Application of acoustical emission as a new effective diagnostic tool in the textile fields

Lubomír Sodomka

Technical university, Textile Faculty, Clothing department, Hálkova 6, 46117 Liberec 1, CR

e-mail : lubomir.sodomka@vslib.cz

Abstract

In the paper the possibility of application of acoustical emisssion (AE) to the solution some structure problems of textiles is being presented. After some theoretical considerations about the using the AE in textile fields, the principles of the experiemental set up of the AE is being shown. The application of AE on the lenght textiles as the carbon fibres are, the application of AE is being presented to the area textiles. The AE spectrum of woven as well as of web fabrics is being registered

Key words

Acoustical emission (AE), textile fabrics, wovens, nonwovens, anisotropy, friction

1. Introduction

The AE is very old phenomenon. The new scientific and technical content has the AE gained about the half of the 20th century in the works of J.Kaiser and his followers [1],[2],[3] and furthers introduced in [4], [5].

Long time the AE has been applied only to the classical materials as the metals , ceramic , wood and others are. As lately as from 1978 the Sodomka,Leistner and Tessmar has been engaged with AE in the AE field and the first publications have been appeared in [6] and have been summarized in [7].

2. Physical principles of AE for textile research

AE is being the physical phenomenon appearing as the stress waves in the condense matter induced through its loading of the physical fields as the mechanical, thermal electromagnetical and radiation are. When the structure changes in condence state are taking place the stress waves are being induced and their energy with them is being propagated.

AE can be applied in two different fields macroscopical and sunmicroscopical (molecular) ones. In the textile research and testing both are being used. AE sources in macroskopical scale are the macroscopical unevenness, crases and cracks in different places of matter, outer friction of fibres, the electrical triboburting as acoustical as well as electrical phenomena. All AE phenomena are being accompanied with the universal thermal vibration and waves which can be detected also with modern AE detector thus defining the resolution of the AE. From the theory the minimal energy, amplitude of AE waves and the maximal AE spectra can be estimated as follows: minimal energy approximately 1eV, amplitude is going to the dimensions of the atom nucleus

(10^{-14}m), atom vibrations frequency is10^{13}Hz.

In [8] the AE energy density in J/m^3 for the AE of metals and textiles have been estimated to quantity 10^{-9}J/m^3 for metals and 10^{-3}J/m^3 for textiles. From this it is possible to deduce that the application of AE to textiles is being very favourable for textiles where the demands on the AE device sensitivity cannot be so great.

3. AE measurements on textiles

For the AE measurements on textiles to different set up have been used. The first one is represented on fig 1. using for the loading of textiles the dynamometers of type

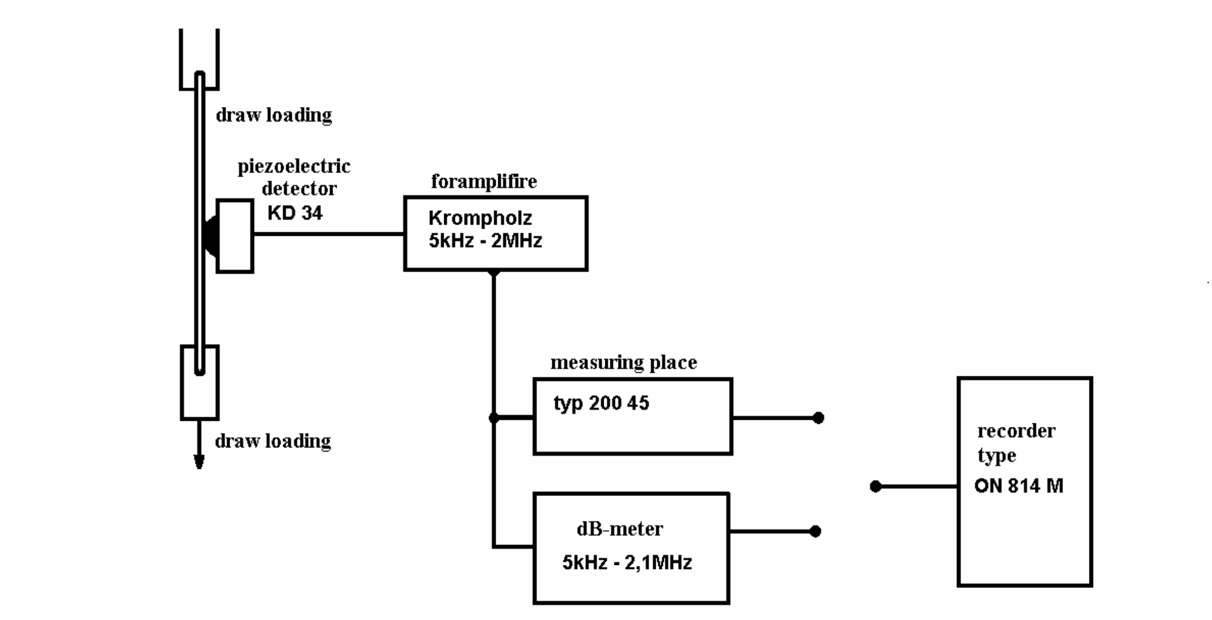

Fig.1 The principle of experimental set up for the AE measurement

Textenser and Tiratest . As the devices of the second type the dynamometer and AE devices the dynamometer of the type and the AE spectrometer Dakel type SEDO have been used.
With these equipments the AE spectra of fibres, woven- , web- and knitting fabrics have been measured.

3.1 . AE measurements on length textiles, carbon fibres
The experimental set up for the AE emission of length textiles especially carbon fibres are being very similar to the set up on the fig1
The obtained AE spectrum together dynamometer curves are being shown on fig.2. From them it is being seen the correlation between force- elongation curve from the dynamometer and the AE spectra envelope. Both are linear.

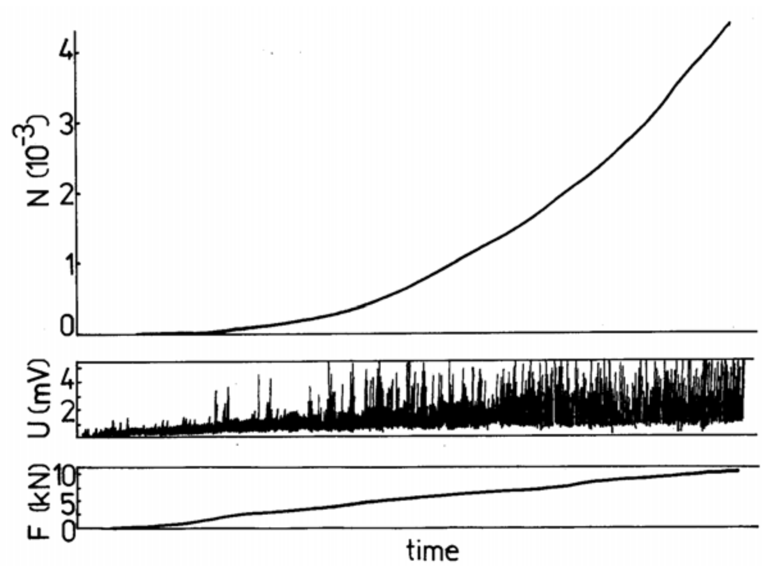

Fig.2 The AE spectrum together with dynamometer curve for the carbon fibres

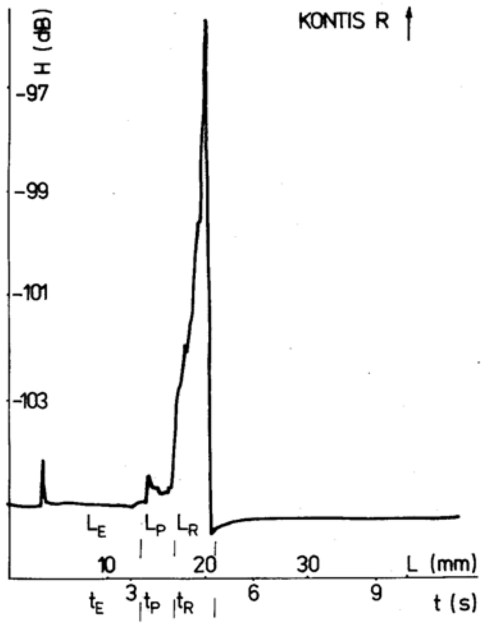

Fig.3. The AE spectrogram of the woven of the type Kontis

The further measurements have been made on the area textiles, wovens and nonwovens. One of the AE spectrograms is being shown on fig.3. The other results

3.2 AE mesurements on the area textiles

The further measurements have been made on the area textiles, woven and web fabrics (nonwovens). One of the AE spectrograms is being shown on fig.4. The other results of AE textile measurements are being summarized in the table 1.

The further AE spectra are being shown for the web fabrics Tatratex in the fig.4 which is the example showing the continuous AE spectra.

The further examples of the application of AE emission to the textile anisotropy are being presented on fig.4a,b,c for the carbon woven fabrics in the warp, werf and 45^0 directions. From the fig.4 it is possible to see on first sight the anisotropy of carbon wovens, The similar graphs have been obtained for the carbon (warp)- glass (werf) woven.

Table 1. The probes of the woven- and web fabrics prepared for the AE tersting
The probe dimension 50mm x 300mm, clamping length 200mm

Material	Stren. N	ductility mm	AE spectra	maximal value of AE pulses
Shuttle woven fabrics				
Letohrad (grey)				
In the warp direction	75	25	Narrow, simple,	55 000
In the werf direction	75	15	Narrow , simple	75 000
In the 45° direction	10	80	wider, more complex	180 000
Letohrad (treated)				
In the warp direction	130	17	Wider, broken	47 000
In the werf direction	130	20	Wider, broken	19 700
In the 45° direction	10	80	Wide, broken	75 000
Many shot wovens				
Kontis (grey)				
In the warp direction	85	17	broken	22 000
In the werf direction	95	28	broken	30 000
In the 45° direction	70	70	broken	103 000
Kontis (treated)				
In the warp direction	90	17		57 000
In the werf direction	95	28		54 000
In the 45° direction	70	70		45 000
Rouniny				
Tatratex longitudinal	165	178	Wide, complex	190 000
Tatratex transveral	0	0	Wide, complex	20 000
Tatratex 45°	185	188	Wide, complex	270 000

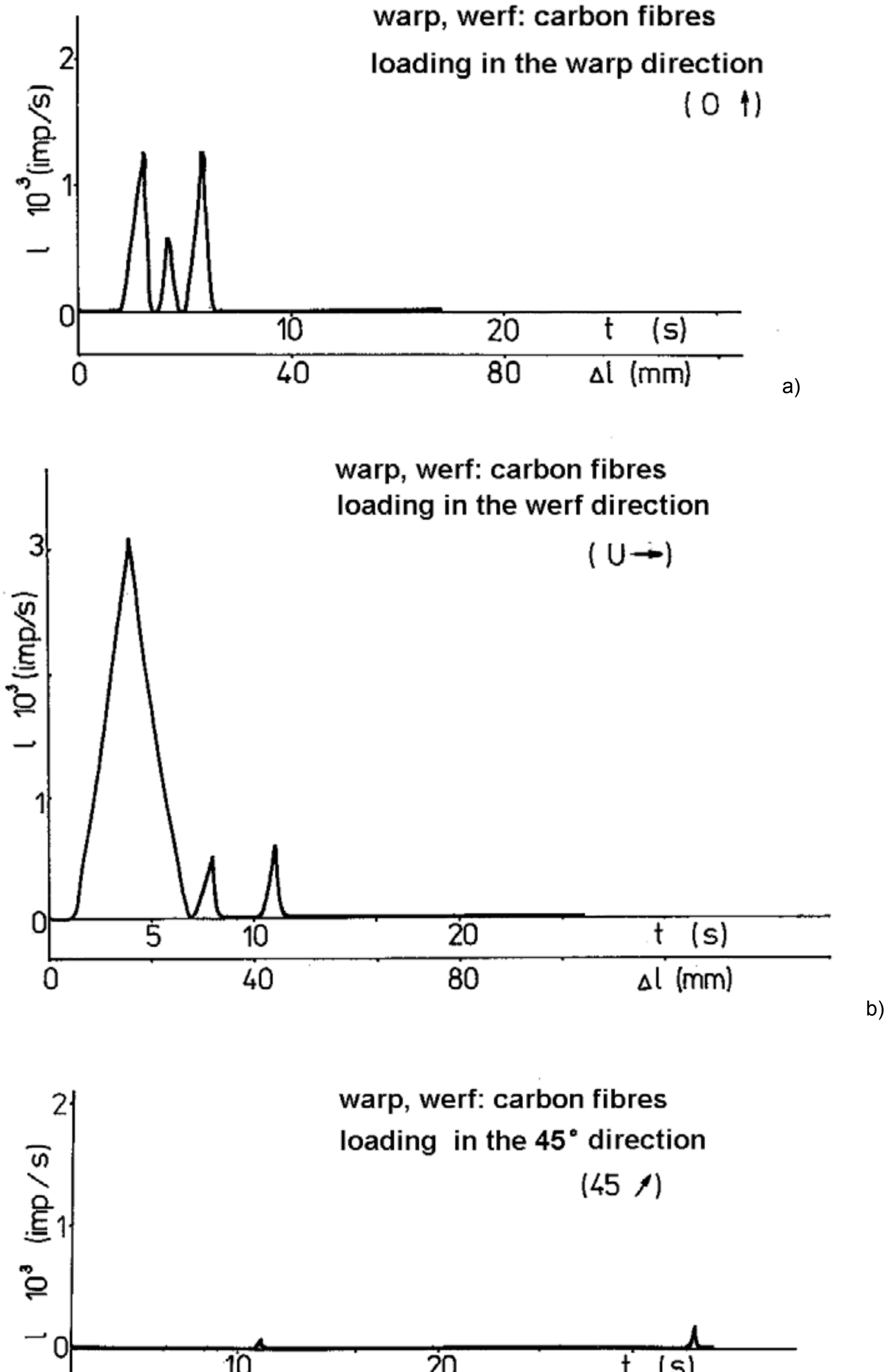

Fig.4.a AE spectrum of the loaded carbon woven in the warp , b: in the werf, c: in the 45^0 directions

4.Synchrone measurements of dynamometric and AE measurements

Some new and actual measurement of the AE have been made on textiles loaded trough the dynamometer Lab.Test 2. The force signal has been taken out and interfaced on the same scale as the AE is being and both signals force and AE can be observed on the same graph as it is being shown on the fig.5, where the AE spectrum of woven textile of the type OPL-L is being presented.

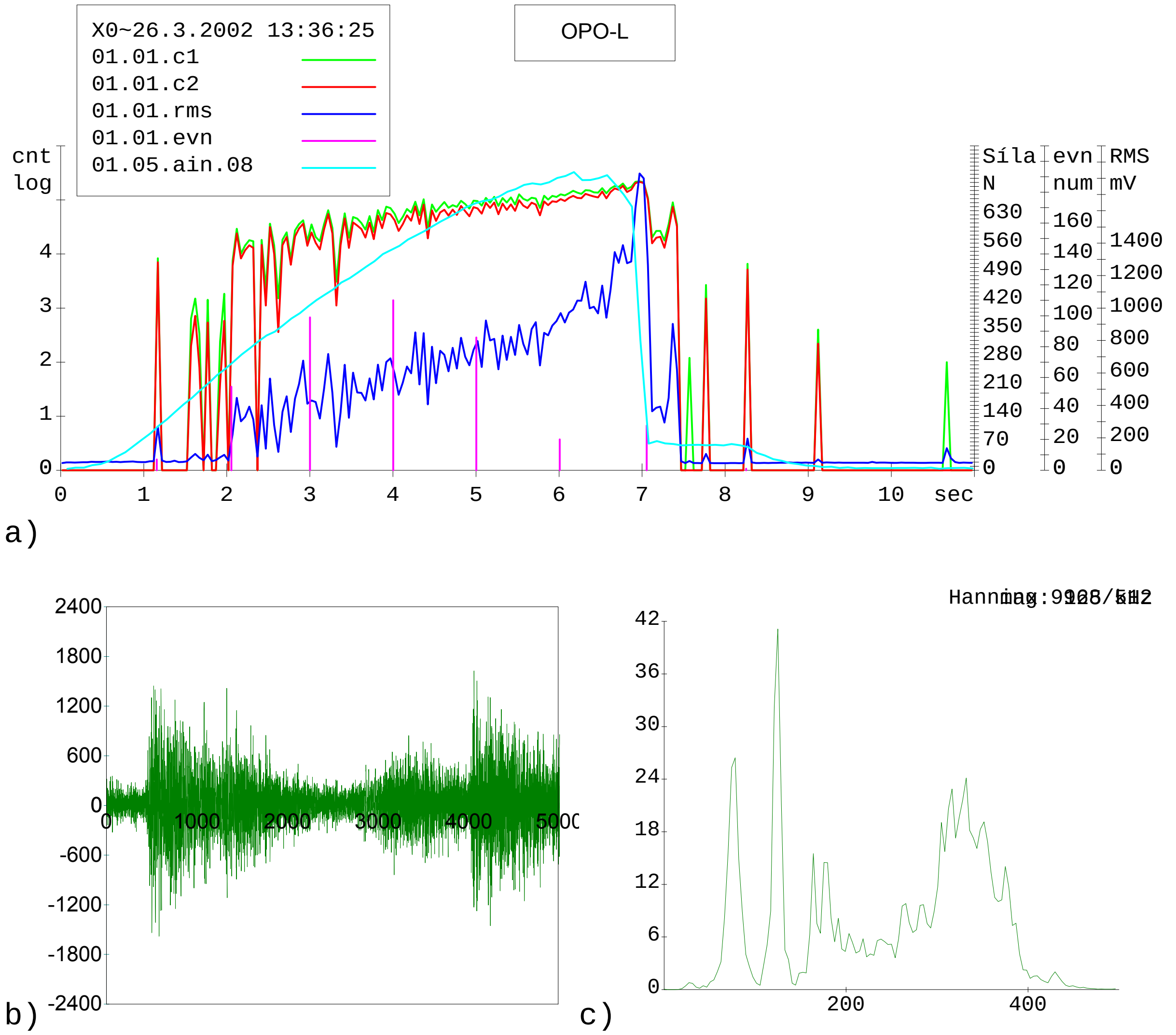

Fig.5. The AE spectrogram of woven type

In the graph the FTT curves are being also present (fig.5c)

4. AE during textile friction

It has been also demonstrated, that the AE can be detected during the textile friction. The example of the AE friction spectrogram is being shown on the fig.6. The induction of the triboelectricity has not been reliably accomplished.

5. Anisotropy of textiles using the AE

From the AE spectra the anisotropy of web textiles can be detemined as it is shown on fig.7a.The results of the detrmination of anisotropy of woven textile of the type Kontis R is being introduced on fig.7b.

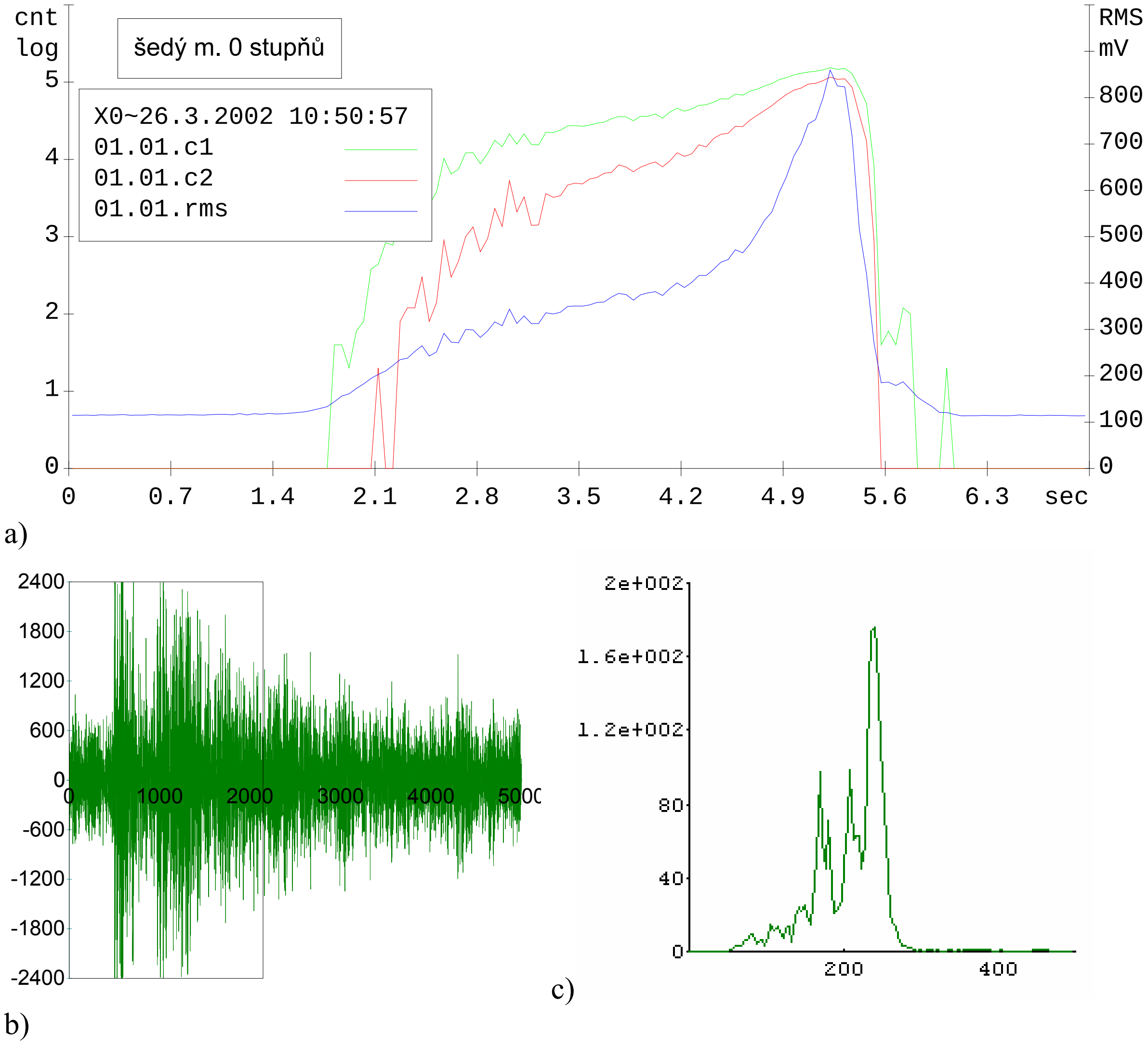

Fig.6 AE spectrogram during friction a) with events spectrum b) and FTTT c).

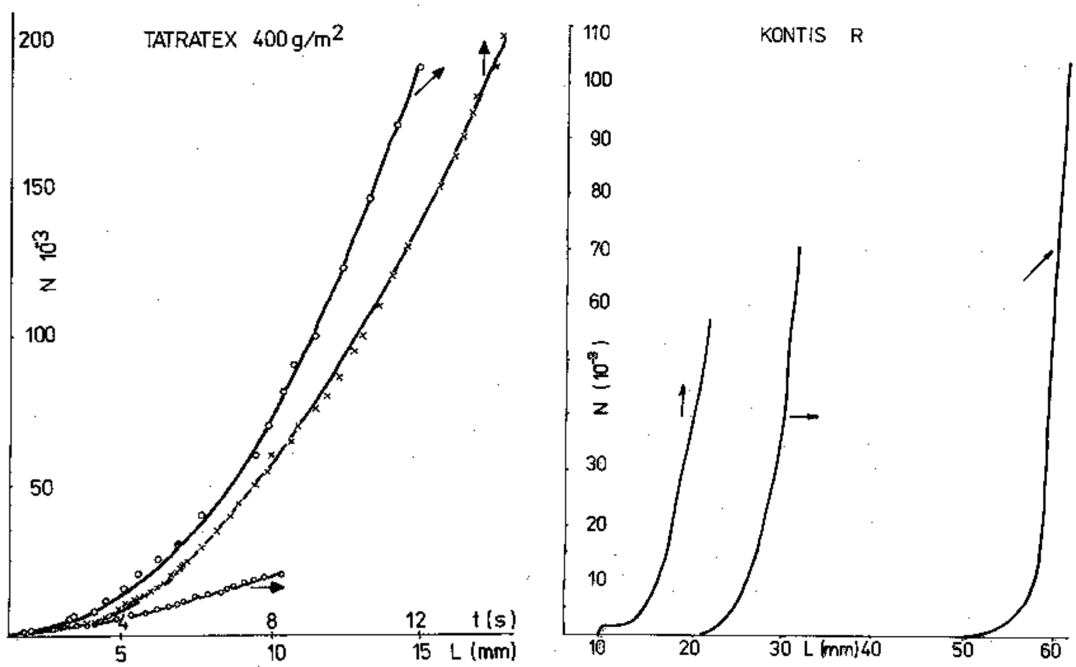

Fig 7.a) The anisotropy of web textile of the type Tatratex 400 , b) anisotropy of woven textile Kontis R as determined from the AE curves.

6. Explanations of the results

In the paper the application of AE together with dynamometric test to the textile anisotropy measurements has been demonstrated. In the fig.12 the anisotropy of the woven Kontis type is being presented in the fig.13 the anisotropy of the nowovens Tatratex type is being shown.
Also further AE spectrograms are giving evidence about the textile anisotropy.
The AE spectrograms can be used also to the identification of the individuality and inimitability of each textile. From the AE spectrogram the elasto-plastic limit can be determined and the for breaking down state can be detected as for textiles as well as for textile composites.

Many solution of further textile problems can be expected.
The AE will be in future used with advantage for the solution of the mechanism of the textile friction.

This paper is being supported through the GACR for the project No106/02/1083/2002

Literature cited

[1] Kaiser,J.: Untersuchungen ueber das Auftreten von Geraeschen beim Zugversuch. Doktordiserataion TH Muenchen 1950
[2] Spaeth,W.: Handbuch der Metalle. Metall Verlag. Berlin 1955
[3] Tatro, C., Liptai, R.G.: Proc. Of th 3rd Symposium on Physics and Nondestructive Testing. San Antonio 1962, p. 145
[4] Morgner, W.: Zur Geschichte der Schallemissionsanalyse. Wiss.Ber. der THZ Heft 24, November 1990,p.1
[5] Sodomka,L.; To the history of the acoustic emission. This Proceeding
[6] Sodomka,L.: The application of AE to the textile evaluation. In Czech . Vlnařský Informativní přehled. 37, 1988, p.33
[7] Leistner,M.: Konzepte der Schallemissions-Grunglagenforschung und die Beitraege der TH Zittau. Wiss.Ber THZ Heft 18, Februar 1989, p.1.
[8] Sodomka,L., et al.: Ausnutzung der Schallemission zur Textilwertung. Wiss. Ber. THZ Heft 18, Februar 1989, p. 89.
[9] Sodomka,L.: Pliseé effect in meshed textiles. Fibres and textiles ,2001, p.201