
Adhesive and Stress-Strain Properties of the Polymeric Layered Materials Reinforced by the Knitted Net

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ABSTRACT

It is known that the textile materials (woven fabric and mesh) used for reinforcing of various polymer films and coatings. This paper discusses reinforcement of thermoplastic polymers based on PE (Polyethylene) and PVC (Polyvinyl Chloride) with a knitted mesh weave loom. According by the research identified adhesion, strength and deformation properties of new polymer laminates. The production of such materials has been discussed in detail and performance of resultant composites material is analyzed and compared with other materials.

Key Words: PE, PVC, Adhesive Strength, Reinforcement, Mesh Fabric, Knitted Textile Mesh, Knitted Fabric, Adhesion.

1. INTRODUCTION

In the last few decades, significant use of reinforced polymeric films with strengthening fillers inside has been observed in with regard to industrial, agriculture and construction applications. Although several scholars have investigated and analyzed their physical, mechanical, cost-effective properties [1-11]. Their benefits have not yet been explored completely. Physical and mechanical and other performance properties of polymer films, coatings and composites can be improved by introducing the structure of various fillers. In layered polymers, oriented fibers, yarns, woven, and knitted fabrics are used as reinforcing elements. There are many possibilities for developing new reinforced films, coverings and composites based on material properties and the

manufacturing techniques used. As a new and perspective strengthening material of layered films can be the knitted textile grid of a "fillet interlacing". The "fillet interlacing" is a less unraveling warp knitting reticular interlacing. Compared with a mesh fabric in knitwear is possible to resolve the shape and proportion of mesh cells. A more stable, porous and non-laddering structure knitted a positive effect on performance properties. The increase of the range of polymeric layers and coverings improve the operational properties on the basis of a combination "polymer - knitted textile grid - polymer". As a reinforcing element is used a knitted cloth of a fillet interlacing from cotton yarn, and/or man-made yarns with surface density equal to 10 up to 100 g/sqm [12-14]. The cells of the knitted

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textile grid can have the monotonous or combined forms of polygons with lateral length no more than 10mm and up to circularity with diameter of 1.5-7mm.

2. EXPERIMENTAL APPROACH

The samples of PE layers and PVC coverings were developed in order to find out the effect of the nature of the reinforcing element on the properties of the layered materials. Following textile material was used as a strengthening element made from:

- (a) Knitted textile grids of the fillet interlacing made from cotton yarn.
- (b) Knitted textile grids of the fillet interlacing made from polyester filament.
- (c) Knitted textile grids of the fillet interlacing made from caprone filament.
- (d) Woven textile grid made from fiberglass filament of the fillet interlacing with the same form and size of the cells. The same counts of the filament were taken in every process of producing the knitted textile grid.

Same counts of the threads were taken in every process of producing the knitted textile grid. The layered composite was developed by thermal treatment, duplicating the polymeric layers and strengthening element as the reinforcement layer placed between them. The reinforced layered materials from PE are formed by heat treatment, duplication of two layers of the film and the strengthening by skeleton placed between them. The reinforced PVC sheet was made by calendaring method. The process begins with making the bottom layer and the mixture of a composition of a polymeric matrix is carried out in two-phase mixing.

The plasticization was carried out in two-worm extruder in four differently temperature zones, with stage-by-stage temperature decreasing by five degrees in each stage. The mixture preparation was made in screw mixer by preventing air access in heating process in order to exclude a thermal

oxidation of the polymer. Afterwards the melt liquid passes through filtering package that excludes foreign substance falling into the film and increases its quality. The ribbon-like composite from the last roller is moved out by cutting. Further homogenization and degassing is carried out on a mill with roll frictions 1:1.14, i.e. distinguished from the speed at 0.14. Ribbon-composite of the rear rotor is removed by cutting. Formation of the sheet reinforced material is carried out in four rolling calender. Reinforcing process is occurred by feeding before made bottom layer, with the knitted grid on its surface and supplying the top layer together to the duplicating roller.

In the duplication process overlaid layers are pressed to each other completely. Thus the duplicating machine starts to process as a pulling device as well. The bottom layer of the polymeric matrix and the knitted grid are unwound and continuously duplicated with the top layer. Under the influence of temperature of the fourth roller of the calender and the doubling process of the duplicating roller the two - top and bottom layers of the polymeric matrix are being bonded on each other through the gaps of the knitted grid on all surfaces. By this way the monolithic reinforced layered film is formed.

The analysis of stress-strain and adhesive properties of the received materials were carried out in normal conditions in the Certification Center "CENTEXUZ" of Tashkent Institute of Textile and Light Industry. Samples of the investigated films and coverings have been selected according to the established requirements. The appearance examination is carried out visually and by using magnifying devices. The holes, cracks, ruptures and pressurized wrinkles were thus checked. The thickness of films and coverings is measured on the thickness indicator device "TP25-II" with the scale division of 0,1mm. Tensile strength and breaking elongation percent is defined at temperature $20 \pm 2^\circ\text{C}$, relative humidity of air $65 \pm 2\%$ in the "AG-1" device. The surface density of the film material is determined under normal conditions, using the instrument "OX-400" with an accuracy of 0.001g measurements. Flexibility of the sample was tested at temperature 25°C with application of a test bar which has a rounding side in

radius 5 ± 0.2 mm from firm wood, plastic or other material with the low heat conductivity. Filament movement in the fabric is tested in "SD-1" device by using a special heavy load on the sample with the size of 30x180 mm depending on a thickness of the material. The adhesion between layers of the layered material was defined by the tensile-testing machine and the speed of the moving active clip of which is 100 mm/minute with schedule record (adhesiogram). Enlarged view of the reinforced polymeric coverings and films is carried out by highly increasing microscope - Nikon. Deformation properties investigated by a standard technique with the relaxometer "Stand".

3. RESULTS AND DISCUSSION

Electronic images of the cross section of reinforced films and coatings show the degree of penetration of the polymer in the reinforcing cage (Figs. 1-2). Electronic images of the cross section of reinforced films (scale enlarged 400 times). In case of reinforcing the PE with fibreglass the element remains separate from the polymeric layer with a visible interface between components. In case of reinforcing with knitted textile grid on the basis of cotton yarn, caprone and especially polyester filamen the interfaces are imperceptible (Fig. 1). The fused PE gets into internal layers of knitted grid and it is welded, forming almost homogeneous mass. PE is not a polar polymer, and the opportunity of formation of internuclear connections with the substance of the reinforcing element is excluded. In the contact process of the polymer to a surface of the element arises Van der Waals intermolecular interaction. In this case the adsorptive and diffusive processes come on the foreground in the zone of contact. The degree of the diffusive processes depends on time. They are initiated by pressure and the measures of increasing the mobility of a macromolecule, i.e. first of all the temperature.

The adsorption and diffusion of macromolecules of the PVC in the fibreglass do not occur. The borders of section between components (Fig. 2) are precisely visible. The fibreglasses and the PVC chemically are not compatible, besides fibreglass does not melt at the same temperature of processing as of polyvinylchloride.

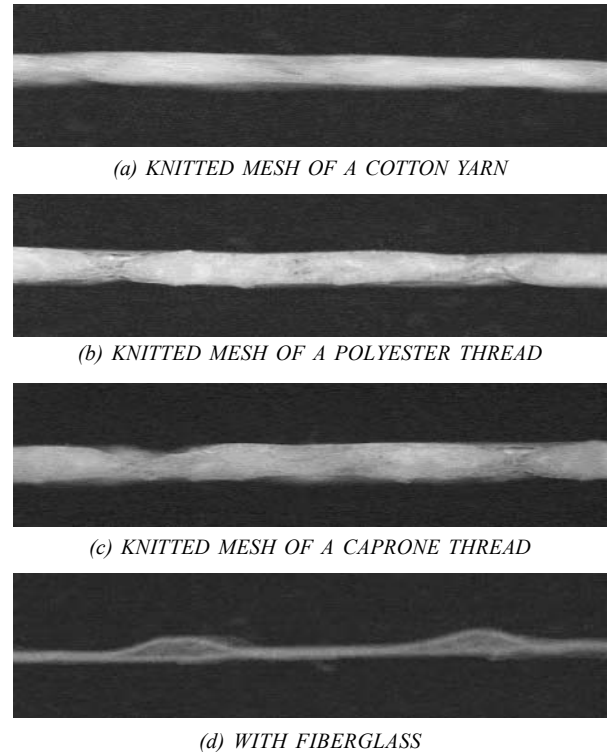


FIG. 1. THE CROSS-SECTION OF REINFORCED PE LAYERS

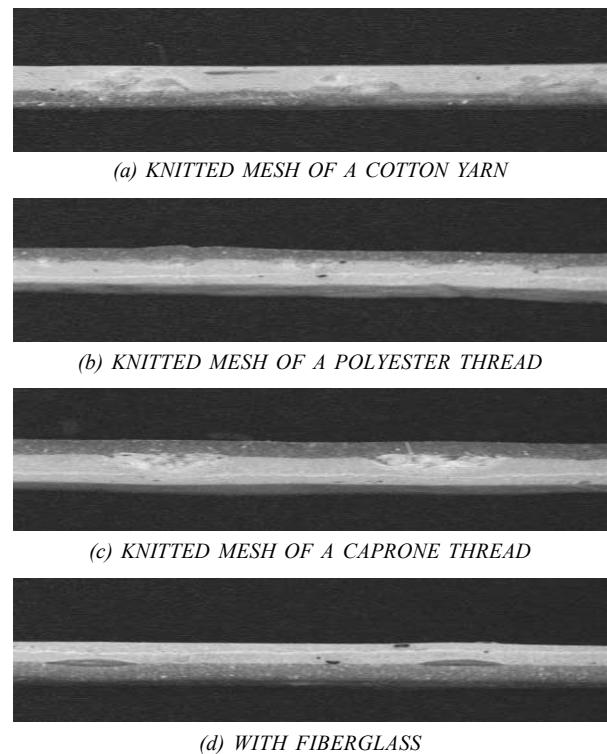
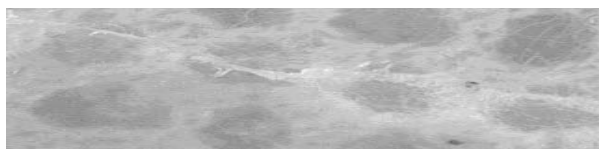


FIG. 2. ELECTRONIC PICTURES OF CROSS-SECTION OF THE REINFORCED PVC COVERINGS

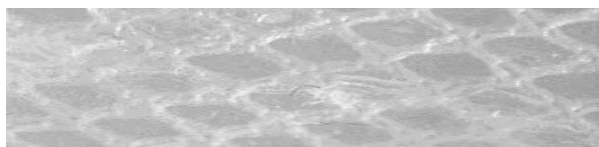
About the character of adsorptive interactions of the reinforcing element and the polymeric matrix (PE and PVC) can be judged according to the following images of the interlayer surface (Figs. 3-4) after their tearing by the tensile-testing machine.

The fiberglass grid remains in a crystal condition during the process of working the layers and consequently the diffusion and adsorption of even the fused polythene does not occur. Adhesive strength of interaction of polythene with fibers of the cotton yarn arises because of hairiness and roughness of their surface. Adhesive strength of interaction of polyester and caprone threads with PE arise because of mutual adsorption and diffusion as a result of mutual fusion and porous structure of the reinforcing element (Fig. 3).

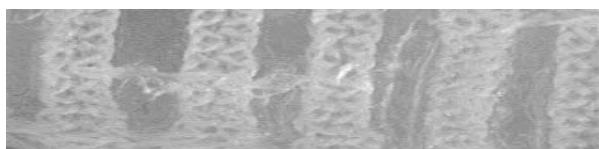
The adhesive strength of interaction of fibreglasses with PVC is too low, even below, than the strength at the delaminating level of the two layers of PVC (Fig. 4). Dielectric permeability of PVC is twice than PE. Therefore



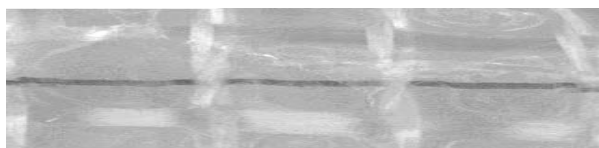
a) KNITTED MESH OF A COTTON YARN



(b) KNITTED MESH OF A POLYESTER THREAD



(c) KNITTED MESH OF A CAPRONE THREAD

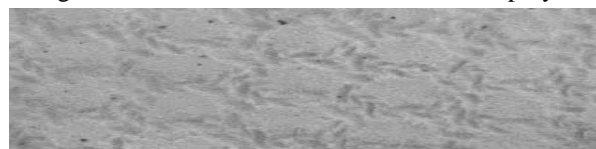


(d) WITH FIBREGLASS

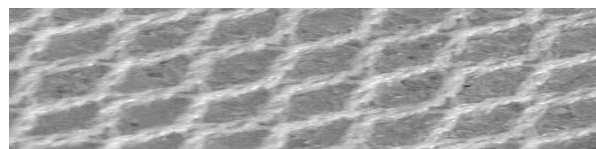
FIG. 3. ELECTRONIC PICTURES OF INTERFACE OF THE LAYERS OF THE REINFORCED PE

the composite materials with PVC and cellulose and with PVC and polyether, alongside with adsorptive and diffusive processes, get an opportunity of chemical inter-macromolecular interaction. The porous structure of the knitted material promotes adsorption and diffusion of melt PVC in their internal layers that is fixed in electronic pictures. The adhesive strength of PVC with cotton yarn, probably, amplifies because of occurrence of intermolecular interactions at the level of hydrogen and donor-acceptor bonds. At the thermal processing of PVC polyester threads are in plastic condition that provides their mutual penetration. Caprone contacts with PVC even more. It is because the caprone fibres are in highly elastic condition and because of possibility of intermolecular hydrogen and donor-acceptor bonds occurrence. As a measure of unit of adhesive strength can serve the peeling strength which is represented in the Figs. 5-6.

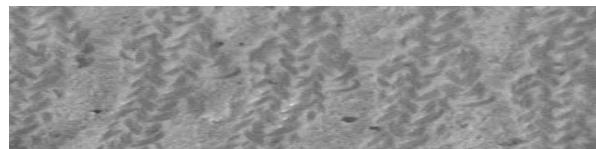
Predictably, in layered PE materials the greatest peeling strength is in the reinforced knitted mesh of a polyester



(a) KNITTED MESH OF A COTTON YARN



(b) KNITTED MESH OF A POLYESTER THREAD



(c) KNITTED MESH OF A CAPRONE THREAD



(d) WITH FIBREGLASS

FIG. 4. ELECTRONIC PICTURES OF INTERFACE OF THE LAYERS OF THE REINFORCED PVC

thread (Fig. 5). And, at the level of 60% of lengthening, the layer is broken off unable to bear the strength of 20N.

In the reinforced PVC coverings (Fig. 6), the adhesive strength at delaminating process of PVC in case of reinforcing by knitted mesh it has appeared in 4-6 times more than at reinforcing woven fibreglass mesh. Rather smooth character of dependence at greater lengthening testifies uniformity of character of interaction on all area of contact. Most likely, during processing with occurrence adsorptive and diffusive interactions all skeleton is in identical condition. Character of dependence in case of reinforcing with cotton yarn and caprone threads has some extreme excesses. This is testifying to occurrence of diverse interaction between materials. For all polymeric layers and coverings more often in practice the required properties are stress-strain properties. Accordingly, it is carried out researches of physico-mechanical properties of PE layers and PVC coverings reinforced with woven fibreglass mesh, with knitted mesh of the cotton yarn, polyester and caprone threads (Table 1).

Table 1 shows that thickness, surface density, strength and relative lengthening at a stretching change with change of the nature of a material of a reinforcing skeleton. The reinforced layer with knitted mesh of cotton yarn has turned out thicker. However, it has the minimal parameters in comparison with others. The reinforced layer with woven fibreglass mesh has the least value of relative lengthening.

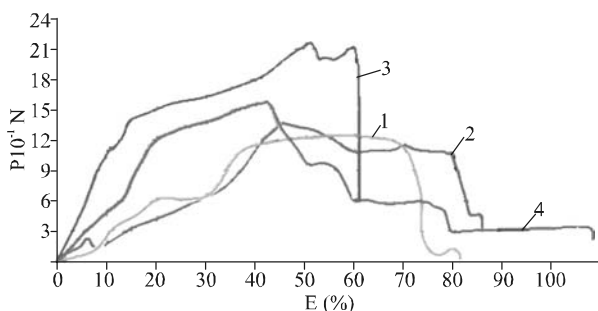


FIG. 5. INTERLAMINAR ADHESIOGRAMS OF LAYERED PE MATERIALS: (1) WITHOUT A REINFORCING ELEMENT (2) WITH FIBREGLASS (3) KNITTED MESH OF A COTTON YARN (4) KNITTED MESH OF A POLYESTER THREAD (5) KNITTED MESH OF A CAPRONE THREAD

At break, relative lengthening at a stretching at smaller values of thickness and superficial density the layer reinforced by a knitted mesh of caprone thread has the maximal value of strength PE. The strength pattern of reinforced PE and PVC materials in longitudinal and cross-section directions from relative lengthening are illustrated in Figs. 7-8.

Identical linear density of threads and the geometrical sizes of gleams of cloths allow carrying out a comparative estimation of cloths various type of fibres. In all cases strength reinforced layers is much more, and the size of relative lengthening in some times is less than in an initial polyethylene layer (Fig. 7). The strength from relative lengthening differs with greater smoothness in comparison with a layer reinforced woven fibreglass mesh. In the schedule of dependence reinforced PE the knitted mesh from a cotton yarn observes wavy character of an increment. The given phenomenon speaks adhesion of tips of separate fibres, i.e. components of a cotton yarn. The strength of knitted-reinforced layers in variants of their knitted cotton yarn and polyester threads is less, than layers reinforced woven fibreglass mesh. In addition, the strength of a final material reinforced by caprone jersey is above than the woven fibreglass mesh. Relative lengthening in all cases knitted meshes is much more than the woven fibreglass mesh. The total effect of hardening appears preferable in case of reinforcing polymeric layers with a mesh knitted cloth. At temperature of duplication PE layers cotton fibres of a yarn in a knitted cloth remain in a crystal condition and polyester and caprone threads

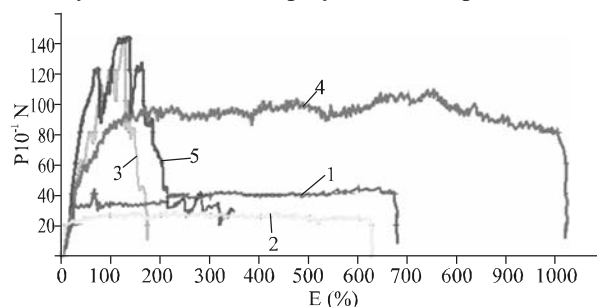


FIG. 6. INTERLAMINAR ADHESIOGRAMS OF LAYERED PVC OF MATERIALS: (1) WITHOUT A REINFORCING ELEMENT (2) WITH FIBREGLASS (3) KNITTED MESH OF A COTTON YARN (4) KNITTED MESH OF A POLYESTER THREAD (5) KNITTED MESH OF A CAPRONE THREAD

in highly elastic condition. Probably this circumstance also influences an end result.

At reinforcing PVC of layered material with a mesh knitted skeleton stress-strain properties noticeably improve in comparison with not reinforced and reinforced woven fibreglass mesh with samples (Fig. 8). Stick-slip nature of the graph of dependence of strength from relative lengthening is revealed at a stretching in longitudinal direction of material reinforced woven fibreglass mesh. The given law has shown, that the maximal strength more than 70N corresponds to relative lengthening of 4% whereas at such lengthening not reinforced PVC layer has strength only 150N. Woven fibreglass mesh, being a strong material, has the limited elasticity and maintains significant breaking strength. However, at certain value there is a

breakage. Therefore the maximum point of the plot of sharp decreases in breaking strength. Further a plot of a bottom-up nature of that evidence on PVC layer. Improvement of strength properties of the compared PVC with woven fibreglass mesh is observed in all samples: accordingly from a cotton yarn, polyester threads and caprone threads in a longitudinal direction 3,1, 9,7, 29,3% and in cross-section 0,1, 5,5, 26,3% respectively. The knitted mesh skeleton having porous structure, strongly contacts with PVC layer. The strength of a material with a mesh caprone knitted cloth with uniform hexahedral gleam had appeared the highest. Such material has as well the highest value of relative lengthening at break. One of the main attributes of thin reinforced polymeric layered materials is their deformability at biaxial stretching. It can be easily

TABLE 1. DEPENDENCE OF PHYSIC-MECHANICAL PROPERTIES OF REINFORCED PE AND PVC FILMS FROM THE TYPE OF MATERIAL OF THE REINFORCING ELEMENT

Reinforcing Element	Thickness (mm)	Strength (N)	Conditional Strength (MPa)	Relative Lengthening (%)	Yield (g/m²)
	PE*				
Woven Fibreglass Mesh	0,37	530,0	28,60	12,65	223
		472,0	27,52	4,57	
Knitted Mesh with Hexahedral Gleam	Cotton Yarn				
	0,6	480,0	12,0	118,0	200,3
		420,0	10,50	117,25	
	Polyester Filament				
	0,4	510,0	25,50	88,5	198,2
		445,0	22,25	105,0	
	Caprone Filament				
	0,4	690,0	34,50	131,0	198,2
		614,0	30,70	110,25	
	PVC*				
Woven Fibreglass Mesh	1,14	921,0	16,163	195,85	1444,6
		869,10	15,29	172,09	
Knitted Mesh with Hexahedral Gleam	Cotton Yarn				
	1,45	950,0	13,10	163,5	1485,5
		870,0	12,00	176,09	
	Polyester Filament				
	1,30	1020,0	15,60	206,5	1465,3
		920,0	14,10	186,0	
	Caprone Filament				
	1,43	1300,0	18,13	200,2	1468,2
1180,0		16,46	180,0		
Note: *numerator is longitudinal, denominator cross-section on orientation of a polymeric matrix and formation of reinforcing skeleton					

Note: *numerator is longitudinal, denominator cross-section on orientation of a polymeric matrix and formation of reinforcing skeleton

performed by folding the thin rectangular plates on a cylindrical surface. The estimation of an intense condition at bend is conducted, as is known, on one of the major geometrical characteristics of flat section (Fig. 9.) to the axial moment of resistance of the section, defined from a parity:

$$W_x = \frac{bh^2}{6} \quad (1)$$

where W is the axial moment of resistance, b is individual width of plate of layered material, h is height in longitudinal section of an element of reinforcing skeleton.

According to the results of the adhesive and strength properties analysis we can see that in case of reinforcing

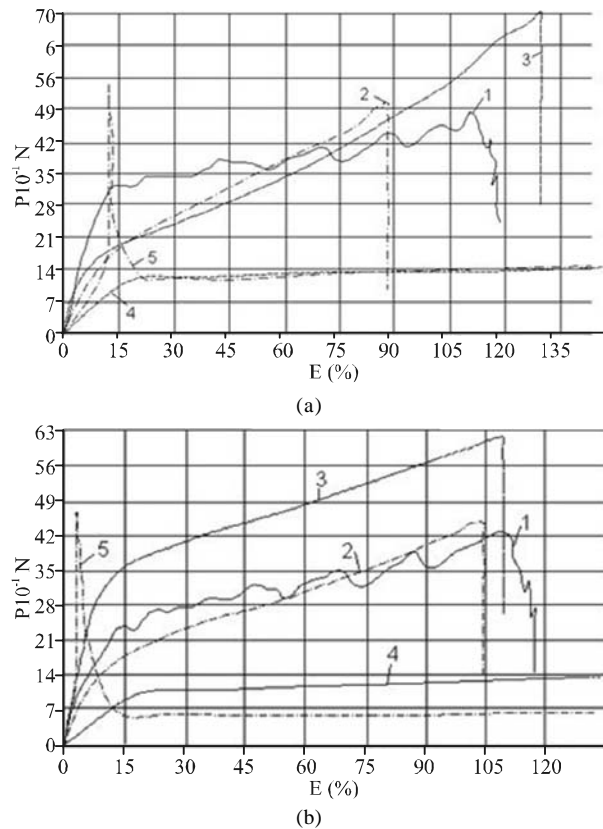


FIG. 7. STRENGTH DEPENDENCE OF REINFORCED PE LAYERS FROM RELATIVE LENGTHENING: IN LONGITUDINAL (a) AND CROSS-SECTION (b) DIRECTION WITH A KNITTED MESH HEXAHEDRAL GLEAMS (1) FROM A COTTON YARN (2) FROM A POLYESTER THREAD (3) FROM A CAPRONE THREAD (4) WITHOUT A REINFORCING ELEMENT (5) WITH FIBREGLASS

PE film with leno interlacing fiber glass fabric the reinforcing element is practically remaining separate from a polymeric layer with a visible surface section between material components. Therefore, at definition of the total moment of resistance of section of the sample is necessary to consider the moment of resistance of each part separately:

$$\Sigma W_x = W_1 + W_2 + W_3$$

If $h_1 = h_2$ then $W_1 = W_3$ and $\Sigma W_1 + W_2$

where

$$W_1 = \frac{bh_1^2}{6} \text{ and } W_2 = \frac{bh_2^2}{6} \quad (2)$$

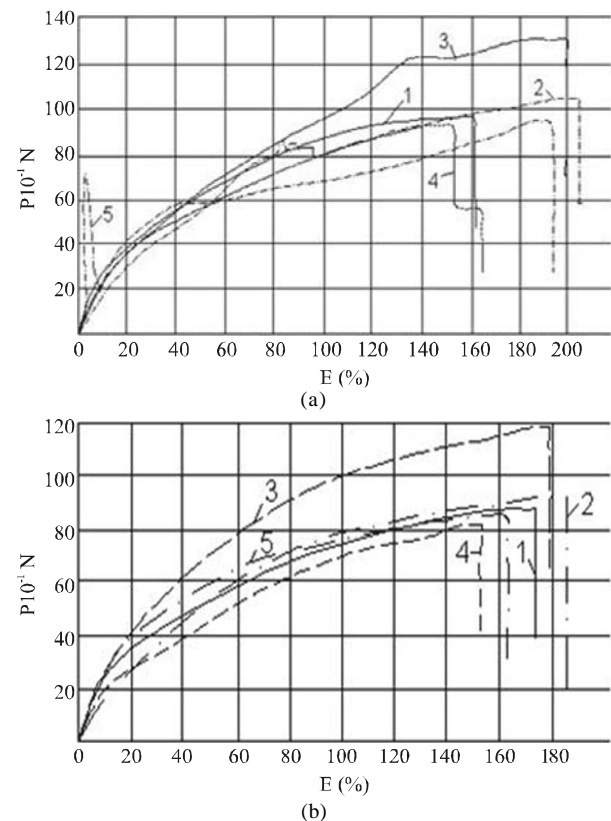


FIG. 8. DEPENDENCES OF STRENGTHENING OF THE REINFORCED PVC OF COVERINGS ON RELATIVE LENGTHENING: IN LONGITUDINAL (a) AND CROSS-SECTION (b) DIRECTION WITH A KNITTED NET HEXAHEDRAL GLEAMS (1) FROM A COTTON YARN (2) FROM A POLYESTER THREAD (3) FROM A CAPRONE THREAD (4) WITHOUT A REINFORCING ELEMENT (5) WITH FIBREGLASS

The layered material on the basis of PE matrix and the reinforcing element from knitted cloth represents a ready monolithic connection formed under action of diffusion and adsorptive processes in a zone of their contact at a mutual fusion. The moment of resistance of section in this case is defined under the formula:

$$W_x = \frac{b(h_1 + h_2 + h_3)^2}{6} \quad (3)$$

In order to quantitatively compare the values of the moment of resistance of the section, defined on dependences Equations (2-3), we will make an assumption of an equal thickness of the layers: $h_1 = h_2 = h_3 = h$ then for PE films with fiber glass fabric we will receive:

$$\sum W_x = W_x = \frac{bh^2}{2} \quad (4)$$

For PE films with a knitted grid:

$$W_x = \frac{3bh^2}{2} \quad (5)$$

The comparison of the moments of resistance for considered variants of formation of layered materials shows, that the value W_x in 3 times is more in case of use of the knitted grid as a reinforcing element, than the fiber

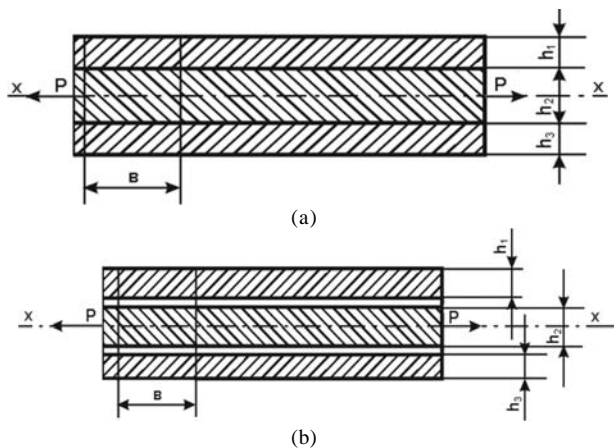


FIG. 9. CROSS SECTION OF LOCAL PART OF THE LAYERED MATERIAL "POLYMER-MESH CLOTH" WITH A REINFORCING ELEMENT. P-AXES STRENGTH, B-SINGLE WIDTH OF THE FILM OF THE LAYERED MATERIAL h_1, h_2 THICKNESS OF THE PE, h_2 -THICKNESS OF THE REINFORCING ELEMENT: A-WITH KNIITED GRID; B-WITH FIBER GLASS

glass fabric. Accordingly the level of normal pressure σ is decreasing at the bend. The results of the analysis of physicomechanical properties shows, that relative lengthening $\varepsilon(\%)$ of the reinforced PE with a knitted grid made of cotton yarn practically does not depend on the orientation of a polymeric matrix and a reinforcing element, making in longitudinal and cross-section directions accordingly 118,0% and 117,25%. For a polyester and caprone thread it is revealed poorly expressed dependence of relative lengthening on the given direction: the difference of values ε is equal 15,7% and 15,8% accordingly. The revealed feature of deformation of the PE films reinforced by knitted grid creates preconditions for maintenance of high mobility of separate links (loops) of the reinforcing element deforming in common and simultaneously with the PE matrix. Reinforcement of polyethylene films, knitted fabric actually creates a material with isotropic properties, able to perceive significant elastic and elastic deformation, which ceteris paribus leads to a minimal amount of plastic strain:

$$\varepsilon_{nl} = \varepsilon_n - (\varepsilon_y + \varepsilon_o) \quad (6)$$

where $\varepsilon_n, \varepsilon_y, \varepsilon_o, \varepsilon_{nl}$ - accordingly full, elastic and plastic deformation.

The equivalence between components of full deformation of knitted grid or a composite material on the basis of PE film and reinforcing element from knitted cloth has great value for the characteristic of its mechanical properties, both in manufacturing processes. its mobility is directly proportional to the share of its disappearing parts (ε_y and ε_o) full deformation of material. Accordingly the maintained product keeps its size and form better. The drawings of deformation relaxation of the samples are illustrated on Figs. 10-11.

Fig. 10 shows that the samples of one layered PE film is steadier against stretching deformation. The difference between the values of the kinetics of relaxation strain doubled the samples with respect to single, is as follows: length -33% and width -40%. Because of orientation of

macromolecules on length the one layered and doubled PE samples the value of indicators on width are increased in limits from 66-75%. Featured deformation of one layered PE films there is practically no plastic deformation after unloading at the minimum values of elastic deformations. As for the PE films doubled, then it follows from the graph, as a result of relaxation in the samples formed by plastic deformation, indicating the irreversibility of deformation processes for a given loading.

From the Fig. 11, we can see the ability to deformation of layered materials as "polymer - mesh cloth" is considerably high, than the not reinforced samples. The sample of reinforced PE with fiber glass fabric on width (1') has the greatest absolute lengthening of 235 mm at a finding under loading within 5 minutes and the further deformation interrupts destruction of the sample. Deformation on length of the sample (1) is insignificant and makes no more than 1mm. This law of kinetic relaxations growth can be explained by a structure of vertically directed two interconnected basic threads. At influence of external longitudinal effort as though wound longitudinal threads are straightened because of presence of leno interlacing.

The comparative analysis of deformation of the reinforced PE shows, that the knitted cloth made of cotton yarn the level of residual deformation is rather high and makes the most part of full deformation. This law is concerning the samples in two directions. There is a common part for deformation of reinforced PE with polyester and caprone thread (Fig. 11), that is almost half of full deformation is

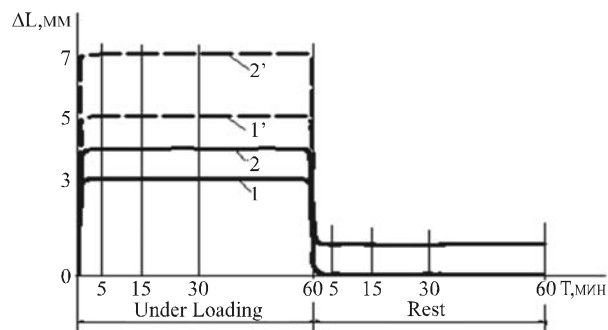


FIG. 10. DRAWING OF DEFORMATION RELAXATION OF PE FILM BY LENGTH (1,2) AND BY WIDTH (1',2'): 1,1' -SINGLE LAYER; 2,2' -DOUBLE LAYER

residual deformation. This level of residual deformation rather is less, than at deformation of reinforced PE with cotton knitted cloth.

Kinetics deformation relaxations on length and width of the knitted-reinforced samples from cotton yarn, polyester thread, and caprone thread accordingly make difference of value: 25, 100 and 6% respectively. The comparative estimation of deformability of mesh cloths on raw materials sort has shown, that the maximum difference of value of deformation is observed for polyester thread. The analysis of deformation relaxation of the samples testifies that caprone and polyester monothreads in the cloth are less susceptible to stretching loading because of structural difference from cotton yarn.

4. CONCLUSIONS

(i) In PE and PVC reinforced composites with knitted grid the strength and elongation percent, adhesive durability is significantly increases. Fiber glass cannot melt at the processing temperature and is chemically non-compatible with PE and PVC. The main reason of the strong bonding of polyester and caprone threads with PVC is promoted:

■ by their finding in highly elastic or plastic condition;

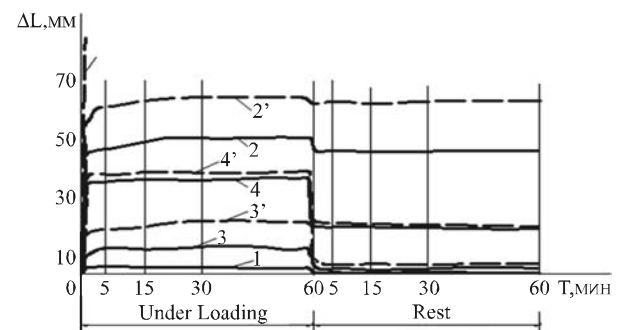


FIG. 11. DRAWING OF DEFORMATION RELAXATION OF REINFORCED PE FILM BY LENGTH (1-4) AND BY WIDTH (1'-4'): 1,1' -WITH FIBER GLASS; 2,2' -MESH CLOTH MADE OF COTTON YARN; 3,3' -MESH CLOTH MADE OF POLYESTER THREAD; 4,4' -MESH CLOTH MADE OF CAPRONE THREAD

- by possible occurrence of their intermolecular hydrogen and donor-acceptor communications by adsorption and film diffusion inside the layers of the knitted material.
- (ii) Advantages of knitted cloths are:
 - in their nonmoving threads;
 - durability of the elasticity of knots;
 - hardening and melting temperatures equivalence of both reinforcing element and the polymer;
 - adhesion and adsorptive forces durability of interaction.
- (iii) It is found out, that proceeding from character of compatibility of PE and the sorts of fibres of reinforcing cloth, it is differently defined the axial moment of resistance of section which influences the normal pressure at bend of cloths.
- (iv) Features of deformation of film materials, including reinforced by mesh cloths are revealed. It is established, that reinforcing PE films with knitted cloth actually creates material isotropic properties capable to perceive considerable elastic and elastic deformations.

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