CHAPTER 1

INTRODUCTION

1.1 THE BACKGROUND OF THIS RESEARCH WORK

Researches have been done on handle characteristics of textiles, as well as comfort characteristics more in the former and less in the latter area of study. Interestingly, a few are underway for comprehensive evaluation of these characteristics. To bring handle and comfort property on a common ground, modeling is necessary by choosing a few important properties. In this regard, Total Hand Value (THV) as determined by Kawabata Evaluation System (KES) is of immense help in representing handle characteristic of a woven or knitted fabric irrespective of the material used.

Thermal Insulation Value (TIV) represents thermal insulation, resulting in cool touch feeling and warm feeling to body, for a fabric meant for apparel or technical textile. Moisture Vapor Transport is yet another characteristic important for comfort and thus the prime characteristics, namely, THV, TIV and Transport of moisture (MT) can well define the combination of handle and comfort. Other secondary characteristics representative of handle are drape, bi-axial stress relaxation, tensile relaxation, tensile modulus, crease recovery to mention a few. Similarly, in the case of comfort the secondary characteristics are air-permeability or breathe-ability, wicking height (or liquid water transport) and both these together represent as major entities for thermal and hygral comfort. It gave rise to the ‘evolution’ of ‘3T models’ in the present work, by taking into
consideration a combination of three prime or secondary variables which are mutually independent measures.

The impetus for research in this subject arose because of its practical and physical significance to fabric manufacturers, processors and last but not the least, the marketers and consumers. A fabric potentially having excellent handle or drape need not necessarily be comfortable. More often than not, a fabric having good handle may apparently have poor comfort. Hence, a comprehensive evaluation is essential to remove the predicament due to contradicting requirements in quality of a fabric. A well balanced fabric meeting both the above requirements forms the choice for a consumer in getting premium quality; and on the part of a manufacturer, premium price.

1.2 RESEARCH OBJECTIVES

The main objectives of this research work are:

- To develop ‘Cool Finish’ using hydrophilic polyvinyl acetate and hydrophilic polyester emulsion on eco-friendly bleached woven cotton fabrics, to impart high TIV and moisture transport coupled with soft handle.

- To develop ‘Lotus Finish’ using fluoro-alkyl emulsion with soft finish surfactant (silicone softener) on bleached woven cotton fabrics.

- To develop ‘Lotus plus Cool Finish’ using fluoro-alkyl emulsion with cross-linking and soft finish agents to impart multi-functional characteristics on five bleached and five dyed woven fabrics.
- To evaluate handle characteristics from KES and thermal and moisture transport characteristics from Thermo Lobao (Model II)
- To design and develop Bi-Axial Stress relaxation Tester (BAST) to evaluate tensile modulus for various types of finished woven cotton fabrics.
- To evolve statistical regression models for comprehensive evaluation of handle and comfort characteristics.
- To measure and study the variation of the effluent load in terms of Total Dissolved Solids (TDS) and other parameters for different bleaching processes.
- To measure the total dissolved solids (TDS) and other effluent characteristics for the eco-friendly Sodium Perborate (SPB) bleaching agent.

1.3 METHODOLOGY TO ACCOMPLISH THE PRESENT RESEARCH

To achieve the above research objectives, fabric samples were produced starting from grey cotton fabric of light & medium weight and construction of plain weave using statistical sample size (n=6). The scoured fabrics were subjected to bleaching operations involving three types of bleaching agents (H₂O₂, SPB and enzyme) and their combinations at three concentrations (corresponding to half, three-fourth and full bleach whiteness). The bleached fabrics were dyed for one other trial. These bleached and dyed fabrics were given finishing treatments by Pad-dry-cure technique at optimized concentration (20 gpl) and standardized operational parameters. Thus ‘Cool’ finished, ‘Lotus’ finished and ‘Lotus plus Cool’ finished fabric samples were developed and evaluated by conducting different characteristic
tests. The test results were statistically analyzed and conclusions have been drawn.

1.4 THE ORGANIZATION OF CHAPTERS

Chapter 2 deals with Literature Review in which the advances in functional textiles, multi-functional textiles, nano-finished textiles, technical textiles, have been covered. The current research studies on comfort and handle characteristics have been reviewed.

Chapter 3 deals with Materials and Methods, in which the various materials including chemicals and reagents used for the experiments and the methods used for investigations are detailed.

Three types of fabric substrates (A, B & C) of light or medium weight (Range of 110-150 gsm) and plain construction were used for woven fabric samples. For all the experiments 100% cotton yarn of 40s Ne was used for the woven fabric samples.

The design of experiments is as per the titles of studies listed below and these are covered sequentially in Chapters 4 to 9.

Study 1: Development of ‘3T Models’ and comfort evaluation of ‘Cool’ finished cotton fabrics. Substrate A was used to prepare sixteen (16) woven bleached and finished fabric samples (medium weight).

Study 2: Comfort characteristics of woven cotton fabrics finished with fluoro-alkyl Nano-‘Lotus Finish’. Substrate B was used to prepare three (3) woven finished fabric samples (light weight).

Study 3: Development of ‘Lotus plus Cool’ finish using fluoro-alkyl emulsion with cross-linking and soft finish agents to impart multi-
functional characteristics. This was done on five bleached and five dyed woven fabrics for the end use of apparels and technical textiles. Substrate C was used to prepare eight (8) finished fabric samples (medium weight).

Study 4: Studies on conventional bleached, bio-scoured and bio-bleached cotton fabrics finished with nano- ‘lotus’ finish and ‘lotus plus cool’ finish. Substrate B was used to produce twelve (12) bleached and finished fabric samples (light weight).

Study 5: Designing and development of Bi-Axial Stress elongation and relaxation Tester (BAST) to evaluate tensile modulus for various types of finished woven cotton fabrics.

Study 6: Statistical Regression and Computerized models for objective and subjective evaluation of handle and comfort characteristics. Subjective assessment and correlation and comparison with instrumental test data was accomplished in this work.

Chapter 4 deals with the preparation of ‘Cool’ finished fabric samples, testing and analysis of test results.

Chapter 5 deals with the preparation of ‘Lotus’ finished fabric samples, testing and analysis of test results.

Chapter 6 deals with the multi-functional characteristics of ‘Lotus plus Cool’ finished cotton apparel fabrics.

Chapter 7 deals with the comparative studies on conventional bleached, bio-scoured and bio-bleached cotton fabrics finished with nano-‘Lotus’ finish and ‘Lotus plus Cool’ finish. It presents innovative measurement of ‘total handle related function’, by name ‘handle weight ratio
(HWR)’ and ‘Net Positive area’ (NPA) equal to HWR’ through a scientific construction using ‘octagonal diagram’, explained in Chapter 9.

Chapter 8 deals with the development of a Bi-Axial Stress elongation and relaxation Tester (BAST) for testing the elongation and stress relaxation simultaneously in warp and weft directions at low stress of 500gf and below. This condition of test simulates the normal wear condition, so that results are practically accurate.

Chapter 9 deals with ‘Programmed’ solutions that have been developed from Artificial Neural Network (ANN) models using twenty types of fabric samples. It also deals with the evolving of ‘3T’ models for comparison with objective and subjective results on seventeen types of fabric samples in which seven and ten fabrics respectively finished by ‘Cool’ and ‘Lotus plus Cool’ finish are analyzed using ‘Octagonal Diagram’ and ‘Correlation matrix’.

Chapter 10 deals with summary and conclusions of the research studies.

1.5 THE IMPORTANCE OF 3T MODELS

New expression for fabric comfort characteristics was evolved and it is named as ‘3T’. It can be beneficially used for accurate estimation, comparison, simulation, and prediction of an unknown fabric’s grade and rank from a selected eight of the KES test variables. It involves ‘3T’ measured from five different estimation procedures such as the following:

From THV obtained from KES, as given below:

$$3T_1 = (THV) + a_1 (TIV) + a_2 (MT)$$  \hspace{1cm} (1.1)
From Tensile Modulus (TM) derived from KES:

Thus, \(3T_2 = (TM)_{KES} + a_1 (TIV) + a_2 (MT)\)  \hspace{1cm} (1.2)

From Tensile Modulus (TM) derived from INSTRON:

Thus, \(3T_3 = (TM)_{INS} + a_1 (TIV) + a_2 (MT)\)  \hspace{1cm} (1.3)

From Bi-Axial Stress Elongation and Relaxation tester (BAST):

Thus, \(3T_4 = (TM)_{BAST} + a_1 (TIV) + a_2 (MT)\)  \hspace{1cm} (1.4)

From Net Positive Area (NPA) of ‘Octagonal Diagram’:

\[3T_5 = (NPA)_{KES} + a_1 (TIV) + a_2 (MT)\]  \hspace{1cm} (1.5)

Two prime variables TIV and MT are constants in the ‘3T’ expression, while the average of five estimations of the third prime variable, being highly correlated to THV gave accurate determination of ‘3T’. Hence, ‘3T’ can be used as an index for ‘comfort quality’ for grading, ranking, comparison and standardization purposes.

\textbf{1.6 SUMMARY OF THE PROGRESS MADE IN THE PRESENT RESEARCH WORK}

Developments have been achieved in the eco-friendly bleaching process using SPB, Enzymes and their combinations with H\(_2\)O\(_2\). Bleach effluent characteristics of these bleaching processes have been studied. The degradation mechanism of bleaching processes has been controlled and the low-stress mechanical characteristics of bleached fabrics have been improved to give better comfort and handle properties.
The ‘Lotus’, ‘Cool’ and ‘Lotus plus Cool’ finished fabrics have been developed and evaluated for their end uses as apparel. Multi-functional characteristics have been incorporated through development of ‘Lotus plus Cool’ finished fabrics and these characteristics have been evaluated.

Regression and Computerized ‘3T models’ have been evolved for comprehensive evaluation of handle and comfort using Artificial Neural Network, Image Processing and Statistical techniques.