

Spectral Analysis of the Mass Irregularity of Slivers Using Uster Tester 3

Abstract

A method of calculation for determining the spectral characteristics of wavelengths and amplitudes of assessed sliver irregularities has been developed. Spectrograms from the Uster Tester 3 apparatus for irregularity measurement were utilised. The absolute and relative amplitude values were determined. A common formula for fast amplitude calculation is proposed.

Key words: periodic irregularity, wavelength, amplitude, spectrogram, sliver.

Introduction

No Uster Tester models, except the Uster Tester 4, present dimensions (units) on the spectrogram ordinate of the diagrams obtained [1,2]. The different models register quantities on the ordinate axis which are a function of the variance calculated from the periodic oscillations measured the amplitude of these oscillations. The normalisation is performed automatically, and the Uster Tester 3 (for example) normalises the amplitudes by standard deviation [3].

Ultimately, the user receives a spectrogram which gives him the possibility to detect the repetition length of the periodic faults using the following simple rule: significant is that fault for which the part of the bar over the basic level is higher than half of the basic level. In most cases, this information is sufficient for enterprises which use the tester to evaluate sliver irregularities.

For scientific research (modelling slivers with periodic faults, simulation, etc.), when an exact value of the amplitude is needed, additional investigations should be carried out [4]. Most frequently, a discrete record of the mass diagram is made, followed by Fourier transformation of the received array and calculation of the length, the amplitude and the phase shifting of the individual harmonics [5]. This method is extremely time-consuming. Besides, the harmonics obtained have lengths multiple to the basic length, and only some of them correspond to the lengths used by Zellweger Uster AG.

These disadvantages, as well as the still wide popularity of the Uster Tester 3 all over the world, were the main motive to develop a method to determine the wave

amplitudes quickly. This method aims to ascertain how the amplitudes can be calculated in natural units from the bars on the diagrams, which represent the amplitudes in a non-dimensionalised manner. For this purpose the Uster Tester 3 report is used, particularly the data for sliver irregularity (the coefficient of variation) and the spectrogram.

Theoretical

While developing our method, the following theoretical assumptions and statements were made.

1. The wavelengths form a geometric array with a step of $\sqrt[3]{2}$.
2. The bar height on the spectrograms depends on the intensity of the periodic oscillation, and presents the oscillation's amplitude as standardised through standard deviation.
3. The variance calculated from each harmonic depends on the amplitude $D_i = A_i^2/2$.
4. When a function is presented as the sum of n-number harmonics, the total variance is the sum of the variances of these harmonics $D = \sum_{i=1}^n D_i$.
5. The standardised values

$$Y_i = (X_i - \mu_x)/\sigma_x$$

of the stochastic variable X_i , where:

μ_x - the mathematical expectation, and
 σ_x - the standard deviation, have variance $D = 1$.

Development of the Calculation Method

We propose that the exact values of the wavelengths will be calculated according to the formula

$$\lambda_i = (\sqrt[3]{2})^{N_i} \quad (1)$$

where N_i is the consecutive number of the bar.

On the contrary, when the wavelength is known, the number of the bar may be determined according to:

$$N_i = \log_{\sqrt[3]{2}} \lambda_i \quad (2)$$

The calculation of the lengths with the exact step (not with the approximate value of 1.15) allows us to arrange the lengths in octaves, each consisting of 5 lengths. Every fifth value is the subsequent power of the number 2.

The numbers of the bars and the corresponding lengths are listed in Table 1. For determination of the amplitudes, the following procedure is proposed:

1. Measurement of the heights of all n bars by means of a ruler (in mm): $A_{graf, i}$.
2. Determination of the variances relevant to the measured amplitudes: $D_{graf, i} = (A_{graf, i})^2 / 2$.

Table 1. Exact values of the wavelengths used by Zellweger Uster AG;

No	λ , cm	No	λ , cm	No	λ , cm	No	λ , cm	No	λ , cm	No	λ , cm	No	λ , cm
1	1.15	6	2.30	11	4.59	16	9.19	21	18.38	51	1176	56	1176
2	1.32	7	2.64	12	5.28	17	10.56	22	21.11	52	1351	-	-
3	1.52	8	3.03	13	6.06	18	12.13	23	24.25	53	1552	-	-
4	1.74	9	3.48	14	6.96	19	13.93	24	27.86	54	1783	-	-
5	2,00	10	4,00	15	8,00	20	16,00	25	32,00	55	2048	-	-

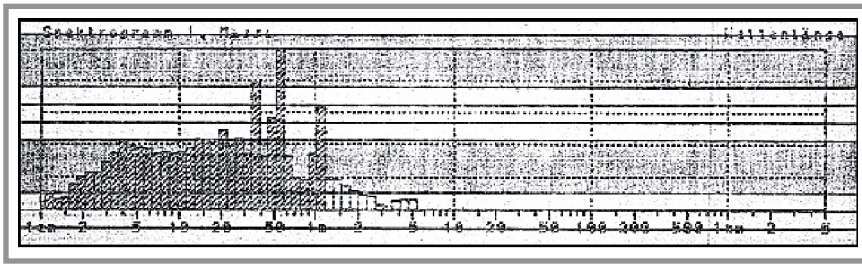


Figure 1. Spectrogram for sliver 1.1.

3. Determination of the total variance:

$$D_{graf} = \sum_{i=1}^n D_{graf,i}$$

4. Calculation of the participation of the individual variance portions in the total variance:

$$P_i = D_{graf,i} / D_{graf}$$

The total variance is equal to 1.

5. Determination of the absolute values of the variations (in tex²):

$$D_i = P_i(CV \cdot T_i/100)^2$$

where *CV* is the sliver's irregularity in

%, and *T_i* - the sliver's linear density in tex.

6. Determination of the absolute values of the amplitudes $A_i = \sqrt{2 \cdot D_i}$.

7. The relative values of the amplitudes can be calculated as a percentage of the mean value: $A_{i, \%} = A_i / T_i \cdot 100$.

This allows us to compare the irregularity amplitudes of slivers with different linear densities more easily. These calculations can be made by means of a computer calculation program. For the

development of the presented method, the Excel all-purpose program from Microsoft was used.

Experimental

Five slivers after the first drawing frame and 5 slivers after the second drawing frame were investigated. The linear densities were 4650 tex and 3703 tex, respectively. The measured irregularities are presented in Table 2. The calculations for the first variant are shown in Table 3, whereas the spectrogram is shown in Figure 1. The data for the other slivers were prepared in the same way.

When the amplitudes are calculated by means of the method presented herein, the total variance in all cases becomes equal to those given, and the proportions between the amplitudes are maintained (the correlation coefficient between the measured and the calculated amplitudes $R=1$). These results verify the calculation method. The relation for sliver denoted as variant 1:1 (in Table 2) is presented in Figure 2.

The next aim of the investigation was to find a universal formula for calculating the amplitudes.

Because the normalisation is carried out using standard deviation, we can expect a relation to exist between the correction coefficient

$$k = A_{i, \%} / A_{i, graf}$$

which determinates the amplitude scale, and the irregularity *CV*. The standard deviation could be presented as

$$S = CV \cdot T_i / 100.$$

From the above relation, it follows that

$$A_i/S = A_{i, \%}/CV = k \cdot A_{i, graf}/CV.$$

In Table 4, the correction coefficients *k* for each variant are given and compared with the irregularities measured. In Figure 3, the relation between the correction coefficients and the slivers' irregularities is shown. As can be seen, a close relation between the correction coefficient and the

Table 2. Measured values of the irregularities.

Variant	Sliver 1.1	Sliver 1.2	Sliver 1.3	Sliver 1.4	Sliver 1.5	Sliver 2.1	Sliver 2.2	Sliver 2.3	Sliver 2.4	Sliver 2.5
CV, %	5.85	5.94	5.95	6.18	6.70	5.97	6.53	6.64	7.31	8.09

Table 3. Calculations for Sliver 1.1; the calculations are presented in the table only for the bars No 1-15 and No 44-45.

No	λ , cm	$A_{graf,i}$, mm	$D_{graf,i}$, mm ²	P_i	D_i , tex ²	A_i , tex	A_i , %
1	1.15	4.00	8.000	0.001839	136.07	16.50	0,35
2	1.32	2.50	3.125	0.000718	53.15	10.31	0,22
3	1.52	3.00	4.500	0.001034	76.54	12.37	0,27
4	1.74	6.00	18.000	0.004137	306.16	24.74	0,53
5	2.00	7.50	28.125	0.006465	478.37	30.93	0,67
6	2.30	9.00	40.500	0.009309	688.85	37.12	0,80
7	2.64	9.00	40.500	0.009309	688.85	37.12	0,80
8	3.03	11.25	63.281	0.014545	1076.33	46.40	1,00
9	3.48	13.25	87.781	0.020177	1493.04	54.65	1,18
10	4.00	16.50	136.125	0.031289	2315.30	68.05	1,47
11	4.59	15.25	116.281	0.026728	1977.78	62.89	1,36
12	5.28	15.00	112.500	0.025859	1913.47	61.86	1,34
13	6.06	14.50	105.125	0.024163	1788.03	59.81	1,29
14	6.96	13.25	87.781	0.020177	1493.04	54.65	1,18
15	8.00	14.00	98.000	0.022526	1666.85	57.74	1,24
44	446	2.50	3.125	0.000718	53.15	10.31	0,22
45	512	2.50	3.125	0.000718	53.15	10.31	0,22
Σ			4350.59	1	73997.6		

Table 4. Comparison between the correction coefficients and the irregularities.

CV, %	5.85	5.94	5.95	6.18	6.70	5.97	6.53	6.64	7.31	8.09
k	0.0887	0.0902	0.0905	0.0931	0.0996	0.0898	0.0949	0.0988	0.1099	0.1221

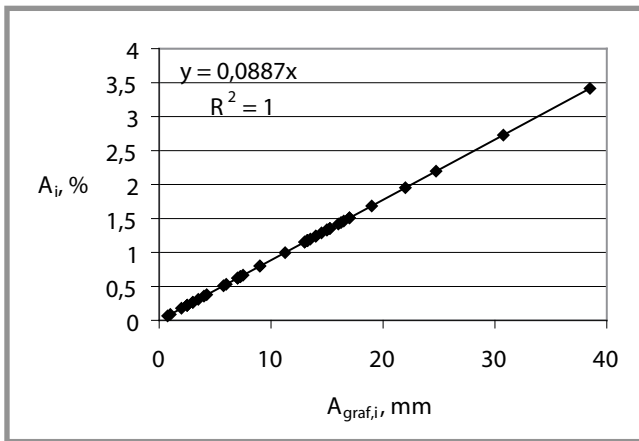


Figure 2. Correlation between measured and calculated amplitudes.

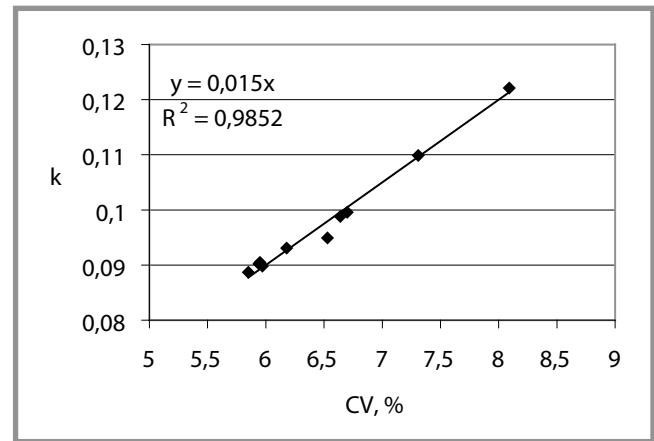


Figure 3. Correlation between correction coefficients and irregularities.

irregularity $R=0.99$ exists. The equation worked out allows us to quickly determine every single amplitude without the need to measure all of them. The empirical formula for such a calculation is:

$$A_i, \% = 0.015 \cdot A_{i, graf} \cdot CV \quad (3)$$

Conclusions

A method has been developed for calculating the length and amplitude of the periodic oscillations using Uster Tester

3 reports which present the coefficient of variation CV and spectrograms of sliver irregularity. The method was verified with experimental data, and the degree of identity obtained is very high. An empirical formula for calculating the amplitudes using the bars' heights and the irregularity value CV has proposed. The information obtained can be used for sliver analysis and for modelling, thus avoiding the time-consuming data checking from the mass diagram and further transformations.

References

1. Uster Tester 3, Zellweger Uster, 1991.
2. Uster Tester 4-SX, Zellweger Uster, 2000.
3. M. Bona, *Statistical Methods for the Textile Industry*, Textilia, Torino, 1993, pp 206-208.
4. M. Bona, *Textile Quality*, Textilia, Torino, 1994, pp 266-272.
5. L. Lozanov, *Determination of the harmonics' influence on the unevenness*, *Textile and Garment*, 1998, 6, pp. 10-13.



Received 11.02.2002 Reviewed 30.02.2003

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