately before the loom was restarted. The output of the sensor is a current signal, which can be easily converted into a voltage and amplified with a stable DC amplifier to enable detection of any movement of the target. A safeguard was provided that prevented the loom from being restarted without the target first being removed. The position of fixing this device on the loom and the cloth fell drift signal produced by the laser sensor are shown in Fig. 8 and Fig. 9, respectively. The output signal provided by the sensor shows the drift of the cloth fell that takes place during the loom stoppage. The rise of the trace indicates a corresponding movement of the fell towards the back of the loom.

The creep of the fell is dependent on the nature and duration of the loom stoppage and other factors. Hence the amount of cloth fell correction required before start-up varies, depending on the loom stoppage duration. Since the sensor enables this amount to be determined, it was possible to move the cloth fell back to where it would have been before the loom stopped. This was done by controlling the stepper motor on the take-up roller, as the number of steps of the motor rotation required could be determined from the required fell displacement. Following this, the let-off was adjusted to restore warp tension to its normal value (Islam & Bandara, 1998).

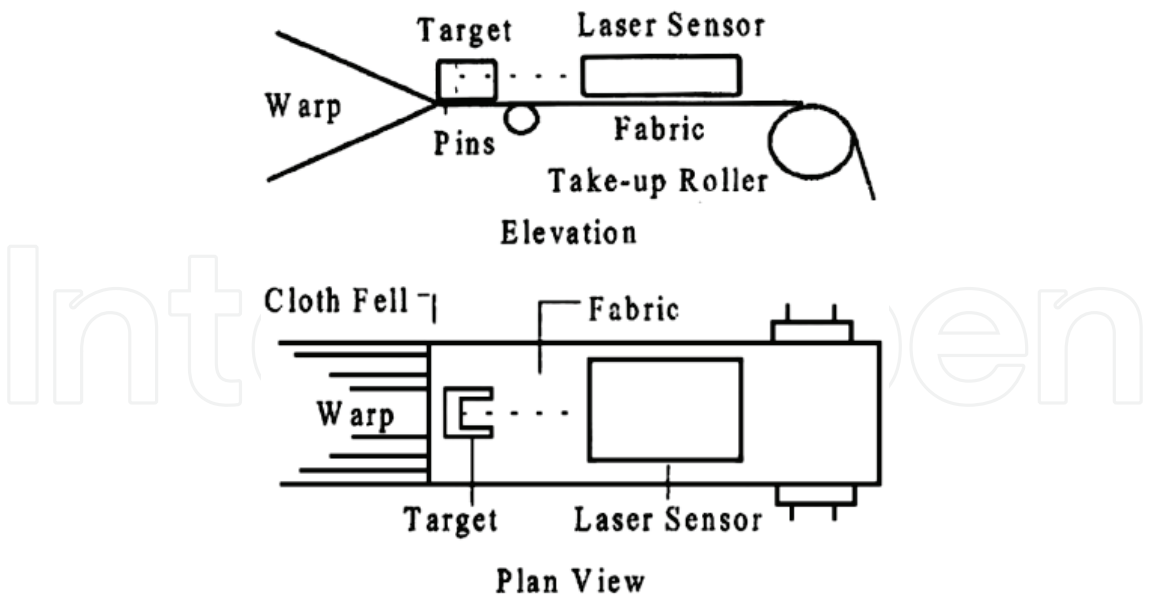


Fig. 8. Placement of the laser sensor on the loom

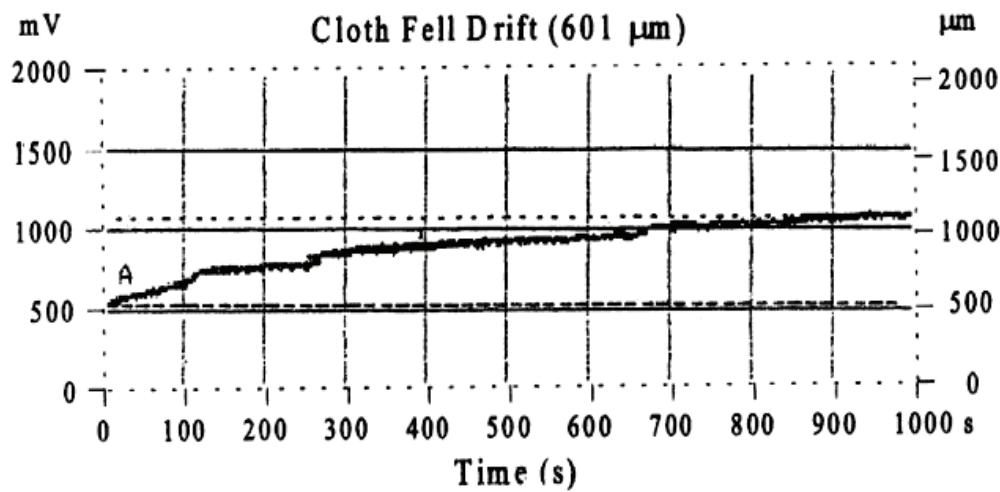


Fig. 9. Fell displacement on a narrow loom with viscose lining fabric

4. Conclusion

In this chapter the importance of the cloth fell position and the effective elements on cloth fell movement were discribed. After that some measurement methods for determining the cloth fell movement durin weaving process and during loom stoppage were presented. However, today no economic method is available to measure the cloth fell position with the required accuracy on the loom.

With regarding to developing and progressing in online electronic systems based on advanced computer programs, It is our hope that a precise method with high speed processing will be designed not only for measuring and monitoring the cloth fell displacement dynamically but also for online controlling and correcting its faults during weaving process. This chapter can be a comprehensive and complete background to help researchers to get innovative ideas.

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## **Woven Fabric Engineering**

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The main goal in preparing this book was to publish contemporary concepts, new discoveries and innovative ideas in the field of woven fabric engineering, predominantly for the technical applications, as well as in the field of production engineering and to stress some problems connected with the use of woven fabrics in composites. The advantage of the book Woven Fabric Engineering is its open access fully searchable by anyone anywhere, and in this way it provides the forum for dissemination and exchange of the latest scientific information on theoretical as well as applied areas of knowledge in the field of woven fabric engineering. It is strongly recommended for all those who are connected with woven fabrics, for industrial engineers, researchers and graduate students.

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