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# Changes in Fabric Handle Resulting from Different Fabric Finishing

**Abstract**
*A method of calculating the general handle factor (GHF) of a woven fabric was developed on the basis of mechanical parameters determined at small stresses with the use of an Instron tension-tester. The influence was estimated of such factors as the kind of finishing, raw material, weft density, and weave of the fabric on the value of the general handle factor (GHF) as calculated according to the proposed procedure. From the analysis of tests, it results that raw woven fabrics are characterised by the lowest value of GHF factor, whereas woven fabrics with elastomeric finishing have the highest GHF factor value; this is in accordance with the assumption accepted in the planning phase of the experiments. When considering the type of weave, fabrics with twill and combined weave are characterised by the best handle, whereas those with a plain weave by the worst. The highest values of the GHF factor were obtained for fabrics with the lowest weft density.*

**Key words:** *handle, woven fabric, general handle factor, weave, finishing, mechanical parameters.*

## Introduction

The mechanical parameters which influence the handle of woven fabrics can be determined with the use of KES-F (Kawabata Evaluation System for Fabrics) apparatuses, FAST (Fabric Assessment System for Textiles) apparatuses, and Instron tension-testers [1-4]. Kawabata proposed that a given fabric can be estimated on the basis of two factors calculated from mechanical parameters determined by the KES-F system: the Total Hand Value (THV) which expresses the general handle value, and the Total Appearance Value (TAV) which determines the fabric's appearance. The fabric's formability coefficient, which is defined as the ratio of bending rigidity to the initial modulus, can be calculated on the basis of results obtained by the FAST system. As of this writing, a summarised factor, which would be the measure of the fabric's handle based on objectified instrumental research with the use of an Instron tension-tester, has not been developed. Only a graphic multi-axial system for presenting the data which characterise a flat textile product has been elaborated; in this system, every quantity measured by the Instron tension-tester is presented on an individual axis [5,6].

The present work aims at approaching the elaboration of a general woven-fabric handle factor on the basis of the mechanical parameters obtained by an Instron tension-tester. It should be emphasised that the solution presented is the first such regarding this question, and that no similar analysis or discussions could be found in the research works published up to now which describe the problem considered.

## Experimental

25 variants of raw woven-fabrics were prepared, from which 10 cotton fabrics manufactured from OE and ring spun yarns with a linear density of 20 tex, and 15 fabrics from classical combed cotton/PES blended yarns of differing polyester fibre content (33%, 50%, and 67%). The test programme was planned in such a way that the fabrics were additionally differentiated by weave (plain, twill, and combined) and by weft density. All variants of the fabrics manufactured are specified in Table 1.

The raw fabrics were finished by means of two types of finishing: normal starch finishing (S) (in general applied for bed linen), and elastomer finishing (E) used for fabric improvement. In this way, in general, 75 fabrics were investigated. The finishings mentioned above were selected at the experiment planning phase; the intention was to select those kinds of finishing which could ascertain the differentiation of the fabric's handle after processing, and also a significant difference in the handle after finishing in comparison with that of raw fabrics. The mechanical properties of all fabrics listed in Table 1,

***Table 1.*** *List of fabric variants.*

| Percent of cotton | Weave | Density, dm$^{-1}$ | Fabric No | | |
|---|---|---|---|---|---|
| | | | raw (R) | starch (S) | elastomeric (E) |
| 100% OE | plain | 220 | 1 | 26 | 51 |
| | | 270 | 2 | 27 | 52 |
| | | 320 | 3 | 28 | 53 |
| | combined | 320 | 4 | 29 | 54 |
| | twill | 320 | 5 | 30 | 55 |
| 100% | plain | 220 | 6 | 31 | 56 |
| | | 270 | 7 | 32 | 57 |
| | | 320 | 8 | 33 | 58 |
| | combined | 320 | 9 | 34 | 59 |
| | twill | 320 | 10 | 35 | 60 |
| 67% | plain | 220 | 11 | 36 | 61 |
| | | 270 | 12 | 37 | 62 |
| | | 320 | 13 | 38 | 63 |
| | combined | 320 | 14 | 39 | 64 |
| | twill | 320 | 15 | 40 | 65 |
| 50% | plain | 220 | 16 | 41 | 66 |
| | | 270 | 17 | 42 | 67 |
| | | 320 | 18 | 43 | 68 |
| | combined | 320 | 19 | 44 | 69 |
| | twill | 320 | 20 | 45 | 70 |
| 33% | plain | 220 | 21 | 46 | 71 |
| | | 270 | 22 | 47 | 72 |
| | | 320 | 23 | 48 | 73 |
| | combined | 320 | 24 | 49 | 74 |
| | twill | 320 | 25 | 50 | 75 |

***Table 2.*** *Mechanical properties of fabrics; weave: P - plain, C - combined, T - twill; the Table 2 is composed of two parts: Table 2a and Table 2b.*
***Table 2a.***

| Property | Unit | Warp / weft | CO 100% OE | | | | | CO 100% | | | | | CO 33% / PES 67% | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | P-22 | P-27 | P-32 | C-32 | T-32 | P-22 | P-27 | P-32 | C-32 | T-32 | P-22 | P-27 | P-32 | C-32 | T-32 |
| Finish | | | Raw | | | | | | | | | | | | | | |
| Width | cm | | 154.0 | 153.2 | 152.8 | 152.2 | 151.7 | 153.8 | 152.8 | 152.2 | 152.2 | 151.7 | 153.2 | 152.2 | 150.3 | 151.1 | 150.8 |
| Number of threads per 1 dm | | warp | 316 | 317 | 318 | 321 | 321 | 319 | 321 | 322 | 323 | 322 | 318. | 319 | 321 | 327 | 329 |
| | | weft | 229 | 284 | 333 | 332 | 327 | 230 | 283 | 335 | 331 | 329 | 238 | 294 | 357 | 321 | 311 |
| Crimp of threads | % | warp | 6.5 | 7.3 | 10.1 | 5.1 | 2.8 | 6.5 | 6.1 | 8.3 | 4.4 | 2.7 | 6.7 | 6.4 | 9.3 | 4.1 | 2.3 |
| | | weft | 5.3 | 6.0 | 7.7 | 8.0 | 7.1 | 5.5 | 6.3 | 6.9 | 7.0 | 6.7 | 5.2 | 6.2 | 8.0 | 7.9 | 7.3 |
| Mass per square meter | g/m$^2$ | | 123.5 | 135.8 | 147.3. | 145.0 | 140.7 | 123.4 | 135.4 | 147.8 | 145.4 | 143.5 | 134.4 | 150.4 | 153.0 | 147.9 | 144.1 |
| Thickness | mm | | 0.33 | 0.32 | 0.32 | 0.38 | 0.40 | 0.32 | 0.32 | 0.33 | 0.39 | 0.41 | 0.32 | 0.32 | 0.33 | 0.39 | 0.38 |
| Finish | | | Starch | | | | | | | | | | | | | | |
| Width | cm | | 142.0 | 141.5 | 141.0 | 141.5 | 140.7 | 140.0 | 140.1 | 140.1 | 140.8 | 140.5 | 141.4 | 139.8 | 139.3 | 140.6 | 141.8 |
| Number of threads per 1 dm | | warp | 343 | 345 | 344 | 342 | 345 | 344 | 345 | 345 | 343 | 345 | 341 | 343 | 347 | 344 | 341 |
| | | weft | 226 | 275 | 326 | 331 | 332 | 223 | 272 | 312 | 316 | 320 | 229. | 281 | 316 | 304 | 308 |
| Crimp of threads | % | warp | 3.3 | 4.2 | 4.6 | 2.7 | 1.7 | 2.7 | 3.5 | 3.8 | 2.4 | 1.5 | 4.2 | 4.9 | 5.0 | 2.9 | 1.8 |
| | | weft | 9.1 | 9.3 | 10.3 | 8.5 | 8.6 | 7.6 | 8.4 | 9.4 | 8.2 | 8.6 | 7.4 | 8.1 | 9.6 | 9.3 | 8.8 |
| Mass per square meter | g/m$^2$ | | 114.3 | 126.0 | 137.57 | 135.4 | 136.1 | 116.1 | 128.5 | 137.09 | 135.8 | 136.4 | 123.9 | 139.4 | 144.9 | 142.7 | 139.9 |
| Thickness | mm | | 0.26 | 0.28 | 0.32 | 0.34 | 0.33 | 0.28 | 0.28 | 0.31 | 0.35 | 0.36 | 0.28 | 0.32 | 0.30 | 0.39 | 0.40 |
| Finish | | | Elastomeric | | | | | | | | | | | | | | |
| Width | cm | | 141.7 | 141.0 | 140.4 | 140.0 | 139.5 | 141.1 | 140.1 | 139.8 | 139.9 | 139.0 | 140.8 | 140.2 | 139.5 | 139.9 | 141.3 |
| Number of threads per 1 dm | | warp | 342 | 344 | 343 | 347 | 345 | 342 | 347 | 346 | 352 | 348 | 344. | 344 | 346 | 346 | 342 |
| | | weft | 225 | 274 | 305 | 307 | 311 | 227 | 278 | 308 | 318 | 318 | 229 | 281 | 316 | 320 | 329 |
| Crimp of threads | % | warp | 4.8 | 5.6 | 5.7 | 3.5 | 2.3 | 4.2 | 4.5 | 5.1 | 3.3 | 2.1 | 3.8 | 4.5 | 5.7 | 3.2 | 1.8 |
| | | weft | 8.2 | 9.1 | 10.0 | 9.7 | 10.0 | 9.5 | 10.2 | 11.3 | 10.7 | 11.5 | 8.4 | 8.8 | 9.5 | 9.4 | 8.9 |
| Mass per square meter | g/m$^2$ | | 115.9 | 127.3 | 136.4 | 134.8 | 136.8 | 116.3 | 130.1 | 137.8 | 139.5 | 139.3 | 120.9 | 134.6 | 148.5 | 145.7 | 144.5 |
| Thickness | mm | | 0.33 | 0.32 | 0.32 | 0.38 | 0.40 | 0.32 | 0.32 | 0.33 | 0.39 | 0.41 | 0.32 | 0.32 | 0.33 | 0.39 | 0.38 |

***Table 2b.***

| Property | Unit | Warp / weft | CO 50% / PES 50% | | | | | CO 67% / PES 33% | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | P-22 | P-27 | P-32 | C-32 | T-32 | P-22 | P-27 | P-32 | C-32 | T-32 |
| Finish | | | Raw | | | | | | | | | |
| Width | cm | | 150.5 | 147.1 | 147.5 | 148.0 | 149.1 | 149.4 | 146.8 | 147.8 | 148.7 | 150.2 |
| Number of threads per 1 dm | | warp | 323 | 329 | 329 | 328 | 324 | 325 | 328 | 330 | 326 | 324 |
| | | weft | 262 | 336 | 341 | 337 | 335 | 253 | 316 | 335 | 326 | 322 |
| Crimp of threads | % | warp | 10.7 | 12.5 | 12.5 | 6.5 | 3.7 | 8.2 | 9.2 | 11.3 | 5.8 | 2.7 |
| | | weft | 5.7 | 8.2 | 8.2 | 7.8 | 7.7 | 6.0 | 7.8 | 7.7 | 7.9 | 7.3 |
| Mass per square meter | g/m$^2$ | | 137.9 | 158.8 | 159.7 | 154.5 | 151.2 | 124.5 | 138.2 | 151.6 | 141.2 | 139.1 |
| Thickness | mm | | 0.31 | 0.31 | 0.33 | 0.42 | 0.4 | 0.34 | 0.32 | 0.34 | 0.43 | 0.43 |
| Finish | | | Starch | | | | | | | | | |
| Width | cm | | 140.6 | 139.4 | 138.9 | 140.5 | 140.5 | 140.5 | 138.2 | 138.5 | 146.1 | 141.9 |
| Number of threads per 1 dm | | warp | 342.0 | 344.0 | 346.0 | 344.0 | 345.0 | 345.0 | 349.0 | 349.0 | 344.0 | 344.0 |
| | | weft | 225.0 | 285.0 | 333.0 | 333.0 | 335.0 | 232.0 | 299.0 | 326.0 | 322.0 | 331.0 |
| Crimp of threads | % | warp | 3.9 | 4.9 | 5.0 | 3.0 | 1.5 | 3.8 | 4.8 | 5.6 | 2.6 | 1.7 |
| | | weft | 8.2 | 9.3 | 9.6 | 8.9 | 9.2 | 9.5 | 10.2 | 10.5 | 8.7 | 9.4 |
| Mass per square meter | g/m$^2$ | | 127.3 | 142.1 | 153 | 148.2 | 150.2 | 124.7 | 142.4 | 151 | 145.2 | 145.2 |
| Thickness | mm | | 0.29 | 0.32 | 0.33 | 0.37 | 0.41 | 0.33 | 0.34 | 0.36 | 0.4 | 0.4 |
| Finish | | | Elastomeric | | | | | | | | | |
| Width | cm | | 139.6 | 139.6 | 139.5 | 140.5 | 140.5 | 140.7 | 140.0 | 138.6 | 139.6 | 140.1 |
| Number of threads per 1 dm | | warp | 345 | 344 | 346 | 344 | 343 | 344 | 343 | 346 | 345 | 345 |
| | | weft | 242 | 286 | 333 | 337 | 328 | 240 | 287 | 333 | 326 | 328 |
| Crimp of threads | % | warp | 4.7 | 5.1 | 6.3 | 3.5 | 1.7 | 4.4 | 4.9 | 5.2 | 3.1 | 2.0 |
| | | weft | 9.7 | 9.2 | 9.6 | 9.8 | 10.0 | 8.3 | 9.2 | 10.7 | 9.7 | 10.0 |
| Mass per square meter | g/m$^2$ | | 129.9 | 145.0 | 154.7 | 151.6 | 147.7 | 125.4 | 134.1 | 145.9 | 142.9 | 141.0 |
| Thickness | mm | | 0.31 | 0.31 | 0.33 | 0.42 | 0.4 | 0.34 | 0.32 | 0.34 | 0.43 | 0.43 |

both in the raw state and after finishing, are presented in Table 2.

Then, all the raw and finished fabrics were tested at small stretching, shearing, compression and bending stresses with the use of an Instron tension-tester, in order to obtain the basic mechanical parameters which influence the handle. The following fabric parameters were determined:

- energy of stretching load (WT),
- linearity of the stretching process (LT),
- resilience after stretching (RT),
- width of the hysteresis loop at shearing (HG),
- width of the hysteresis loop at bending (HB),
- loading energy of compression (WC),
- linearity of the compression process (LC),
- resilience after compression (RC),
- coefficient of static friction ($\mu_s$), and
- coefficient of kinetic friction ($\mu_k$).

## Elaboration of the general handle factor of fabrics

When elaborating the general handle factor, the assumption was made that the finished woven fabrics should have a better handle than the raw fabrics, and that the elastomerically finished fabrics should also be characterised by a better handle (due to the improving finish applied) than those which were finished in the classical way by starch.

In the first investigation phase, the kinds of trends in changes to the particular parameters (determined by the Instron tensile-tester), which exist depending on the type of finishing were estimated. Next, plots of values of the particular mechanical parameters for all raw and finished fabrics were drawn. The particular test variants were arranged on the abscissa of every plot (for every parameter), beginning with the test of fabric No 1 through intermediate tests (according to Table 1), up to the test of fabric No 75. The order was arranged in such a manner that the first group consisted of raw fabrics, the next of fabrics with starch finishing, and the last with elastomer finishing. The plots are presented in Figure 1.

The arrangement of samples within one group of fabrics depends on the changes in quality of the fabric's surface assumed in the experimental plan. The increase in weft density in fabrics of plain weave from 220/dm, though 270/dm to 320/dm results in an increase in the warp overlaps per square unit of the fabric's surface, whereas the changes of weave from plain through combined to twill cause an increase in the number of long links which in turn improve the smoothness of the fabric. The fabrics were also arranged according to the increase in the polyester fibre content.

The partial trends within one group of fabrics, e.g. raw or finished fabrics, as well as fabrics of a particular weave, have not been the subject of these considerations. Such trends were and will be the subjects of independent analysis.

Straight lines, which characterised the trends in changes to every parameter determined, were drawn on the plots (beginning from the raw fabrics in the direction of the starch (S) and the elastomerically (E) finished fabrics). The analysis of these plots allowed us to estimate how the values of the particular parameters changed in dependence on finishing, which (in accordance with the assumption accepted at the beginning of our consideration) should improve the handle of fabrics.

The analysis performed allowed us to state that in the case of the following two parameters:
- the stretching linearity (LT) presented in Figure 1b, and
- the resilience after stretching (RT) presented in Figure 1c

no visible trend occurs in the dependence of finishing. Therefore, these two parameters were omitted in further considerations as having no distinct influence on the fabric's handle.

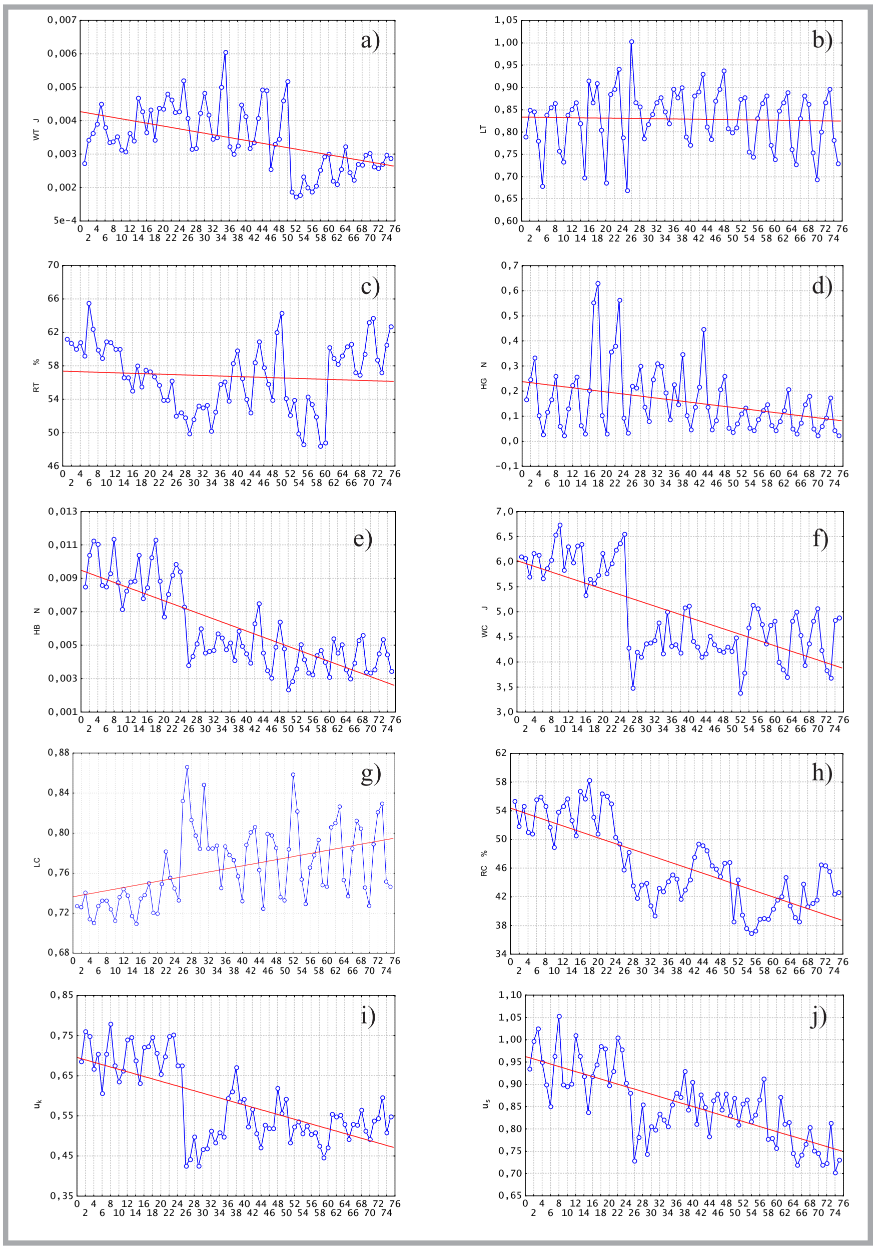


***Figure 1.*** *Trends of the particular parameters for fabrics arranged, starting from raw fabrics, through fabrics finished with starch (S) to fabrics elastomerically finished (E); a) energy of stretching load WT, b) linearity of the stretching process LT, c) resilience after stretching RT, d) width of the hysteresis loop at shearing HG, e) width of the hysteresis loop at bending HB, f) loading energy of compression WC, g) linearity of the compression process LC, h) resilience after compression RC, i) coefficient of static friction* $\mu_s$*, and j) coefficient of kinetic friction* $\mu_k$*.*

In the case of the remaining mechanical parameters, it was observed that their values decreased, beginning with the highest parameter values of raw fabrics, through those of fabrics with starch finishing (S), and ending with the parameters of fabrics which were elastomerically (E) finished (Figures 1a, 1d, 1e, 1f, 1h, 1i, and 1j). Only in the case of the linearity of compression (LC) was a contrary tendency noted, i.e. an increase in the parameter value in the direction of fabrics with better finishing. These considerations allowed us to assume that the following parameters (determined with the use of the Instron tensile-tester) influence the fabric's handle:
- energy of stretching load (WT),
- width of the hysteresis loop at shearing (HG),
- width of the hysteresis loop at bending (HB),
- energy of compression (WC),
- linearity of the compression process (LC),
- resilience after compression (RC),
- coefficient of static friction ($\mu_s$), and
- coefficient of kinetic friction ($\mu_k$).

A procedure similar to that of the elaboration of the general quality factor GQF [5] was applied in further considerations, approaching the elaboration of one summarised fabric handle factor (the general handle factor GHF). All the parameters listed above (determined by the Instron tensile-tester) were accepted as the individual parameters for elaborating the general factor.

Degrees of importance *u* (from *u*=1 to *u*=5) were assigned to all parameters determined by the Instron tensile-tester, proportionally to the pitch of the line which indicates the trend of the particular parameters (in the direction from the raw fabrics to the fabrics finished elastomerically). The greater the trend deflection from the horizontal line was noted, the higher the degree of importance was assigned. Next, the weight coefficient was calculated for every parameter from the following formula:

$$p_i = \frac{u_i}{\sum_{i=1}^{8} u_i} \cdot 100 \qquad (1)$$

where:
$u_i$ - degree of importance of the *i*-th parameter, and
$p_i$ - weight coefficient of the *i*-th parameter.
The assigned degrees of importance ($u_i$) and weight coefficients ($p_i$) calculated are specified in Table 3.

Next, the relative values of the particular factors were calculated. These values are equal to the ratio of the particular parameter's value of the given variant of fabric to the maximum value of all values which were obtained in this parameter:

$$b_{ik} = \frac{a_{ik}}{a_{i\max}} \qquad (2)$$

where:
$b_{ik}$ - relative value of the i-th parameter for the k-th fabric variant,
$a$ - absolute value of the *i*-th parameter for the *k*-th fabric variant, and
$a_{imax}$ - maximum value of the *i*-th parameter from all values of this parameter determined by the Instron tensile-tester.

It should be emphasised that most often, when elaborating the general quality factor (GQF), the quotient of the value of the parameter determined is calculated using the optimal value as a divider. However, in the case analysed, there has hitherto been a lack of data which could allow us to accept the optimal value as a divider, and the maximum value obtained by measurement was taken instead of this.

The value of the general quality factor (GQF) was calculated for each fabric variant from the formula:

$$GQF_k = \sum_{i=1}^{8} p_i \cdot b_{ik} \qquad (3)$$

where:
$GQF_k$ - value of the general quality factor *GQF* for the *k*-th fabric variant.

***Table 3.*** *Specification of importance degree „u" and weight coefficients „p".*

| No | Parameter | Figure 1 | Designation | u | p |
|---|---|---|---|---|---|
| 1 | WT | a | $a_1$ | 2 | 6.3 |
| 2 | HG | d | $a_2$ | 2 | 6.3 |
| 3 | HB | e | $a_3$ | 5 | 15.6 |
| 4 | WC | f | $a_4$ | 5 | 15.6 |
| 5 | LC | g | $a_5$ | 3 | 9.4 |
| 6 | RC | h | $a_6$ | 5 | 15.6 |
| 7 | $\mu_s$ | i | $a_7$ | 5 | 15.6 |
| 8 | $\mu_k$ | j | $a_8$ | 5 | 15.6 |
| Sum | | | | 32 | 100 |

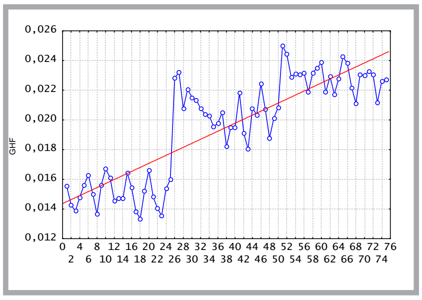


***Figure 2.*** *Trend of the general handle factor $GHF_{IN}$ for all fabric variants.*

Considering that the trend of compression linearity changes (LC) in dependence of fabric finishing is contrary to the trends of all remaining parameters, the sign of the component concerning compression linearity (LC) in the $GQF_k$ sum was accepted as minus. Finally, the equation describing the general quality factor as determined on the basis of the parameters measured with the use of the Instron ten-

***Equations 4 and 6.***

$$GQF_{IN} = 6.3\cdot\frac{WT}{WT_{\max}} + 6.3\cdot\frac{HG}{HG_{\max}} + 15.6\cdot\frac{HB}{HB_{\max}} - 9.4\cdot\frac{LC}{LC_{\max}} + 15.6\cdot\frac{RC}{RC_{\max}} + 15.6\cdot\frac{\mu_s}{\mu_{s\max}} + 15.6\cdot\frac{\mu_k}{\mu_{k\max}} \qquad 4)$$

$$GHF_{IN} = \frac{1}{6.3\cdot\frac{WT}{WT_{\max}} + 6.3\cdot\frac{HG}{HG_{\max}} + 15.6\cdot\frac{HB}{HB_{\max}} - 9.4\cdot\frac{LC}{LC_{\max}} + 15.6\cdot\frac{RC}{RC_{\max}} + 15.6\cdot\frac{\mu_s}{\mu_{s\max}} + 15.6\cdot\frac{\mu_k}{\mu_{k\max}}} \qquad 6)$$

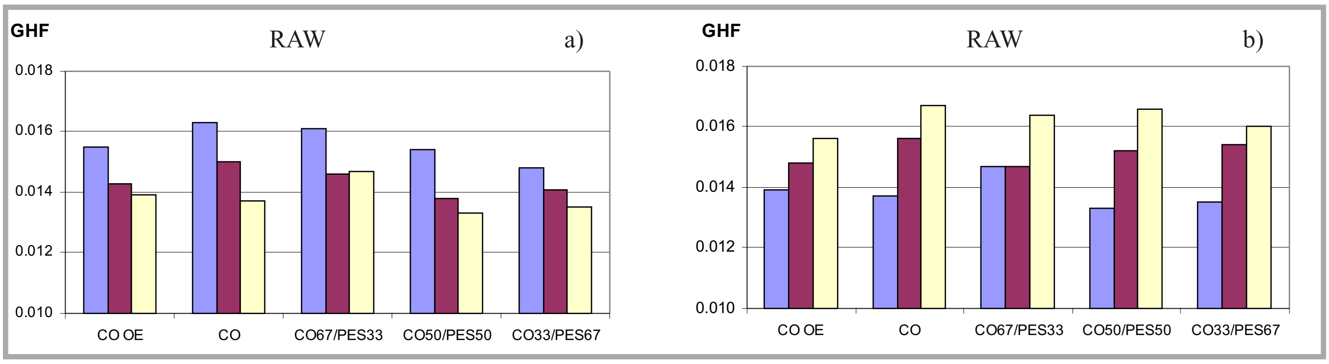


***Figure 3.*** *General handle factor GHF for raw fabrics in dependence on: a) weft density, ▢ - 220/dm, ▢ - 270/dm, ▢ - 320/dm; b) weave of the fabric, ▢ - plain, ▢ - combined, ▢ - twill.*

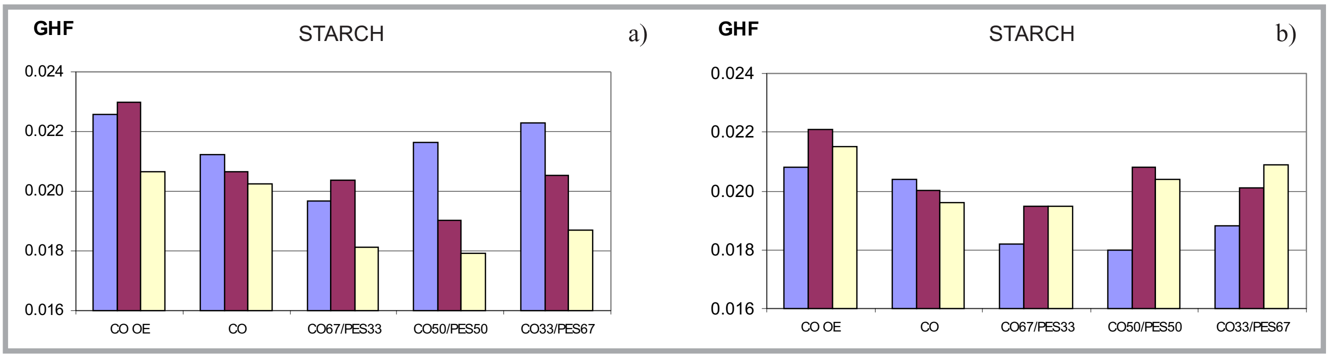


***Figure 4.*** *General handle factor GHF for fabrics finished with starch in dependence on: a) weft density, ■ - 220/dm, ■ - 270/dm, □ - 320/dm; b) weave of the fabric, ■ - plain, ■ - combined, □ - twill.*

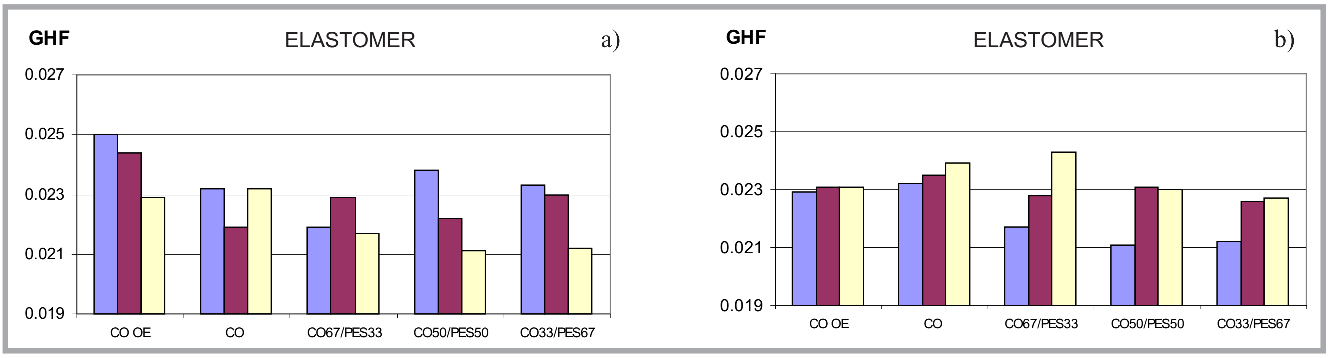


***Figure 5.*** *General handle factor GHF for fabrics elastomerically finished in dependence on: a) weft density, ■ - 220/dm, ■ - 270/dm, □ - 320/dm; b) weave of the fabric, ■ - plain, ■ - combined, □ - twill.*

sile-tester ($GQF_{IN}$) can be described as presented in (4).

The procedure which was accepted for calculating the general quality factor assumed that the value of the output parameters increases with the increase in the fabric's quality. In the case of the mechanical parameters determined with the use of an Instron tensile-tester, a contrary situation can be observed; that is, with the increase in the value of particular output parameters (excluding the compression linearity LC), a worsening in handle is observed.

Considering this behaviour of the finished fabrics, the reciprocal of the general quality factor calculated from formula (4) was proposed as a measure of the fabric's handle. This measure was designated as the 'general handle factor' (GHF) of fabrics, based on the mechanical parameters determined with the use of an Instron tensile-tester, and its value can be calculated from the following formula:

$$GHF_{IN} = \frac{1}{GQF_{IN}} \quad (5)$$

The final shape of the equation (6), which allows us to calculate the general handle factor on the basis of measurements of the mechanical fabric parameters with the use of an Instron tensile-tester, was obtained by the substitution of $GQF_{IN}$ in formula (5) by equation (4).

With the use of equation (6), the values of the general handle factors for all variants of raw and finished fabrics manufactured for conducting the experimental part of this investigation were calculated. The values obtained are presented in Figure 3. According to our expectations, it could be stated that the values of the factor tend to increase, beginning with those of raw fabrics, through those of fabrics with starch finishing (S), and finally with values for elastomeric finishing (E). This confirms the rightness of the procedure we proposed (Figure 2), as by experimental planning such kinds of finishing were designedly accepted which could ascertain a differentiation of the fabrics' handle, and of its improvement compared to the handle of raw fabrics.

However, on the basis of the values calculated it can be stated that the remaining factors, i.e. the type of raw material used, weave, and weft density, also have an influence, independently of the influence of finishing type.

## Analysis of Influence of Weft Density, Weave, and Finishing Type on the General Handle Factor

The influence of weft density and the weave used on the general handle factor of raw fabrics is shown in Figure 3. It was noted that when considering woven fabrics of plain weave, the fabrics with the smallest weft density (220/dm) are characterised by the best handle, those of 270/dm weft density by a worse handle, and those of 320/dm by the worst handle. Among fabrics of 320/dm weft density, the highest value of the general handle factor could be noted for fabrics with twill weave, a lower value for fabrics with combined weave, and the lowest for those with plain weave. Similar trends could also be observed for the majority of finished fabrics, although not for all (see Figures 4 and 5).

For fabrics with starch finishing (S) manufactured from cotton rotor yarn and polyester ring spun yarn with a content of CO 67%/PES 33%, the maximum value of the general handle factor was achieved for fabrics of intermediate weft density (270/dm). Moreover, the fabrics manufactured from cotton rotor yarn and polyester ring spun yarn with a content of CO 50%/

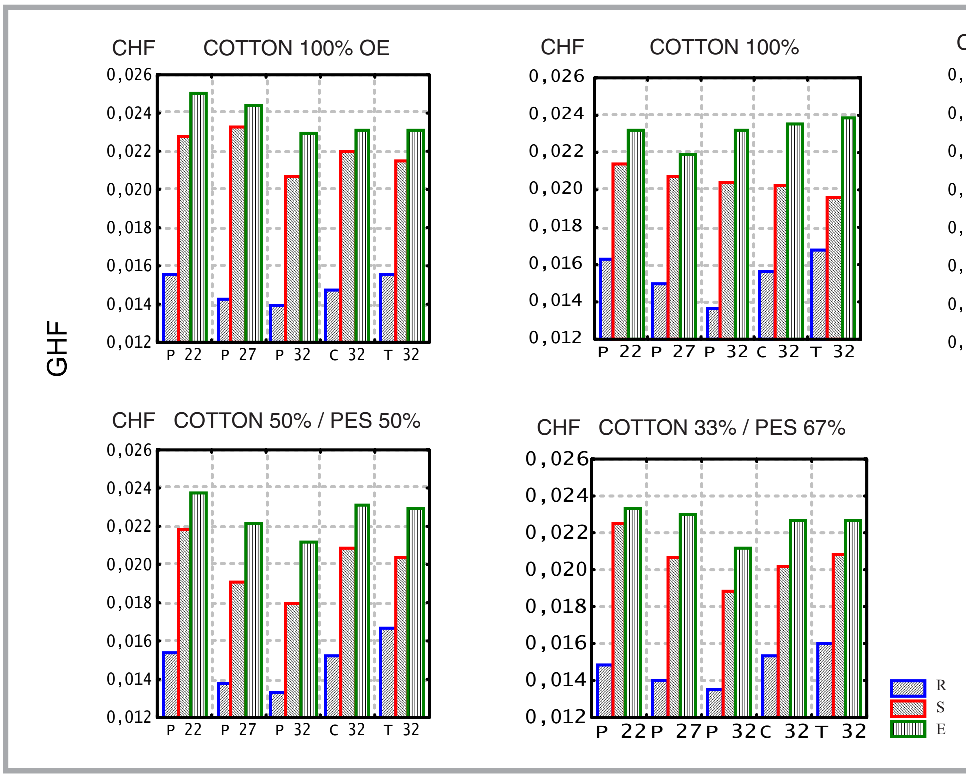


***Figure 6.*** *Influence of the type of finishing on the general handle factor GHF; R - raw, S - starch finishing, E - elastomer finishing.*

PES 50% and combined weave are characterised, in the case of starch finishing (S), by better handle than fabrics of twill and plain weave (Figure 5).

Using elastomeric finishing (E), it was noted that in two cases (for fabrics of plain weave manufactured from cotton rotor yarn and of blended cotton/polyester ring spun yarn with a content of CO 67%/PES 33%) a distinct difference in the trends observed for raw fabrics was stated, together with opposite trends for both of the fabric groups mentioned above.

No explicit influence of the type of raw material used on the handle of raw and finished fabrics was observed, though fabrics manufactured from different raw materials differ among themselves by the value of the general handle factor. However, as a rule it can be stated that the factors of fabrics with a content of PES fibres have a lower value.

The influence of the type of fabric finishing on the value of the general handle factor (GHF) are presented in Figure 6. The results are arranged separately for each group of fabrics manufactured from the same raw material, as listed below:

- GIM1 - fabrics from cotton rotor yarn,
- GIM2 - fabrics from cotton ring spun yarn,
- GIM3 - fabrics from blended ring spun yarn of content Co67/PES33,
- GIM4 - fabrics from blended ring spun yarn of content Co50/PES50, and
- GIM5 - fabrics from blended ring spun yarn of content Co33/PES67.

The highest general handle factor of all analysed groups of fabrics was noted for fabrics with elastomeric (E) finishing, whereas raw fabrics were characterised by the lowest value of the general handle factor, which means the worst handle.

## Summary and Conclusions

The experimental investigations and the theoretical analysis carried out allowed us to state that:

- A general factor of handle quality, based on mechanical parameters determined with the use of an Instron tensile-tester, was elaborated; and the influence of weft density, weave, raw material, and finishing was analysed.
- A possibility exists of anticipating the fabric's handle on the basis of tests performed for obtaining the mechanical parameters of the fabric with the use of an Instron tensile-tester.
- The authors suggest that a comparative analysis be carried out between the general handle factor (GHF) and the THV obtained from the KES-F system as a continuation of this research.


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