Cloth Fell Control to Prevent Start-up Marks in Weaving

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The creep of the cloth fell position during a loom stoppage is a primary cause of start-up marks in fabrics woven on power looms. This creep can be measured with accuracy by use of a non-contact type sensor. One such method which uses a laser-based position sensor is described. Under controlled conditions, the measurement permits correction of cloth fell position to minimise start-up marks.

1. INTRODUCTION

On a power loom, uniform pick spacing is achieved mainly by ensuring a constant rate of fabric take-up. During beat-up, this enables the reed to produce a constant cloth fell displacement, resulting in a regular pick spacing. Cloth fell displacement during beat-up is influenced also by factors such as the movement of the back rail (Inui and Kurata, 1968,1969) and yarn tension variation due to shedding (Efremov, 1970), but during weaving under steady conditions their effect remains practically constant.

Loom stoppages disturb the uniform conditions that prevail during weaving at normal speed. When weaving is restarted, these disturbances cause pick spacing to be affected over a number of newly added picks, until normal weaving conditions are re-established. The resulting visible marks on the fabric are generally known as start-up marks or set marks (Vangheluwe and Kiekens, 1995; Wolfhorst and Obolenski, 1990).

A major cause of start-up marks has been recognised as the cloth fell creep due to visco-elastic properties of the warp and the cloth during a loom stoppage (Greenwood, 1957). Since the warp and the cloth are under tension, their lengths undergo small amounts of variation due to this creep, which affects the position of the cloth fell. Creep is time-dependent, so longer loom stoppages may lead to more severe marks.

There are also other factors that significantly contribute to start-up marks. The reed may not reach its normal speed in the first cycle after a restart, causing the initial beat-up speed to be less than normal. Further, the lower speed prevents the reed from reaching its dynamic front centre position which reduces cloth fell displacement at beat-up. The oscillations of the back rail also have an influence on start-up marks, as it takes a few cycles of weaving before the back rail movements stabilise.

On looms with high rates of weaving, the problem of start-up marks seems to be more severe (Mohamed, 1992). Loom manufacturers have adopted various start-up procedures that minimise the problem, and these generally allow for the creep of the cloth fell during the stoppage. None of these methods, however, involves the direct measurement of cloth fell drift, and its use to ensure that the amount of compensation applied corresponds to the drift that actually takes place during a stoppage. This paper describes a method of measuring cloth fell drift on a loom, that was found to be effective in minimising start-up marks.

2. BACKGROUND

Greenwood and Cowhig (1956) and Greenwood and Vaughan (1956) described the relationship of pick spacing to cloth fell displacement during beat-up and explained how a disturbed cloth fell position leads to start-up marks. Waesterberg and Nordhammer (1956) and Tsien (1961) have indicated how to relate start-up marks to the visco-elastic behaviour of the warp and fabric on a loom. Experimental studies have been carried out by subjecting yarns, as well as combinations of warp and fabric, to repeated cyclic loading to induce time-dependent relaxation of these materials in the context of weaving (Vangheluwe and Kiekens, 1995; Waesterberg and Nordhammer, 1956).

Loom manufacturers have offered a number of measures to prevent start-up marks. These include:

- minimising fell drift by reducing warp tension during a loom stoppage and restoring it before loom restart (Benelli, 1992; Dornier, 1992*a*);
- compensating for fell drift by applying initially an increased tension on the warp depending on the nature of start-up (Inui and Kurata, 1970; Nissan, 1983), and delaying the resumption of let-off at start-up (NuovoPignone, 1993);
- actuating take-up and let-off to position the cloth fell at a predetermined position (Dornier, 1992*b*, NuovoPignone, 1994; Sulzer, 1994*a*,*b*; Toyoda, 1992,1993*a*,*b*); and
- ensuring that the normal loom speed is achieved in the first loom cycle itself after restart (Dornier, 1989) or withholding pick insertions and take-up until the loom speed has built up (Picanol, c.1993).

These methods involve some correction of cloth fell position before a loom restart, but do not involve measurement of cloth fell drift. However, attempts to measure fell drift, as an aid to repositioning the cloth fell correctly, have been reported. One of the devices proposed used a spiked wheel (Kohlhass, 1981), placed on the fabric as close as possible to the fell, which follows the movement undergone by the cloth. The wheel is attached to a shaft encoder which records the incremental distance moved by the fabric at the fell during a stoppage.

An apparently more effective method of measuring cloth fell drift directly used an eddy current type proximity sensor (Sulzer, 1995). The movable armature of the detector is attached to the cloth fell by the use of needles during a loom stop, and hence follows the actual movements undergone by the cloth fell.

Locating the sensor very close to the cloth fell has certain practical problems.

3. RESEARCH OBJECTIVES

The work reported in this paper was mainly intended for studying the creep of the cloth fell during loom stops of varied duration and identifying a suitable method for measuring the amount of such creep. Several methods were tried out, and a laser based proximity sensor was found to be effective. Once its reliability was established, the measurement enabled the correction of the cloth fell position to its normal position before restarting the loom, so as to minimise start-up marks.

While the actual cloth fell displacement during beat-up may range up to a few millimetres, depending on the fabric involved, the cloth fell creep that takes place during a loom stoppage is only a fraction of a millimetre. Therefore, any method used to determine cloth fell drift needs to be capable of measuring displacements of the order of a few micrometers.

Determining the cloth fell position directly is not a straightforward operation. The main reason is that the fell is not solely determined by the last pick in the fabric. Pick spacing at the fell is usually greater than that in the fabric, due to the slipping back of one or more of the picks that were last inserted, as shown in Fig. 1. Further, the movement of the reed up to its front centre position during beat-up makes it impractical to locate any measuring device directly above or below the cloth fell. The reed itself could not be used as a sensor of cloth fell position, due to the slipping back of picks. Any information obtained by direct contact of the reed with the fell would only be available too close in time to beat-up to be of use in readjusting cloth fell position (Sternheim, 1989).

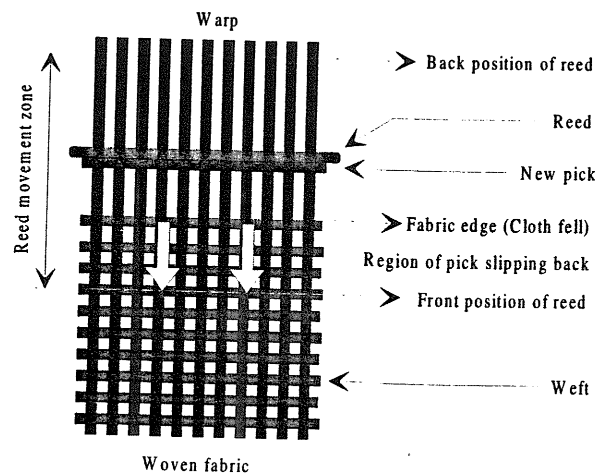

Fig. 1 Cloth fell and its relationship to reed front centre position

Optical sensors, which are currently available in a variety of forms, seem to be the most promising for this purpose. Their main advantage is the non-contacting nature of the measurement.

4. EXPERIMENTAL APPARATUS AND PROCEDURES

A Saurer 60B narrow fabric loom was used to weave viscose filament yarns (167 dtex, 42 filaments, warp: 320 tpm, weft: 80 tpm), which are highly susceptible to start-up marks. The loom was modified to have stepper motor driven take-up and let-off, and a spring loaded back rail arrangement. A PC was used to control warp tension and enable fine adjustments to the cloth fell position. The absence of temples on the loom was an advantage, as the stepper motors could be used to adjust cloth fell position without interference. Fig. 2 shows a schematic diagram of the main components of the experimental loom.

A plain fabric with 34 ends/cm and 24 picks/cm was woven at 310 picks/min, under a warp tension of 2–2.5 cN/tex. The normal pick spacing was calculated as the average value of that obtained by measuring ten fault-free samples of fabric. Each sample was measured for pick spacing over seven consecutive picks. At a start-up mark, pick spacing over three picks including the last pick before stoppage and five picks after it were measured. This was repeated over five positions across the fault, in the fabric width direction, and the results averaged (Islam and Bandara, 1996*c*).

Initially, to observe cloth fell drift during loom stoppages, an optical microscope and a

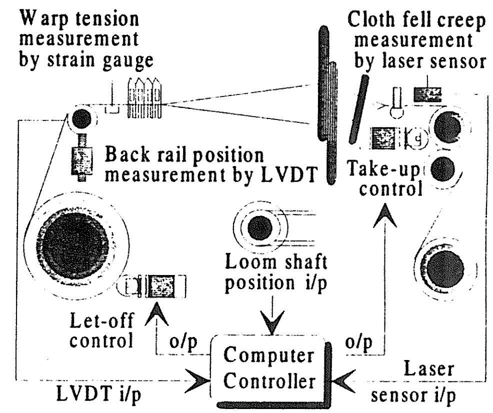

Fig. 2 Instrumentation and experimental loom control system

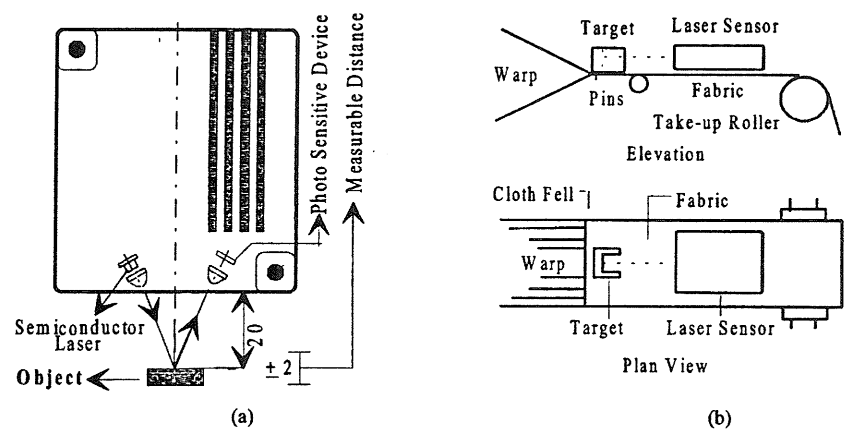

Fig. 3 The laser sensor: (*a*) physical configuration, and (*b*) placement on loom

small video camera was tried out. This equipment had to be removed each time the loom was restarted, as the reed movement did not allow them to remain mounted vertically above the cloth fell.

A laser analogue displacement sensor was then considered, due to its comparatively small physical dimensions. This device, shown in Fig. 3(*a*), 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 μm (Anon., c.1992). The working distance, which is the separation between the target and the front edge of the detector is, 20 ± 2 mm, and this allowed the sensor to be located a safe distance away from the reed. Within this range, the output signal of the sensor varies linearly with distance.

This device could be mounted horizontally, provided that a suitable target could be placed on the fabric very near the fell, that could be detected by the laser beam. 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 shape of the target made tilting of it unlikely after placement and its base was provided with two fine needle points at the edge close to the cloth fell, to prevent it rotating or slipping on the fabric (Fig. 3(*b*)).

Since the sensor had a working range of 20 ± 2 mm from the target, a guide on the sensor mounting plate was used to lower the target plate accurately onto the fabric. 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.

Since measurement periods ranging from several seconds to several minutes were used, it was found convenient to record the measurements on a digital storage oscilloscope. The oscilloscope traces displayed a high degree of stability after a brief warming-up period. It was first necessary to check that the sensor and amplifier combination gave a stable output when the target was held without any movement over a period of several minutes. The results of this test confirmed that the required stability was present (Islam, 1996*d*).

5. EXPERIMENTAL RESULTS

5.1 Loom Start-up Speed

The reed should reach normal beat-up speed at the first beat-up in order to eliminate the effect of reed speed on start-up marks. On the narrow fabric loom used, it was found that this would, in fact, be possible by starting the sley close to the 90° degree position so that a sufficiently long part of a loom cycle was available for the sley to gain speed. Fig. 4 shows how the looms speed at beat-up varies with the starting position of the sley over the first four cycles following a loom start-up. Each point on the graph was obtained by averaging five measurements.

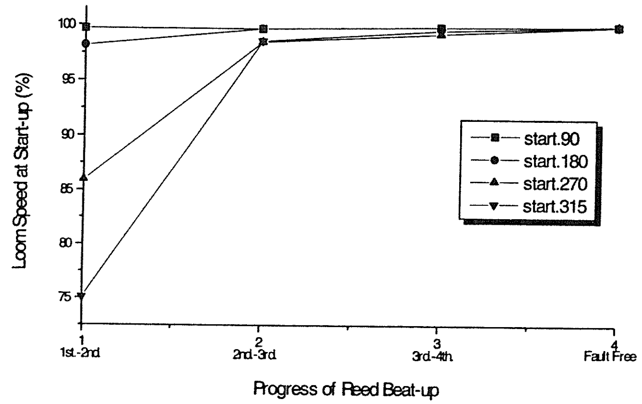

Fig. 4 Machine start-up behaviour at different starting angles

5.2 Weaving Without Cloth Fell Correction

In the weaving trials, to produce start-up marks the loom was allowed to weave for several minutes and was stopped for 300 s at closed shed, i.e. at 315°, to reduce warp tension and hence minimise the drift of the cloth fell. Start-up from different shaft positions (i.e. 90°, 180°, 270° and 315°) was tried. The variation of pick spacing over the first five picks, as well as three picks inserted before the stoppage, is as shown in Fig. 5. Each point was obtained by averaging five repeat readings.

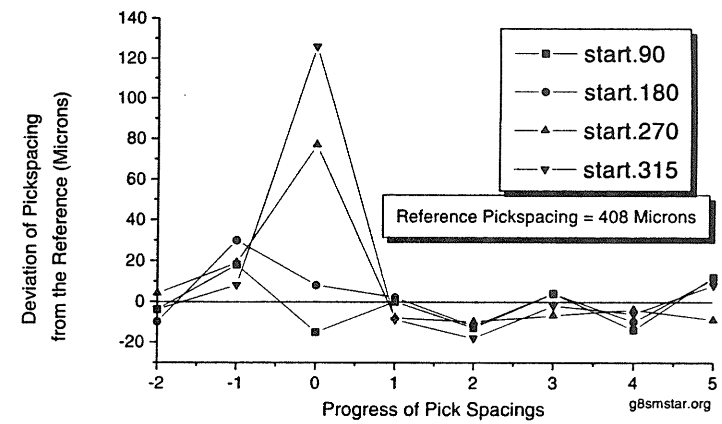

Fig. 5 Influence of loom starting position on pick spacing variation

At all starting positions except 90°, a greater than normal pick spacing was obtained just after the first beat-up. However, when the loom was started from the 90° position, a thick place was seen in the fabric, which indicated that the cloth fell had drifted towards the back of the loom, and with the normal beat-up speed obtained when starting from this position the slightly increased cloth fell displacement lead to the thick place.

5.3 Cloth Fell Correction

The creep of the cloth 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.

5.4 Cloth Fell Creep Measurements

The cloth fell drift signal profiles produced by the laser sensor are shown in Fig. 6. Trials were carried out by weaving over a sufficiently long period and then stopping the loom. 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. While the trend was generally the same each time, there were differences in the actual magnitude of the drift depending on the nature and duration of stoppage. This method of fell drift measurement was also tried out on a Sulzer L5100 loom with a polyester–cotton warp, and Fig. 6(*b*) shows the drift observed.

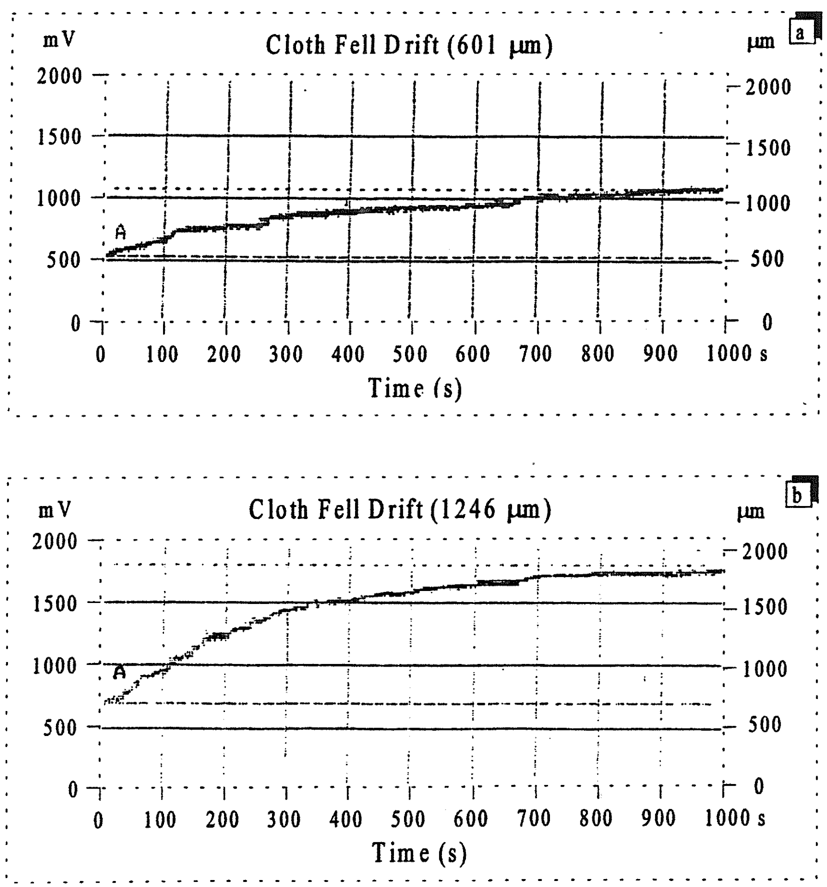

Fig. 6 Fell displacement: (*a*) on a narrow loom with viscose lining fabric, and (*b*) on an air jet loom with polyester–cotton fabric

5.5 Effect of Cloth Fell Correction on Pick Spacing

With the spring-loaded back rail arrangement used on the experimental loom, it was found that the cloth fell shifted towards the back of the loom during a stoppage (Islam

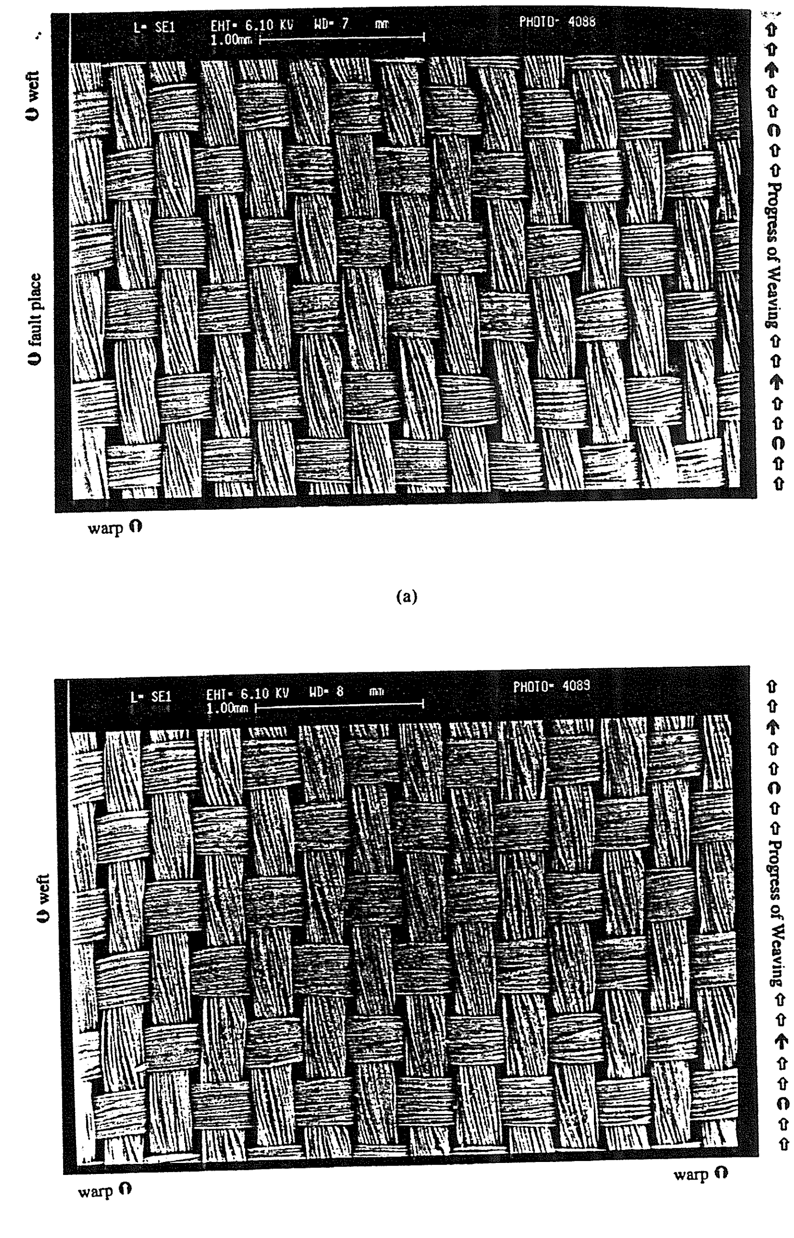

Fig. 7 SEM Micrograph of plain weave lining fabric produced: (*a*) without cloth fell correction, and (*b*) with cloth fell correction

1996*a*,*d*; Islam and Bandara, 1996*b*,*c*). In these experiments, the creep of the cloth fell was measured to be approximately 50 µm for a stoppage time of 300 s. Under the control of the PC, the take-up stepper motor was moved three steps to compensate for this amount of fell drift in order to bring the cloth fell to its correct position. The let-off was also adjusted as necessary to restore the warp tension. Restarting the loom from the 90° position in this manner showed that the procedure was effective, as there was no visible start-up mark in the fabric.

5.6 SEM Micrographs

Fig. 7 gives examples of SEM micrographs of fabric produced at a start-up following a 300 s stoppage during which the loom was at the closed shed position. Fig. 7(*a*) shows the fabric obtained without cloth fell correction, and Fig. 7(*b*) the fabric woven after cloth fell correction. A distinct pick spacing variation is seen in the form of an open place in the fabric woven without the correction. When the loom was started after initiating the control functions described above, no visible fault appeared in the fabric.

6. CONCLUSIONS

The method of using a laser analogue displacement sensor was found to be effective in measuring cloth fell drift during a loom stoppage. Further, the correction of cloth fell position on the basis of such measurement enabled satisfactory elimination of start-up marks. The effectiveness of the method is due to the fact that the fell correction provided is in keeping with the actual drift that takes place during each stoppage, and is not carried out in an indirect way.

The method used for the measurement of cloth fell drift on the experimental loom is not likely to be suitable for use on a wide loom. An alternative optical method will be necessary, which directly senses the creep of the fell in a non-contact manner.

On a wide loom, interference from the fabric temples may not allow accurate adjustment of cloth fell position. However, if the procedure is aided by feedback from the fell drift sensor, it will be possible to make the correction more accurately.

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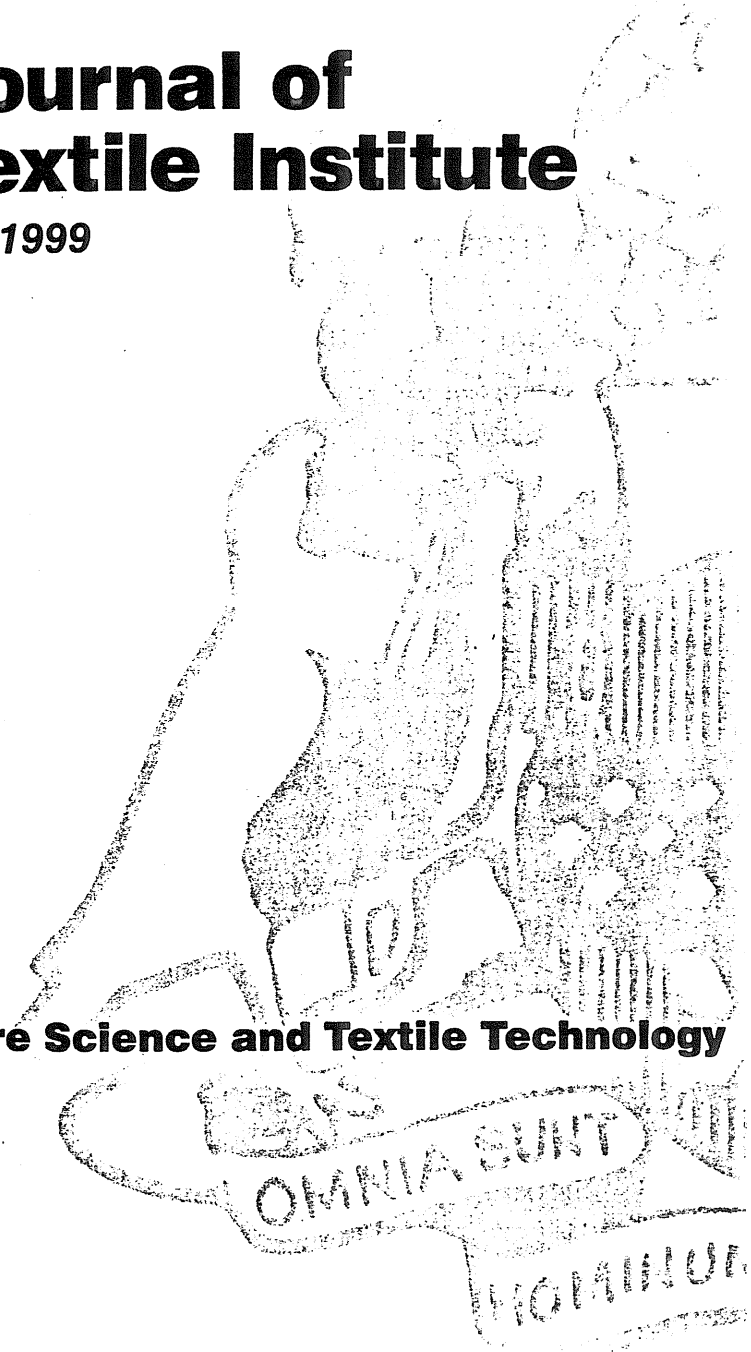

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