Fabric hand measurement for quality control in apparel manufacturing

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The validity of the new method for measuring fabric hand designed by sultan and sheta and developed by the authors (with the principle of withdrawing a circular specimen of fabric through a hole) was checked in an Egyptian garment factory to find out the correlation between seam pucker in the garment and the normalized fabric hand force. Also the correlation was deduced between fabric hand force measured by the developed tester and the fabric assessment obtained using the Kawabata Evaluation System (KES).
تم إختيار صلاحية الطريقة الجديدة لقياس ملمس القماش التى صممت بواسطة "سلطان" "وشتا" (التى تعتمد على فكرة سحب عينة مستديرة من القماش من خلال ثقب) وذلك بتطبيقها فى أحد مصانع الملابس لإيجاد العلاقة بين جودة الوصلات الحياكية فى الملابس وقوة ملمس القماش. كذلك تم استنتاج العلاقة بين قوة ملمس القماش المحددة بواسطة الجهاز المطور، وتقييم خواص ملمس القماش عن طريق استخدام أجهزة "كواباتا" وإستنتاج توافق الطريقتين.

Keywords: Fabric hand force, Xiormalized fabric hand force, Seam pucker, Kawabata evaluation system

1. Introduction

Seam pucker is considered as one of the most important defects resulting from the sewing operation in garment manufacturing. The scientific explanation of this defect has been related to three mechanical properties of the sewn fabric. These properties are the bending rigidity, the surface smoothness and the fabric compressibility (softness). The seam pucker grade deteriorates due to low bending rigidity, smooth surface and low fabric compressibility. As these three properties are also involved in the mode of fabric deformation during the simple test of fabric hand [1-4], it is expected that a correlation between the fabric hand force and seam pucker grade could be found. In this case the fabric hand tester shown in fig. 1 could be applied for quality control of fabrics used in the garment factory. Also this tester controls the suitability of fabric hand to the style of garment required (draping, anti-drape or fitting style).

2. Experiments for the relation between fabric hand and seam pucker

A series of practical tests has been carried out in one of the garment manufacturing companies on seven different fabrics [5], as shown in table 1. The seam pucker grade was measured using AATCC standard replica at the sewing processes of different parts of the garment. Then samples from each tested fabric were taken to measure the fabric hand force using the developed simple tester. The relationship between fabric hand and seam pucker grade was plotted and a good correlation was deduced (correlation factor R^2=0.94) as shown in fig. 2. This result shows that knowing the fabric hand force, one can predict the corresponding seam pucker grade. Thus, efforts, to avoid low seam pucker grade, can be made during sewing.

3. Experiments for kawabata evaluation

The same above seven fabrics were tested on kawabata instrument for the different fabric mechanical properties, (bending, shearing, surface roughness, compressibility, etc.) [6], and the seam pucker grade in the different fabric samples was tested. Five different tests were performed using Kawabata Evaluation System (KES), generating 17 different mechanical characteristics, namely tensile, shearing, bending, surface and compression.

Figs. 3 to 8 show the correlation between the seam pucker, fabric hand, and the individual fabric properties. As Expected, the correlations are not very strong, because fabric hand involves all the properties combined.

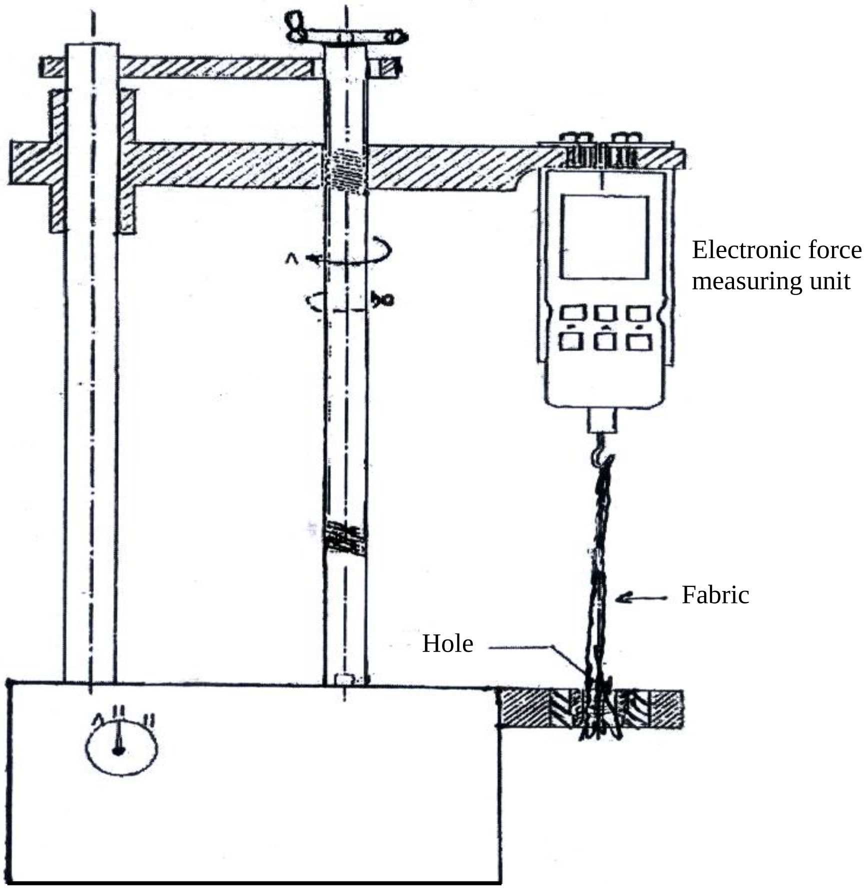

Fig. 1. Fabric hand tester with electronic force measuring device

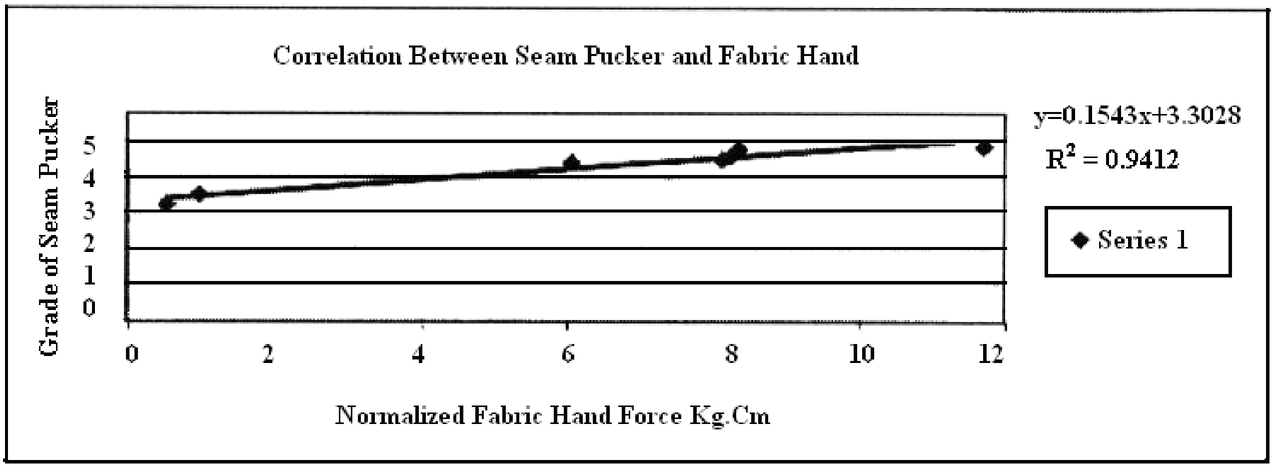

Fig. 2. Correlation between seam pucker and fabric hand force.

Table 1
shows the summarized results and comment on the highlights of the test results follow

Sample 1	Roughest surface (highest SMD) Less bendable, higher bending rigidity than most samples (high B)
Sample 2	Among the most bendable samples (low B) Among samples having the roughest surface (high SMD) More compressible than most samples (high RC)
Sample 3	Among the smoothest samples (low SMD) Higher shearing stiffness than most samples (high G) Low tensile extensibility (low EMT) but with high tensile resilience (high RT)
Sample 4	Thickest sample Highest bending rigidity(highest B) Among those with highest tensile extensibility (high EMT) Highest resilience in compression (highest RC)
Sample 5	Lowest shearing stiffness (lowest G) Highest surface friction (highest MIU)
Sample 6	Most bendable(lowest B) Highest shearing stiffness(highest G) Highest tensile extensibility (highest EMT) lowest tensile resilience (lowest RT) Also highest compressibility (highest EMC) with lowest resilience in compression (lowest RC) Lowest Surface friction (lowest MIU)
Sample 7	Thinnest and smoothest sample (lowest (SMD) Lowest tensile extensibility (lowest EMT) Least compressible (lowest EMC) Among most bendable o the fabrics(low B)

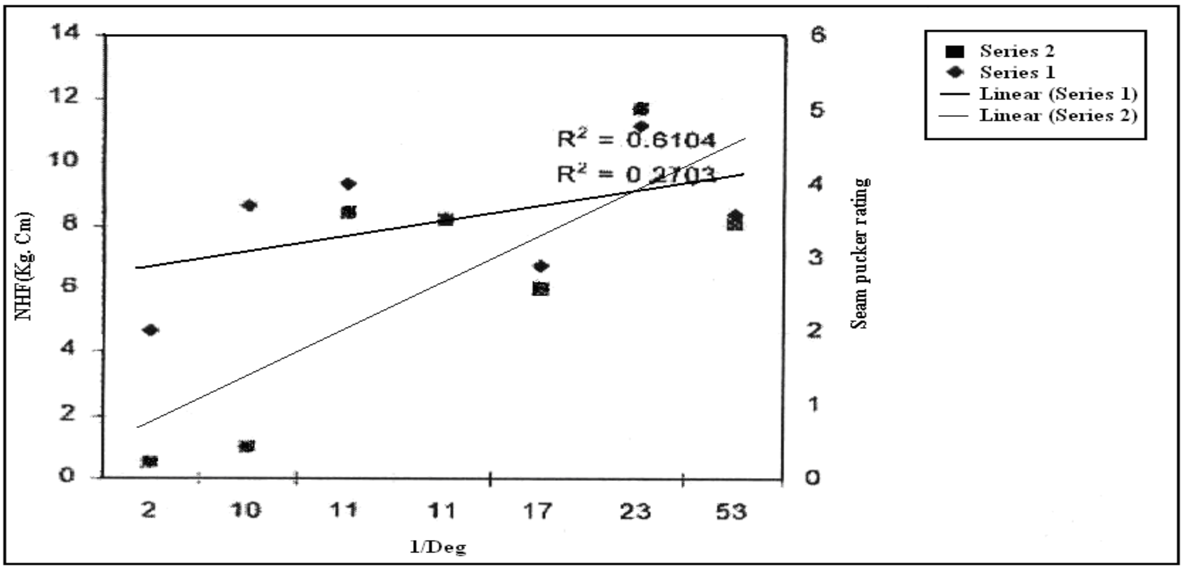

Fig. 3. Correlation between seam pucker, fabric hand force and compressibility.

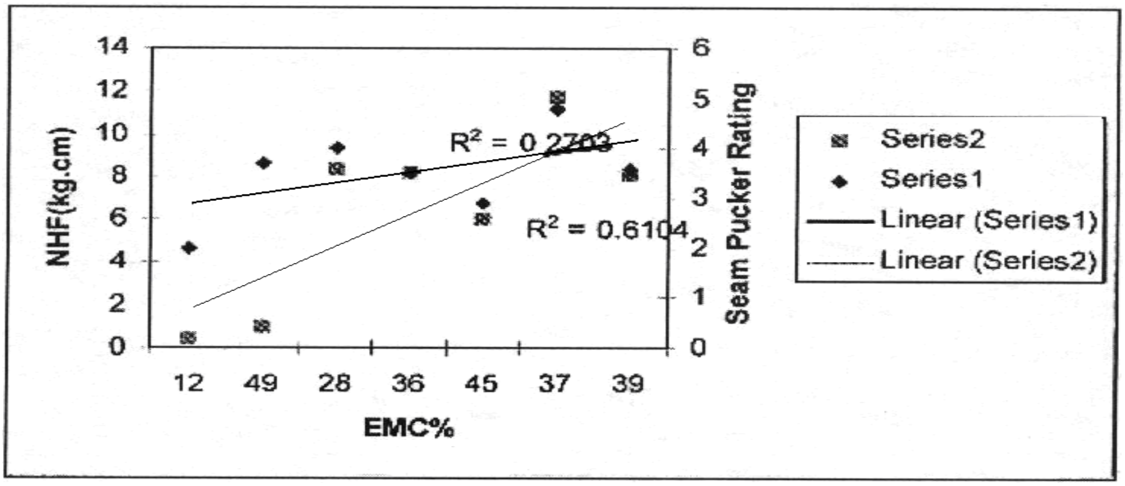

Fig. 4. Correlation between seam pucker, fabric hand force and shearing.

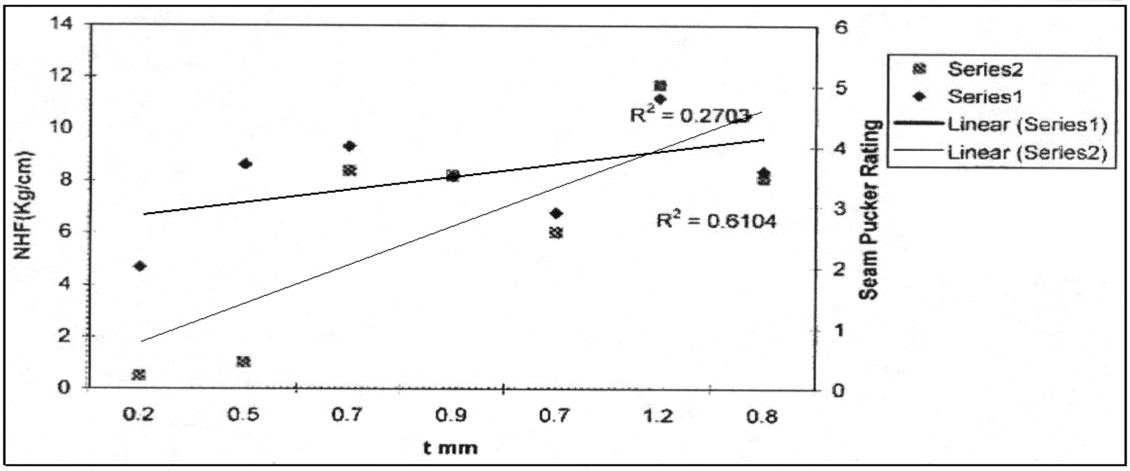

Fig. 5. Correlation between seam pucker, fabric hand force and fabric thickness.

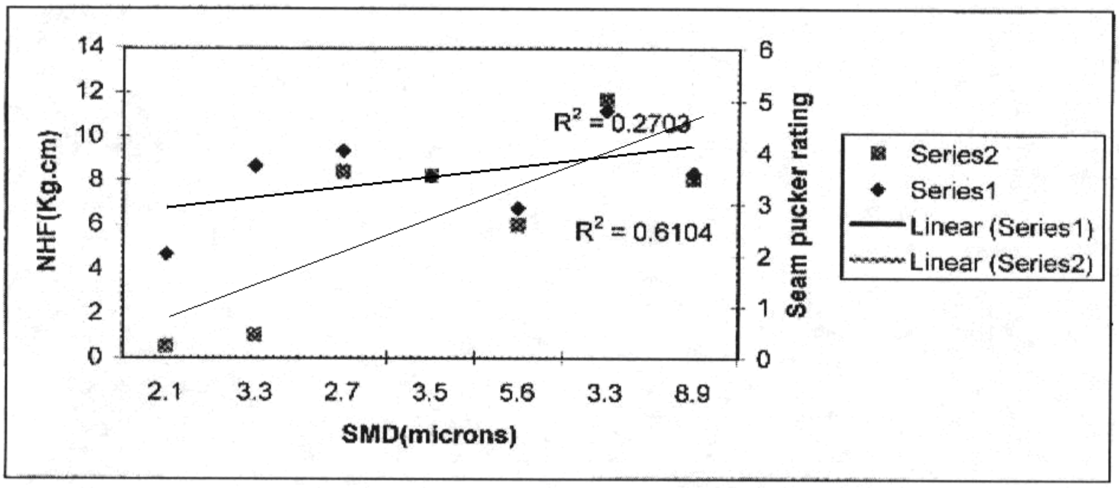

Fig. 6. Correlation between seam pucker, fabric hand force and fabric roughness.

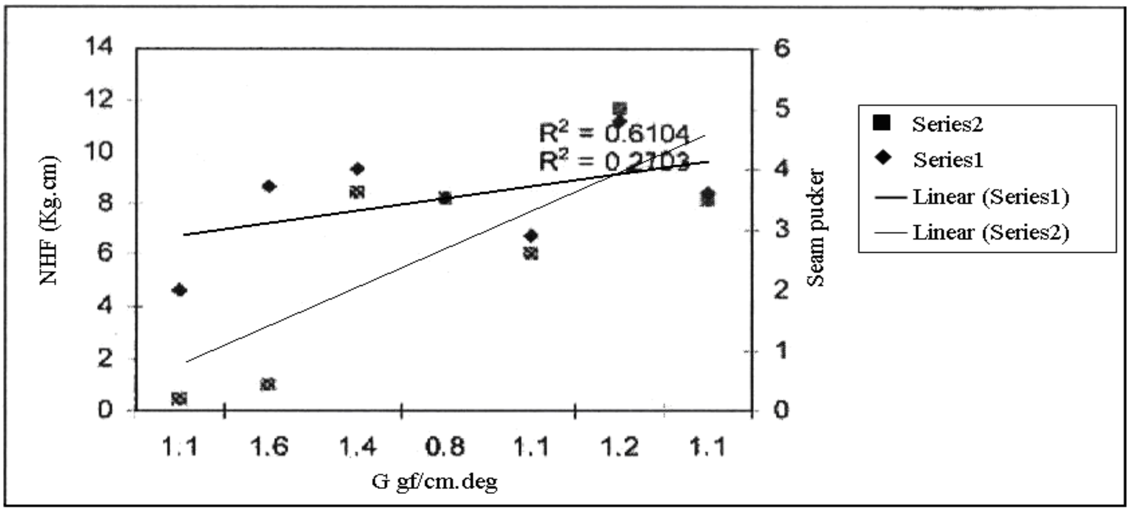

Fig. 7. Correlation between seam pucker, fabric hand force and shear thickness.

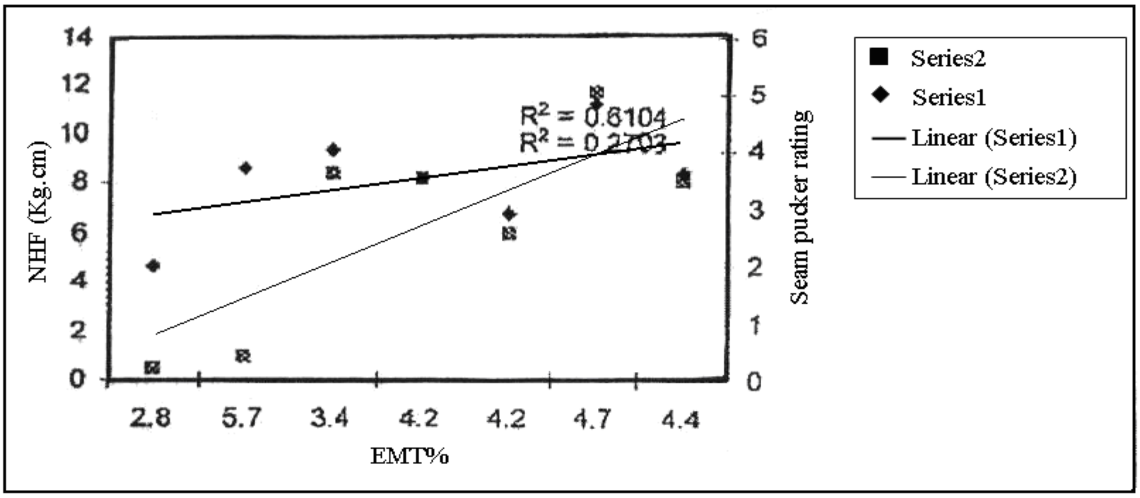

Fig. 8. Correlation between seam pucker, fabric hand force and fabric roughness.

4. Bending stiffness

Fabrics samples 2, 6 and 7 are the most bendable compared to the rest of the samples, and from the results of the seam pucker grade, these 3 fabrics also show the worst seam pucker grade. This could be explained by the effect of bending stiffness when the fabric is subjected to buckling due to differential feed of fabrics during sewing.

Fabric sample 4 shows the highest bending stiffness by Kawabata measurement. It, also, shows the highest seam pucker grade. This result agrees with the theory of seam pucker formation. The fabric with the high stiffness in bending resists the buckling to which it is subjected when the sewing stitch is inserted with the result that the fabric length between stitches on one fabric is longer than that on the other fabric sewn to it causing the seam pucker.

5. Shear stiffness

Fabric samples 5 and 7 shows lower shear stiffness than the other fabric samples, which contributed to lower seam pucker grade relative to the other fabrics.

6. Surface roughness

Kawabata measurements shows that fabric sample 7 has the lowest surface roughness compared to all the other samples, which contributed to the industrial test results showing the lowest seam pucker grade. The surface roughness is needed to minimize the fabric slippage and to decrease the differential feed of fabric during sewing, thus avoiding seam pucker.

7. Compressibility

Kawabata measurements show that fabric sample 7 has the lowest compressibility, relative to the other samples, and the industrial measurement of seam pucker in the sewing of this sample shows the lowest grade (2).

8. Fabric hand force as a substitute for the five mechanical properties of kawabata when using artificial neural network

An artificial neural network was applied by the author in a previous work [7] to predict the seam pucker rating for a group of fabrics during sewing process, using 15 properties individually measured by KES and fed into the ANN. When the specific hand force was used to replace 5 of the fabric properties, the accuracy of the network prediction obtained was essentially unchanged. This is a strong proof that the single value is equivalent to the five fabric properties. These fabric properties are: bending stiffness in warp and weft directions, shear rigidity, surface roughness and compressibility.

The good correlation between the ANN predicted seam pucker rating using the specific hand force and the values obtained by subjective evaluation show that the mechanism of fabric withdrawal through a hole involves the five properties mentioned above. This also means that there is a strong correlation between fabric hand force and the five Kawabata measurements as a group working together. This does not only Validate the test method developed, but also represents substantial saving in the testing effort to determine the probability of defects in processing of the fabric in garment manufacturing.

9. Conclusions

1. A correlation was found between the seam pucker grade measured in laboratory and the normalized fabric hand force measured by the simple tester (with the principle of withdrawing fabric specimen through a hole)
2. A correlation was found between the seam pucker grade measured in garment factory and the normalized fabric hand force measured by the simple test
3. A correlation was found between seam pucker values obtained by factory measurements and the corresponding values obtained by laboratory tests.
4. The mechanism of fabric withdrawal through a hole proved to be equivalent to the five fabric properties involved in assessing fabric hand by means of the KES of fabric hand, when these properties are used in Artificial Neural Network.
5. The new simple tester for fabric hand proved to be very effective in predicting the grade of seam pucker in the fabric during sewing in fabric manufacturing
6. Correlations were found between the fabric hand force measured by the new method and the fabric assessments obtained using the KES. This proves that the developed fabric hand tester is a simple substitute for kawabata group of testers for assessing the fabric hand quality in the garment factories. This new tester has also the advantage of indicating the grade of seam pucker in fabric manufacturing, so that optimization of sewing machine parameters could be applied to achieve high quality in garment manufacturing.

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