ОРГАНІЗАЦІЯ ОБ'ЄДНАНИХ НАЦІЙ З ПИТАНЬ ОСВІТИ, НАУКИ І КУЛЬТУРИ

МАЛА АКАДЕМІЯ НАУК УКРАЇНИ ПІД ЕГІДОЮ ЮНЕСКО

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PROPERTIES OF NON-NEWTONIAN FLUID

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Abstract

The widespread use of polymer and nanopowder additives now again reflects interest in non-Newtonian fluids.Therefore, we made a non-Newtonian liquid based on an aqueous starch solution at home andinvestigated the properties of non-Newtonian liquids.
The optimal ratio of components that determine the special properties of the non-Newtonian system based on an aqueous solution through the cloud is found; substantiated its practical application.

Introduction

In the work "Properties of non-Newtonian fluid" the works of scientists who studied the properties of non-Newtonian fluids are analyzed, emphasis is placed on the fact that interest in non-Newtonian fluids is associated with the development of biomechanics, bionics, biohydrodynamics, food industry.
The object of study is a non-Newtonian fluid based on an aqueous starch solution. The subject of research is the properties of non-Newtonian fluids.
Purpose: to find the optimal ratio of components, which determines the special properties of non-Newtonian fluid based on an aqueous starch solution; justify its application.A number of research tasks were set: analyze information about non-Newtonian fluids; to make a non-Newtonian liquid at home, establishing the optimal ratio of components, and to study its properties; to investigate the rheological properties of the obtained liquid;justify the practical use of such material.

Hypothesis

Newtonian liquid is a mixture of starch and water of a certain ratio with special properties.

Material and methods

In [1], it was found that extruded potato starch is almost completely dispersed throughout the solution and is practically not precipitated by centrifugation at room temperature. Therefore, this type of starch was chosen to obtain non-Newtonian materials. To establish the ratio of components, 10 samples were first prepared in the ratio of components given in table. 1 (experiment 1). Samples 1-6 were immediately stratified into water and starch. The sedimentation of the solutions was observed for an hour - a clear separation of water and starch was visible. Non-Newtonian properties were observed only in sample 10, where the ratio of starch: water is 1 to 1.

The composition of the components for the experiment 1

Sample	1	2	3	4	5	6	7	8	9	10
Starch, g	1	1	1	1	1	1	1	1	1	1
Water, g	10	9	8	7	6	5	4	3	2	1

The composition of the components for the experiment 2

Sample	1	2	3	4	5	6	7	8	9
Starch, g	1	2	3	4	5	6	7	8	9
Water, g	9	8	7	6	5	4	3	2	1

Subsequently, we changed the proportion for potato starch and water (experiment 2, table 2). A non-Newtonian effect was observed for samples 5 and 6, where the ratio of starch to water is 5 to 5 and 6 to 4. Stable, homogeneous and uniform white mixtures were obtained (Fig. 1). With a further increase in the starch content (samples 7-9), an inhomogeneous lumpy mixture is formed.

When observed for 24 hours, a stable effect of sedimentation stability was found for samples 5 and 6. Thus, the optimal ratio of components to obtain a non-Newtonian fluid was experimentally proven. The active component of non-Newtonian fluids is water, the amount of which significantly changes the rheological properties of the system, in particular, viscosity. We study the dependence of the viscosity of the starch solution on the concentration at a temperature of 18 ˚C, using a capillary viscometer (diameter 0.86 mm) (Pic. 2).

Pic.2 Measurement the viscosity of the solution starch by viscometer

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Material and methods

Calculate the dynamic and specific viscosity[2].

The results of measurements and calculations are given in table 3.

table 3.Dynamic and specific viscosity aqueous starch solution

Aqueous starch solution, ml / water, ml	τ,c	η, · 10^{-3}Pa·c	η_{spe}
0\10	88	1,1	0
1\9	98	1,2	0,11
3\7	136	1,7	0,54
4\6	172	2,1	0,95
5\5	204	2,5	1,3

Assess whether it is possible to use non-Newton fluids based on an aqueous solution of starch to create a lying policeman. Let us investigate the preservation of the properties of a non-Newtonian fluid from the rate of action[3]. The value of the velocity of the ball, given in table. 4.

table 4. Fall height and speed value

h, m	0,39	0,8	1,57	2,3	3,4	4,7	6,2	9,7
υ, km/hour	10	15	20	25	30	35	40	50

Research of properties non-Newtonian fluid depending on the height of the falling ball

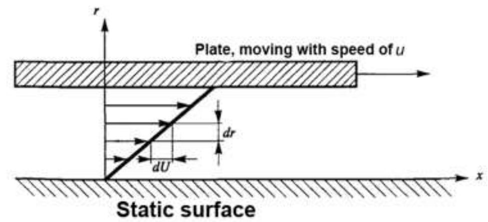
We offer to make artificial road irregularities of the "lying policeman" with the use of aramid fabric covering a flexible plastic pipe, which would ensure a smooth flow of liquid. The pipe is filled with an aqueous solution of starch, which hardens when hit at speeds exceeding 10 km / h for the residential area.

Let's model the behavior of a non-Newtonian fluid when exposed to it at a certain rate. To do this, we chose a dilating liquid (aqueous solution of potato starch), because its rheological behavior can be described using the flow diagram of the Quetta (Pic. 4) [4]. Consider the simplest case of a linear relationship between the tangential stress τ and the velocity gradient

$$\frac{du}{dr}$$

Let's describe the steady flow of a viscous fluid, the fluid is between two plates, one of which is stationary and the other is displaced at velocity u. You can calculate the velocity of the fluid flowing per unit time through the cross section [4]:

Quetta flow diagram



and the velocity gradient: $u = \frac{dx}{dt}$ **where** $\frac{dx}{dr}$ **characterizes the shift γ of the fluid ayers or deformation** $\gamma = \frac{dx}{dr}$

Then the velocity gradient we can express as the shear rate: $$\frac{du}{dr}\ \frac{du}{dr} = \frac{d}{dr}(\gamma) = \frac{d\gamma}{dt}$$

Therefore, we can establish for a non-Newtonian fluid the dependenceof the tangential stresses τ on the velocity gradient or shear rate: $$\tau = \mu\frac{du}{dt} = \mu\frac{d\gamma}{dt}$$

where μ is the dynamic viscosity of the Nenton fluid, Pa · s

Results

The optimal ratio of components for the production of non-Newtonian liquid was experimentally proved, its sedimentation stability was investigated and the viscosity of aqueous solutions of starch was determined. When creating a lying policeman, we suggest using aramid fabric in combination with a plastic tube filled with non-Newtonian fluid. These materials must correspond in their properties to the shear rates to which they will be subjected during operations.

Conclusions

Newtonian fluids change their density and viscosity when exposed to physical force. This makes it especially promising for such substances to be used under variable loads. If a solution of starch of a certain concentration is sharply affected by force, it acquires the properties of a solid body. This is due to the fact that starch particles swell in water and form conglomerates in the form of chaotically woven molecules. A non-Newtonian effect was observed for samples in which the ratio of starch to water was 5 to 5 and 6 to 4. Sedimentation-stable, homogeneous and uniform white mixtures were obtained. Thus, the optimal ratio of components to obtain a non-Newtonian fluid has been experimentally proven. The dependence of the viscosity of the starch solution on the concentration at a temperature of 18 ˚C was studied using a capillary viscometer. Dynamic and specific viscosity are calculated. When the starch concentration increased 5 times, the specific viscosity increased 11.8 times. The possibility of using non-Nenton fluids of different viscosities to create a "lying policeman" has been established. It is proposed to use aramid fabric in combination with a plastic plastic tube filled with non-Newtonian fluid. These materials must correspond in their properties to the shear rates to which they will be subjected during operation. The rheological behavior of a non-Newtonian fluid is described using the Quetta flow scheme.

References

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