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Investigation of Dimensional Changes During Garment Production and Suggestions for Solutions

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Abstract
Dimensional change problems experienced in textile products have always been an important subject and in the focus of attention. Today it is expected that dimensional changes in fabrics, the basic material of textile products, must range within certain limitations. Fabrics processed in the finishing divisions are wound or decatized in various forms according to the fabric structure and the demands of garment manufacturers. However, fabrics may be distorted in these storing processes, which results in undesired dimensional changes under the stress incurred. Nevertheless fabrics are required to be delivered to garment manufacturers at specific tension values. Indeed these values are not acquired as expected; consequently, it is known that they represent a core conflict subject between finishing plants and garment manufacturers. The present study investigated the structures of garment manufacturers and dimensional change problems they experience during fabric layout. The aim was to determine the severity of the problem in terms of the garment manufacturer and fabric types, which cause problems frequently, and to search for solutions to overcome this issue by means of a survey study. Solutions which would increase production efficiency and reduce processing time have been emphasized.

Key words: *dimensional change, knitted fabric, relaxation, relaxation time.*

Introduction

As knitted garment production has developed recently, dimensional change problems related with knitted fabrics have been a prominent quality issue. It is evident that garment manufacturers experience difficulties during production due to this problem and sometimes they confront problems with their clients because of discrepancy in measurements. Especially dimensional change issues with knitted fabrics have such a high incident rate that they constitute 60% of all production errors. This variation issue has been investigated by several researchers from different points of view and studies are still being continued. The maximum shrinking ratio for knitted fabrics is expected to be 5% [1]. In terms of the knitting structure, it was observed that shrinkage in low density knitted fabrics was greater than that in high density fabrics. The use of fine yarns also increases the shrinkage due to the more open structure of the knitted fabric [2]. Incorporation of elastomeric yarn into 100% cotton knitted fabrics at the half-and-half rate exhibits a positive effect on the deformation observed on cotton knits after wet treatment and facilitates the gaining of the flexibility characteristic [3]. Relaxation shrinkages vary according to the material used. While cotton knitted fabric could easily develop deformation during wet treatment, wool posed fewer problems due to its flexible characteristic. Acrylic is a material which develops the least dimensional deformation because of its hydrophobic structure [4]. Elasticity and dimensional stability enhances with an increase in the rate of elastane [5]. It was revealed that whereas density, knitting pattern and washing have an effect on widthwise and lengthwise dimensional change, the yarn type and yarn fiber blend affect lengthwise dimensional change more significantly [11]. A lower amount of space between the courses and wales of cotton/lycra blended fabric was observed compared to that in 100% cotton single jersey fabric, regardless of the loop length, due to the flexion quality of lycra blended fabrics [10]. Various relaxation methods (relaxation process with ultrasonic waves) have different effects on the dimensional characteristics of knitted cotton fabric. Ultrasonic wave energy gives superior regularity in texture to knitted fabrics compared to other methods [6]. When structures of cotton/spandex fabric and 100% cotton single jersey fabric with different knitting densities are compared under dry, wet and full relaxation states, it was found that the cotton/spandex single jersey structure has superior dimensional stability than the 100% cotton structure in a full relaxed state [7]. It was reported that

Table 1. *Distribution of manufacturers across the cities.*

Location of manufacturers	Number of companies
Izmir	11
Denizli	13
Istanbul	11

Kalkanci M, Kurumer G. Investigation of Dimensional Changes During Garment Production and Suggestions for Solutions.
FIBRES & TEXTILES in Eastern Europe 2015; 23, 3(111): 8-13.

continuous vapour application for a brief time affects the dimensional stability of knitted fabrics positively and reduces dimensional change [8]. A marginal difference between the dry relaxation shrinkages of knitted fabrics with different loop lengths has been reported [9].

The present study examines the significance of the dimensional change issue in fabrics in terms of enterprises and discusses solution suggestions.

Materials and methods

In the present study, a survey was conducted covering 35 manufacturers from the knitted and woven fabric sectors in the cities of Denizli, Izmir and Istanbul in Turkey in order to investigate the significance of fabric dimensional change issues experienced by garment manufacturers and precaution measures taken by them for prevention of the problem. The distribution of manufacturers according to their location is exhibited in ***Table 1***. The research was conducted based on inquiry questions classified in 3 sections. The first section includes questions regarding company information; the second section covers fabric types which present the highest dimensional change as well as company knowledge and opinion concerning the dimensional change problem according to their experience; and the questions in the third section investigate the priority and significance of dimensional distortion issues. For the questions in the third section, the five-point Likert Scale was utilised as a measurement tool. In the conclusion, views regarding possible precaution measures against fabric dimensional change issues experienced during the garment production stage are discussed.

Results and discussion

As a result of face-to-face interviews with the cutting department staff of the 35 manufacturers in the cities of Denizli, Izmir and Istanbul, the following findings were acquired.

Group survey study findings

Company activity area
Activity areas of the respondent companies which may have multiple operation areas are exhibited in ***Figure 1***.

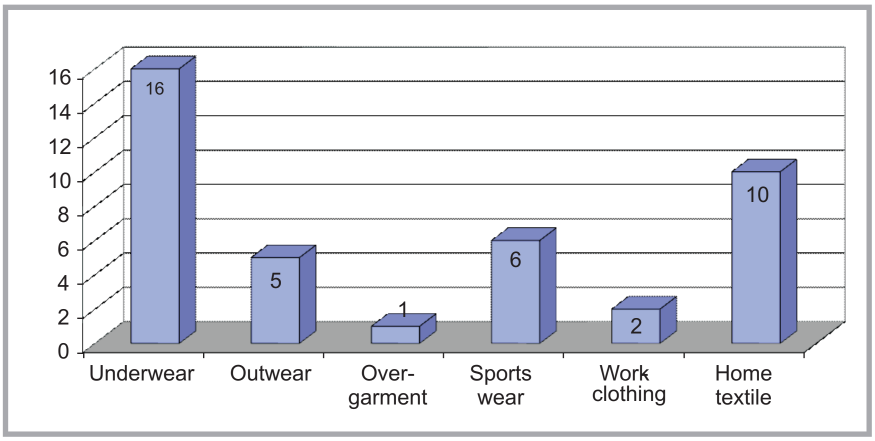


Figure 1. *Company activity area.*

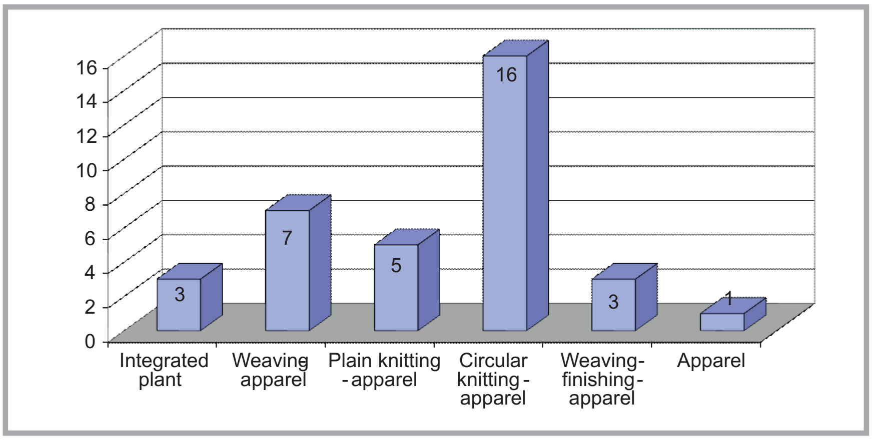


Figure 2. *Facility structure.*

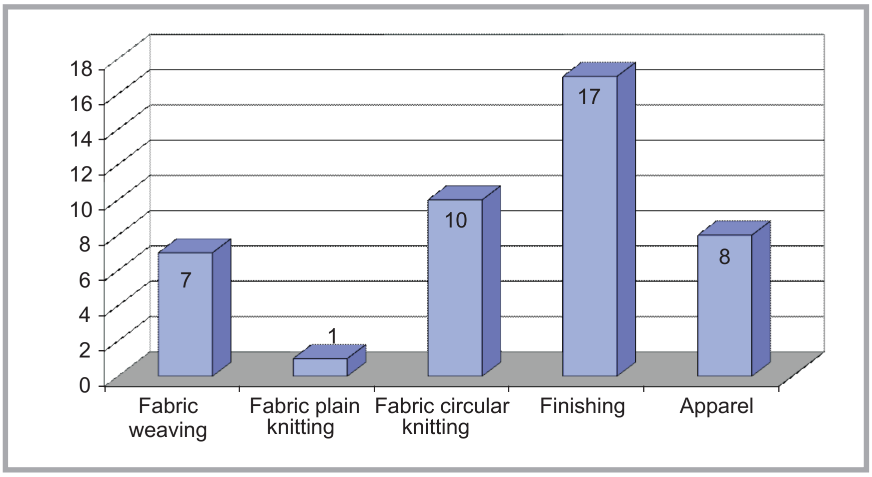


Figure 3. *Services outsourced to subcontractors.*

The most extensive activity area is underwear production, with a 40% rate (16 responses).

Facility structure
The distribution of the respondent manufacturers is presented in ***Figure 2***. Based on this chart, the largest facility conglomeration was in circular knitting, representing 46% (16 manufacturers).

Services received from contractors
The manufacturers participating in the study may outsource several services from subcontractors. Hence companies mostly outsource circular fabric knitting, representing 23% (10 companies) and the finishing service, 40%, (16 companies) to contractors, as presented in ***Figure 3***.

The most frequently outsourced service is the finishing process, with a 40% rate.

Table 2. Daily garment production capacity

Daily number of garments manufactured	Number of companies	Company percentage, %
1,000 – 1,500 pieces	2	6
1,500 – 2,500 pieces	15	43
2,500 – 10,000 pieces	15	43
25,000 – 30,000 pieces	1	3
60,000 – 100,000 pieces	2	6

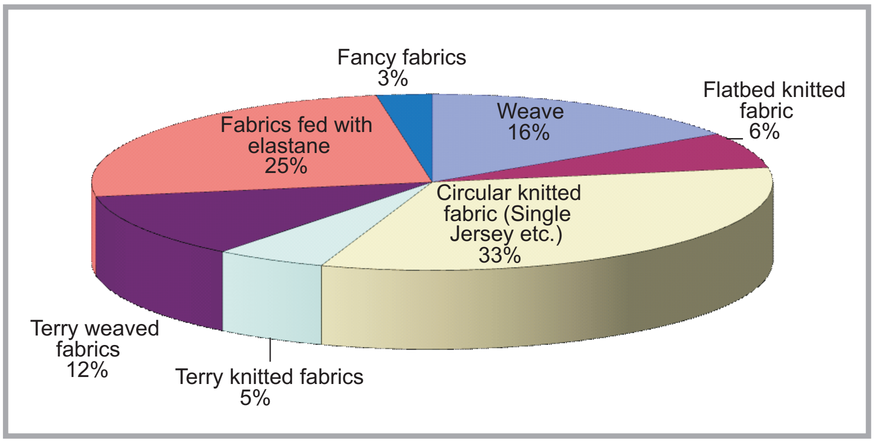


Figure 4. *Fabric types processed.*

However, as finishing processes, which include wet treatments, are performed under various conditions, which are required to be under controlled conditions from the very beginning at the raw material stage, it is possible that fabrics incur various internal tension loadings during these processes. This is a disadvantageous situation in terms of the dimensional change problem.

Daily garment production capacity

Based on ***Table 2***, 43% of the companies (15 companies) produce 1,500 – 2,500 pieces daily, and another 43% (15 companies) 2,500 – 10,000 pieces daily.

Fabric types processed

Fabric types processed by the manufacturers and their usage rates regarding these fabrics are exhibited in ***Figure 4***. According to the exhibition, mostly circular knitted fabric was used - 33%, and secondly elastane blend knitted fabric - 25%.

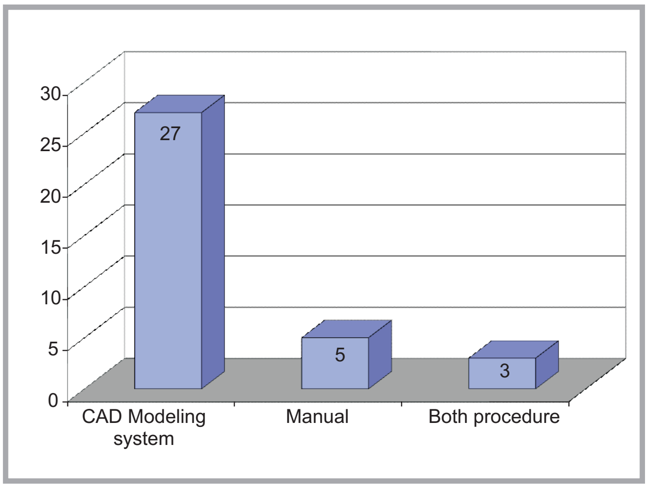


Figure 5. *Modeling procedure at manufacturers.*

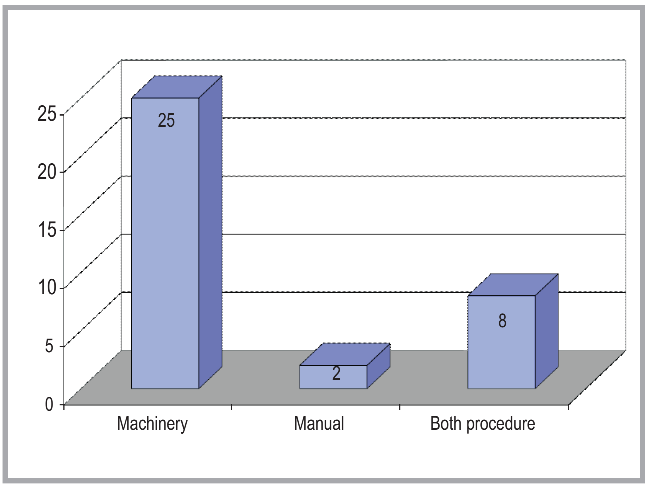


Figure 6. *Layout procedure.*

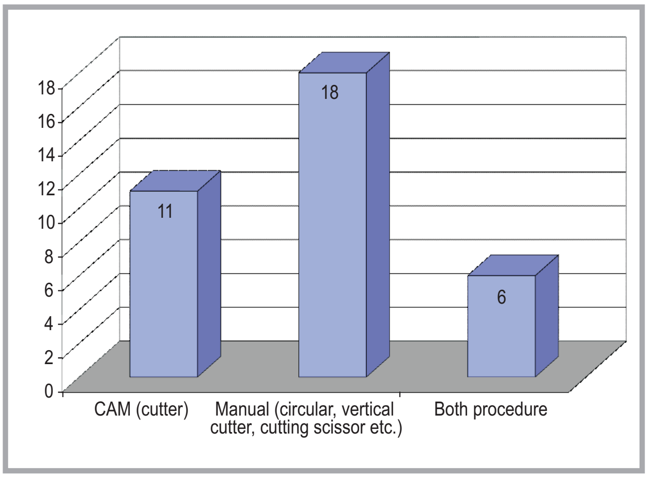


Figure 7. *Cutting procedure.*

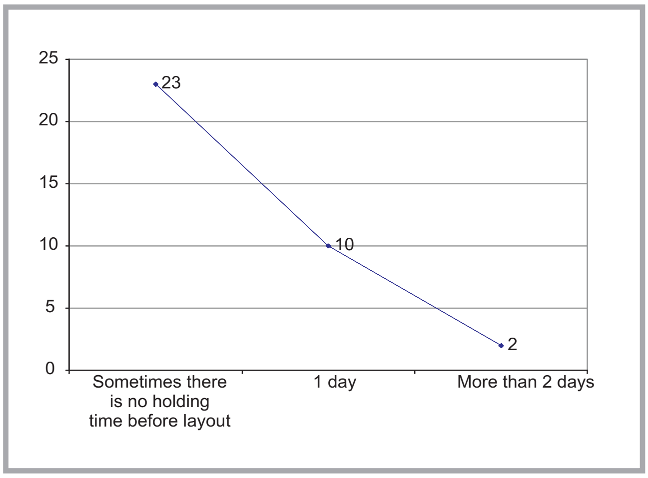


Figure 8. *Holding period of fabric batches.*

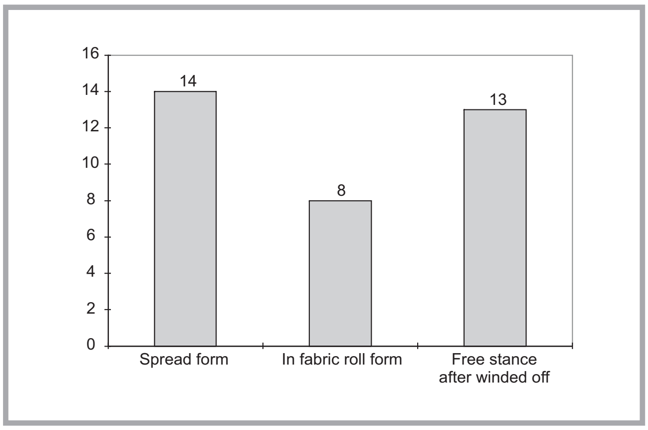


Figure 9. *Holding form of fabric batches.*

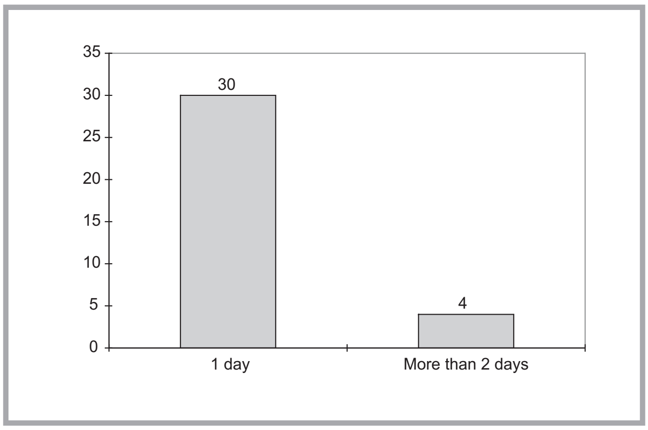


Figure 10. *Adequate holdingtime for fabrics.*

Figure 11.

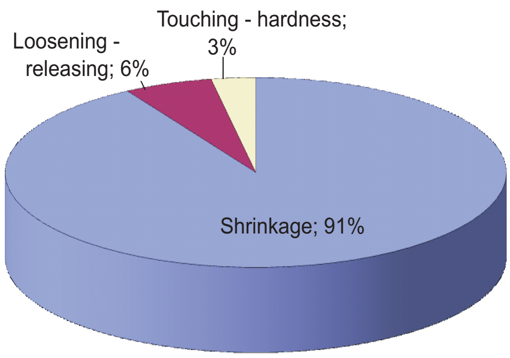


Figure 11. *Possible issues experienced in the cutting procedure.*

Figure 12. *Fabrics which exhibit the highest dimensional change incidents.*

Figure 13. *Percentage of dimensional change in products in relation to all garment production errors.*

Figure 12.

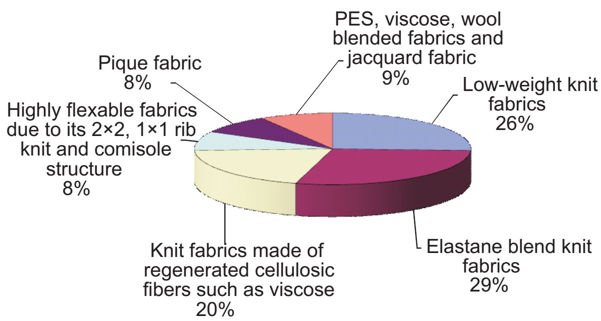
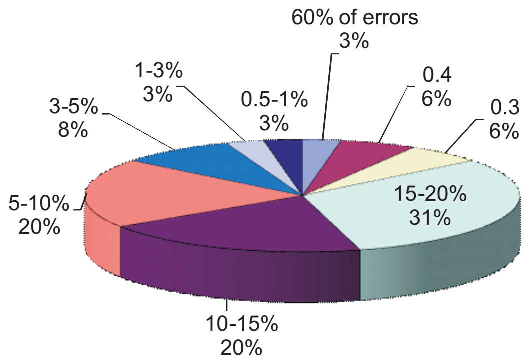


Figure 13.



Pattern making procedure at the garment manufacturers

77% of the companies surveyed (27 companies) stated that they make patterns by means of the CAD modeling system, 14% (5 companies) manually, and 9% (3 companies) use both procedures, as presented in ***Figure 5***.

Fabric spreading procedure at the garment manufacturers

71% of the companies surveyed (25 companies) stated that they perform the spreading procedure by means of machinery, 6% (2 companies) manually, and 23% (8 companies) use both, as presented in ***Figure 6***.

Cutting procedure of the garment manufacturers

31% of the companies surveyed (11 companies) stated that they perform the cutting procedure by means of computer aided cutting machines (CAMs), 51% (18 companies) by using conventional cutting machines, and 17% (6 compa-

Table 3. *Reasons for holding fabrics before the spreading procedure.*

Reasons for holding fabrics before the spreading procedure?	Number of companies	Company percentage, %
To relieve the tensions incurred by fabrics during the production process	24	69
To allow fabric to absorb natural moisture	4	11
To avoid size problems in the fabric, to keep widthwise and lengthwise shrinkage under control	6	17
To allow the fabric to cool down	1	3

Table 4. *Significance of dimensional change issue. 1) Strongly disagree, 2) Disagree, 3) I have no idea, 4) Agree, 5) Strongly agree.*

	Evaluation questions regarding the dimensional change.	Assessment	1	2	3	4
1	Current customer complaints regarding dimensional change constitute a significant part of overall complaints.	Number of responses	2	5	6	13
		%	6	14	17	37
2	Holding the fabrics laid before the cutting procedure causes significant difficulties in the deadline.	Number of responses	1	2	7	15
		%	3	6	20	43
3	The cutting procedure without holding fabrics in the laid-out position for a certain period causes significant dimensional change issues.	Number of responses	-	2	6	16
		%		6	17	46
4	Fabrics are required to be held for resting before the cutting procedure.	Number of responses	-	-	1	17
		%			2	49
5	It is important to shorten the holding period of fabrics.	Number of responses	-	1	3	17
		%		3	9	49
6	Different types of fabrics require different holding periods.	Number of responses	-	-	2	24
		%			6	69
7	It is important to work on a technique shortening the holding period.	Number of responses	-	-	1	24
		%			3	69

nies) use both procedures, as presented in ***Figure 7***. Companies primarily use automation in their pattern making, spreading and cutting procedures.

Group survey study findings

Storing period for fabric batches coming from the finishing facility before the spreading procedure

66% of the companies surveyed (23 companies) stated: "according to the work order, sometimes there is no holding time before spreading", as presented in ***Figure 8***. To avoid experiencing difficulties regarding the deadline, the majority of companies need to take fabric batches into the spreading process without holding them before this procedure, which consequently causes dimensional change issues.

Holding procedure before spreading

Although only part of the companies surveyed responded to question, it was found that 40% of respondents (14 companies) hold the fabrics in a "spread" form, 23% (8 companies) in a fabric roll form, and 37% (13 companies) in the free stance after unreeling the fabric, as presented in ***Figure 9***.

Reason for holding fabrics before the spreading procedure

69% of the companies surveyed (24 companies) stated that the reason for holding fabrics is "to relieve the tensions incurred during the production process", as presented in ***Table 3***. Other reasons emphasized by the companies for the holding period can also be seen in this table.

Adequate time to hold fabrics before the spreading process

The companies surveyed evaluated that they based the adequate holding time required before the layout procedure on their experience. According to the survey, 88% of the companies surveyed (30 companies) indicated the adequate holding time was that "fabrics must be held at least 1 day before the layout procedure", as presented in ***Figure 10***.

Possible issues that can be experienced during the cutting procedure performed without maintaining fabric hold

Companies indicated possible issues that they might experience when starting the cutting procedure without holding the fabrics before this process, exhibited in ***Figure 11***. According to this figure, the most frequent issue emphasised is shrinkage observed on fabric parts along the widthwise and lengthwise directions - 91% (32 companies).

Fabrics which exhibit the highest dimensional change incidents

Regarding the fabrics which exhibit the highest dimensional change, 26% (9 companies) of the companies surveyed indicated "low-weight knitted fabrics", 29% (10 companies) "elastane blend knitted fabrics", and 20% (7 companies) "Knitted fabrics made of regenerated cellulosic fibers, such as viscose", as exhibited in ***Figure 12***.This result supports the literature findings [3, 12].

According to the quality control activity results, what is the percentage of widthwise and lengthwise shrinkage errors of fabrics in proportion to overall garment production errors?

When the companies surveyed considered the percentage of shrinkage errors in regard to overall garment production errors, 3% of the companies (1 company) indicated that "shrinkage constitutes 60% of all garment production errors", and 30% (11 company) that "shrinkage constitutes 15 to 20% of all garment production errors", as exhibited in ***Figure 13***. Thus the highest share among all production errors was "shrinkage" because 30% of the respondent companies (11 companies) indicated that "shrinkage constitutes 15 to 20% of all production-borne errors."

Group survey study findings

Priority and significance of issues experienced by manufacturers regarding dimensional change

1. As can be seen from the companies' responses in ***Table 4***, the majority of answers accumulated on the right hand side of the table, namely the "Agree" and "Strongly agree" choices, which proves that there is such an issue in practice. In regard to the first expression, "Current customer complaints regarding dimensional change constitute a significant part of the overall complaints", the percentage of companies who stated "Agree" (37%) and "Strongly agree" (26%) constitute the majority - 63%.
2. In regard to the second expression, "Holding the fabrics laid out before the cutting procedure causes significant difficulties in the deadline", the total percentage of companies which stated "Agree"(43%) and "Strongly agree"(29%) constituted the majority - 71%.

3. In regard to the third expression, " The cutting procedure without holding fabrics in a laid- out position for a certain period causes significant dimensional issues", the total percentage of companies which stated "Agree"(46%) and "Strongly agree"(31%) constituted the majority - 77%.
4. In regard to the fourth expression, "Fabrics are required to be held for resting before the cutting procedure", the total percentage of companies which stated "Agree"(49%) and "Strongly agree"(49%) constituted the majority - 98%. It means that they were of the opinion that fabrics are required to be rested before cutting.
5. In regard to the fifth expression, "It is important to shorten the holding period of fabrics", the total percentage of companies which stated "Agree"(49%) and "Strongly agree"(40%) constituted the majority - 89%, which suggests that the holding period must be shortened.
6. In regard to the sixth expression, "Different types of fabrics require different holding periods", the total percentage of companies which stated "Agree"(69%) and "Strongly agree"(26%) constituted the majority - 95%.
7. In regard to the seventh expression, "It is important to work on a technique shortening the holding period", total percentage of the companies which stated "Agree"(69%) and "Strongly agree"(29%) constituted the majority - 98%, which reveals that this was found to be very important.

Conclusions

As a preliminary the garment production activity, the finishing process is required to deliver fabric with desired shrinkage rates to the initial garment production stage. However, as stated by the companies surveyed, this does not take place in reality. In the contemporary sector, in practice there are several methods and measurements which are taken based on the experience of staff and their know-how derived from production errors. These are summarised below:

1. Fabrics scheduled to be delivered from the finishing facility to the spreading division are required to be unreeled instead of being stored on a fabric roll so that fabric tension can be relieved.
2. Knitted fabric must be wound off and held free from the fabric roll so that fabric tension can be relieved.
3. Utmost care must be paid during winding fabric on a roll to prevent widthwise and lengthwise over-strain.
4. It is important not to expose fabrics to differing weather conditions while they are held in the fabric roll form.
5. According to the pressing test results of spread fabric, an extra length is required to be added to pattern dimensions; in regard to risky fabrics, a small batch of trial production is required to assign adequate pattern allowances.
6. Vibrating spreading tables are useful in relieving the tension present in the fabric as it is applied after completing the fabric spreading procedure.
7. There are machines with a vapour unit included inside to prevent dimensional change; however, these require substantial investment.
8. It has been observed recently that artificial neural networks have been introduced to the textile and garment production sector for estimation of numerous parameters. For the estimation of dimensional changes in knitted fabrics, the artificial neural network (ANN) method and regression model were applied for determination of the dimensional characteristics of Single Jersey, rib fabrics and Thessaloniki knitting pattern double-layer fabrics made of 100% cotton ring yarn. It was emphasised that the characteristics of fabrics, especially knitted fabrics, can be estimated by means of ANN models with significant accuracy [13 - 15].

Finally, regarding the efficacy of all these precaution measures, shrink-proof finish is required to be applied to fabrics from the very beginning of the production process and all process parameters must be kept under control limits. Fabrics are required to be produced by keeping the loop formation and tension under control. All tensions and feedings must be kept under control during the finishing process.

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Received 11.03.2014 Reviewed 02.10.2014