1.ROTATION

Z. Osmanov, A. Razmadze

School № 42 named after I.N. Vekua

First I want to talk about are liquids, which move down. Rod begins to rotate. In cause of viscosity liquid rotates too. Let us consider it's small element, which is situated, on the surface. For it is being at rest it is necessary all the forces, acting on this element be balanced. They are gravitating, centrifugal, and reacting forces. Surface takes such a shape under action of centrifugal force.

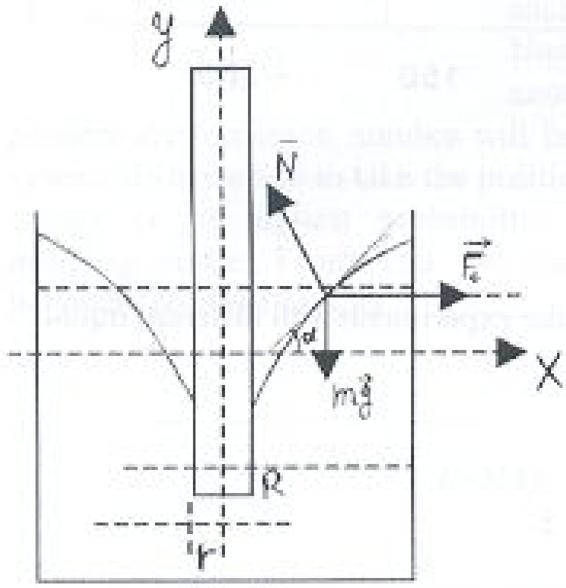


Fig 1.

Tangent of tangent angle inclination in point with coordinate x is :

$$\mathrm{tg}\alpha(x) = \frac{\omega^2(x)x}{g} = y'(x)$$

And how we know it's equal to derivative function. From this I have got function of surface and from equal of initial and final volumes we got that height of falling is:

$$H = \frac{\omega_0^2 r^4 R^4}{4g(R^2 - r^2)^2}\left[3 + 2\left(\frac{R}{r}\right)^2 + \left(\frac{r}{R}\right)^4 - 6\left(\frac{r}{R}\right)^2 - 12\ln\frac{R}{r}\right]$$

One of idealisations is that w was calculated for the unlimited coaxial cylinders:

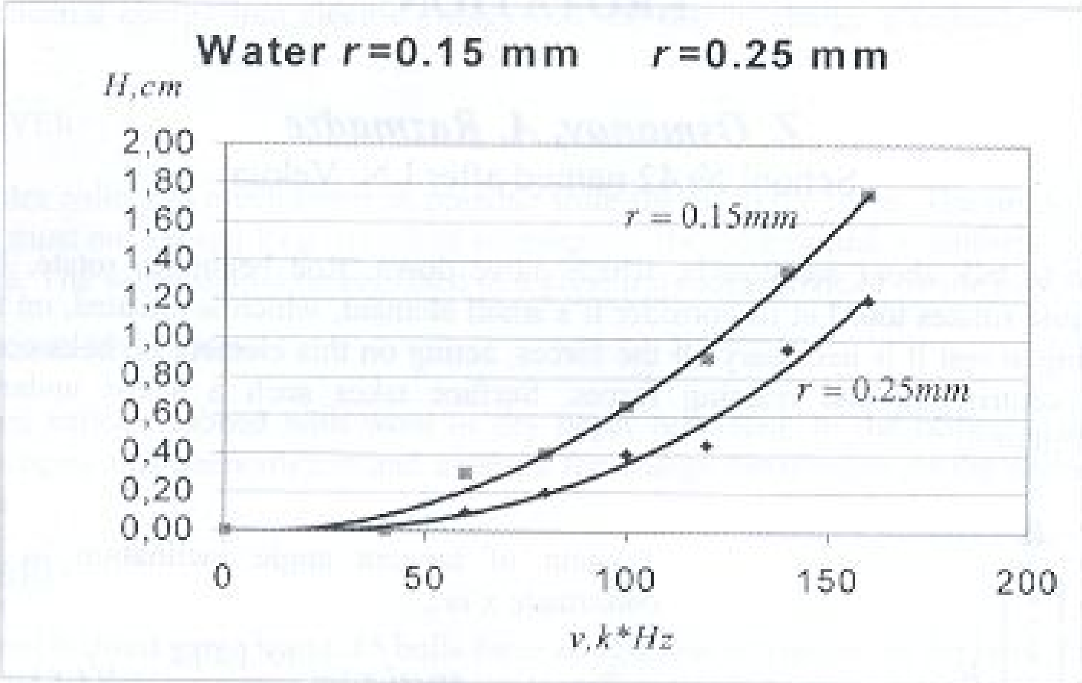
$$\omega(x) = \frac{\omega r^2}{R^2 - r^2}\left(\frac{R^2}{x^2} - 1\right) \qquad x \in [r, R]$$

From the proposed theory we can find such a tendentious:

1. With increasing of ω (angular velocity) - height of falling increases.
2. With increasing of R (radius of vessel) - height of falling increases.
3. With increasing of r (radius of rod) - height of falling decreases.

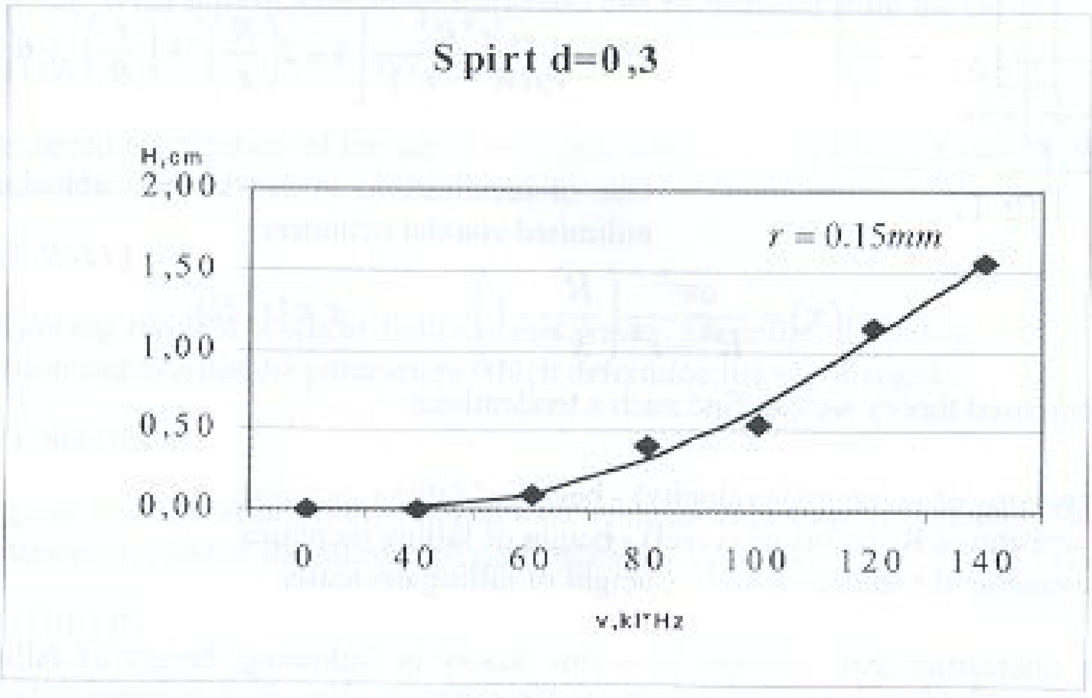
Note: It is interesting that outcome from this theory is following: height of falling does not depend on next liquid parameters: viscosity and density.
Proposed theoretical results are in good agreement with experiments.

To approve theory I want to present some experimental data. Here we can see the detention between height of falling and frequency for water when rod's radiuses are different.



Graph 1.

The next graph shows us that nothing changes when we make experimentswith different liquid.



Graph 2.

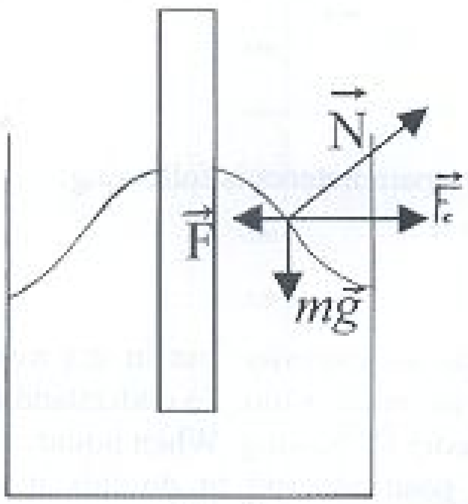


Fig 2.

Next I want to talk about are liquids which make upward motion on the rod. In order to understand difference between these liquids let us again consider small element of the liquid. It is obvious that for being at rest there must be a force, compensating the action of all other forces. Let us understand its origin.

The liquids, which make upward motion on the rod, are polymer liquids and in cause of their structure they posses elasticity. In order to understand the nature of this elasticity let us speak about one molecule. If we leave molecule to its own devices it's one end will freely fluctuate. Generally it will take such a size in which it will be possible to change more forms. Now if we will pull the another end the possible conformation number will be decreased. As the system always tends to take the position with the minimal energy or of highest probability, there appears the restoring force. From this we can understand that polymers posses elasticity.

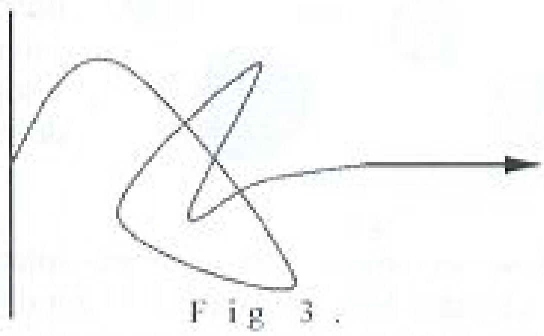


Fig 3.

$E=3\xi kT$ – Jung's module for polymers.

ξ – Number of cohesion.

Let us consider an elementary prism in liquid. In cause of viscosity different layers of liquid moves with different velocities. That's why initial right prism became inclinative. In cause of elasticity increased size will tend to become initial. That's why liquid makes upward motion.

More qualitatively we can represent this phenomenon in the following way: we have a rod and stretched along the whole length elastic. It is not difficult to understand that it tries to contract the rod and makes itself to climb on it. To get quantitative dependence of climbing height on some parameters, we are interested in normal component of this stretch. In cause prism is elastic it is obeyed on Hook's law.

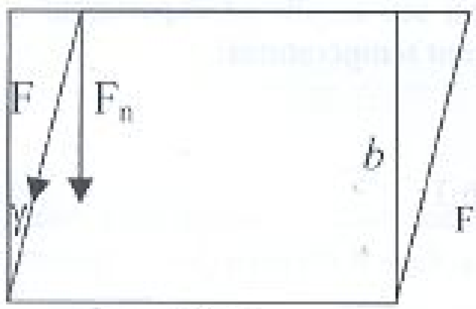


Fig 5.

The projection of tension on normal axis is following:

$$dF_n = \frac{EdS\Delta b}{b}\cos\gamma$$

For displacement we have:

$$dF_\tau = GdS_1\gamma$$

On the other hand force that makes prism to change its form is difference between viscosity forces:

$$dF_\tau \sim dS_1 \eta b V''(x)$$

Pressure acting on rod is following:

$$p = \frac{dF_n}{dS} \approx \rho g H$$

from this we can judje about height of rising.The dependance from parameteres is following:

$$H \sim \frac{\eta^2}{\rho g}\frac{1}{\sqrt{R^2+9r^2}}\frac{\omega^2}{E}\frac{R}{r}$$

We can see that height depends on viscosity, but in it's own turn viscosity depends on some parameters too. To understand it qualitatively let us talk about theory of flowing. When liquid flows molecules change their positions and to do this it is necessary to posses definite energy.

From this theory we have that with temperatures increasing viscosity decreases and with angular velocities increasing it decreases too.

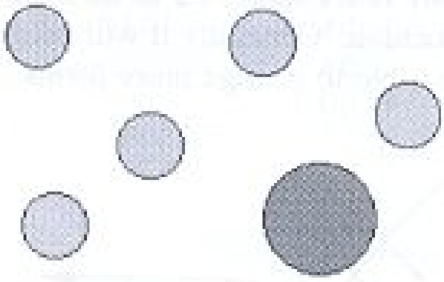


Fig 6.

How we know polymers are entangled to each other long molecule. It is not difficult to understand that if one molecule's end moves in to one place, another can move to another. From this consideration we can get following tendentious:

1.With T increasing viscosity decreases.

2.With ω increasing viscosity decreases.

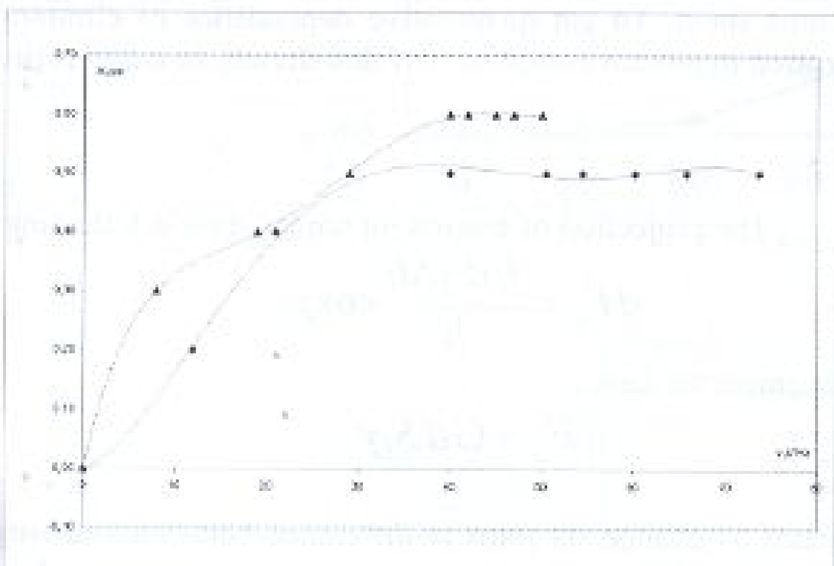
3 with increasing of concentration viscosity increases.

4.With increasing of molecule's length viscosity increases.

Fig 7.

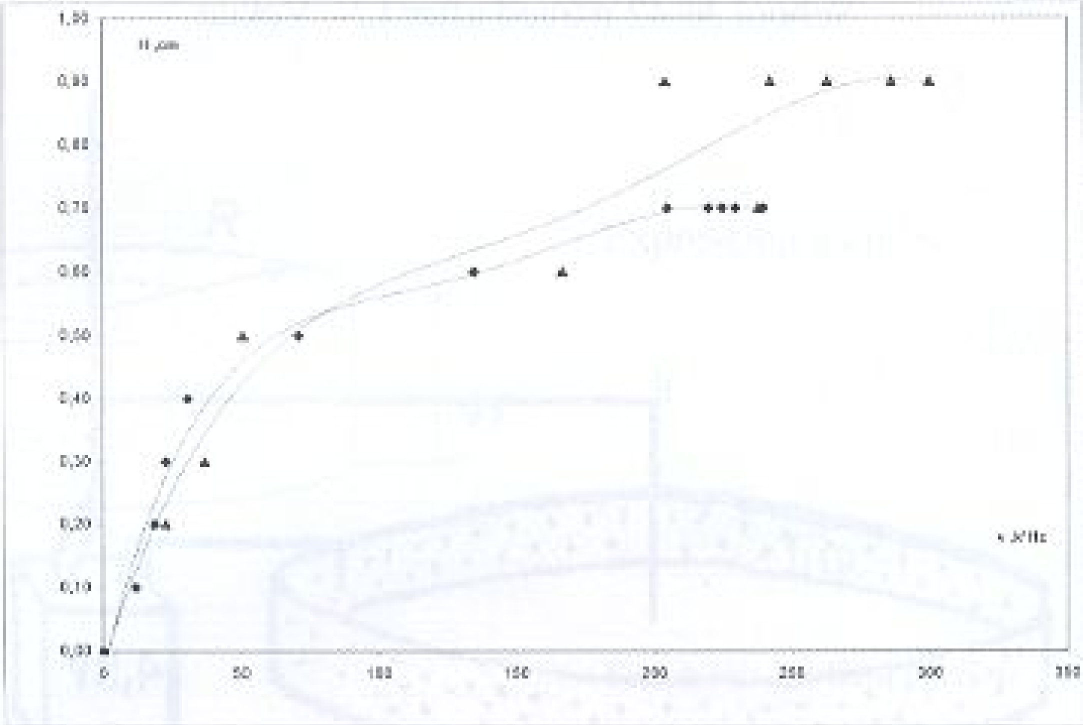
5.With increasing of molecule's mass viscosity increases.

To approve getting dependence here we can see results of experiment at different temperatures:



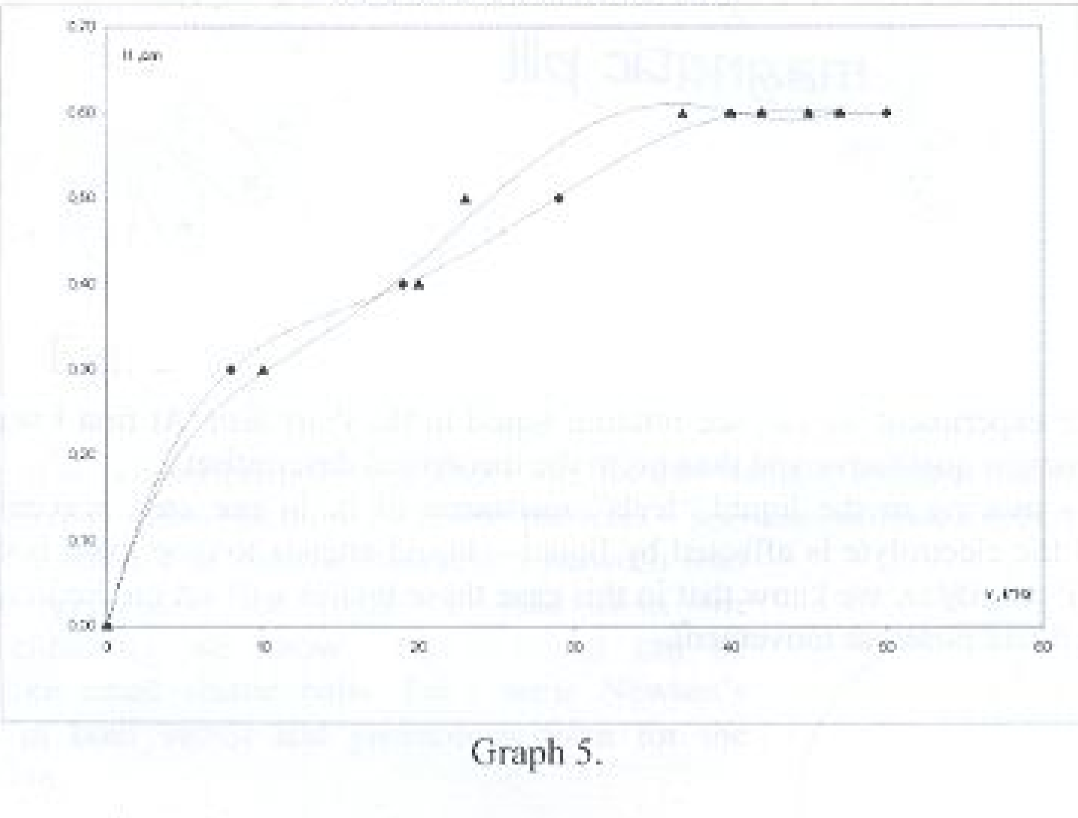
Graph 3.

Different rod's radii:



Graph 4.

Different concentrations:



Graph 5.

From experiment we can see that the height either of downward or upward motion goes on constant. I can explain it such a way: at this time when H goes on constant we can see splash and waves. At definite w centrifugal force is more than elastic. The energy decreases in cause of making waves and on splash. The flow transforms from laminar into turbulent.