AREA TEYTILE ANISOTROPY ESTIMATED ALSO USING ACOUSTIC EMISSION

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Abstract

In the paper the anisotropy of mechanical properties of webs and web textiles produced using the short fibres and spun bonding technology is being studied. In both cases the web and web textiles has been reinforced through the needleing . The main structure parameters as well as the physical and geometrical properties of fibres has been determined and its orientation and filling factors measured using the section technique. The mechanical properties have been measured on the dynamometer LabTest II 2.05 accompanied with the acoustic emission (AE) spektrometer XEDO-DAKEL. The AE spectra of web textiles have been presented demonstrating also the anisotropy of these ones. From the measurements and using the tensor theory the polar diagram have been constructed.
The anisotropy of web textiles has been measured also through the new type of centrifugal dynamometer after Sodomka and the results denonstrated.

Key words

Anizotropy , web textiles, spun bonding, needleing, orientation and filling factors, acoustic emission, tensor theory, polar diagram

1. Introduction

The object of our research and contribution is the anisotropy of polypropylen web and web textiles reinforced through the needleing.
The anisotropy of textiles is defined as the dependence of the arbitrary textile properties on the measuring direction. The anisotropy of mechanical properties is very important property of area textiles applied directly in praxis or as the reinforced matter for the textile composites. The anisotropy of mechanical properties of area textiles is given through the fibre material, fibre orientation, fibre filling and fibre interaction (bonding), through fibre distribution and fiber ordering. From this point of view the area textiles are being devided in highly ordered structure (woven, knitted textiles) and quite disordered (web textiles with randomly oriented fibres) and disordered web textiles with different degree of fibre orientation. It has been shown [1],[2],[3],[4] that on the anisotropy properties of area textiles for the mathematical describing the tensor calculus can be applied when the area textiles can be considered as continuum. This is done in the cases, if the waves speading in the textiles have the wave length longer as the distnances between fibres are. Therefore it is very important to know the wave spectra appearing in the area textiles. Because the area textiles can be approximated as the thin plates, it is naturally to suppose that in the textiles only the Lambe waves can be present and exceptionaly the Rayleigh waves and in the layered textiles the Stonley waves can be detected[5],[6],[7],[8],[9],[10]. The aim of this contribution is to measure the fibre orientation and its relation to anisotropy of mechanical properties of area textiles measured through the dynamometer and acoustical emission (AE) using XEDO-DAKEL spectrometer.

2. Orientation of fibres in web textiles

Web textiles are belonging to area textiles, if the thickness of textiles are in dimension negligible with regard to used linear dimensions in the plane of textiles. The properties espcially the mechanical properties are depending on the mechanical propertis of fibres. When the fibres are in the textiles quite free, The mechanical properties of the paralell fibres in the web is being determined with the count of the properties of single fibres. In the chosen direction, determined in the polar coordinate system through angle θ, the properties of the textile in this direction are being depended on the number of fibres N(θ). I the angle interval Δθ let be ΔN fibres, then the probability ΔP(θ) , that any fibre is being fallen in the angle interval Δθ, centred about the angle θ is

$\Delta P = \Delta N / N(\theta) = n(\theta)\Delta\theta / N(\theta)$, $n(\theta) = \Delta N/\Delta\theta$, $n(\theta)$ is angle density of fibres (1)

If the single fibre has the property $f_{i,}$, then the total property F of the web textile can be computed as follows

$F = \Sigma\, \Delta P(\theta) f_{i,} = \Sigma\, f_i\, n(\theta)\Delta\theta / N(\theta) = \Sigma\, f_i\, \Delta P(\theta)/\Delta\theta = \Sigma\, f_i\, p_i$, $p_i = \Delta P(\theta)/\Delta\theta$ (2)

P_i is the angle probability density.

For the continuously distributed fibres with probabilityx density p and single fibre property f, the average property of the web textle will be

$F = \int f(\theta)\, p(\theta)\, d\theta$ (3)

From this elementary theory it is evident, that for the detemination average propertiy of web fabric it is necessary to point out the angle density of fibres n(θ) for the angle θ, that is meaning the angle density of fibres , $n(\theta) = \Delta N/\Delta\theta$. For set this quantity it is possible to use different experimental methods as for instance the section and filling factors methods are. All this is being done for the investigation of the structure and mechanical properties anisotropy of web textiles. An another method for these measurements the acoustic emission (AE) is also apllied.

For the estimation of anisxotropy the anisotropy coefficient S_A has been introduced by Sodomka elsewhere,which is defined as follows

$S_a = (V_{max} - V_{min}) / (V_{max} + V_{min})$ (4)

kde V_{max} a V_{min} are the maximal respectively minimal values in the polar diagram.

3. Web textiles used to measurements

For the measurements of the structure and mechanical properties anisotropy the spun bonded polypropylen web textiles of the type Tatratex of the area mass 200 g/m^2, ,300 g/m^2, 400 g/m^2, 500 g/m^2, 600 g/m^2,800 g/m^2,1000 g/m^2,1200 g/m^2 have been chosen. The structure anisotropy, that is meaning the orientation of the fibres in the web textiles, has been quantified

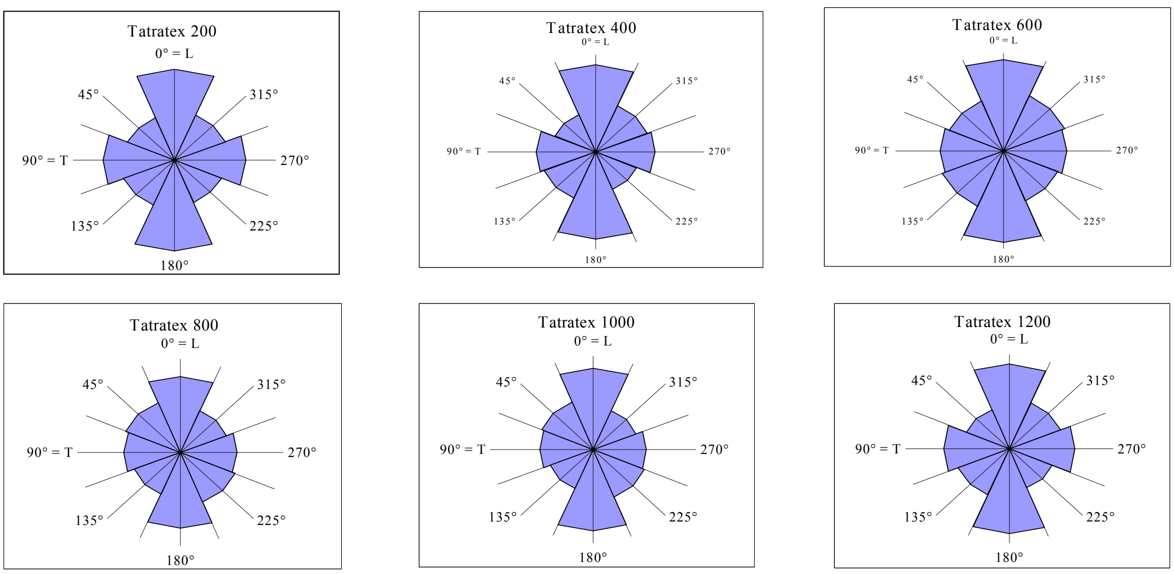


Fig.1 The fibre orientation rosettes for the undeformed web textiles

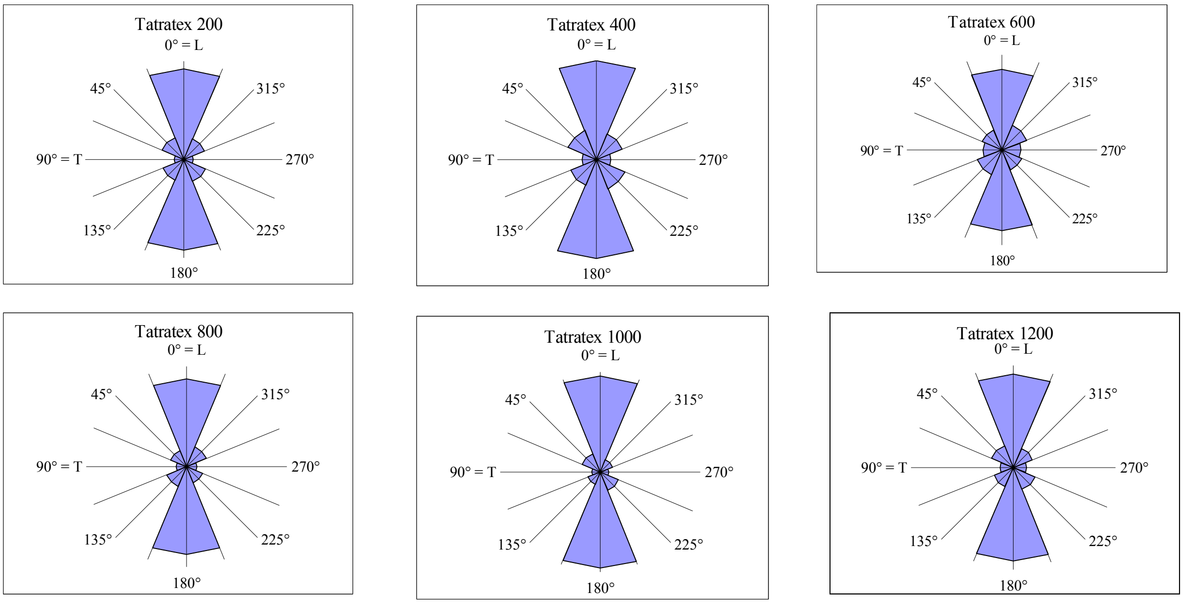


Fig.2 The fibre orientation rosettes for the drawn deformed web textiles

undeformed and on the fig.2 a),b)c),d),e)f),g),h) for the drawn deformed ones.
From the orientation rosettes it is being seen that the web textile is having approximately the orthotropic symetry, which has been for the drawn deformed textiles improved as well as their anisotropy.
When the coeffcient of anisotropy defined through the relation (1) is being calculated, it is being obtained the values summarised in the tab.1 for the undeformed and in the tab.2 for the drawn deformed web textiles.

Tab.1 The anisotropy degree of the web textiles Tatratex

Název netkané textilie	S_{AM} [1]	S_{AS} [1]		S_{RMS} [1]	S_U [1]	S_ρ [1]	S_f [1]
		S_{AS1}	S_{AS2}				
Tatratex 200	**0,39**	**0,33**	**0,80**	**0,58**	**0,33**	**0,56**	**0,43**
Tatratex 300	**0,16**	**0,39**	**0,72**	—	—	—	—
Tatratex 400	**0,24**	**0,37**	**0,75**	**0,07**	**0,22**	**0,57**	**0,51**
Tatratex 500	**0,28**	**0,31**	**0,66**	—	—	—	—
Tatratex 600	**0,15**	**0,26**	**0,62**	—	—	—	—
Tatratex 800	**0,27**	**0,26**	**0,79**	—	—	—	—
Tatratex 1000	**0,27**	**0,32**	**0,84**	**0,30**	**0,19**	**0,33**	**0,17**
Tatratex 1200	**0,22**	**0,33**	**0,75**	—	—	—	—

S_{AM} **- anisotropy degree of Young modulus**
S_{AS}, S_{AS1}, S_{AS2} **– anisotropy degree of the fibre orientation**
S_{RMS} **– anisotropy degree of the RMS of AE**
S_U **- anisotropy degree stupeň anizotropie napětí**
S_ρ **- anisotropy degree of the power signal of AE**
S_f **– anisotropy degree of the frequncy signal breath**

Tab.2 The degree of anisotropy web textiles Tatratex

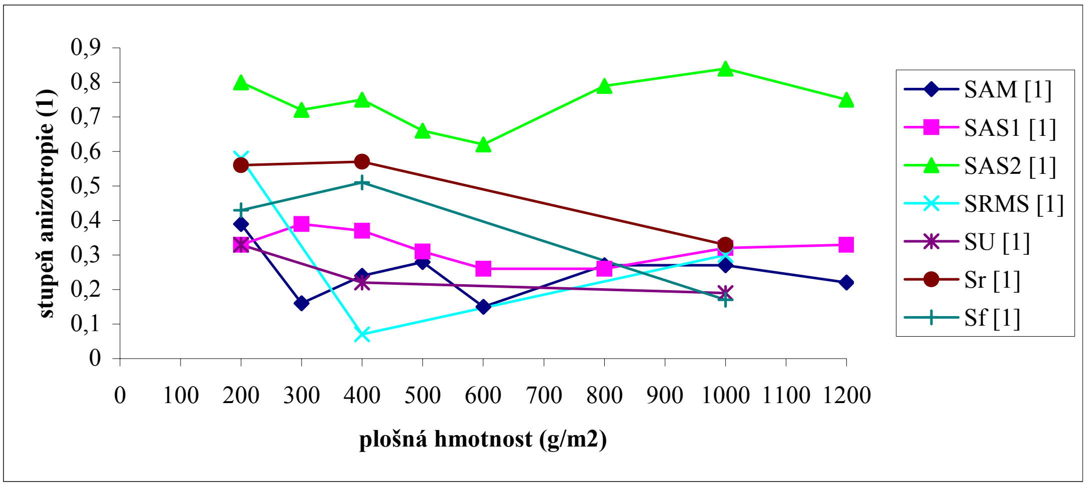
4. Mechanical properties and its anisotropy of web textiles

As it can be expected and confirmed by the theory of section 2., the structure anisotropy is being induced the anisotropy of the mechanical properties of the web textiles. The polar diagrams of the mechanical properties presented through Young modulus for the web textiles are being shown on the fig.3.

In these polar diagrams the the orthotropy is more evident and exact than on the structure diagram orientation rosettes are. Very interessting is the change of the form of polar diagram on the area mass of the web textiles They are changing from the cross to elipsis and back to the cross. The theoretical explanation of this effect has not been recognised.

The anisotropy coeffcients of the polar diagrams are summarised in the tab.3 and the dependences of the anisotropy corëfficient on the area mass of the web textiles using diffrent measuring methods (structure, Young modulus, AE parameters are being presented on fig.4.

anisotropy degree



area mass

Fig 4. The dependence of anisotropy coefficient S_A on the the area mass

5. Acoustical emission (AE) spectra indicating the anisotropy of web textiles

The another method which can be used for the anisotropy detemination of web textiles is the acoustical emission (AE) .The example of the AE spectrum for the three oreintation L T and 45^0 is being presented for the Tatratex 200, 400 and 1000 on the fig.5, fig.6 and fig.7. To describe the anistropy quantitatively the quntity have tobe be chosen. For exaple : 1. the maximal value of the RMS, and its corresponding time, the maximal value of the power spectrum and its breadth. The results have been introduced already on the fig.5

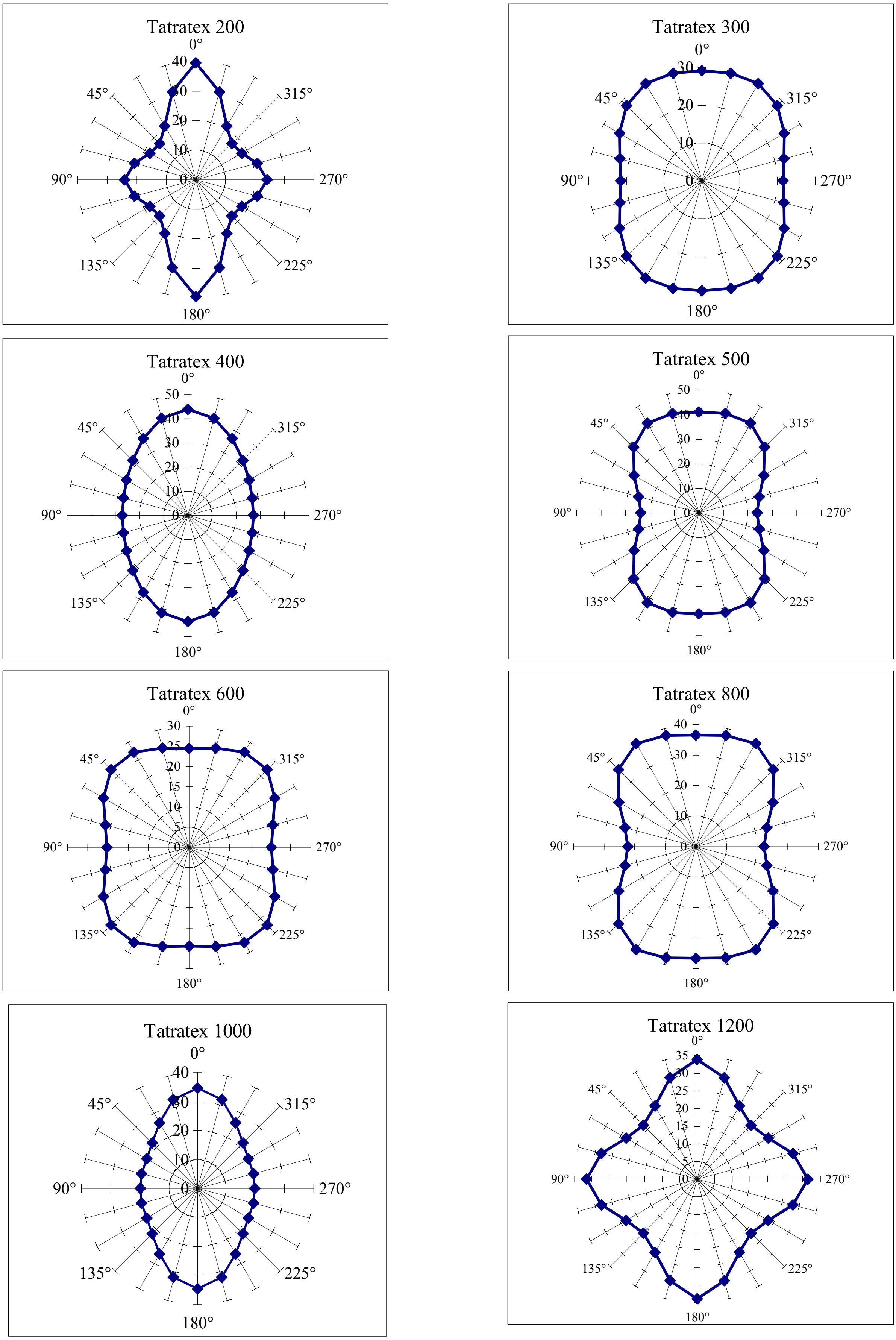
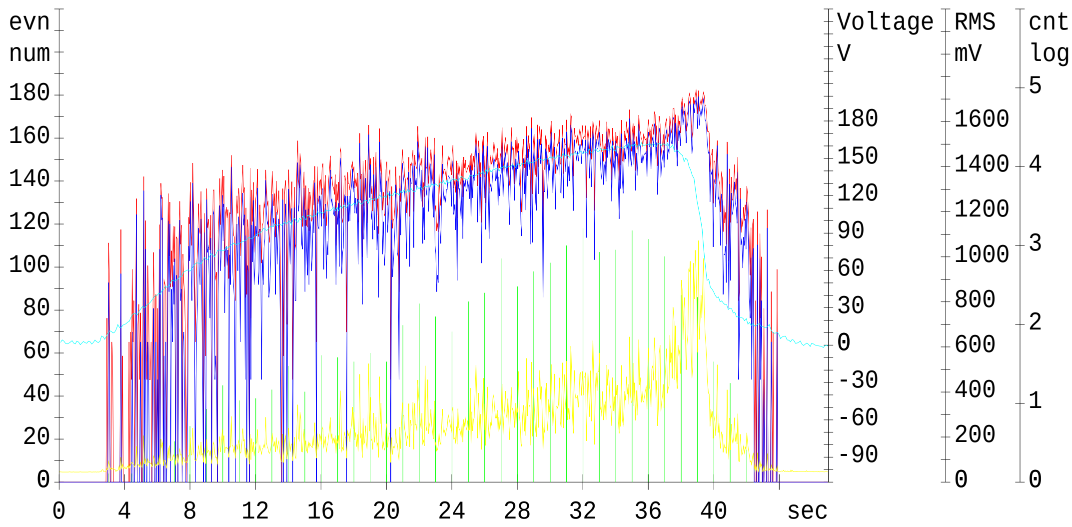
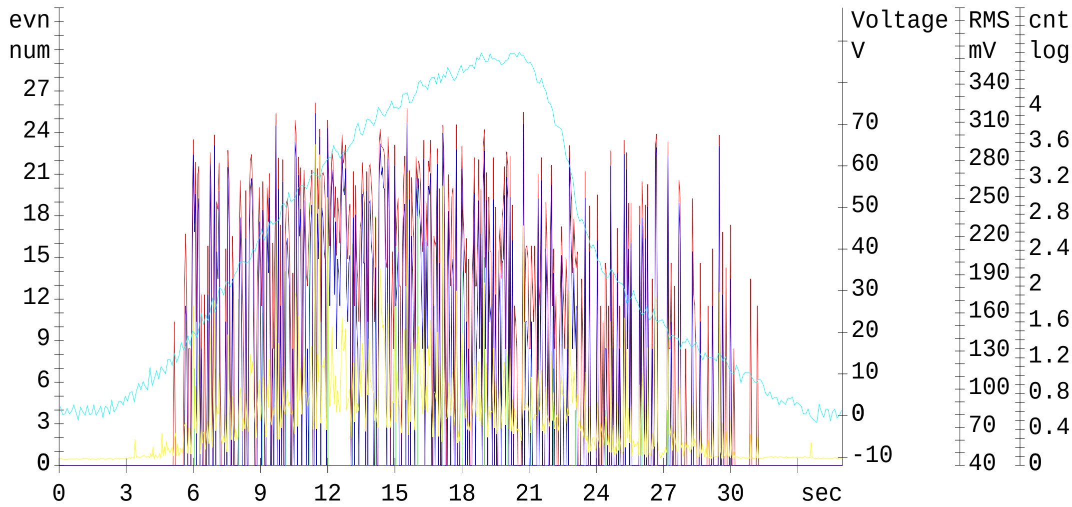


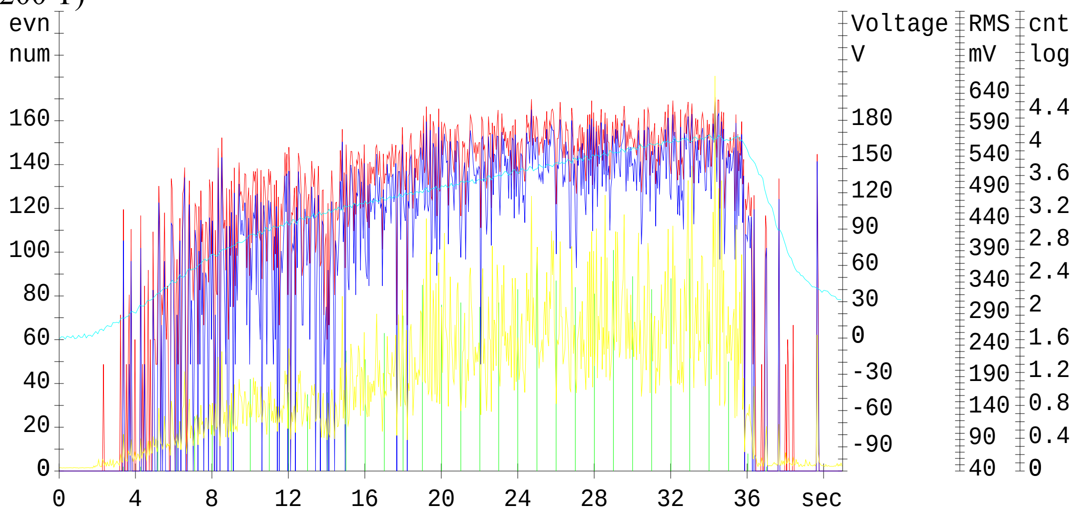
Fig.3 The polar digrams of Young modulus for the web textiles



200 L)

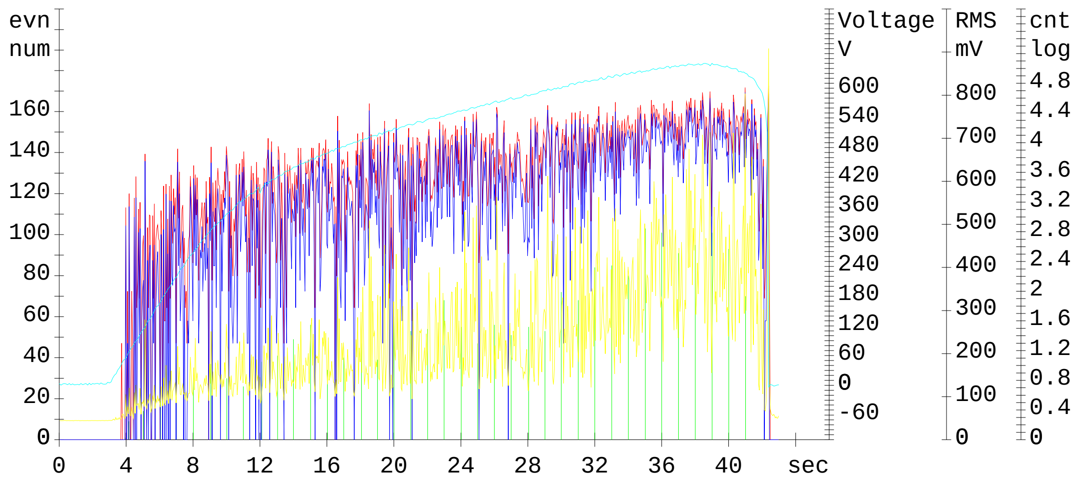


200 T)

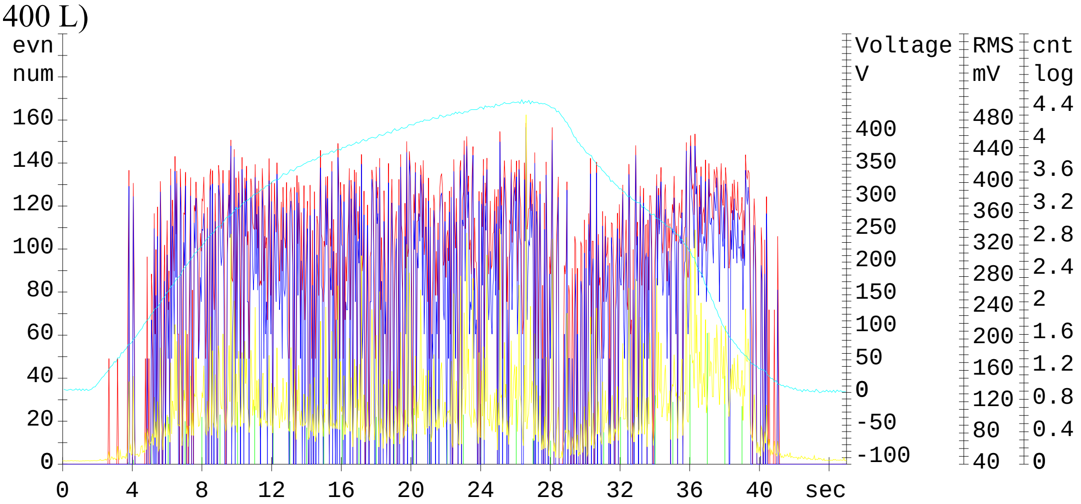


200 45)

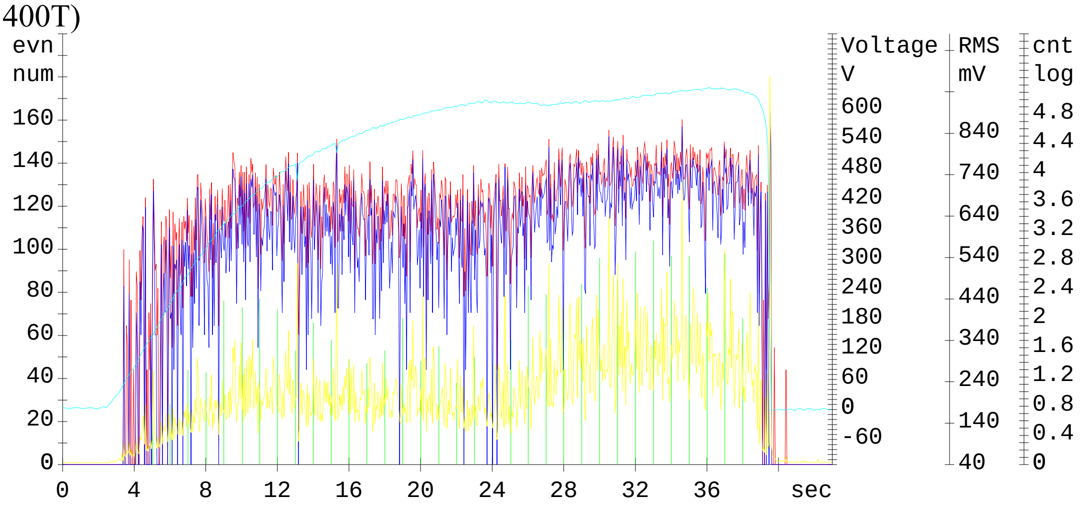
Fig.5. AE spectrum for the web textile Tatratex area mass 200 for orientations L,T, and 45.



400 L)

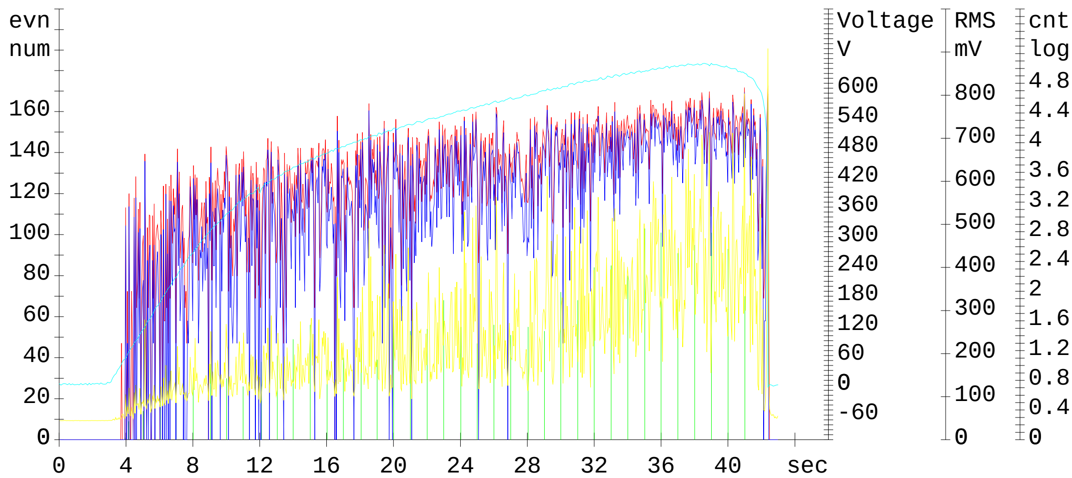


400T)

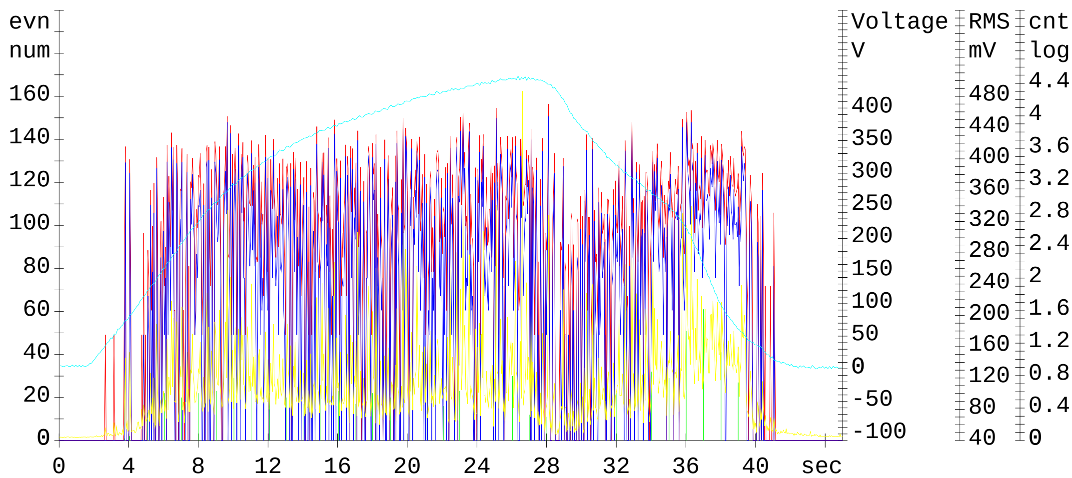


400 45)

Fig.6 AE spectrum for the web textile Tatratex area mass 400 for orientations L,T, and 45.



1000 L)



1000 T)

1000 45)

Fig.7 AE spectrum for the web textile Tatratex area mass 1000 for orientations L,T, and 45.

From the fig.5,6 and 7 it is being seen that the AE spectra made after the textiles deformations are being a good indicator of the uniqueness of the each textile and as well as of the anisotropy of wovens and nonwovens. From these figures the connection between deformation cureves and AE spectra are also being observable.

References

[1] Sodomka, L.: Struktura a vlastnosti pevných látek. SNTL Praha 1967.

[2] Sodomka, L.: Structure and properties of solids. Illife London 1967.

[3] Sodomka, L.: Physics of condense matter I, II, III. Adhesiv Liberec 2002, 2003.

[4] Sodomka, L.: Structure, properties, diagnostics, and new technologies of separating, joining and bonding of textiles . Technical University Liberec 2002.

[5] Landau, L. D., Lifčic, E. M.: Mechanics of continua. Moscow 1953.

[6] Unger, K., et al.: Festkoerperphysik. Akad. Verlag Leipzig, p. 383, 1979.

[7] Beltzer, A. I. Acoustic in solids. Springer Verlag, Berlin 1988.

[8] Royer, D., et alElastic waves in solids I, II. Springer Verlag Heidelberg 2000.

[9] Sodomka, L., Valíček, J.: Application the theory of noise and fluctuations to the acoustical emission of textiles. Int. Conference of Noise and Fluctuation, Prague June 2003.

[10] Sodomka, L.: [10] Plisé effect. Fibres and Textiles 2002.

[11] Sodomka, L.: Optical methods of textile structure determination . Textil 33, p. 257, 1978.

[12] Kotásková, L.: Diploma work. Technical University Liberec 2002.

[13] Váňová, L.: Diploma work. Technical University Liberec 2002.

[14] Sodomka,L.: Structure, properties, diagnostics and new technologies of the separating, joining and bonding of textiles. TU Liberec 2002.

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