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TECHNOLOGY

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Beeva D.A., Berbekova I., Beev A. A., Kvashnin V.A. Polyhydroxyether's

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Abstract: Review article devoted to methods of synthesis of polyhydroxyethers - simple thermoplastic polyesters intended for the production of coatings, adhesives, varnishes, paints

Keywords: polyhydroxyether, polycondensation, diphenol, epichlorhydrin

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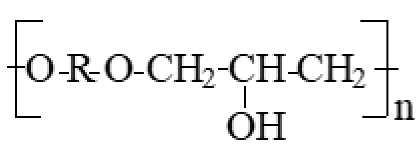
Polyhydroxyether's (polyoxyethers) is a simple linear polyethers having the structure:



, where R is the remainder of diphenol.

Polyhydroxyether is a thermoplastic polymer, which is obtained by the interaction of dihydric phenols with epichlorhydrin or *n* — diglycidic ethers diphenols with diphenols. Unlike epoxy resins, derived from the same starting compounds, polyhydroxyether have a large molecular weight and contain virtually no epoxide groups [1,2,3], so the polymer is thermally stable and can be processed by methods used for thermoplastics [4]. On the basis of polyoxyethyl get thermoplastic coatings and adhesives with good properties.

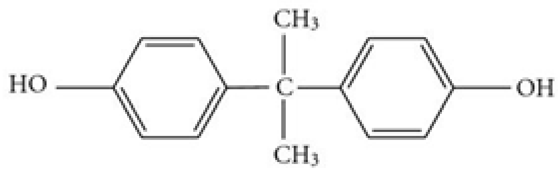
The first polyhydroxyether as epoxy resin, were synthesized in the early 30-ies, but until the end of the second world war, they have not found practical application.

In 1949 there were reports about the production of polyhydroxyethyl for the manufacture of films and fibers in Western countries. These polymers received one — stage or two-stage method in industrial scale.

The coatings based on polyhydroxyether has been applied in the USA in 1961. Utracki L. A., considering the history of commercialization of polymeric materials, according to [5, 6] that the first industrial polyhydroxyether of bisphenol A released in 1962 by the firm Union Carbide under the trade name «Phenoxy». Then began the development of these polymers for the production of plastics, films, adhesives, etc. By 1965, polyhydroxyether of different molecular weight have become widely available [7]. In the world polyhydroxyether based on diphenylolpropane and epichlorohydrin, are known under the trade name «Phenoxy» (USA) and «Epiterm» (Poland), produced and used widely in industrial scale. Russia has not developed the technological scheme of the synthesis of polyhydroxyether in large volumes. There is a pilot plant which allow to obtain polymers with a molecular weight of 20 -100 thousand.

The leading position among all manufacturers of phenoxy resin is firm InChem Phenoxy Resin, located in the state of South Carolina, USA. The company was founded in 1992 and manufactures a wide range of chemical products, phenoxy resin in granules, powders, solutions and aqueous emulsions.

The main monomers for the synthesis of phenoxy –resins are epichlorohydrin and bisphenol A.



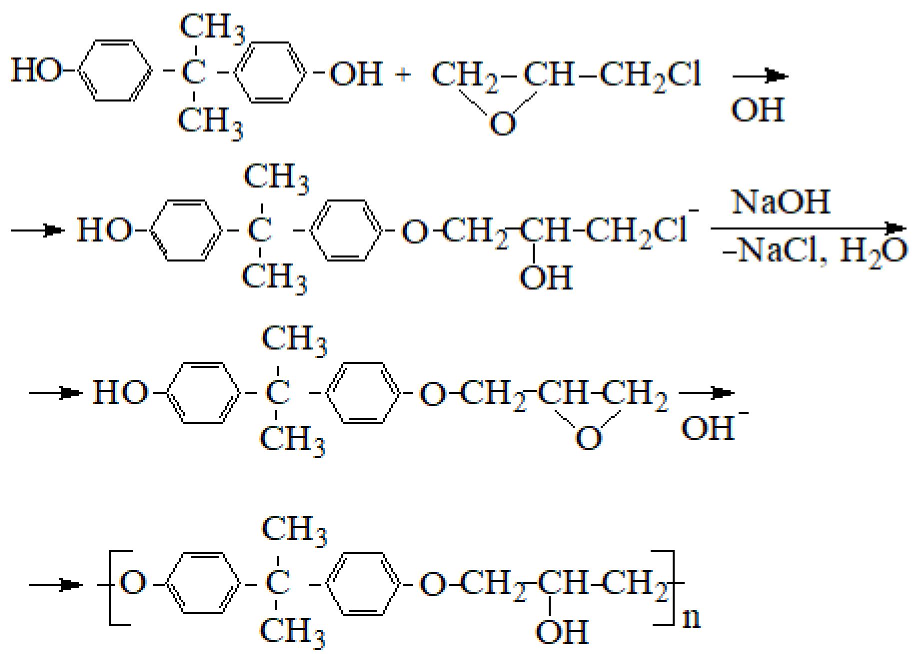
Bisphenol A

Bisphenol A (4,4′— dioxidiphenylpropane, Dian). Diphenylolpropane was first synthesized in 1891 by the Russian scientist A. P. Dianin by condensation of phenol and acetone (hence the letter «A» in the trivial name bisphenol). In honor of the famous chemist received a substance in many countries called Dian.

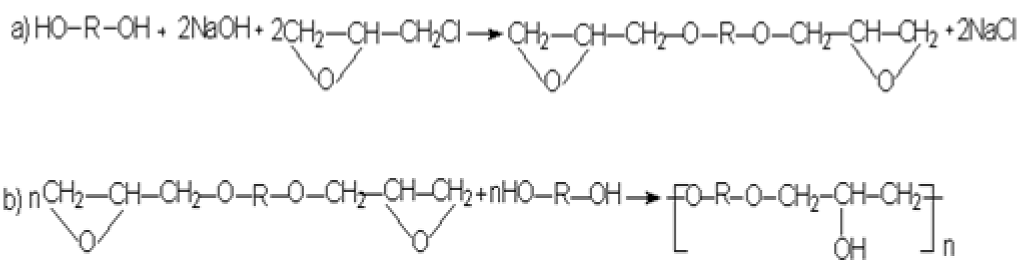
In industry diphenylolpropane for the first time in 1923 started to produce the German firm «KurtAlbert» for the production of synthetic resins. However, the wide spread and significant growth in the production of this diphenol occurred in the 50-ies of the last century. Since then, diphenylolpropane is increasingly used in the chemical industry to produce valuable chemical products epoxy resins, polycarbonates, etc [8]. In the world today it produces about 2.8 to 3.0 million tons of diphenylolpropane in the year.

The ways of obtaining polyhydroxyether's

Synthesis of thermoplastic polyhydroxyether based on bisphenol A proceeds similarly to the synthesis of epoxy resins by polyaddition with subsequent cleavage of hydrogen chloride at the intermediate stage :



So runs the «direct» one-step process of obtaining polyhydroxyether. There is also an «indirect» two-step method, the first stage of which receive *p*-diglicidilether (for example, diphenylolpropane) and in the second stage, carry out its interaction with bisphenolate.



Depending on the method and conditions of synthesis get polyhydroxyether with a molecular weight of from 20000 to 100000, which are used for obtaining of plastics, adhesives, coatings, and adhesives.

The available literature on the synthesis and study of polyhydroxy-ditch is very limited and is patent in nature. However, the analysis and synthesis of data presented in the literature reveal the following basic methods of synthesis of polyhydroxyether:

1. the interaction of diphenol and epichlorhydrin in solution with the participation of alkaline catalysts;
2. interaction of low molecular weight diepoxides with diphenolate in the block at an elevated temperature in the presence of catalysts of Friedel-crafts;
3. interaction of low molecular weight diepoxides with diphenolate with the participation of alkaline catalysts;
4. polymerization monoglycidyl esters;
5. heterophase synthesis of diphenol with epichlorhydrin with appropriate selection of solvent, catalyst, emulsifier, mixing mode.

These methods have certain advantages and disadvantages. However, they vary based on the conditions of synthesis and the source substance, the catalyst, which allows, depending on the applications of polymers to choose one or the other method.

The authors suggest a method for the synthesis of polyhydroxyether with a molecular weight above 30,000 by processing diphenol (for example, 2,2 bis-(4,4′-oxyphenyl)propane) equimolecular number of epichlorhydrin (e.g., epichlorohydrin) and excess alkali NaOH in aqueous medium at a temperature of 150-200°C.

A method in its seeming simplicity is complicated by a relatively high reaction temperature, which is above the boiling point of the used liquid components of the solvent — water and epichlorhydrin, which may lead to violation of equipollence reagents in the reaction mixture. In addition, the water and epichlorhydrin are mixed only partially, so interfacial phenomena will hinder the flow of the main reaction.

The result is a six-hour boiling of a mixture of epichlorhydrin (0.1 mol), 2,2-

bis(4-oxyphenyl)-propane (0.1 mol) and 0.11 mole of sodium hydroxide in 65 g of 36.9% strength ethanol was obtained white powder which melted at 160-165 °C and has an intrinsic viscosity of 0.43 DL/g (1 % solution in m-cresol, 25 °C).

In the study of the regularities of synthesis of polyhydroxyether from epichlorhydrin has been shown [9] that the amount of alkali is decide-conductive factor determining the intrinsic viscosity of the resulting polymer. The greater the amount of sodium hydroxide, the viscosity is higher (table 2).

Interaction equimolecular quantities of multi-core two-atomic phenol and epichlorhydrin carried out in the presence of the same amount or excess alkali.

Table 1

The influence of the quantity of alkali on the characteristic the viscosity of polyhydroxyether

The amount of sodium hydroxide, mol/mol diphenol the	Characteristic solution viscosity in *m*-cresol at 25°C, dl/g
1,015	0,33
1,035	0,42
1,055	0,48
1,075	0,58
1,095	0,80

Stepwise introduction of alkali, and a stepped heating contribute to the occurrence of exothermic process of joining the molecules of epichlorhydrin to bisphenol molecule and increase the speed of endothermic processes — dehydrochlorination and addition polymerization. However, the reaction is carried out in solution slows it down, does not allow to achieve high molecular weight, as in the presence of bases, in solutions of epoxy oligomers is enhanced by an open circuit. Therefore, the methods discussed above do not allow to obtain high molecular weight reaction products.

Polyhydroxyether suitable for the production of films and press articles having high mechanical and thermomechanical properties are obtained by reaction equimolecular quantities of epichlorhydrin and diphenol in an aqueous-organic medium under the action of alkali metal hydroxides. The method is also used by step-heating and step-wise introduction of alkali.

A method of obtaining a thermoplastic polyhydroxyether, suitable for the manufacture of packaging films, characterized by improved physico-mechanical properties and low content of substances extracted in contact with food.

Japanese researchers [10] to obtain polyhydroxyether on the basis of epichlorhydrine and diphenol in the solvent used hexamethylphosphorotriamide. For the synthesis use different divinelys. The use of the amide solvent, which can play the role of a catalyst affects the reaction rate.

For the methods of synthesis of polyhydroxyether «direct» way, i.e. interaction diphenols and epichlorhydrin, it is possible to identify the most common methods for obtaining high molecular weight of the product:

— equimolar ratio of the starting reagents and the catalyst or in small excess of the latter;

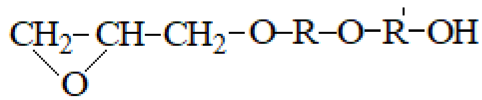
— the use as catalyst of alkali metal hydroxides, aqueous-organic medium. Organic solvents can be miscible (ethanol, DMSO) and non-soluble (toluene, butanol) with water;

— the need for a high degree of purity of the starting monomers to obtain a product with a high molecular weight mono-functional impurity substances lead to an open circuit, and the monomers with a functionality of more than two lead to branching and increased polydispersity. It is important to note stepwise heating

the reaction mixture stepwise and the introduction of catalyst allows you to adjust sequentially occurring exothermic and endothermic reactions, which is very important in the development of the process technology on a larger scale.

The disadvantages of most methods is the contamination of the product with salts, catalysts, which degrades the dielectric properties of the product. Drawback — the duration of the process (8-24 hours), reducing its effectiveness in an industrial environment.

A separate group can provide methods of obtaining polyhydroxyethers high molecular weight of by polymerization of simple monoglycidyl ethers of the following structure:

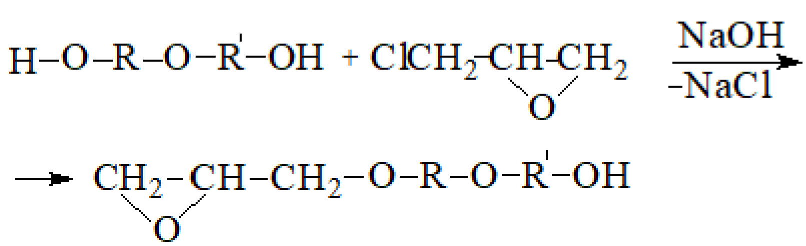


where R is a phenyl radical.

R — is a substituted or unsubstituted divalent aliphatic radical containing more than two carbon atoms.

The polymer chain growth occurs by the interaction glycidil-ether group of one molecule with oxyaliphatic group of another molecule.

Monoglitseridy the broadcast receive according to the scheme:



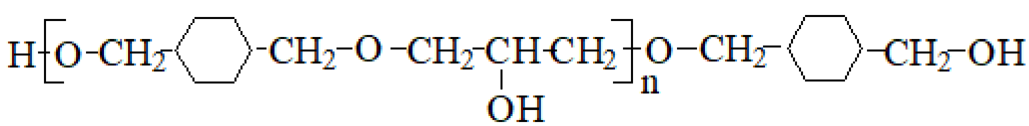
Homopolymerization the compounds synthesized high-molecular polyhydroxyether for protective coatings. As catalysts use of Lewis acids.

Used for the synthesis of esters containing aromatic residues of different structure that allows you to adjust the properties of the polymers.

Patented the method of preparation of high-molecular polyhydroxyether with a molecular weight of 50-500 thousand by catalytic addition polymerization of (4-epoxypropoxyphenyl-4-hydroxyphenyl)dimethylmethane.

Polyhydroxyether for the preparation of compositions and methods for their preparation provides Darrell with employees. The reaction is carried out block polymerization or interaction monoglycidyl esters in solution at a temperature of 20-200 °C depending on the solvent. The process is carried out in methyl isobutyl ketone, cellosolve, methyl ethyl ketone in the presence of salts.

Weather-resistant coating is obtained by polymerization of mono-glycidyl ether of 1,4-cyclohexanedimethanol in the presence of catalysts of Friedel-Crafts, for example, BF3 [11]. The thermoplastic product has the following structure:



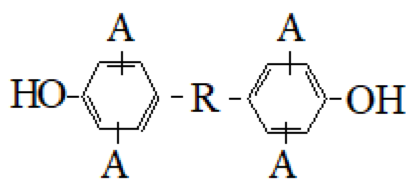
In the processing of crosslinking agents, for example, amines, fatty acids, polyisocyanate get net polymers.

The synthesis of polyhydroxyether homopolymerization has some advantages. Monoglycidyl esters contain in their molecule one phenolic hydroxyl and one group that gives the opportunity to avoid the application of the two-component system and virtually eliminate all the error in the ratio of functional groups. Propose to carry out the reaction in the block or the solvent in the presence of catalysts of Friedel-Crafts. But the Chrome studies are not allowed to polyhydroxyether with a molecular weight above 12-15 thousand by this method.

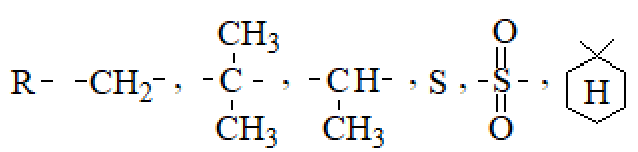
Depending on the starting substances can be identified and the third group methods are «indirect» method of obtaining polyhydroxyether through interaction diglycidyl esters diphenols (or diepoxides) diphenolate. Based on the analysis of experimental data was reported that attempts to obtain high molecular weight products by direct polyaddition of a diisocyanate diepoxide compounds and bisphenols were unsuccessful. Greatest molecular weight of polyhydroxyether reached 8000.

However, in the patent literature, there is a lot of information about how to obtain polymers of high molecular weight reaction diepoxides and diphenols.

So to improve the resistance to solvents and combustion, thermal characteristics is proposed a method of producing polyhydroxyether based on diglycidyl esters and bisphenol General structure:



A – H, Cl, Br, CH_3, C_2H_5;



where

As diepoxide compounds have been used aliphatic, aromatic glycidyl ethers, epoxide coat dienes, diglycidyl ethers of dicarboxylic acids, mixtures of these diepoxides. Catalysts of polyaddition served tertiary amines of diverse structures.

To obtain linear high-molecular polyhydroxyether [12] the interaction of diepoxides with bisphenolate was carried out at a molar ratio of 0,5:1 to 0,9999:1 at a temperature below the softening temperature of the mixture in the presence of catalytic quantities of a tertiary amine.

Polyhydroxyether to obtain film materials with good adhesion to glass offer to synthesize the interaction of block and diepoxides diphenols. As catalysts use tertiary amines, derivatives of quaternary ammonium bases, N-alkylamide, N, N-dialkylamide acids, dialkyl- or tetraalkylammonium urea or thiourea, dimethylacetamide, dimethylformamide. Before the end of the synthesis the product can enter the filler. The process of addition polymerization is carried out at temperatures of 110-140 ° C for 20-22 hours [13].

I propose to obtain high molecular weight products of low molecular weight epoxy resins and bisphenols in the presence of catalysts of lithium hydroxide [14] or tertiary amines.

The synthesis of polyhydroxyether with a molecular weight of about 84200 carried out in the presence of catalysts — salts phosphonium, hydroxides alkaline or alkaline-earth metals. As starting compounds are diglycidyl ether of 4,4′-dihydroxydiphenylpropane and bisphenols. Methods of blockpolymerization diglycidyl esters and bisphenol, as shown by literature data, allow to avoid a large amount of contaminated wastewater. However, these methods require the use of high temperatures, lengthy processes used catalysts contaminate the final product, degrading the dielectric properties.

There are several reports about getting polyhydroxyether on the basis of diepoxides and bisphenol in solvents.

Thermoplastic polymer for the manufacture of sockets for radio, electronic devices, abrasive-, and chemical-resistant coatings get [7,15] in the methyl ethyl ketone from the starting materials 100% purity in the presence of Quaternary ammonium bases. Synthesis continues 75-80 hours at a temperature of about 80 °C.

Branched polyhydroxyether to cover film, protect them from gas bubbles, water [16] the environment ethylcellsolve, methanol in the presence of tertiary ammonium salts. The process finished after 20 hours of synthesis at a temperature of 90 °C.

The improved synthesis of the epoxy resin and polyhydroxyether low in aliphatic halogen interaction is carried out at 80-120 °C diglycidylether ether diphenol with diphenols in the environment of aromatic hydrocarbon or ketones in the presence of 0.2-1 % aliphatic compounds containing at least one hydroxyl group, for example, polyethylene glycol, and from 1 to 3 moles of alkali metal hydroxide.

Polyhydroxyethers with improved processability, mechanical strength and gas-protective properties, receive in a two-phase system water— organic solvent with the aid of catalysts of the basic nature or catalysts of interphase transfer. Synthesized polyhydroxyethers used for forming packages for oil, beer, wine, seasoning, cosmetics.

The disadvantages of methods for the synthesis of polyhydroxyethers in solutions on the basis of diepoxides and diphenols are the duration of the process, large amounts of toxic waste water, a high proportion of reactions of chain breakage.

The USSR had developed technology for producing polyheterophase condensation of diphenol with epichlorhydrin with appropriate selection of solvent, catalyst, emulsifier, mixing mode. The process is carried out in the presence of sodium carboxymethyl cellulose as an emulsifier and a solvent of the organic phase of isopropyl alcohol at a temperature of 80 °C for 3-6 hours with continuous stirring [17]. However, the widespread introduction and dissemination of the method has not received due to the large contamination of the final product salts, catalyst, emulsifier and impair properties of the polymer, low manufacturability of the process due to the partial crosslinking of the resulting polymer.

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GEO-INFORMATION SYSTEMS

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Bespalova L., Krivoguz D. Spatial analysis of topography of Kerch peninsula using GIS and its impact on landslides

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Abstract: Various impacts of landslides have increased in past decades due to the rapid growth of urbanization in the developing world. Landslide effects have damaged many aspects of human life and the natural environment, and many difficulties remain for accurate assessments and evaluations. Main goal of this article is to analyze main topographical factors of Kerch peninsula and describe impact if this factors on landslide process. Factor, analyzed in this work include slope, steam power index, profile and plan curvature, mass balance index and terrain wetness index. The most important factor, that influenced on landslide processes is slope angles.

Keywords: Toporgaphy, Kerch peninsula, Landslides, GIS, Spatial analysis

From the point of view of relief-forming factors, it is important to consider the morphometric indices of the relief of the Kerch Peninsula [7]. These include:

- Slope
- Stream power index
- Plan and Profile curvature
- Topographic Wetness Index
- Mass balance index

Slope of the surface is an indicator of the slope steepness, ratio of exceeding the parameters of the terrain relative to the surface on which it is observed; fixes the intensity of the height difference between two points on the surface. In mathematical terms, the slope of the surface is equal to the tangent of the angle between the rise of the slope and the horizontal surface (Figure 1) [13, 16].

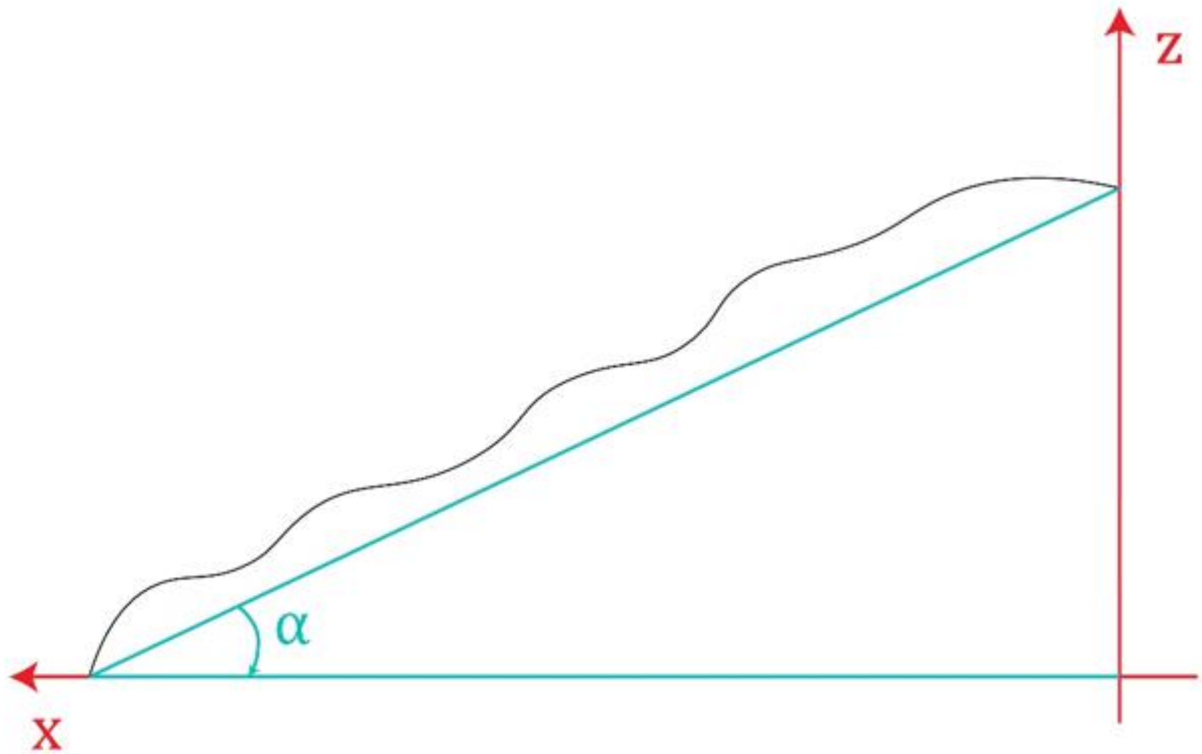

Figure 1. Schematic representation of the calculation of the slope of the surface

The determination of the slope angle of the surface according to the Zevenbergen-Thorn algorithm [17] is calculated by the formula 1:

$$\alpha = \tan^{-1}\left(\sqrt{\left(\frac{z_6 - z_4}{2l}\right)^2 + \left(\frac{z_2 - z_8}{2l}\right)^2}\right) \quad (1)$$

where $z_{(2 \ldots 8)}$ — elevation indicators for certain raster cells, l — distance between individual height elements (spatial resolution of the raster). In this case, the units of absolute height and spatial resolution are equal to each other and as a rule are measured in meters.

For flat areas, such as territory of the Kerch Peninsula, V. Zhuchkova and E. Rakovskaya [1] proposed a classification of gradations of the surface slope (Table 1).

Table 1

Classification of slope by V. Zhuchkova and E. Rakovskaya

Less than 1°	flat (subhorizontal) plains
1-3°	Slightly inclined plains (very gentle slopes)
3-5°	gentle slopes (inclined plains)
5-7°	sloppy slopes
7-10°	sloping slopes
10-15°	strongly sloping slopes
15-20°	steep slopes
20-40°	very steep slopes
More than 40°	steep slopes

The slope of the surface is a fundamental geomorphic parameter that is naturally associated with the following processes and landscape characteristics [7, 10]:

- surface runoff and drainage — the steeper the slope, the more intense of runoff and the less infiltration of moisture into the soil thickness. Thus, bias is of fundamental importance for the regime of soil moistening, especially — the upper layers;

- erosion — the intensity of erosion grows exponentially with increasing of the slope. This is explained by the fact that as the gradient increases, the kinetic energy of the sediments remains constant, but the transport accelerates in the direction of the foot. As a result, the kinetic energy of the runoff exceeds the kinetic energy of the sediments, when the slope goes over the mark of 8.5 °, which promotes the appearance of erosion processes;
- thickness of the soil profile on the slope naturally varies according to the slope and relative height. As a rule, the soil stratum is smaller in elevated inclined areas due to erosion processes and gravitational movement of the material, and gradually increases in the direction of the lowered areas with a slight slope;
- the amount of solar energy also depends on the slope, since it determines the angle of incidence of sunlight on the earth’s surface. Increasing the slope of the surface in the direction of sunlight increases the angle of their fall, and hence the amount of energy that the surface receives. This determines the microclimatic features of the site, in particular the temperature, evapotranspiration and moisture of the upper layers of the soil;
- features of the vegetation cover collectively reflect all of the above characteristics, since they directly or indirectly affect such edaphic factors as water and temperature regime of the soil, the mechanical composition of the root-containing layer, the content of nutrients, etc.

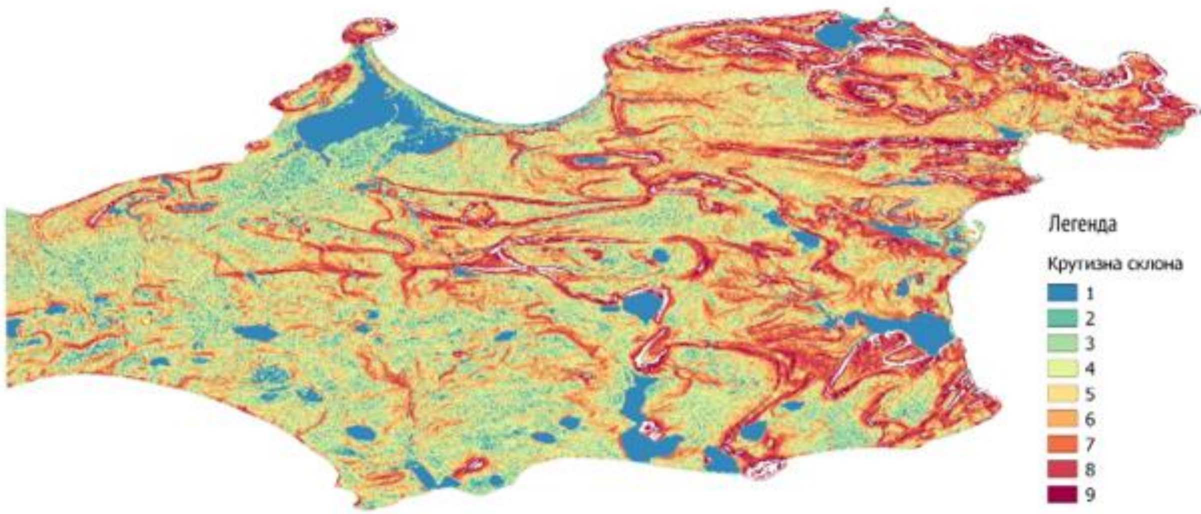

Figure 2. Steepness of the slopes of the Kerch Peninsula

Distribution by area occurred as follows in Table 2.

Table 2

Distribution of different classes of slopes steepness over the area

Type of slope	Area, km^2
flat (subhorizontal) plains	226,7391
Slightly inclined plains (very gentle slopes)	187,3897
gentle slopes (inclined plains)	289,7629
sloppy slopes	622,3431
sloping slopes	250,6452
strongly sloping slopes	570,7517
steep slopes	266,0778
very steep slopes	330,3291
steep slopes	107,7023

The largest area of the Kerch Peninsulas territory is occupied by sloppy slopes and strongly sloping slopes, having an area of 622 and 571 km², respectively. Concerning the slopes on which there is the greatest probability of formation of landslides, their area is about 107 km² and geographically they are located in the eastern part of the peninsula.

An important factor in the formation of landslides is a destructive effect of the underlying soil composition of atmospheric precipitation [2, 3]. With abundant deposition on the surface, short-term watercourses are formed, which lead to significant erosion processes, changes in soil composition and favorable conditions for the formation of landslides on the territory [6, 14].

The steam power index (SPI) is calculated by the formula 2.

$$SI = \ln(1 + CA * \tan G) \quad (2)$$

where CA is the catchment area, G is the steepness of the slope.

In its essence, the flux power index is a measure of the potential erosive force of surface currents, i. e. the larger the catchment area and the slope, the greater the value of the SPI. Thus, the greater the volume of water entering a certain point of the surface from the areas above it and the higher the speed of these flows, the higher the probability of erosion processes.

SPI is used to describe the potential flow erosion at a given point on the topographic surface. If the catchment area and the slope angle increase, the amount of water falling on flat surfaces and the flow rate will increase, which will lead to an increase in flow capacity and intensification of erosion processes[4].

SPI rate depends on the erosion potential of the streams, the thickness of the soil horizons, the organic substances contained, the acidity of the soils, the content of silt and sand, and the nature of the vegetation cover.

Since the SPI depends on the slope, it is, as it were, its consequence in the part of the formation of the potential flow erosion parameter [9].

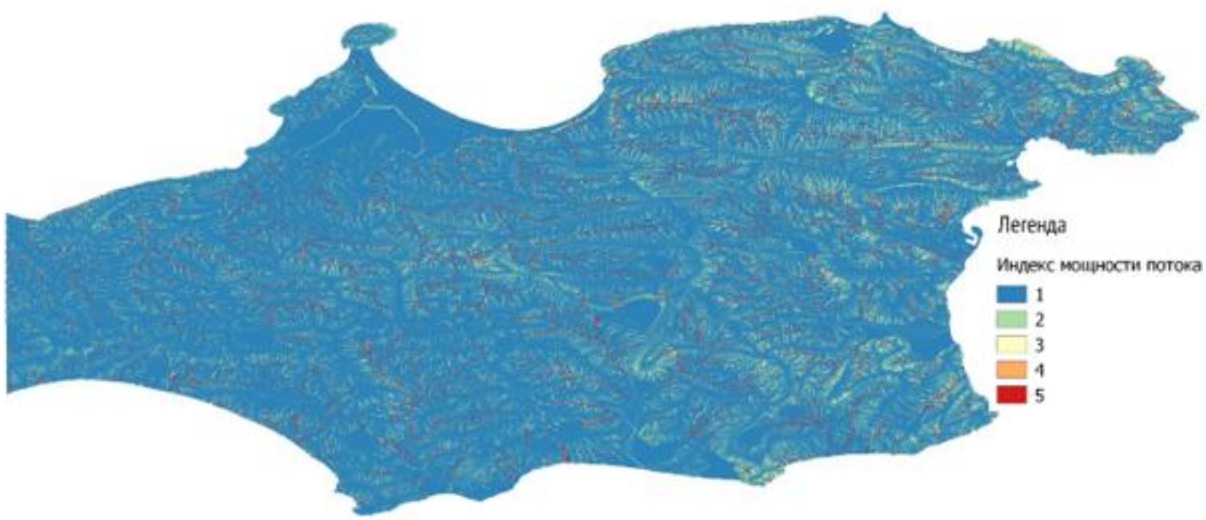

Figure 3. Calculated SPI of Kerch peninsula

Erosion processes on the territory of the Kerch Peninsula, which depend of atmospheric precipitation, are rather poorly developed.

Table 2

Distribution of SPI

Class	Area, km²
1	2747,033
2	80,81874
3	28,52946
4	14,62019
5	17,09549

According to the table 2 territories, largely affected by this process have an area of 31 km^2 or 1% of the total territory, which together with the fact that the level of precipitation on the Kerch Peninsula is very low, indicates a weak contribution of this factor to landslides process.

Plan curvature is the curvature of the line formed by the intersection of the earth's surface and the vertical plane. Being a derivative of the second order, it describes the gradient of the slope along a given contour [5, 12].

Negative values of vertical curvature indicate the convexity of the surface. Positive values indicate that the surface is concave. Zero values are characteristic of a flat surface.

Plan curvature has a significant effect on the acceleration or deceleration of the flow across the entire surface. When the water flow accelerates, the amount of accumulated precipitation in the lower part of the slope increases, which leads to its considerable erosion.

Since vertical concave slopes lead to increased erosion processes, an increased level of erosion-type processes is observed on these slopes [16].

Profile curvature is the curvature of the line formed by the intersection of the earth's surface with a plane perpendicular to the orientation direction of the maximum gradient (exposure). As a second-order derivative, the profile curvature describes the gradient of exposure along a given contour.

Positive values indicate that the surface is convex at a given point, while negative values indicate concavity.

Profile curvature, along with plan curvature, indicates a more dynamic course of processes of sliding of rock masses in concave areas of slopes.

The cumulative measure of the curvature of the earth's surface, which identifies its convex sections with positive values, and concave — negative regardless of direction.

The imposition of plan and profile curvature leads to an increase in the total curvature of the surface. At those points where this value is maximal and the facts of the formation of significant landslides are observed.

The calculation of the curvature of the surface according to the Zevenbergen-Thorn [17] algorithm takes place according to formulas 3 and 4.

For plan curvature:

$$PLANC = \frac{-2\left(\frac{\left(\frac{z_4+z_6}{2}-z_5\right)}{l^2}*\left(\frac{(z_2-z_8)}{2l}\right)^2+\frac{\left(\frac{z_2+z_8}{2}-z_5\right)}{l^2}*\left(\frac{(z_6-z_4)}{2l}\right)^2-\frac{(z_3-z_1+z_7-z_9)}{4l^2}*\left(\frac{(z_6-z_4)}{2l}\right)*\left(\frac{(z_2-z_8)}{2l}\right)\right)}{\left(\left(\frac{(z_6-z_4)}{2l}\right)^2+\left(\frac{(z_2-z_8)}{2l}\right)^2\right)}*100 \quad (3)$$

For profile curvature:

$$PROFC = \frac{-2\left(\frac{\left(\frac{z_4+z_6}{2}-z_5\right)}{l^2}*\left(\frac{(z_6-z_4)}{2l}\right)^2+\frac{\left(\frac{z_2+z_8}{2}-z_5\right)}{l^2}*\left(\frac{(z_2-z_8)}{2l}\right)^2-\frac{(z_3-z_1+z_7-z_9)}{4l^2}*\left(\frac{(z_6-z_4)}{2l}\right)*\left(\frac{(z_2-z_8)}{2l}\right)\right)}{\left(\left(\frac{(z_6-z_4)}{2l}\right)^2+\left(\frac{(z_2-z_8)}{2l}\right)^2\right)}*100 \quad (4)$$

where $z_{(2 \ldots 8)}$ — elevation indicators for certain raster cells, l — distance between individual height elements (spatial resolution of the raster).

The topographic wetness index (TWI) is usually used to study the on-going hydrological processes. The TWI helps to determine the areas on which due to various circumstances there is a waterlogging of the soils. According to K. Ballerin, TWI is an index that is able to show regions that are saturated with water or have a potential for this [8, 15, 16].

The index is calculated by the formula 5.

$$TWI = \ln\left(a / \tan\beta\right) \quad (5)$$

where, a is the specific catchment area; β is the slope angle (in radians)

The topographical character of the terrain affects not only the soil moisture, but also can indirectly affect its pH. These indicators are crucial for vascular plants. Also, TWI index correlates well with the level of groundwater and soil pH.

To calculate the values of the index of the topographic moisture index we can use spatial data, namely the digital terrain model.

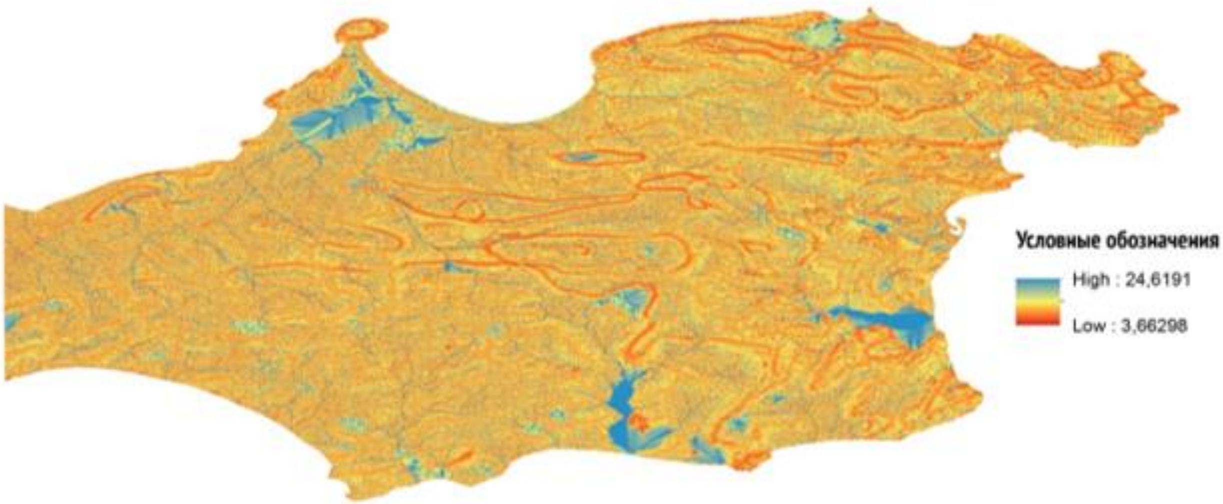

Figure 4. Calculated TWI of Kerch peninsula

An important indicator that characterizes the possibility of forming landslides is the *mass balance index (MBI).*

It shows the prerequisites for the development of dangerous gravity processes in a certain area and reflects the possible violation of the destruction of ground masses. By this indicator it is possible to identify dangerous landslides.

Negative values MBI the areas of the territory at which the deposition processes take place, for example, depressions and valleys. Positive values of MBI show erosion areas — convex slopes of hills. Values close to zero are confined to territories approximately equal to the level between erosion and sedimentation processes, which is characteristic of a flat terrain [11].

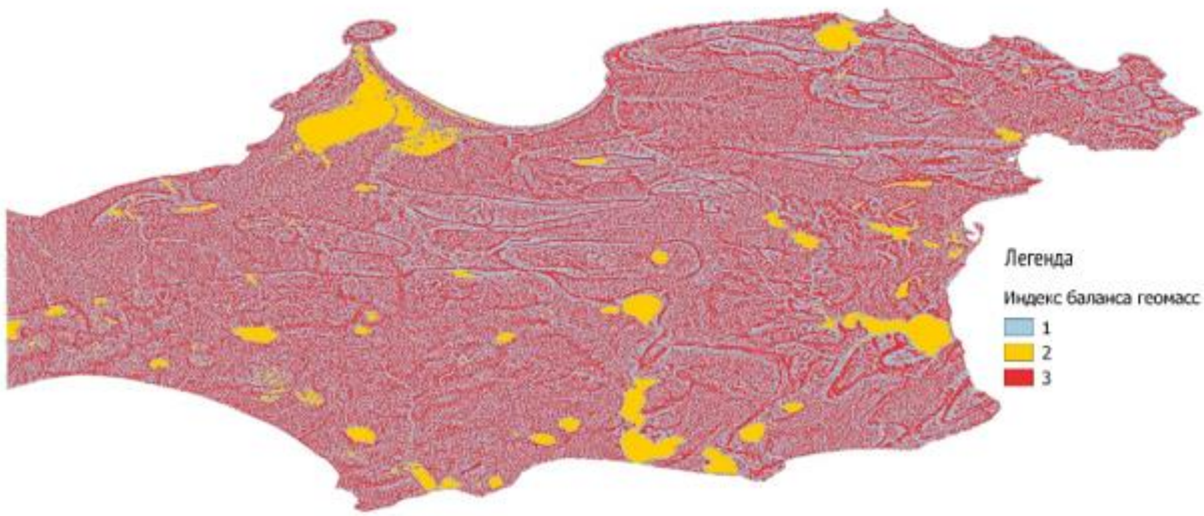

Figure 5. Calculated MBI of Kerch peninsula

MBI can be calculated by formula 6.

$$MBI = \begin{cases} f(TC) * \left(1 - f(S)\right) * \left(1 - f(VDN)\right), \text{для } f(TC) < 0 \\ f(TC) * \left(1 + f(S)\right) * \left(1 + f(VDN)\right), \text{для } f(TC) > 0 \end{cases} \quad (6)$$

where, S — the slope angle indicator, TC — the index of the total curvature of the surface, VDN — the catchment area.

Thus, the territories on which the deposition processes take place occupy 1,440 km², while the territories at which erosion processes are active are about 1,350 km². In turn, the area of the territory occupied by flat areas of the terrain is only 151 km².

Conclusion

Thus, it can be seen that the territory of the Kerch Peninsula has a rather heterogeneous relief. It is represented mainly by a weakly hilly terrain, for which a rather weak amount of precipitation is characteristic. The nature of the curvature shows that most spread types of territory are convex hilly regions. Potential areas where erosion can occur as a consequence of undermining precipitation is practically absent. This can significantly contribute to the active development of both erosion processes and landslides.

Most important factor for landslide process is slope angle. Territories with slope angles, that lead to landslides have an area about 450 km^2 or 20% of the total area, that is a big value at all. That's why morphometric parameters plays an important role in forming landslide territories in Kerch peninsula.

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Goncharuk E.O., Getmantseva V. V. Andreeva E. G., Guseva M.A. Algorithm of constructive modeling of complex forms sleeves in automated intelligent environment

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Abstract: The article substantiates the need in developing methods for intellectualizing CAD software for clothing, presents the results of work aimed at developing the creative potential of the designer, describes the method of sleeve modeling developed by the authors, which allows to organize an active dialogue between the designer and the automated system in the process of designing new products.

Keywords: constructive modeling, parametric designing of clothes, intellectualization, sleeve "flashlight"

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1. Introduction.

Automation of stages of sewing design products remains one of the topical scientific trends in the garment industry. But, despite the rapid pace of general automation of the production process, the stages of constructive modeling of complex cuts clothing are still carried out in manual or semi-automatic mode. This can be explained by the fact that the work at the modeling stages is based on the creative analysis and personal experience of the designer [1]. Stages of modeling are difficult to algorithmize. It is necessary to focus on the introduction of intellectualization methods into this process to automate these stages. The methodology of solving this problem has already been considered in a number of papers [2,3,4,5]

The basic principles of intellectualization of the automated engineering process of clothing designs are theoretically determined on paper [6]. However, in practice this issue has not been fully implemented. At present, the vector of CAD for clothes development is shifted towards the implementation of 3D graphics, leaving behind the «creative» specifics of the garment designer’s work in 3D space [7].

2. Materials and Methods.

A study of the traditional manual modeling process of three-dimensional clothes was conducted to develop methods of constructive modeling of complex garments details in an automated intellectual environment. As a research subject, a short sleeve with pinches on the cap and the bottom of sleeve (sleeve-flashlight) was chosen.

3. Results and Discussion.

Based on the results of the study:

— parametric characteristics of the structure were defined and systematized [8], through which the dialogue is organized between the automated system and the designer (Table 1);

— an algorithm for constructing a design that allows to automate fully the stage of modeling was developed.

The system of parametric characteristics of the sleeve-flashlight construction contains the necessary information on the planar sweep and the volumetric form of the sleeves. The developed system of parameters is structured in accordance with the sequence of actions of the designer and the decisions made by him, while developing the models of clothing (Table 1, Figure 1).

Table 1

System of parameters for the description of MC (model construction) of sleeves with pinches on the cap and the bottom of sleeve

N	Coefficient	Description of the parameter
1	2	3
1	Шр	The initial width of the sleeve at the depth of the cap (Basic Construction)
2	Δ Шр	Size of sleeve extension
3	Шр'	The width of the model sleeve at the level of the depth of the cap (МК) is Шр' = Шр + Δ Шр
4	kр	Coefficient of extension of a sleeve
5	Шрн	The initial width of the sleeve at the bottom (BC)
6	Шр′н	The width of the model sleeve on the bottom (MC)
7	Др	The length of the basic construction of sleeve (BC)
8	Др′	Length of model sleeve (MC)
9	Вок	The initial height of the sleeve cap (BC)
10	Δ14	The value of raising the highest point of the sleeve
11	Вок′	Height of the model cap of a sleeve (MC) Bok '= Bok + Δ14
12	Δ14х	The value of the displacement of the highest point of the cap of the sleeve (with an irregular pinch on the front and back sections)
13	Δ332	The value of displacement of the beginning point of the sleeve extension in the back upper part of the cap
14	Δ355	The value of a displacement of the beginning point

N	Coefficient	Description of the parameter
1	2	3
		of the sleeve extension in the front upper part of the cap
15	L1	The initial line, describing the lower back part of the sleeve cap (BC)
16	L4	The initial line describing the lower front part of the sleeve cap (BC)
17	L2	The initial line, describing the upper back part of the sleeve cap (BC)
18	L3	The initial line describing the upper front part of the sleeve hose (BC)
19	L2′	A model line describing the upper back part of the sleeve cap (MC)
20	L3′	A model line describing the upper front part of the sleeve hose (MC)
21	kc2	The coefficient of pinches on the upper rear portion of the sleeve
22	kc3	Coefficient of pinches on the upper front portion of the sleeve hose
23	ΔДрн	Elongation of the sleeve along the midline of the sleeve at the bottom
24	P1	Extension in the middle section of the sleeve through the highest point of the cap
25	P2=P3	Expansion of lateral areas along the front and back notches

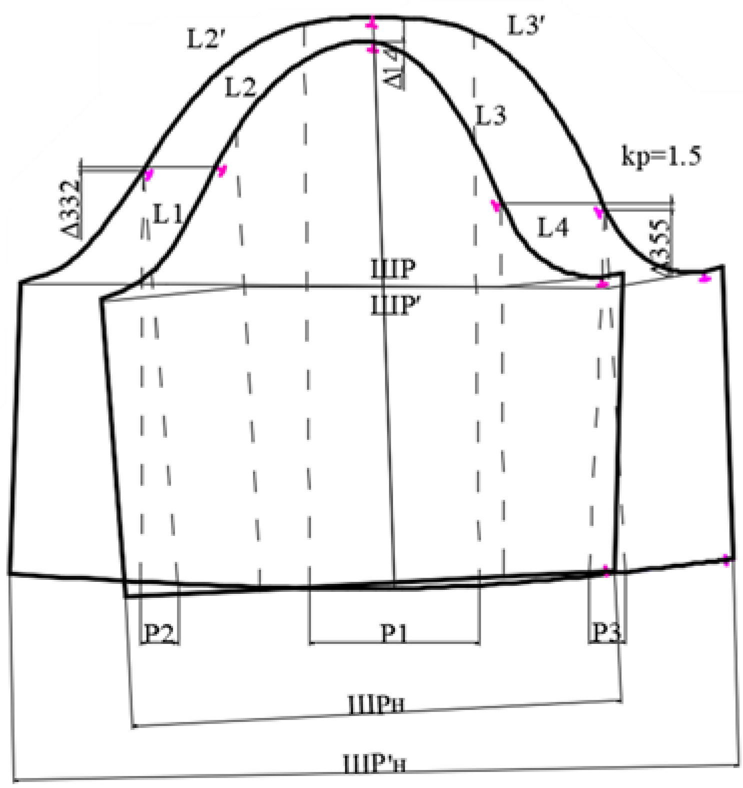

Figure 1. Parameters describing the MC of sleeve «flashlight»

The developed system of parameters will be used in developing dialog windows of the software product and for creating the bases of recommended parameter values. Using intuitively understandable and detailed characteristics in the process of automated design will allow the designer to be immersed into a creative working atmosphere and to take into account all aspects of modeling as much as possible.

In the process of developing a new algorithm for modeling a sleeve with pinches along the cap and the bottom of the sleeve, literature that covers the problem of modeling sleeves was studied. Methods that were analyzed are presented bellow:

1. Constructive modeling of clothes: Study letter for universities / AI Martynova, EG Andreeva — Moscow: Moscow State University of Design and Technology, 2006. — pp., from silt;

2. Technique of cutting. Eight hundred drawings of models, detailed drawings and visual diagrams / Lin Jacques; M .: RIPOL classic, 2009. — 592 p .: ill.

3. Modeling and designing of women's clothing / Mueller and son; — 1 volume, Moscow: Publishing house «EDIPRESS-KONLIGA», 2008.-231 p .: ill.

4. Women's clothing in detail / N. V. Erzenkova. — 3rd edition. — Mn .: «Polymya», 1992. — 320s.: Ill. ;

The absence of a universal method for obtaining a model hose design was revealed based on the results of the analysis of the modeling methods of the «flashlight» sleeve. A number of shortcomings are typical for modern techniques:

— Clear parameters and modeling coefficients are not specified;

— no recommendations are given for drawing a graphical contour of the sleeve construction.

The revealed shortcomings of the methods exclude the possibility of their use for the development of automated algorithms.

When developing a new algorithm for modeling a sleeve with pinches along the cap and the bottom of the sleeve, the shortcomings listed above were taken into account. The technique for constructing a sweep of a sleeve of a complex shape (Fig. 2) was developed on the basis of the parameters presented above (see Table 1). A special feature of this method is that it is completely mathematically describes all the stages of construction, which in turn makes this technique adapted for the automated design process.

1. Preparation of the BC sleeve for modeling (Fig. 2b):

a. Measurement of the sleeve on the bottom (Шрн)

b. Calculation of the extension of the sleeve with accounting the coefficient of extension relatively to the length of the bottom (cuff) of the sleeve. The value of the coefficients varies kp = 1.1-2.5 (depending on the design project).

c. From the highest point of the cap of the sleeve 14, the line of the warp thread is lowered

2. Dilution of the sleeve for a given amount of extension (Fig. 2c):

a. Parallel expansion of the middle section of the sleeve

By the notch 14 of the highest point of the cap of the sleeve, the BC is expanded in parallel for 70-75% with the extension P1.

$$\text{P1} = 0.7 \ldots 0.75k\text{p} * \text{Шрн}$$

b. Conical expansion of lateral areas

The remaining 25-30% of the expansion are conically expanded along lines parallel to the line of the warp thread of a sleeve drawn from 332 and 335 evenly on the back and front.

$$\text{P2} = \text{P3} = (0.25 \ldots 0.30k\text{p})/2 * \text{Шрн}$$

3. Forming the sleeve cap:

a. Raising the cap of the sleeve, depending on the properties of the specified material from point 14 upwards

Δ14 = 0.5 ... 5.0 cm

b. The cap of a sleeve is formed in three directions:

i. From point 332, the guiding line of the upper section of the back part of the sleeve cap matches with *the guiding line of* the corresponding *back lower part*;

ii. From point 335, the guiding line of the upper section of the front part of the sleeve cap matches with *the guiding line of* the corresponding *front lower* *part*;

iii. The guiding line at the highest point of the cap is *horizontal* and passes through 14′;

4. Forming the bottom of the sleeve

Forming the bottom of the sleeve occurs along two guides, matching the front and back parts of the bottom after conical expansion. ΔDrn = 0.3 … 1.5 cm

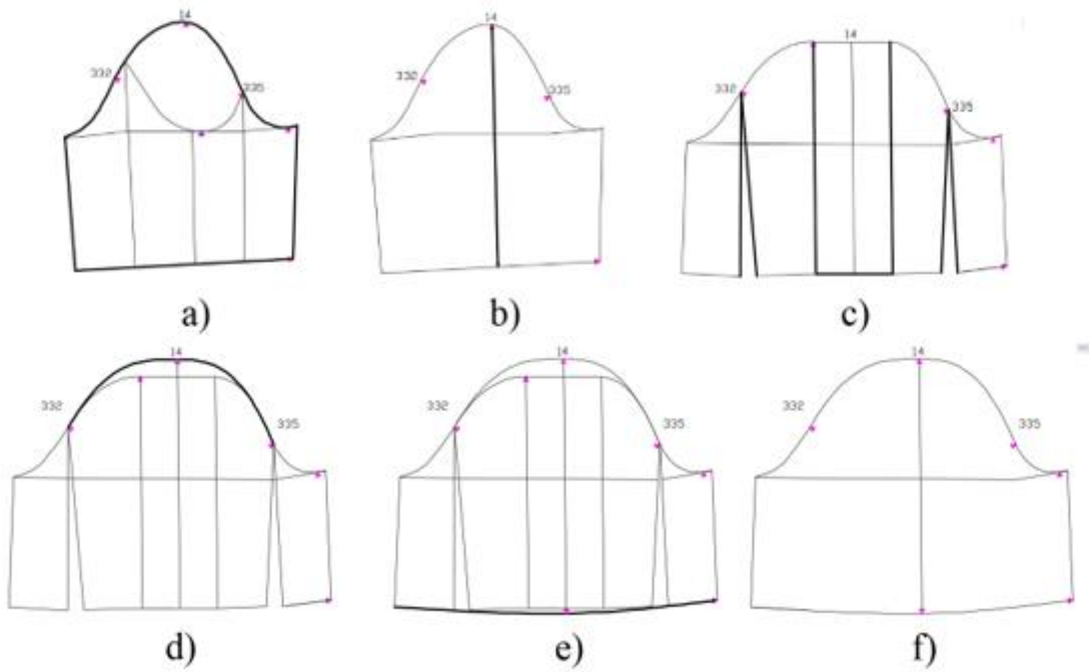

Figure 2. Sequence simulation of the design of the sleeve «flashlight»

1. BC of the sleeve drawing; b) application of the line of the warp thread and the line of the sleeve; c) parallel and conical expansion of a sleeve; d) forming the cap of the sleeve; e) forming a smooth curve of the bottom of the sleeve; f) MC of the sleeve flashlight drawing

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