Research Paper

MODELING OF RELATION BETWEEN THE PARAMETERS OF THE TEXTILE PROCESS AND THERMAL COMFORT AND TOUCH OF THE END PRODUCT

Monia Kabbari1*, Adel Ghith1 and Faten Fayala1,2

*Corresponding Author: Monia Kabbari moniakabbari@yahoo.fr

In this paper, we present a decision tree model established to characterize the textile touch and the thermal comfort of knit materials that have sustained the treatment of scratching. The objective of the model is to appear the relations between the input parameters of the treatment of scratching such as characteristics of samples, number of passages and features of output parameters which are thermal comfort and touch. To confirm the results obtained by the model, we compared them to consumer’s opinions deducts from a questionnaire. The comparison showed a concordance between the rules of decisions trees established and the questionnaire results.

Keywords: Comfort, Decision tree, Modeling, Scratching, Touch

INTRODUCTION

For the textile industry, comfort properties of fabrics become more and more important especially in terms of thermal and touch characteristics. For this reason, several processes to improve the quality of fabrics have been completed. Among these processes we find scratching that has as objectives to improve the touch of fabrics and its thermal properties. The process can be considered as a complex system in which the input variables correspond to the adjustable process parameters and the output variables to the measurable features representing the product quality. In order to optimize the product quality, it is necessary to found a mathematical model characterizing the relationship between the input and output variables. Many research methods have been proposed. Pizzi and Pedrycz (2008) realized the classification of data by their separation. It is the supervised learning strategy which corresponds to a maximum separation between classes but the data in classes are compact. Suguraman et al. (2007) used the decision tree method. Liu et al. (2009) used the mutual information measure based method and the hyperbox generation based method was used.

1 Department of Textile, Monastir National School of Engineers, Monastir, Tunisia.
2 LESTE (Laboratory of Thermal and Energy Systems), University of Monastir, Tunisia.
by Thawonmas and Abe (1997). There also exists some works on unsupervised variable selection using conditional Gaussian networks like those of Zeng and Cheung (2009) and data clustering technical (Bandyopadhyay, 2005). Recently, some new variable selection methods have been developed using fuzzy techniques, such as a modified fuzzy decision trees with supervision (Chang et al., 2010), Xing and al proposed fuzzy model for input variable selection based on numerical learning data, Xing et al. (2003) and Alibi et al used in their works neural networks (Alibi et al., 2008). In our study, we choose the decision tree method because of its simplicity. It is a form of multiple variable analysis. It provides unique capabilities to supplement complement and substitute for:

- Traditional statistical forms of analysis (such as multiple linear regression).
- A variety of data mining tools and techniques (such as neural networks).
- Recently developed multidimensional forms of reporting and analysis found in the Fields of business intelligence.

Figure 1 presents an illustration of a decision tree.

**MATERIALS AND METHODS**

To lead well this survey, three samples with the same structure have been studied.

These samples are made of 100% cotton, 50% cotton/50% polyester and 50% cotton/30% polyester/20% acrylic. They are invisible fleece (Figure 2) and realized with the parameters presented in Table 1.

These samples have sustained the treatment of scratching. The only parameter changed was the number of passages. This treatment consists of extricate some fibers and fragment of yarns. The results permit to improve some features such as the touch and the thermal comfort.

**Figure 2: Stitch of Invisible Fleece Fabric**

**Table 1: Characteristic of Samples**

<table>
<thead>
<tr>
<th>Diameter (inch)</th>
<th>Gauge (E)</th>
<th>Metric number of ground yarn</th>
<th>Metric number of duffel yarn</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20</td>
<td>1/40</td>
<td>1/28</td>
</tr>
</tbody>
</table>

**EXPERIMENTAL METHODS**

Experimental measurements have been done to characterize the degree of improvement gotten. The properties chosen to measure are thickness, weight area, adiathermic power, air permeability and UST deformations.

This article can be downloaded from http://www.ijerst.com/currentissue.php
Thickness and Weight per unit area was measured according to the standards of ISO. Adiathermic property was measured using the apparatus of adiathermic power presented in Figure 3c according to AFNOR « NFG 07-107 ».

Air permeability was determined using Air Permeability Tester TEXTEST FX 3300 according to the standard ISO 9073.

And the UST deformations consist of the reproduce of the passage of human finger on a textile surface thanks to the geometry of a stiletto utilized this effect. These measurements were realized with the UST device (Universal Surface to Test), presented in Figure 3b, which is a device permitting to measure the microstructure of the textile surface. Features measured by this device are the permanent deformation, the elastic deformation and the visco-elastic deformation.

RESULTS

Table 2 presents the characteristics of materials before and after scratching.

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Where, P0 corresponds to zero passage, P1 one passage, P2 two passages and P4 four passages.

The analysis of the results obtained is presented following:

- The best thickness for the three knits is found in the passage 4.
- The best weight area for the three knits is achieved by the passage 4.
- The best air permeability for the three knits duffel is found in the passage 2.
- The most improved heat conductivity for the 100% knit cotton and for the PES/C one is in the passage 2, while for the multi-fibers, the adhiathermic power is better in the passage 4.
- The plastic distortion and the one elastic: the passage 4 is the best for the PES/C and multi-fibers knits, but for the sample made in cotton the passage 1 is the best.
Modeling

To model the phenomenon, we use the CHAID decision tree analysis. It is a tool of help at the decision and in the exploration of information. It permits to model simply, graphically and quickly a measured phenomenon more or less complex. Its legibility, its rapidity of execution and the few of necessary hypothesis has explained its present popularity.

Criterion of Segmentation

The first step of modeling is to define a table of contingency (Table 4) crossing the variable to predict and the describe candidate.

This table is obtained from the database created by the characteristics measured.

Table 3 presents our database with the notations used in decision tree (decrease (D), increase (A)).

After creation of the table of contingency, the next step corresponded to cross the attribute class in k modes and the describer candidate in L modes. An example of table was presented in Table 5. It was the table of crossing the attribute of thickness.
To value the pertinence of the variable in the segmentation, CHAID proposed to use the Khi-2 very known in statistic, whose formula is the following:

\[
x^2 = \sum_{k=1}^{K} \sum_{l=1}^{L} \left( \frac{nk_l - n_k - nl}{n} \right) \frac{n_k l - n_k l}{n} \quad \text{(1)}
\]

The criteria of Khi-2 vary from 0 at +∞. It is not easy to manipulate it because it favors the describers having a high number of modes. It is often better to normalize it by the number of degree of liberty, by using for example the t of Tschuprow whose domain of definition is [0; 1].

\[
t = \frac{x^2}{n \sqrt{(k-1)(L-1)}} \quad \text{(2)}
\]

Last stage of the construction of the tree is to affect a conclusion to every leaf of the tree that can be read like a rule of prediction of the type attribute-value “if premise then conclusion; (Ricco Rakotomalala, 2005).

**RESULTS AND DISCUSSION**

Seen that we treated the samples on the same machine, therefore we have the same diameter and the same gauge and also we have the same metric number, so we used like input parameters the number of passage and raw material.

After the construction of primary output trees that are thickness, air permeability, adiathermic power, breaking force, elastic deformation, we deducted the final output tree of the touch, the thermal comfort and deterioration.

We cite two examples of a decision tree of primary outputs, for example the tree of thickness since the most important result of scratching is the increase of this parameter and the tree of air permeability.

In following the way root leaf we can predict that for all the three knit studied:

1. If we have a number of passages equal to 2 then we have a gain in thickness.
2. If we have a number of passages equal to 4 then we have a gain in thickness.
3. If we have a number of passages equal to 1 then we have a gain in thickness.
The way root leaf indicates that for all the three knit studied:

1. If we have a number of passage equal to 1 or 2 then we have a loss in air permeability.
2. If we have a number of passage equal to 4; a 100% C knit or a PES /C knit then we have a gain in air permeability.
3. If we have a number of passages equal to 4 and a multifibers knit then we have a loss in air permeability.

After the elaboration of all decision trees of primary outputs we deduct the decision trees of final outputs as following:

**Decision Rules**

1. If we have a knit 100% Cotton, a number of passages equal to 2 and a middle gain in thickness and in elastic deformation, then we have a middle touch.
2. If we have a knit PES /C, number of passage equal to 4 and a high gain in thickness and in elastic deformation, then we have a middle touch.
3. If we have a multifibres knit, a number of passages equal to 4 and a high gain in thickness and in elastic deformation, then we have a good touch.

The decision rules are now predicted from the decision tree. Examples of rules are:

1. If we have a 100% Cotton invisible fleece knit, a number of scratching passage equal to 2 and a middle loss in air permeability with a high gain in the adiathermic power, then we have a middle thermal comfort.

2. If we have a PES/C invisible fleece knit, a number of scratching passage equal to 4 and a high loss in air permeability with a middle gain of the adiathermic power, then we have a good thermal comfort.

3. If we have a multi-fibers invisible fleece knit, a number of scratching passages equal to 2 and a middle loss in air permeability with a middle gain in the adiathermic power, then we have a good thermal comfort.

This objective evaluation was followed by a questionnaire which is based on the hand method. Persons asked are experts in the textile domain; they evaluate the quality of samples by their touch feeling. So the statistics showed these results:

- 90% notice that the best touch of the cotton invisible fleece fabric is found in passage 2.
- 70% notice that the best touch of the invisible fleece PES /C fabric is found in passage 4.
- 80% notice that the best touch of the multi-fibers invisible fleece fabric is found in passages 2.

While comparing the experimental results with those provided by the decision trees and the questionnaire, we note that the same interpretations are obtained:

- The best passage for the 100% cotton invisible fleece knit is the passage 2.
- The best passage for the 50% PES / 50% cotton invisible fleece knit is the passage 4.
- The best passage for the multi-fibers invisible fleece knit is the passage 2.

**CONCLUSION**

To evaluate the quality of the textile materials, two methods were presented, the objective one based on physical and mechanical measures and the subjective method based on a sensory analysis.

While elaborating models of decision tree compared with the results of a survey of the consumers’ preferences, we notice that the relation between the different input and output parameters is more visible. So to obtain a final character of a textile fabric at scratching, we fix the number of passage for a given material, what shows that the method of the decision tree is efficient to facilitate the tasks of the industrials.

This model helps the industrialists to choose the best parameters of manufacture without having recourse at several tests. But we can complete this work by a sensory analysis; it permits to answer to the need of industrials that are confronted to a type of touch that they must characterize in term of sensory and to represent at the screen a tactile sensation through the appearance.

**REFERENCES**


