14. THREAD DROPPER

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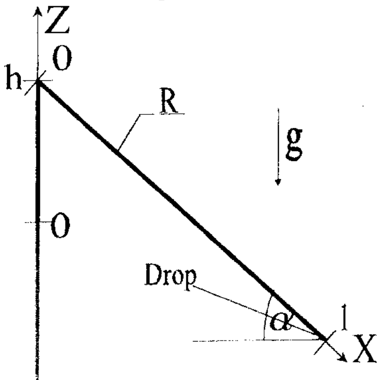
A thread consists of many thin fibers. Average radius of the fibers and average distance between neighbor fibers is of order 10 μm. Fibers are sinuous.

Thread is straight on both sides of the vessel in our model. Length of the underwater part of the thread is much bigger then radius of a fiber. That means that depth of immersion of the thread has no influence on the phenomena observed. Temperature of water is equal to temperature of surrounding air and doesn't change in time. Front surface of water in a thread is assumed to be stationary, because the potential energy change due to the surface shape variation is negligible.

The forces acting on water in a thread are force of gravity(F_G), force of surface tension(F_S) and force of viscous friction(F_V). Water can evaporate from the side surface of a thread. In some conditions this factor can has considerable influence on the motion of water.

Let us list conditions under which a drop will be observed. If H is maximal height on which water can be lifted in a thread by surface tension then h shouldn't be more than H to let water to enter external part of a thread. Also l should not extend$(h + \frac{\pi R \theta \sigma}{\rho S g}) / \sin\alpha$ to let a drop appear (R-radius of a thread, S-area occupied by water in a cross section of a thread, θ – wettability of a thread). In other case force of surface tension will stop water on the end of a thread. Also rate of evaporation shouldn't be more then rate at which water enters a thread.

Angle between drop's surface and horizon increases with growth of its mass. Drop falls when force of surface tension reaches its maximal value. Drop can form also on the way to the end of a thread. It is hardly possible if a thread is uniform. A real thread has some fibers ending out of the thread. They let some water to flow out. If we assume that water flown out of the thread has shape of a half sphere, its radius should extend following value to guarantee further forming of a drop: $\sqrt{\frac{6\theta\sigma}{\rho g}}$



Describing motion of water in a thread lets us find the time when the first drop appears and the time when it falls (Time is equal to zero in the moment of immersion of a thread in water). We write down Newton's second law for variable mass:

$$\frac{d\vec{P}}{dt} = \vec{F}_S + \vec{F}_G + \vec{F}_V$$

A computer solves this equation using Runge method of solving differential equations.

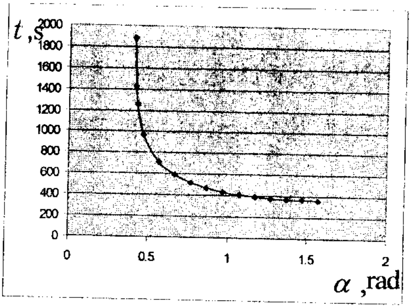


Fig.1 Dependence of time of fall of first drop on the angle α

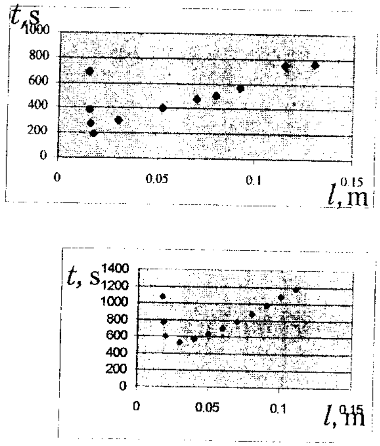


Fig.2 Experimental and theoretical dependence of time of fall of first drop on l

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References:

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