OBJECTIVE ASSESSMENT OF FABRIC DEFECTS -
DESIGN OF A COMPUTERISED INSPECTION SYSTEM

S.N. Niles, S. Fernando and Nirmali de Silva
Dept. of Textile & Clothing Technology, University of Moratuwa
OBJECTIVE ASSESSMENT OF FABRIC DEFECTS – DESIGN OF A COMPUTERISED INSPECTION SYSTEM

S.N. Niles, S. Fernando and Nirmali de Silva
Dept. of Textile & Clothing Technology, University of Moratuwa

ABSTRACT

Inspection of fabrics is a major consideration in fabric manufacture, as well as in the manufacture of garments and other fabric-based goods. In the Sri Lankan industry almost all fabric inspection is carried out by manual methods, and is therefore subjective and prone to human error. Various automated fabric inspection systems have been developed in various parts of the world. These systems are, however, rather costly. The purpose of this research is to design a cost-effective fabric inspection system for the objective assessment of fabric defects. This system is being designed with special relevance to the Sri Lankan industry, and should be capable of giving consistent results irrespective of user. Image processing techniques are used to scan images of the test fabric, compare it with an ideal sample with which the system has been calibrated before the commencement of inspection, and identify defects, according to pre-learnt rules. The information gathered would then be used to grade the fabric, either by giving the frequency of occurrence of defects or by assigning points. A new classification method for common defects has been designed, that will facilitate easy grading according to commonly used grading systems. A coding system for defects has also been designed, which will help in the reporting of defects to the user.

INTRODUCTION

The occurrence of defects is a major concern in any manufacturing industry. The quality of the product manufactured, the categorisation of a material on the basis of its quality and the usability of the material in question will depend to a great extent on the frequency of occurrence of defects. Hence the need for adequate quality inspection to determine the occurrence and severity of defects at a required level of accuracy cannot be denied.

Fabric defect detection has been a long-felt need in the textile and apparel industry. Surveys carried out as early as 1975\textsuperscript{1} show that inadequate or inaccurate inspection of fabrics has led to fabric defects being missed out, which has in turn had drastic effects on the quality and subsequent costs of the fabric finishing and garment manufacturing processes. A more recent survey carried out in the United States indicates that fabric defects are responsible for nearly 85% of the defects found in the garment industry, and that the manufacturer is able to recover only about 45-65% of his profits from factory seconds.\textsuperscript{2} This fact has been found to be true even of leading garment manufacturers in Sri Lanka.

From the viewpoint of the fabric finisher, fabric defects such as oil stains will necessitate special action, while defects such as slubs, thick or thin places, and streaks can cause differential dyeing and resultant shade variation, which may be unacceptable to the garment manufacturer.
The foregoing indicate the importance of achieving fabric with minimum defects from the point of view of the fabric manufacturer, finisher and garment manufacturer, and this research seeks to design a system which will be of relevance to all such categories.

EXISTING METHODS OF FABRIC INSPECTION

A review of the current situation as regards fabric inspection is necessary to understand the need to develop a low-cost system for the objective assessment of fabric defects.

Manual Inspection

In the Sri Lankan industry, the greater part of fabric inspection has yet to move into the realm of complete automation. The inspection of fabric is automated to the extent that the fabric is fed automatically on an inspection table, but the actual inspection and decision-making is done manually by the fabric inspector. This system involves an inspection table, which is inclined at 60° to the horizontal. The fabric is fed at a slow speed by a set of feed rollers along the table, which has a glass front. Lighting is provided by a fluorescent light behind the fabric. More recent systems use the computer purely as a recording and calculating device, the actual defect identification and grading being done by the inspector. Such systems, though simple, have the following shortcomings:

1. The results of the inspection, if they are to be of an acceptable level of reliability, will require a great deal of experience and skill on the part of the inspector. At best, however, it can be seen that many factors, such as fatigue, environmental conditions and personal feelings can have some bearing on the result of the inspection.
2. However experienced the inspector may be the result would, at best, be subjective to the vision of the inspector. This means that two inspectors with different vision capabilities may come up with different results. It has been shown that only about 50% of the faults detected are reproducible from person to person. This could be disadvantageous to at least one party involved in the inspection process.
3. It has also been found that the maximum period of concentration of an inspector would be 20-30 minutes, after which fatigue sets in. It is also shown that if no special event is detected in 20 seconds the concentration of the inspector diminishes, and only the most clearly visible defects are detected.
4. The system can be run only at the speed at which the inspector would be capable of viewing and identifying defects. High-speed systems would require that the fabric be stopped every so often and viewed by the inspector while stationary. This would entail a reduction in the overall productivity of the process.

Thus it can be seen that the manual inspection system can give discrepant results when carried out by different inspectors, as is bound to happen when
inspected at different stages of the life cycle of the garment. For example, let us consider a situation where a fabric is manufactured, processed and sent to a garment factory for cutting and making up into garments. A manual inspection system leaves ample room for the inspector in the garment factory to disagree with the inspection of the inspector in the weaving mill. This is not only due to the reasons mentioned above, but also due to the difference in inspecting conditions in the two situations.

**Developments in Automated Fabric Inspection**

While manual inspection is the most widely used method in the local industry, the need for automated fabric inspection has been felt as far back as 1969. Many attempts have been made to develop automated fabric inspection systems, and far-reaching results have been achieved. However, it may be observed that not all these systems are relevant to the local situation, and most of them are extremely costly, thereby putting them out of the reach of many potential local users, who are small-scale producers.

One of the latest developments in the area of fabric inspection is that of online fabric inspection. Examples of such systems are those developed by the National Textile Centre, USA\(^5\), and the Image Science and Machine Vision Group of the Oak Ridge National Laboratory, USA\(^6\). In such systems inspection of fabrics is on the loom itself during production. This enables the weaver to make necessary adjustments to the loom settings and process parameters in order to eliminate fabric defect occurrence. In addition, extra inspection time could be saved. While this is doubtless an excellent innovation, it also suggests certain drawbacks:

1. Online inspection on the loom will have to be done after the weft insertion and beat-up. This will require additional space on the loom to accommodate the image acquisition system, and this will increase the floor area occupied by the loom. Therefore such a system might substantially decrease the productivity rate per floor area, which would not be desirable in a country like Sri Lanka, with the high cost of floor space.

2. The loom may be subject to vibration during operation. Such vibration could have an adverse effect on the image capture device and as a result on the quality of the scanned images.

3. The generation and presence of dust and fluff, which is a very real problem in local weaving mills, could affect the efficiency of the scanning equipment and light sources.

4. In normal looms the fabric fell is within easy reach of the operator if thread breakage needs to be repaired. The presence of an inspection area will cause the fabric fell to be further away from the operator, making it inconvenient to carry out any piecing that needs to be done.

5. While the previously mentioned advantages of the online inspection system are undoubtedly true, it has to be admitted that the system also presupposes that the defects caused beyond the area of inspection are either negligible or non-existent. This, however, need not be the case, since there are possibilities of defects due to abrasion on the take-up rollers and back beam, as well as handling defects. For instance a survey in a
leading garment factory in Sri Lanka shows that the amount of post-loom defects is as great as 48% of the total defects.

6. An online inspection system, which inspects the fabric on the loom itself, is of use to the fabric manufacturer, but does not take into consideration the needs of the finisher and garment manufacturer, who may also need to inspect the fabric.

7. The loom-state fabric is in a state of tension, whereas at the point of garment manufacture and usage it is in a more relaxed condition. The thread density, for instance, will be rather different in the relaxed state. In addition, defects that are not obvious on-loom (in the tensioned state) may become obvious in the relaxed state. The converse may also hold true.

Numerous systems have been developed over the years for the purpose of online fabric inspection. Sophisticated processing techniques are used to process the data and analyse the fabric defects. While not underestimating the use of these systems, it has to be pointed out that they have two major constraints as regards the Sri Lankan industry, viz. cost and relevance. An automated fabric inspection system that has been developed abroad may cost about Rs. 5 million upwards.

**DESIGN OF THE SYSTEM**

The following areas have been identified which need to be addressed in order to develop a cost-effective system of fabric inspection for the Sri Lankan industry:

1. The identification of defects which are of particular relevance to the local industry. (Data has been collected from leading textile and garment factories and buying offices in an effort to identify the most relevant defects.)
2. The categorisation of these defects in a meaningful manner.
3. The design of a system that is adequate to detect the above defects and grade the fabric accordingly.

**Defect Categorisation & Coding.**

The number of woven fabric defects that have been identified and classified are legion, and it would be time consuming, unrealistic and probably unnecessary to prepare for all of them individually. The 4-point grading system developed by the American Society for Quality Control, for instance, defines around 54 different defects, while ISO standards specify around 116 defects in 6 categories. In addition, since grading is often on the basis of length and severity of the defect, it would be logical to classify similar defects together, so that the software would treat them as one defect. This would require careful classification, since, however similar two defects may be, it would defeat the objectives of the inspection if they were not treated similarly by the grading system.
It has been found that there are certain defects that are more common in occurrence than the others, and for this stage of the research it was decided to concentrate on these defects. Grover & Hamby have shown that the most common defects are slubs, holes, broken picks, jerked-in picks, coarse picks, thick and thin places and broken selvages. Oil stains have also been found to be quite common. Investigations among some of the local textile mills and garment factories have shown that the defects that occur for the larger part generally fall within this classification. While there are other defects pertaining to finished fabric, and fabric woven from filament yarns, they have not been considered at this stage. Plain woven grey fabric has been used for the study so far, and at this stage the defects in the fabric selvage, as well as defects due to dyeing, printing and finishing have not been considered.

Fabric defects can be categorised in various ways. A fabric manufacturer may be more concerned about the actual source of the defects, and would prefer the classification to be on this basis. However, the finisher and garment manufacturer would be more concerned about the impact of the defect on their product, and in this case the extent and severity would form a more suitable basis for defect classification. Since the inspection would depend on the detection of the defect by a vision-based system, it would be appropriate to base the defect categorisation the basis of appearance. A further consideration is that the more popular fabric grading systems utilise the size of the defect as a basis for the allocation of points (as discussed later). Therefore the proposed system uses the basis of the appearance of the defects to classify them.

Defects could be also be classified as minor defects, which are fairly obvious at first glance, major defects, which are very obvious even at a distance, and critical defects, which are extremely severe, and could result in the complete rejection of the fabric.

The appearance of various defects, as well the results of the processing of these defects using various image processing filters were studied. The causes of these defects and the way that various grading systems treat them were also considered. The following categories were identified as a result:

Type 1 : Defects involving a hole or opening in the fabric.
Type 2 : Defects involving yarn-related protrusions.
Type 3 : Defects causing a variation in the surface appearance.
Type 4 : Defects due to improper interlacing of yarns (variation from the expected structure).

The common defects that fall into each of these categories, together with their cause, are given in Table 1.

Having developed the above defect classification, it becomes necessary to derive some method by which these defects can be identified, and at the same time give sufficient information for further action. Some form of coding system seems to suggest itself. Work has already been done in this area in the development of the Fabric Defect and Analysis System (FDAS), which has been studied in the course of this research. The coding techniques used in
Predetermined Motion Time Study systems such as GSD have also been studied. The outcome is a system will be based on a few letters and numbers, which do not have as many sub-classifications as FDAS and will be easily referred to and understood both by the user and the processing software. The derivation of the coding system is as follows:

1. The most important defect parameter from the point of view of a vision-based inspection system is its appearance. This is referred to in the above classification.
2. Most point grading systems depend on allocating points for a defect on the basis of the size of the defect. Hence the size of the defect is another important parameter.
3. The user of a fabric will be interested in the orientation of the defect, which will enable him to make certain decisions (for example, cutting of the fabric). The position of the defect will also be needed.
4. In addition to the above, the nature of the defect (i.e. whether it is critical, major or minor) will also be of relevance. (This, however, will depend on the intensity of the inspection that the user requires, and will have to be learnt by the system before inspection commences).

Based on the above rules a coding system is being proposed where the defect would be identified by the code TSDN (x,y), the interpretation of which is given in Table 2.

The following algorithm is used to identify and code a defect that is noted:

1. If a defect is identified check the defect type
2. Check the direction of the defect
3. Measure the defect size
4. Determine the nature of the defect
5. Write code to file.

The advantage of such a coding system is two-fold. It provides a fairly simple way of passing information between software modules, and it also helps to mark the defects in a manner that could be easily understood by an operator with a reference card.

**Image Acquisition & Processing**

As the fabric is fed the image will be captured by an appropriate image capture device, and then processed. It is proposed to use a Charge Coupled Device (CCD) camera with a zoom lens. Most of the currently available systems use a series of CCD cameras to cover the entire fabric width. While this ensures that the entire fabric width is covered, it will require additional processing in order to seam the frames captured from different parts of the width. A zoom lens with a sufficient field of view and focal length, with capacity to avoid aberration of images will help to capture the entire width in one frame.

For the purpose of experimentation in developing the image processing software images scanned using a flatbed scanner have been used. Image
capture modules would have to be added to the software to make it compatible with a CCD camera.

The fabric would be fed by means of a stepper motor. The software would regulate the rotation of the motor, and the stops at the end of each step would be utilised for the capture of each frame. These frames would then be transferred to a computer, stored sequentially and processed. A block diagram of the system is shown in Figures 1 & 2.

**Processing & Results**

Prior to the start of the operation, an ideal fabric piece is used to calibrate the device. The pattern thus obtained is used as a reference pattern. The frames that are captured are converted into an appropriate data pattern using a suitable algorithm, and compared with the reference pattern. The actual grading would be then carried out using appropriate neural networks.

The image of a fabric frame is subtracted from the image of the reference sample. The result is then refined using an edge detection algorithm. A Sobel edge operator has been used in the experiments, while the possibility of using a Laplacian of Gaussian operator is also being explored. The pattern is then analysed using a neural network to decide if there is a variation. Frames that show variations are further segmented, and the number of variations counted. If further information is required (as for a point grading system), the areas showing variations are then analysed and the defect identified. The defects are then allocated points depending on the defect size and type. The total number of points would then be used to calculate the points as required by the inspection system. Figure 3 shows some of the figures generated during processing.

While more processing would obviously be needed for inspection which use point grading systems, those systems that use the frequency of occurrence of the fabric, such as the 1 in 9 system specified by Marks and Spencer, would require very little processing after image segmentation.

Matlab has been chosen as the programming language in which to develop the software for the purpose of this research. It is intended to use a Back Propagation Network for the processing.

Once the grading is carried out, the system would generate a report, which would indicate the position of the various defects, as well the number of points as required by the grading scheme, and indications as to the quality of the fabric.

**CONCLUSION**

The prototype for the proposed system is yet to be built, and it is hoped that the final system could be customised with separate diagnostic modules which would be useful for different stages of the process. While the current research
is concentrated on the inspection of plain weave grey fabrics, it is hoped that it
could be modified in the future to include processed fabrics of different
structures. It is hoped that the completion of the research will see the
development of a system which, by minimising the amount of processing and
related parameters, will be in terms of cost within the reach of the textile and
apparel industry in countries like Sri Lanka, while still giving the required
results within the scope of customer expectations.

ACKNOWLEDGEMENTS

The authors would like to place on record their gratitude to the personnel in
various establishments in the textile and garment industry for their support
during the data collection stage of the research. Special thanks are also due to
Dr. Nihal Kodikara of the Department of Statistics and Computer Science of
the University of Colombo, and Mr. GC de Silva of the Department of
Computer Science and Engineering, University of Moratuwa for their ready
advice regarding the computing aspects.

REFERENCES

1 KNELL, A.L., Automatic Fabric Inspection. Textile Institute and Industry
January 1975.
2 DORRITY, J.L., VACTHSEVANOS,G, & JASPER, W., Real Time Fabric
Defect Detection and Control in Weaving Processes. NTC Annual Report
1995. P.1
3 MEIER, R., UHLMANN, J. & LEUENBERGER, R., More than meets the
eye- a quality revolution. Textile Month, February 1999. P.34
4 ibid.
5 DORRITY, J.L., VACTHSEVANOS,G, & JASPER, W., Real Time Fabric
Defect Detection and Control in Weaving Processes. NTC Annual Report
1994.
6 HAMED SARI-SARRAF & GODDARD (JR), J., Vision-based On-Loom
Fabric Inspection, Oak Ridge National Laboratory, USA, 1996.
7 EDIRISOOYIKA, E.A.B.C., KARUNANAYAKÉ, K.P.J.P.K., &
WANASINGHE, P.G.H., Automated Fabric inspection System. University
8 POWDERLEY, D., Fabric Inspection & Grading, (Bobbin International,
Columbia, USA, 1987).
9 ISO 8498: 1990 (E/F)
10 GROVER, B.E., & HAMBY, D.S., Handbook of Textile Testing & Quality
11 SRINIVASAN, K., DASTOOR, P.H., RADHAKRISHNAIAH, P., &
JAYARAMAN, S., FDAS: A Knowledge-based Framework for Analysis
of Defects in Woven Textile Structures. Journal of the Textile Institute,
1992, 83 No3.
12 General Sewing Data Manual.
### Table 1 - Categorisation of Common Fabric Defects

<table>
<thead>
<tr>
<th>Category</th>
<th>Name of Defect</th>
<th>Description</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Break-out</td>
<td>4 or more ends broken</td>
<td>Shuttle fault, objects between harness &amp; reed, change motion</td>
</tr>
<tr>
<td></td>
<td>Crack</td>
<td></td>
<td>Splinters, rough edges etc.</td>
</tr>
<tr>
<td></td>
<td>Moiré pick</td>
<td>Triangular hole in fabric</td>
<td>Pick caught in a warp knot</td>
</tr>
<tr>
<td></td>
<td>Holes</td>
<td></td>
<td>Careless handling, sharp or rough edges</td>
</tr>
<tr>
<td></td>
<td>Pimple</td>
<td>Very small hole</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shuttle mark</td>
<td>Weltsome mark on warp</td>
<td>Abrasion of shuttle</td>
</tr>
<tr>
<td></td>
<td>Broken ends</td>
<td>Loose ends or fabric</td>
<td>Non-removal of ends after piecing</td>
</tr>
<tr>
<td></td>
<td>Broken picks</td>
<td>Separation of picks</td>
<td>Shuttle fault, wrong well tension, yarn defects</td>
</tr>
<tr>
<td></td>
<td>Warp smash</td>
<td>Runner of warp and well</td>
<td>Shuttle displacement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Burnout</td>
<td>Thick place in the yarn</td>
<td>Spinning defect</td>
</tr>
<tr>
<td></td>
<td>Drawback</td>
<td>Tight &amp; slack places in the same warp</td>
<td>Sizing, crossed ends</td>
</tr>
<tr>
<td></td>
<td>Frost</td>
<td>Foreign matter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jerk-in pick</td>
<td>Loose picks drawn into fabric</td>
<td>Shuttle faulty</td>
</tr>
<tr>
<td></td>
<td>Knot</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slubs</td>
<td>Loose fibres in yarn</td>
<td>Spanning faults</td>
</tr>
<tr>
<td></td>
<td>Uneven picks</td>
<td></td>
<td>Yarn faults</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Blowout</td>
<td>Area at the width of the fabric</td>
<td>Displacement of well</td>
</tr>
<tr>
<td></td>
<td>Break</td>
<td>Wrong number of picks in a pattern</td>
<td>Improper matching, wrong pattern chain</td>
</tr>
<tr>
<td></td>
<td>Burn out</td>
<td>Patterns of bars and stripes parallel to the selvage</td>
<td>Yarn variations, fabric structure variations</td>
</tr>
<tr>
<td></td>
<td>Course thread</td>
<td></td>
<td>Wrong yarn count</td>
</tr>
<tr>
<td></td>
<td>Furrowed</td>
<td>Happy appearance of surface</td>
<td>Preliminary broken filaments</td>
</tr>
<tr>
<td></td>
<td>Crease</td>
<td>Sharp fold</td>
<td>Bad handling, tension</td>
</tr>
<tr>
<td></td>
<td>Tight end</td>
<td>Packing</td>
<td>Excessive tension, shrinkage of yarn</td>
</tr>
<tr>
<td></td>
<td>Tight pick</td>
<td>Packing</td>
<td>Excessive tension, shrinkage of yarn</td>
</tr>
<tr>
<td></td>
<td>Double ends</td>
<td>Two ends at one</td>
<td>Wrong dens, loose thread, sizing</td>
</tr>
<tr>
<td></td>
<td>Fillers</td>
<td>Wide width-wise streaks</td>
<td>Change in yarn</td>
</tr>
<tr>
<td></td>
<td>Filling bars</td>
<td>Narrow width-wise streaks</td>
<td>Change in yarn</td>
</tr>
<tr>
<td></td>
<td>Hard size</td>
<td>Rough patches</td>
<td>Excessive size</td>
</tr>
<tr>
<td></td>
<td>Misprint</td>
<td>Break in the pattern</td>
<td>Well stop motion, wrong shedding</td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>End in wrong reel dent</td>
<td>Careless drawing in</td>
</tr>
<tr>
<td></td>
<td>Mixed pack</td>
<td>Wrong count of pick</td>
<td>Mix-up in well preparation</td>
</tr>
<tr>
<td></td>
<td>Section mark</td>
<td>Warp bands of different colour etc</td>
<td>Yarn variations</td>
</tr>
<tr>
<td></td>
<td>Set mark</td>
<td>Change in visible yarn density in fabric</td>
<td>Stoppage of loom</td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>Angular displacement of well</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slack Place</td>
<td>More picks than desired</td>
<td>Bad let-off or take-up</td>
</tr>
<tr>
<td></td>
<td>Thin Place</td>
<td>No pick</td>
<td>Bad let-off or take-up, faulty well stop-motion</td>
</tr>
<tr>
<td></td>
<td>Wavy fabric</td>
<td>Thick and thin places on cloth</td>
<td>Bad let-off or take-up</td>
</tr>
<tr>
<td></td>
<td>Wrong draw</td>
<td>Warp drawn in wrong place</td>
<td>Careless drawing in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Slack thread</td>
<td>End running loosely</td>
<td>Bad drawing, wrong tension</td>
</tr>
<tr>
<td></td>
<td>Slough-off</td>
<td>Several yarns being woven together in one pick</td>
<td>Stepping off of several warp ends</td>
</tr>
<tr>
<td></td>
<td>Warp end-out</td>
<td>Yarn not weaving in cloth 3&quot; or more</td>
<td>Faulty warp stop motion</td>
</tr>
<tr>
<td></td>
<td>Warp skip</td>
<td>Warp ends not weaving in</td>
<td>Harness fault</td>
</tr>
<tr>
<td></td>
<td>Floats</td>
<td>Main causes of warp &amp;/or well</td>
<td>Yarn breaks, entanglement</td>
</tr>
<tr>
<td></td>
<td>Loop</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2 - Coding of Defects for Identification and Processing

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
<th>Values</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Type of Defect</td>
<td>H</td>
<td>Hole</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y</td>
<td>Yarn-related protrusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>Surface variation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>Interlacing error</td>
</tr>
<tr>
<td>S</td>
<td>Size of defect (inches)</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Direction of defect</td>
<td>W</td>
<td>Warp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>Weft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>Neither</td>
</tr>
<tr>
<td>N</td>
<td>Nature of defect</td>
<td>C</td>
<td>Critical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>Minor</td>
</tr>
<tr>
<td>x</td>
<td>Starting position of the defect in the warp direction (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>Starting position of the defect in the weft direction (cm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D - 61
Fig. 1 – Block diagram of the proposed system

1 – Fabric Roll
2 – Fabric Takeup Roller
3 – Feed Roller
4 – Delivery Roller
5 – Light source (transmitted light)
6 – CCD Camera
7 – Processing Unit (see Figure 2)
8 – Report on Defects and Grading

Fig. 2 – Block diagram of the Processing Unit

Calibration Data

Digital signal from
CCD Camera

Reference
Signal

PC Processing
Unit

Defect & Grading
Results

Display

Report

(a) slab (protrusion)
(b) processed image of (a)

(c) Mispick
(d) Reference image
(e) Subtracted image

(f) Sobel operator applied to (c)

Fig. 3 – Some images generated during processing