

AREA TEXTILE 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 exceptionally 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

especially the mechanical properties are depending on the mechanical properties of fibres. When the fibres are in the textiles quite free, The mechanical properties of the parallel 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 $N(\theta)$. In the angle interval $\Delta\theta$ let be ΔN fibres, then the probability $\Delta P(\theta)$, that any fibre is being fallen in the angle interval $\Delta\theta$, centred about the angle θ is

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

If the single fibre has the property f_i , then the total property F of the web textile can be computed as follows

$$F = \sum \Delta P(\theta)f_i = \sum f_i n(\theta)\Delta\theta/N(\theta) = \sum f_i \Delta P(\theta)/\Delta\theta = \sum f_i p_i, p_i = \Delta P(\theta)/\Delta\theta \quad (2)$$

P_i is the angle probability density.

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

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

From this elementary theory it is evident, that for the determination average property of web fabric it is necessary to point out the angle density of fibres $n(\theta)$ 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. Another method for these measurements the acoustic emission (AE) is also applied.

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

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

where V_{max} and 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 Tatrutex of the area mass $200 \text{ g/m}^2, 300 \text{ g/m}^2, 400 \text{ g/m}^2, 500 \text{ g/m}^2, 600 \text{ g/m}^2, 800 \text{ g/m}^2, 1000 \text{ g/m}^2, 1200 \text{ g/m}^2$ have been chosen. The structure anisotropy, that is meaning the orientation of the fibres in the web textiles, has been quantified

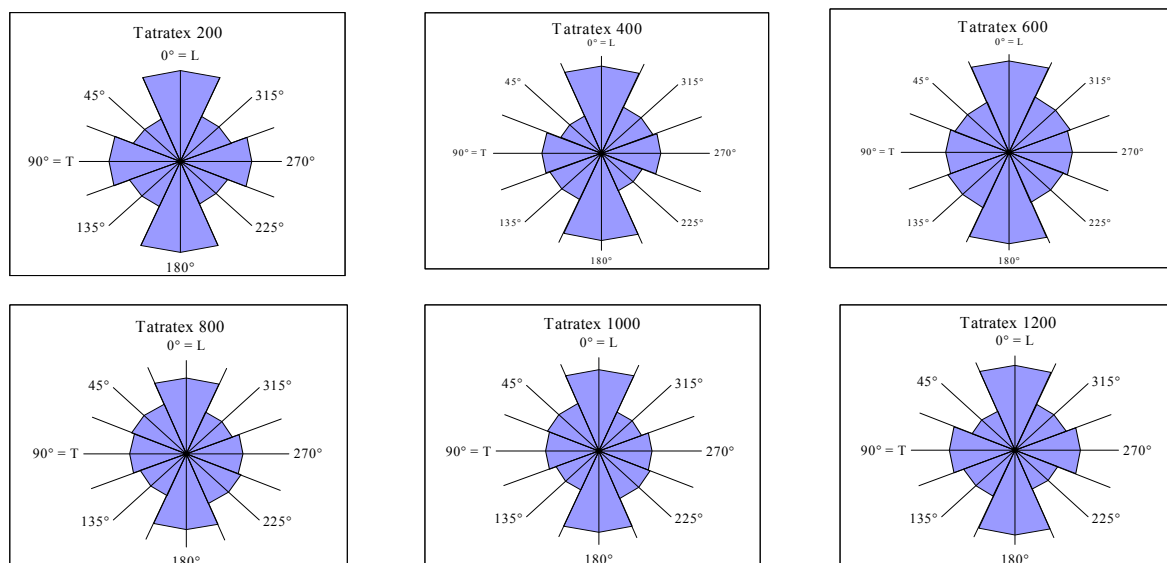


Fig.1 The fibre orientation rosettes for the undeformed web textiles

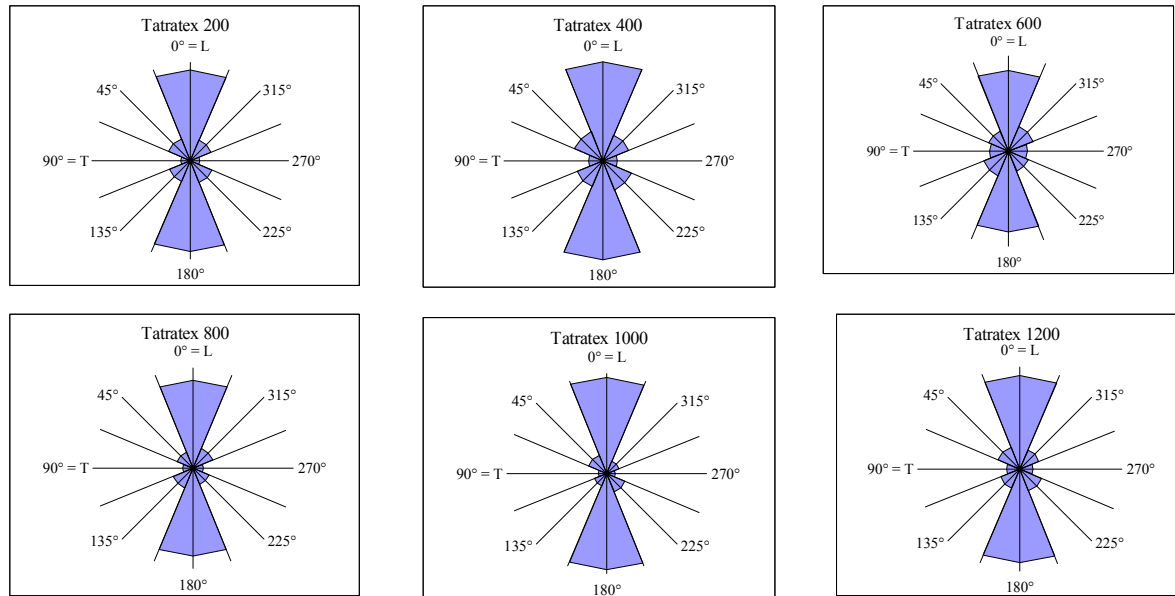


Fig.2 The fibre orientation rosettes for the drawn deformed web textiles

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 symmetry, which has been for the drawn deformed textiles improved as well as their anisotropy.

When the coefficient 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 Tatratrex

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}				
Tatratrex 200	0,39	0,33	0,80	0,58	0,33	0,56	0,43
Tatratrex 300	0,16	0,39	0,72	—	—	—	—
Tatratrex 400	0,24	0,37	0,75	0,07	0,22	0,57	0,51
Tatratrex 500	0,28	0,31	0,66	—	—	—	—
Tatratrex 600	0,15	0,26	0,62	—	—	—	—
Tatratrex 800	0,27	0,26	0,79	—	—	—	—
Tatratrex 1000	0,27	0,32	0,84	0,30	0,19	0,33	0,17
Tatratrex 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 frequency signal breath

Tab.2 The degree of anisotropy web textiles Tatrutex

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 interesting 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 coefficients 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

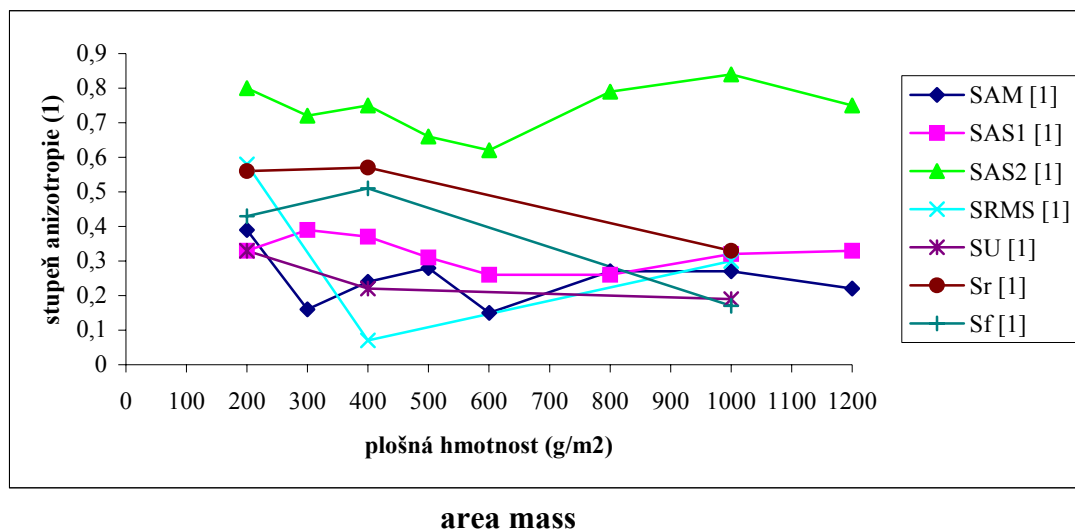


Fig 4. The dependence of anisotropy coefficient S_A on the the area mass

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 Tatrutex 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

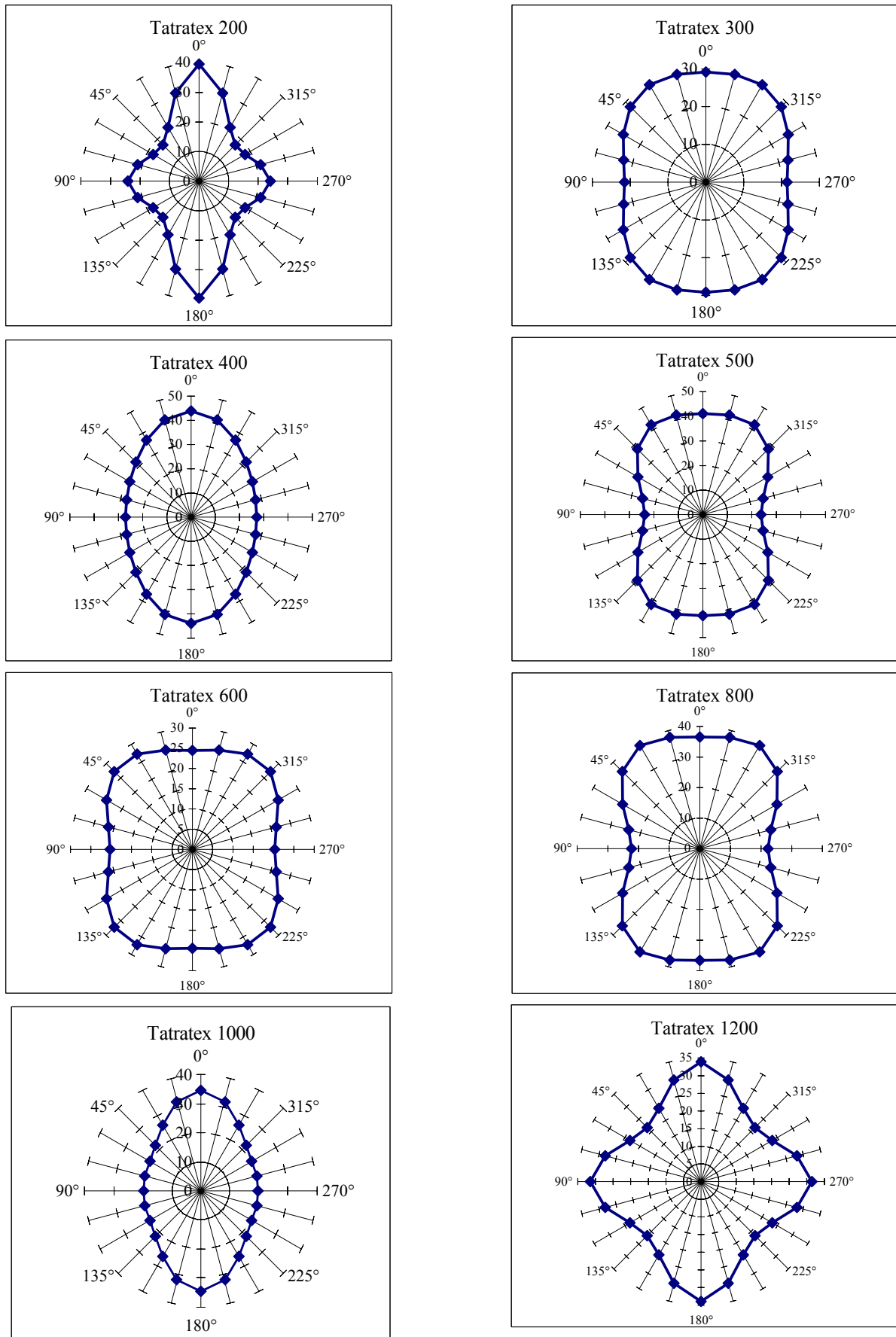


Fig.3 The polar digrams of Young modulus for the web textiles

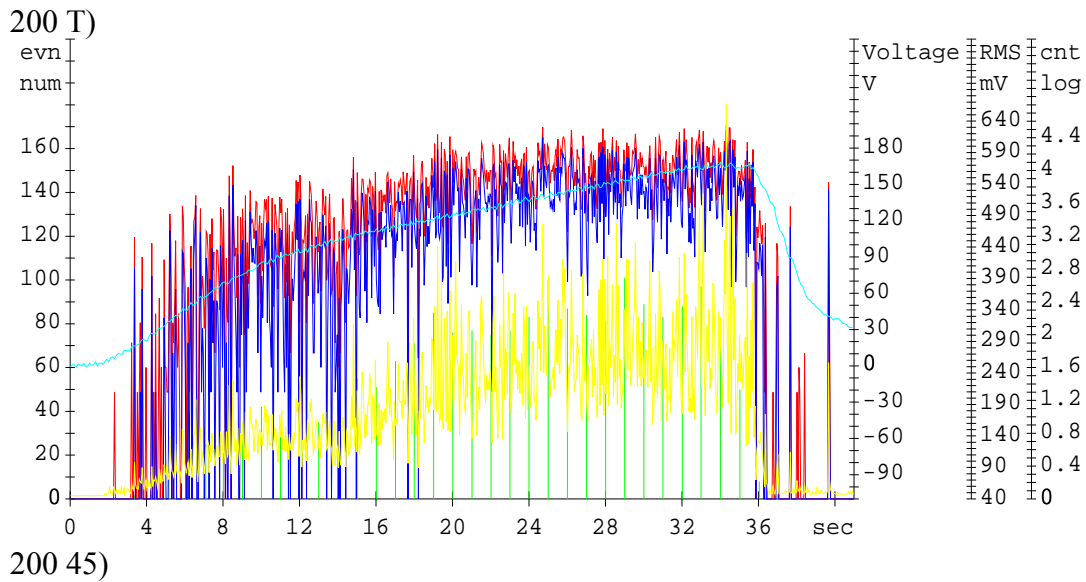
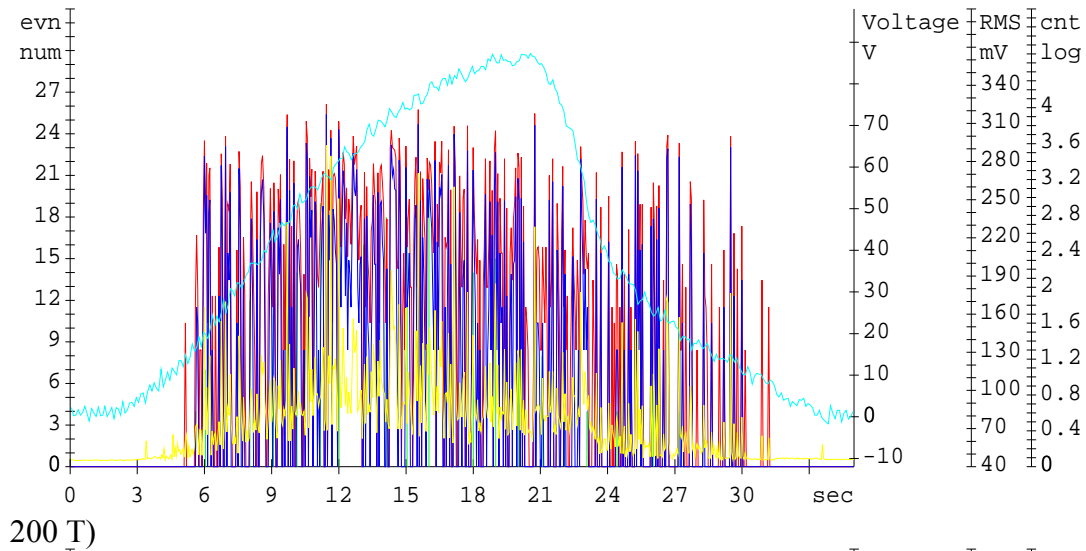
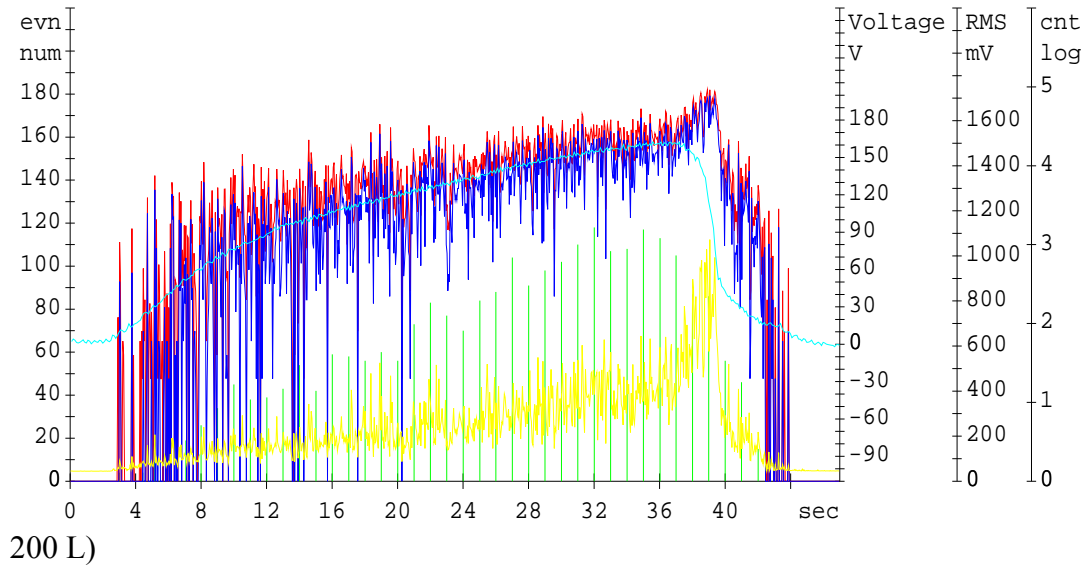


Fig.5. AE spectrum for the web textile Tatrutex area mass 200 for orientations L,T, and 45.

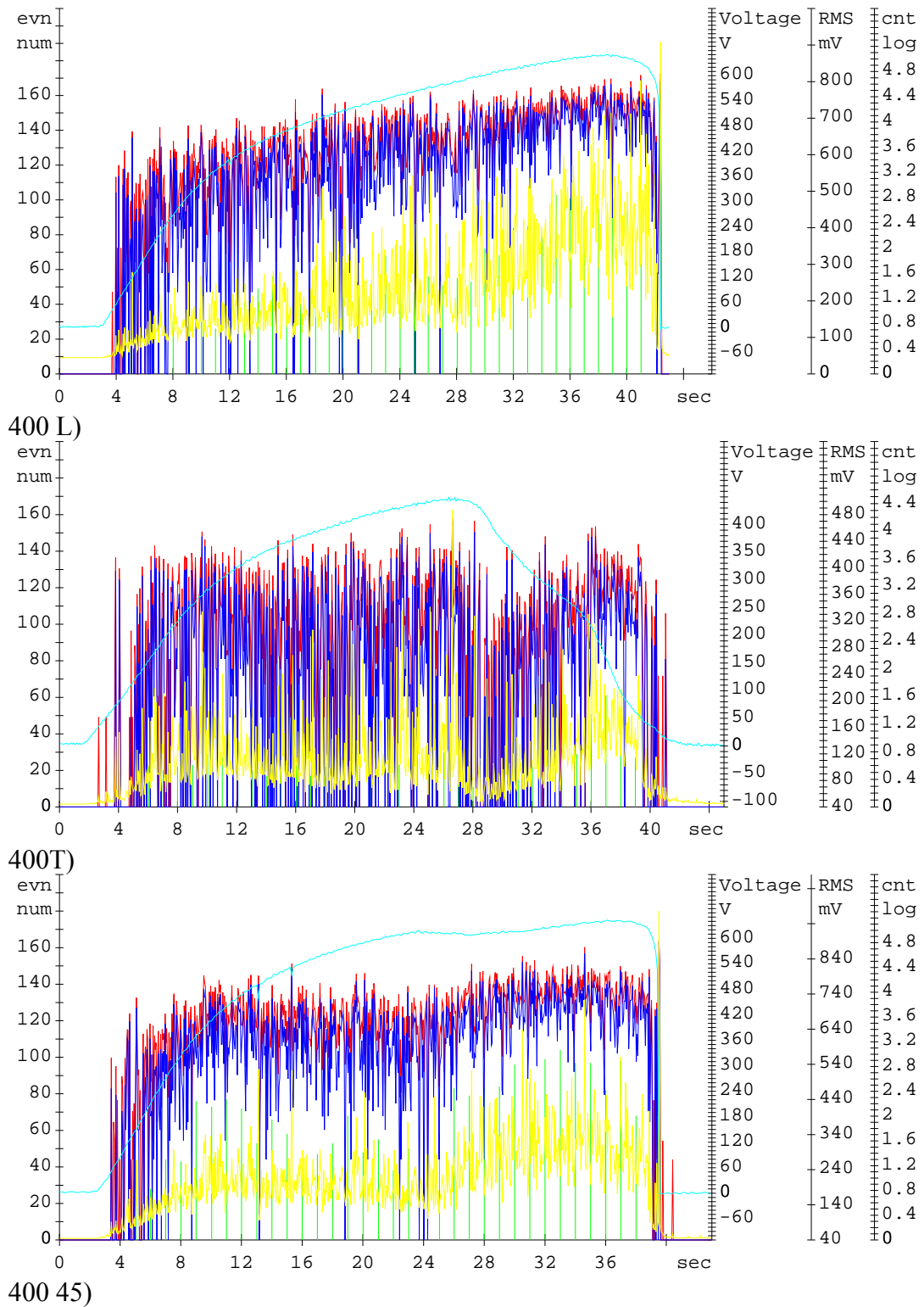
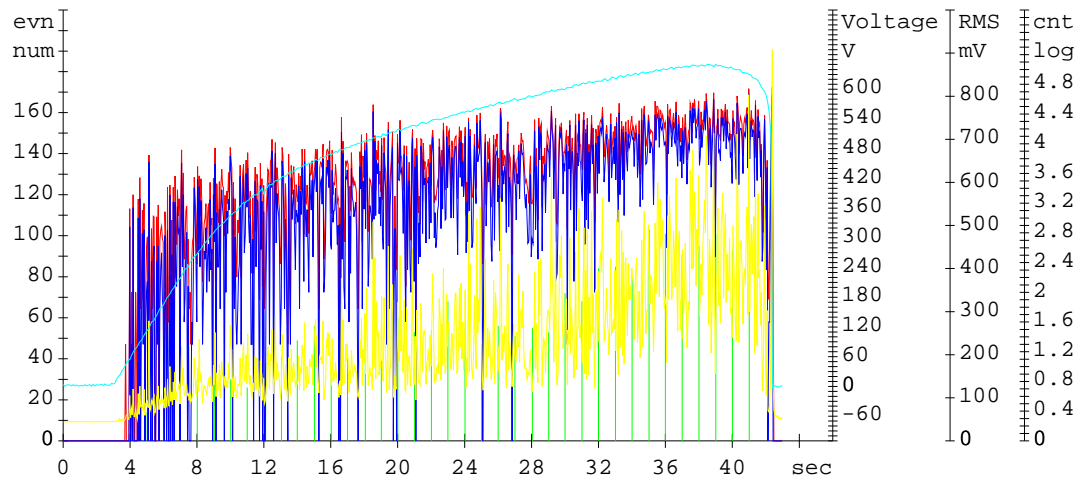
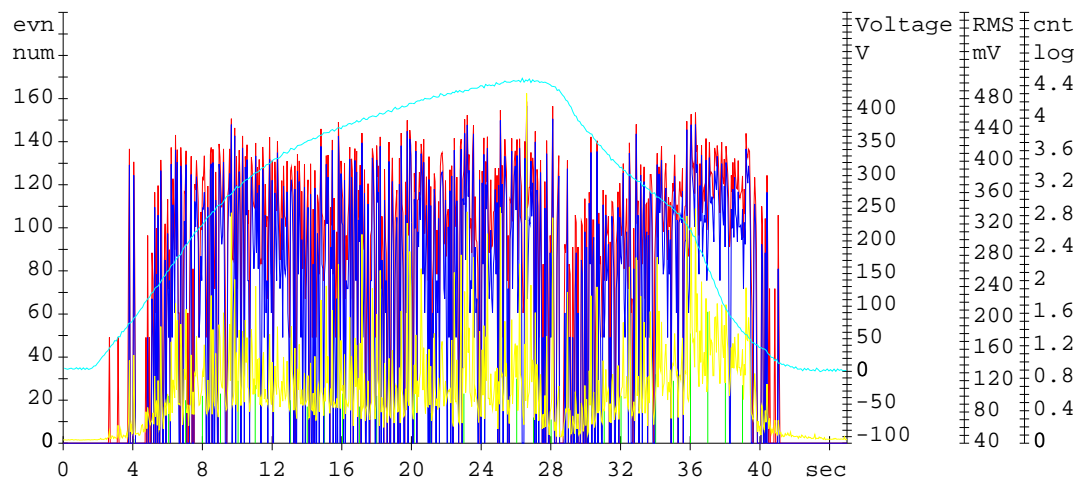


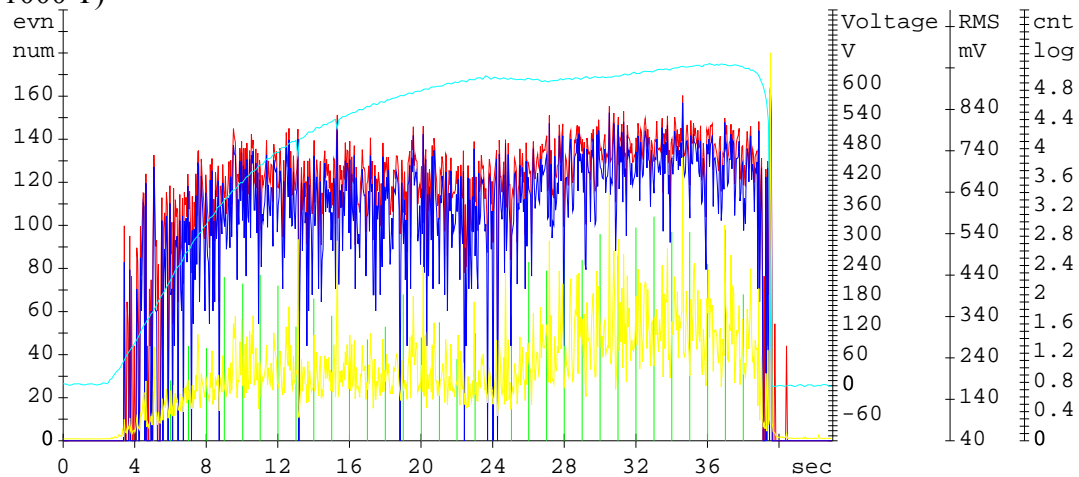
Fig.6 AE spectrum for the web textile Tatrutex area mass 400 for orientations L,T, and 45.



1000 L)



1000 T)



1000 45)

Fig.7 AE spectrum for the web textile Tatrax 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 curves and AE spectra are also being observable.

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