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Evaluation of Fabric Comfort Quality by Novel Test Methods and Grading & Ranking Techniques

S Viswanaath[1], P Lakshminarayana[2], J Hayavadana[3], T Ramachandran[4]
[1]Principal, Vishnu Lakshmi College of Engg. & Tech., Coimbatore, Tamil Nadu
[2,3]Professors, University College of Engg. & Tech., Osmania University, Hyderabad, Andhra Pradesh
[4]Principal, Karpagam Institute of Technology, Coimbatore, India

Abstract- *Two novel methods of evaluation of 'Fabric Comfort Quality' (FCQ) for preparing standard test reports in the newly designed format are presented and the methods are based on eight '3T ' values and 'Octagonal Diagram'. A newly evolved software takes care of the computations and arrives at the overall '3T ' of the tested fabric for low stress mechanical, thermal and moisture transport properties. In the present research paper two PVA - finished fabrics of commercial origin are compared for their ' Grades and Ranks ' and their test results obtained using new testing instruments are also presented.*

I. INTRODUCTION

Our goal in the present research work is to simulate the usual assessment of standard fabrics in a novel way by scientific testing procedures those are different from the present in principle as well as in application. New expression for fabric comfort characteristics was evolved and named as '3T' (1,2). In the extension to the previously reported work, in this report '3T' measured from eight different estimation procedures is illustrated. The eight estimates are given in Table 1, and these served towards delivering a single value of '3T'. This was obtained by constructing an 'octagonal diagram' plotted from 'computerized 3T-models' using suitable mathematical formulae described in Section II of this article. The differences in the new methods of testing fabrics can be noticed from Table 1 titled as '3T 'values, given in next section. A set of eight mathematical expressions lead to a novel quality evaluation system (QES) for 'fabric comfort quality '(FCQ) that can be used for the evaluation of comfort characteristics of a cotton or a blended fabric. The eight mathematical expressions are developed on the basis of the '3T' models (A). The eight mechanical properties (B) tested and used for evaluation of a cotton/blended fabric are as follows: Tensile Modulus (TM1) measured Uni-axially on Instron; Tensile Modulus (TM2) measured Bi-axially on Bi-Axial Stress & Strain Tester (BASS); Maximum Tensile Elongation (TE%); Tensile Relaxation (TR%) and Frictional coefficient (MIU) at a load of 500g measured on BASS; Compression Resilience (CR%) at a load of 500g measured on DST; Drape (DR%); Bending Rigidity (BR%) measured on combined Drape & Stiffness Tester (DST). Area (A1) of 'Octagonal Diagram' (C1) is estimated from B drawn to scale in the form of an 'Octagonal Diagram' (C1). This is representative of the total hand value of the fabric under concern. The eight '3T' estimates are also plotted in the form of 'Octagonal Diagram' designated as (C2) by using a similar formula (given in section 2.4) and the Area (A2) is obtained. The square root of (A2) is representative of the average 3T - value of the fabric chosen for evaluation of comfort characteristics. From these overall values of '3T' of Fabric- A and Fabric-B, the 'Grades' and 'Ranks' are arrived.

II. Materials & Methods

Cotton plain woven fabric, with 2/40s Ne warp count, 40s Ne weft count, 96 ends / inch and 74 picks / inch and 122g/m^{2}gsm was

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used. Non-ionic PVA based micro-emulsion was procured from Resil Chemicals, Tirupur, and finishing treatment was given to impart durable handle characteristics to the fabric, after pretreatment with silicone softener. Fabric A was bleached – finished fabric with 15gpl PVA, whereas, Fabric B was bleached –finished fabric with 25 gpl concentration of PVA finish.

Two instruments shown in Fig.1a&1b, for testing, i.e. BASS and DST were designed and fabricated by the first author of this research work. The Tensile Elongation and Relaxation (TE and TR %), Drape (DR %) and Bending Rigidity (BR %) were estimated by principles which are different from the existing (3). In the BASS, the Tensile Modulus was measured by taking the average of maximum tensile elongation % in the two perpendicular directions along warp and weft after applying a load of 500gram and using the formula, TM = Load (Kg) /Elongation%. Similarly, TM was measured by using the same formula, on Instron in uni-axial condition of the fabric. The two fabric samples, A & B, six in number each, (statistical sample size of n=6 was used) with PVA finish of 10 –30 gpl concentration range were subjected to various mechanical property evaluations and analytical studies. Similar conditions were adopted for testing the thermal and moisture transport properties on Thermo-labao model-II. The test results were statistically analyzed and conclusions were drawn.

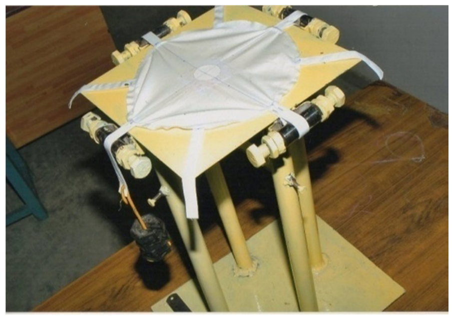

Fig 1. (a). Newly developed bi-axial stress & strain tester (BASS)

Fig 1. (b). newly developed drape & stiffness tester (DST)

Table 1. '3T' Models

Tensile Modulus (TM) from Instron	Bi-Axial Stress & Strain Tester (BASS)	Drape & Stiffness Tester (DST)
$3T1= (TM1)_{INS} + a_1 (TIV) + a_2 (MT)$ (1.1)	$3T2= (TM2)_{BASS} + a_1 (TIV) + a_2 (MT)$ (1.2) $3T3 = (TE\%)_{BASS} + a_1 (TIV) + a_2 (MT)$(1.3) $3T4 = (TR\%)_{BASS} + a_1 (TIV) + a_2 (MT)$(1.4) $3T5=(MIU)_{BASS} + a_1(TIV)+a_2(MT)$ (1.5)	$3T6 = (CR\%)_{DST} + a_1 (TIV) + a_2 (MT)$ (1.6) $3T7=(100/DR\%)_{DST} + a_1 (TIV) + a_2 (MT)$ (1.7) $3T8=(100/BR\%)_{DST} + a_1 (TIV) + a_2 (MT)$ (1.8)

Note:a_1= 1.5 and a_2 = 10, are the constants obtained from the statistical regression analysis of each of the three variables.

Computation of Area of Octagonal Diagram (8 sides) from 'Radial line' distances

In the 'Octagonal Diagram' (OD) the eight variables will have to be taken in a cyclically fixed order as per the sequence of mathematical expressions, and accordingly, $a_1$to a_8 are the following: TM1,TM2,TE,TR, MIU, CR,DR, BR. These form the octagonal diagram, in which the tested parameters occupy the radial lines (not sides) of the OD.

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Area of Octagonal Diagram = $1/2\sqrt{2}[a_2(a_1+a_3) + a_4(a_3+a_5) + a_6(a_5+a_7) + a_8(a_7+a_1)]$ (1)

III. Results & Discussion

The various remarks on results obtained are tabulated in Tables 2&3 and the discussion of the same follows.

Table 2. Low-stress mechanical, thermal and moisture transport properties

S.No.	Property	Fabric - A	Fabric - B	Remarks (Refers to Fabric-B)
1	TM1 a_1	0.31	0.312 - 3.0 cm	Same tensile modulus (+ 0.65 % diff.)
2	TM2 a_2	0.33	0.332 - 3.0 cm	Same tensile modulus (+ 0.6 % diff.)
3	TE% a_3	1.52	1.51 - 3.0 cm	Same extensibility (-0.66 % diff.)
4	TR % a_4	41.8	40.8 - 2.9 cm	Lesser tensile resilience (-2.4 %)
5	MIU a_5	0.136	0.134 - 2.96 cm	Less smoothness (-1.4 7 %)
6	CR % a_6	52.5	42.6 - 2.4 cm	Less compression resilience (- 18.9 %)
7	DR % a_7	70	72 -3.1 cm	Lower drape (- 2.86 %)
8	BR % a_8	72	74 -3.1 cm	Higher bending stiffness (+ 2.8 %)
9	TIV % (tog)	69.5% (0.695)	67.5% (0.675)	Lower thermal insulation value (- 2.9 %)
10	MT g/m^2/day (s)	1092 (0.0126)	1090 (0.0126)	Same moisture transport (- 0.18 % diff.)

3.1. Analysis of C1 - Ref. FIG. 2. (a)

The eight low stress mechanical properties were plotted in the Octagonal Diagram, C1. The figures in the FABRIC - B column beside the main parameter represent the radial line lengths for C1 of Fabric - B. It is clear from C1 that fabric - B occupies lesser area and also it is found that fabric - B has lower magnitude of compression resilience (CR%) and all other seven values were nearly the same to that of fabric - A. This accounted for lower THV of 3.24 for fabric – B as against 3.30 for fabric - A.

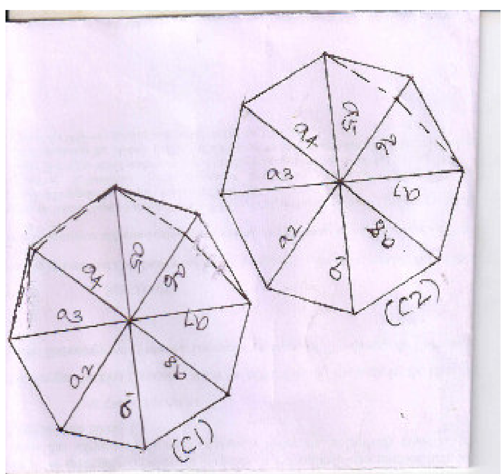

Fig. 2. (a) Octagonal Diagram (C1) – eight handle parameters
Fig. 2. (b) Octagonal diagram (C2) ; eight '3T' values.

Table. 3. Eight '3T' Values & Results of C1 & C2

S.No.	Property	Fabric - A	Fabric - B	Remarks (Refers to Fabric-B)
1	3T1 (a_1)	0.7835 - 3 cm	0.7760 - 3 cm	Equal FCQ
2	3T2 (a_2)	0.8035 - 3 cm	0.7960 - 3 cm	Equal FCQ
3	3T3 (a_3)	1.9935 - 3 cm	1.974 - 3 cm	Equal FCQ
4	3T4 (a_4)	42.30 - 3 cm	41.26 - 3 cm	Equal FCQ
5	3T5 (a_5)	0.61 - 3 cm	0.60 - 3 cm	Equal FCQ
6	3T6 (a_6)	53.0 - 3 cm	43.0 - 2.4 cm	Less FCQ
7	3T7 (a_7)	1.90 - 3 cm	1.85 - 3 cm	Equal FCQ
8	3T8 (a_8)	1.862 - 3 cm	1.815 - 3 cm	Equal FCQ

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9	SR - A1- FIG.2. (a)	55.83	54.80	Diff. in handle: (- 1.84 %); Ratio of THVs = 1.019.
10	SR - A2- FIG.2. (b)	9.41	8.79	Diff. in fabric comfort quality: (- 6.6 %); Ratio of 3Ts = 1.07.

3.2. Analysis of C2 - Ref. FIG.2. (b)

The eight '3T' values were plotted in the form of Octagonal Diagram; C2.The figures in the FABRIC- B column beside the main parameter represent radial line lengths for C2 of Fabric-B. It is clear from C2 that fabric - B occupied relatively less area compared to fabric - A and thus it accounted for slightly lower '3T6', in view of lower value for compression resilience, CR%.

Overall fabric - B was having nearly the same objective and subjective handle property compared with fabric -A, as revealed by Octagonal Diagram (C1) in terms of A1 shown in Fig.2. (a) and in terms of A2 in Octagonal Diagram (C2) for the eight different estimates of the '3T' values shown in Fig.2. (b). This investigation suggests that an intelligent and sustainable evaluation method or system which assures to deliver more prudent results of fabric handle quality and fabric comfort quality is essential for especially commercial purposes, as well as for standardization purposes. It is worthwhile to mention here that fabric-B, the bleached – 25 gpl PVA finished fabric has subjectively equal, functionally equal but significantly (- 6.6 %) lower fabric comfort quality (FCQ) compared with the bleached – 15 gpl PVA finished fabric- A. This conclusion of the present investigation suggests the importance of '3T' evaluation.

The Grading of fabrics is by relative basis and if for Fabric – A, 10 points are considered as the Grade, then Fabric – B will have 9.34 as its Grade. Fabric – A has Rank 1 and Fabric – B has Rank 2 in the order of FCQ.

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