FUNCTIONAL QUALITY CHANGES OF SOME DOMESTIC FOAMED PLASTICS UNDER THE INFLUENCE OF EXTERNAL FACTORS

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High-molecular foamed plastics, such as polyurethane (PU), polyester of polyether foams, foamed polystyrene, porous rubber materials, are used as shock absorbant and heat-insulating materials, first of all in building engineering, upholstery and packaging. The basic property which is a requisite of functional suitability is their mechanical resistance and porous structure, which change due to the external physical factors, including atmospheric factors. Professional literature indicates that the resistance to weather conditions of PU is questionable [1, 2]. Establishing certain quality criteria is the basis of proper choice in main application areas.

1. Domestic elastic polyurethane foams

Quite broad evaluation of elastic polyurethane foams based on investigation of mechanical properties has been undertaken. During examination, anisotropy of the plastics, and relative humidity and temperature were taken into account [3].

One of the properties characteristic to an elastic foam is the determination of elastic hysteresis in the stress cycle at compression in given conditions. Five domestic elastic polyurethane foams – 3 polyester and 2 polyether – of various relative densities were examined. It was recorded that examined foams show basic differences according to the type of polyol used to their production. Polyester foams absorb more than twice as much mechanical energy as polyether foams do, and they are also characterized by higher damping capacity. This capacity is also connected with relative density and is higher in case of lower density. Some deversifications in damping capacity depending on the foam expansion direction have also been noticed [4].

Next, the influence of relative humidity on elastic recovery of the above mentioned elastic polyurethane foams has been examined [5]. Foam samples were squeezed using unit strain 50 and 90 per cent and next, after compressing forces had been removed, the existing plastic strains after 0.5, 1, 2, 3 and 24 hours were being obserwed. Elastic recovery occured at different relative humidities (65 and 90 per cent) at temperature of 23°C. The results showed that foams destressed after squeezing in the direction consistent with the expansion direction – regardless of relative humidity of the enviroment – demonstrated lower plastic strain value than those decom-



pressed in the direction perpendicular to the expansion direction. It is connected with the macrostructure of examined foams, which in the expansion direction had cells more elongated. All examined foams decompressed in a hightened relative humidity in all of the assumed control times were characterized by lesser deformations. It has also been noticed that the rate of elastic recovery depending on used humidity is diverse only after the first half hour of decompression. Taking into account the type of foams, it has been noticed that increased relative humidity at the destressing time of polyester foams hastens elastic recovery when compared to polyether ones. It should be assumed that polyester foams exhibit higher stress relaxation due to the bigger amount of hydrogen bonds in the polymer. Generally, it has been noted that relative humidity, increased to 90 per cent during decompression, diminishes plastic strain of the above mentioned compressive forces even to 90 per cent of initial thickness. This phenomenon is accounted for by the penetration of water molecules in between polymer chains and facilitating their return to the position assumed before squeezing.

Further examination [6] was aimed at checking the suitability of autoclave test adopted from American standards [7, 8] to quality evaluation of domestic PU elastic foams. It has been determinated that it constitutes a simple hastened ageing method for these materials. Compressive stress changes examination of elastic recovery gives an opportunity to grasp general tendencies of changes in urethane polymer under the influence of increased humidity and temperature. To achieve this aim the above mentioned samples of 5 domestic elastic polyurethane foams were used, which after drying and air conditioning were exposed to water vapour of 120°C at the pressure of 100 kPa for 5 hours and then were again dried and conditioned.

The resistance of foams to autoclave conditions was evaluated on the basis of percentage changes in compressive stress at the unit strains of 25 and 50 per cent and changes in plastic strain.

The above mentioned mechanical properties determine funcional suitability of elastic foams. The results are comprised in Table 1.

Shown results confirm clear changes undergoing in examined properties, however, plastic strain examination makes possible only the evaluation of changes essential from the point of view of functionality. The autoclave test may be considered then to be a simple examination method of accelerated ageing and should be present among basic examinations of domestic elastic PU foams.

2. Stift polyurethane foams

Stift polyurethane foams are materials for building construction and are used as cores in universal screen plates designated for walls of buildings and roofing. These plates are within steel sheet or aluminium facings. The core of stift PU foam serves

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Table 1. Compressive stresses at unit strain 25 and 50 per cent and plastic strain of elastic polyurethane before and after the activity of autoclave conditions*

Symbol of density of foam kg/m^3	Direction	δ_{s25}, kPa		Percentage of losses	δ_{s50}, kPa		Percentage of losses	E_t, per cent	
		before	after		before	after		before	after
S-37	Z	5.09	3.10	39	6.02	4.00	34	7.2±2.9	66.0±4.3
	X	4.63	2.88	38	5.84	3.79	35	11.0±3.1	71.9±3.4
S-30	Z	5.20	3.38	35	5.64	3.79	33	7.5±2.0	23.5±4.2
	X	4.10	2.72	32	4.68	3.16	32	10.8±2.5	55.1±5.3
S-28	Z	4.23	2.78	34	4.81	3.42	29	26.9±6.1	72.5±3.9
	X	3.79	2.54	33	4.70	3.28	30	44.3±8.2	81.5±6.0
T-42	Z	3.97	2.94	25	5.15	3.92	24	6.4±0.6	6.4±0.8
	X	3.96	2.97	25	4.86	3.67	24	7.2±0.5	7.4±0.8
T-25	Z	3.36	2.64	21	3.57	2.90	19	7.3±0.5	9.3±0.7
	X	3.00	2.41	20	3.45	2.84	18	7.8±0.6	10.4±0.8

*average of 3 measurements

the role of athermic insulator. Resistance properties and heat conduction of foamed plastics are connected with relative density and closed cell structure [9]. Screen plates during exploitation are exposed to changing weather conditions which may induce changes in cell structure, thus the influence examination of changeable external conditions on cell structures of these plates has been initiated [10]. Stift PU foams, Syspur system SH 4050/1 taken from domestic screen plate PW 8/B and East German PW 9/B were the objects of examination. Foams were exposed to the activity of hydrothermic cycles as an accelerated activity of atmospheric factors. The cycle lasted 48 hours and included:

- immersion in water of the temperature 49±3°C for 1 hour,
- hot water shower of the temperature 71±3°C for 3 hours,
- dry air heating (humidity 10 per cent, 71°C) for 3 hours,
- freezing at the temp. of 30±3°C below zero for 3 hours,
- dry air heating of the temp. 71°C for 18 hours.

Open cell volume, relative density, and water absorptivity were measured. The results given below illustrate clearly undergoing changes.

It has been shown that during the activity of hydrothermic cycles (the activity of external factors) cell structures changes take place. They are expressed in the open cell volume increase, water absorptivity increase and relative density decrease.

Table 2. The measurement results of open cell volumes, relative density and water absorptivity

Measurement	Polyurethane foam from PW 8/B plate			Polyurethane foam from PW 9/B plate		
	original	after 1 cycle	after 2 cycles	original	after 1 cycle	after 2 cycles
Open cell volume per cent	4.13±0.84	10.13±1.19	11.59±1.73	4.56±0.39	5.64±0.96	7.24±0.95
Relative density kg/m^3	46.97	45.02	44.63	48.99	45.13	44.01
Water absorptivity after 24 hours per cent of volume	1.41	1.64	1.72	0.88	1.10	1.54

It should be noted that the destruction of closed cell structure takes place mainly during the first hydrothermic cycle. Changes in the facing adhesion to foam have been also observed.

3. Foamed shock absorbing plastics

Foamed plastics are also used as shock absorbing materials and due to that, research projects have been initiated in co-operation with the Packaging Research and Development Center in Warsaw to investigate their usability in packaging [11]. Three various types of domestic elastic polyurethane foams, foamed polysterene used in building construction and packaging, and foamed latex and black porous rubber were all objects of examination. Basic properties have been established together with macrostructure, which for domestic foamed plastics is not know, even though it is, as may be concluded from professional literature, significant for shock absorbing usage [12, 15]. The results of same examination are presented in Table 3.

On the basis of numerical data it was established that in the case of PU polyether foams there is a correlation between relative density and other properties. Open cell content also depended on relative density and polymer type did not matter. Compressive stresses confirmed that examined foams exhibit mechanical anisotropy. What is more, for all PU foams stress values for expansion direction were slighty higher than for perpendicular. In plastic strain examination, cell anisotropy was confirmed. Minor plastic strains were shown in cases where squeezing was consistent with foam expansion direction.

Table 3

Type of material	Relative density kg/cm^3	Resilience %	Open cell content %	Direction*	Amount of per 1 cm, in the direction	Plastic strain (Et) at unit strain, % 50%	90%	Compressive stress δS at unit strain, kPa 50%	90%
Polyester S-30	29.9	30	96.8	Z	11	2.0	5.2	5.64	73.27
				X	15	3.1	7.9	4.68	70.20
Polyether PU T-25	25.1	47	97.1	Z	20	2.2	7.0	3.57	51.16
				X	25	3.3	8.2	3.45	47.43
Polyether PU T-42	41.9	49	95.6	Z	15	0.9	2.5	5.15	72.94
				X	19	2.0	4.6	4.86	71.15
Foamed latex	102.9	63	89.6	Z	19	4.0	2.1	5.48	61.60
				X	23	0.9	1.3	8.07	116.73
Porous rubber	519.2	54	54.4	Z	23	1.8	–	90.20	–
				X	17	3.5	–	340.10	–
Building construction foamed polysterene 1	14.9	–	67.4	Z	105	Compressive stress at 10 per cent strain kPa			
				X	118	70.10			
Packaging foamed polysterene 1	19.9	–	27.6	Z	81	135.00			
				X	79				
Packaging foamed polysterene 2	44.3	–	12.6	Z	139	381.40			
				X	136				

*direction Z – consistent with the expansion direction
direction X – perpendicular to the expansion direction

Foamed latex showed low relative density, good resilience, considerable domination of open cells, low compressive strength and slow elastic recovery in the foam expansion direction. Porous rubber was characterized by high relative density, lower open cell volume and high compressive strength. Foamed polysterenes show a dependence of a rising type between relative density and compressive stress, whereas the relation between open cell content and compressive stress is of the opposite kind.

On the basis of presented research and his own research establishing shock absorbing properties of shock absorbers, the project was realized by J. Głuski of COBROp. in Warsaw [13].

Due to the usage of foamed plastics for packaging, often long-lasting, during transport and storage in various climatic conditions and being in contact with packaged metal objects, the examination of their mutual influence has been initiated [11, 14]. Such corrosion examination was undertaken in 16 week period of direct interaction, taking into account temperature changes (25-38 degress Centgrade) and relative humidity changes (65-95%) and water extract pH of examined plastic. Research results were determined by loss of weight corrosion degree increasing together with time length of foam-metal contact. Previously mentioned foamed shock absorbing materials were used in research.

Various degrees of corrosion reaction were observed, in some cases – accelerating, in other – inhibitory. For examle:

– steel, inhibitory action of all foamed plastics except for packaging foamed polysterene ?,

– zinc, all foamed plasics accelerate corrosion process, but porous rubber and PU T-25 foam in the highest degree,

– aluminium, some plastics show a tendency to some acceleration of corrosion process (loss of weight 0.043-0.061 mg/cm^2),

– copper, all foamed plastics inhibit corrosion process (loss of weight 0.046--0.077 mg/cm^2).

This cycle of research in shock absorbing foamed plastics, in co-operation with COBROp. was completed by the prepared project of cushioning in transport packaging.

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ZMIANY WŁAŚCIWOŚCI UŻYTKOWYCH NIEKTÓRYCH KRAJOWYCH TWORZYW SPIENIONYCH POD WPŁYWEM CZYNNIKÓW ZEWNĘTRZNYCH

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Streszczenie

Badania właściwości krajowych pianek poliuretanowych, styropianów i porowatych materiałów gumowych miały na celu scharakteryzowanie ich właściwości użytkowych i odporności na wybrane czynniki zewnętrzne. Właściwością warunkującą przydatność użytkową elastycznych pianek poliuretanowych stosowanych jako materiały amortyzacyjne była odporność mechaniczna na ściskanie (odkształcenia trwałe, relaksacja, histereza) w warunkach zmiennej wilgotności oraz struktura komórkowa. W przypadku sztywnych pianek poliuretanowych stosowanych w budownictwie oceniano trwałość w zmiennych warunkach atmosferycznych (cykle hydrotermiczne) będącą podstawowym kryterium przydatności. Właściwości mechaniczne badanych tworzyw spienionych, stosowanych jako materiały amortyzacyjne w opakowaniach były zależne od makrostruktury. Określano także wpływ tworzyw spienionych na wybrane metale. Po określonym czasie, w zmiennej temperaturze i wilgotności stwierdzono różny stopień oddziaływania korozyjnego.

ИЗМЕНЕНИЕ ПОТРЕБИТЕЛЬНЫХ СВОЙСТВ НЕКОТОРЫХ ПЕНОПЛАСТОВ ОТЕЧЕСТВЕННОГО ПРОИСХОЖДЕНИЯ ПОД ВЛИЯНИЕМ ВНЕШНИХ ФАКТОРОВ

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Резюме

Исследование свойств отечественных полиуретановых пенок, пенополистирола и пористых резиновых материалов должны были охарактеризовать

их потребительные свойства и устойчивость к избранным внешним факторам. Свойством, обуславливающим потребительную пригодность упругих полиуретановых пенок, которые применяются в качестве амортизационных материалов, была устойчивость к сжатию (прочная деформируемость, релаксация, гистерезис) в условиях переменной влажности и клеточная структура.

В случае жёстких полиуретановых пенок, применяемых в строительстве, оценивалась прочность при разных атмосферных условиях (гидротермические циклы), будущая основным критерием пригодности. Механические свойства исследуемых пенопластов, применяемых в качестве амортизационных материалов в упаковках зависели от макроструктуры. Определялось тоже влияние пенопластов на избранные металлы. По истечении определённого срока в разных температурах и в разной влажности была замечена разная степень коррозии.