Abstract

Fabric hand is the quality of a fabric assessed by the reaction obtained from the sense of touch. Fabric hand is the person's estimation when feeling fabrics between fingers and thumb. Assessment of a textile material obtained from the sense of touch is an essential consideration in fabric development and marketing. Technological developments have introduced new or modified non-conventional textile products like automotive textiles, home textiles, diapers, nappies etc. also known as specialty textiles. And the first assessment made of these new fabrics is that of hand. There are various existing technologies, techniques, and Kawabata hand equations available to determine hand for conventional textiles such as shirting, suiting, lady dress material etc. And these equations cannot be applied to the specialty textiles because the kind of stresses acting on these fabrics are completely different from those of apparel fabrics. Therefore, a driving force for the development of various approaches to determine hand of non-conventional textile products is rising due to increased demand of these products. Four specialty fabrics such as automotive car seat fabrics, bed linen fabrics, stretch fabrics, and denim fabrics were selected for development of hand evaluation system, as these fabrics account for a major market share in technical textile, home textile, comfort clothing, and denim clothing sectors respectively.

In this research, in the first section, the experiment was planned to determine the effect of weave design, spinning technology, yarn count, fabric construction parameters and post weaving treatment on the fabric hand. The influence of these parameters was studied on low-stress mechanical properties such as bending, shear, compression, tensile, and surface properties. Different approaches were studied that can be used to develop hand evaluation systems for textile fabrics. So that these approaches can further be utilized to develop hand evaluation system for specialty fabrics. The different approaches used were subjective, experimental, computational, and artificial neural network.

The computational approach was used to develop the primary and total hand equations. And the artificial neural network was used to determine the hand values of specialty fabrics. The suitability of the already existing Kawabata hand equations (experimental equations) using primary hand values similar to the specialty fabrics' primary hand values was also checked. For validating the results, the correlation coefficient was determined. The computational approach uses the multiple stepwise block regression method. The first step in the computational approach is the subjective assessment of the fabrics and the primary attributes. For this purpose, the judges/experts were selected from the field relating to the shortlisted products (bed linen, denim etc.) such as manufacturing field, product development, quality assurance, academics, etc. Technical experts in respective fields, middle commercial professionals, and actual users of the fabrics were considered. Using systematic statistical methodologies and questionnaires, the role of various mechanical stresses and their respective weightage in generating hand equations was determined.

The subjective assessment of fabrics was conducted by a panel of judges to identify the primary hand attributes and the related mechanical parameters playing an important role in the fabric hand evaluation of the specialty fabrics. The primary hand expression was identified along with their weightages. The coefficient of concordance was determined to find out the agreement among the judges and to check the reliability of the subjective hand results. The Kawabata Evaluation System (KES) was used to evaluate the low-stress mechanical properties of the fabrics. In the second step, the low-stress mechanical properties were regressed with the subjective primary hand values. The order of blocks was obtained according to their importance to the primary hand values. The regression process continues till the order of importance of each block was determined. Thus, a linear equation was obtained for predicting objective primary hand values. The translation equation from PHV to THV will follow the same regression method. The obtained primary hand values were regressed with the subjective total

hand values. The sequence of importance of the primary attributes blocks was obtained. And thus, the coefficients were obtained for the primary and total hand equations.

In the artificial neural network method, the multi-layered feed-forward back-propagation trained neural network was used. Training is an important feature of neural networks. The objective of the training process is to minimize the squared error between the network output and the desired output. All neurons in the next layers are connected to each other, and the output neuron has no forward connection to another layer. After building a model, the model was trained for predictive analysis, where it develops an understanding of how output parameters were influenced by input factors. The data points are separated into two groups: a train set and a test set. A training set and a test set were used to train the model and to test it for unknown data and prediction. The number of epochs is the number of times this process is repeated. A larger number of epochs will take longer, but it will also improve the accuracy of present data.

After testing the model, authentication of the model was done by determining the correlation coefficient and grand mean error percentage. The model architecture and parameters are modified if there are no noteworthy outcomes in the model. In this research, the low-stress mechanical properties were chosen as inputs to the neural networks. The output layer had one node total hand values of the specialty fabrics. It was observed that the THV obtained using the computational approach were the most correlated with the experimental values followed by artificial neural network values. In comparison to the experimental values, the computational model is highly correlated with subjective values. It depicts that the computational values more accurately portray and grasp consumer preferences, which is a critical part of hand evaluation.

In this research, an attempt was made to develop an objective method of fabric hand evaluation of automotive car seat fabrics to engineer, design and produce good quality car seat fabrics. Five primary hand attributes such as conformability, smoothness, softness, flexibility, and

stretchability were defined and considered for car seat fabrics. Computational method was used to develop primary and total hand equations for car seat fabrics. From consumer point of view, smoothness got the highest weightage in the survey. Conformability a new primary attribute included that plays an important role in the evaluation of THV. The surface properties and shear properties have the greatest influence on the THV followed by bending and compression properties for car seat fabrics.

A computational method was also developed for the prediction of hand value of the bed linen fabrics by using stepwise block regression method. The objective evaluation of fabric hand would contribute to engineering and developing the bed linen fabrics that offers maximum comfort while sleeping. The four primary hand properties such as soft feeling, smoothness, fullness, and stiffness were defined and considered for the bed linen fabrics. The experimental total hand values were also determined by using existing hand equation for futon's cloth and the statistical approach was applied to investigate the correlation between subjective, experimental, and computational total hand values. An excellent correlation of 0.89 was found between the subjective and computational total hand values. And the moderate correlation of 0.77 was found between subjective and experimental hand values. The friction, roughness, and compression were the dominant factors as they are involved in the real dynamics of bed linen use.

Performance index is an estimation of how well a product works to meet its defined goals. Performance of bed linens depends on many factors such as fabric dimensional parameters, comfort related transmission behavior, hand value and aesthetic properties. Therefore, a committee comprising academia and industry experts were involved to find out what else could be considered to determine the performance of the bed linen fabrics and an effort has been made to develop a standard equation to evaluate the Bed Linen Performance Index (BLPI)

objectively. The fabric properties considered for BLPI were total hand value, one-way transport capacity, abrasion resistance, air permeability, pilling resistance, crease recovery angle, thermal resistance, and drapability.

Stretch woven textiles are widely employed because of their excellent elongation and recovery properties. The stretch fabrics used in this research can be used as action stretch sportswear fabrics. Computational and artificial neural network models were developed to predict total hand value of stretch fabrics. Five primary hand attributes such as softness, smoothness, fullness, stiffness, and stretchability were defined and considered for stretch fabrics. Stretch% was also included along with low-stress mechanical properties to predict primary hand values. The correlation between subjective, computational, and artificial neural network total hand values was investigated using a statistical method. The prediction accuracy of both the models was found to be very high. The study finds that both the models can predict the total hand value of stretch materials with a tolerable level of accuracy.

Denim fabrics has become a wardrobe staple due to its versatility to be worn in a variety of fashions. In this research, denim fabrics were studied to understand their unique hand by developing hand evaluation system using computational method. Also, the effect of various washes like enzymatic, bleach, acidic, and stone wash were also studied on the hand behavior and surface morphology of denim fabrics. Five primary hand attributes such as softness, smoothness, fullness, flexibility, and stretchability were defined and considered for denim fabrics. Due to its basic material and structure, denim fabrics are sometimes associated with drawbacks such as poor insulation and cooler sensations. Therefore, the Q_{max} and thermal conductivity were also considered as the primary attributes for estimation of total hand value. The subjective and computational hand values without thermal characteristics had a correlation of 0.85. And a correlation of 0.88 was found between the subjective and computational hand

values with inclusion of thermal properties. This indicates that the thermal properties also play a significant role in determining the hand of the denim fabrics. It was observed that the enzymatic wash fabric has the highest total hand value followed by the acid, bleach, and stone washed fabrics.

Thus, it could be stated that the major stresses on these specialty fabrics were being identified under real-world dynamics and the hand evaluation systems for these specialty fabrics were developed using various approaches. This hand evaluation system tool helps to facilitate the construction of new specialty and high-quality fabrics as per consumer requirement. The total hand value of the specialty fabrics could be estimated well using the developed equations and can be utilized by the fabric manufacturers, product development and quality assurance for development of new specialty products.