The second group of cone channels, the loss of pressure medium in which the maximum. For the uniform treatment of such channels is recommended to change the flow regime of the cone to ring slit (№ 5...7) or to apply a one-way AFM (№ 6).

In the third group, consisting of a channel with the local resistance, AFM's still rough surface, perpendicular to the flow (№ 10...15). For processing to change the direction of flow through the leveling devices.

For a uniform treatment of channels with blades, which are the fourth group (№ 16...26), it is necessary to ensure an even flow environment in each of the channels, by forming the flow profile at the entrance of these channels.

In the fifth group included micro, requiring the use of working environments with low effective viscosity and low dispersion of abrasive filler (№ 27).

In analyzing the motion of individual abrasive grains in a flow is established that they move along the current lines. In steady flow the distance between neighboring grains is not changed. This confirms the supposition about the formation of elastic chains in the flow [1]. Established that the grain, into contact with the treated surface, the flow performs rotational motion. Studies education media vortices near walls or in the flow with the flow in the channel was not observed.

Research has identified the nature of the flow in channels of different media configurations and taken into account in calculating the roughness of the surface finish and performance of AFM on the previously developed technique [3].

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EXPERIMENTAL DETERMINATION FACTOR TO VISCOSITY, ELASTICITY AND PLASTICITY MEDIA FOR ABRASIVE FLOW MACHINING PROCESS*

Numerical values of factors of viscosity, elasticity and plasticity of a media are established. Experimental dependences of viscosity and elasticity of environment on degree of its filling and granularity of abrasive grains are revealed.

Keywords: abrasive flow machining, rheological characteristics, viscoelastic media, flowable abrasive particles, shear rate.

The one of the new types of such processing is abrasion-extrusion processing (AFM), which is consist in removing the layer of material from the surface of the treated channel at extruding under pressure through it, working environment, consisting of a viscosity and elasticity foundation, filled of solid working elements (most often – abrasive or diamond grains).

AFM is difficult process. In its implementation there are a number of physical phenomena that influence for quality and productivity of processing. For the introduction of abrasive extrusion processing in the production of specific details must be made a sufficiently large volume of experimental studies, related with determining the optimum composition of the working environment and modes of its extrude, caused by physical-mechanical and geometrical characteristics of processed channels. Such researching needs a lot of costs, which constituting up to 60 % of the total cost of implementing this technology in production.

The main parameters of technological process of abrasive extrusion processing is the volume of the working environment, pressure of the hydraulic system installation in burst and the host operating cylinder of installations for AFM, value (dispersion) and percentage (concentration) of abrasive grains in the working environment, its physical and mechanical characteristics, and also the number of processing cycles. The geometric characteristics of the processed feed have great influence on the quality and productivity of the process – its radius and length, area and perimeter of the cross-sectional and also initial physical and chemical properties of the surface layer.

Cutting ability of the working environment as abrasive tools depends of flow's conditions in the processed channel

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and its viscoelastic and plastic properties. Viscous and plastic properties determine its fluidity, the elastic properties – stiffness. For the theoretical calculations of the flow characteristics of working environment with AFM it needs to experimentally establish dependence of the effective viscosity η, Poisson's ratio and Young's modulus of working environment of the degree of its filling and dispersion of abrasive grains.

Characteristics of the working environment depends on the degree of filling of the polymer base (*Ka* concentration of abrasive grains in the medium), of their size (*Ba* grits), and also of a pressure in filing cylinder P_{in}.

If the *Ka* and *Ba* are changed, changes are not only in the density c the medium and its viscosity, but also in its rheological characteristics – coefficients of tangential and normal stresses, flow velocity and shear rate, and also all the curves of the shear flow dependency of shear stress.

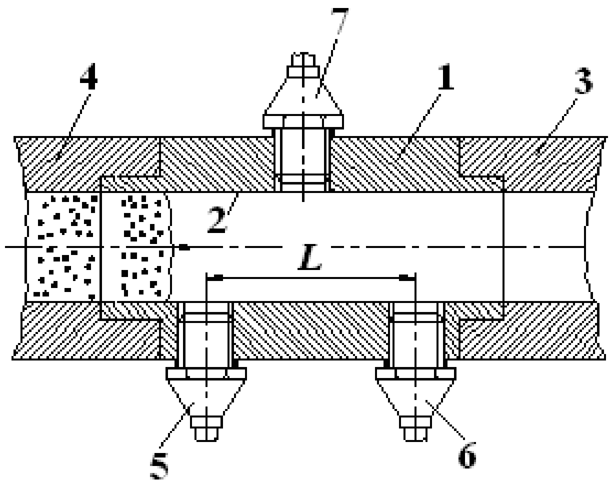
Because the nature of viscous flow abrasive medium at the extrusion processing a circular channel with big length the same to fluid flow in a capillary viscometer, for the researching of viscous properties a similar method was developed, based on the experimentally established values of maximum flow rate ω_{max} and drop of pressures ΔP on the section of a cylindrical channel *L* length and diameter *d*. Substituting the experimental values ω_{max} and ΔP in in the transformed Puayzel's formula for known *L* and *d* value of the effective viscosity η is defined.

$$\eta = \frac{\Delta P}{\omega_{max}} \cdot \frac{R^2}{8 \cdot L}.$$

For registration the parameters system of defined set of research was applied. Experiments were conducted on an experimental set UESH-25 with using a special device (fig. 1).

Device consists of a steel hull 1, which was subjected to heat treatment, with round channel 2 with 25 мм in diameter, coinciding with the diameter of working cylinders *3* and *4* UESH-25 – installation, with pressure sensors *5* and *6*, and also a temperature sensor *7*.

On the oscillogram (figure 2) pressure change in the current moment in sections of sensor *5* (P_1) and *6* (P_2) recorded. Time is defined on the oscillogram for step cutoff t_c = 0.2 c. On the line P_1 the start point of deviation from the zero level of evidence *1* is revealed. Similarly, the beginnings of the emergence of the pressure's environment at point *2* for the line P_2 is found. Through found points *1* and *2* vertical lines to the lines P_1 and P_2 are held pursuant. The distance t_c between the normals corresponds to the minimum duration of an environment from cross-section *1* to cross-section *2*. By the known distance between cross-sections (L = 0.07 м) and t_c maximum speed of flow ω_{max} is calculated in this section. Then find the point *3*,



a

b

Fig. 1. Device for the study of viscous and plastic properties: *a*– scheme; *b* – the body of device with two adapters

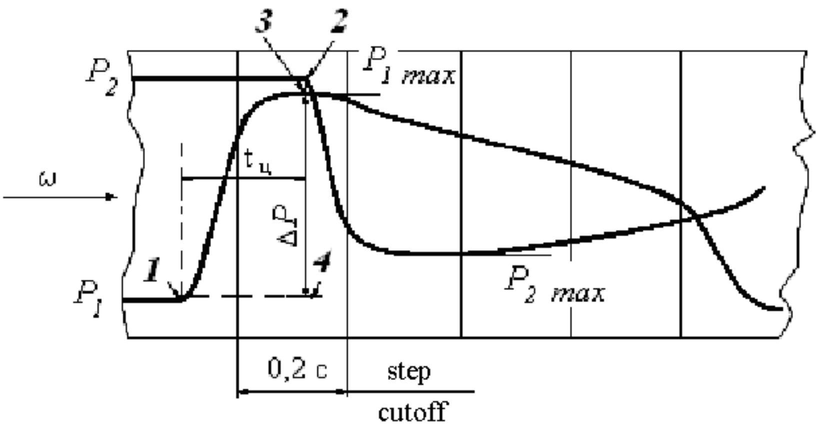


Fig. 2. Scheme of registration data on the oscillogram

which is intersection of the normal through the point *2*, lying on P_2 line, and point *4* by P_1 line.

The exact values of physical quantities t_c and ΔP were calculated taking into account the calibration of sensors and size of step cutoff t_c. The pressure difference between the two cross-sections $\Delta P = P_1 - P_2$ equal to the distance between points *3* and *4* on the oscillogram, multiplied by the scale calibration. Six experiments with randomization of time and temperature controlled environment was conducted for each experimental conditions.

The researching of dependence the coefficient η of *Ba* and P_{in} was carried out according to Kono plan ($m = 2$, $n = 3$). For the mathematical processing the coding variables $X_1 = Ba$; $X_2 = P_{in}$; $Y_1 = \eta$ was produced. Granularity *Ba* and the pressure P_{in} were varied factors. Each experiment was repeated six times with randomization time. Terms of experiments on the nine modes and experimental results are given in table 1.

As a result of studies found that the higher the degree of filling polymer base working environment by abrasive, the higher its effective viscosity. Bigger factor з observed when lesser magnitude filled with abrasives at equal weight's filling *Ka* abrasives of different grain *Ba*.

Increasing of P_{in} during extrusion of environment improves processing's conditions by increasing shear stress and flow rate of the medium and the velocity gradient.

Young's modulus and Poisson's ratio is characterized elastic properties of the working environment. Elastic characteristics of the medium depend of degree of filling *Ka* and dispersion of the filler *Ba*. The numerical values of these indicators are needed when calculating the contact working environment with workpiece and evaluated by change in length $l - l'$ and diameter $d' - d$ of sample of environment during its compression load *F* (fig. 3).

Guides axle *5* installed in bronze bushings of base *2* devices with interference, and in the sleeve weight plates *3* – with sliding landing. The sample of working environment is forming in the working cylinder of the experimental setup UESH 25, determined in a certain position that ensures its dimensional stability. The nominal diameter of the specimen before the deformation $d = 25$ mm, the nominal length of the specimen before deformation $l = 50$ mm. Cross-sectional area of the sample – $S = 0.00049$ m^2. Measuring the size of the sample was held by using calipers and micrometers.

The mass of weight plates and additional cargo were chosen so, that specimen is deformed predominantly elastically and linear dependence of its size on the applied load was carried. Total weight was 150 *g*. Waiting time was 3...10 seconds.

It is possible to experimentally determine their values, based on the definitions of Young's modulus and Poisson's ratio μ:

$$F = \frac{m_{load}\, g}{S} = E\frac{l' - l}{l}; \ \mu = \frac{(d - d')/d}{(l' - l)/l}, \text{ и}$$

where m_{load} – mass of the applied load.

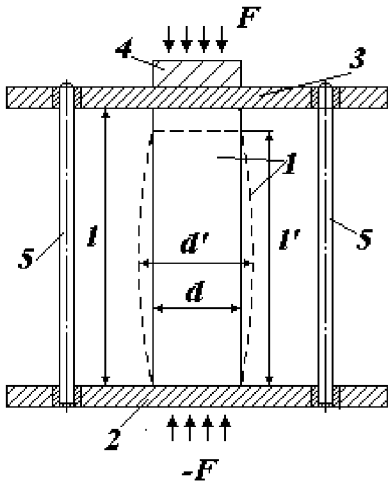


Fig. 3. Device and circuit measurement of Young's modulus and Poisson's ratio environment: *1* – sample of the working environment; *2* – base adjustment; *3* – weight bracket; *4* – extra weight; *5* – steered axles; *6* – micrometer

Table 1

Dependence the coefficient η of *Ba* and P_{in}

№	*Ba*, мкм	P_{in}, МПа	η, Па·с
1	300	9,0	36,892
2	400	9,0	36,093
3	500	9,0	29,215
4	300	7,5	32,368
5	400	7,5	30,402
6	500	7,5	23,204
7	300	6,0	27,283
8	400	6,0	24,166
9	500	6,0	16,223

Table 2 shows the results of studies of Young's modulus depending on the degree of the working media content and size of abrasive filler.

Experimentally determined (fig. 4) that an increase of *Ka* for more than 80 %, fixed abrasive in polymer-based environment is significantly reduced. This phenomenon leads to loss of yield and environmental fallout of grains of the polymer base that significantly impairs the conditions of abrasive-extrusion processing. Therefore, this figure was adopted for the boundary condition for the maximum degree of filling. The value of Poisson's ratio μ of the polymer base without abrasive filler – 1.34, for filling among its experimentally measured value varies in the range 0.4…0.42.

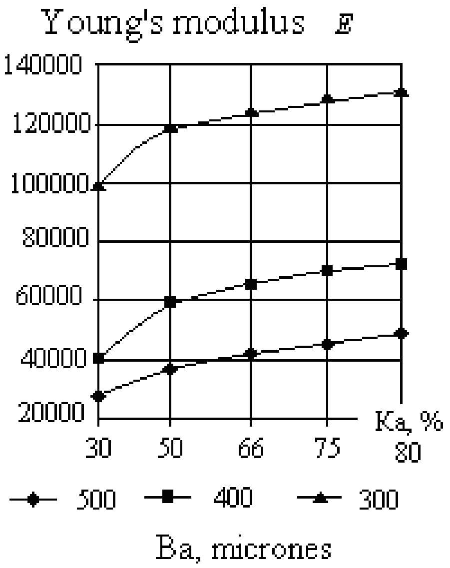


Fig. 4. Dependence of Young's modulus of the working environment on the degree of filling of abrasive grains and the quantity of abrasive filler

Young's modulus *E* increases with the degree of filling and reduced dispersion of abrasive grains. This effect is explained with the help of the transformed Kargin–Slonimsky–Rous model [1], which is describe the working environment as a visco-plastic medium full of elastic chains formed by abrasive grains and the polymer base.

In polymer-based unfilled chain abrasive grains are absent. Reduction of dispersion of the filler with the same mass filling leads to an increase in the number of abrasive grains in the medium. The greater the number of abrasive grains in the medium to longer chains occurs in the environment, length of segments which, in turn, decreases. Shorter segments of the chain cause its high elasticity and viscosity. The plasticity of the medium reduced.

To assess the cutting properties of the studied working media used the method of simplices with the same initial data and constraints, composition of the medium and P_{in}. The results of experimental studies abrasive extrusion processing showed that the optimum cutting ability, measured by the value of surface roughness after treatment or change in processing ΔRa, value of the material removed layer Δh, is achieved using a composition of the working environment in which the elasticity of the medium is maximal. The coefficients of viscosity and plasticity at the same time used to set the boundary conditions abrasive extrusion processing specific details. Numerical indicators of viscosity, elasticity and plasticity of the working environment depends on the geometric characteristics of the processed channel and the requirements of the surface layer of detail.

The developed technique allowed to determine experimentally the flow rate ω_{max} and the coefficient of effective viscosity з of media of different compositions with abrasive flow machinig process, which can be used to calculate the pressure-spending environment characteristics in the processed channels.

The degree of influence of filling abrasive *Ka*, *Ba* quantities of abrasive grains and the inlet pressure P_{in} of viscous, elastic and plastic properties of the medium were set. With increasing P_{in} and content of abrasive in the medium *Ka* environmental factors з increases. This is due to the fact that with increasing shear rate more intensively destroyed the spatial structure of the medium. The effective viscosity, shear and normal stresses become larger. So for a medium-grit $Ba = 400$ microns with $P_{in} = 6$ MPa – $\eta = 24{,}166$ *Pa*; with $P_{in} = 9$ MPa – $\eta = 36{,}093$ *Pa*, i. e. is 65...70 % more.

Table 2

Elastic characteristics of working environments

Ba, мкм	*Ka*, %	Young's modulus	Poisson's ratio
0	0	22,760	1.34
320	30	97,955	0.411
320	50	119,600	0.411
320	66	124,300	0.411
320	75	128,250	0.411
320	80	132,500	0.411
400	30	40,480	0.40
400	50	59,200	0.40
400	66	65,100	0.40
400	75	70,400	0.40
400	80	73,100	0.40
500	30	27,000	0.42
500	50	37,000	0.42
500	66	42,000	0.42
500	75	46,000	0.42
500	80	51,000	0.42

Experimental determination of the coefficients of viscosity, elasticity and plasticity allows for the theoretical calculations of accuracy, productivity and quality abrasive extrusion processing. Obtained numerical values of the elastic-visco-plastic medium allow the choice of contact of abrasive grains [2]. Having established contact on the proposed methods [3; 4] it possible to calculate the performance of AFM and the roughness of the treated surface details.

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MODEL-BASED STUDY OF OXIDATION PROCESSES IN A JET ENGINE FUEL LIQUID PHASE

The process of oxidation in hexadecane liquid phase as a conventional model of oil hydrocarbons is investigated. The oxidation product structure is defined by means of Chromatography/Mass Spectrometry.

Keywords: high-temperature oxidation, hexadecane, oxygen-containing organic compounds, jet fuel.

Aviation kerosene is utilized in aircraft engines as a fuel and also as a coolant. Therefore, it should have the property of strong stability against high-temperature oxidation.

It would be of interest to investigate the processes flowing in high-temperature jet engine fuel oxidation liquid phase.

Hexadecane (HD) is a conventional model of oil hydrocarbons (fig. 1).

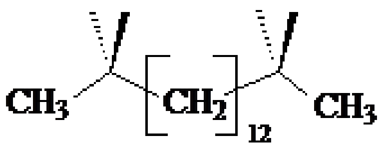

Fig. 1. Hexadecane

Hexadecane behavior in the process liquid phase oxidation was investigated by various authors and by different ways of reactor thermostatting [1].

The term "high-temperature" oxidation is usually applied to the processes flowing at the temperatures of 150 to 170 °C in case of hexadecane oxidation.

Previous research [1] has established that HD oxidation flowing at high temperature is an exothermal process.

At a certain moment, the so-called time-limited "thermal explosion" takes place in oxidation [1]. After the end of exothermal stage, the oxidation progresses at a lower speed. Under the assumption [2] it occurs owing to formation of polar nanophase (inverted microemulsion, "water in oil" – type) on the basis of primary and secondary hydrocarbons oxidation products.

The nucleus of such reversed micellar aggregate under the assumption [2] contains a small amount of mono- and polycarboxylic acids and alcohols (polyols). The average sphere includes mainly fragments of ethers and esters. The external sphere consists mainly of long hydrocarbon chains providing stabilization of micelle in the non-polar hydrocarbon environment (fig. 2).

Changes of the oxidized hydrocarbon phase structure has been experimentally studied [2] indirectly, through a method for water-stain solubilization, for example, methyl-orange (MeOr).

Judging by changes in MeOr band position taking place with a rising hexadecane oxidation degree, the authors [2] have assumed that the localization of stain molecules in the oxidized hexadecane polar nanophase corresponds to a moderately polar oxidation product layer containing chemical bonds of type C–O–C, or similar ones.

Shift of MeOr absorption band in the process of increasing hexadecane oxidation degree has been obtained [2].

At the stage of deep oxidation the mechanism of reaction is especially complex. The prime oxidation products are generated. The physical and chemical properties of system are developed and they determine the system operational performance.