

Effect of loom settings on fabric cover and beat-up force

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The effect of shed geometry and shed timing on 50:50 cotton/vincel fabric cover, especially fabric reediness, has been studied on a shuttle loom and the combination of weaving conditions that gives best cover and least stress on loom and warp yarns determined. It is observed that the shed unbalancing shows improvement in fabric cover. Shed timing, on the other hand, shows variable responses with the so-called 'normal' shed timing, resulting in a fabric of lowest reediness and highest pick density. The compromised setting for best fabric cover and least stress on loom was observed at high level of shed unbalancing and normal shed timing.

Keywords: Beat-up force, Fabric cover, Fabric reediness, Pick density, Shed geometry, Shed timing

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1 Introduction

Beat-up process is fundamental in woven fabric production and has significant influence on fabric quality and cover. To understand the process of fabric formation, several theories¹⁻⁴ on the mechanics of beat-up process have been put forward, leading to experiments and developments in the measuring techniques. The theories established the fundamental relationship between take-up rate, pick spacing, cloth fell position and beat-up force (BUF). Attempts^{3,5} have been made to experimentally verify and extend the theories. The effects of various factors on the beat-up process have also been investigated^{4,6-8}. Although many of these researchers have already explained the effectiveness of some settings in affecting weaving of fabrics with different properties, little seems to be known⁹ on how do the various combinations of loom settings influence reediness and fabric quality. The present work was, therefore, aimed at investigating the effect of various degrees of shed unbalancing in combination with different shed timings on fabric cover (with emphasis on reediness). The effect of loom settings on BUF and peak warp tension has also been studied with a view to establish the best loom setting for the minimum BUF/peak warp tension and the best fabric cover.

2 Materials and Methods

2.1 Yarn and Fabric Specifications

Both warp and weft yarns were made of 50/50 cotton/vincel, with a folding twist of 10 twists/inch. Other details include:

Weft thread density	: 16 picks/cm
Warp thread density	: 18 ends/cm
Reed count	: 11s
Width in reed	: 1.50m
Yarn count (warp and weft)	: 2/60 tex
Yarn twist (warp and weft)	: 4 twists/cm

2.2 Loom Setting

The loom used for the study was the Crompton and Knowles (4×3 box), running at 115 picks/min. On this loom, an extra pair of rollers was fixed between the back rail and the heald frame (with the stop motion unit removed) to enable passive shed unbalancing⁴. The positions of the extra pair of rollers used were:

- (i) A balance shed at 0 cm extra roller position (0 cmERP); this is the zero position of the rollers, and
- (ii) Unbalanced sheds at 2.5 cmERP, 5.0 cmERP and 7.5 cmERP by raising the position of the rollers to 2.5, 5.0 and 7.5 cmERP respectively above the zero level.

On this loom, the use of various shed timings (0°–30°; 30°–60°; and 60°–90° referred to as late, normal and early shed timings respectively) was

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possible. For shed timing adjustment, the healds were leveled with the reed at front centre and in this position, the Shirley timing gauge (screwed to the crankshaft hand wheel) was set at 0° (late shed timing). The fabric samples were woven at this setting with various combinations of shed geometries. The shed timing was adjusted with the aid of the Shirley timing gauge in steps of 15° till it reaches 90° (early shed timing). After this initial production of fabric samples, it becomes obvious to obtain the samples with best cover at the highest extra roller position (7.5 cmERP) and shed timing (40° - 60°). More samples were, therefore, woven at 7.5cmERP and 35° - 85° shed timing range, but this time in steps of 5° so as to establish the actual shed timing that gives the best fabric cover for this loom and present weaving conditions.

The loom already has a system of strain gauges built into the reed baulk that could measure the amount of force applied by the reed to the fell of the fabric being woven. Details of its working principle have been described elsewhere⁴. A Sulzer Ruti warp tension meter (Model RUTI 3120) was used to measure dynamic warp tension¹⁰.

2.3 Tests

The woven samples were taken out from the loom, conditioned in an atmosphere of 20°C and 65% RH for 48h and then the number of threads/cm was determined by taking ten readings at random across each sample. The Shirley air permeability tester was used to assess the air permeability of fabric samples¹¹. The warp thread spacings (M1 and M2) and flattened thread diameters (a1 and a2), as shown in Fig. 1, were measured using the 'projectina'. Reediness of each sample was then calculated using the following formula:

$$\% \text{ Reediness} = \frac{(M2 - M1) * 100}{(M1 + M2 + a1 + a2)}$$

3 Results and Discussion

3.1 Fabric Cover

3.1.1 Pick Density

Table 1 shows that the shed geometry affects pick density slightly. The more unbalanced is the shed, the higher is the pick density. This is in agreement with the general belief that shed unbalancing leads to increase in pick density. This is because the shed

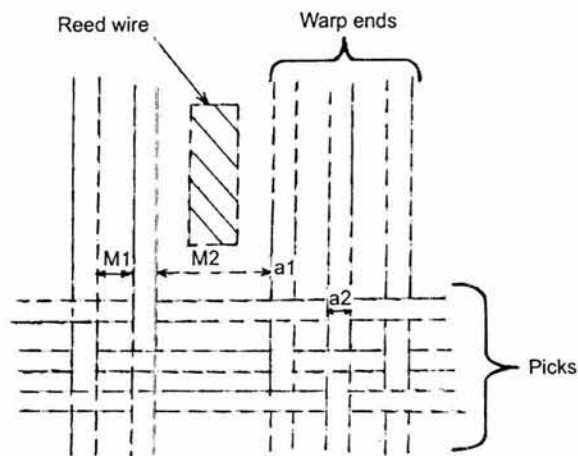


Fig. 1—Warp spacing

Table 1—Effect of loom setting on pick density

Roller height cmERP	Picks/cm						
	0 ^a	15 ^a	30 ^a	45 ^a	60 ^a	75 ^a	90 ^a
0	42.1	44.3	44.1	44.0	42.2	43.8	43.3
2.5	41.9	44.0	44.0	43.7	42.2	43.8	43.8
5.0	42.4	44.2	45.9	41.8	43.7	42.4	43.9
7.5	43.8	43.8	45.0	43.2	42.0	42.2	46.2

^aShed timing in deg

unbalancing results in reduction in inter-yarn pressure, which reduces frictional resistance to pick movement. This makes it easier to push the picks close together. Also, the higher the degree of unbalance, the lower will be inter-yarn pressure. It has been observed⁷ that this reduction in pressure equally makes it easier for picks to slip out as the reed recedes after beat up (especially in weaving high sett fabrics), thus negating the closer packing of picks. Generally, there is an increase of 4.75 - 15% in pick density above the nominal pick density set by the pick wheel. Table 1, however, shows that the shed timing does not seem to show a trend in pick density, though the highest pick density was observed at 30° and 90° shed timings. Arthur⁹ observed a slight increase in pick density at early shed timing.

3.1.2 Reediness

Shed timing (Fig. 2) does not affect reediness, though the least value of reediness was observed at 45° shed timing. The second set of samples woven with shed timing increments of 5° does not show any

discernable trend. Arthur⁹ had earlier shown a slight reduction in reediness with early shed timing, probably due to the effect of increased pick density obtained with early shed timing. On the other hand, the average value of reediness at all shed timings for different shed geometries shows that the % reediness decreases with the increase in degree of shed unbalance (Fig. 2), confirming that shed unbalancing is the main loom setting that affects fabric reediness⁹. An explanation for this observation is that as the picks slide across the warp during beat up, it is likely that they will push the relatively slack ends sideways to a more stable position, thus reducing grouping of the ends. This implies that the more is the pick movement across the warp during beat up, the more will be the reduction in reediness. Therefore, the slipping backwards of picks (as reed recedes after beat up for unbalanced shed) should also contribute to reduction in reediness. It will be interesting to investigate how reediness in fabrics woven with 'active' shed unbalancing is compared with the 'passive' system used here, since the former is claimed¹² to prevent slipping back of picks as the reed recedes. Another plausible explanation¹⁰ is that when the reed group ends together, the fibres projecting from adjacent warp threads get entangled and they remain grouped together until the entanglement is broken. It is well known that with unbalanced shed, when the shed is fully open, the ends that are under higher tension will be pulled a little out of the formed fabric, while the less tensioned ends will be drawn into the fabric. This action will therefore break the entanglements, thus setting the grouped ends free to move to a more stable position, i.e. as arranged on the warp beam.

3.2 Air Permeability

Fig. 3 shows some reduction in air permeability of the samples with the increase in shed unbalancing. This is expected as there is an increase in pick density with the increase in shed unbalancing. Also, the reduction in reediness, which implies better spacing of ends, should add to a reduction in airflow across the fabric samples¹⁰. Shed timing does not seem to show any trend except that the least value of air permeability was recorded at 90° shed timing.

3.3 BUF/Peak Warp Tension

Table 2 shows that the shed unbalancing leads to a substantial reduction in BUF and that as the degree of asymmetry increases, the reduction in BUF becomes more substantial. In raising the roller height from 0

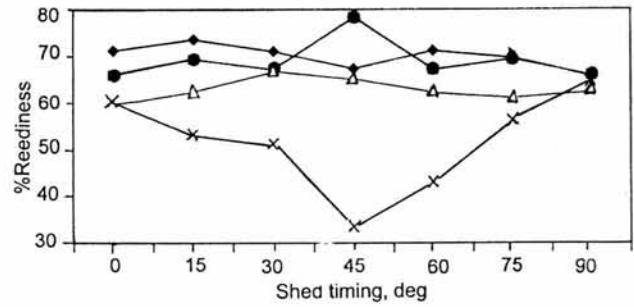


Fig. 2—Effect of loom setting on fabric reediness (—◆— 0 cm ERP, —●— 2.5 cm ERP, —Δ— 5.0 cm ERP, and —x— 7.5 cm ERP)

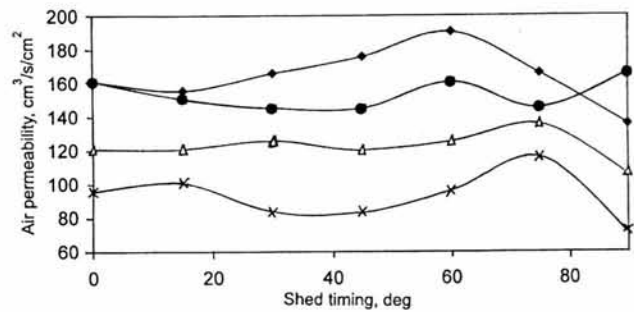


Fig. 3—Effect of loom setting on air permeability (—◆— 0 cm ERP, —●— 2.5 cm ERP, —Δ— 5.0 cm ERP, and —x— 7.5 cm ERP)

Table 2 – Effect of loom setting on beat-up force

Roller height cmERP	Beat-up force, g/end						
	0 ^a	15 ^a	30 ^a	45 ^a	60 ^a	75 ^a	90 ^a
0	16.90	18.30	13.45	18.25	18.60	20.45	14.20
2.5	16.35	17.10	12.60	13.70	15.85	17.75	14.20
5.0	17.10	16.00	11.95	10.65	12.95	14.30	12.90
7.5	14.40	16.00	10.05	8.23	9.60	12.60	12.25

^a Shed timing in deg

cmERP to 5 cmERP, there is 42% reduction in BUF at 45° shed timing and when the roller is raised further to 7.5 cm ERP above the line of neutral shed, 48% reduction is observed. However, when the shed timing is zero (late shed timing), the change in BUF is not consistent and the reason for this is unknown. Other researchers^{4,12,13} have made similar observation and the reason postulated by most of them is that an unbalanced shed results in unequal distribution of warp tension between the two warp sheets so that there is reduced inter-yarn pressure between the ends and the newly inserted pick being beaten into place. This indicate that as the degree of shed asymmetry

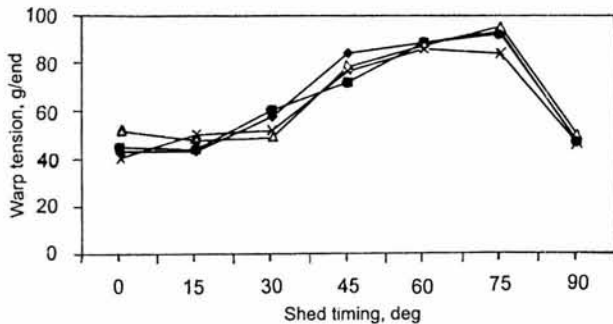


Fig. 4—Effect of loom setting on peak warp tension (—◆— 0 cm ERP, —●— 2.5 cm ERP, —△— 5.0 cm ERP, and —×— 7.5 cm ERP)

increases, this inter-yarn pressure should reduce further hence corresponding reduction in BUF. Ito⁶ has proved this line of argument experimentally using a model loom. Table 2 also reveals that the shed timing in the region of 30° - 60° (i.e. around region of 'normal' shed timing) give the lowest BUF. Specifically with shed timing increments of 5°, the minimum BUF is obtained at 7.5cmERP and 50° shed timing. Eldeeb⁴ observed minimum BUF at 60° shed timing using virtually similar weaving conditions on the same loom, while Ding¹⁴ obtained minimum BUF at 45°. It, therefore, shows that there are other salient factors that affect minimum BUF obtainable in weaving.

Fig. 4 shows the effect of loom settings on peak warp tension (i.e. warp tension when the reed is at front centre position). Maximum warp tension occurs at about 75° shed timing for all shed geometries and there seems to be two points of minimum warp peak tension observed at 0° and 90° shed timings in all the cases. The maximum tension observed at 75° may be due to the fact that at this point, the shed is fully opened during beat-up peak. The minimum tension observed at 0° shed timing is most likely because the shed is closed at beat up, but the reason for the very low tension at 90° is not clear.

4 Conclusions

Shed timing and shed unbalancing have some effect on the cloth making process and consequently the fabric cover. There is a combination of settings that can lead to production of high quality fabrics and the best fabric cover can be obtained at 'highest' level of shed unbalance and 'normal' shed timing.

While the highest degree of unbalance is at 7.5cmERP, it will be possible to raise the roller even

higher both on this loom and others. But care should be taken not to go to a level whereby at open shed, the upper warp sheet will have zero tension value, leading to sagging of the ends. Minimum BUF is observed at highest level of shed unbalance and 'normal' shed timing. Expectedly, the warp peak tension is a function of degree of shed opening at beat up, though for high sett fabrics, the situation will be different.

There are certain interactions between the cloth making processes and the loom settings. Both the best cover and minimum BUF are obtainable at high level of shed unbalance and 'normal' shed timing. However, this ideal setting may vary slightly for different looms, especially for high speed modern looms running at around 235 picks/min in which the beat-up process occurs in a smaller fraction of loom cycle than on shuttle looms.

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