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OBJECTIVE MEASUREMENT OF FABRIC HANDLE

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ABSTRACT

A manual fabric handle-meter has been developed based on the idea of withdrawing a circular fabric specimen through a suitable hole and measuring the maximum withdrawal force. The instrument has been used to measure the specific handle force, for a group of commerical fabrics used for light dressing, and it has been found that it has a high significant correlation to the subjective ranking of fabric handle. Another group of fabrics specially designed to study the effect of some fundamental specifications of yarn and fabric on fabric handle. Also the effect of finishing operations on fabric handle has been measured. The developed handle-meter has proved to be sensitive enough to detect any change in fabric handle caused by any change in technological parameters.

I. INTRODUCTION

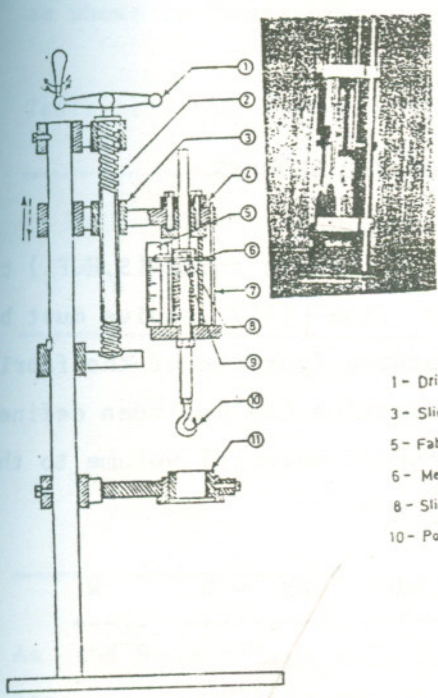
Fabric handle is one of the most important properties to evaluate fabric comfort which influences its acceptance and utility of gramment. In fact fabric handle is a fundamental aspect upon which the fabrics are generally sold. Although fabric handle can be judged by human hand, it is a subjective judgment, and it is necessary for objective insumental measurement for quantitative comparitive values of fabric handle. This quantitative evaluation eleminates personal error, and gives accurate values especially for quality control laboratories and warehouses.

In the field of quantitative measurement of fabric handle Sheta [1] developed a method to measure the "specific handle force" using an attatchment on the Instrone tester. It consists of a disc with a hole through which a circular fabric specimen is withdrawn from its centre (the same principle of the present developed tester). Also Alley [2] used a nozzle through which the fabric sample was extracted by the Instron tester, and a "hand modulus" was calculated.

Matsue and others [3] discribed a system for measuring fabric hand using an equation relating the basic mechanical properties of the fabric and the sensory defferential limen to fabric hand. Kobayashi [4] applied the technique of information theory to classify the fabric handle by logical symbols by selecting four factors, namely; flexibility, compressibility, extensibility and resilience as physical factors of fabric handle. Kawabata and others [5] established a relationship between fabric handle and its mechanical properties such as tensile, bending, shearing, compression, surface characteristics, weight and thickness. They developed a KES-F systems to measure these properties and transfer the data to determine the total hand using a formula designed to reflect the subjective hand as close as possible. Behery [6] compared the fabric hand assesment by Alley [2] method and Kawabata [5] method and deduced that there is a fairly good agreement between the quantitative values obtained.

II. PRINCIPLE OF THE MANUAL FABRIC HANDLE-METER

Figure (1) shows the construction of the fabric handle-meter.



1- Driving wheel 2- Power screw
3- Sliding nut 4- Spring balance hohder
5- Fabric withdrawal hook
6- Metalic ring 7- Scale
8- Sliding indicator 9- Fixed rod
10- Pointer 11- Balance spindle collar

Fig. (1) The manual fabric handle-meter

It consists mainly of a power screw (2) which can be rotated by the driving wheel (1). The rotation of the power screw (2) moves the sliding nut (3) upward or downward according to the direction of rotation. The spring balance holder (4) is fixed to the sliding nut (3) and moves with it. The upward movement of the spring holder (4) is used to withdraw the circular fabric specimen from its centre by hook (10) through the metallic ring (11); as illustrated in photo. The maximum resisting force to the withdrawal of the fabric specimen can be read on a scale (5) by the sliding indicator (6) which slides on the fixed rod (7) and is pushed by the pointer (8) protruding from the balance spindle collar (9) when the specimen passes totally the ring, and the force drops to zero. The balance scale is calibrated in grammes according to the stiffness of the used spring.

III. REPRESENTATION OF THE RESULTS

For measuring the fabric specific handle force (S.H.F.) to compare different fabrics, the ring (11) radius must be selected to satisfy a certain packing fraction of the fabric inside the ring. The packing fraction (B) has been defined [7] as the ratio of the maximum fabric material volume to the ring hole volume.

Therefore;
$$B = \frac{2\pi (R - H/2)\, H\, W/\rho}{\pi R^2 h\, H} = \frac{2R - H}{\rho} \cdot \frac{W}{R^2 h}$$

Where : R is the fabric specimen radius, in cms.;

R_h is the hole radius , in cms.;
H is the hole height , in cms.;
W is the fabric weight , in $gms./cm^2$;
ρ is the fabric fibre material density, in gms/cm^3

The specimen size and the hole height are kept constant (R 12.5 cms & H=2 cms) and take the fibre density as 1.5 $gms./cm^3$ for cotton. If (B) has a constant value for all the fabrics, thus it will require a certain ring hole radius for each fabric weight (W) which is not practical. The packing fraction (B) must have a certain range (from 18 % to 36 %) to insure nearly the same mechanism of fabric deformation in all cases and avoid fabric jamming at higher value of (B) or slipping at lower value of (B). Thus there is a suitable ring hole radius for each range of farbric weight as shown in Table (1).

Table (1): The suitable hole radius (R_h) for each fabric

Hole radius (R_h mms.)	The approximate range of fabric weight (w $gms./m^2$)		
5	30	:	58
7	58	:	116
10	116	:	234
14	230	:	460

As the hole radius will change, thus the hole inside surface area (A cm^2) will change and will affect the value of the fabric handle force (H.F.) as the frictional area between the withdrawal fabric and hole will change. Thus for obtained a comparitive fabric specific handle force (S.H.F.), irrespective to the value of the packing fraction (B) and the hole surface area (A), it must divide the fabric handle force (H.F) by the packing fraction (B) and the area (A cm^2).

$$S.H.F. = \frac{H.F.\ (gms.)}{B\ A\ (cm^2)} \qquad gms./cm^2.\ \text{hole area.}$$

IV. COMPARISON BETWEEN THE SUBJECTIVE AND OBJECTIVE HANDLE

The subjective fabric handle has been done on fifteen commercial light dressing fabrics with different finish by using the paired-comparison method [9] of ranking assessment (the detailed specifications of each fabric are given in Table (2). Thus 105 pairs have been presented to seven persons, skilled in textile trade, to judge them. Each judge ranked fifteen pairs only to prevent the effect of fatigue on the results. As the judge can be influenced by the colour of the fabric a simple screen has been arranged so that the fabric cannot be seen but can be handled freely. The results of the subjective ranking test of the fabric handle are recorded in Table (3). The coefficient of the cosistency is found to be equale to 0.95 which means that the judges in the test are in very close agreement with each other . Also it shows a good measure of consistency in judging the fabric handle subjectively by the skilled textile trad persons. The ranking handle score (R.H.S.) to each fabric has been taken as the results of the subjective testing of the fabric handle. The same fabrics have been tested objectively by using the developed apparatus and the fabric specific handle force (S.H.F) has been taken as the objective fabric handle.

Table (2)
Fabric Specifications & Properties

Sample No.	$P_1 \times P_2$ / $N_1 \times N_2$	yann matl.	weave design	fabric finish	fabric measured properties: wt. gm/m^2	thick. mm.	dens gms/cm^3	drape coeff %	S.H.F gms/cm^2
1	58x28 / 120x120D	Viscose	plain	grey	120.0	.209	.578	92.59	1612
2	-	-	-	Bleached	118.3	.188	.629	56.11	1208
3	-	-	-	Dyed	128.3	.186	.690	49.84	910
4	-	-	-	Printed	135.7	.182	.746	39.79	606
5	21x20 / 14/1x14/1	Cotton	-	Grey	210.3	.448	.469	97.51	1310
6	-	-	-	Dyed	200.3	.390	.514	64.55	705
7	38x30 / 50/1x50/1	33%C 67%P	-	-	101.6	.177	.574	66.96	900
8	19x28 / 40/1x40/1	35%c 65%Tergal	-	-	128.2	.197	.651	82.99	1100
9	42x36 / 210/2x210/2D	Silk	-	Bleached	75.3	.090	.837	54.00	469
10	47x46 / 30x30D	Nylon	-	Dyed	36.3	.090	.403	78.31	860
11	46x48 / 30/1	Cotton	Rib Knitted	Grey	230.5	.677	.340	56.11	1169
12	-	-	-	Bleached	239.5	.685	.350	41.76	630
13	36x55 / 16/1	-	-	Grey	168.0	.528	.318	26.56	1489
14	-	-	-	Yellow Dye	190.0	.593	.320	24.75	828
15	-	-	-	Blue Dye	227.0	.703	.323	25.91	1300

Where: P_1 = ends/cm., P_2 = picks/cm., N_1 = warp count, N_2 = weft count &
S.H.F = the fabric specific handle force.

The correlation coefficient between the subjective fabric handle (R.S.H.) and the objective fabric handle (S.H.F.) is 0.89 which is highly significant with more than 99 % confidance limit. This shows that the developed method of objective measuring of fabric handle is a good substitute for

Table (3)
Subjective Fabric Handle Test

Sample No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	S RHS	f	f²	SHF
1	--	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	-6	36	1612
2	1	--	0	0	1	0	0	0	0	1	1	0	1	0	1	6	-1	1	1208
3	1	1	--	0	1	0	1	1	0	1	1	0	1	1	1	10	3	9	910
4	1	1	1	--	1	1	1	1	0	1	1	0	1	1	1	12	5	25	606
5	0	0	0	0	--	0	0	0	0	0	1	0	1	0	0	2	5	25	1310
6	1	1	1	0	1	--	1	1	1	1	1	0	1	1	1	12	5	25	705
7	1	1	0	0	1	0	--	1	0	1	1	0	1	0	1	8	1	1	900
8	1	1	0	0	1	0	0	--	0	1	1	0	1	0	1	7	0	0	1100
9	1	1	1	1	1	0	1	1	--	1	1	1	1	1	1	13	6	36	469
10	1	0	0	0	1	0	0	0	0	--	1	0	1	0	0	4	-3	9	860
11	1	0	0	0	0	0	0	0	0	0	--	0	1	0	0	2	-5	25	1169
12	1	1	1	1	1	1	1	1	0	1	1	--	1	1	1	13	6	36	630
13	1	0	0	0	0	0	0	0	0	0	0	0	--	0	0	1	-6	36	1489
14	1	1	0	0	1	0	1	1	0	1	1	0	1	--	0	8	1	1	828
15	1	0	0	0	1	0	0	0	0	1	1	0	1	1	--	6	-1	1	1300

Where: S = sum = R.H.S. = Fabric Subjective Ranking Handle Score;
S.H.F. : Fabric Objective Specific Handle Force ;

$$f = S - \frac{n-1}{2} \; ;$$

n = number of samples = 15 ;

$$T = \Sigma f^2 = 266 \; ;$$

$$T_{max} = \frac{n^3 - n}{12} = 280 \; ;$$

$$d = \frac{T_{max} - T}{2} = 7 \; ; \text{ and Therefore :}$$

$$\text{Coeffiecient of Consistency } \zeta = 1 - \frac{d \times 24}{n^3 - n} \quad \text{(for odd numbers)}$$

$$= 0.95$$

the subjective ranking method and should be preferred because of its accuracy and it saves personal error and time. Figure (2) shows the relationship between the specific handle force (S.H.F.) and the subjective ranking handle score (R.H.S.); this relationship can be expressed by the following emperical formula: R.H.S. = - 0.0115 S.H.F. + 18.5574

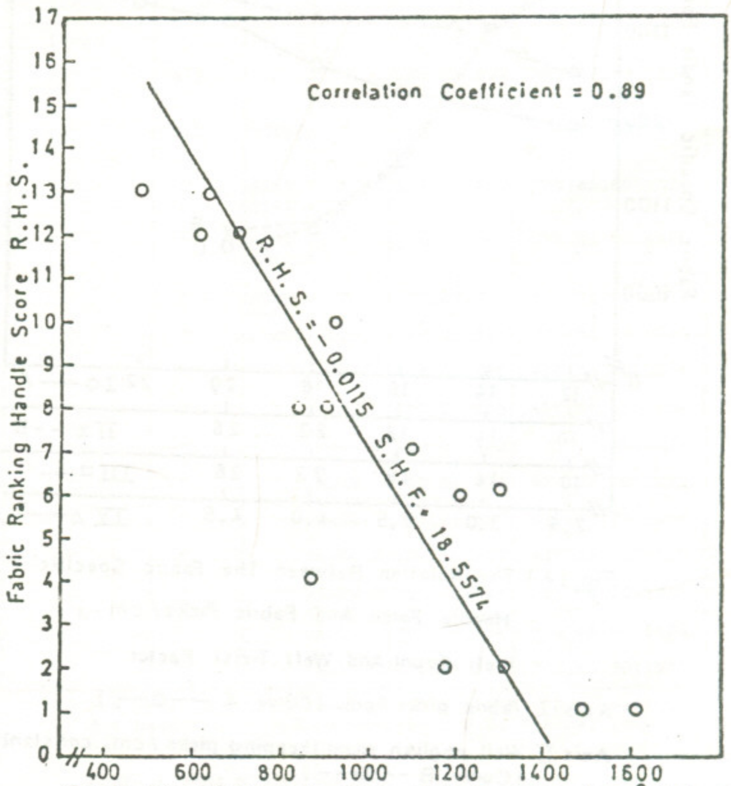


Fig. (2) The Correlation Between The Specific Force And The Ranking Score Of Fabric Handle

From this formula it is clear that the smallest value of S.H.F. has the highest score that is to say the best fabric handle.

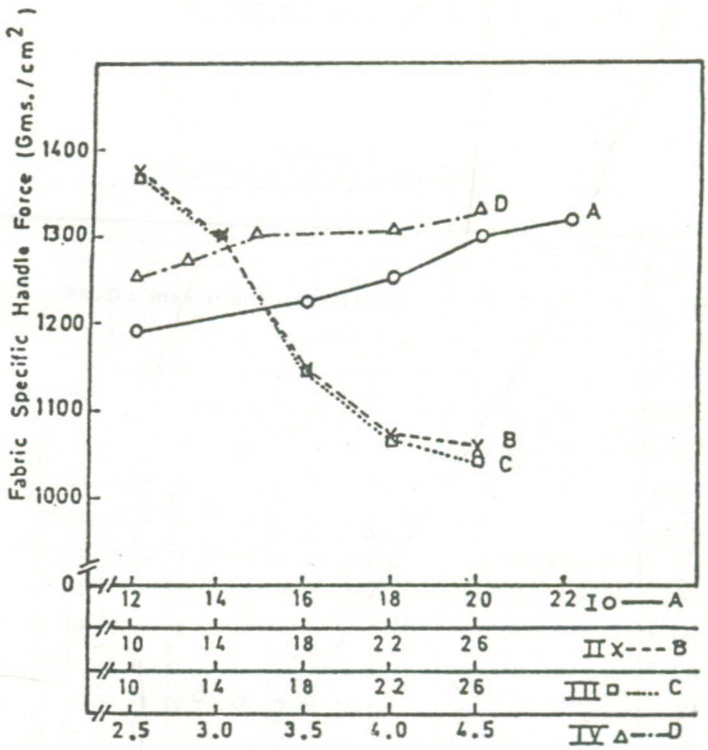


Fig. (3) The Relation Between The Fabric Specific Handle Force And Fabric Picks/cm., Weft Count And Weft Twist Factor

Axis: I Fabric picks/cm. (Curve A ——o——)

Axis: II Weft english count (keeping picks/cm. constant) (Curve B ---X---)

Axis: III Weft english count (changing picks/cm. to keep fabric cover factor constant) (Curve C ·—□—·)

Axis: IV Weft twist factor (Curve D —·—Δ—·—)

V. PRACTICAL APPLICATION

In this investigation thirty one samples of fabric have been

Table (4) cont.

Sample No.	$\frac{P_1 \times P_2}{N_1 \times N_2}$	weft twist factor	weft matl.	weave design	fabric measured properties: wt. gm/m^2	thi-ck. mm.	dens gms/cm^3	drape coeff %	S.H.F gms/cm^2
16	$\frac{20 \times 20}{14 \times 14}$	4.0	100%C	plain	202.0	.432	.468	81.40	1302
17	-	4.5	-	-	200.0	.424	.472	83.40	1324
18	-	3.2	100%P	-	221.0	.441	.501	86.80	1370
19	-	-	65%P, 35%C	-	218.0	.432	.505	85.00	1338
20	-	-	50%P, 50%C	-	208.0	.442	.471	83.00	1318
21	-	-	35%P 65%C	-	207.0	.441	.469	81.80	1302
22	-	-	100%C	8h.S.	208.0	.521	.399	52.30	1114
23	-	-	-	1/7T.	204.0	.490	.416	54.00	1134
24	-	-	-	4/4T.	205.0	.500	.410	54.90	1166
25	-	-	-	$\frac{3\ \ 1}{2\ \ 2}$T	203.0	.482	.421	55.30	1250
26	-	-	-	4x4B.	200.0	.472	.424	56.80	1233
27	-	-	-	2x2B.	201.1	.450	.447	60.70	1254
28	-	-	-	4-4W.R	204.5	.452	.452	63.00	1320
29	-	-	-	2-2W.R	206.2	.454	.454	64.50	1347
30	-	-	-	H.C.	207.0	.540	.383	66.00	1478
31	-	-	-	M.L.	199.7	.510	.392	63.80	1530

Where : P = polyester , C = cotton , S = satin , T = twill , B = basket , W.R. = warpril , H.C. = honey comb , H.L. = mock leno.

$P_1 x P_2$ = ends x pick/cm .

$N_1 x N_2$ = warp x weft English count ,

and S.H.F = Specific handle force.

woven of warp count 14/1 cotton and 20 ends/cm., while the weft yarns are varied in count, twist, picks/cm. and the percentage of cotton and polyester blend, also the weave design differs. Detailed specifications of each fabric are given in Table (4). Another group of a fifteen commertial fabrics of different material and finish (which have been tested subjectively in Table (3)) has been selected with the detailed specifications given in Table (3) to show the

Table (4)
Fabric Specifications and Properties

Sample No.	$\frac{P_1 \cdot P_2}{N_1 \cdot N_2}$	weft twist factor	weft matl.	weave design	fabric measured properties: wt. gm/m^2	thick. mm.	dens gms/cm^3	drape coeff %	S.H.F gms/cm^2
1	20x12 / 14x14	3.2	100%C	plain	196.0	.411	.477	76.75	1191
2	20x16 / 14x14	-	-	-	200.0	.410	.488	77.95	1224
3	20x18 / 14x14	-	-	-	204.0	.420	.486	79.50	1248
4	20x20 / 14x14	-	-	-	206.7	.432	.478	80.30	1300
5	20x22 / 14x14	-	-	-	216.9	.432	.502	83.50	1320
6	20x20 / 14x10	-	-	-	228.1	.451	.506	86.43	1380
7	20x20 / 14x18	-	-	-	202.9	.451	.450	78.80	1149
8	20x20 / 14x22	-	-	-	186.5	.460	.405	77.30	1079
9	20x20 / 14x26	-	-	-	170.0	.452	.376	76.35	1060
10	20x16 / 14x10	-	-	-	210.4	.443	.475	85.40	1368
11	20x22 / 14x18	-	-	-	209.3	.441	.475	81.20	1145
12	20x24 / 14x22	-	-	-	195.4	.432	.452	76.85	1077
13	20x26 / 14x26	-	-	-	182.8	.430	.425	76.00	1040
14	20x20 / 14x14	2.5	-	-	208.0	.432	.481	75.40	1252
15	20x20 / 14x14	2.8	-	-	207.8	.442	.470	78.80	1268

effect of finishing operations. The fabric specific handle force (S.H.F.) has been measured by using the developed apparatuse. Also the fabric stiffness represented by the fabric drape coefficient and the fabric density (from its weight per unit area and thickness) have been measured as they are the most important fabric properties which affecting the fabric handle [5 and 8].

V.1. Effect of Pick Density

It is clear from Figure (3), curve (A), that increasing the pick density increases the fabric specific handle force. This can be due to the increase of the fabric bending resistance, as it is clear in the increase in the fabric drape coefficient as shown in Table (4).

V.2. Effect of Weft Yarn Count

From the analysis of the results given in Table (4) for the fabric of different weft yarn counts it is clear that the finer the yarn; keeping the number of picks/cm. the same; the lower is the fabric drape coefficient is and in turn it leads to a lower value of specific handle force, as shown in Figure (3) curve (B). Figure (3) curve (C) indicates the same effect although the same number of picks/cm. changes for each weft count to keep the fabric cover factor the same. This indicates that the finer yarn count has a considerable lower value of the fabric specific handle force irrespective to the yarn spacing. This is due to the lower stiffness of fine yarns.

V.3 Effect of Weft Yarn Twist Factor

From Figure (3) curve (D) it is clear that the fabric specific handle force slightly increases with the increase weft twist factor. This may be attributed to the high yarn stiffness at high twist level, which in turn increases fabric stiffness and resistance to bending.

V.4. Effect of Fabric Weave Design

From Table (4) it is clear that the fabric weave design has an effect on the specific handle force, keeping all other parameters the same. The longer the float length in the fabric weave, the more ability of the fabric to bending and folding occurs. Consequently this leads to lower fabric drape coefficient and specific handle force as in the 8 harness satin. This is because the longer floats give less number of intersection points between the warp and weft yarns in the fabric; thus they allow the yarns to move freely and reduce the resistance to bending and folding.

V.5. Effect of Fabric Finshing

Table (2) shows samples of grey fabric and other samples of the same fabric with different finish. It is clear that the fabric finish improves the fabric handle as it is shown by the decrease in the drape coefficient and specific fabric handle. This may be due to the chemical ingredients in the final finish of the fabrics to increase the aesthetic properties of the fabric by improving its handle to be acceptable as apparel fabrics.

VI. CONCLUSION

It is clear from the results of the developed apparatus in measuring the fabric handle quantitatively that this method is found to be subistitute the traditional objective ranking method and it is better because it is sensitive, quick and accurate. It is also saves time, avoids personal error and give quantitative comparative value of fabric handle. Also the developed method is sensitive enough to discover any change in the fabric handle due to any change in the technical specification of the yarn, fabric or finshing. Thus it is an accurate and simple method for design the fabric with certain specifications to give the required acceptable fabric handle to suit each end use and give a comfortable using of the apparel fabrics.

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