Assessment of the Fatigue Durability of Standard Smooth and Fancy Flame Cotton Yarns Using a Statistical Model

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Abstract

The fatigue durability of smooth and fancy flame cotton yarns was assessed using a Wöhler’s curve. It was found that the characteristic of fatigue durability of the curve determined for cotton fancy flame yarns enables the determination of the complete diagram of these curves. In turn, for smooth yarns a Wöhler’s curve containing only the areas of quasi-static strength and those of low-cycle strength can be determined.

Key words: static strength, fatigue durability, Wöhler’s curve, smooth cotton yarns, fancy flame yarns, statistical model.

Introduction

The issue of calculation of fatigue durability in conditions of variable loads is the subject of wide interest of engineers in various fields of science [2, 9]. The assessment of fatigue durability is often carried out at the stage of designing or exploitation of machines and devices. Fatigue durability at the stage of exploitation concerns existing prototype units. In this case, phenomenological models of fatigue damage accumulation requiring a minimal number of experimental data are usually used [1]. Such information can be obtained from the analysis of a Wöhler’s curve, and possible executive corrections can be applied at the design stage [6]. This approach to the assessment of the material studied is recommended as it leads to a reduction of costs connected with the elimination of defects which could be found in the ready product. During the analysis of fatigue durability, statistical data relating to distributions of the parameters of material fatigue are often used. Forecasting fatigue durability is an important aspect of the assessment of fatigue durability. Moreover it should have a statistical character and use probabilistic methods. However, such methods are very difficult and not very accessible in engineering practice. For those reasons, their pragmatic applicability is also slight. Because of the fact that no studies describing the methodology of measurements of the assessment of the fatigue durability of fancy flame yarns has been found so far, it was decided to fill the existing gap. Knowledge of the characteristic of fatigue durability creates the possibility of the breakage prognosis of yarns, both smooth and fancy flame, in the technological operations following spinning. In those operations, the conditions in which the existing temporary tensions of yarns can be close to the maximal values of their strength.

During the use of a ready textile product, forces impacting the article do not belong to the category of quick-changeable forces and are characterised by maximum values. In this regard, the process of destroying the ready textile product lasts much longer, with stresses being considerably lower than the strength of the given material. This finding implied the range of strains to be considerably smaller than the durability of the given material.

Material and methods of investigations

To perform the technological identification of smooth and decorative yarns, American cotton Strict Middling of average fibrous length 27.78 - 28.58 mm and thickness 150 - 162 mtex was chosen. Smooth and fancy flame cotton yarns of 30 tex and 40 tex linear density, typical for a spinning mill of fine thread in the range of yarns of medium thickness utilised for garments, were chosen for the investigation. Both kinds of yarns were produced on a spinning frame - Zinser From 351 equipped with Fancy-Draft modules, i.e. an option enabling the production of flame yarn by changing the main draft and number of twist [2]. The static strength of smooth and fancy flame yarns was determined according to PN-EN ISO 2062:1997. Measurements of the static strength of yarns were conducted with an Instron 5544 tensile tester. The samples of fancy flame yarns were fixed in the clamps of the tensile tester and the place of the effect was located at half the distance between the clamps of the Instron tensile tester, equaling...
500 mm, whereas the speed of testing equalled 150 mm/min.

In order to characterise changes in the static strength of fancy flame yarns in relation to smooth ones of similar linear density, the coefficient of static durability was introduced:

$$\eta_p = \frac{R_{m_1}}{R_{m_2}} \times 100\%.$$  (1)

These yarns were subjected to changeable cyclic fatigue loads maintained till the moment of the total break of the yarns mentioned. The investigations of fatigue durability were conducted at nine levels of strain, making twenty positive repetitions of tests for each of the levels defined. Tests in which the breaking of the yarn was confirmed in the place of the effect of the flame were accepted as the criterion of fancy flame destruction. In the case of smooth yarns, tests in which the break occurred at approximately half of the distance between the clamps of the tensile tester were recognised as positive. Because of the stochastic character of strength proprieties of the yarns analysed, the number of series was increased. The strength properties of smooth and fancy flame cotton yarns were determined using an Instron 5544 tensile tester and presented in Table 1.

Investigations of the fatigue strength were conducted at eight levels of strain, carrying out 20 positive repetitions of tests for each of the levels defined. Tests in which the crack was detected were accepted as the criterion of destruction. The investigations of the fatigue strength of yarns were conducted using an Instron 5544 tensile tester and Test Profiler software. The average value of Young’s modulus for smooth yarns $M_p$ as well as fancy flame yarns $M_{pf}$ was arbitrarily accepted as the minimal value of the cycle load $\sigma_{min}:

$$\sigma_{min} = M_p = const.$$  (4)

Taking into consideration traditional designations applied in the textile industry, the linear limit of elasticity $R_e$ was defined as the modulus of the initial elasticity $M_p$ in the next part of the article. The modulus of initial elasticity of smooth yarns $M_{p_1}$ and fancy flame yarns $M_{pf}$ was determined with Merlin software of the Instron 5544 tensile tester during

### Table 1. Strength properties of smooth and fancy flame cotton yarns determined using an Instron 5544 tensile tester [2].

<table>
<thead>
<tr>
<th>Statistic parameter analysed</th>
<th>Symbol</th>
<th>Smooth cotton yarns, tex</th>
<th>Fancy flames cotton yarns, tex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average breaking force, cN</td>
<td>$R_{m_1}$</td>
<td>431,17  570,51  395,07  547,38</td>
<td></td>
</tr>
<tr>
<td>Coefficient of variation of breaking force, %</td>
<td>$V(R_{m_1})$</td>
<td>9,67  6,15  6,34  10,11</td>
<td></td>
</tr>
<tr>
<td>Average tenacity of yarn, cN/tex</td>
<td>$\overline{W}_t$</td>
<td>14,37  14,26  13,17  13,68</td>
<td></td>
</tr>
<tr>
<td>Average relative breaking elongation, %</td>
<td>$\overline{e}$</td>
<td>7,41  6,49  7,44  7,50</td>
<td></td>
</tr>
<tr>
<td>Coefficient of variation of elongation at break, %</td>
<td>$V(e)$</td>
<td>9,94  6,05  6,09  11,90</td>
<td></td>
</tr>
<tr>
<td>Young’s modulus (modulus of initial elasticity), cN/tex</td>
<td>$M_{p_1}$</td>
<td>2,74  2,59  2,75  2,38</td>
<td></td>
</tr>
<tr>
<td>Coefficient of variation of modulus of initial elasticity, %</td>
<td>$V(M_{p_1})$</td>
<td>11,33  18,22  25,68  16,76</td>
<td></td>
</tr>
<tr>
<td>Coefficient of static strength, %</td>
<td>$\eta_p$</td>
<td>91,63  95,95</td>
<td></td>
</tr>
</tbody>
</table>

$$\sigma_{a} = \frac{\sigma_{max} - \sigma_{min}}{2}.$$  (3)

$$\sigma_{a} = \frac{\sigma_{max} + \sigma_{min}}{2}.$$  (2)

Before the beginning of the investigations, the range of amplitude of the load of the cycle - $\sigma_a$ at which investigations of fatigue durability were performed was determined (Figure 1).

![Figure 1. Scheme of determining the Wöhler’s curve of the yarns investigated [2].](image-url)
the static strength investigations. The maximum strength of the cycle \( \sigma_{\text{max}} \) was calculated on the basis of the average stress breaking the yarn \( \bar{\sigma} \). Because of the material investigated, the coefficient of the real strain of the cycle \( \sigma_{\text{r}} \) dependent on the level of stresses in the given cycle was introduced to characterise the maximum stress of the cycle. It was arbitrarily assumed that the fatigue durability would be determined at the eight levels of maximal stress [2]:

\[
\sigma_{\text{max}} = [0.98 \bar{\sigma}, 0.95 \bar{\sigma}, 0.85 \bar{\sigma}, 0.75 \bar{\sigma}, 0.65 \bar{\sigma}, 0.55 \bar{\sigma}, 0.50 \bar{\sigma}, 0.40 \bar{\sigma}]^{T}, \text{ cN/tex.}
\]

The coefficient of the real stress of the cycle \( \sigma_{\text{r}} \) was accepted arbitrarily on the basis of earlier experiments [3]. The average breaking stress of yarns \( \bar{\sigma}_{\text{b}} \) was determined from 50 measurements carried out for each yarn. The acceptance of the maximal upper value of the cycle load \( \sigma_{\text{max}} = \sigma_{\text{f}} = 0.98 \bar{\sigma} \) was caused by the fact that in the case of fatigue investigations at the stress \( \sigma_{\text{max}} > 0.9 \bar{\sigma} \) over 99% samples of yarns underwent failure at a number of fatigue cycles \( N_{p} \geq 1 \) and \( N_{s} \geq 1 \), where \( N_{s} \) - number of fatigue cycles determined for fancy yarn, \( N_{p} \) - number of fatigue cycles determined for smooth yarn. Thus this range was close to that of stresses causing the failure of yarns. In turn, the acceptance of the bottom value of the cycle load \( \sigma_{\text{max}} = \sigma_{\text{f}} = 0.40 \bar{\sigma} \) resulted from the fact that the fatigue durability was close to the range of fatigue limit strength considered as the fatigue strength of the material causing its unrestricted work at periodically changeable loads.

Aiming at the determination of a Wöhler’s curve for the yarns analysed in conditions of the definite cycle of the loads and estimation of the results of fatigue cycles influencing the magnitude of coefficients of the real stress of the cycle of the yarns analyzed, non-linear regression was applied to approximate dependences obtained with logarithmic functions [13]:

- for cotton smooth yarns:
  \[
  \hat{\sigma}_{\text{w}} = B_{0} + B_{1} \cdot \ln(N_{t}), \quad (5)
  \]
- for cotton fancy flame yarns:
  \[
  \hat{\sigma}_{\text{f}} = B_{0} + B_{1} \cdot \ln(N_{t}), \quad (6)
  \]

where:

\[\{B_{0}; B_{1}\}^{T} \] – vector of the coefficient of the logarithmic function,

\( \hat{\sigma}_{\text{w}} \) and \( \hat{\sigma}_{\text{f}} \) – value of the regression function of the coefficient of the real stress of the cycle for cotton smooth yarn and cotton fancy flame yarn, respectively,

\( N_{a} \) and \( N_{p} \) – number of fatigue cycles determined for smooth yarn and cotton fancy flame yarn, respectively.

For calculation of the coefficients of regression functions \( B_{0} \) and \( B_{1} \) the method of the smallest sums of the squares of deviations was applied, solving the following system of Equations [8]:

\[
\begin{align*}
B_{1} \left( \sum_{i=1}^{n} h \cdot N_{i} \right)^{2} + B_{0} \left( \sum_{i=1}^{n} h \right) \cdot \sum_{i=1}^{n} N_{i} &= \sum_{i=1}^{n} h \cdot \sigma_{i} \cdot N_{i} \\
B_{1} \left( \sum_{i=1}^{n} \ln(N_{i}) \right)^{2} + B_{0} \left( \sum_{i=1}^{n} \ln(N_{i}) \right) &= \sum_{i=1}^{n} \ln(N_{i}) \cdot \sigma_{i}
\end{align*}
\]

\( (7) \)

After transformations, the values of coefficients \( B_{0} \) and \( B_{1} \) were obtained and presented in Equations 8 and 9:

\[
B_{1} = \frac{\sum_{i=1}^{n} \ln(N_{i}) \cdot \sigma_{i} - \sum_{i=1}^{n} \ln(N_{i}) \cdot \sum_{i=1}^{n} \ln(N_{i}) \cdot \sigma_{i}}{n \cdot \sum_{i=1}^{n} \ln(N_{i})^{2} - (\sum_{i=1}^{n} \ln(N_{i}))^{2}}
\]

\[
B_{0} = \frac{\sum_{i=1}^{n} \ln(N_{i}) \cdot \sigma_{i} - \sum_{i=1}^{n} \ln(N_{i}) \cdot \sum_{i=1}^{n} \ln(N_{i}) \cdot \sigma_{i}}{n \cdot \sum_{i=1}^{n} \ln(N_{i})^{2} - (\sum_{i=1}^{n} \ln(N_{i}))^{2}}
\]

\( (8) \)

\( (9) \)

The agreement of the output of the model with that of the object was estimated on the basis of the coefficient of the multiple correlation \( R \), expressed by the following formula:

\[
R = \sqrt{\frac{\sum_{i=1}^{n} (\hat{\sigma}_{\text{w}} - \sigma_{\text{w}})^{2}}{\sum_{i=1}^{n} (\sigma_{\text{w}} - \bar{\sigma}_{\text{w}})^{2}}}
\]

\( (10) \)

where:

\( \sigma_{\text{w}} \) – output of the object in \( i \)-th experiment,

\( \hat{\sigma}_{\text{w}} \) – output of the model in \( i \)-th experiment,

\( n \) – number of tests in the experiment,

\( \bar{\sigma}_{\text{w}} \) – average value of output of object and model,

The significance of the regression function determined was checked on the basis of the dependence occurring between the statistics \( F \) and coefficient of the multidimensional correlation ‘\( R \)’:

\[
F_{k, n-k-1}^{\text{crit}} = \frac{n-k-1}{k} \cdot \frac{R^{2}}{1-R^{2}}.
\]

\( (12) \)

In order to obtain a regression equation useful for steering the process of the production of the yarns examined and simultaneously fulfilling requirements at the specified level of significance (\( \alpha = 0.05 \)), the initial condition must be fulfilled:

\[
F_{k, n-k-1}^{\text{crit}} \geq F_{\text{calc}},
\]

\( (13) \)

where: \( F_{\text{calc}} \) – critical value of \( F \) – Snedecor’s statistics determined from tables of Fisher’s and Snedecor’s distribution at the level of significance \( \alpha = 0.05 \) and at the number of degrees of freedom \( k \) and \( n - k - 1 \).

To determine the limits of the confidence interval of the feature studied (the real strain of the cycle for cotton smooth yarn), the following dependence was used [4]:

\[
P(\bar{\sigma}_{\text{w}} - t_{n-1} \cdot s \leq \bar{\sigma}_{\text{w}} \leq \bar{\sigma}_{\text{w}} + t_{n-1} \cdot s) = 1 - \alpha
\]

\( (14) \)

\( s \) – standard deviation calculated from formula:

\[
s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (\sigma_{\text{w}} - \bar{\sigma}_{\text{w}})^{2}}
\]

\( (15) \)

\( \alpha \) – level of significance,

\( t_{n-1} \) – Student’s variable read from tables of the Student’s distribution for \( n - 1 \) degrees of freedom in a way that allows the following inequality to be fulfilled by the probability \( 1 - \alpha \), assumed in advance:

\[
P(\bar{\sigma}_{\text{w}} - t_{\alpha} < \bar{\sigma}_{\text{w}} < \bar{\sigma}_{\text{w}} + t_{\alpha}) = 1 - \alpha
\]

\( (16) \)

The relationship (7 – 16) was also applied for cotton fancy flame yarns [2]. The Wöhler’s diagrams are presented in Figures 2 and 3.
yarns can be observed in the range of low-cycle loads, i.e. $\sigma = [0.55, 0.75]$, which means that fancy flame yarns are characterised by over 95% higher fatigue durability than cotton smooth yarns of the same or similar linear density. In the range of low-cycle loads, considerable differences in the fatigue durability of fancy flame yarns can be noticed. In the case of the area of high-cycle loads, i.e. at $\sigma = [0.50, 0.40]$, smooth yarns, in contrast to fancy flame yarns, do not achieve limit values from this range.

The assessment of fatigue durability below the coefficient of the real stress $\sigma = 40\% R_{sp}$ is baseless for cotton smooth yarns of 30 and 40 tex linear density. The unlimited fatigue strength of fancy flame yarns of 30 tex linear density equals $N_{un lim}$ (at a stress of $\approx 6.58$ cN/tex). In turn, for smooth yarns of this linear density we can only speak of the average fatigue durability, which for the maximum load of the cycle $\sigma_{max} = 5.71$ cN/tex equaled $N_n = 1325$ cycles, can be estimated.

In summary, it can be stated that diagrams of curves presented in Figures 2 and 3 represent a traditional way of recording and analysis of results of the assessment of fatigue durability [3]. The results of fatigue durability assessment presented earlier are subject to large dispersions. The dispersion of results around the average value grows together with the growth of the level of the stress $\sigma_{max}$. The feature mentioned is perceptible for all linear densities of smooth cotton yarns and fancy flame considered, the main causes of which are differences resulting from the characteristics of the material investigated. The variability of the structure of the material investigated also can result from the technological process and conditions of the investigation. Thus a traditional curve should be designed with statistical investigations in order to obtain the full characteristic of the fatigue durability of the material.

The aim of the planning of statistical investigations is to determine the minimal number of tests necessary to confirm the accuracy of Wöhler’s curves obtained. The diagrams of fatigue durability in semi-logarithmic or the logarithmic system of co-ordinates should be straight lines, thanks to which the results of investigations can be processed using linear dependences between the parameters considered. Simultaneously making an assumption that stresses are magnitudes determined while planning the experiment, then the logarithms of fatigue durability are random magnitudes characterised by the normal distribution of the probability. That is why Wöhler’s curves describing the fatigue durability of the given material can be processed on the basis of linear dependences in the semi-logarithmic or logarithmic system of co-ordinates [5, 6].

The theoretical line of the regression can be applied in the following form:

$$\eta = \delta + \beta \cdot (x - \bar{x})$$

(17)

where: $\eta = E(Y|x)$ is the value of the magnitude of the logarithm of durability expected $\text{lg} N = Y$, where the logarithm of the stress established is $\text{lg} \sigma = \text{X} = x$.  

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**Figure 2.** a) Diagram of Wöhler’s curve for smooth cotton yarns of 30 tex linear density, approximating the logarithmic function of the equation $\sigma_n = -0.105\ln(N_{\sigma}) + 1.1816$, where $R^2 = 0.98$ and $F_{calc} = 335.85 > F_{crit} = 5.99$; b) full diagram of the Wöhler’s curve for cotton fancy flame yarns of linear pulp 40 tex, approximating the logarithmic function of equation $\sigma_n = -0.047\ln(N_{\sigma}) + 1.1029$, where $R^2 = 0.986$ and $F_{calc} = 109.04 > F_{crit} = 7.71$.

**Figure 3.** a) Diagram of Wöhler’s curve for smooth cotton yarns of 40 tex linear density, approximating the logarithmic function of the equation $\sigma_n = -0.12\ln(N_{\sigma}) + 1.2878$, where $R^2 = 0.98$ and $F_{calc} = 270.49 > F_{crit} = 5.99$; b) full diagram of the Wöhler’s curve for cotton fancy flame yarns of linear pulp 30 tex, approximating the logarithmic function of equation $\sigma_n = -0.05\ln(N_{\sigma}) + 1.1158$, where $R^2 = 0.987$ and $F_{calc} = 148.09 > F_{crit} = 7.79$. 

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[Image of Wöhler’s curves for smooth and fancy flame yarns]
Estimation of the theoretical line of regression is the experimental line of regression in the form of equation:

\[ \hat{Y} = B_0 + B_1 \cdot (x - \bar{x}) \]  

(18)

In the opinion of Kocača and Szala [6], Wöhler’s curve diagrams match the probability - P of the failure of samples, equaling 50%. This fact allows for the use of the linear correlation on the basis of the method of smallest squares. Accepting corresponding pairs of values from the investigations of fatigue durability conducted

\[(x_1, y_1); (x_2, y_2); \ldots; (x_n, y_n)\]  

(19)

the dependences considered can be described by a linear equation in the form [4]:

\[ \hat{Y} = B_0 + B_1 \cdot x \]  

(20)

where: \(B_0\) and \(B_1\) are coefficients of the function of regression.

The value of parameters \(B_0\) and \(B_1\) is determined by the method of smallest squares, according to which the sum of squares of deviations among values \(\sigma_i\) determined from Equation 20 for \(N = N_i\) and the values obtained during the experiment should reach the minimum:

\[ \sum_{i=1}^{m} (\sigma_i - B_0 - B_1 \cdot N_i)^2 = \min \]  

(21)

A suitable equation is obtained when partial derivatives of the left side of Equation 21 in relation to \(B_0\) and \(B_1\) are equated to zero. Differentiating with respect to \(B_0\) gives:

\[ \frac{\partial}{\partial B_0} \left[ \sum_{i=1}^{m} (\sigma_i - B_0 - B_1 \cdot N_i)^2 \right] = \]  

(22)

\[ = -2 \sum_{i=1}^{m} (\sigma_i - B_0 - B_1 \cdot N_i) = 0 \]

Dividing both sides of this relationship by the general number \(n\) of pairs of corresponding values obtained during the experiment, equation (22) can be expressed in the following form:

\[ B_0 = \bar{\sigma} - B_1 \cdot \bar{N} \]  

(23)

Substituting the value calculated into Equation 20, the following equation is obtained:

\[ \hat{Y} = \bar{\sigma} + B_1 \cdot (N - \bar{N}) \]  

(24)

After differentiation expression (21) with respect to \(B_1\), the following equation is obtained:

\[ \frac{\partial}{\partial B_1} \left[ \sum_{i=1}^{m} (\sigma_i - B_0 - B_1 \cdot N_i)^2 \right] = \]  

(25)

\[ = -2 \sum_{i=1}^{m} (\sigma_i - B_0 - B_1 \cdot N_i) = 0 \]

Suitably transforming formulae (23) and (25) and also substituting values from these formulae, after reduction, the \(B_1\) value is obtained in the form:

\[ B_1 = \frac{\sum_{i=1}^{m} N \cdot \sigma_i}{\sum_{i=1}^{m} N^2} \]  

(26)

where:

\[ \sum_{i=1}^{m} N \cdot \sigma_i = \sum_{i=1}^{m} (N_j \cdot \sigma_{ij} - \bar{N} \cdot \sigma_j) \]  

(27)

In the literature, Equation 20 often has the form:

\[ \log N = B_0 + B_1 \cdot \sigma \]  

(33)

The equation of regression for smooth yarns (30 tex) is described by the logarithmic function in the form:

\[ \hat{\sigma}_{nm} = 1.181 \times 0.105 \cdot N_p \]  

The coefficient of the multiple correlation \(R = 0.991\); the F-Snedecor’s statistics \(F_1^* = 336.75 > F_{crit} = 5.99\), whereas the confidence interval is \(2.855 < N_p < 6.226\). In turn, the equation of regression for fancy flame yarns (30 tex) has the form:

\[ \hat{\sigma}_{nm} = 1.115 + 0.050 \cdot N_p \]  

The coefficient of multiple correlation \(R = 0.986\); the F-Snedecor’s statistics \(F_1^* = 148.09 > F_{crit} = 7.71\); whereas the confidence interval is \(3.038 < N_p < 10.08\).
The equation of regression for smooth yarns (40 tex) is described by a logarithmic function in the form: \[ \sigma_{sn} = 1.252 + 0.114N_n \], the coefficient of multiple correlation \( R = 0.991 \); the F-Snedecor’s statistics \( F_{6,1} = 175.85 \) > \( F_{crit} = 5.99 \), whereas the confidence interval is \( 3.259 < N_n < 6.340 \). In turn, the equation of regression for fancy flame yarns (40 tex) has the form \[ \sigma_{sp} = 1.116 + 0.048N_p \]. The coefficient of multiple correlation \( R = 0.985 \); the F-Snedecor’s statistics \( F_{4,1} = 138.40 \) > \( F_{crit} = 7.71 \), whereas the confidence interval is \( 3.155 < N_p < 10.40 \).

Summary
The assessment of the fatigue durability of yarns using the statistical approach represents the failure of yarns in the area of low-cycle loads. In the course of one-sidedly positive tensile straining, tension has the character of plastic cracking. Theoretically the failure of this type of yarns proceeds at limiting plastic strains comparable with strains at static loads. The fatigue durability of cotton fancy flame yarns is higher. However, in comparison with the assessment of static durability, the relations are converse and the course of failure of the material is significantly different from the typical course for static loads. The value of the absolute increase in the rate of elongation of the sample equal to 150 mm/min had a direct influence on the results obtained while performing investigations of static strength. In the case of the assessment of fatigue durability, the absolute increase in the rate of elongation was considerably higher, which approximately equalled over 1000 mm/min and was dependent on the constant (for all yarns analysed) frequency of stresses programmed \( f_c = 4 \) Hz. In the case of yarns of 30 tex and 40 tex linear density the coefficient of static strength \( \eta_p \) for fancy flame yarns equalled 91.63% and 95.95%, respectively. Changeable loads acting on the yarns and causing their failure had an influence on the fatigue durability of smooth and fancy flame cotton yarns. Fatigue strength significantly differs from typical static strength at constant static elongations.

Conclusions
1. Decorative effects designed in the form of flames for yarns of all linear densities considered had a direct influence on the variability of the physical proprieties of these yarns.
2. The characteristics of fatigue durability described with Wöhler’s curves and determined for cotton fancy flame yarns made it possible to determine the full diagram of these curves, including...
the area of quasi-static strength, the area of low-cycle strength and also the area of high-cycle strength. In contrast to fancy flame yarns, the Wöhler’s curve for smooth yarns included only the areas of quasi-static durability and those of low-cycle strength. It can be stated that assuming static strength as the criterion of usefulness is not completely legitimate.

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