ôANALYSIS DEGRADATION OF POLYSTYRENE WITH NANOFILLERS

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Resume

The paper is focused on the experimental investigation of the montmorillonite nanofillers effect on deformation properties of polystyrene KRASTEN 171. In some cases, combination of a low amount of clay with dispersed polymeric phase may cause synergistic effects leading to very fair balance of mechanical behaviour. This seems to be a consequence of complex influencing the multiphase system by clay such as modification of components (reinforcement) and parameters of the interface accompanied by influencing the dynamic phase behaviour, i.e., the compactibilizing effect. The paper analyses the effect of nanocomposites and type of the material on the individual measured parameters, relations between them, strength and deformation behaviour. Deformation was evaluated by non-contact optical system (Video-Extensometry). With the addition of nanofillers decreased deformation increases ε_L.

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1. Introduction

The aim of this paper is determination of the effect of montmorillonite nanofillers on mechanical properties of polystyrene KRASTEN 171 evaluated by a non-contact Video-Extensometry method, which provides new results from tensile tests.

Contact - less strain measuring is currently used as a progressive method for metals, as well as plastics. This method provides many advantages and allows obtaining more information about materials than by conventional methods. Local deformation values better characterize the deformation behaviour of materials.

Video-Extensometry is a non-contact method for strain measuring, which enables the scanning of both longitudinal and transverse strain components from the surface of the test specimen [1 - 3]. Experimental equipment consists of CCD (Charge Coupled Device) camera and a computer, which process the camera signal by appropriate software. Suitable contrast marks (dots) are dashed on the scanned surface of the specimen. Specimen is appropriately illuminated during the measurement in such manner to obtain the best contrast between the specimen surface and dashed dots [4 - 6]. The PC program records a gravity centre position of individual dots during test and enables the saving of picture sequences simultaneously. After specimen scanning the evaluation of the strain components will be completed and final results from co-ordinates of gravity centre of individual dots will be calculated by used SW (software application Matlab 7) [7, 8]. This method enables the scanning of the deformation in two directions by one camera system and deformation kinetics development is recorded during Video-Extensometry measuring [9].

2. Experimental material and methodology

The material used in this study is polystyrene KRASTEN 171 with addition of montmorillonite nanofillers Nanofil9 (Table 1).

For the experiments was used samples produced according to ISO 3167 - type A.

The specimens were made by injection technology on machine Battenfeld of VA according to standard ISO 294-1. Melt temperature 220°C, form temperature 45°C, injection speed 200 mm/s, injection pressure 80 bar (8 MPa), holding pressure 60 bar (6 MPa), holding pressure time 12 s. Evaluation of mechanical properties of polymers was done according to standard ISO 527-2/1A/50.

2.1 Montmorillonite

Montmorillonite (MMT), based on layered clays, was used as filler. MMT, aluminosilicate of the smectite family, is a 2:1 clay (three-layer structure), meaning that it has 2 tetrahedral sheets sandwiching SiO_4 a central octahedral sheet Al_2OH_6 (Fig. 1) [10 - 13]. This configuration is periodically repeated by minerals, and between repeats the three-layer is interlayer area filled in the normal state of water and hydrated ions of alkali and alkaline earth crystal lattice, the resulting imbalance of charge in the lattice [14 - 20].

The chemical composition of MMT is represented by the following crystal-chemical formula: $(Na,Ca)_{0,33}(Al,Mg)_2Si_4O_{10}(OH)_2{\bullet}nH_2O$ [2]. Nanocomposite contains additives to support intercalation and exfoliation of the nanoclay and also small amounts of agents for easier processing.

2.2 Tensile tests

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The tensile tests were performed under static conditions on standard specimens by loading rate 1 mm/min. Results of tensile testing are in (Fig. 2). For each type of material were ruptured 3 samples. Table 2 shown the average values of 3 measurements.

2.3 Video-Extensometry

Surface of specimens was covered with grid of contrast (black) dots (5 x 10 dots) with size 0.5 mm and with step 1 mm Fig. 3.

Surface of specimen was scanned during all tensile tests by CCD camera with graphics resolution 640 x 480 pixels. The images were evaluated after a test and the coordinates of centers of dots were obtained. The deformations were determined according to Eq. (1.)

$$\varepsilon_L = \frac{dv}{dy} \qquad (1)$$

where:

ε_L - longitudinal deformation increments

v [mm] - displacement in direction y (direction y = direction of loading)

The deformation was evaluated for each two adjacent points. Evaluation was performed by comparing the first image with the last one where the sample was still intact. Finally we obtained the matrix of values for any deformation, whose output is the deformation map (Matlab).

3. Results and discussion

New methodology for recording increments of deformations – Video-Extensometry was used in this paper. It is a convenient tool to study of the deformation kinetics. Based on the deformation maps, the distribution of deformation, deformation gradients and values of local

Table 1

Properties and preparation the investigated material.

Designation	Krasten (g)	Nanofil9 (g)	Screw speed (min^{-1})	Number of granulation n
KR 1	4000	0	100	2
KR 2	3960	40	100	2
KR 3	3880	120	100	2
KR 4	3800	200	100	2

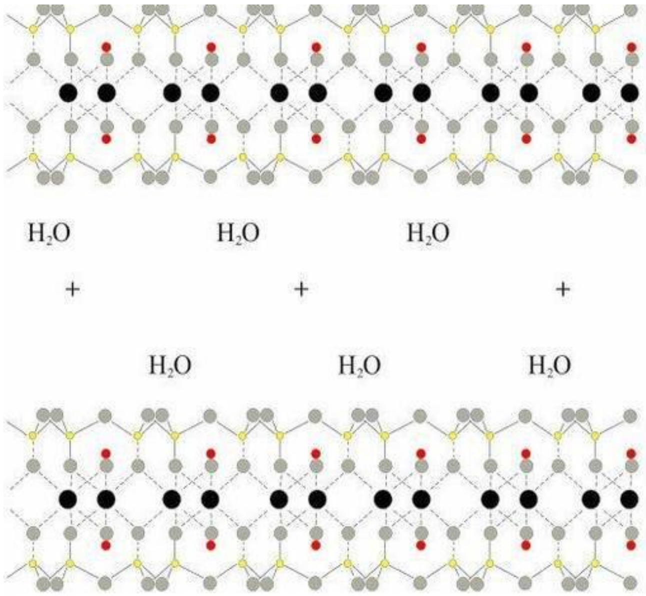

Fig. 1. Arrangement of montmorillonite [2].
(full colour version available online)

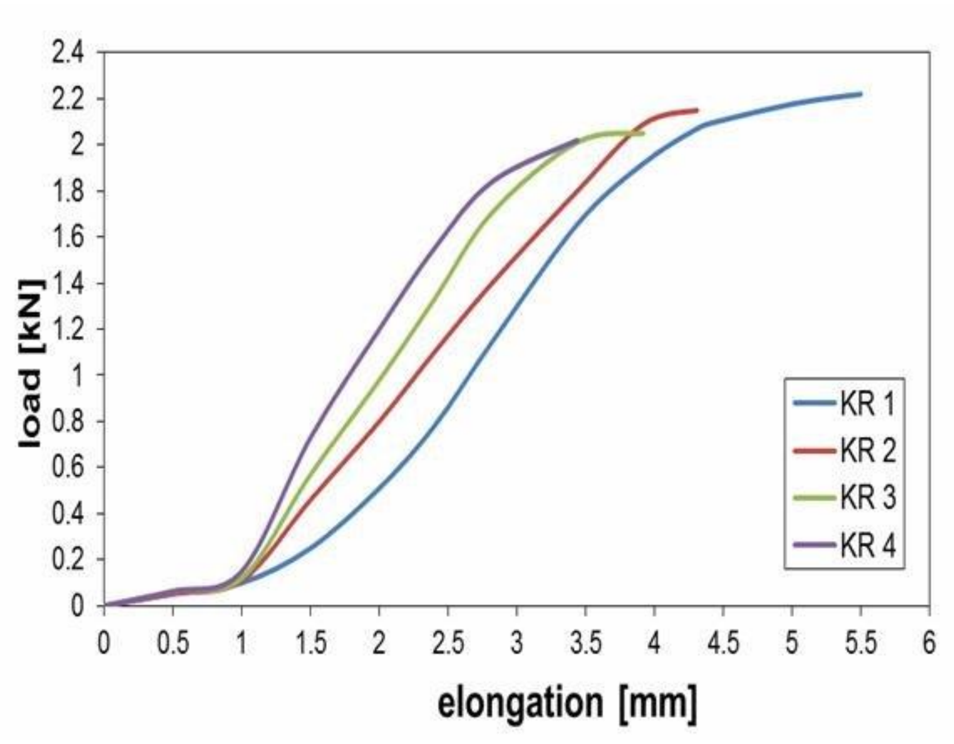

Fig. 2. Load- elongation curves for investigated materials.
(full colour version available online)

Table 2

The mechanical properties of investigated materials.

Designation	F_m (N)	R_m (MPa)	A (%)
KR 1	2165 ± 31.3	54 ± 1.00	5.2 ± 0.09
KR 2	2108 ± 39.4	53 ± 1.53	4.5 ± 0.11
KR 3	2006 ± 52.3	50 ± 1.00	3.9 ± 0.09
KR 4	1878 ± 63.2	47 ± 2.31	4.4 ± 0.18

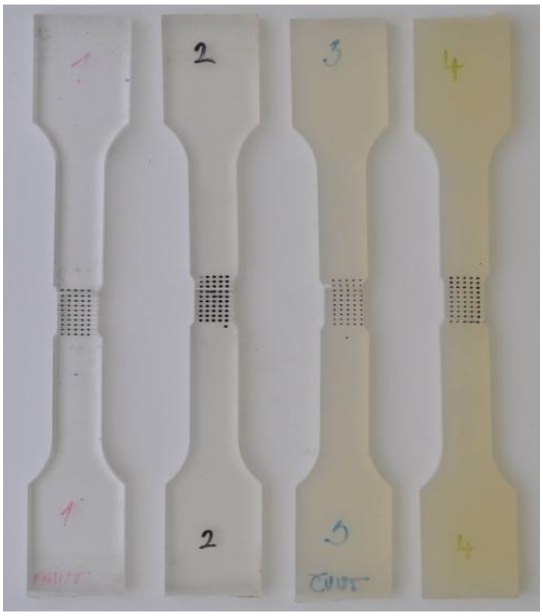

Fig. 3. Specimens with raster for Video-Extensometry measuring.
(full colour version available online)

Table 3

Increment of deformation for investigated materials.

Designation	ε_L (%)		
	Average	Maximum	Minimum
KR 1	2.82	7.43	0.15
KR 2	2.16	5.72	0.55
KR 3	1.34	3.62	0.11
KR 4	0.93	3.76	0.10

deformations we can to differentiate differences in the localization of deformation more sensitively.

The results of Video-Extensometry measurement of investigated materials are deformation maps Fig. 4. Coordinate x and y in Fig. 4 describe the position of dots on specimen. Deformations maps show distribution of increment of deformation, which represent colour range. Deformation increments were determined according to Eq. (1.) in the loading direction. In (Table 3) are statistical data of longitudinal deformation increments ε_L, which correspond to maps in Fig. 4.

The values of longitudinal deformation increments εL are decreased by adding of particles of nanofillers (Table 3). The maximal decrease was observed for material KR 3 with the highest proportion of montmorillonite.

Doping of the base material polystyrene (PS) with nanofillers particles has an effect on the plastic deformation increments. Deformation is more heterogeneously distributed in the composite material than in the natural material.

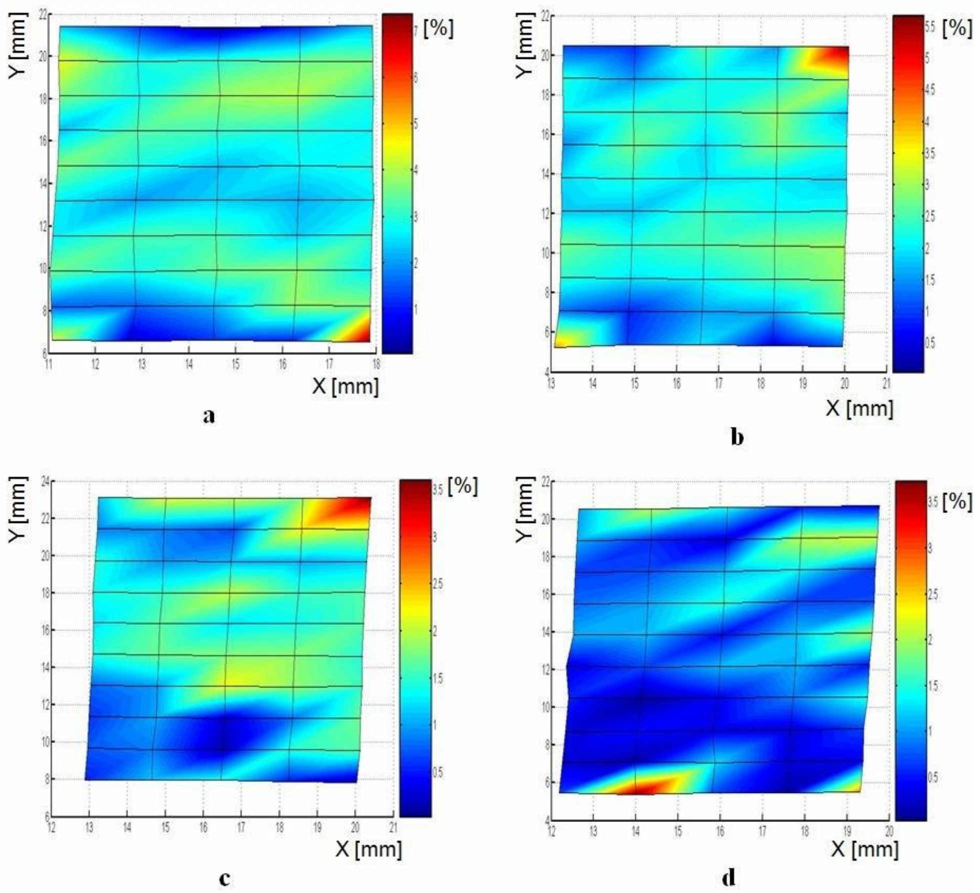

Fig. 4. Deformation maps of investigated materials KR 1 (a), KR 2 (b), KR 3 (c) and KR 4 (d).
(full colour version available online)

4. Conclusions

We have successfully applied Video-Extensometry measurements to determination the kinetics of local deformation processes in polystyrene KRASTEN 171 with the successive addition of montmorillonite nanofillers.

Effect of fillers based on montmorillonite was investigated by tensile tests.

The value of Rm material (KR 1) polystyrene without nanofiller was 54 MPa. With the gradual addition of nanofillers decreased Rm material (KR 2) 53 MPa, material (KR 3) 50 MPa and material (KR 4) 47 MPa. Polystyrene without nanofiller (KR 1) had maximum elongation of 5.2 %, material (KR 2) had elongation of 4.5 %, material (KR 3) had elongation of 3.9 % and material (KR 4) had elongation of 4.4 %.

Additions deformations were determined using contactless methods Video-Extensometry; the highest value of 7.43 % had a homogeneous material without nanofiller (KR 1) and minimum 3.62 % had material (KR 3).

Experiments not confirmed a significant effect on the deformation of nanofiller particles.

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