

# DEVELOPMENT AND IMPLEMENTATION OF PRODUCTION TECHNOLOGIES FOR PRODUCING COMPOSITE MATERIALS AND TIRES BASED ON POLYURETHANE SYSTEMS FEATURES OF POLYURETHANE RHEOLOGY

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## ABSTRACT

The objects of the study were thermal polyurethane thermoplastic elastomers (PUTP), obtained by the reaction of 4,4-diphenylmethane diisocyanate, hydroxide-containing polyester with a molecular weight of 2000 (polyethylene glycol adipate) and 1,4-butadiol (industrial name VITUR). -T-1413)

It was found that the dependence of the logarithm of the effective viscosity ( $\eta_{eff}$ ) of the PUTEP melt on shear stress at various temperatures in the studied range of shear rates (from 1 to 100 s<sup>-1</sup>) represents parallel straight lines. This makes it possible to use the analytical dependence of the effective viscosity on temperature to describe the rheological behavior of PUTEP melts, which also takes into account the influence of shear stress on the viscosity of the melt

carbon-chain and heterochain polymers are determined by many factors, such as the thermodynamic properties of the components, their molecular weight, the degree of phase dispersion, the ability of the components to crystallize, etc.

Composite materials, which are reinforced or filled polymers, play an important role in technology. The development of these materials and improvement of their properties is a complex problem, in which a significant place belongs to the physical chemistry of surface phenomena in polymers. Therefore, the problems of physical chemistry of filled polymers are problems of physical chemistry of surface phenomena in polymers.

**Keywords:** development, rheology, modification, polyurethane, technology, tires, vulcanization, extruder.

## Introduction

Polyurethanes form a large group of industrial thermoplastic elastomers, the macromolecules of which have a complex structure, characterized by a wide molecular weight distribution and the presence of N-C=O, NH side chains. Mixtures obtained by mixing in a melt have a relatively high viscosity, which depends on temperature and strongly on changes in speed or shear stress, while the melts exhibit a characteristic elasticity of 600-700% and strength of up to 40 MPa. Glass transition temperatures are relatively low – 200°C.

The mixing method in the manufacture of compositions has the advantage of simple technology. To prepare polymer mixtures, all you need is an extruder or other mixing device. However, only thermoplastics that are processed in the same temperature range and are relatively

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compatible so that their mixtures remain stable throughout the entire molding cycle can be mixed.

Blends of PUTEPU with other polymers often exhibit characteristic signs of macromolecular incompatibility [1-3], with their structure representing either micro-block separation [4] or droplets or fibrils of one component in the matrix of another (composite-type structure) [5]. Studies have shown that the supramolecular structure of the composite type exists in a molten state [282, 283], making possible the existence of so-called “rheological special” compositions [6].

The composition must be mixed in two stages. [7-9], with dispersed mixing followed by a laminar mixing stage. The problem of the connection between the properties of the resulting compositions and its composition is systematically studied and continues to receive intensive development throughout the world. The super molecular structure of polymer products mainly determines their physical, mechanical and operational properties the work [10] shows that for the original polyurethane, when the extruder screw speed increases from 20 to 40 rpm, the yield strength does not change, the tensile fracture stress decreases, and the density increases. [11]. The noted deterioration in strength properties is consistent with data on the peculiarities of processing polyolefins by extrusion [12-13] and can be explained by increased sensitivity to temperature and shear effects. As the number of revolutions increases, the deformation of the structure components decreases; therefore, to obtain a high-quality product with increased physical and mechanical properties, the technological process should be carried out at minimum values of rotation speed of the extruder screw, which significantly reduces productivity

The successful implementation of the melt mixing process and the production of mixtures with specified performance properties or the ability to be easily processed was possible thanks to the correct selection of components and their rheological characteristics. The ratio of the rheological parameters of the components determines the results of obtaining dispersed mixtures, i.e. the size of dispersed particles of a component present in a mixture in a lower concentration [14]. The elastic characteristics of the components determine, in turn, the formation of a composition structure of the “drop in a matrix” or “layers in a matrix” type after the stage of laminar mixing of the melt and the entire mixing process [15-16]. Reliable rheology over a wide range of shear rates or stresses is of paramount importance in predicting or modeling the characteristics of a mixture or mixing process. Additional physical characteristics required for these applications are the surface tensions [293] of the melts and knowledge of the properties of the interfacial layers [17].

## Method

When manufacturing the compositions, each of the components was selected in such a way that the final product would have a set of necessary properties, for example, high tensile strength, high wear resistance, etc. The polymer mixing method is used to form melts into products that optimally combine the properties of the components. When mixing, a static distribution of components in the mixture is achieved, which makes it possible to obtain products with a specific morphology, which is optimal for many areas of application of such products.

### **Development of technology for the mixing process.**

Polymer mixtures are currently produced by mixing ingredients on a number of types of equipment, such as disk, cone screw and cascade disk screw extruders, with the latter being the most promising because allows you to control and conduct the processing process step by step. They are characterized by high mixing efficiency, small dimensions and energy intensity with

relatively high productivity.

It was of interest to determine the maximum productivity of an installation based on a cascade extruder while maintaining high quality of the mixture, as well as to conduct a comparative analysis of the energy costs of installations based on screw and cascade disc screw extruders and to select the most economical and radial machine design. A cascade type extruder, brand ChII63x25, was used in the work and the technical characteristics are given in Table 3 (Table 3).

During the processing process, significant shear forces arise, which, at elevated temperatures, create conditions for the occurrence of oxidative destruction. With a significant increase in the rotation speed of the extruder working bodies, the melt temperature increases. Taking these features into account, the cascade extruder provides for autonomous rotation of the disk and screw, which allows you to regulate the thermomechanical load on the melt in the disk and screw zones.

The optimal melt temperature when processing PUTEF brand VITUR-T-1413 is  $170 \pm 5^\circ\text{C}$ , the shear rate gradient in the disk zone, depending on the productivity, ranges from 400 to  $500 \text{ s}^{-1}$ . Therefore, based on the graph of  $t=f(n)$  and  $r=f(n_g)$  (Fig. 3.), we clarified the range of working gaps (N) and disk rotation speed ( $n_g$ ), which are 1.5-2.0 mm  $150\text{-}170 \text{ min}^{-1}$  respectively. In this case, an equilibrium occurs between destructive phenomena, which makes it possible to obtain mixtures with stable physical and mechanical properties in a fairly wide range of  $n_g$ . In this case, the shear rate gradient is  $400\text{-}500 \text{ s}^{-1}$ , the melt viscosity is  $(4.5\text{-}5.0) \cdot 10^2 \text{ N s/m}^2$ , the residence time in the disk zone is 7-22. After determining the optimal shear rate gradient for a given grade of polyurethane, we determined H and  $N_g$  based on specific conditions and as a result we obtained  $H = 3 \text{ mm}$ ;  $N_g = 100 \text{ min}^{-1}$ .

**Table 1.** Extruder Specifications.

| Characteristics                                               | Extruder type |      |
|---------------------------------------------------------------|---------------|------|
|                                                               | I             | II   |
| Productivity, kg/hour                                         | 185           | 140  |
| Diameter, mm                                                  |               |      |
| Disk                                                          | 185           | -    |
| Auger                                                         | 90            | 63   |
| Length, mm                                                    |               |      |
| Disk                                                          | 160           | -    |
| Auger                                                         | 380           | 1575 |
| Rotation speed, $\text{min}^{-1}$                             |               |      |
| Disk                                                          | 25-275        | -    |
| Auger                                                         | 14-140        | 180  |
| Drive electric motor power, kW                                | 50            | 42   |
| Electric motor power, kW                                      | 6,0           | 12,4 |
| Range of adjustment of working gaps, mm                       | 0,1-15        | -    |
| Compressed air consumption, $\text{m}^3/\text{h}$             | 4,5           | 4,5  |
| Water consumption for extruder cooling, $\text{m}^3/\text{h}$ | 1,0           | 1,0  |

Based on the found value of  $n_g$ , using the data presented in to process the composition, we determined the productivity of the feeder and the screw rotation speed associated with the productivity of the disk zone, which for our case is 50 kg/h and 49-52 minutes. Moreover, in the

screw zone with a thread depth of 6 mm, the melt has an average velocity gradient of 70-80 s, a shear stress of 1.37-1.5 N/m and is characterized by a residence time in this zone of 70-110 s.

As an experimental test has shown, with a cascade extruder productivity of 40-80 kg/h according to the mode calculated above, the physical and mechanical characteristics of the mixtures are the highest. This can be explained by the fairly high plasticization ability of the disk zone and the short time the mixture remains under the permissible thermomechanical influence of the working parts of the disk and screw zones. At productivity above 80 kg/h, the melt flow rate increases significantly compared to the optimum. This indicates the occurrence of mechanical-chemical processes, namely, the overcoming of the process of mechanical destruction over recombination.

Studies carried out on a disk extruder have shown that exceeding the shear stress of more than 0.2 MPa at the optimal temperature leads to mechanical destruction of the mixture. At similar numerical values of shear strain and optimal processing temperature on the ChP63x25 extruder, the mixture destructs.

It should be noted that mechanical-destructive processes can be slowed down by increasing the gap at the narrowest point of the disk zone and thereby reducing the shear rate gradient and shear stress.

However, increasing the gap is possible up to a certain value, around which the mixing capacity of the equipment begins to decrease.

In this work, a modernized extruder of the ED 90/185, the place of the extruder ChP63x25 allows reducing the reduced energy costs by 1.5 times (0.205 and 0.309 kW/h kg, respectively), which provides significant energy savings.

#### **Development of technology for granulation compositions.**

For the production of massive tires, recipes were developed and the optimal version of the recipe is provided in table 2

**Table 2.** Rubber compound formulation for tire production

| Name of ingredients          | On 100 parts by weight of rubber. |      |      |      |      |      |
|------------------------------|-----------------------------------|------|------|------|------|------|
|                              | Sample number                     |      |      |      |      |      |
|                              | 0                                 | 1    | 2    | 3    | 4    | 5    |
| PUTEP                        | 10                                | 50   | 25   | 20   | 32   | 70   |
| Butyl rubber                 | 90                                | 50   | 75   | 80   | 68   | 30   |
| Sulfur                       | 2,0                               | 2,0  | 2,0  | 2,0  | 2,0  | 2,0  |
| Sulfenamide                  | 1,0                               | 1,0  | 1,0  | 1,0  | 1,0  | 1,0  |
| Zinc whitewash               | 3,0                               | 3,0  | 3,0  | 3,0  | 3,0  | 3,0  |
| Oleic acid                   | 1,0                               | 1,0  | 1,0  | 1,0  | 1,0  | 1,0  |
| Stearin                      | 0,5                               | 0,5  | 0,5  | 0,5  | 0,5  | 0,5  |
| Nitrodiphenylamine           | 0,3                               | 0,3  | 0,3  | 0,3  | 0,3  | 0,3  |
| Product 4010 A               | 1,0                               | 1,0  | 1,0  | 1,0  | 1,0  | 1,0  |
| Microwax                     | 1,0                               | 1,0  | 1,0  | 1,0  | 1,0  | 1,0  |
| Rosin                        | 1,0                               | 1,0  | 1,0  | 1,0  | 1,0  | 1,0  |
| Flektol-flakes               | 2,0                               | 2,0  | 2,0  | 2,0  | 2,0  | 2,0  |
| SPP resin                    | 2,0                               | 2,0  | 2,0  | 2,0  | 2,0  | 2,0  |
| Oil PN-6                     | 14,0                              | 14,0 | 14,0 | 14,0 | 14,0 | 14,0 |
| Technical hydrocarbon PM-105 | 65,0                              | 65,0 | 65,0 | 65,0 | 65,0 | 65,0 |

Granulation is the process of shaping a material into small pieces (pellets). Granulation is necessary to provide the substance with improved technological properties, to prevent drainage and increase flowability, to ensure the possibility of using the material in small portions, to facilitate loading, transportation, etc.

The most common methods are granulation of thermoplastic elastomers and their mixtures from the melt. In this case, as in our case, the processes of mixing, plasticization and granulation, as well as the removal of moisture and volatile substances, are combined.

In production, the melt mixture is forced through the extruder head in the form of a rope, which is cut into granules by rotating knives immediately after leaving the head after cooling in air.

We decided that granulation should be carried out after air cooling due to the hydrolytic instability of polyurethane. Appearance of granules measuring 3x4 mm.

## Result

Based on the optimal recipe, we produced the composition on a laboratory roller for 12 minutes and at a temperature of 90C. Subsequently, the composition was subjected to a vulcanization process. The results of physical and mechanical tests of the vulcanizate and the data obtained are shown in Table 3.

**Table 3.** Results of physical and mechanical tests of polyurethane-based vulcanizate

| The name of indicators                     | Track numbers  |                 |                  |                   |
|--------------------------------------------|----------------|-----------------|------------------|-------------------|
|                                            | 1 <sup>x</sup> | 2 <sup>xx</sup> | 3 <sup>xxx</sup> | 4 <sup>xxxx</sup> |
| Tensile strength at tensile strength, MPa  | 24,0           | 250             | 26,0             | 26,5              |
| Relative elongation                        | 340            | 340             | 350              | 370               |
| Conditional stress at 100% elongation, MPa | 11,0           | -               | 12,5             | 14,0              |

Basically, the research results are presented in a form that is inconvenient for their engineering use. The most suitable form of the viscosity curve for such an application seems to be the approximation described by a logarithmic parabola:

$$\log h = B_0 + B_1 \log \gamma + B_2 \log^2 \gamma$$

where h is the melt viscosity in poise and  $\gamma$  is the shear rate, s<sup>-1</sup>.

The term B<sub>0</sub> represents the standard viscosity at  $\gamma = 1$  s<sup>-1</sup>, i.e.

$\varphi_0 = 10$ , B<sub>1</sub> is a measure of the dependence of viscosity on shear rate at

B<sub>2</sub> = 0.

In the work, petroleum polymer resin was used to improve the mechanical strength of rubber. Therefore, the resin content and its effect on the viscosity of the composition were determined. Basically, research results are presented in a form that is inconvenient for their engineering use. The most suitable form of the viscosity curve for this application seems to be the approximation described by a logarithmic parabola and we used the following formulas for. Basically, the research results are presented in a form that is inconvenient for their engineering use. The most suitable form of the viscosity curve for this application seems to be the approximation described

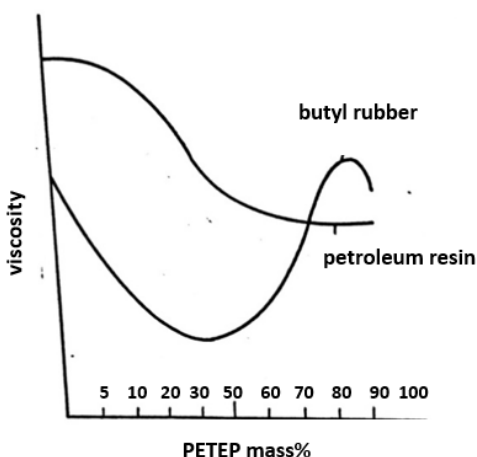
by a logarithmic parabola:

The experimental dependence of the melt viscosity of a mixture of petroleum polymer resin and PUTEP on the shear rate and composition of the composition was studied. The data obtained are presented in Figure 1

Figure 1 shows the experimental dependence of the melt viscosity of a mixture of petroleum-polymer resin and PUTEP on the shear rate and composition of the composition. Since confidence intervals for parameters can be easily estimated, unambiguous comparison of composition rheology is feasible.

Standard measures of melt viscosity and elasticity are convenient for predicting the rheological characteristics of a mixture of a certain composition based on the known characteristics of the components. Such an assessment can be reliably performed based on a reliable mixing law. Attempts made in this direction were aimed at clarifying the various empirical rules of mixing proposed by Arrhenius in 1887. However, at present, the only "engineering" type seems to be the mixing law proposed by Kasaija and Mori. It has been successfully applied to mixtures consisting of components that differ significantly in melt viscosity.

There is strong experimental evidence that the sigmoid shape of property-composition curves for mixtures is of a general nature. To a first approximation, this is easily explained based on the concept of dense packing, which is obtained from knowledge of the patterns of flow of concentrated suspensions or effects associated with the role of exchange interaction between suspended micro heterogeneous components of the mixture and the matrix. Since compositions whose composition falls in the extreme region change their properties most significantly compared to prediction based on any of the known approaches, and since these changes often occur in a favorable direction, a number of studies have been undertaken to clarify the apparent role of the boundary interfacial layers, separating the components of a micro heterogeneous mixture.



**Figure 1.** Dependence of viscosity at shear rate on the composition of the compositions PUTEP

Indeed, even standard measurements of the dependence of the specific volume of the melt on the composition of the composition, carried out on flowing melts, showed that in a certain concentration range the density of the melt in the boundary interphase layer significantly exceeds



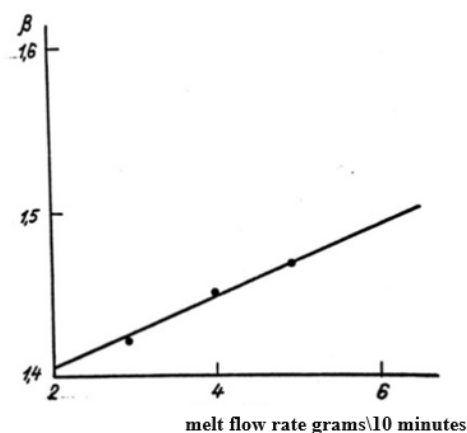
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the density of the components. Thus, the flow mechanism of these compositions obviously differs from the flow of bi-component mixtures, since the mutual “wetting” of the components depends both on their molecular structure and on the thermal and shear prehistory of the system. The introduction of additives leads to the development of the surface of the interfacial layer and a decrease in the grain sizes of the components, as a result of which the flow mechanism changes - the flow of particles is initiated. The change in the nature of the flow is accompanied by a decrease in the viscosity of the melt and a significant decrease (especially at high shear rates) in the elasticity of the melt. Secondly, as the melt flows, a fibrillar structure is formed in accordance with the mechanism shown in Figure 2. At the same time, the highly elastic properties of the melt, assessed by the degree of swelling, improve after the introduction of these plasticizers. At the same time, it was shown that in polymer melts, during rapid movements of macromolecules that meet the conditions of rheological tests and processing, the nodes of the fluctuation network of engagements that inhibit the movement do not have time to disintegrate. As the speed of movement of macromolecules increases, the lifetime of the total number of nodes of two contacting macromolecules increases, i.e. number of nodes between them. As a result, the adhesion between the polymer chains increases and the polymer acquires properties characteristic of a forced highly elastic state. Therefore, at critical speeds, the movement of individual macromolecules will not occur, but the movement of chain conglomerates will be realized, connected to each other and transferred to a forced highly elastic state, i.e. the well-known “flow disruption” effect will occur.

In polydisperse polymers, unlike monodisperse ones, this transition is not clearly expressed and occurs in a latent form, since with an increase in the shear rate of macromolecules, forming conglomerates, they gradually pass into a highly elastic state, in order of decreasing their molecular weight. As a result, the rheological characteristics, reflecting the viscoelastic properties of the melt, also change gradually with increasing shear rate.

When plasticizers are introduced into a polymer, the number of nodes in an equilibrium state, depending on the specific chemical structure of macromolecular units, and the distance coinciding with the transverse size of the chain do not change; however, the characteristic lifetime of an elementary unit, depending on the nature of the polymer and its state of distance from the glass transition temperature. At the same time, plasticization of polymers leads to an increase in the speed of movement of the macromolecule due to the fluidity of the melt, i.e. increase in shear rate relative to shear stress. This should lead to an increase in the number of nodes and, as a consequence, to an acceleration of the process of transition of macromolecules into a forced highly elastic state, i.e. to improve the characteristics of the highly elastic state of the polymer melt. The manifestation of high elasticity of macromolecules depending on the speed of movement is confirmed by the presence of a correlation between the degree of swelling and the flow rate of the melt (Fig. 2), invariant with respect to the above additives (plasticizers), despite the different plasticizing ability of petroleum polymer resins.

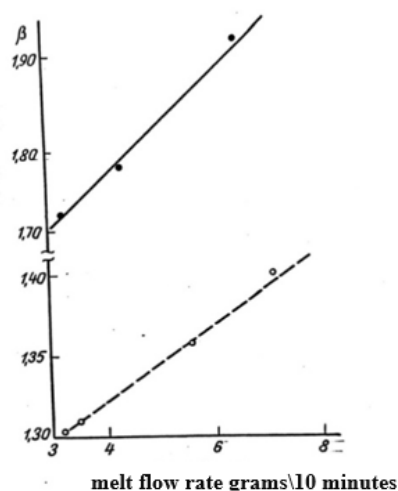
When mechanically and chemically mixing petroleum polymer resin and butyl rubber, containing 5 and 9%, with thermoplastic elastomer PUTEF, taken in quantities of 5, 10 and 15%, there is a decrease in effective viscosity, an increase in the melt flow rate and the degree of swelling (Fig. 3.). The increase in fluidity of the compositions is explained by the presence of petroleum polymer resin with a lower molecular weight than that of the thermoplastic elastomer urethane blocks.



**Figure 2.** Dependence of the degree of swelling of the melt on the fluidity index PUREP

Thus, we can conclude that both crystalline and non-crystalline polymers are characterized by a certain supramolecular structure, however, in a viscous fluid state, the supramolecular formations of polymers are fragile and easily disintegrate under the influence of thermal motion and stress. Only temporary ordered micro regions of a fluctuation nature (structural macroblocks) also arise, which by their nature resemble regions of short-range order in liquids, but are characterized by greater stability and order. In general, the structure of polymers can be represented in the form of two parts: one part consists of free segments, the thermal movement of which is quasi-independent, and the other is a molecularly ordered structure distributed throughout the entire volume, consisting of interconnected ordered micro-regions.

When temperature and pressure change, the number of segments redistributes between the ordered and disordered parts of the polymers.



**Figure 3.** Dependence of the degree of swelling of rubber samples based on PUTEP + Resin + Butyl rubber

Thermoplastic polyurethanes (PUTEP), which are similar in properties to cross-linked polyurethane elastomers, can at the same time be processed like conventional thermoplastics. To



select optimal processing modes for PUTEP, it is necessary, as shown above, to know their rheological properties in a wide range of temperatures and shear stresses.

$$\lg \eta_{\text{ef.vis.}} = \lg \eta_{\tau 0} - E \times \lg e / R \times (1/\tau_0 - 1/\tau)$$

where E is the flow activation energy, kJ/mol;  $\tau$  - shear stress Pa;  $\eta_{\text{eff}}$  - effective melt viscosity at temperature T/v K/Pas;  $\eta_{\tau 0}$  is the highest Newtonian viscosity at the lowest test temperature (T0), Pas; R - gas constant; a0 is a constant for a given polymer, Pa-1 D.

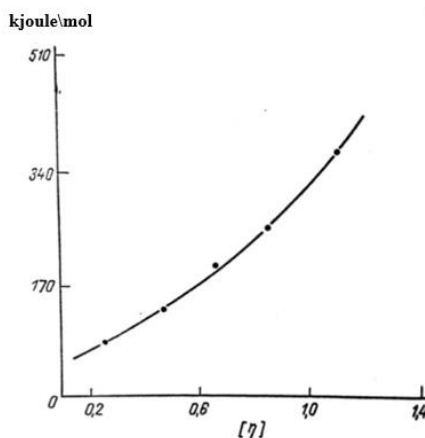
For a number of samples of PUTEP and the composition at different test temperatures with the same intrinsic viscosity ( $\eta$ ), different characteristics were obtained and the obtained data are presented in Table 4

**Table 4.** Characteristics of PUTEP at various test temperatures

| Nº | °C  | E, kJ/mol | A x 1 Pa-10 <sup>5</sup> | a0   |
|----|-----|-----------|--------------------------|------|
| 1  | 160 | 183,8     | 1,7                      | 4,13 |
| 2  | 185 | 199,0     | 2,2                      | 5,30 |
| 3  | 190 | 268,0     | 2,5                      | 5,40 |

Polyurethane thermoplastic (PUTEP) elastomer melts are characterized by high values of, which indicates a narrow temperature range of fluidity of these polymers. This appears to be due to the presence of nodes in physical and chemical networks caused by the strong molecular interactions of the rigid polyurethane blocks.

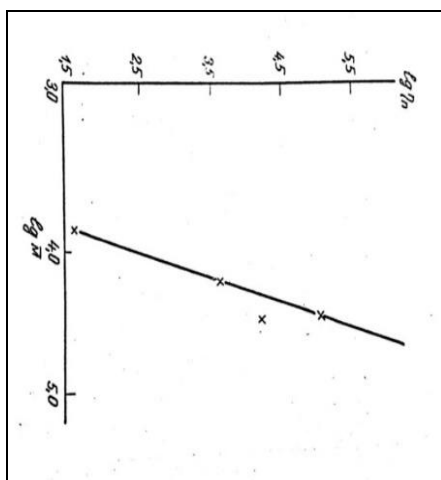
Since the corresponding values of E for PUTEP with sufficiently large intrinsic viscosity and length of rigid blocks exceed the energy of thermal decomposition of urethane bonds (85-170 kJ/mol), the flow of such systems is apparently mechanic-chemical in nature and is accompanied by reverse destruction of the polymer structure.



**Figure 4.** Dependence of flow activation energy on the characteristic viscosity of a polyurethane solution.

The discovered patterns of rheological behavior of PUTEP melts make it possible to give some recommendations for optimizing temperature conditions and the method of their processing.

For example, the intrinsic viscosity of PUTEP should probably not exceed 0.7. Above this limit, the physical and mechanical properties of the material do not change, and the melt viscosity and  $E$  increase significantly, which indicates a significant narrowing of the processing temperature range. For processing by extrusion and calendaring, it is advisable to recommend PUTEP grades with low and medium hardness, characterized by a less strong dependence of melt viscosity on temperature and shear stress. PUTEP grades with increased hardness should be processed mainly by injection molding. At the same time, due to the high “shear compliance” of the melt and under the influence of high shear stresses developed during the processing process, one should expect a significant reduction in the viscosity of the melt, which improves the manufacturability of the process.



**Figure 5.** Dependence of  $\lg \eta_p$  of the highest Newtonian viscosity of the polyurethane melt on  $\lg m$  of the number-average molecular weight of polyurethane

As can be seen from Figure 5, in turn, the logarithmic dependence of the highest Newtonian viscosity of the PUTEP melt on molecular weight in the range of 7000–55000 is linear. In this case, the exponent in the known equation for the dependence of viscosity on molecular weight is 4.0, which slightly exceeds the value of this parameter. A similar anomaly is observed for melts of other polymers.

## Conclusion

1. Insufficient properties of compositions based on them limit their use in tires and rubber products. polyurethane is modified with petroleum polymer resin of the SPP-6 brand to improve the joint mixing and joint vulcanization of PU with other components.

2. An optimal formulation of a rubber mixture based on polyurethane has been developed, thanks to which it can be produced on a laboratory roller at 40–60°C, within 10–15 minutes

4. Physico-mechanical and operational properties (strength level, conventional tensile strength at 100% tensile strength; nominal tensile strength at 300% tensile strength, relative tensile strength, relative residual deformation, tensile strength, elasticity, bond hardness with metal, fatigue strength under repeated tension, coefficient thermal aging at a temperature of 120°C, swelling level within 48 hours, resistance to aggressive environments).

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5. Adding a certain amount of petroleum polymer resin to various mixture compositions improves the properties of the vulcanizate, including improving the mutual dispersion of the components in the mixture. The introduction of plasticizers increases the tensile strength ( $E_{ten} = 200\%$ ,  $V = 250$  rpm) from 1,500 to 1,92 thousand cycles, and the hardness of adhesion to metal. These figures are higher than those corresponding to massive tires

6. A technology has been developed for producing injection molded tires of various types and modifications from polymer composite material. Extensive testing of injection molded tires has been carried out on electric vehicles, automobiles and agricultural machinery in the field, recording the tire's high mechanical strength

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## **РАЗРАБОТКА И ВНЕДРЕНИЕ ПРОИЗВОДСТВЕННОЙ ТЕХНОЛОГИИ ПОЛУЧЕНИЯ КОМПОЗИЦИЙ И ШИН НА ОСНОВЕ ПОЛИУРЕТАНОВЫХ СИСТЕМ. ОСОБЕННОСТИ РЕОЛОГИИ ПОЛИУРЕТАНА**

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### **РЕЗЮМЕ**

Объектами исследования являлись термополиуретановые термопластичные эластомеры (ПУТП), полученные реакцией 4,4-дифенилметандиизоцианата, гидроксидсодержащего полиэфира с молекулярной массой 2000 (полиэтиленгликольадипат) и 1,4-бутадиола (промышленное наименование). ВИТУР). -Т-1413)

Установлено, что зависимость логарифма эффективной вязкости ( $\eta_{эф}$ ) расплава ПУТЭП от напряжения сдвига при различных температурах в исследованном диапазоне скоростей сдвига (от 1 до 100 с<sup>-1</sup>) представляет собой параллельные прямые линии. Это позволяет использовать для описания реологического поведения расплавов ПУТЭП аналитическую зависимость эффективной вязкости от температуры, учитывающую также влияние сдвиговых напряжений на вязкость расплава.

Углеродцепные и гетероцепные полимеры определяются многими факторами, такими как

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термодинамические свойства компонентов, их молекулярная масса, степень дисперсности фаз, способность компонентов к кристаллизации и др.

Важную роль в технологии играют композиционные материалы, представляющие собой армированные или наполненные полимеры. Разработка этих материалов и улучшение их свойств представляет собой сложную задачу, значительное место в которой принадлежит физикохимии поверхностных явлений в полимерах. Поэтому проблемы физикохимии наполненных полимеров — это проблемы физикохимии поверхностных явлений в полимерах.

**Ключевые слова:** разработка, реология, модификация, полиуретан, технология, шины, вулканизация, экструдер.

## **POLİURETAN SİSTEMLƏRİ ƏSASINDA KOMPOZİTİƏRDƏN ŞİNLƏRİN İSTEHSAL TEXNOLOGİYASININ İŞLƏNİLİB HAZIRLANMASI VƏ TƏTBİQİ. POLİURETANLARIN REOLOGİYASININ ARAŞDIRILMASI**

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### **XÜLASƏ**

Tədqiqatın obyektləri 4,4-difenilmetan diizosiyanat, molekul kütləsi 2000 (polietilen qlikol adipat) və 1,4-butadiol (sənaye adı) olan hidrosid saxlayan poliefirin reaksiyası nəticəsində əldə edilən termal poliuretan termoplastik elastomerlərdi (PUTP). VITUR). -T-1413)

Müəyyən edilmişdir ki, tədqiq edilmiş yerdəyişmə sürətləri diapazonunda (1-dən 100 s-1-ə qədər) müxtəlif temperaturalarda PUTEP əriməsinin effektiv özlülüyünün (ηeff) loqarifminin yerdəyişmə gərginliyindən asılılığı paralel düz xətləri təmsil edir. Bu, PUTEP ərimələrinin reoloji davranışını təsvir etmək üçün effektiv özlülüyn temperaturdan analitik asılılığından istifadə etməyə imkan verir ki, bu da ərimənin özlülüynə yerdəyişmə gərginliyinin təsirini nəzərə alır.

karbon zəncirli və heterozəncirli polimerlər bir çox amillərlə müəyyən edilir, məsələn, komponentlərin termodinamik xassələri, onların molekulyar çəkisi, fazaların dispersiya dərəcəsi, komponentlərin kristallaşma qabiliyyəti və s.

Gücləndirilmiş və ya doldurulmuş polimerlər olan kompozit materiallar texnologiyada mühüm rol oynayır. Bu materialların inkişafı və xassələrinin təkmilləşdirilməsi mürəkkəb bir problemdir ki, burada polimerlərdə səth hadisələrinin fiziki kimyasına mühüm yer verilir. Buna görə də doldurulmuş polimerlərin fiziki kimyası problemləri polimerlərdə səth hadisələrinin fiziki kimyası məsələləridir.

**Açar sözlər:** emal, reologiya, modifikasiya, poliuretan, texnologiya, şinlər, vulkanizasiya, ekstruder.